Arctic Bay Harbour Development

Environmental & Socio-Economic Baseline Report

Public Services and Procurement Canada

PSPC No. R.110729.001

11 August 2021

317071-00037

Advisian
Worley Group
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PROJECT: 317071-00037-00-EN-REP-0001: Arctic Bay Harbour Development – Environmental & Socio-Economic Baseline Report

Rev	Description	Author	Review	Advisian approval	Revision date
0	Issued for Use	L. Pittman / D. Pinto / M. Yu	V. Burdett-Coutts	H. Kullmann	11-Aug-21

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Abbreviations and Acronyms

Acronym/abbreviation	Definition
ABA	Acid Base Accounting
AFA	Arctic Fishery Alliance
AGP	Acid Generating Potential
AIA	Archaeological Impact Assessment
AIS	Automatic Identification System
AOPS	Arctic and Offshore Patrol Ships
ARD	Acid Rock Drainage
CALA	Canadian Association for Laboratory Accreditation
CCME	Canadian Council of Ministers of the Environment
CD	Chart Datum
CEGEP	Collège d'enseignement général et professionnel
CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada
COC	Chain of Custody
COP	Convention on Biological Diversity
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSAS	Canadian Science Advisory Secretariat Science
DAS	Disposal at Sea
DFO	Fisheries and Oceans Canada
DFO- FFHPP	DFO-Fish and Fish Habitat Protection Program
DFO-SCH	DFO-Small Craft Harbour
DHC	Disturbed Human-Caused
EBSA	Ecologically and Biologically Significant Area
ECCC	Environment and Climate Change Canada
EEZ	Exclusive Economic Zone
ELC	Ecological Land Classification
EQuIS	Environmental Quality Information System

Acronym/abbreviation	Definition
ESEB	Environmental and Socio-Economic Baseline
ESWG	Ecological Stratification Working Group
FAO	Food and Agriculture Organization
FYI	First Year Ice
GN	Government of Nunavut
GN-CGS	GN Department of Community and Government Service
GN-CH	GN Department of Culture & Heritage
GN-DoE	GN Department of Environment
GN-EDT	GN Department of Economic Development & Transportation
GN-PPD	GN Department of Petroleum Products Division
GPS	Global Positioning System
HHWLT	Higher High Water Large Tide
HHWMT	Higher High Water Mean Tide
HRQ	Haul Road and Quarry
HTA	Hunters and Trappers Association
HTO	Hunters and Trappers Organizations
HWM	High water mark
IACR	Indexed Value of Additive Cancer Risk
IBAs	Important Bird Areas
IBKS	Inuit Bowhead Knowledge Study
ICSP	Integrated Community Infrastructure Sustainability Plan
IFMP	Integrated Fisheries Management Plan
IHT	Inuit Heritage Trust
IIBA	Inuit Impact and Benefit Agreement
IQ	Inuit Quajimajatuganjit
ISQG	Interim Sediment Quality Guidelines
IUCN	International Union for the Conservation of Nature
LLWLT	Lower Low Water Large Tide

Acronym/abbreviation	Definition
LLWMT	Lower Low Water Mean Tide
LUP	Land Use Plan
LWM	Low water
Mbps	Megabits per second
MBS	Migratory Bird Sanctuaries
MEPS	Marine Ecology Progress Series
MIG	Milne Inlet Graben
ML	Metal Leaching
MPA	Marine Protected Area
MS-NP	Modified Sobek Neutralization Potential
MUN	Memorial University of Newfoundland
MWL	Mean Water Level
MYI	Multiyear Sea Ice
NAICS	North American Industry Classification System
NBRLUP	North Baffin Regional Land Use Plan
NCRI	Nunavut Coastal Resource Inventory
NEAS	Nunavut Eastern Arctic Shipping
NFA	Nunavut Fisheries Association
NGMP	Nunavut General Monitoring Plan
NHC	Nunavut Housing Corporation
NIRB	Nunavut Impact Review Board
NMCA	National Marine Conservation Area
NNF	Nanisivik Naval Facility
Non-PAG	Non-Potentially Acid Generating
NPC	Nunavut Planning Commission
NPR	Neutralization Potential Ratio
NRI	Nunavut Research Institute
NSSI	Nunavut Sealink Supply Inc.

Acronym/abbreviation	Definition
NTI	Nunavut Tunngavik Inc.
NTU	Nephelometric Turbidity Units
NWB	Nunavut Water Board
NWHS	Nunavut Wildlife Harvest Study
NWMB	Nunavut Wildlife Management Board
OW	Open Water
PAG	Potential Acid Generating
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PEL	Probable Effects Level
PLI	Point Load Index
PSIR	Project Specific Information Requirements Document
PSPC	Public Services and Procurement Canada
PSU	Practical Salinity Unit
QA/QC	Quality Assurance/Quality Control
QIA	Qikiqtani Inuit Association
RCMP	Royal Canadian Mounted Police
RDL	Reportable Detection Limits
ROV	Remote Operated Vehicle
RPD	Relative Percent Difference
RQD	Rock Quality Designation
RWO	Regional Wildlife Organization
SAO	Senior Administrative Officer
SAR	Species at Risk
SARA	*Species at Risk Act*
SCH	Small Craft Harbour
SDR	Screening Decision Report
SFE	Shake Flask Extraction (test)

Acronym/abbreviation	Definition
SST	Sea Surface Temperature
TC	Transport Canada
TEL	Threshold Effects Level
the Program	Geotechnical investigations in Arctic Bay
the Project	Arctic Bay SCH
TI	Tallurutiup Imanga
TOC	Total Organic Carbon
TSS	Total Suspended Solids
UDS	Upland Dwarf Shrub
ULB	Upland Lichen Barren
UNID	Unidentified (species)
USDA	United States Department of Agriculture
VECs	Valued Exponent Components
VSECs	Valued Socio-Economic Components
WGD	Wetland Graminoid Drainage
WQ	Water Quality
WS	Western Science
WSD	Wetland Dwarf Shrub Drainage
WSP	Wastewater Stabilization Pond
XRD	X-Ray diffraction

1 Introduction

1.1 Project Overview

1.1.1 Background

Fisheries and Oceans Canada – Small Craft Harbours (DFO-SCH) through Public Services and Procurement Canada (PSPC) are planning the construction of a small craft harbour (SCH) in the Hamlet of Arctic Bay, Nunavut. The Arctic Bay SCH (the Project) is part of the Inuit Impact and Benefit Agreement (IIBA) (IIBA 2019) negotiated for the Tallurutiup Imanga (TI) (Lancaster Sound) National Marine Conservation Area (NMCA) – see Figure 1 in Appendix 1 for figure of NMCA.

Arctic Bay is a hamlet on the northwest coast of Baffin Island (Borden Peninsula), in Admiralty inlet (73° 1.529'N, 85° 7.203'W) (see Figure 1-1), and is located in the Qikiqtaaluk Region, within the North Baffin Regional Land Use Plan (NBRLUP) area (NPC 2000).

Worley Canada Services Ltd. and Ikpiaryuk Services Ltd. in joint venture, operating as Advisian-Ikpiaryuk JV, have been retained by PSPC to perform detailed design, community consultation and regulatory support services for the development of the Project. This Environmental and Socio-Economic Baseline Report (ESEB) builds upon the Environmental and Socio-Economic Survey (ESES) (Advisian 2019b) produced by Advisian in January 2020, where Advisian was engaged by DFO-SCH to perform a feasibility study of the SCH in Arctic Bay (Advisian 2020a). The ESES included field surveys for the Valued Ecosystem Components (VECs) and Valued Socio-Economic Components (VSECs) to be assessed for potential residual effects during the territorial permitting process. This report defines the existing conditions for the VECs and VSECs within the Study Areas identified for the Project.

1.1.2 Existing Infrastructure

Arctic Bay has one small breakwater which provides a semi-sheltered area for small craft moorage. The rubble mound breakwater is approximately 150 m long and opens to the south (see Photo 1-1) and is not sufficient to support small craft boating needs. There is minimal information on the history of the breakwater. However, it is understood from community consultations that the breakwater may have originated as a weather station rock jetty, which was extended to form the partially protected harbour as it is observed today. Anecdotal information from the Government of Nunavut Department of Economic Development & Transportation (GN-EDT) archives suggest the jetty extension was constructed in 1992 or 1993.

Photo 1-1 Existing Breakwater in Arctic Bay

Source: Advisian, taken September 17, 2020

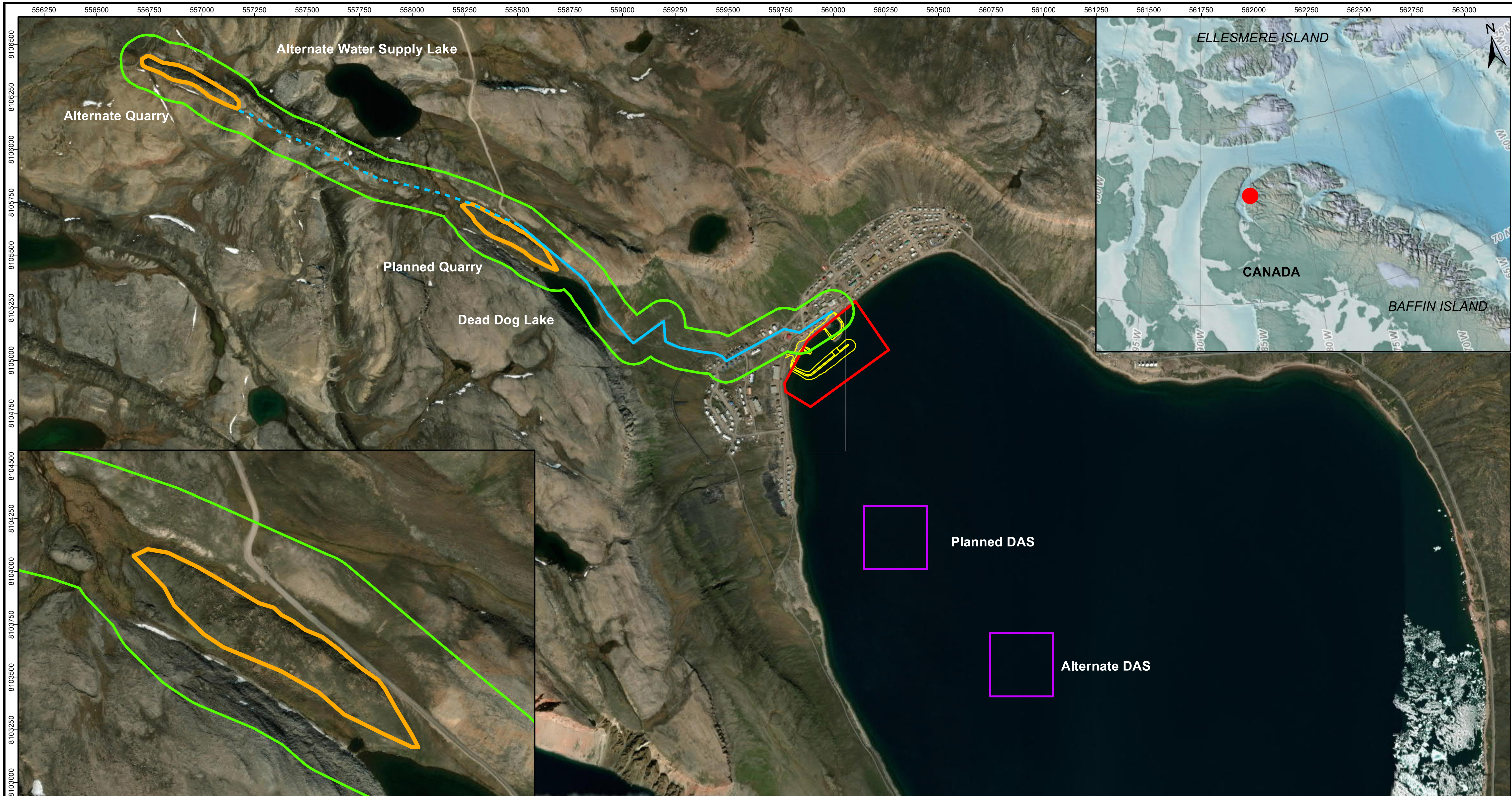
1.2 Supporting Documentation

Documents that have been developed in support of design and regulatory compliance requirements are summarized in Table 1-1.

Table 1-1 Arctic Bay Harbour Development Supporting Documentation

Name	Purpose	Reference
Project Description	This document summarizes the Arctic Bay SCH project as a submission requirement for the Nunavut Impact Review Board.	(Advisian-Ikpiaryuk JV 2021d)
Project Specific Information Requirements (PSIR) Document	This document elaborates on the Arctic Bay SCH project providing specific details as a submission requirement for the Nunavut Impact Review Board.	(Advisian-Ikpiaryuk JV 2021e)
Community Consultations	This report summarizes the activities and feedback received from the community during consultations conducted throughout the Advisian Feasibility Study.	(Advisian 2019a)

Name	Purpose	Reference
Seismic Refraction and Sub-Bottom Profiling Survey Report	Appended to the initial geological assessment for Arctic Bay, this document aimed at classifying the subsurface material and bedrock overburden within the SCH footprint.	(Frontier 2019)
Archaeological Impact Assessment	To preliminarily survey the Project site for areas of archaeological significance.	(Lifeways 2019)
Arctic Bay Community Feedback Notes	This document summarizes feedback received from the community during consultations conducted by DFO-SCH in February 2020 after completion of the feasibility study.	(DFO-SCH 2020)
Arctic Bay Small Craft Harbour Development – First and Second Consultation Summary Reports	These reports summarize the feedback received from the community during the first and second consultations of the harbour development.	(Advisian-Ikpiaryuk JV 2020) and (Advisian-Ikpiaryuk JV 2021f)
Coastal Processes and Wave Climate Report	This report summarizes modelling conducted of the coastal processes and sedimentation patterns of the existing and future SCH configurations. It also outlines a wave climate and agitation study executed to confirm the future harbour will be compliant within harbour guidelines and be functional and safe for users.	(Advisian-Ikpiaryuk JV 2021a)
Community Consultation Log	The Consultation Log provides a detailed record of consultation activities that have occurred in support of the Project since the Feasibility Study. It details the dates and location of meetings, the participating individuals or organization, the input received and how the Project addressed the input, such as through design modification or the development of mitigation and/or management plans.	(Advisian-Ikpiaryuk JV 2021b)
Construction Environmental Management Plan	This plan has been developed that details measures to be implemented to minimize negative environmental and socio-economic impacts associated with the construction phase of the Project.	(Advisian-Ikpiaryuk JV 2021c)



Legend

- Site Location
- SCH Footprint
- Haul Road (existing road to planned quarry)
- Potential Haul Road (to alternate quarry if required)

Study Areas

- SCH Study Area
- DAS Study Area
- Quarry Study Area
- Haul Road and Quarry (HRQ) Study Area

Project Study Area = HRQ + SCH Study Areas

0 200 400 800
Metres
1:18,000
WGS 1984 UTM Zone 16N

N

Locations approximate.

FISHERIES AND OCEANS CANADA
SMALL CRAFT HARBOURS
ARCTIC BAY

PROJECT STUDY AREAS AND LOCATION

Date: 30-JUN-21	Drawn by: KR	Edited by: KR	App'd by: VB
		Project No. 317071-00037	
		FIG No 1-1	REV 0

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FILE LOCATION: U:\YVR\317071\00037_PWGS_ArcBay\CES\10_Eng\16_Geomatics\01_MXD\PSIR\Fig1-1_AB_Site_Location_Study_Areas.mxd

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
NOAA Environmental Satellite, Data, & Information Service (NESDIS), National Geophysical Data Center (NGDC), IBCAO, GEBCO

1.3 Project Components

The Project components include footprints both in the marine and terrestrial environments, with a SCH and a potential disposal at sea (DAS) site in the marine environment, and a quarry and haul road in the terrestrial environment (Figure 1-1). Marine traffic, sealift operations and other ship operations are not considered in this ESEB.

1.3.1 Quarry

Two potential quarries were investigated during the 2019 Field Program. These locations ranged in distance from 1.5 km (planned) to 3 km (alternate) northwest of the community breakwater. They were chosen due to preferred rock characteristics, minimized interference with existing cabins and the community, and avoidance of sites of archaeological significance. After assessment, the planned location was the one closer to the community for logistical reasons due to its proximity to the SCH site.

1.3.2 Haul Road

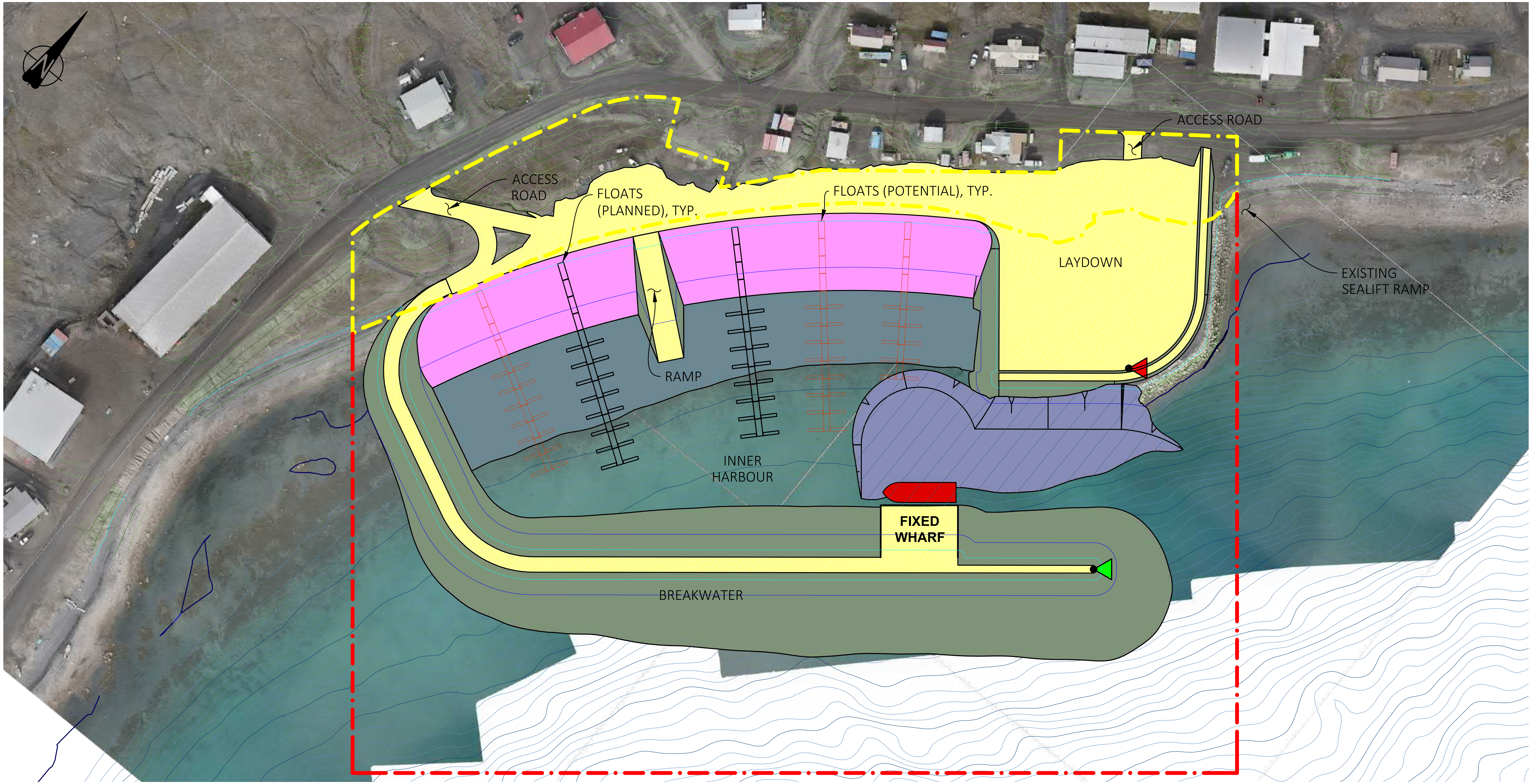
A haul road which is required to transport quarry material from the quarry to the SCH will use the existing road that travels from Arctic Bay to Victor Bay. The length of road used for hauling operations will be approximately 1.5 km and will be upgraded and maintained to account for the increased traffic.

1.3.3 Small Craft Harbour

The Project will consist of the following: a rock breakwater; a fixed wharf; a boat launch ramp; a laydown area for boat and sealift storage; and, floating docks that would be removed during the winter (see Figure 1-2). The Project will also preserve the existing sealift ramp and adjacent sealift laydown areas.

1.3.4 Disposal at Sea Location

Harbour dredging is part of the design, where the options for sediment disposal will be either at sea or repurposed, for project construction as infill, or used by the Hamlet. Two potential DAS sites were identified based on technical feasibility, proximity to the dredge site, comparative water depth, and through community consultation. After assessment, the planned location was decided as the one closer to the community for logistical reasons due to its proximity to the SCH site. This location is only 550 m from the SCH, compared to the 1.4 km distance to the alternate DAS site. If it is shown to be suitable for use on land, the Hamlet has indicated that it may have use for the dredge material (Section 3.1.7 in the Community Consultation (Advisian 2019a)).



LEGEND:

Line	BATHYMETRIC CONTOUR (1m INTERVALS)
Line	BATHYMETRIC CONTOUR (0.5m INTERVALS)
Line	TOPO CONTOUR (1m INTERVALS)
Line	TOPO CONTOUR (0.5m INTERVAL)
Yellow dash-dot line	GN-CGS LAND TRANSFER
Red dash-dot line	CIRNAC LAND TRANSFER
Pink fill	GRAVEL - NON DRIVEABLE
Green fill	FILL OR CUT SIDE SLOPE
Yellow fill	GRAVEL - DRIVEABLE
Hatched fill	DREDGE -5m
Grey fill	DREDGE -1.5m
Triangle symbol	NAVIGATION LIGHT

PLAN
1:1500

m0 10 20 30 40 50 100 m

1:1500

FISHERIES AND OCEANS CANADA
SMALL CRAFT HARBOURS
ARCTIC BAY

GENERAL ARRANGEMENT

Date:	26-FEB-21	Drawn by:	JLC	Edited by:	TJM	App'd by:	VBC

Advisian Worley Group

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Worley Project No. 317071-00037

FIG No 1-2

REV 0

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USER NAME: aaron.ledsham
ISSUING OFFICE: VANCOUVER, BC
PLOT DATE & TIME: 8/7/2021 8:45:39 AM
SAVE DATE & TIME: 8/7/2021 8:45:29 AM
FILE LOCATION: U:\YVR\317071\00037_PWGS_ARCBAYCES\11_DRAWINGS\14_ENV_PLANNING\DFO-SUPPL_REP\DWGS\317071-00037_FIG1-2.DWG

1.4 Study Areas

1.4.1 Environmental

Study Areas for each Project component were determined based on potential construction footprints for the SCH, haul road and quarry (Figure 1-1). The Study Areas for the quarry and haul road include the potential locations, either existing and new construction options, and a 100 m buffer. When referenced together, the haul road and quarry is referred collectively as the HRQ Study Area. The DAS site footprint is unknown at this time, but based on Advisian's experience with similar projects it was estimated to be 100 m x 100 m and, thus the DAS Study Area is 200 m x 200 m. Should DAS be required for this project, the details and boundaries of the DAS deposition site will be determined in compliance with the Environment Climate Change Canada (ECCC) permitting process. When all Study Areas are discussed, they will collectively be referred to as the Project Study Areas.

For many of the marine organisms discussed, they are mobile with migratory routes or ranges that extend beyond the SCH and DAS Study Areas. This is particularly true of marine mammals who will be discussed in the broader context of the marine corridor that connect Admiralty Inlet and Lancaster Sound (TI). Broader marine water bodies discussed in this ESEB are presented in Figure 1-3.

1.4.2 Socio-Economic

The socio-economic study area included an area within the municipal borders of Arctic Bay and the marine environment where socio-economic effects of the proposed development are likely to occur (see Figure 2-1).

1.4.3 Archaeological

The archaeological Study Area is the same as the one for environmental, however if features were observed only a 30 m buffer would be required for mitigation during the Project construction.

FILE LOCATION: U:\YVR\317071\00037_PWGS_ArcBayCES\10_Eng\16_Geomatics\01_MXD\Baseline\Fig1-3_AB_MarineCorridors.mxd

PLOT DATE & TIME: 1/8/2021 8:41:50 AM
SAVE DATE & TIME: 1/8/2021 8:41:45 AM
USER NAME: kenneth.w.ritchie
ISSUING OFFICE: BURNABY GIS

Legend

- Site Location
- Talluritiup Imanga NMCA

0 50 100 200
Kilometres
1:6,000,000

PUBLIC SERVICES AND PROCUREMENT CANADA
ARCTIC BAY HARBOUR DEVELOPMENT
ENVIRONMENTAL AND SOCIO-ECONOMIC BASELINE

PROJECT MARINE CORRIDORS

Date: 08-JAN-21	Drawn by: JH	Edited by: KR	App'd by: VB

Public Services and Procurement Canada

Advisian

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Project No. 317071-00037

FIG No **1-3**

REV 0

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1.5 Scope of Study

The objective of the ESEB report is to define VECs and VSECs baseline conditions to allow for the assessment of potential effects to inform the regulatory process. This includes summaries of the physical, biological, socio-economic, and archaeological environment as outlined in Table 1-2 to inform the existing conditions assessment. Information was gathered from a combination of desktop review, field programs, and Inuit Quajimajatuqanjit (IQ). Desktop review and field program survey methodologies are provided in the respective sections of this report.

Methodology for the IQ program for the Project is provided in Section 2.3. Results of the IQ program are incorporated into the desktop review and discussion sections of each discipline.

The scope of the ESEB included the following VECs and VSECs:

- Physical
  - Oceanography and Ice
  - Water Quality
  - Sediment Quality
  - Geological
- Biological
  - Species at Risk and Environmental Designated Areas
  - Terrestrial Vegetation (including rare plants)
  - Terrestrial Wildlife
  - Migratory and Marine Birds
  - Fish and Fish Habitat
  - Marine Mammals
- Socio-Economic
  - Education
  - Housing and accommodation
  - Labour force and Economic activity
  - Community Infrastructure and Services
  - Local Businesses
  - Land and Resource Use
  - Archaeological

1.6 Objective

The ESEB report objectives for the VECs and VSECs are detailed in Table 1-2.

Table 1-2 VECs and VSECs for the Arctic Bay Project

VEC/VSEC	Relevant Study Areas	Objectives	Report Section
IQ (Inuit Knowledge)	Project	• Land use in the Project Study Areas including fishing, hunting, trapping, plant harvesting and any other traditional or cultural uses as identified by local Inuit land users. • Local Inuit knowledge of fish, marine and land mammals, migratory and marine birds. • Marine access requirements for users during the open-water and iced-in season (i.e., skidoos). • Harvesting of marine and terrestrial species – seasonal patterns, locations, and changes observed over time. • Potential DAS sites within a feasible travel distance that have low biological biodiversity and are deemed acceptable to local harvesters. • Input and feedback to harbour design such as wind direction and strength, currents, seasonal changes to ice, water and ice access, current boating practices, traffic, and community needs.	Section 2, IQ was incorporated within each discipline chapter. A discussion on local land and resource use can be found in Section 13.2.6.
Oceanography and Ice	SCH, DAS	• To determine baseline wind and wave conditions during the summer months, land-fast ice conditions, and currents from a desktop review and IQ collection. • Assess current speed and direction in the vicinity of the SCH Study Area using drogue drifters during flood and ebb tide.	Section 3
Species at Risk (SAR) and designated areas	Project	• Desktop review and field program survey to determine potential SAR present in the Project Study Areas. • Identify marine and terrestrial species designated species as identified by federal or territorial agencies, including species listed under the *Species at Risk Act* (SARA), its critical habitat or the residences of individuals of the species.	Section 6
Marine Water Quality	SCH, DAS	• Desktop study to describe marine water and sediment quality characteristics of the SCH and DAS Study Areas	Section 3

VEC/VSEC	Relevant Study Areas	Objectives	Report Section
Marine Sediment Quality	SCH, DAS	• Marine water and sediment quality field program survey within the potential dredging (load) and disposal site (if required). • Summarize field survey results in reference to Canadian Council of Ministers of the Environment (CCME) guidelines.	Section 5
Geological	Project	• Desktop review and a field program survey to determine geologic conditions within the Study Areas.	Section 6
Vegetation	HRQ	• Desktop review and a field program survey to determine terrestrial plant species, plant communities that occur within the Study Areas.	Section 8
Wildlife	HRQ	• Desktop review and field program survey to determine the presence of terrestrial wildlife, including marine and migratory birds. Important habitats of these species will also be identified. • Summarize habitat within the Study Areas to a level sufficient to support permitting requirements.	Section 9
Migratory and Marine Birds	Project		Section 10
Fish and Fish Habitat	SCH, DAS, HRQ (only if fish bearing fresh water sources)	• Desktop review to identify fish and fish habitat that may be present in the Study Areas. • Create a habitat map based on field data (intertidal, subtidal) within the SCH and DAS Study Areas • Understanding of water circulation patterns and water quality parameters and the impact of tidal fluctuation. • Summarize habitat quality to a level that is sufficient to support permitting with territorial and federal regulators.	Section 11
Marine Mammals	SCH, DAS	• Identify key marine mammal species found in Arctic Bay, Lancaster Sound and Admiralty Inlet. • Review relevant literature pertaining to marine mammals of Arctic Bay and the marine corridor of Lancaster Sound and Admiralty Inlet. • Provide baseline biological and ecological information for identified marine mammal species such that there can be effective effects assessment and mitigation planning, to be used during the detailed design and permitting phase.	Section 12

VEC/VSEC	Relevant Study Areas	Objectives	Report Section
Socio-Economic	Project	• Characterize the socio-economic conditions of the community, including: – Population, education and labour force activity; – Infrastructure and services: health services, education, police, utilities and infrastructure including roads and land; – Resource use in the area, including subsistence harvesting, tourism, trapping and guiding operations (local and regional); – Traffic patterns; community health and wellness; and – Other valued socioeconomic components as determined through community consultation.	Section 13
Archaeological	Project	• Inventory archaeological sites within the Study Area and to assess the potential impacts of the various project components on archaeological resources. • Identify archaeological materials, document location and content, and provide data to be used in the development of recommendations for mitigation or avoidance.	Section 14

1.7 Field Program

Field programs were carried out in open-water season of 2019 and 2020 (see categories underlined in Section 1.5). The goal of the 2019 field program was to determine existing conditions for the VECs identified, to gather information on seabed and quarry substrate characteristics, and to confirm if any archaeological sites existed within the Project Study Areas. The goal of the 2020 field program focused on a second-year study for the fish and fish habitat characteristics to support the Fisheries Act Authorization (FAA) application to DFO's Fish and Fish Habitat Protection Program (DFO-FFHPP) and for the geophysics program to support information requirements for detailed design.

The field programs were carried out with issuance of the permits outlined in Table 1-5 and conducted in accordance with relevant conditions in the Nunavut Impact Review Board (NIRB) Screening Decision Report (SDR). An annual report was submitted to the Nunavut Research Institute (NRI) to describe the field programs for both 2019 (Advisian 2020c) and 2020 (Advisian 2020b). Weather conditions and tides during the field program survey dates are provided in Table 1-3 and Table 1-4.

Table 1-3 Survey Dates, Weather and Environment for the 2019 Field Program

Arctic Bay			
August 9, 10			
Weather (Marine)	Sunny, calm (no wind) 8°C		
Weather (Terrestrial)	Cloud cover: 10–95% Precipitation: 0 mm Temperature: 10-11°C Wind: 2-5 km/h		
Chart Datum (CD) Depth Surveyed (m)	<u>SCH Study Area:</u> Minimum 0.5 m Maximum 20 m <u>DAS Study Area:</u> Minimum 53 m Maximum 60 m		
Arctic Bay (#5865) Tides			
August 9		***August 10***	
Time	**Height (m)**	**Time**	**Height (m)**
01:40	0.7	03:10	0.8
07:33	1.7	08:44	1.5
14:01	0.6	15:16	0.6
20:30	1.8	21:46	1.8

Table 1-4 Survey Dates, Weather and Environment for the 2020 Field Program

Arctic Bay						
September 19–24						
Date	**Sept 19**	**Sept 20**	**Sept 21**	**Sept 22**	**Sept 23**	**Sept 24**
Weather (Marine)	Sunny, calm (no wind) 0 to 2 °C	Sunny, calm (no wind) 0 to 2 °C	Sunny, calm (no wind) 0 to 2 °C	Windy (10 to 15 SE), 0 to 2 °C	Windy (10 to 15 SE), 0 to 2 °C	Sunny, calm (no wind) 0 to 2 °C
Weather (Terrestrial)	Cloud cover: 0-10% Precipitation: 0 mm Temperature: 0 to 5°C Wind: 2-5 km/h	Cloud cover: 0-10% Precipitation: 0 mm Temperature: 0 to 5°C Wind: 2-5 km/h	Cloud cover: 0-10% Precipitation: 0 mm Temperature: 0 to 5°C Wind: 2-5 km/h	Cloud cover: 30 to 40% Precipitation: 20 mm Temperature: 0 to 5°C Wind: 10 to 15 km/h	Cloud cover: 30 to 40% Precipitation: 20 mm Temperature: 0 to 5°C Wind: 10 to 15 km/h	Cloud cover: 0-10% Precipitation: 0 mm Temperature: 0 to 5°C Wind: 2-5 km/h
Chart Datum (CD) Depth Surveyed (m)	Project Footprint: Minimum 0.5 m Maximum 20 m					

Arctic Bay (#5865) Tides			
September 19		***September 20***	
Time	**Height (m)**	**Time**	**Height (m)**
01:24	2.2	02:04	2.2
07:36	0.1	08:12	0.1
13:48	2.2	14:28	2.2
19:53	0.2	20:35	0.2
September 21		***September 22***	
Time	**Height (m)**	**Time**	**Height (m)**
02:44	2.1	03:26	2.0
08:49	0.2	09:28	0.3
15:10	2.2	15:55	2.1
21:19	0.3	22:07	0.4

Arctic Bay			
September 23		***September 24***	
Time	**Height (m)**	**Time**	**Height (m)**
04:11	1.8	05:04	1.6
10:11	0.4	11:01	0.5
16:45	2.0	17:43	1.9
23:04	0.6		

Table 1-5 Field Program Permits

Regulatory Authority	Permit Type	Associated Activity	Location	Permit #	Issued	Expiry
Federal						
Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC)	Land Use Plan (LUP)	Drilling and soil sampling	SCH	N2021S0003	18/03/2021	03/03/2023
Fisheries and Oceans Canada (DFO)	DFO compliance verification by a QEP	Drilling and water withdrawal	Quarry, SCH			
Territorial						
Nunavut Impact Review Board (NIRB)	Screening Decision Report	Any development of land and water resources within Nunavut as determined by NPC's conformity determination	Quarry, SCH	19YN031	15/09/2020	NA
Nunavut Planning Commission (NPC)	Conformity Determination	Development of land and water resources within Nunavut	Quarry, SCH	149425	10/01/2020	NA
Nunavut Research Institute (NRI)	Research License	All activities that require field work toward the design and regulatory compliance	Quarry, SCH	02 058 19N-M	18/01/2021	30/04/2021
Nunavut Water Board (NWB)	Type B Water License	Water withdrawal and drill fluids disposal	Quarry	8BD-ABH2122	17/03/2021	16/03/2022
Government of Nunavut – Community and Government Services (GN-CGS)	Land Use Permit	Construction on Commissioners Land or Untitled Municipal Lands.	Quarry, SCH foreshore	LUP-2021-001	04/02/2021	31/05/2021
Municipal						
No municipal permits were issued, however the hamlet was aware of the geotechnical program						

1.8 Desktop Study Sources

Desktop studies were completed for each of the VECs and VSECs identified in Section 1.5. A significant feature of understanding environmental and socio-economic processes in Nunavut is the co-evolution of knowledge systems of Western Science (WS) and IQ in influencing decision making. Several studies have been undertaken in Nunavut which are integral to assisting in management decisions and incorporate traditional knowledge in an understanding of community dynamics in Nunavut.

The following sources were especially helpful in providing valuable regional context to the ESEB:

- Qikiqtaaluk Inuit Qaujimajatuqangit and Inuit Qaujimajangit Iliqqusingitigut for the Baffin Bay and Davis Strait Marine Environment. Qikiqtani Inuit Association (QIA 2018c)
- The Nunavut Coastal Resource Inventory (NCRI) for Arctic Bay 2010 (Government of Nunavut 2010b)
- Inuit Bowhead Knowledge Study (IBKS) (NWMB 2000), described in Part 5 of the *Nunavut Agreement*
- Tallurutiup Tariunga Inulik: Inuit Participation in Determining the Future of Lancaster Sound (QIA 2012)
- Draft Nunavut Land Use Plan (NPC 2016a)
- The Nunavut Wildlife Harvest Study (NWHS) (Priest & Usher 2004) described in Part 4 of the *Nunavut Agreement*
- Inuit Heritage Trust (IHT): Place Names Program (IHT 2007)
- NBRLUP (NPC 2000)
- Government and territorial websites (e.g. NPC, Nunavut Wildlife Management Board [NWMB]).
- White paper publications (e.g. Marine Ecology Progress Series (MEPS))
- Technical reports (e.g. Canadian Science Advisory Secretariat Science [CSAS] Advisory Reports and other Fisheries and Oceans Canada [DFO] publications).
- Online databases (e.g. Committee on the Status of Endangered Wildlife in Canada [COSEWIC], International Union for the Conservation of Nature [IUCN]).
- Statistics Canada
- Nunavut Bureau of Statistics
- The Hamlet of Arctic Bay Integrated Community Infrastructure Sustainability Plan (ICSP) Vol.1 and Vol. 2 (Government of Nunavut 2011b)
- The Hamlet of Arctic Bay 2019/2020 Infrastructure Plan (Government of Nunavut 2019a)
- The Nunavut Planning Commission’s Summary of Community Meetings on the Draft Nunavut Land Use plan (NPC 2012)
- Nunavut Tourism (Government of Nunavut 2019b)
- GN-EDT and GN - Community and Government Services (GN-CGS) Arctic Bay community profiles (Government of Nunavut 2018a)
- Nunavut Housing Corporation’s annual report 2018-2019 (NHC 2018)

2 Inuit Quajimajatuqanjit – Traditional Knowledge Study

2.1 Program Objectives

IQ, although often translated as Inuit Traditional Knowledge, also includes important Inuit values, principles, cultural beliefs and behaviours. Its literal translation is "that which has long been known by Inuit". There are many different definitions of IQ that aim to describe its holistic nature. The QIA has recently provided the following description that has guided our understanding of IQ (QIA 2018b):

> *"Inuit Qaujimajatuqangit is a morality that is the base for Inuit existence. It is the belief system at the core of Inuit identity and governs Inuit society. It is born through a collective effort to survive in extreme conditions where no one else could and there is no other way to do so but together. Within this ideal lives a great life-affirming admiration to the land and animals. It is about living through helping each other. It is the Inuit way."*

IQ, as we understand it, is not merely a collection of information about the land and wildlife, but also an approach and set of principles to conducting research and project development that is based in respect and collaboration. The local knowledge holders we worked jointly with were also actively guiding decisions on the concept designs and early planning of the SCH for Arctic Bay. Our IQ program therefore aimed to gather local Inuit knowledge of marine habitat, wildlife, land use, year-round access for harvesting, and areas of cultural value in and around the proposed Project to support early Project decision-making and planning; and, to inform the environmental-screening process in the next phase.

We are grateful to the residents of Arctic Bay who graciously shared their time, knowledge and thoughtful feedback during our workshops.

Program objectives for the IQ program are provided in Table 1-2.

2.2 Intellectual Property

This ESEB was prepared with IQ gathered by Advisian and IQ reported in various regional studies. Advisian considers all IQ to be the intellectual property of the knowledge holders. The Land Use and Occupancy map presented in Figure 2-1 was created jointly by Advisian and local knowledge holders to inform DFO-SCH's Lancaster Sound Small Craft Harbour Feasibility Study for Arctic Bay (Advisian 2020a). Any use of Figure 2-1, other than for the purpose stated, shall be done only with the express consent of DFO-SCH and the knowledge holders.

2.3 Methodology

IQ was collected during:

- Three design workshops in November 2018, June 2019, and November 2019 with members of the Ikajutit Hunters and Trappers Association (HTA) in Arctic Bay.
- One land use and wildlife focused workshop with three active Inuit hunters and fishers in June 2019.

- One verification workshop with the same Inuit hunters and fishers in November 2019.
- One ice access and travel routes interview with an active Inuit hunter, outfitter and dog team owner in March 2021.

The first design workshop in November 2018 concentrated on gaining an understanding from HTA members of the current conditions for accessing water and ice in Arctic Bay and the specific needs for a SCH. With the aid of an interpreter and aerial maps and photographs, an open dialogue between HTA members and the consultation team occurred allowing feedback and local knowledge from the most active users of the harbour to be obtained. IQ was noted and marked on maps during discussions by our Indigenous knowledge facilitator on topics such as: wind direction and strength, currents, seasonal changes to ice, DAS sites, water and ice access, and current boat traffic and ramp use. The workshop also provided an opportunity for the consultation team to advise the HTA of the field program being planned for the summer of 2019 and to describe the research activities expected to be conducted. Of interest to the HTA was the coordination of local support to the field team.

The second design workshop, conducted in June 2019, presented concept designs that had been developed using the IQ and feedback provided in the first workshop. With the help of Mishak Allurut (a local interpreter, active hunter and Arctic Bay Guardian), the workshop allowed HTA members to see how their suggestions and local knowledge had been directly considered in the design of the concept options and provide their feedback on any changes needed and any preferred options. IQ was noted during discussions by our Indigenous knowledge facilitator on topics such as: changes to ice once the harbour is built, seasonal access for hunters during construction, DAS sites, quarry and haul road options, and project schedule. The workshop also allowed the consultation team to provide further details to HTA members on the field program being planned for August 2019.

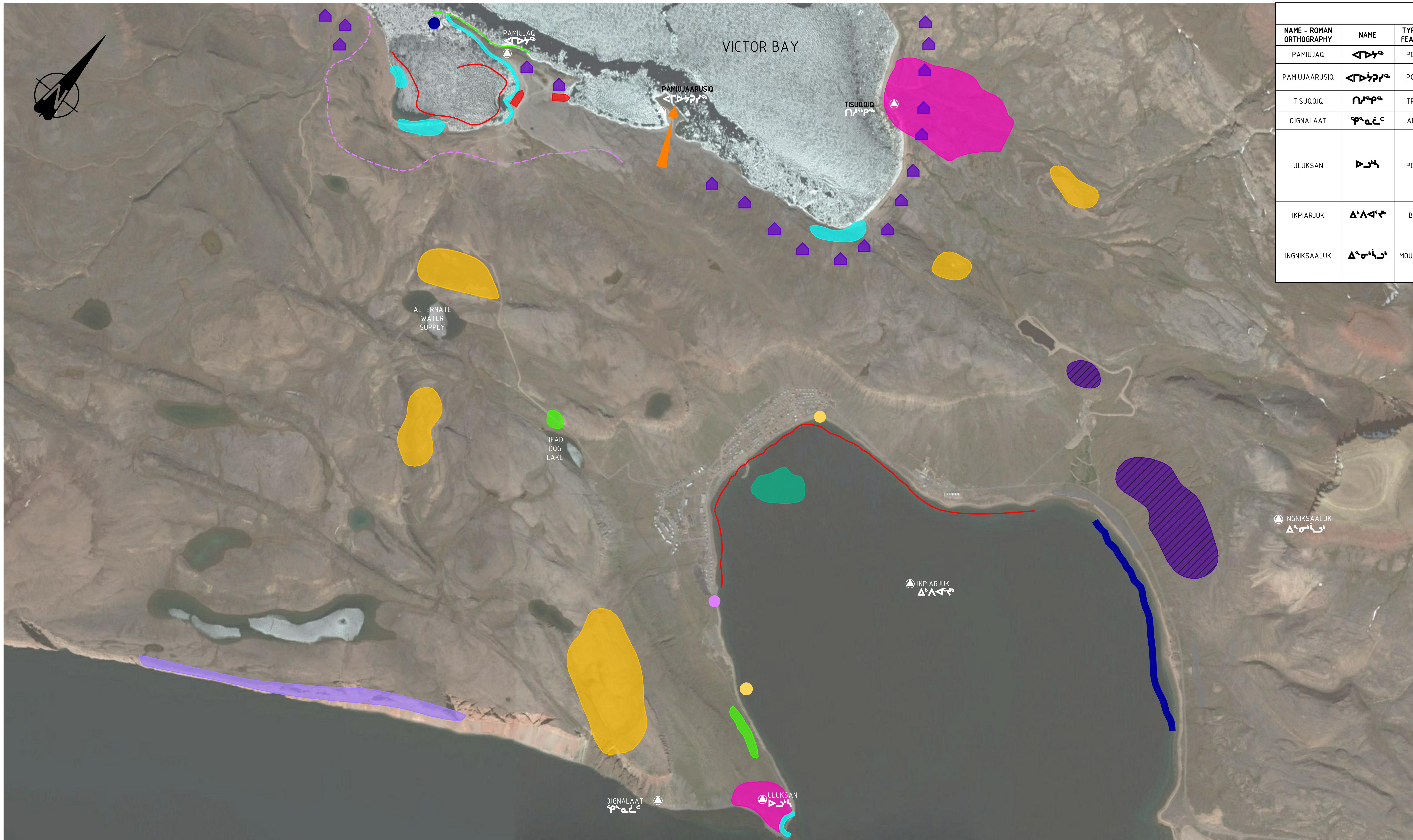
A land use and wildlife focused workshop (IQ workshop) was conducted in June 2019 with three currently active Inuit hunters and fishers (knowledge holders): Jonah Oyukuluk, Olayuk Nagitarvik, and Tom Nagitarvik. The knowledge holders were selected by the HTA for being especially knowledgeable of harvesting areas in and around Arctic Bay and for being currently quite active out on the land and water. With the help of Mishak Allurut acting as interpreter, knowledge holders were asked to read a project information sheet and consent form and then complete and sign the form before the start of the workshop. The consent form described the workshop's objectives, methods, and uses for the information, allowed the knowledge holder to specify where a copy of the transcript and map should be sent, and whether the knowledge holder wished to be acknowledged by name for their contribution. In an effort to better understand the potential interactions between harvesting rights and anticipated Project activities, discussions during the workshop focused on harvest locations, water and ice access, fish, marine and land mammals, birds and other wildlife and the potential locations of the proposed SCH, quarry and haul routes in relation to land use activities (e.g. fishing, hunting, gathering and trapping). Land use and occupancy, and any culturally or ecologically valued areas were marked on maps and later digitized (see Figure 2-1). During discussions, a questionnaire was used as a checklist for guidance only, so that information could flow in a manner that was natural for the participants and not restricted or bound to any strict process.

A third design workshop with the HTA was held in November 2019 to present the results of the field program, further refine the design concepts and to discuss the proposed quarry and haul route in more detail. A verification workshop was also held in November 2019 to ensure that the information gathered during the earlier IQ workshop (June 2019) was not misinterpreted or presented in a manner unintended by the knowledge holders. All knowledge holders consented to their knowledge being shared with the team and for the purpose of informing the ESEB, the AIA (Lifeways 2019) and the overall Feasibility Assessment. Consent was also provided by the knowledge holders to have their knowledge presented as noted in the Land Use and Occupancy map (Figure 2-1). We have attempted to join IQ with results from the field studies to allow the project team, in collaboration with community members, to make informed decisions on the design and construction planning of the SCH that reflects local peoples' needs, priorities and values.

A brief land use interview with knowledge holder and outfitter, Tom Nagitarvik, was conducted in March 2021 to better understand ice access and skidoo trails along the shoreline and haul route. The locations of sled dog teams were also confirmed with Mr. Nagitavik to minimized disturbance to the dogs as a result of the geotechnical drilling program.

A review of existing and accessible IQ research relevant to the Project area was also conducted to provide valuable regional context to the baseline study. Desktop study sources have been provided in Section 1.8. Where applicable, topic specific IQ information has been incorporated into this report. Additionally, a map of land use and occupancy information compiled during the HTA design workshops, IQ focused workshop and verification has been provided (see Figure 2-1). The map also includes place names in the area from the IHT database. A discussion on local land and resource use can be found in Section 13.2.6.

The IQ findings are based on a small number of workshops and a selection of readily available literature, and do not represent the full intensity and extent of Inuit use and occupancy of either the Project Study Areas or the surrounding region.



INUIT PLACE NAMES

NAME - ROMAN ORTHOGRAPHY	NAME	TYPE OF FEATURE	DESCRIPTION
PAMIUJAQ	ᐸᒥᐅᔭᖅ	POINT	THIS POINT LOOKS LIKE THE TAIL OF A FOUR-LEGGED ANIMAL. GOOD CAMPING PLACE AND SEAL HUNTING DURING MOST OF THE YEAR.
PAMIUJAARUSIQ	ᐸᒥᐅᔮᕈᓯᖅ	POINT	THE NAME MAKES REFERENCE TO PAMIUJAQ (A NEIGHBOURING POINT). DURING SUMMER AND SPRING THEY WAIT FOR SEALS AND NARWHALS ON THE SHORES OF THIS POINT.
TISUQQIQ	ᑎᓱᖅᑭᖅ	TRAIL	THE NAME REFERS TO THE THE RIVER AND THE VALLEY THAT CONSITUTE A TRAIL. THE MEANING OF THE NAME IMPLIES "SLIDING DOWN."
QIGNALAAT	ᕿᓐᓇᓛᑦ	AREA	THE NAME REFERS TO A HILL AND A CLIFF. PART OF THE CLIFF AND HILL IS DARK.
ULUKSAN	ᐅᓗᒃᓴ	POINT	THIS IS A VERY OLD NAME. THERE SOME VERY OLD SOD HOUSES IN THE AREA, THAT WERE MADE BY TUNIIT PEOPLE. GOOD CAMPING PLACE AND SEAL HUNTING DESTINATION. THERE USED TO BE CARIBOU AROUND THE BAY. THEY NAMED THE PLACE FOR THE FLAT ROCKS THAT ARE GOOD MAKE ULUS. LONG TIME AGO SOME WHALING SHIPS ANCHORED THERE. SOMEONE FROM THE INUIT SETTLEMENT STOLE SOMETHING FROM THE SHIPS, AND SEVERAL INUIT WERE KILLED. THERE ARE SOME VERY OLD GRAVES IN THE AREA.
IKPIARJUK	ᐃᒃᐱᐊᕐᔪᒃ	BAY	THE NAME REFERS TO THE NAME OF THE BAY BEING LIKE A SACK. THE PRESENT SETTLEMENT IS LOCATED BY THE SHORES OF THIS BAY. WHALING SHIPS USED TO ANCHOR HERE.
INGNIKSAALUK	ᐃᖕᓂᒃᓵᓗᒃ	MOUNTAIN	THIS MOUNTAIN IS LOCATED AROUND THE CURRENT SETTLEMENT. THE ROCKS UP THERE WERE USED AS FLINT STONES TO MAKE FIRE. IN THE PAST THERE USED TO BE A LOT OF CARIBOU AT THE BOTTOM OF THIS MOUNTAIN. ANOTHER EXPLANATION FOR THE MEANING OF THIS NAME REFERS TO THE MOUNTAIN RESEMBLING THE EDGE OF A TRADITIONAL INUIT LAMP.

PLAN
1:15000

LEGEND:

- FISHING (NETS AND SOME CASTING)
- VARIOUS BIRDS (NESTING)
- SEAL / MARINE MAMMAL WAITING AREA
- CLAMS
- POLAR BEAR (HARVESTED)
- POLAR BEAR (MAIN AREA OF SIGHTINGS)
- CARVING STONE
- NARWHAL PODS (SOMETIMES GREATER THAN 100 IND.)
- NARWHAL (NOT OBSERVED OVER PAST 10 YRS)
- TENTS / CABINS
- BERRY HARVESTING
- SLED DOG AREAS
- FOOD CACHE (CURRENT, STILL IN USE)
- RAVENS NEST
- BELUGA (HARVESTED)
- SPRING ICE ACCESS
- BOATS
- SOURCE INUIT HERITAGE TRUST: PLACE NAMES PROGRAM. INUIT HERITAGE TRUST INCORPORATED. JUNE, 2005

m 0 100 500 1000m
1:15000

NOTES:

1. WATER DEPTHS WITHIN THE RED SURVEY BOUNDARY PROVIDED BY FISHERIES AND OCEANS CANADA. SURVEY WAS PERFORMED ON SEPTEMBER 14, 2018 BY AQUATICS-ESI, PROJECT NO. 18S022002, DRAWING NO. A1, REVISION 2, DATED 19/01/07

REV	DATE (DD-MMM-YY)	REVISION DESCRIPTION	DRAWN	DRAFT CHK	DESIGNED	ENG CHK	APPROVED	CUSTOMER
D	20-DEC-19	ISSUED WITH FINAL REPORT	JLC	-	DP	-	HGK	-
C	10-DEC-19	ISSUED FOR CLIENT REVIEW	JLC	-	DP	-	HGK	-
B	28-NOV-19	ISSUED FOR INTERNAL REVIEW	JLC	-	DP	-	HGK	-
A	25-OCT-19	FOR DISCUSSION	JLC	-	DP	-	HGK	-

REF DRAWING No	REFERENCE DRAWING TITLE

D SHEET | SCALE SHOWN

OneWay to zero harm

WORLEYPARSONS PROJECT No
307071-01306

ENGINEERING AND PERMIT STAMPS (As Required)

PRELIMINARY
DO NOT USE FOR CONSTRUCTION
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CUSTOMER

"This drawing is prepared for the use of the contractual customer of Worley Canada Services Ltd. and Worley Canada Services Ltd. assumes no liability to any other party for any representations contained in this drawing."

Advisian
Worley Group

ARCTIC BAY
LAND USE AND OCCUPANCY MAP
FIGURE 2-1

DRG No 307071-01306-00-CI-DSK-0002
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LOCATION: U:\YVR\307071\01306_DFO_LANSTHARST\11_DRAWINGS\15_1_AND_E\02_MARINE\01_SKETCHES\ARCTICBAY\307071-01306-00-CI-DSK-0002.DWG

USER NAME: jennifer.coppendale

PLOT DATE & TIME: 20/12/2019 10:30:14 AM
SAVE DATE & TIME: 20/12/2019 10:29:48 AM

3 Oceanography, Ice and Weather

Program objectives for oceanography and ice are provided in Section 1.6, Table 1-2.

3.1 Desktop Review

Understanding climate and oceanographic patterns of the coastal waters fronting Arctic Bay is important for determining potential long-term effects to sediment transport because of the presence of physical structures of the SCH. Collection of baseline information on tidal currents and circulation patterns will be used to inform a sediment-transport model, which will be used to assess effects and develop mitigation and monitoring measures.

3.2 Daylight and Temperature

Typical of high latitude areas, Arctic Bay experiences extremes of total darkness or total light at certain periods of the year (see Figure 3-1). During the months of 24-hour sunlight, temperatures on average reach 7.5°C, with the warmest recorded temperature being 18.5°C (June 2000). February is Arctic Bay's coldest month when temperatures on average reach -33.2°C with the coldest recorded temperature being -53°C (February 1979) (Government of Canada 2020c). A monthly breakdown of average temperatures between 1981 to 2010 for the Nanisivik airport, approximately 18 km away from Arctic Bay, is provided in Figure 3-2.

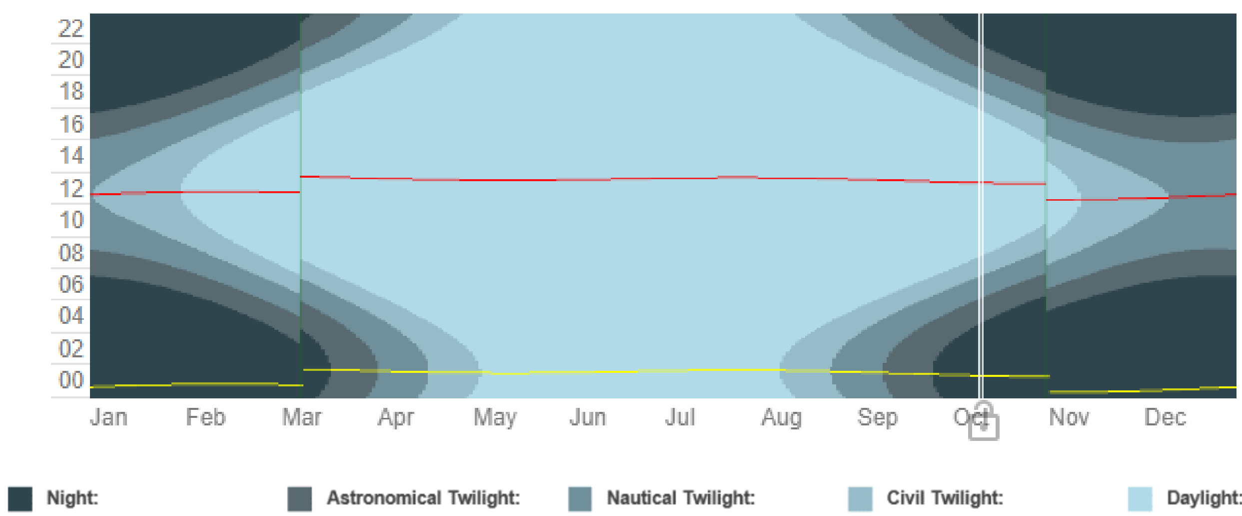

Figure 3-1 Sunrise, Sunset, Dawn, and Dusk Times of Arctic Bay Canada

Source: Time and Date AS (2020)

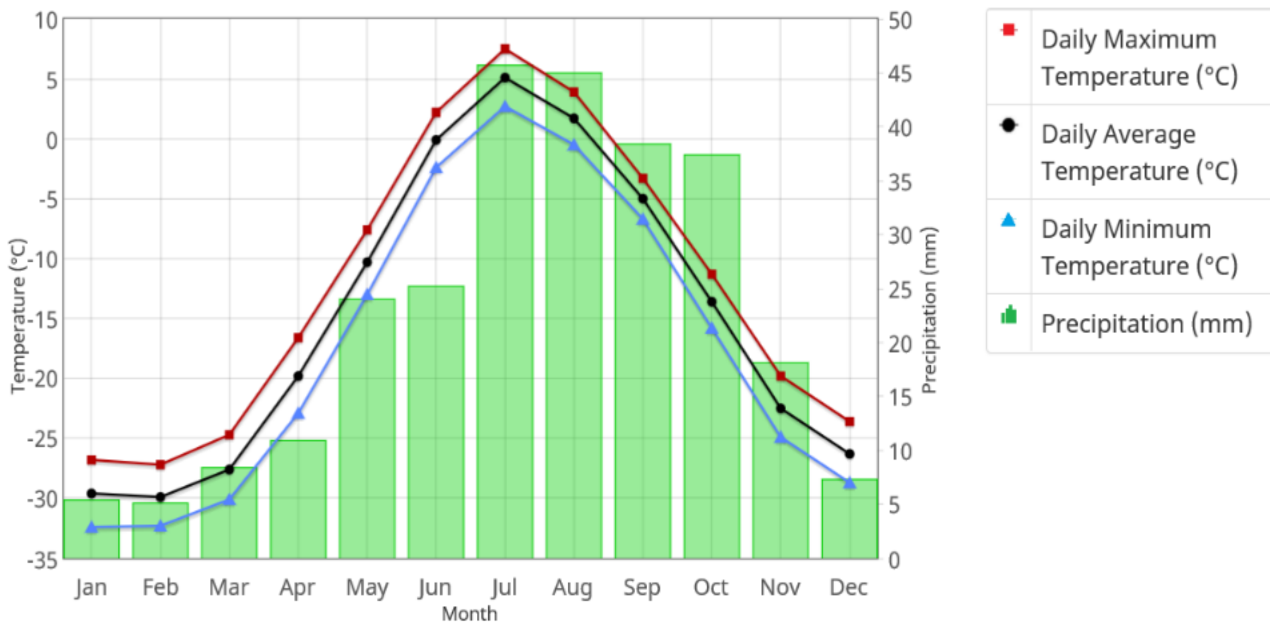

Figure 3-2 Weather Averages from 1981 to 2010

Source: Government of Canada (2020b)

3.3 Precipitation

Average rainfall, snowfall, and snow depth in Arctic Bay from 1981-2010 (Government of Canada 2020c) are provided in Table 3-1 and depicted in Figure 3-2.

Table 3-1 Precipitation Averages in Arctic Bay

Month	Average Rainfall (mm)	Average Snowfall (mm)	Average Snow Depth (mm)
January	0	54	290
February	0	52	310
March	0	84	320
April	0	112	310
May	0.1	240	260
June	6.7	177	130
July	37	85	0
August	29.2	150	10
September	4.4	323	60

Month	Average Rainfall (mm)	Average Snowfall (mm)	Average Snow Depth (mm)
October	0	382	170
November	0	179	250
December	0	75	270

Source: Government of Canada (2020c)

3.4 Sea Ice Concentrations and Thickness

Sea ice is a fundamental component of Arctic environments that has a significant effect on the spatial and temporal distribution of marine life across all trophic levels. This influence subsequently has shaped socio-economic and cultural practices for the Inuit who are dependent on the harvest of these animals. In Arctic Bay, there are four distinct cyclical icing conditions throughout the year: iced, break-up, open water (ice-free), and freeze up. General terms and conditions used to describe ice conditions are summarized in Table 3-2.

Based on the 30-year average from 1981–2010, the typical break-up date for Arctic Bay is the week of July 16 (Figure 3-3, Panel A), and freeze up begins the week of October 8 (Figure 3-3, Panel B).

Recent years are seeing the effects of climate change and the 30-year averages are not necessarily applicable. A nine year (2009–2018) data set provides insight on annual variability as informed by ice charts and satellite images (Figures 2A to 2C, Appendix 1). Figure 3-4 demonstrates representative images of the four conditions of the ocean in the waters of Arctic Bay.

Overall, the Arctic has been experiencing a significant reduction in multi-year sea ice (MYI). Currently over 70% of the Arctic sea ice is first-year-ice (FYI) and melts seasonally. This thin ice melts faster and breaks up easier than MYI and can be moved more easily by wind (Kwok 2018). Figure 3-5 presents the average ice and snow thicknesses for years between 1959–1970, note there is no current ice thickness data available. In Arctic Bay, the presence of MYI is 1% to 15% during the time of ice break-up as depicted in Figure 3, Appendix 1.

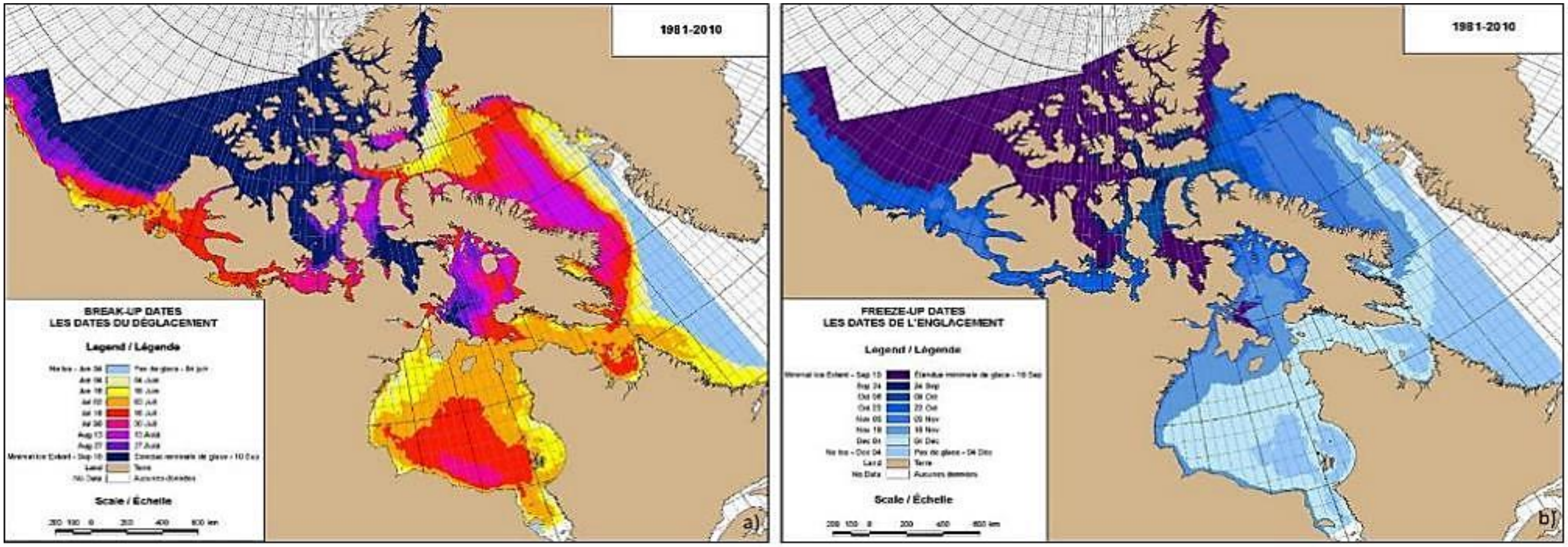

Figure 3-3 30-Year Ice a) Break-up Dates and b) Freeze-up Dates

Source: Government of Canada (2020a)

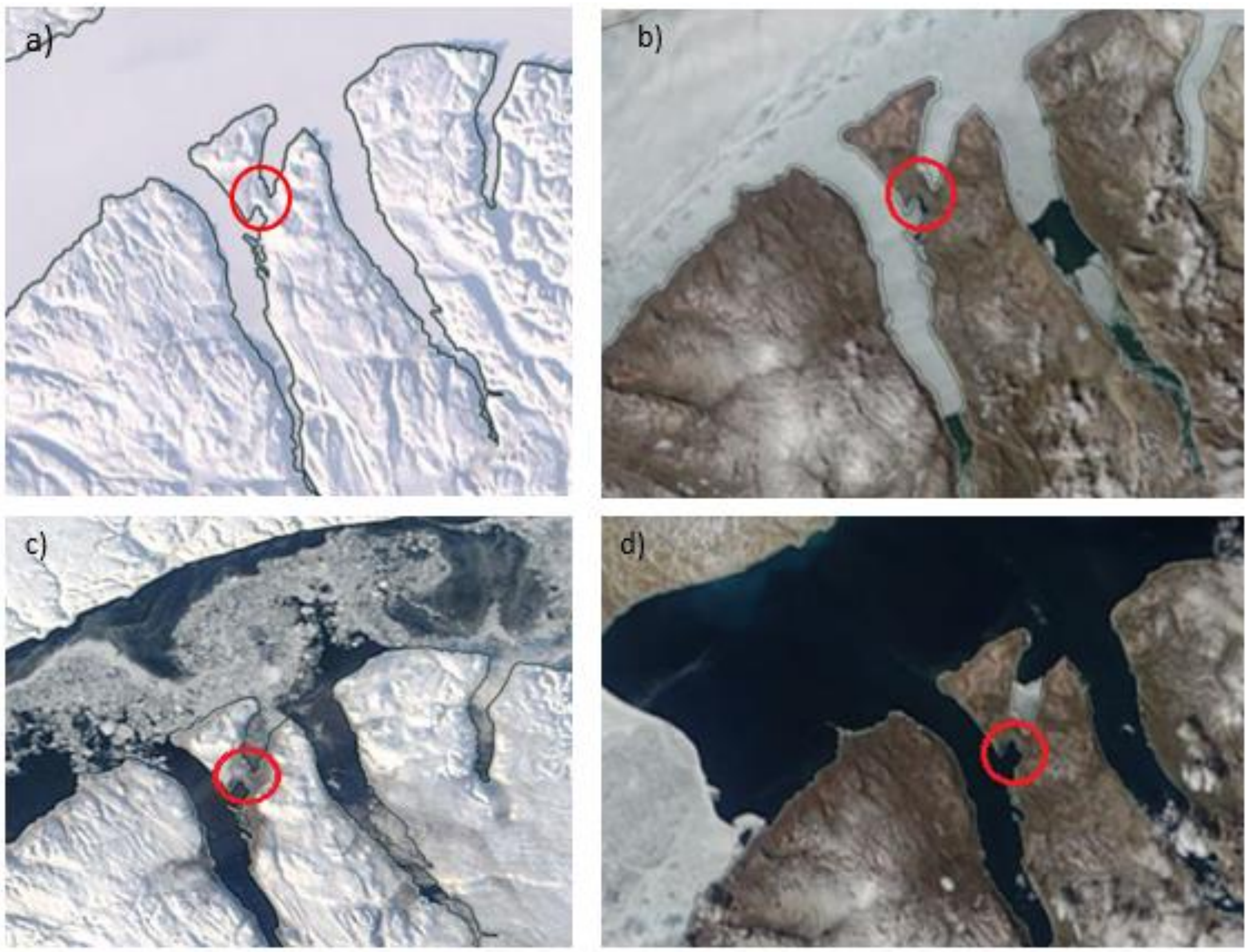

Figure 3-4 Distinct Ocean Cycling Conditions - Arctic Bay: a) Iced; b) Break-up (July 9, 2018); c) Freeze-up (October 9, 2018); d) Open Water (July 9, 2017)

Source: Worldview (2020)

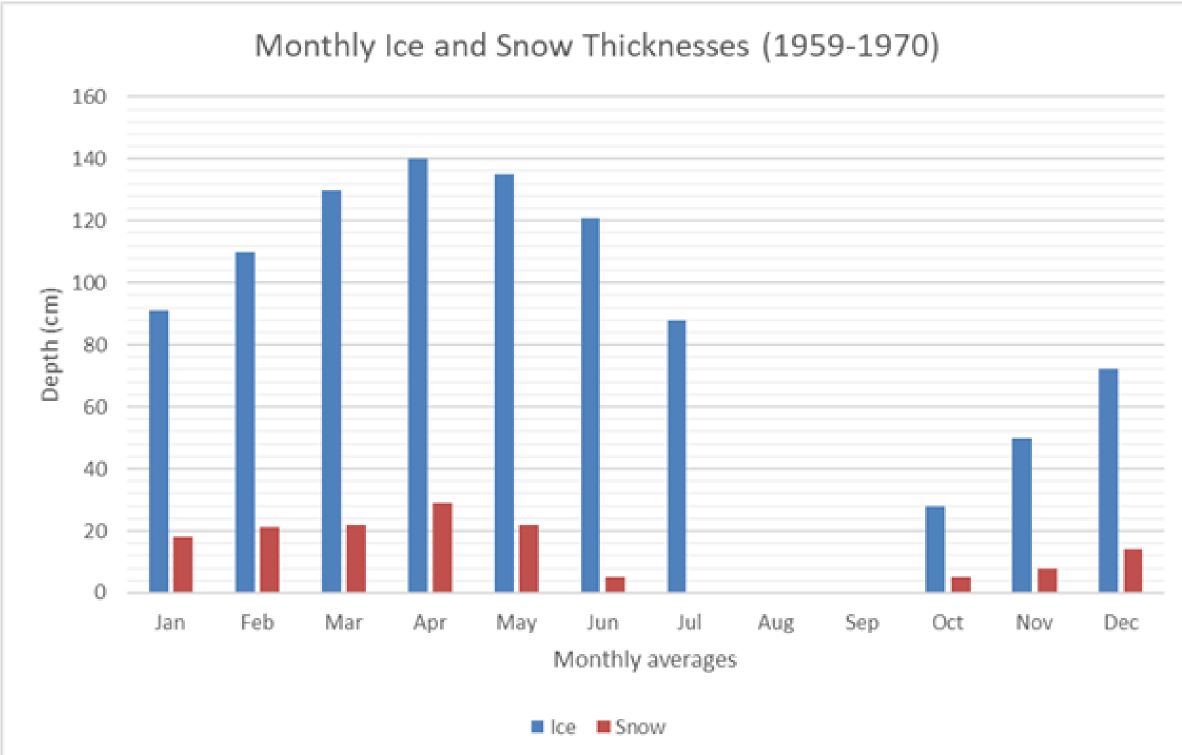

Figure 3-5 Average Ice Thickness and Snow Depth, Arctic Bay, 1959 to 1970

Source: Government of Canada (2020e)

Table 3-2 Categories of Arctic Sea Ice which may be used in this Report

Terms	Definitions
Anchor ice	Submerged ice attached or anchored to the bottom, irrespective of the nature of its formation.
Break-up	This term refers to a particular length of time in which ice disappears in a given area (generally one to two weeks). However, break-up does not necessarily imply a decay or melt of ice, but also can indicate a movement of ice out of a particular area.
Fast ice	Ice which forms and remains fast along the coast. It may be attached to the shore, to an ice wall, to an ice front, between shoals or grounded icebergs. Vertical fluctuations may be observed during changes of sea level. It may be formed *in-situ* from water, or by freezing of floating ice of any age to shore, and can extend a few metres or several hundred kilometres from the coast. It may be more than one year old in which case it may be prefixed with the appropriate age category (old, second-year or multi-year). If higher than 2 m above sea level, it is called an ice shelf.
First year ice	Sea ice of not more than one winter's growth, developing from young ice; 30 cm or greater. It may be subdivided into thin first-year ice – sometimes referred to as white ice –, medium first-year ice, and thick first-year ice.

Terms	Definitions
Floe edges	Created at the end of winter/beginning of spring as non-land fixed ice breaks away from land-fixed ice. Floe edges are composed of thick land-fixed ice at the interface of fully or partially open-water.
Freeze-up	This term refers to a particular length of time in which ice appears in a given area (generally one to two weeks). However, freeze-up does not necessarily imply a growth of ice, but can also indicate a movement of ice into a particular area.
Ice edge	The demarcation at any given time between open-water and sea, lake, or river ice whether fast or drifting.
Ice foot	A narrow fringe of ice attached to the coast, unmoved by tides and remaining after the fast ice has moved away.
Landfast Ice	A type of immobile sea ice that primarily forms off the coast in shallow water for a certain period of time. In high Arctic, landfast ice may linger for several years dependent on weather conditions. Typically landfast ice starts to grown in fall and melts away completely in summer. The offshore extension of landfast ice varies, dependent largely on coastal bathymetry and topography. This type of sea ice has a profound influence on coastal resources and residents.
Multi-year ice	Old ice which has survived at least two summer's melt. Hummocks are smoother than on second-year ice, and the ice is almost salt-free. Where bare, this ice is usually blue in colour. The melt pattern consists of large interconnecting, irregular puddles and a well-developed drainage system.
Polynya	Areas of persistent open-water surrounded by sea ice. Discussed further in Section 7.3.

Source: Environment and Climate Change Canada, ECCC (2016b); NPC (2016a)

3.5 Water Temperature

Site specific seasonal water temperature data was unavailable. The World Atlas (2021) concluded that Arctic sea surface temperature (SST) down to a depth of 200 m ranges from -1.9°C to -1°C, and warms as depth increases to temperature of 2°C at the seabed (World Atlas 2021). As on trend with global observations, the Arctic (SST) has experienced an increase of 0.5°C per decade from 1982 to 2017 in the open water season of Beaufort Sea, Hudson Bay and Baffin Bay (Government of Canada 2019b).

Water temperatures was an average of 2.4 C at seabed during field surveys, which aligns with the general Arctic water temperature conditions summarized in the world atlas (World Atlas 2021). Water temperature measurements taken during the 2019 and 2020 field programs are discussed in Section 4.2.4.1.

3.6 Tides and Currents

3.6.1 Tides

In 2020 a tide gauge was deployed in Arctic Bay and obtained a 77-day tidal record to establish a set of updated tide levels. These updated tide levels were provided to Advisian by DFO-SCH (DFO 2020) and are provided in Table 3-3.

Table 3-3 Tide Levels at Arctic Bay

Tide	Elevation (m, CD)
Extreme Predicted High*	3.3
Higher High Water Large Tide (HHWLT)	3.0
Higher High Water Mean Tide (HHWMT)	2.4
Mean Water Level (MWL)	1.5
Lower Low Water Mean Tide (LLWMT)	0.6
Lower Low Water Large Tide (LLWLT)	0.0
Extreme Predicted Low*	-0.4

*Estimated, based on extremes at the reference station of Resolute Bay.

Source: DFO (2020)

3.6.2 Currents

3.6.2.1 Desktop Review

Sailing Directions quotes tidal currents to be “slight”, which is to be expected given the relatively small size of the bay and low tidal range. Some wind-driven surface currents are expected for southern winds.

3.6.2.2 Field Program

Collection of surface current data was required to characterize surface current patterns within the vicinity of the DAS Study Area. This data will be used to inform the development of a sediment dispersion model if DAS is required for the dredged material. The drogue is essentially a surface float with a global positioning system (GPS) tracker, the surface float was set up with an automatic identification system (AIS), which enabled it to be tracked throughout the day so that its location was known for retrieval. A demonstrative photo is provided in Photo 3-1.

Photo 3-1 Demonstrative Photo of Drogue Deployment, Photo taken in Arctic Bay

Methodology

A surface drogue was deployed on August 10 at the north eastern end of the DAS Study Area at 11:53, which was high tide (1.4 m). The drogue was monitored using the AIS tracking system and picked up off the tip of Oulouksione Point at 15:45 at low tide (0.6 m).

Results

Over the four-hour period that the drogue was deployed it travelled a total distance of 2.3 km. The mean and maximum currents recorded were 0.16 m/s and 0.28 m/s respectively and the net movement was toward the south. The maximum current was located at the end of the drogue track, near the mouth of the bay entering into Adams Sound. Wind data collected from Environment Canada at the time of the survey indicates relatively calm weather during the track with light winds reaching 5 km/hr from the north. Figure 3-6 shows the path of the drogue and Figure 3-7 illustrates the tide cycle where tidal height was receding during deployment.

PLAN

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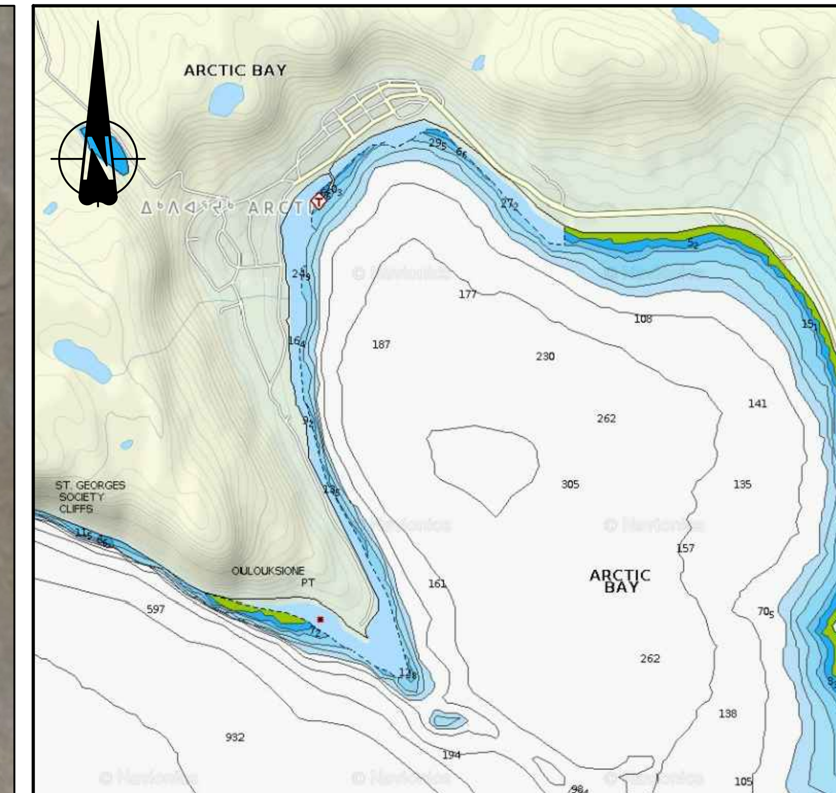

PLAN - CHART

NTS

ENVIRONMENTAL AND SOCIO-ECONOMIC BASELINE
ARCTIC BAY

DROGUE DEPLOYMENT PATH
AUGUST 10, 2019

Date: 30-NOV-20	Drawn by: JLC	Edited by: JLC	App'd by: HGK

WorleyParsons Project No. 317071-00037

FIG No **3-6** REV **A**

OneWay to zero harm

Advisian

Ikpiaryuk Services Ltd.

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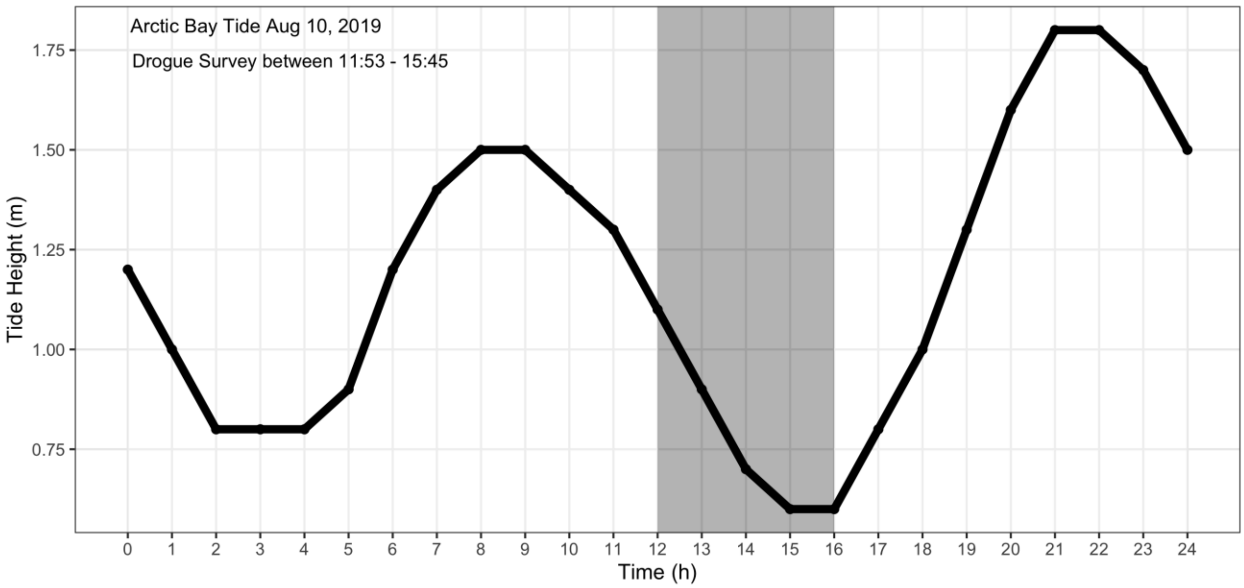

Figure 3-7 Tide Cycle for Drogue Survey (represented by grey columns)

Discussion

The drogue measurements are consistent with expectations that the tidal currents in the bay are low. In addition, the receding tide cycle, causing ebb currents, at the time of deployment pulled the drogue out from the bay into Adams Sound, as would be expected. The winds, although light, would also help push the drogue south. Near the end of the track, the drogue is near the constricted entrance of Arctic Bay and currents are their highest, as expected. Surface currents will also be influenced by period of strong winds.

3.7 Wind, Wave and Storm

For the purpose of design, data recorded only during the open water season were used for the wind analysis which lead to wave and storm surge analyses. The extent of open water season was determined by examining the historical ice cover data and adding two months in the fall for climate change considerations. This results in a period from 15 July to 22 December and increases the number of large storm events creating a larger wave event which governs design. A wind rose representing the open water season for Arctic Bay is presented in Figure 3-8.

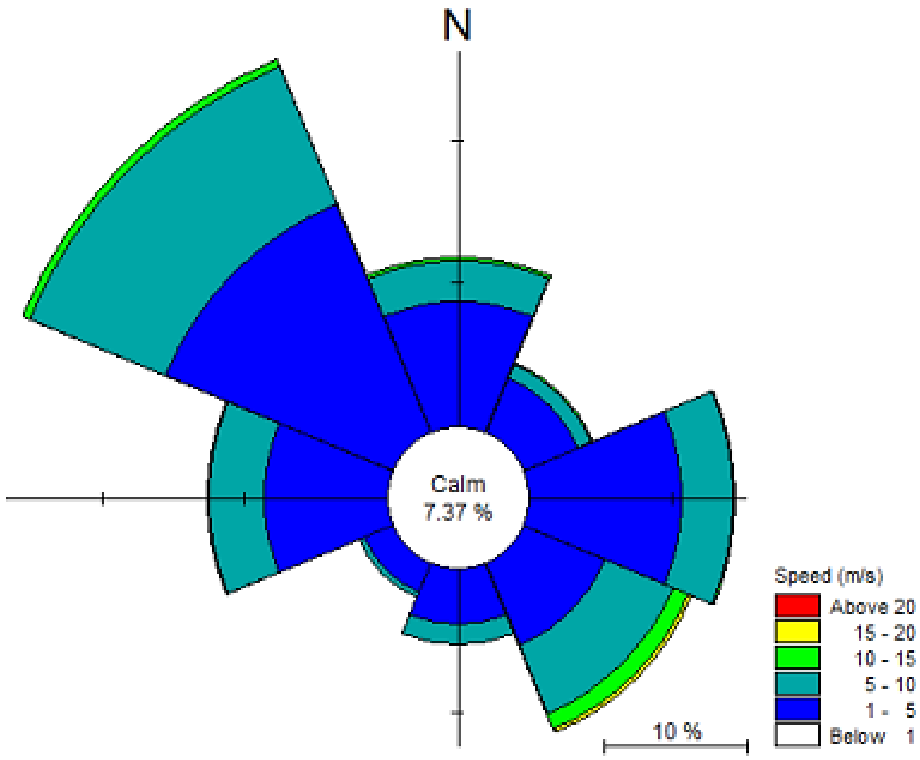

Figure 3-8 Arctic Bay Wind Rose for Open Water Season

Source: Section 4.4.4 of Advisian (2020a)

As observed, southeasterly storms are most dominant in Arctic Bay. An extreme analysis was performed using the Gumbel method for the major fetch directions, i.e. southeast, south and southwest. The results of extreme wind analysis are provided in Table 3-4.

Table 3-4 Extreme Wind Speeds for Major Fetch Directions in Arctic Bay

Return Period (Years)	Speed (m/s)		
	Southeast	South	Southwest
1	12.7	7.8	6.1
10	20.7	17.1	9.3
25	23.1	19.9	10.3
50	24.9	22.0	11.0
100	26.8	23.9	11.7

Source: Section 4.4.4 of Advisian (2020a)

The frequency and monthly distributions of storms were analyzed for one year and 1-in-50 year storm events for south and southeast storms. Storms from the south cause wave heights ranging from 0.25 – 0.40 m for one year events and 1.20 m – 1.40 m for 1-in-50 year storm events. While storms from the southeast cause wave heights of 0.40 m – 0.6 m for one year and 1.4 m – 2.0 m for 1-in-50 year storms (Figure 3-9 and Figure 3-10).This study considers a wind speed of 15.2 m/s (55 kph) as the storm threshold (Beaufort scale). The strongest storms occur in the fall and early winter months (September to January), with the most frequent in October and November (Figure 3-11).

The observed distributions are warnings for potentially severe future conditions in the context of climate change and may result in a longer open water season extending beyond the month of October. This causes the more frequent winter storms to affect coastal infrastructure prior to freeze-up. These storms will result in a more intense wave climate and damaging storm surges which would otherwise have been prevented from reaching the coast by ice coverage.

Arctic Bay	South Storm

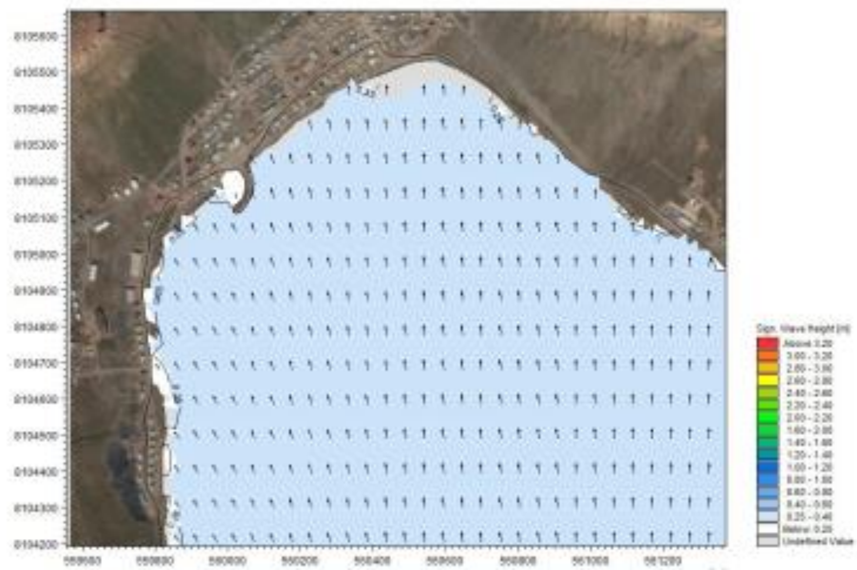

Figure B-1. Simulated significant wave height for 1 year storm from south

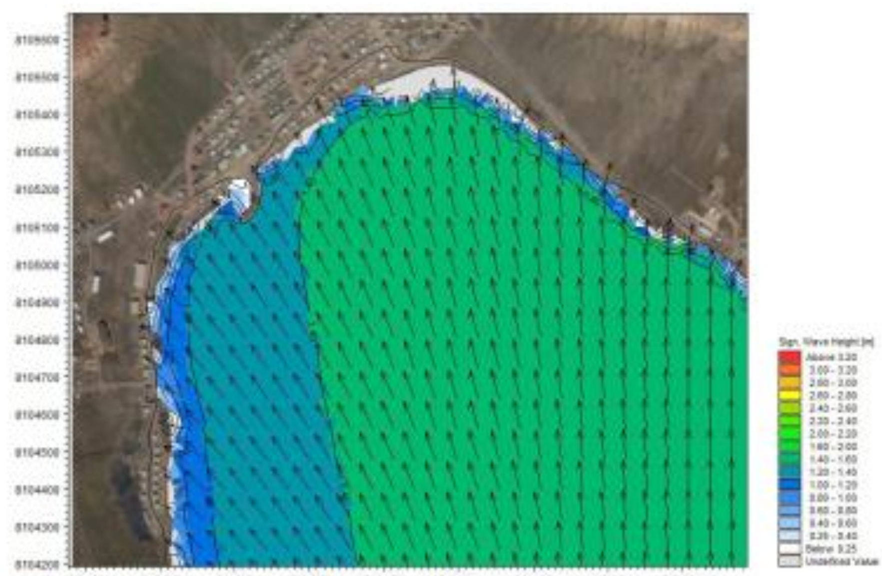

Figure B-2. Simulated significant wave height for 50 year storm from south

Figure 3-9 Simulated Significant Wave Height at Arctic Bay: top) One-Year Storm from South; and bottom) 50-Year Storm from South

Source: Appendix 4.2 of Advisian (2020a)

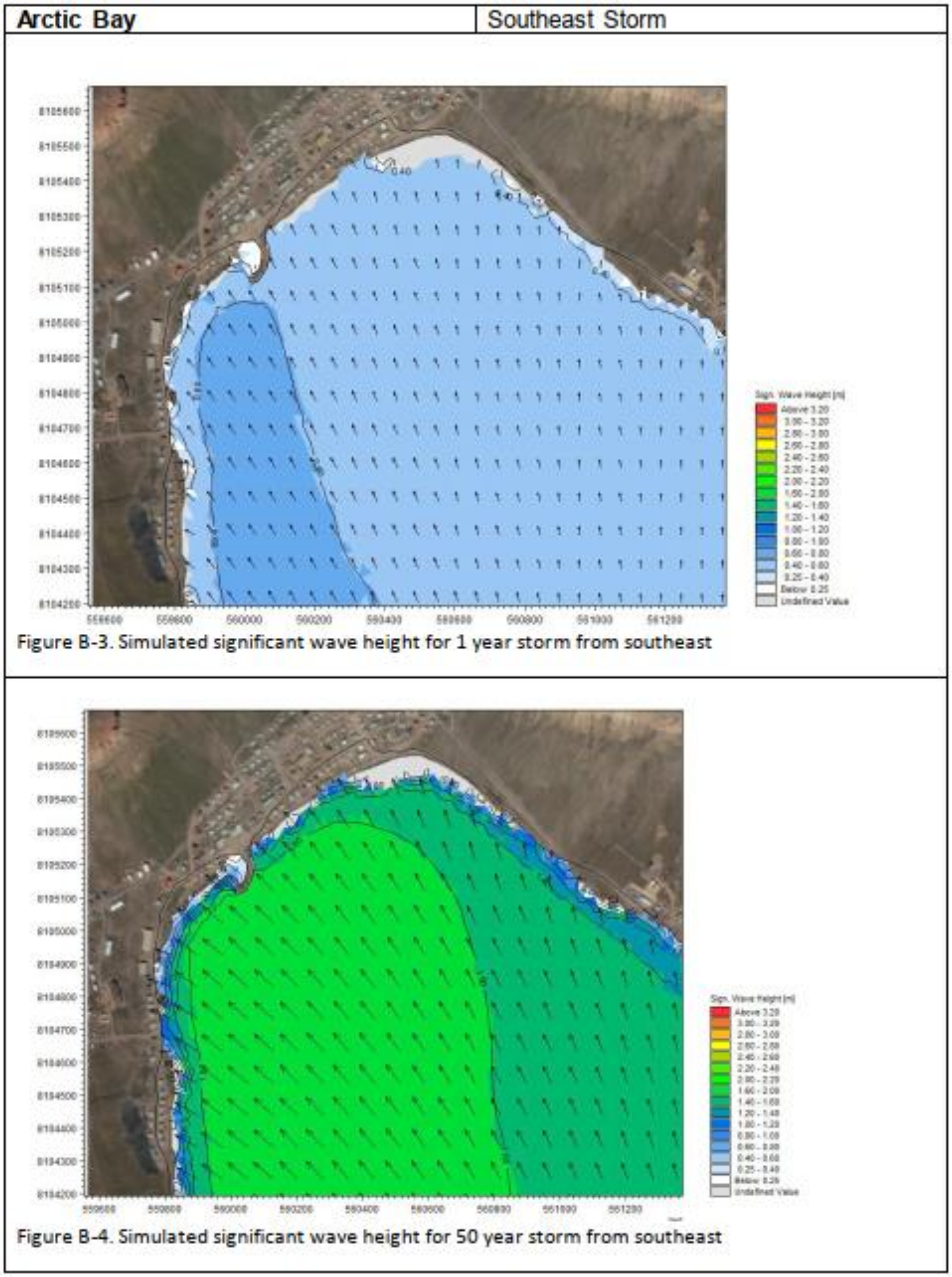

Figure 3-10 Simulated Significant Wave Height at Arctic Bay: top) One-Year Storm from Southeast; bottom) 50-Year Storm Southeast

Source: Appendix 4.2 of Advisian (2020a)

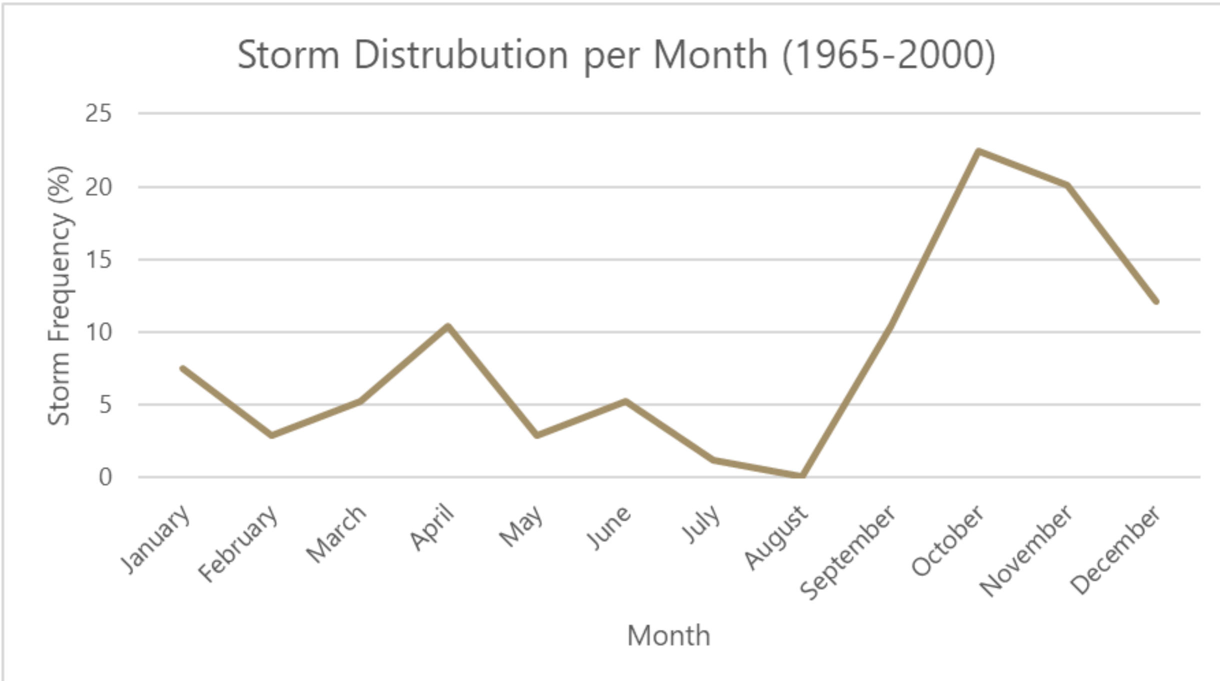

Figure 3-11 Arctic Bay Storm Distribution

Source: Section 3.3 of Advisian (2020a) and raw data from Government of Canada (2020d)
Note: missing data between 1966 to 1999

4 Marine Water Quality

Program objectives for water quality are provided in Section 1.6, Table 1-2. This section summarizes the marine water quality existing conditions informed from a desktop study and field program undertaken in the open water season of 2019 and 2020.

4.1 Desktop Review

Water quality data for Nunavut is limited, particularly at the local scale. The Nunavut General Monitoring Plan (NGMP) classifies water quality monitoring into two categories: project monitoring (project specific within a local study area), and general monitoring (addresses information on the long-term state and health of aquatic ecosystems in the Nunavut territory) (NGMP 2013). There is no established mechanism for the monitoring of marine water quality in the NGMP (NGMP 2013). The lack of marine water quality data for the Arctic is identified as a knowledge gap by NPC due to its potential impact on marine mammals and seabirds (Government of Canada 2018d). The Northern Contaminants Program is one organization that collects marine water quality information (Government of Canada 2018a). Understanding marine water quality is important in Nunavut, particularly in the context of climate change, where changing conditions of sea ice and freshwater runoff are important drivers in Arctic water quality (Nummelin et al. 2015). Understanding these variables provides a broader understanding of variable seasonal effects on coastal and offshore processes (Government of Canada 2002).

Within communities, the influence of storm water runoff, the effectiveness of wastewater treatment, and localized spills can influence marine water quality. Storm water run-off in Arctic Bay is poorly understood, but its impact is likely at a localized level, as Arctic Bay is a relatively unimpacted area. It is common for communities in Nunavut to have their wastewater collected and brought to a wastewater stabilization pond (WSP), which discharges to the marine environment (Krumhansl et al. 2016). Until 2010, wastewater from Arctic Bay was brought to a WSP 2.5 km east of the community, with effluent discharging south into Arctic Bay. This lagoon was decommissioned and a new WSP was commissioned in 2012, along the catchment divide, about 0.7 km north of the old WSP, discharging north through a wetland area to Victor Bay. Both WSPs likely have no impact to the water quality within the SCH Study Area as the old WSP is no longer discharging and new WSP is discharging into a different bay with no direct connectivity to Arctic Bay.

Anthropogenic influence on marine water quality due to spills has not been studied in Nunavut, particularly at the local scale in communities such as Arctic Bay. No information on water quality was provided by knowledge holders during the IQ Workshop (June 2019).

4.2 Field Program

4.2.1 Methodology

4.2.1.1 Survey Location

Marine water quality in Arctic Bay was assessed over two sampling events; August 10, 2019 and September 22, 2020. Water samples were collected from four locations in 2019 and seven locations in 2020, as shown in Figure 4-1. Some samples were collected at the same location in 2019 and 2020. Sample locations were selected to give a broad overview of water quality in the vicinity of the SCH Study Area. Sample locations and depths are provided in Table 4-1.

Table 4-1 Water Quality Sampling Locations (2019 and 2020)

Sample ID	Latitude	Longitude	Time	Sample Depth Category	Depth (m)	Station Depth (m)	Tide Height (m)	Chart Datum Depth (m)	Sampled Both Years
August 19, 2019									
AB WQ1	73° 1.761'N	85° 9.525'W	13:36	S	1	22	0.9	21.1	Y
			13:56	D	21				Y
AB WQ2	73° 1.904'N	85° 9.438'W	14:07	S	1	16	0.7	15.3	Y
			14:17	D	15				N
AB WQ3 (duplicate of AB WQ2)	73° 1.904'N	85° 9.438'W	14:29	S	1	16	0.7	15.3	NA
			14:38	D	15				NA
AB WQ4	73° 1.961'N	85° 9.520'W	14:47	S	2	4	0.7	3.3	Y
AB WQ5	73° 1.998'N	85° 9.472'W	14:58	S	1	1.7	0.7	1.0	Y
September 22, 2020									
AB WQ1	73° 1.761'N	85° 9.525'W	15:30	S	1	25	1.1	23.9	Y
				D	Not repeated in 2020 due to unfavourable weather conditions				N
AB WQ2	73° 1.904'N	85° 9.438'W	15:20	S	1	5	1.2	3.8	Y
			15:30	D	15				Y
AB WQ4	73° 1.961'N	85° 9.520'W	14:08	S	1	5	1.2	3.8	Y
AB WQ5	73° 1.998'N	85° 9.472'W	14:20	S	1	2	1.2	3.8	Y

Sample ID	Latitude	Longitude	Time	Sample Depth Category	Depth (m)	Station Depth (m)	Tide Height (m)	Chart Datum Depth (m)	Sampled Both Years
AB WQ6	73° 1.872'N	85° 9.734'W	13:50	S	1	5	1.2	3.8	N
AB WQ7	73° 1.981'N	85° 9.305'W	13:55	S	1	10	1.2	8.8	N
AB WQ8 (replicate of AB WQ7)	73° 1.981'N	85° 9.305'W	13:40	S	1	10	1.2	8.8	N

Note: S = Shallow (1 m below surface), D = Deep (1 m above seabed)

4.2.1.2 Field Survey Techniques

Physicochemical analysis was only undertaken in 2020 with a YSI Pro4 DSS probe and taken at each water quality sampling location. The YSI was lowered over the side of the vessel to document a vertical profile of the water column. The YSI was programmed to take a reading every half second, and recording was undertaken on the descent through the water column.

Water quality samples were collected by an experienced marine scientist and a local Inuit assistant. Samples were collected from each sampling location using a 5.0 L Teflon lined Niskin bottle deployed from a vessel. When depths were greater than 8 m, two samples were taken from each site, one at the surface (1 m below surface) of the water column and one from the bottom of the water column (1 m above seabed). Due to rough weather conditions during the 2020 field survey, deep samples were not always possible to collect for safety concerns. The Niskin was lowered over the side of the vessel to the required depth, a messenger was deployed to close the bottle, and the Niskin was retrieved to the surface with the contained sample. Once at the surface, the water sample was decanted into specific laboratory supplied containers for the required analyses. Sample containers were appropriately labelled using indelible ink to write the sample location number, depth of sample and date and immediately stored in coolers. Samples remained in refrigerated condition until dispatched to the analytical testing laboratory, where they are maintained at four degrees Celsius (4°C).

All samples are retained at the analytical laboratory in British Columbia for three months from the date of submission for repeat/verification testing if required. The 2019 samples were analyzed by Bureau Veritas Laboratory and the 2020 samples were analyzed by ALS Environmental.

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SCH Footprint

Study Area

SCH

DAS

Water Quality Sampling Location

2019

2020

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Metres

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WGS 1984 UTM Zone 16N

PUBLIC SERVICES AND PROCUREMENT CANADA
ARCTIC BAY HARBOUR DEVELOPMENT
ENVIRONMENTAL AND SOCIO-ECONOMIC BASELINE

WATER QUALITY SAMPLING LOCATIONS

Date: 08-JAN-21	Drawn by: JH	Edited by: KR	App'd by: VB

Public Services and Procurement Canada

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Project No. 317071-00037

FIG No 4-1

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4.2.2 Laboratory and Data Analysis

4.2.2.1 Field

Physicochemical parameters measured included the following:

- Temperature
- Salinity
- pH
- Turbidity
- Conductivity
- Dissolved Oxygen

Data were analysed using R statistical software (R Core Team 2020 V. 4.0.3). Water depth was first corrected using DFO tide height predictions for Arctic Bay on the date and time samples were collected. Because a depth sounder was not used, the YSI probe occasionally touched bottom and would be embedded in the sediment. This was visible by a noticeable spike in turbidity readings when the probe was at the deepest depths. The field team continued lowering the YSI until a noticeable change in the weight (touching bottom) or due to a turbidity jump. To account for this, data were cleaned to remove readings taken after the probe touched bottom, when required.

4.2.2.2 Laboratory

Laboratory data were directly imported into the Environmental Quality Information System (EQuIS) 5.5.1 database (Earthsoft, Concord, MA). Quality control checks were conducted to confirm data are admissible for use. The results were compared to the CCME – Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME 2003). These guidelines provide nationally endorsed, science-based goals for maintaining quality in aquatic ecosystems and are used for guidance to assess marine water quality. Water quality results were compared to long term guidelines.

Samples sent to the laboratory for analysis included the following analytes:

- Nutrients (ammonia, nitrate, nitrite, phosphorous, orthophosphate, total organic carbon)
- Physical parameters (pH, total suspended solids)
- Total metals
- Dissolved metals

4.2.3 Quality Assurance / Quality Control (QA/QC)

4.2.3.1 Field QA/QC

The field QA/QC measures for the water quality field survey included procedures to reduce the risk of cross-contamination. The following QA/QC procedures were incorporated during sampling to ensure the highest quality results:

- Using qualified environmental staff experienced in marine water sampling and field supervision of local assistants.
- Decontaminating all water sampling equipment by washing with a phosphate-free detergent solution, followed by thorough rinsing with analyte-free (de-ionized) water, prior to collecting a sample at each location.
- Prevention of cross-contamination by wearing a new pair of nitrile gloves for each sampling location when handling samples and sampling equipment.
- Storing samples in appropriately cleaned, pre-treated and labelled sample containers.
- 'Blind labelling' all field QA/QC duplicate samples in the field with QA/QC field numbers which do not relate to the sampling location names.
- Field duplicate samples were collected at WQ2 (2019) and WQ7 (2020) to determine the variability in analytical parameters.
- Keeping water samples cool (4°C) after sampling and during transport.
- Maintaining a clean and organized work area.
- A regimented process for sample documentation was used, including:
  - Labelling all field sample containers and field data sheets with pencil / indelible ink and waterproof labels.
  - Backing up electronic data (i.e. positional data from GPS, photographs), in duplicate, at the end of each field day and labelling electronic files.
  - Keeping thorough notes, including photographs, GPS coordinates, tidal/weather conditions, and recording potential confounding factors observed during field days and at sites.
- Transporting samples under Chain of Custody (COC) documentation.

4.2.3.2 Laboratory QA/QC

Laboratory analysis was conducted in accordance with professional standards using accepted testing methodologies, quality assurance, and quality control. The laboratory used for water quality sample analyses is Canadian Association for Laboratory Accreditation Inc. (CALA) accredited for the methods used and is experienced in the analysis of marine sediments. QA/QC procedures for contaminant assessment were used from sampling through to completion of laboratory analysis included:

- Chain of custody documentation
- Field and intra-laboratory QA/QC protocols

Laboratory QA/QC included procedures to promote high quality laboratory results as well as measures to verify the results. These procedures included analysis of laboratory method blanks, laboratory matrix spikes, laboratory spiked blanks, and laboratory duplicates.

A validation of the analytical data was undertaken to confirm that the data quality was suitable for undertaking an assessment to characterise water quality. This validation included a consideration of results for laboratory blanks, standards, spikes, and field and laboratory duplicate samples and is assessed against CCME (2016b).

4.2.4 Results – Physicochemical

Physicochemical parameters measured included the following:

- Temperature
- Salinity
- pH
- Turbidity
- Conductivity
- Dissolved Oxygen

Table 4-2 and Figure 4-2 provide summaries of the physicochemical parameters for depth profiling at each sample location. pH was documented but is not shown as it was measured as part of laboratory testing and the laboratory results are more pertinent (see Section 4.2.5.1). Across sites, depth profiles were taken between 0.03 m and 14.18 m.

4.2.4.1 Temperature

Temperature was consistent across depth at sites WQ1, WQ4, WQ6, and WQ7 with a mean temperature of 2.4°C. Only site WQ2 changed significantly with depth, where temperature was slightly higher at depth (14.18 m) and at the surface (0.13 m) than in the middle of the water column with a max temperature of 2.9°C. Temperature at site WQ5 was slightly lower than the other sites with a mean of 1.79°C, but this site was shallow so no change with depth was evident.

4.2.4.2 Salinity

Salinity was consistent across depth at sites WQ4, WQ5, WQ6, and WQ7 with a mean salinity of 28.34, 28.30, 28.35, and 28.34 practical salinity units (psu), respectively. Haloclines were evident at sites WQ1 and WQ2 where salinity increased significantly with depth, with a minimum of 28.34 psu at 0.82 m depth at site WQ1 and a maximum of at 28.53 at 14.18 m at WQ2.

4.2.4.3 Dissolved Oxygen

Dissolved oxygen profiles varied across sample locations and decreased with depth. The maximum value was 11.01 mg/L at WQ2, and the minimum value was 10.43 mg/L at WQ7. The largest change in dissolved oxygen was 10.55 mg/L to 11.01 mg/L at WQ2.

4.2.4.4 Turbidity

Turbidity profiles were consistent across depth and location for sites WQ1, WQ4, WQ6, and WQ7 with a mean of 0.29 nephelometric turbidity units (NTU) and minimum and maximum of 0.16 NTU and 1.03 NTU, respectively. Turbidity at site WQ5 was higher with a mean, minimum and maximum of 15.08 NTU, 14.19 NTU and 16.38 NTU, respectively.

4.2.4.5 Conductivity

Conductivity profiles were consistent across sites WQ1, WQ4, WQ6, and WQ7 with a mean of 25,717 µS/cm. At site WQ2, conductivity was consistent in the top 12 m of water before increasing in the lower 2m of the measured water column to a maximum of 26,227 µS/cm. Conductivity at site WQ5 was lower than the other sites and was more variable, ranging from 25,165 µS/cm to 25,279 µS/cm with a mean of 25,236 µS/cm.

Table 4-2 Summary Statistics for Depth Profiles of Physicochemical Water Quality Parameters

Sample ID	Depth (m)						Temperature (°C)						Salinity (psu)					
	WQ1	WQ2	WQ4	WQ5	WQ6	WQ7	WQ1	WQ2	WQ4	WQ5	WQ6	WQ7	WQ1	WQ2	WQ4	WQ5	WQ6	WQ7
Mean	6.0	7.3	2.9	0.24	2.5	5.2	2.4	2.6	2.4	1.8	2.4	2.4	28.3	28.4	28.3	28.3	28.4	28.3
Median	5.6	7.2	3.7	0.17	2.6	5.6	2.4	2.5	2.4	1.8	2.4	2.4	28.3	28.3	28.3	28.3	28.4	28.3
SE	0.5	0.5	0.2	0.1	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Min	0.8	0.1	0.0	0.03	0.2	0.2	2.4	2.4	2.4	1.7	2.4	2.4	28.2	28.3	28.3	28.3	28.3	28.3
Max	12.9	14.2	4.1	0.99	3.7	9.6	2.4	2.9	2.4	1.8	2.4	2.4	28.3	28.5	28.3	28.3	28.4	28.3
Sample ID	Dissolved Oxygen (mg/L)						Turbidity (NTU)						Conductivity (µS/cm)					
	WQ1	WQ2	WQ4	WQ5	WQ6	WQ7	WQ1	WQ2	WQ4	WQ5	WQ6	WQ7	WQ1	WQ2	WQ4	WQ5	WQ6	WQ7
Mean	10.7	10.7	10.5	10.7	10.7	10.5	0.2	0.3	0.3	15.1	0.5	0.2	25,694	25,821	25,714	25,236	25,722	25,738
Median	10.7	10.7	10.5	10.7	10.7	10.5	0.2	0.2	0.3	14.8	0.4	0.2	25,691	25,781	25,714	25,251	25,724	25,739
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	3.1	13.8	0.2	12.6	0.8	0.6
Min	10.6	10.6	10.5	10.7	10.6	10.4	0.2	0.2	0.3	14.2	0.3	0.2	25,653	25,759	25,710	25,165	25,704	25,728
Max	10.8	11.0	10.6	10.7	10.9	10.6	0.7	1.0	0.4	16.4	1.3	0.2	25,732	26,227	25,717	25,279	25,725	25,743

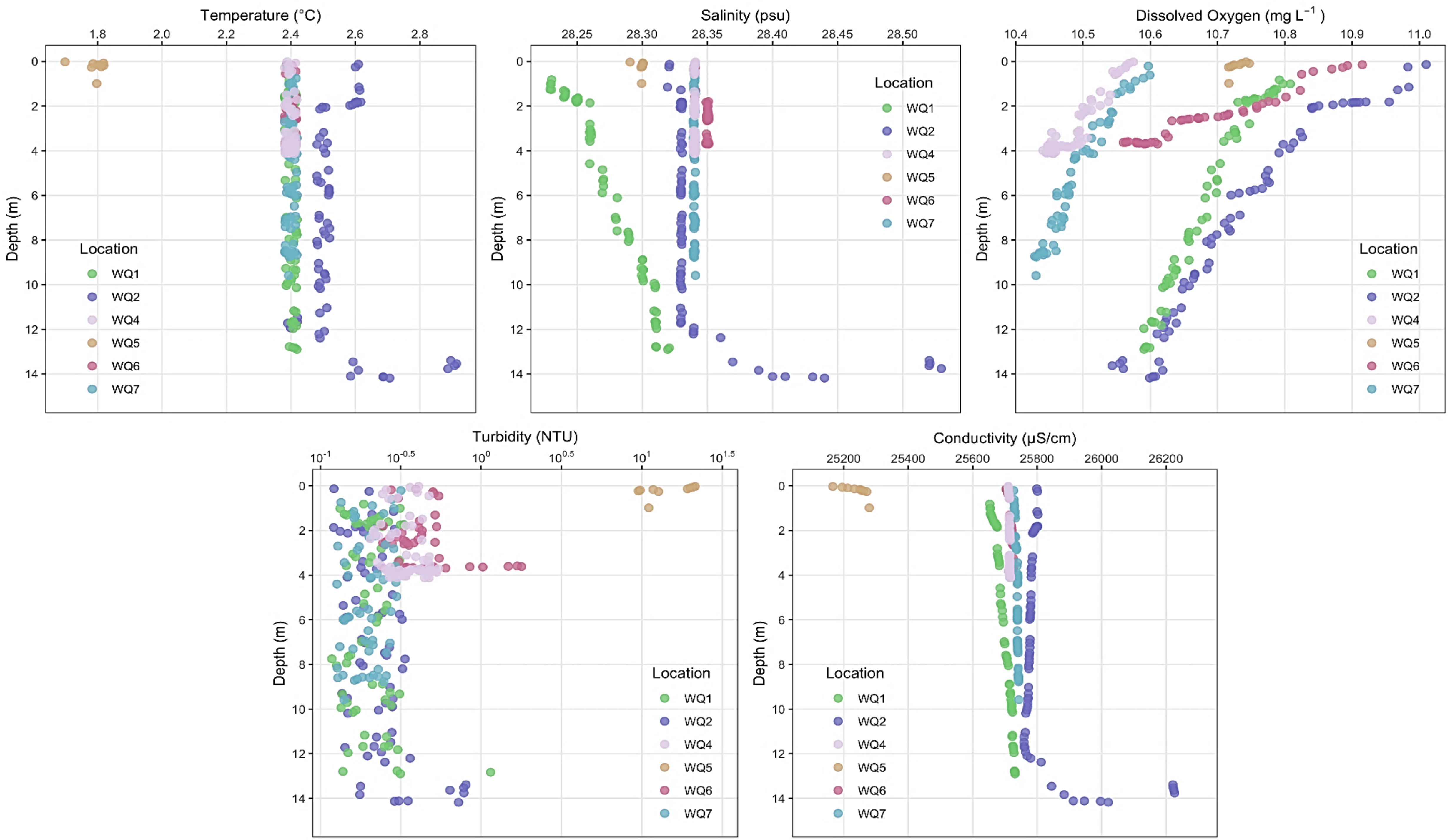


Figure 4-2 Dissolved Oxygen, Conductivity, Temperature, Salinity, and Turbidity Profile for each Water Quality Sampling Location

Note: Turbidity values were log transformed before plotting for interpretability.

4.2.5 Results – Laboratory

The results for chemical analyses for water quality are summarized below and presented in Table 1 (general water chemistry), Table 2 (total metals), and Table 3 (dissolved metals) in Appendix 2. Results are compared against the CCME (2003) long term marine water quality guidelines for the protection of aquatic life.

4.2.5.1 Major Ions, Nutrients and Physicochemical

Results of laboratory analysis for major ions, nutrients and physiochemical parameters are presented in Table 1 of Appendix 2, and summarized in Table 4-3.

Table 4-3 Laboratory Analysis Results for Major Ions, Nutrients, and Physiochemical Parameters

Parameter	2019	2020
pH	Consistent across depth and sample location. Values ranged from 7.92 to 8.02.	Consistent across depth and sample location, ranging from 7.87 to 7.93.
Nutrients	Below the reportable detection limits (RDL) across sampling locations except for the following: Ammonia was generally elevated at depth (ranged from 0.11 mg/L to 0.78 mg/L) compared to surface samples (ranged from < 0.010 mg/L to 0.67 mg/L).	Below the RDL across depth and sampling locations, except for ammonia concentration at AB WQ2 deep (0.0064 mg/L).
Water hardness	Consistent across sampling locations and was generally elevated at depth compared to surface samples. Total hardness (as $CaCO_3$) ranged from 4,130 mg/L to 5,440 mg/L.	Consistent across depth and sampling locations and was elevated at depth compared to surface sample at AB WQ2. Total hardness (as $CaCO_3$) ranged from 4620 mg/L to 5030 mg/L.
Total organic carbon (TOC)	Consistent across depth and sampling locations. Concentration ranged from 44 mg/L to 63 mg/L.	Consistent across depth and sampling locations. Concentration ranged from 0.93 mg/L to 1.53 mg/L.

4.2.5.2 Total Metals

Results of laboratory analysis for total metals are presented in Table 2 of Appendix 2 and are summarized below and in Table 4-4.

- Total metal parameters were below their respective CCME long term marine water quality guidelines, where a guideline exists.
- Antimony, beryllium, bismuth, iron, mercury, nickel, selenium, silicon, silver, thallium, tin, titanium, and zirconium were below respective RDLs in all samples.

- Arsenic, barium, boron, cadmium, calcium, lithium, magnesium, manganese, molybdenum, potassium, sodium, strontium, sulphur, uranium, vanadium, and zinc were present above respective RDLs in all samples. Concentrations of all analytes were relatively consistent across depth and sample location.

Table 4-4 Summary Statistics for 2019 and 2020 Total Metals Water Quality Data in the Small Craft Harbour Study Area

Metal / Metalloid	2019					2020				
	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)	Median (µg/L)	Standard Deviation (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)	Median (µg/L)	Standard Deviation (µg/L)
Aluminum	34.0	66.0	48.7	47.5	12.2	5.4	752.0	117.3	12.6	279.9
Antimony	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	0.8	2.0	1.3	1.2	0.5	1.4	1.7	1.4	1.4	0.1
Barium	4.7	9.4	6.5	5.5	2.2	7.2	13.7	8.3	7.5	2.4
Beryllium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bismuth	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Boron	2,850	3,730	3,188	3,010	394.9	2,680	3,000	2,854	2,840	103.7
Cadmium	N/A	N/A	N/A	N/A	N/A	0.038	0.052	0.042	0.040	0.006
Calcium	275,000	352,000	303,500	284,500	36,248	312,000	328,000	322,428	323,000	5,255
Chromium	N/A	N/A	N/A	N/A	N/A	0.3	1.3	0.4	0.3	0.4
Cobalt	0.10	0.16	0.13	0.13	0.02	0.025	0.808	0.137	0.025	0.296
Copper	0.25	1.22	0.66	0.66	0.38	0.25	2.29	0.61	0.25	0.76
Iron	15.0	30.0	25.3	26.5	5.4	5.0	1,430	216.7	14.0	535.1
Lead	0.1	0.4	0.3	0.3	0.2	0.025	1.650	0.304	0.082	0.596
Lithium	123.0	162.0	137.3	129.0	17.4	109.0	128.0	117.0	117.0	6.8
Magnesium	837,000	1,110,000	936,667	873,500	123,990	934,000	991,000	958,429	956,000	24,241

Metal / Metalloid	2019					2020				
	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)	Median (µg/L)	Standard Deviation (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)	Median (µg/L)	Standard Deviation (µg/L)
Manganese	0.3	2.7	1.4	1.3	0.9	0.58	25.30	4.30	0.76	9.26
Mercury	N/A	N/A	N/A	N/A	N/A	0.0025	0.0025	0.0025	0.0025	0.0000
Molybdenum	7.8	10.1	8.7	8.1	1.1	9.0	9.5	9.3	9.3	0.2
Nickel	1.1	1.4	1.2	1.1	0.1	0.25	1.55	0.44	0.25	0.49
Phosphorous	N/A	N/A	N/A	N/A	N/A	25.0	25.0	25.0	25.0	0.0
Potassium	258,000	335,000	287,000	270,000	35,282	302,000	327,000	317,714	319,000	7,740
Selenium	0.5	0.5	0.5	0.5	#DIV/0!	N/A	N/A	N/A	N/A	N/A
Silicon	N/A	N/A	N/A	N/A	N/A	500.0	1100	585.7	500.0	226.8
Silver*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sodium	7,490,000	9,810,000	8,310,000	7,735,000	1,039,750	8,780,000	9,330,000	9,157,143	9,230,000	216,311
Strontium	5,460	7,310	6,118	5,655	826	6,560	7,100	6,810	6,800	192.2
Sulphur	633,000	830,000	702,500	656,500	89,310	949,000	989,000	969,429	964,000	16,061
Thallium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tin	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Titanium	N/A	N/A	N/A	N/A	N/A	2.5	15.2	4.3	2.5	4.8
Uranium	2.2	3.0	2.5	2.3	0.3	2.2	2.4	2.3	2.3	0.1
Vanadium	N/A	N/A	N/A	N/A	N/A	1.4	3.2	1.7	1.4	0.7

Metal / Metalloid	2019					2020				
	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)	Median (µg/L)	Standard Deviation (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)	Median (µg/L)	Standard Deviation (µg/L)
Zinc	6.0	33.4	11.1	6.8	10.9	1.5	17.9	7.1	5.0	6.8
Zirconium	N/A	N/A	N/A	N/A	N/A	0.25	0.60	0.30	0.25	0.13

Notes:

* Samples below laboratory RDL were set to one half RDL for purposes of completing summary statistics.

N/A All samples were below laboratory RDL. No summary statistics completed.

(yellow) Value exceeds CCME Marine Water Aquatic Life

4.2.5.3 Dissolved Metals

Results of laboratory analysis for dissolved metals are presented in Table 3 of and are summarized below and in Table 4-5.

- Dissolved metal parameters were below their respective CCME long term marine water quality guidelines, where a guideline exists.
- Antimony, beryllium, bismuth, iron, mercury, nickel, selenium, silicon, silver, thallium, tin, titanium, and zirconium were below respective RDLs in all samples
- Arsenic, barium, boron, cadmium, calcium, lithium, magnesium, manganese, molybdenum, potassium, sodium, strontium, sulphur, uranium, vanadium, and zinc were present above respective RDLs in all samples. Concentrations of all analytes were consistent across depth and sample location.

Table 4-5 Summary Statistics for 2019 and 2020 Dissolved Metals Water Quality Data in the Small Craft Harbour Study Area

Metal / Metalloid	2019					2020				
	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)	Median (µg/L)	Standard Deviation (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)	Median (µg/L)	Standard Deviation (µg/L)
Aluminum	13.0	28.0	19.3	18.5	4.9	2.5	5.4	3.3	2.5	1.3
Antimony	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	2.1	2.9	2.5	2.5	0.3	1.28	1.43	1.36	1.36	0.06
Barium	4.2	8.3	5.7	4.9	1.8	7.3	9.1	7.8	7.7	0.6
Beryllium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bismuth	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Boron	2,930	3,790	3,312	3,150	376.2	2,690	3,020	2,864	2,850	116.7
Cadmium	N/A	N/A	N/A	N/A	N/A	0.030	0.048	0.039	0.038	0.006
Calcium	279,000	346,000	303,333	286,000	30,917	316,000	348,000	331,857	333,000	9,856
Chromium	0.25	0.59	0.31	0.25	0.14	0.25	1.00	0.66	0.64	0.24
Cobalt	0.05	0.12	0.08	0.08	0.03	0.025	0.136	0.041	0.025	0.042
Copper	N/A	N/A	N/A	N/A	N/A	0.22	0.44	0.29	0.24	0.09
Iron	5.0	21.0	7.7	5.0	6.5	N/A	N/A	N/A	N/A	N/A
Lead	0.05	0.22	0.08	0.05	0.07	0.051	0.058	0.054	0.054	0.003
Lithium	123.0	156.0	136.2	129.5	14.8	110.0	119.0	114.6	115.0	3.3
Magnesium	842,000	1,060,000	925,167	880,000	98,394	949,000	1,090,000	1,009,571	1,010,000	47,826

Metal / Metalloid	2019					2020				
	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)	Median (µg/L)	Standard Deviation (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)	Median (µg/L)	Standard Deviation (µg/L)
Manganese	0.25	2.28	1.02	0.72	0.87	0.47	7.96	1.67	0.55	2.78
Mercury	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Molybdenum	7.8	9.8	8.6	8.1	0.9	8.77	9.78	9.24	9.31	0.34
Nickel	0.68	1.13	0.92	0.94	0.15	N/A	N/A	N/A	N/A	N/A
Phosphorous	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Potassium	260,000	328,000	285,167	269,500	31,192	307,000	346,000	327,143	329,000	14,053
Selenium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Silicon	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Silver*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sodium	7,070,000	9,190,000	7,893,333	7,525,000	876,143	8,400,000	8,700,000	8,562,857	8,570,000	119,543
Strontium	5,570	7,130	6,090	5,760	675.4	6,460	7,080	6,817	6,930	254.9
Sulphur	617,000	777,000	684,833	657,500	70,754	926,000	1,010,000	973,857	986,000	32,891
Thallium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tin	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Titanium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Uranium	2.09	2.82	2.38	2.25	0.30	2.18	2.31	2.23	2.22	0.04
Vanadium	N/A	N/A	N/A	N/A	N/A	1.01	1.41	1.32	1.38	0.14

Metal / Metalloid	2019					2020				
	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)	Median (µg/L)	Standard Deviation (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)	Median (µg/L)	Standard Deviation (µg/L)
Zinc	2.5	30.0	7.1	2.5	11.2	2.1	8.0	4.1	3.3	2.6
Zirconium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

* Samples below laboratory RDL were set to one half RDL for purposes of completing summary statistics.

N/A All samples were below laboratory RDL. No summary statistics completed.

(yellow) Value exceeds CCME Marine Water Aquatic Life

4.2.6 Data Validation

4.2.6.1 Laboratory Accuracy and Precision

The analytical laboratory incorporated a range of QA/QC methods to ensure accuracy and precision of data. The results of the QA/QC completed are detailed below.

Laboratory Method Blanks

An assessment of blank samples reported by the laboratory demonstrates concentrations below the RDL for most parameters, so cross-contamination of samples does not appear to have occurred.

Laboratory Duplicates

CCME (2016a) recommends that laboratory duplicate samples should be within a relative percent difference (RPD) of ±20% for metals and nutrients and ±0.3 pH units or pH. In 2019, a review of laboratory QC results shows all RPDs to be within acceptable limits. No laboratory duplicate samples were collected in the 2020 sampling program.

Matrix Spikes

To verify that the physical properties or characteristics of the matrix do not interfere with the analytical result, a known concentration of the chemical of interest is mixed into a sample of the required matrix. Matrix spikes measure the analytical methodology's performance on a specific matrix type. CCME (2016a) states that recovery limits of 70% to 130% for metals are acceptable.

A review of laboratory QC results identified that all matrix spike recoveries met the acceptability criteria for all analytes except nitrate plus nitrite (35%) and nitrite (37%) in the 2019 sample analysis. The 2020 sample analysis showed that all matrix spike recoveries met the acceptability criteria for all analytes.

4.2.6.2 Field Duplicate Analysis

Field duplicates are samples that are split from the original sample. These QC samples identify variation associated with sub-sample handling and repeatability of sample collection procedures and laboratory analysis. Data quality targets in CCME (2016a) recommend an RPD of less than 20% between parent and duplicate samples. For concentrations near the detection limit, acceptance criteria are relaxed, for example, within five times of the RDL, a criterion that may be used is that the difference between the duplicate and parent sample concentrations should be less than two times the RDL (CCME 2016a).

RPD results for duplicates collected as part of the marine water quality program are presented in Table 1 (general chemistry), Table 2 (total metals), and Table 3 (dissolved metals) of Appendix 2 and summarized in Table 4-6.

Table 4-6 Field Duplicate RPD Results Exceeding CCME (2016) Data Quality Targets

Location	Date	Parameter	RPD
WQ2 DEEP	10-Aug-2019	Ammonia as N	150.6%
WQ2 SHALLOW	10-Aug-2019	Ammonia as N	63.4%
WQ2 SHALLOW	10-Aug-2019	Total Suspended Solids (TSS)	86.7%

The high RPD results for the ammonia samples are likely related to the lab needing to dilute the samples in order to bring the analyte into the calibrated range of the instrument, while the high RPD for TSS is possibly related to sample variability.

4.2.6.3 Holding Times

All water samples that required refrigeration were stored in coolers and then transported to the laboratory chilled, where samples were stored under refrigeration until analyzed.

Samples were submitted in accordance with laboratory recommended holding times except for all orthophosphate, nitrate, and nitrite samples. Standard methods for pH analysis state that pH should be analyzed within 15 minutes of sampling, and therefore is generally measured in the field. Analysis of pH was completed outside of standard holding times. A summary is provided in Table 4-7.

Table 4-7 Arctic Bay Marine Water Quality Holding Times

<table>
<tr><th>Year</th><th>Parameter</th><th>Sample Date</th><th>Sample Delivery Date</th><th>Sample Analysis Date</th><th>Number of Days Passed</th><th>Recommended Hold Time (Days)</th></tr>
<tr><td rowspan="7">2019</td><td>Mercury (dissolved)</td><td rowspan="7">August 10</td><td rowspan="7">August 14</td><td>August 15</td><td>5</td><td>28</td></tr>
<tr><td>Mercury (total)</td><td>August 15</td><td>5</td><td>28</td></tr>
<tr><td>TOC</td><td>August 20</td><td>10</td><td>28</td></tr>
<tr><td>Ammonia as N</td><td>August 15</td><td>5</td><td>28</td></tr>
<tr><td>Nitrate/Nitrite</td><td>August 15</td><td>5</td><td>3</td></tr>
<tr><td>Orthophosphate</td><td>August 15</td><td>5</td><td>3</td></tr>
<tr><td>Total Metals</td><td>August 19</td><td>9</td><td>180</td></tr>
<tr><td rowspan="3">2020</td><td>Mercury (dissolved)</td><td rowspan="3">September 22</td><td rowspan="3">October 6</td><td>October 9</td><td>17</td><td>28</td></tr>
<tr><td>Mercury (total)</td><td>October 9</td><td>17</td><td>28</td></tr>
<tr><td>Total Organic Carbon</td><td>October 8</td><td>16</td><td>28</td></tr>
</table>

Year	Parameter	Sample Date	Sample Delivery Date	Sample Analysis Date	Number of Days Passed	Recommended Hold Time (Days)
	Ammonia as N			October 8	16	28
	Nitrate/Nitrite			October 9	17	3
	Orthophosphate			October 9	17	3
	Total Metals			October 7	15	180

Note: Bolded parameters indicate holding time exceedance.

4.3 Discussion

Marine water quality in Arctic Bay was consistent across sampling locations and depth. Physicochemical parameters were generally consistent across sampling locations and depth, except for dissolved oxygen which showed a constant decrease with depth in all sampling locations. At AB WQ2, conductivity, salinity, temperature, and turbidity values were also consistent with depth, but greatly increased from 12 m to 14 m. Visual observations in this sampling location confirmed a higher turbidity than other locations.

Metal concentrations were below respective CCME (2003) guidelines. Across all sample locations, dissolved metal concentrations were comparable to total concentrations, indicating that metals typically are not bound to solids, except for total aluminum, copper, iron, and zinc which were about twice the respective dissolved concentrations. However, there are no CCME guidelines for any of these parameters. pH, hardness, alkalinity, TOC, TSS, sulphur and metals concentrations were generally consistent across shallow and deep samples.

No IQ assessment was completed at the site-specific level.

5 Sediment Quality

Program objectives for sediment quality are provided in Section 1.6, Table 1-2. This section summarizes the marine sediment quality existing conditions informed from a desktop study and field program undertaken in the open water season of 2019 and 2020.

5.1 Desktop Review

Sediment quality in Nunavut, including Arctic Bay, has not been widely studied. The collection of sediment quality data is generally driven by discreet project requirements, for which there have been few in the region.

In Arctic Bay, sediment quality has the potential to be influenced by stormwater discharges from residential and industrial areas, effluent outfall from waste disposal, and spills from various shoreline activities. Effluent quality monitoring at treatment plants is known to be a challenge for communities in Nunavut (Wooton et al. 2008).

Until 2010, wastewater from Arctic Bay was brought to a WSP 2.5 km east of the community, with effluent discharging south into Arctic Bay. This lagoon was decommissioned and a new WSP was commissioned in 2012, along the catchment divide, about 0.7 km north of the old WSP, discharging north through a wetland area to Victor Bay. Both WSPs likely have no impact to the sediment quality within the SCH Study Area as the old WSP is no longer discharging and new WSP is discharging into a different bay with no direct connectivity to Arctic Bay.

The municipal waste management facility, located approximately 2 km east from the centre of town, includes domestic wastes, construction wastes, metal wastes and hazardous goods. Metals/hazardous wastes are separated from domestic wastes by being placed on either side of the access road heading towards the new WSP (Hamlet of Arctic Bay 2019c). Hazardous wastes are further segregated from metals by storage in a sea can for disposal to an appropriate disposal facility in southern Canada. The bulk metals/hazardous waste storage area is not bermed or lined and runoff from the facility currently flows into the sewage treatment wetland (Hamlet of Arctic Bay 2019c). Based on the distance from the SCH site, it is unlikely there would be any influence from the waste management facility runoff to the sediment chemistry at the SCH site.

Anthropogenic influence on marine sediment quality due to spills has not been studied in Nunavut, particularly at the local scale in communities such as Arctic Bay. No information on sediment quality was provided by knowledge holders during the IQ Workshop. During the consultation period however, knowledge holders indicated that there was potentially a contaminated area immediately west of the existing breakwater. In the community it is thought that decades ago something was dumped in the water that resulted in bubbling and subsequent fish mortality. After World War II there was a weather station adjacent to the existing breakwater and it is possible that lead-acid batteries were thrown in the water.

5.2 Field Program

5.2.1 Methodology

As dredging would likely be required for construction of the SCH, the sediment sampling program was developed to address the requirements of the ECCCs DAS Regulations and associated ECCC guidance including: the Applicant's Guide to Applying for a DAS Permit (Government of Canada 2019d), and Minimum Sample Collection Requirements (ECCC 2018a). Due to potential DAS requirements, survey effort focused on the Project footprint (load site) and a potential DAS site (disposal site) (Figure 1-1).

Sediment sample collection was designed to support a DAS permit application to ECCC with the number of samples at the load site based on the ECCC's 2018 Atlantic Guidance 'Characterization of Dredged Material for Open Water Disposal' (ECCC 2018a). Based on assumptions of some dredged sediments being repurposed, it is expected that a volume of up to 10,000 m^3 in an area that is 12,000 m^2 may need to be disposed at sea. This potential dredge footprint corresponds to a minimum of seven (7) sediment samples required to characterize the material at the load site under higher certainty conditions and a minimum of 14 to 28 samples required for lower certainty conditions.

During the 2019 feasibility field program, sediment sampling at the load and disposal sites was complicated due to very compacted sediments, which was confirmed by the 2019 geophysics program (Advisian 2019c). Because of this, no samples were collected at the DAS site in 2019 and it was further agreed upon with ECCC in 2020 that additional sampling at this time was not necessary.

5.2.1.1 Survey Locations

Sediment quality at the SCH load site was assessed over two sampling events, in August 2019 and September 2020. Sediment samples were taken from 10 locations in the SCH area as shown in Figure 5-1. Sampling locations, dates of collection, and water depths are summarized in Table 5-1.

Table 5-1 Sediment Quality Sampling Locations at the Arctic Bay SCH Load Site

Sample ID	Latitude	Longitude	Date	Time	Depth (m)	Tide Height (m)	Chart Datum Depth (m)
AB LS1	73° 1.908'N	85° 9.737'W	2019-08-10	9:23	2.2	1.5	0.7
AB LS2	73° 1.994'N	85° 9.458'	2019-08-10	9:42	2.1	1.5	0.6
ABLS SQ 1	73° 1.925'N	85° 9.715'W	2020-09-19	14:29	3.1	2.1	1.0
ABLS SQ 2	73° 1.958'N	85° 9.671'W	2020-09-19	14:56	3.6	2.2	1.4
ABLS SQ 3	73° 1.979'N	85° 9.569'W	2020-09-19	15:21	2.9	2.1	0.8
ABLS SQ 4	73° 2.000'N	85° 9.362'W	2020-09-19	15:50	5.1	2.0	3.1
ABLS SQ 5	73° 2.033'N	85° 9.457'W	2020-09-19	20:38	0.0	0.3	0.0

Sample ID	Latitude	Longitude	Date	Time	Depth (m)	Tide Height (m)	Chart Datum Depth (m)
ABLS SQ 6	73° 2.010'N	85° 9.530'W	2020-09-19	20:55	0.0	0.2	0.0
ABLS SQ 7	73° 1.922'N	85° 9.790'W	2020-09-21	11:49	1.1	0.6	0.5
ABLS SQ 8	73° 1.980'N	85° 9.503'W	2020-09-21	11:20	1.6	0.4	1.2

Legend

- SCH Footprint
- SCH Study Area

Dredge Areas

- EL -1.5m
- EL -5m

Sediment Quality Sampling Locations

- Sample Lost
- Collected (2019)
- Collected (2020)

0 25 50 100
Metres

1:2,500

WGS 1984 UTM Zone 16N

Imagery Source: CHS July 2017

Locations approximate.

PUBLIC SERVICES AND PROCUREMENT CANADA
ARCTIC BAY HARBOUR DEVELOPMENT
ENVIRONMENTAL AND SOCIO-ECONOMIC BASELINE

SEDIMENT SAMPLING LOCATIONS (PLANNED & COLLECTED) AT THE SMALL CRAFT HARBOUR

Date: 08-JAN-21	Drawn by: KR	Edited by: KR	App'd by: VB
Public Services and Procurement Canada	Advisian · Ikpiaryuk Services Ltd.	Project No. 317071-00037	
		FIG No 5-1	REV 0

PLOT DATE & TIME: 1/8/2021 8:33:49 AM
SAVE DATE & TIME: 1/8/2021 8:33:36 AM

FILE LOCATION: U:\YVR\317071\00037_PWGS_ArcBayCES\10_Eng\16_Geomatics\01_MXD\Baseline\Fig5-1_AB_SedimentQualitySampling.mxd

5.2.1.2 Field Survey Techniques

Sample Collection

The 2019 samples within the SCH were collected using a Ponar grab sampler deployed from a vessel. The Ponar was lowered over the side of the vessel to the seabed and then retrieved to the surface, with an intact sample. The Ponar collects a sample approximately 8 cm in depth over an area of 225 cm^2 (15 cm x 15 cm area). In 2020, no samples were able to be collected using the Ponar, as the sediment in both the SCH and DAS study areas were very compacted, confirmed by the 2019 geophysics program (Advisian 2019c). An alternative snorkel collection technique was executed where safe to do so. This involved using a stainless-steel coring device. The core collects a sample approximately 15 cm in depth over an area of 75 cm^2 (15 cm x 5 cm area) and resulted in the collection of six sediment samples. Two other samples were collected by walking the intertidal zone with the coring device.

Sample Processing

Sediment samples were logged and processed after collection. At each sample site a sediment log of each sample was recorded on a field data sheet, providing a description of the composition of each sample, including the following information:

- Colour and evidence of staining
- Texture
- Odour
- Presence of debris and biological material
- Photograph of each sediment sample

Once samples were logged and photographed, they were placed into large stainless-steel mixing bowls and homogenized using gloved hands (powderless nitrile gloves) and stainless-steel sample scoop. Samples were stored in specific containers, supplied by the laboratory, for the required analyses. Sample containers were appropriately labelled using indelible ink to write the sample location number and date on both the label and the lid of the container and immediately stored in coolers. Samples remained in refrigerated condition until dispatched to the analytical testing laboratory, where they were maintained at 4 deg. Celsius (°C).

All sample material held at the analytical laboratory is retained for three months from the date of submission for repeat/verification testing if required.

Raw data (field logs) including sample photographs are provided in Photo 1 of Appendix 3 for 2019 and 2020.

5.2.1.3 Laboratory Analysis

Based on a review of existing information in the area, known land uses within the catchment and the requirements of the DAS Regulations and (Government of Canada 2019d), sample analysis included:

- TOC

- Total metals (suite of 34)
- Polycyclic aromatic hydrocarbons (PAHs)
- Polychlorinated biphenyls (PCBs)
- Sediment grain size

5.2.2 Data Analysis

Laboratory data were directly imported into the EQuIS 5.5.1 database (Earthsoft, Concord, MA). Checks for data quality have been conducted to confirm data are admissible for use. The results were compared to the following guidelines:

- ECCC - criteria under DAS Regulations
- CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME 1999b). These guidelines provide nationally endorsed, science-based goals for maintaining quality in aquatic ecosystems and are used for guidance but not as strict criteria for DAS. Sediment quality data are compared to the following marine guidelines:
  - Interim Sediment Quality Guideline (ISQG), which is based on the Threshold Effects Level (TEL), or the concentration of an analyte below which adverse biological effects are rarely expected (less than 25% of the time).
  - Probable Effects Level (PEL) concentration, which is the level at which adverse biological effects occur more than 50% of the time.

5.2.3 Quality Assurance / Quality Control

5.2.3.1 Field QA/QC

The field QA and QC measures for the sediment sampling program included procedures to reduce the risk of cross-contamination. The following QA/QC procedures were incorporated during sampling to ensure the highest quality results:

- Using qualified environmental staff experienced in sediment sampling, field supervision of local assistants and sediment logging.
- Using a survey vessel that was inspected and washed down.
- Decontaminating all sediment sampling equipment and associated utensils by scrubbing with a brush and phosphate-free detergent solution to remove excess sample material, followed by thorough rinsing with analyte-free (de-ionized) water.
- Prevention of cross-contamination by wearing a new pair of nitrile gloves for each sampling location when handling samples and sampling equipment.
- Storing samples in the appropriately cleaned, pre-treated and labelled sample containers.
- 'Blind labelling' all field QA/QC duplicate samples in the field with QA/QC field numbers which do not relate to the sampling location names.
- Keeping sediment samples cool (4°C) after sampling and during transport.

- Maintaining a clean and organized work area.
- A regimented process for sample documentation was used, including:
  - Labelling all field sample jars and field data sheets with pencil/ indelible ink and waterproof labels.
  - Backing up electronic data (i.e. positional data from GPS, photographs), in duplicate, at the end of each field day and labelling electronic files.
  - Keeping thorough notes, including photographs, GPS coordinates, tidal/weather conditions, and recording potential confounding factors observed during field days and at sites.
- Transportation of samples using Chain of Custody documentation.

5.2.3.2 Laboratory QA/QC

Laboratory analysis was conducted in accordance with professional standards using accepted testing methodologies, quality assurance, and quality control. The laboratory used for sediment sample analyses is CALA accredited for the methods used and is experienced in the analysis of marine sediments. QA/QC procedures for laboratory analysis included:

- COC documentation
- Field and intra-laboratory QA/QC protocols

Laboratory QA/QC included procedures to promote high quality laboratory results as well as measures to verify the results. These procedures included analysis of laboratory method blanks, laboratory matrix spikes, laboratory spiked blanks, and laboratory duplicates.

A validation of the analytical data was undertaken to confirm that the data quality was suitable for undertaking an assessment to characterize material proposed for dredging and disposal. This validation included a consideration of results for laboratory blanks, standards, spikes, and field and laboratory duplicate samples and is assessed against CCME (2016b).

5.2.4 Results

The 2019 and 2020 sampling program produced samples that were collected within the SCH Study Area and targeted the proposed dredge footprint. No samples were collected within the DAS study during either sampling program due to compacted sediments or engagement with ECCC. The summary of results from the laboratory analysis are a combination of the 2019 and 2020 sampling programs rather than a comparison between the two years as only two samples were collected in 2019 in different locations within the SCH Study Area (see Table 5-1).

5.2.4.1 Physical Characteristics

Sediment samples collected within the SCH Study Area were predominantly sand with varying percentages of gravel, silt, and clay. The exception to this was AB LS2 which was predominantly clay with lower percentages of silt, sand, and gravel (refer to Figure 5-2 and Table 4, Appendix 2). Raw sediment samples photos are provided in Photo 1 of Appendix 3.

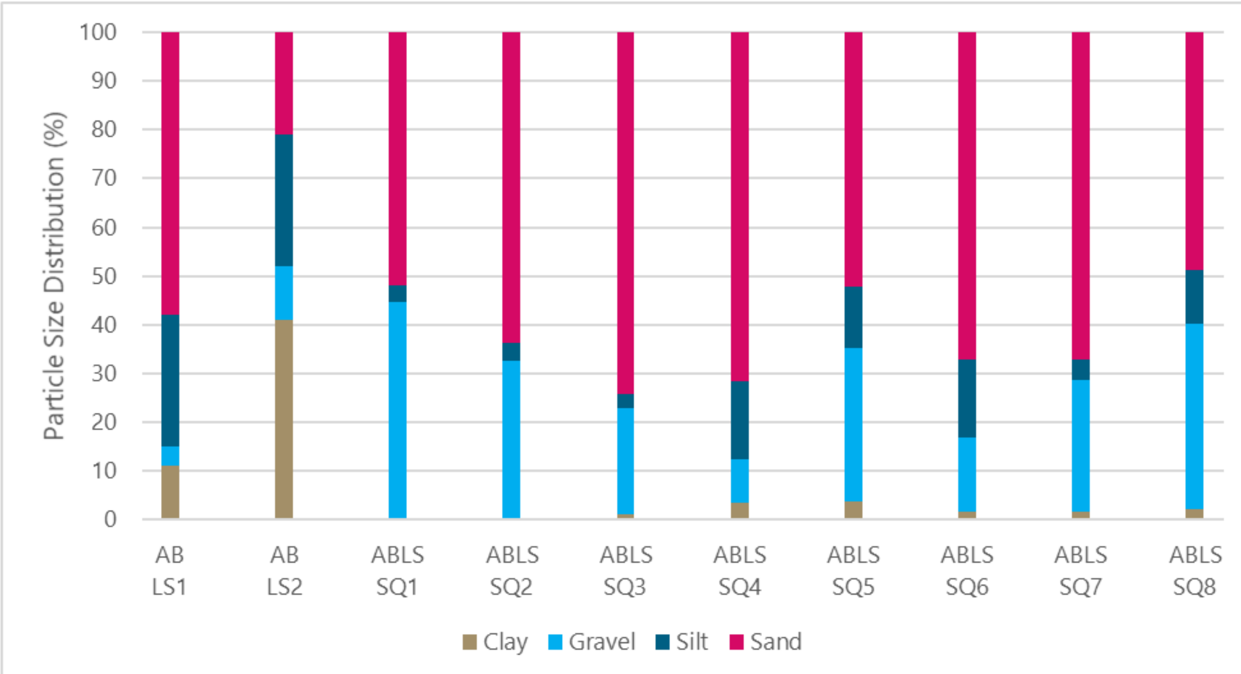


Figure 5-2 Particle Size Distribution of Sediments within the Small Craft Harbour Study Area

5.2.4.2 Chemical Characteristics

The results of chemical analyses for sediments within the SCH Study Area are summarized below and presented in Table 4 (General and Salinity), Table 5 (Metals and Metalloids), Table 6 (PAHs), and Table 7 (PCBs) of Appendix 2.

Results are compared against the DAS Regulations and CCME Sediment Quality Guidelines (CCME 1999a).

Metals and Metalloids

Table 5-2 provides summary statistics for metals and metalloids in the SCH Study Area and Table 5, Appendix 2 provides a summary of the laboratory results for samples taken during this survey.

Metal and metalloid guideline exceedances are presented in Figure 5-3 and are summarized below:

- Copper concentrations were above the CCME ISQG (18.7 mg/kg) at all sampling locations except ABLS SQ1 (16.4 mg/kg)
- Lead was above the CCME ISQG (30.2 mg/kg) and PEL (112 mg/kg) at ABLS SQ8 (12 100 mg/kg)
- Mercury was above the DAS Regulations (0.75 mg/kg), CCME ISQG (0.13 mg/kg), and PEL (0.70 mg/kg) at ABLS SQ2 (0.827 mg/kg)

- The following were below laboratory RDL limits:
  - Bismuth (four of ten samples)
  - Cadmium (one of ten samples)
  - Mercury (three of ten samples)
  - Selenium (all samples)
  - Silver (eight of ten samples)
  - Tin (seven of ten samples)
  - Tungsten (all samples)

Table 5-2 Summary Statistics for 2019 and 2020 Metals and Metalloids Data in the Small Craft Harbour Study Area

Metal / Metalloid	2019					2020				
	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Median (mg/kg)	Standard Deviation (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Median (mg/kg)	Standard Deviation (mg/kg)
Aluminum	16,200	16,800	16,500	16,500	16,200	11,000	19,100	13,400	12,550	2,647
Antimony	0.15	0.23	0.19	0.19	0.15	0.12	121	15.30	0.18	42.71
Arsenic	3.59	5.12	4.36	4.36	3.59	3.60	5.68	4.51	4.38	0.75
Barium	96.70	306.00	201.35	201.35	96.70	53.2	198	112.7	105	55.72
Beryllium	0.81	1.01	0.91	0.91	0.81	0.47	1.03	0.67	0.63	0.19
Bismuth	0.16	0.25	0.21	0.21	0.16	0.10	2.20	0.46	0.17	0.72
Boron	19.50	30.90	25.20	25.20	19.50	10.20	19.10	14.03	13.15	3.06
Cadmium	0.10	0.16	0.13	0.13	0.10	0.01	0.098	0.042	0.036	0.027
Calcium	1860	4850	3355	3355	1860	1,560	2,780	2,086	2,060	473
Chromium	28.70	36.90	32.80	32.80	28.70	17.80	28.50	21.50	20.80	3.40
Cobalt	13.10	15.20	14.15	14.15	13.10	8.3	12.5	9.85	9.43	1.43
Copper	37.40	44.30	40.85	40.85	37.40	16.4	36.5	24.2	21.8	6.58
Iron	33400	33500	33450	33450	33400	23,500	35,000	26,775	25,250	3,918
Lead	12.70	21.80	17.25	17.25	12.70	7.58	12,100	1,525	13.42	4,273
Magnesium	7290	9970	8630	8630	7290	5,450	7,710	6,196	6215	731
Manganese	231	276	253.50	253.50	231	181	312	218	205	41.9
Mercury	N/A	N/A	N/A	N/A	N/A	0.0025	0.827	0.110	0.0078	0.290
Molybdenum	1.44	2.06	1.75	1.75	1.44	0.55	1.28	0.90	0.86	0.24

Metal / Metalloid	2019					2020				
	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Median (mg/kg)	Standard Deviation (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Median (mg/kg)	Standard Deviation (mg/kg)
Nickel	27.40	34.10	30.75	30.75	27.40	17.8	27.8	21.1	20.2	3.33
Phosphorous	353	369	361	361	353	234	360	293	286	38.9
Potassium	2,400	3,440	2,920	2,920	2,400	1,290	2,560	1,790	1,740	426.2
Selenium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Silver*	0.03	0.07	0.05	0.05	0.03	0.10	0.21	0.11	0.10	0.04
Sodium	4,330	6,320	5,325	5,325	4,330	2,030	4,460	3,041	2,315	862.9
Strontium	20.40	29.00	24.70	24.70	20.40	10.2	30.9	17.9	14.9	7.08
Thallium	0.13	0.14	0.13	0.13	0.13	0.08	0.18	0.10	0.09	0.03
Tin	0.60	1.06	0.83	0.83	0.60	1.0	7.0	1.8	1.0	2.1
Titanium	105	177	141	141	105	59.3	599	239	193	180
Tungsten	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Uranium	N/A	N/A	N/A	N/A	N/A	0.582	1.17	0.758	0.709	0.194
Vanadium	40.90	54.70	47.80	47.80	40.90	35.9	75.5	47.9	44.9	12.9
Zinc	51.60	77.00	64.30	64.30	51.60	45.7	88.3	56.9	50.8	14.6
Zirconium	12.40	17.60	15	15	12.40	6.4	11.5	7.9	7.6	1.6

Notes:

* Samples below laboratory RDL were set to one half RDL for purposes of completing summary statistics.

N/A All samples were below laboratory RDL. No summary statistics completed.

Value exceeds CCME ISQG

Value exceeds ECCC DAS, CCME ISQG, and CCME PEL

Value exceeds CCME ISQG and PEL

Polycyclic Aromatic Hydrocarbons

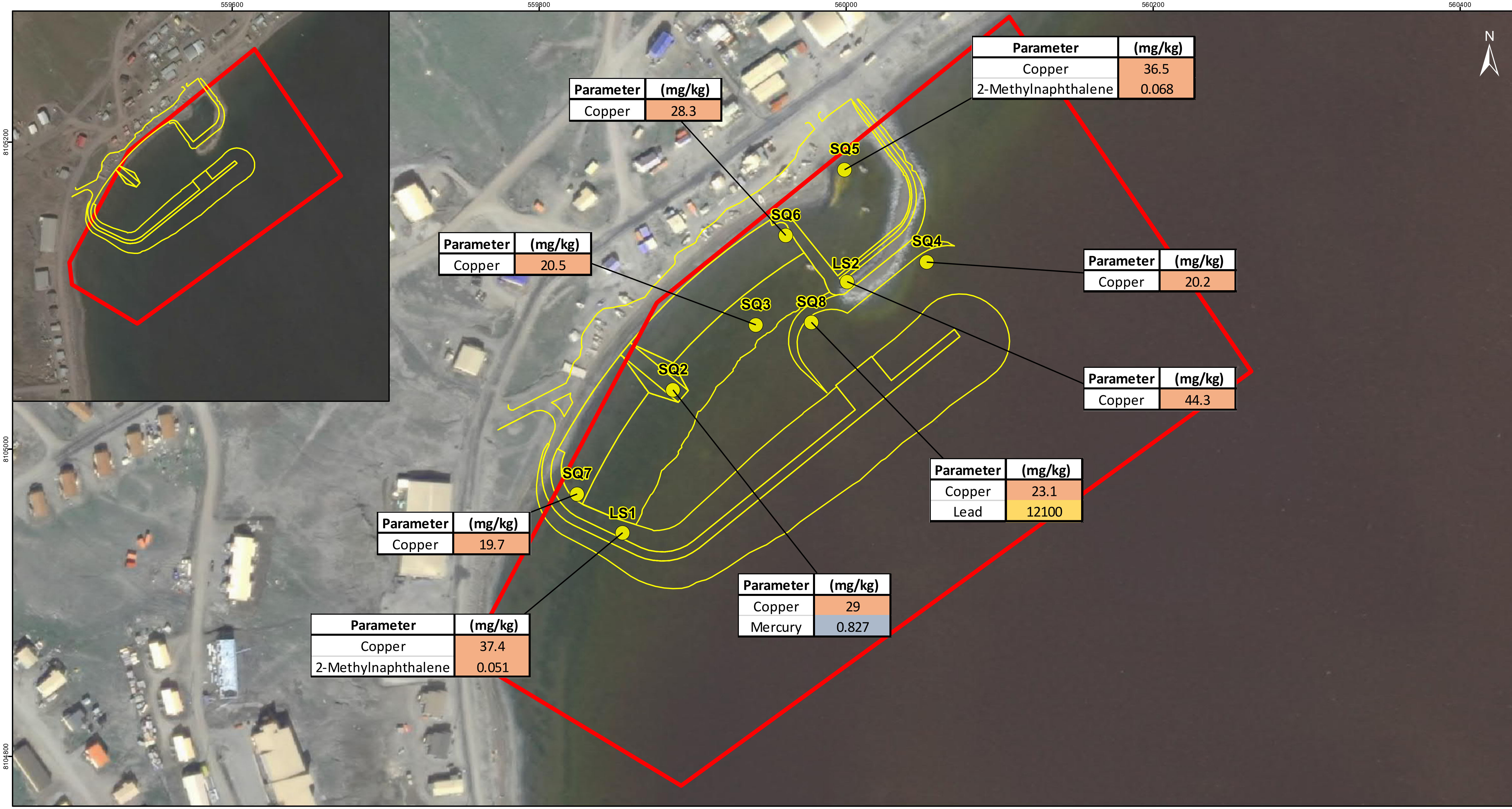
PAH results are in Table 6, Appendix 2. PAH guideline exceedances are presented in Figure 5-3 and are summarized as follows:

- 2-methylnaphthalene at sampling locations AB LS1 (0.051 mg/kg) and ABLS SQ5 (0.068 mg/kg) were above their respective CCME ISQG. Detection limits for 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, dibenzo[a,h]anthracene, fluorene, and naphthalene at ABLS SQ1 to 8 (except for 2-methylnaphthalene at ABLS SQ5) were above their respective CCME ISQGQ therefore a comparison cannot be made.
- Total PAHs were below the DAS Regulations (2.5 mg/kg) at all sample locations.
- The following parameters were below laboratory RDL at AB LS1 and AB LS2:
  - Acenaphthene
  - Benzo[a]pyrene
  - benzo[a]pyrene (Total Potency Equivalent)
  - benzo[k]fluoranthene
  - dibenzo[a,h]anthracene
  - indeno[1,2,3-cd]pyrene, Indexed Value of Additive Cancer Risk (IACR)
- The following parameters below laboratory RDL at AB LS2 but above laboratory RDL at AB LS1:
  - Acenaphthylene
  - Anthracene
  - Benzo[a]anthracene
  - Benzo[g,h,i]perylene

Polychlorinated Biphenyls

Results of PCB analysis are presented in Table 7, Appendix 2, and summarized as follows:

- Only Aroclors and total PCBs were analyzed in 2019 at sampling locations AB LS1 and AB LS2
  - Total PCB concentrations were below respective CCME ISQG, CCME PEL, and DAS regulation guidelines at both locations.
  - Aroclor 1254 concentrations were below respective CCME ISQG and PEL guidelines at both locations.
- Only Individual congeners and homolog groups were analysed in 2020 at sampling locations ABLS SQ 1 to 8
  - Total PCB concentrations were below respective CCME ISQG, CCME PEL, and DAS Regulations guidelines at all locations.



Legend

SCH Footprint

SCH Study Area

Sediment Sampling Locations

Sediment Sample Collected

Guidelines Exceeding
CCME Marine Sediment (ISQG)
CCME Marine Sediment (ISQG) and CCME Marine Sediment (PEL)
EC Disposal at Sea Regulations, CCME Marine Sediment (ISQG), CCME Marine Sediment (PEL)

0 25 50 100

Metres

1:2,500

WGS 1984 UTM Zone 16N

Imagery Source: CHS July 2017

Locations approximate.

PUBLIC SERVICES AND PROCUREMENT CANADA
ARCTIC BAY HARBOUR DEVELOPMENT
ENVIRONMENTAL AND SOCIO-ECONOMIC BASELINE

SEDIMENT SAMPLING EXCEEDANCES SUMMARY

Public Services and Procurement Canada

Advisian

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5.2.5 Data Validation

See Section 4.2.6 for data validation methodology summary.

5.3 Discussion

Particle size distribution of sediment samples collected in the SCH Study Area was relatively similar between locations ABLS SQ1 to 8, consisting mostly of sand with varying percentages of gravel, silt, and clay. The exception was location AB LS2 which was predominantly clay with lower percentages of silt, sand, and gravel. AB LS2 was collected in close proximity to the existing breakwater (Figure 5-1) and it is possible the sediment at this location has been influenced by the structure (i.e. construction materials or influence on deposition). AB LS1 also consisted mostly of sand, however had a larger proportion of silt and clay compared to sampling locations ABLS SQ1 to 8. It is not expected that there are differences in grain size collection between the two sediment collection methods as the core and the Ponar are retrieved from underwater while closed. During the geological program in 2019 (Advisian 2019c), the substrate was considered similar throughout the site. The shoreline comprised mainly coarse sub-rounded to angular gravel and cobbles with gravelly sand. The gravel and cobbles included various lithologies and occasional ice rafted boulders (beach deposits) were evident in the intertidal/supratidal area. The intertidal zone contained coarser deposits of sand, gravel and cobbles compared to subtidal sediments which were predominantly sand with lesser amounts of gravel. Results from sub-bottom profiling and seismic refraction indicated the surface layer comprised of sands and gravels to be compact to dense and up to 6m thick. Due to the compact to dense seabed materials, the sampler was unable to effectively penetrate the seabed and collect representative samples in some locations, including within the DAS Study Area. In 2020, no sampling occurred again at the DAS site.

Physical characteristics of the beach can be viewed from the fish and fish habitat intertidal survey (see results in Section 11.2.3.1). The intertidal and shallow subtidal areas can be visually observed to be dominated by gravel, cobble, and sand with some boulder. The presence of cobble and boulders in the intertidal and shallow subtidal areas was not reflected in the sediment collection which targeted subsurface collections.

Concentrations of metals were generally consistent across sampling locations, except for lead and antimony at ABLS SQ8 and mercury at ABLS SQ2. Lead concentrations were approximately 800 times the mean concentration of all other sampling locations, and exceeded CCME ISQG, and CCME PEL. Antimony was approximately 600 times the mean concentration of all other sampling locations. It is possible these levels of lead and antimony are related to the assumption that lead-acid batteries from the historical weather station were dumped in the vicinity of the breakwater.

The concentration of mercury at ABLS SQ2 was above CCME ISQG, CCME PEL, and DAS regulations, but was below these guidelines at all other locations. Overall mercury concentrations are low across the SCH Study Area and the source of the higher concentration observed at ABLS SQ2 is unknown. Copper concentrations were also above the CCME ISQG at all sampling locations except for ABLS SQ1. However, there are not enough studies to compare concentrations as there are limited studies in the area.

Where a guideline existed, about half of PAHs were below CCME ISQG at all sampling locations except for 2-Methylnaphthalene at AB LS1 and ABLS SQ5. The remaining parameters (see Section 5.2.4.2) consisted of samples below respective RDLs, which were also above the CCME ISQG due to higher laboratory detection limits used in 2020. At all locations total PAH concentrations were below DAS regulations.

Total PCBs were below CCME ISQG, CCME PEL, and DAS regulations at all locations. Aroclors and total PCBs were analyzed in 2019 and were measured below detection limits at both sampling locations. Basing total PCB concentrations from Aroclor analysis can result in error as environmental weathering may alter the Aroclor profile making it difficult to match Aroclor patterns (CCME 2001). In 2020 individual congeners and homolog groupings were analyzed and PCBs were detected at all locations except ABLS SQ7.

Concentrations of metals (and other contaminants) in sediments depends largely on regional and local geology and oceanography, particle size and proximity to contaminant sources (Nunavut General Monitoring Plan (NGMP 2013)), and there is not enough information available in the literature to draw meaningful comparisons to sediment quality results in the SCH Study Area.

6 Geology

Program objectives for the geological features are provided in Section 1.6, Table 1-2.

This section summarizes the existing geological site conditions, including soils, landforms and permafrost, which form the foundation for the ecosystems of Baffin Island and an assessment of the potential for Acid Rock Drainage (ARD) / Metal Leaching (ML) in association with the use and exposure of rock during construction. Both a desktop review and a 2019 site reconnaissance and walkover survey were completed to define the existing conditions.

6.1 Desktop Review

A desktop review was undertaken to determine known characteristics of the geology in and around Arctic Bay and inform the planning for the site reconnaissance and walkover survey.

6.1.1 Regional Geology

Arctic Bay is within the Borden Basin, which consists of three rift systems. The largest of these is Milne Inlet Graben (MIG) which spans the Borden Peninsula and areas southeast of Milne Inlet (Turner 2009). The MIG is approximately 250 km long and contains the Bylot Supergroup which comprises over 1,500 m of platform, shelf, and slope carbonate rocks deposited between approximately 1,270 to 723 million years before present.

Bedrock geology near the community forms part of the Arctic Bay and Society Cliffs Formations (see Figure 4 in Appendix 1), which are part of the Eqalulik and Uluksan Groups, respectively. The Arctic Bay formation predominantly consists of mudstones (shale) and is understood to be approximately 200 m thick (Turner 2009). The overlying Society Cliffs Formation comprises dolostone. The area also includes predominantly northwest or north-northwest trending diabase dykes (Pehrsson & Buchan 1999) associated with the Franklin igneous event (approximately 723 million years ago).

6.1.2 Topography and Drainage (Surface Features)

Arctic Bay and the surrounding area are characterized by mountains and valleys which have either been carved out by glaciers or intruded by diabase dykes. Valley walls and cliffs are dominated by individual and coalescing rock fall talus cones and boulder tongues, with very steep rock walls at the top, becoming gentler due to the accumulation of talus nearer the base.

The community is located at the northwestern head of the bay, which is relatively flat, sloping gently to the shoreline and from the shoreline the seabed also slopes gently into the bay. Patterned ground is shown on aerial imagery present on slopes north of the community, which could indicate ice wedge polygons and/or solifluction processes within the seasonal active soil zones above the permafrost.

Drainage is controlled by valleys which also includes Marcil Lake that supplies the community with drinking water (see Figure 13-1 for location). There are several small streams which flow through and/or around the community into the bay during the summer (see Figure 11-6).

6.1.3 Soils

Based on the Canadian Soil Classification System (National Research Council of Canada 1998), there are four major Soil Orders found in Nunavut; Brunisols, Cryosols, Gleysols and Regosols (Aarluk 2012) (see Table 6-1 for description).

The dominant soil order in Arctic Bay, as is true for many northern locations, is likely Cryosols (Agriculture and Agri-Foods Canada 2017), which is characteristic of locations in the Continuous Permafrost Zone (see Section 6.1.4, and Figure 6-1). These regions, characterized by long, cold winters and short, cool summers, result in mean annual soil temperature at or below 0°C. This leads to permafrost conditions, where the ground remains frozen for two or more consecutive years. The frequent freeze-thaw cycles associated with these cold environments contribute not only to the presence of permafrost near the soil surface but also to a suite of soil-forming processes known as cryoturbation. Cryoturbation refers to soil movement that arises from frost action, and is sometimes also referred to as "frost churning" (CSSS 2020).

Due to the presence of permafrost and a shallow active layer, Brunisolic Cryosols (both Static and Turbic) are expected to be present on the variable nearshore and littoral deposits exposed on the shoreline, with Regosols present as thin and weakly developed in areas of bedrock exposure.

Table 6-1 Soil Forms

Type	Description
Brunisols	Show poor and thin soil development
Cryosols	Found in material where permafrost is present within 1 m of the surface
Gleysols	Soils were the water table is shallower than 1 m from the surface
Regosols	Landforms or surface where there has been no soil development and are usually found on bedrock, or young and active landforms such as beaches, floodplains, landslides and other active or dynamic landforms

Source: National Research Council of Canada (1998)

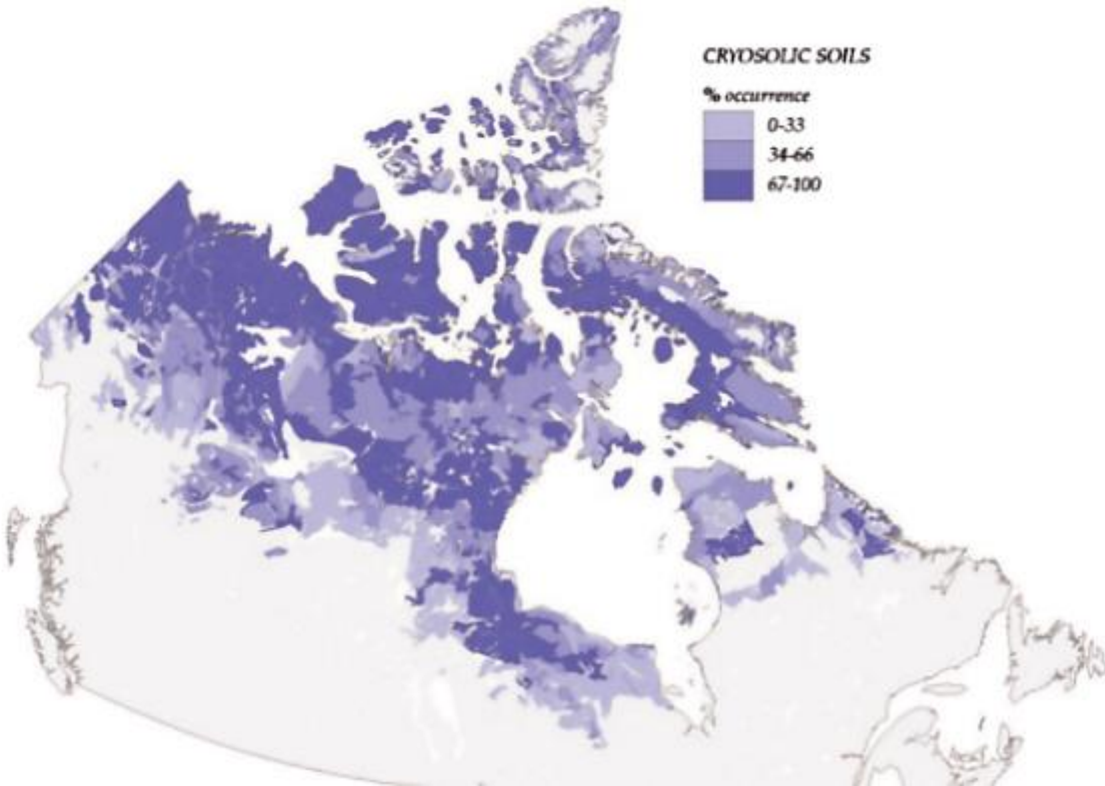

Figure 6-1 Distribution of Cryosols in Canada Generated from the Soil Organic Carbon Digital Database of Canada

Source: Tarnocai and Lacelle (1996)

6.1.4 Permafrost

Permafrost is considered a condition where a material remains below 0°C for a minimum of two years. A typical permafrost classification is divided into three zones (continuous, discontinuous and sporadic) on the basis of the percentage of the land area underlain by permafrost (International Permafrost Association 2015). All of Baffin Island is in the Continuous Permafrost Zone (Osterkamp 2001) where sub-sea permafrost is not expected in Arctic Bay (Journeaux Associates 2012) (see Figure 6-2). However, Advisian's experience on marine projects at Nanisivik and Milne Inlet indicate that sub-sea permafrost is likely to be present at Arctic Bay below the wharf and/or breakwater.

The ground in Arctic Bay may consist of one or more of the following: soil, rock, ice or organic material. The permafrost of Baffin Island uplands has been estimated to be 400 to 700 m thick (Aarluk 2012) with a surface active layer that can vary widely from less than 1 m in wet soils to greater than 5 m in rock outcrop. Limited data is available to assess permafrost conditions. One monitoring well was installed as part of the Geological Survey of Canada's collaboration with Nunavut communities and the territorial government (Ednie & Smith 2015). Ground temperature was monitored from 2008 to 2014 and indicated an average thaw depth of the active surface layer to be approximately 1.3 m below ground surface. It should be noted that the depth of the active layer is dependant on subsurface conditions (soil and rock) and other factors such as sun exposure.

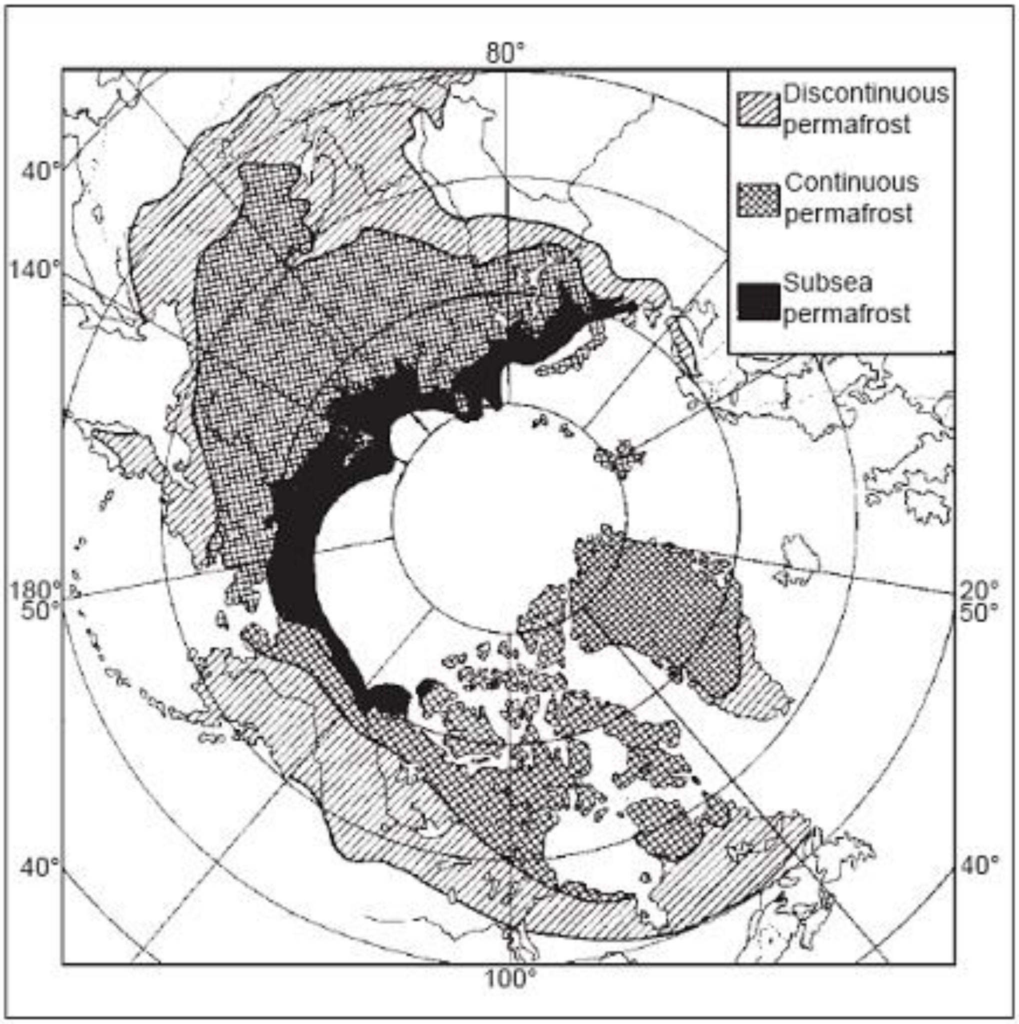

Figure 6-2 Distribution of Permafrost in Canada

Source: J. Brown et al. (1997)

6.2 Field Program

A non-intrusive site reconnaissance survey was undertaken within the HRQ Study Area from August 8 to August 10, 2019.

A drilling program was undertaken at the planned quarry location in the March of 2021. Drilling was required to assess variability including obtaining Rock Quality Designation (RQD) to assess rock mass quality, obtain rock defect data, collection of rock cores for additional rock strength testing at depth, and ARD testing. In addition to confirming the feasibility of obtaining rock armour dimensions (block sizes) of the size confirmed by detailed design. Results from this investigation were not available for the preparation of this report.

6.2.1 Methodology

6.2.1.1 Survey Location

The survey area targeted the Project Study Areas limited to the reachable intertidal areas within the SCH Study Area. Tide heights on the date of the survey are provided in Section 1.7, Table 1-3.

6.2.1.2 Field Survey Techniques

The field survey consisted of:

- Site reconnaissance and walkover survey within the footprint of the identified and proposed quarry locations to identify actual and potential hazards for design and construction.
- Assessment of exposed rock outcrops including rock weathering, rock strength, and observable structural defects within the footprint of the planned and alternate quarry.
- Collection of rock samples from the planned and alternate quarry for durability, rock strength and ARD testing (see locations in Figure 6-3).
- Walkover and drive along the haul road to note salient features which may need to be taken into consideration for future planning (such as creek crossings).
- Walkover survey of the intertidal areas within the SCH Study Area to identify surface deposits and geomorphological features which aid to explain sub-surface soil and/or rock conditions.
- Drilling work was completed in the winter, using a skid mounted drill rig with support equipment. The drill sampled both sediments and rock cores. The drilling work used the level ice as a working platform.

6.2.1.3 Laboratory Analysis – Rock type, durability, strength, and ARD testing

Laboratory analysis was conducted of the following variables with results provided below.

Petrographic Analysis

A sample from the planned quarry was collected and sent to Vancouver Petrographic Ltd. in Langley for petrographic analysis on a thin section and rock description.

Point Load Index Testing

Approximately 30 kg of rock samples were collected from Locations 1 to 3 (Figure 6-3). These rock samples were collected from exposed bedrock outcrops with a maximum width of approximately 10 cm to allow for point load strength tests and rock durability testing.

Out of the approximately 30 kg of rock samples collected from the Locations 1 to 3 nine (9) samples were selected for Point Load Index (PLI) testing. Lump samples were tested in accordance with ASTM D5731-08 (standard test method for determination of the point load strength index of rock and application to rock strength classifications).

Results of the PLI tests are provided Table 1 in Appendix 5. As shown, Is_{50} results range from approximately 3 MPa to 12 MPa indicating strong (R4) to extremely strong (R6) rock strength with Is_{50} values typically >4 MPa and <10 MPa indicating very strong (R5) rock strength.

Rock Durability Testing

Two rock samples were sent to Golder Associates Ltd.'s Burnaby laboratory for durability testing. Samples were crushed to minus 37.5 mm sieve and then subjected for the following tests:

- Los Angeles Abrasion Test to obtain its resistance to degradation of large-size coarse aggregates by abrasion and impact.
- Relative density (specific gravity) and absorption of coarse aggregates.
- Soundness of aggregate by magnesium sulphate.
- Durability index.

6.2.1.4 Site and Laboratory Analysis – SCH Site

Standard penetration tests were completed every 1.5 m within the sediments/soils. Pocket penetrometer tests were completed on recovered samples. Vane shear tests were completed in the soft clays of two (2) boreholes. Logs were prepared of all boreholes.

Laboratory testing was completed on samples taken every 1.5 m for gradation tests. Two (2) undisturbed samples of the clays were recovered for laboratory triaxial testing.

Legend

- Potential Quarry
- Potential Haul Route - Existing Road/Track
- Potential Haul Route - Construct New Road
- Dolerite Dike
- Photo Location
- Location

0 50 100 200
Metres

N

Locations approximate.

FISHERIES AND OCEANS CANADA
SMALL CRAFT HARBOURS
ARCTIC BAY

PLANNED AND ALTERNATE QUARRY LOCATIONS & HAUL ROAD ROUTES

Date: 28-MAY-21	Drawn by: KR	Edited by: KR	App'd by: JG
		Project No. 317071-00037	
		FIG No 6-3	REV 0

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Imagery Source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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6.2.2 Results

6.2.2.1 Geological Site Conditions

The rock types identified are part of the predominantly northwest or north-northwest trending diabase dykes (Pehrsson & Buchan 1999) associated with the Franklin igneous event (approximately 723 million years ago). Multiple locations were identified during the drive including outcrops near cabins at the shoreline of Victor Bay as shown in Photo 6-1. Multiple outcrops west of the road between the community and Victor Bay were observed, with the closest outcrop parallel to the road, approximately 1.2 km away from the community. An outcrop was also identified approximately 800 m southeast of the sewage lagoon as well as a prominent outcrop at Oulouksione Point (see Figure 3-6 for this location).

Photo 6-1 shows a typical dolerite outcrop. Outcrops close to Victor Bay and Oulouksione Point are accessible by vehicle. Both locations comprise predominantly slightly to moderately weathered surfaces, frost shattered in part, dark grey to black dolerite. Outcrops identified at Victor Bay, Oulouksione Point, and close to the sewage lagoon were deemed to all have potential issues including proximity to existing cabins, distance from the harbour and the need to haul through the community and sites with archeological significance (Oulouksione Point). Therefore, although these sites are likely to have suitable rock, other sites were explored.

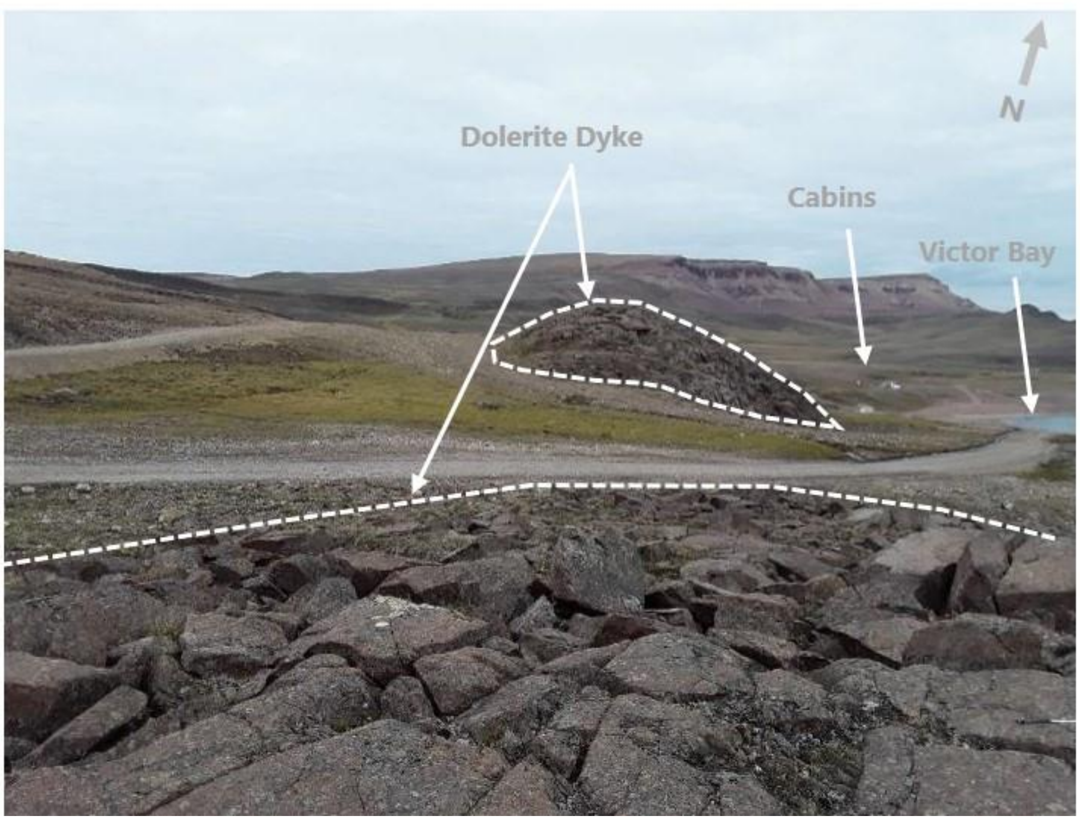


Photo 6-1 Standing on Dolerite Outcrop Looking Northwest Towards Cabins at Victor Bay

During the feasibility stage, two quarry locations were shortlisted for consideration and review with the hamlet and HTA, Location 1 (alternate) and Location 2 (planned). The planned quarry is located immediately beside the Victory Bay road, whereas the alternate is 2 km further away from the road. The planned and alternate quarry are part of the same dolerite dyke which appears to extend approximately 3 km trending northwest to southeast. The dolerite dyke appears to contain slightly to moderately weathered surfaces, frost shattered in part, of dark grey to black dolerite. The planned quarry can be observed directly from the road which links the community to Victor Bay. Photo 6-2 is looking southeast towards the dolerite dyke, and a view from the road looking north to northwest towards Victor Bay is shown in Photo 6-3.

The planned quarry has been selected for the project based on consultations with the community and the GN's Planning and Lands office.

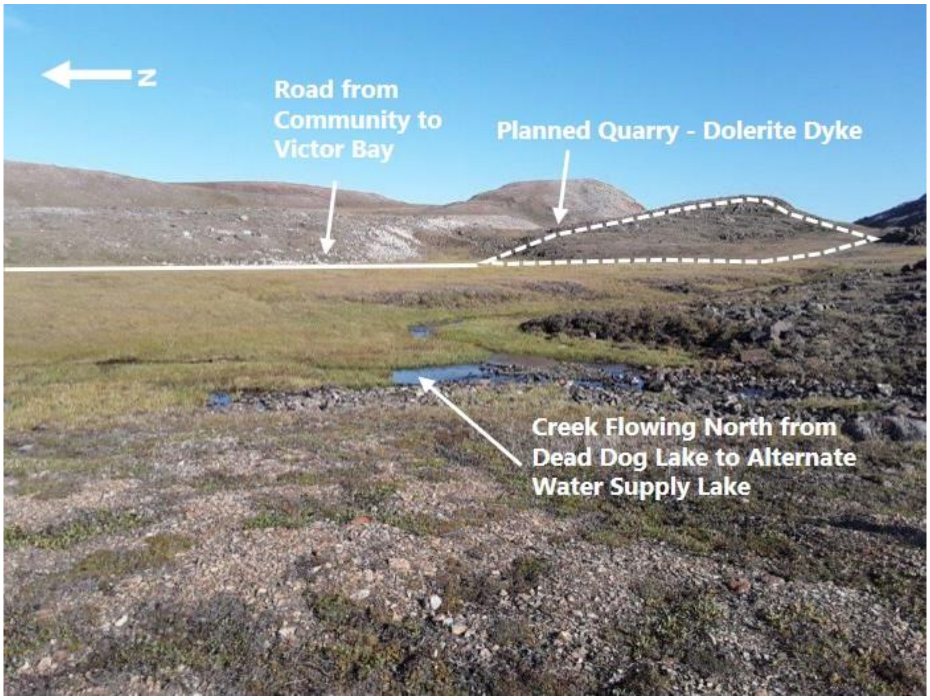


Photo 6-2 View of the Planned Quarry looking Southeast

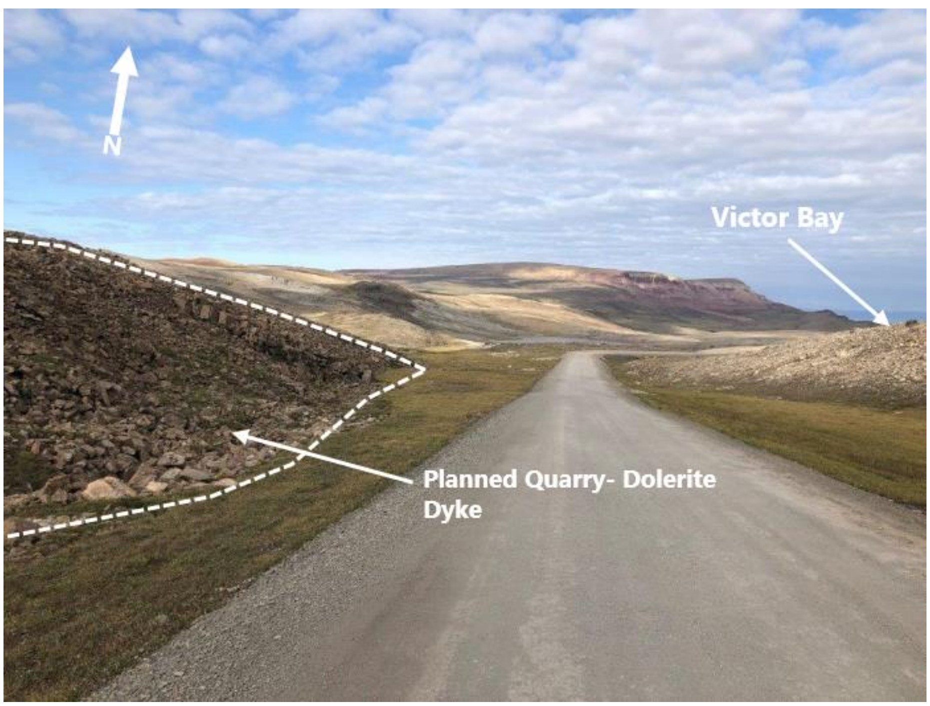


Photo 6-3 View of Planned Quarry from Road Looking North

6.2.2.2 Soils

The ground surface at both the planned and alternate quarry location appear to comprise either bedrock at surface and/or frost shattered rock.

The ground surface at the SCH comprises mainly coarse sub-rounded to angular gravel and cobbles with gravelly sand. The gravel and cobbles include various lithologies and occasional ice rafted boulders (beach deposits) are evident in the intertidal/supratidal area.

6.2.2.3 Topography and Drainage (Surface Features)

The planned and alternate quarry are separated by a creek running between Dead Dog Lake and the Alternate Water Supply Lake (see Figure 1-1, see foreground of Photo 6-2). Drainage features make the planned quarry a more ideal location for water management during construction as the dyke flows north, away from the Alternate Water Supply Lake.

6.2.2.4 Rock Strength, Rock Durability, and ARD Testing

Point Load Index (PLI) Testing

Results of the PLI tests are provided in Table 1 in Appendix 5. As shown, Is_{50} results range from approximately 3 MPa to 12 MPa indicating strong (R4) to extremely strong (R6) rock strength with Is_{50} values typically >4 MPa and <10 MPa indicating very strong (R5) rock strength. The results of the rock durability tests are presented in Table 6-2.

Table 6-2 Rock Durability Test Results (Planned Quarry)

Test	Requirement	Test Result (%)	
		One surface sample collected in Sep 2019	Rock core samples collected in Mar/Apr 2021
Absorption (ASTM C127)	Not more than 2%	0.66%	0.70%
Abrasion, 500 Revolutions (ASTM C131)	Not more than 30%	24.1%	15.2%
Magnesium Sulphate Soundness 5 Cycles (ASTM C88)	Not more than 15%	0.40%	0.60%
Petrographic Examination	Absence of weakness or materials that could result in significant alternation in durability	Petrographic analysis did not show anything to suggest significant alteration	
Durability (ASTM D3744)	No index less than 35	87	80
Bulk Specific Gravity - (Saturated Surface Dry, ASTM C127)	Not less than 2.65	2.96	2.84

Acid Rock Drainage Potential (Planned Quarry)

The MEND classification criteria developed in BC and described in MEND (2009) is as method used to classify rock according to their ARD potential. This criterion uses the neutralization potential ratio (NPR), a ratio of the neutralization potential capacity of the samples to its acid potential to classify geological materials in terms of their ARD in one of the following three categories:

1. NPR< 1: The rock is classified as 'Potentially Acid Generating' (PAG).
2. 1≤NPR≤2: The ARD potential is uncertain and the rock is classified as 'Uncertain'.
3. NPR> 2: The rock is classified as 'Non-Potentially Acid Generating' (Non-PAG).

NPR is calculated as the ratio of the Modified Sobek Neutralization Potential (MS-NP) and the Acid Potential (AP).

ARD testing was completed on a total of five (5) samples. One (1) grab surface sample was collected during a site reconnaissance survey in 2019 and the other four (4) samples were collected from rock cores collected during the geotechnical drilling program in March/April 2021. Results from the five (5) samples are provided in Table 6-3.

Table 6-3 Acid Rock Drainage Results (Planned Quarry)

Sample ID	Sample Type	Sample Depth (mbgs)	Neutralization Potential Ratio (NPR)	ARD Potential
Surface sample collected in September 2019				
AB01	Surface Sample	NA	NA	Non-PAG
Core samples collected in March/April 2021				
BHQ21-01 (GB-01-01)	Rock Core		NA	Non-PAG
BHQ21-01B (GB-01B-02)	Rock Core		80.3	Non-PAG
BHQ21-02 (GB-01B-01)	Rock Core		17.3	Non-PAG
BHQ21-02 (GB-01B-03)	Rock Core		5.9	Non-PAG

6.2.2.5 SCH Site

The drilling program at the SCH site encountered subsurface conditions typically consisting of gravelly sand/sandy gravel above the high tide level, overlying till. In the marine area the subsurface conditions typically consisted of silty sand overlying silty sandy clay or clayey silty sand, overlying sand (only in two boreholes), overlying shale bedrock. Overburden thicknesses varied up to about 5 m in the eastern areas and about 1.5 m in the western area.

No permafrost was found in the drilling at the SCH site.

6.3 Discussion

The rock at both the planned and alternate quarry locations comprises of Dolerite (Diabase), and where these dolerite dikes are present are expected to be suitable rock for general fill and rock armour. The suitability of the dolerite for use as rock armour was confirmed with laboratory testing to confirm rock durability and ARD requirements.

Sediments encountered were weak clays, assumed to be re-worked till. The presence of the weak clay will be an important driver in the design of the new infrastructure.

7 Species at Risk and Designated Areas

Program objectives for SAR in Arctic Bay study area are provided in Table 1-2. This section summarizes the desktop review and field program results from season of 2019 and 2020.

7.1 Species at Risk

Species discussed in this section have been assessed by international (IUCN), federal (COSEWIC and SARA), territory agencies (GN Department of Environment [GN-DoE]), and the NBRLUP (NPC 2000). A list of the at-risk vegetation, wildlife, marine and migratory birds, marine fish and marine mammals that have potential to occur in the Project Study Areas and their likelihood of occurrence are listed in Table 7-1. Threatened or Endangered species may occur, but none were identified during field program (see applicable sections for more information).

DFO has generated an Aquatic SAR map; however, at this time it does not include Arctic Bay (Government of Canada 2019e).

Table 7-1 Status of Flora and Fauna in the terrestrial and marine Environment with the Potential to be Present in the Project Study Areas

Species	Latin Name	Inukitut		IUCN Status	COSEWIC Status	SARA Status	Nunavut Rank	Study Area	Likelihood of Occurrence	Justification
		Syllabics	Transliteration							
Vegetation										
Porsild's bryum	*Haplodontium macrocarpum*	ᐃᕝᕈᐃᔭᖅ	Ivruijak	No Status	Threatened	Threatened	S2	Quarry	Low	Known distribution only on Ellesmere Island in Nunavut but site environmental conditions are not inhibitive
Wildlife										
Barren-ground caribou (Baffin Island herd)	*Rangifer tarandus*	ᑐᒃᑐᖏᑦ	Tuktuit	Vulnerable	Threatened	No Status	S4	Quarry	Possible	Historical harvest records near the Project
Wolverine	*Gulo gulo*	ᖃᕝᕕᒑᕐᔪᒃ	Qavvigaarjuk	Least Concern	Special Concern	Special Concern	S3	Quarry	Low	Within mapped range, but observations are rare and not documented locally
Migratory Birds										
Buff-breasted sandpiper	*Calidris subruficollis*	ᓴᑦᖃᕆᓪᓚᒃ	Satqarillak	Near Threatened	Special Concern	Special Concern	S3	Quarry/SCH	Low	Outside mapped breeding range so unlikely to breed near Project but habitat is present
Ivory gull	*Pagophila eburnean*	ᖃᑯᓪᓗᒃ	Qakulluk	Near Threatened	Endangered	Endangered	S1	Quarry/SCH/DAS	Possible	Near year-round mapped range but outside breeding range and breeding habitat not present therefore unlikely to breed near Project
Peregrine falcon	*Falco peregrinus*	ᑭᒡᒐᕝᕕᐊᕐᔪᒃ	Kiggarviarjuk	Least Concern	Not at Risk	Special Concern	S4	Quarry/SCH	Possible	Within mapped breeding range and habitat is present
Red knot	*Calidris canutus*	ᓯᔾᔭᕆᐊᖅ	Sijjariaq	Near Threatened	Endangered	Endangered	S2	Quarry/SCH	Likely	Within mapped breeding range and habitat present in some areas; therefore, it is likely to occur and likelihood of nesting near Project is moderate
Red-necked phalarope	*Phalaropus lobatus*	ᓴᐅᕐᕌᖅ	Saurraaq	Least Concern	Special Concern	Special Concern	S3	Quarry/SCH/DAS	Low	Habitat present, but at the northern extent of mapped breeding range
Ross's gull	*Rhodostethia rosea*	ᓇᐅᔭᑦ	Naujat	Least Concern	Threatened	Threatened	S1	Quarry/SCH/DAS	Unlikely	Outside mapped breeding range, preferred habitat is not present, and unlikely to be present; potential to be present only during stating or foraging
Fish										
Lumpfish	*Cyclopterus lumpus*	ᓂᐱᓴ	Nipisa	Near Threatened	Threatened	No Status	NR	SCH/DAS	Unlikely	Are distributed throughout the North Atlantic Ocean, with occasional incidental catch up to 65° N in Davis Strait, but more common to the south with highest abundance around Newfoundland (COSEWIC 2017b). They are primarily a demersal fish (bottom dwelling). Lumpfish prefer waters that are greater than 300 m, but do migrate to shallow coastal waters in the early summer (April, May) to spawn

Species	Latin Name	Inukitut		IUCN Status	COSEWIC Status	SARA Status	Nunavut Rank	Study Area	Likelihood of Occurrence	Justification
		Syllabics	Transliteration							
Northern wolffish	*Anarhichas denticulatus*	ᓂᐱᓴ	Nipisa; Kerak; Qeraq	Endangered	Threatened	Threatened	NR	SCH/DAS	Unlikely	Canadian range includes Baffin Bay (south of 66° 36.603' N, 61° 18.638'W on the Baffin Island coast), Labrador, northeast Newfoundland Shelves, Grand Banks, Flemish Cap, the Gulf of Saint Lawrence and the Scotian Shelf. It is most common in deep waters of the continental shelf (500 to 1000 m), and only occasionally observed in Baffin Bay/Davis Strait. A biogeographic range map for the Northern wolfish is available in (Government of Canada 2018e)
Spotted wolffish	*Anarhichas minor*	ᑕᕐᓴᓕᒃ ᑲᓇᔪᖅ	Tarsalik Kanajuq	Near Threatened	Threatened	Threatened	NR	SCH/DAS	Possible	The northwest Atlantic range of this species includes the Davis Strait (south of 68° 17.682'N, 66° 35.026'W on the Baffin Island coast), the Labrador Sea, the Gulf of St Lawrence, the east coast of Newfoundland, on the Grand Banks and on the Scotian Shelf. Preferred depths are between 200 and 750 m. A biogeographic range map for the Northern wolfish is available in (Government of Canada 2018b)
Thorny skate	*Amblyraja radiata*	ᐃᓴᕈᓖᑦ ᐃᖃᕐᒥᐅᑕᖅ	Isaruliit Iqarmiutaq	Vulnerable	Special Concern	No Status	NR	SCH/DAS	Possible	Distributed continuously from Baffin Bay (records are rare north of 68 ° latitude), Davis Strait, Labrador Shelf, Grand Banks, Gulf of St Lawrence, Scotian Shelf and Bay of Fundy to Georges Bank over a wide range of depths (18 m to 1200 m). Nunavut range not north of Baffin Island, depth range > 18 m. A distribution map is available in Figure 5a of (COSEWIC 2012b)
Marine Mammals										
Atlantic Walrus (High Arctic population)	*Odobenus rosmarus*	ᐊᑦᓛᑎ ᐊᐃᕖᑦ (ᖁᑦᑎᑐᒥ ᐊᐃᕖᑦ ᐅᓄᕐᑐᑦ ᑲᑎᙵᔪᑦ)	Atlaati Aiviit (Quttitumi Aiviit unurtut katingajut)	Near Threatened	Special Concern	No Status	S3	SCH	Possible	Recorded in this area year-round, especially through the summer.
Bearded seal	*Erignathus barbatus*	ᐅᔾᔪᒃ	Ujjuk	Least Concern	Data Deficient	Not Applicable	NR	SCH	Possible	Year-round presence from hunting record and observations; identified high-density area.
Beluga whale (Eastern High Arctic/Baffin Bay population)	*Delphinapterus leucas*	ᕿᓚᓗᒐ ᖃᑯᕐᑕᖅ (ᑲᓇᖕᓇᖕᒐᓂ ᖁᑎᒃᑐᖅ/ᓴᓐᓂᕈᑎᐅᑉ ᐃᒪᖕᒐᓄᑦ ᑲᑎᙵᔪᑦ)	Qilaluga qakurtaq (Kanangnangani Qutiktuq/Sannirutiup Imanganut katingajut)	Least concern	Special concern	No Status	NR	SCH	Likely	Recorded summer presence throughout Lancaster Sound
Bowhead whale (Eastern Canada-West Greenland population)	*Balaena mysticetus*	ᐊᕐᕕᖅ	Arviq	Least Concern	Special Concern	No Status	NR	SCH	Possible	Within identified critical habitat; recorded summer presence throughout Lancaster Sound
Harp seal	*Pagophilus groenlandicus*	ᖃᐃᕈᓕᒃ	Qairulik	Least Concern	Not Assessed	Not Applicable	NR	SCH	Likely	Recorded in this area throughout open-water season.
Hooded seal	*Cystophora cristata*	ᓇᑦᑎᕙᒃ	Nattivak	Vulnerable	Not at Risk	Not Applicable	NR	SCH	Unlikely	Within range but near the northwestern limit; considered uncommon in this area

Species	Latin Name	Inukitut		IUCN Status	COSEWIC Status	SARA Status	Nunavut Rank	Study Area	Likelihood of Occurrence	Justification
		Syllabics	Transliteration							
Killer whale (Northwest Atlantic/Eastern Arctic population)	*Orcinus orca*	ᐋᕐᓗᒃ	Aarluk	Data Deficient	Special Concern	No Status	NR	SCH	Likely	Recorded feeding in the area when the ice breaks up, through the summer until as late as October
Narwhal	*Monodon monoceros*	ᑑᒑᓕᒃ	Tuugaalik	Least Concern	Special Concern	No Status	NR	SCH	Possible	Recorded summer presence throughout Lancaster Sound, including calving
Polar bear	*Ursus maritimus*	ᓇᓄᖅ	Nanuq	Vulnerable	Special Concern	Special Concern	S3	Quarry/SCH	Likely	Recorded year-round in the Lancaster Sound area, with cubs; Borden Peninsula is a known denning and summer sanctuary site
Ringed seal	*Pusa hispida*	ᓇᑦᑎᖅ	Nattiq	Least Concern	Special Concern	No Status	NR	SCH	Likely	Year-round presence from hunting record and observations.

Notes:

Sources for status: CESCC (2016); Government of Canada (2019p); IUCN (2020). Table updated to October 2020

Sources for Inuktitut names: Translations provided by Parenty Reitmeier Translation Services

- Terrestrial Vegetation
  - Likelihood of occurrence within Project Study Areas was based upon a qualitative assessment of results of potential habitat. Other factors such as known locations were also incorporated.
    - Likely: Study Areas are located within areas that have known occurrence records and most of the area is habitat for the species;
    - Possible: Study Areas are located within areas that have known occurrence records and some habitat may be available for the species;
    - Low: Study Areas are located outside areas that have known occurrence records and habitat may be available for the species;
    - Unlikely: Study Areas are located outside areas that have known occurrence records and habitat is not identified.
- Wildlife and Migratory Birds Probability Description
  - Likelihood of occurrence within Project Study Areas was based upon a qualitative assessment of results of potential habitat. Similarly, other factors such as breeding range, location of known colonies, etc. were incorporated.
    - Likely: Study Areas are located within the mapped range and the majority of the area is available habitat;
    - Possible: Study Areas are located within the mapped range and some of the available habitats may provide suitable breeding or other life-stage requirements;
    - Low: Study Areas are located within the mapped range and some of the available habitat may provide marginal breeding or other life-stage requirements;
    - Unlikely: Study Areas are located outside of the mapped range or outside of known colonies (or the species is colonial and such a colony would likely be known to locals given its proximity to the Hamlet), and available habitat is generally not present.
- Fish Probability Description
  - Possible: based on biogeographic range and literature may be in the SCH and DAS Study Areas
  - Unlikely: based on biogeographic range and desktop review is unlikely to be in the SCH and DAS Study Areas
- Marine Mammal Probability Description
  - Likely: based on biogeographic range, desktop review and IQ and may be in the proposed Study Area with regularity
  - Possible based on biogeographic range and desktop review and IQ and may be in the proposed Study Area on an irregular basis
  - Unlikely: based on biogeographic range and desktop review and IQ, and is unlikely to be in the proposed Study Area

Nunavut Territorial Rank (CESCC, 2016): S1=critically imperiled, S2=imperiled, S3=Vulnerable, S4=apparently secure, NR=not ranked.

7.2 Designated Areas

The United Nations *Convention on Biological Diversity* known as Aichi Target 11 (Convention on Biological Diversity 2010), committed countries, including Canada to conserving 10% of coastal and marine areas by 2020. On August 1, 2019, Canada had met and exceeded this goal reaching 14% with recent Arctic designations (National Observer 2019). The announcement of the TI NMCA contributed to this goal. NMCAs, Ecologically and Biologically Significant Areas (EBSAs), Important Bird Areas (IBAs), and Migratory Bird Sanctuaries (MBS) are all ultimately designed and designated for the protection or conservation of species and species habitat. Information on these designated areas as they relate to the Project are identified below.

Federally, marine habitat designations are managed by Parks Canada, DFO, and Transport Canada (TC). These three federal bodies signed the IIBA (Government of Canada 2019k) along with the QIA. The IIBA covers the requirements for any protected areas established within Canada's High Arctic Basin (Tuvaijuittuq) (Atlas of Marine Protection 2019).

The NBRLUP (NPC 2000) has also presented existing and proposed protected areas, some of which are included in the NMCA and Marine Protected Areas (MPAs) described in Section 7.2.1.

7.2.1 National Marine Conservation Areas and Marine Protected Areas

NMCAs and MPAs are managed by the federal government through Parks Canada, DFO and TC. The purpose of these areas is to protect and conserve representative marine habitat for the benefit, education and enjoyment of Canadians (Government of Canada 2019j).

NMCAs are established to represent a marine region and include protection of the seabed, water column above it and may include wetlands, estuaries, islands, and other coastal lands (Parks Canada 2017). They are protected from activities such as ocean dumping, undersea mining, and oil and gas exploration and development. Traditional fishing activities are permitted but must be managed with the conservation of the ecosystem as the main goal. Specifically, as defined by Parks Canada (2017) NMCAs are designed and designated to:

- Represent oceanic and lake diversity
- Maintain ecological processes and life support systems
- Provide a model for sustainable use of marine species and ecosystems
- Encourage marine research and ecological monitoring
- Protect depleted, vulnerable, threatened or endangered marine species and their habitats
- Provide for marine interpretation and recreation
- Contribute to a growing worldwide network of marine protected areas

MPAs are designed for long-term conservation of ocean systems and environments (DFO 2019), though some activities are permitted depending on their impacts to the ecological features encompassed within MPAs. MPAs contribute to a healthy marine environment by protecting and conserving marine species and populations and the diversity of ecosystems that marine organisms depend on such as connected waterways, underwater canyons, and hydrothermal vents. In addition, MPAs are designed to support economic goals of society and contribute to Canadian culture by protecting areas with cultural heritage value (DFO 2019).

7.2.1.1 Tallurutiup Imanga National Marine Conservation Area

The establishment of the TI NMCA (Government of Canada 2019l; Inuit Tapiriit Kanatami 2019) was announced on August 1, 2019, however an Order Designating the TI NMCA under the Oceans Act has not been issued at the time of this report (Government of Canada 2020). The new TI NMCA is approximately 108,000 km^2 and reaches 1.9% of Canada's 10% 2020 target (Government of Canada 2019h) (see Figure 5, Appendix 1. In addition, the federal government announced infrastructure investments for communities in the TI region (Justin Trudeau 2019), which is the basis for the Feasibility Assessment.

Arctic Bay is within the TI NMCA, however there is an area in the waters fronting Arctic Bay that would include the SCH and DAS Study Areas that are excluded through Article 4 of the IIBA (IIBA 2019).

7.2.1.2 Tuvaijuittuq Marine Protected Area

The Tuvaijuittuq MPA was designated on July 29, 2019 and reaches 5.6% of Canada's 10% target (Government of Canada 2019f). Located off the coast of northwest Ellesmere Island, this MPA is approximately 319,411 km^2 and includes the marine waters off northern Ellesmere Island starting from the low water mark and extending to the outward boundary of Canada's Exclusive Economic Zone (EEZ) (Government of Canada 2019g). This MPA is north of Arctic Bay (Figure 5 of Appendix 1).

7.2.2 Ecologically and Biologically Significant Areas

EBSAs are areas within Canada's oceans that have been identified through formal scientific assessments as having special biological or ecological significance when compared with the surrounding marine ecosystem (DFO 2004b). The identification of EBSAs is a key component of basis for the development of federally designated areas (Cobb 2011). EBSAs are designated by government using criteria set out by, and facilitated by, the Conference of the Parties to the Convention on Biological Diversity (COP) (CBD 2019). The criteria include:

- Uniqueness or rarity
- Special importance for species' life history
- Important for at-risk species and habitats
- Vulnerability, fragility, sensitivity, or slow recovery
- Biological productivity and diversity
- Naturalness

The five Arctic marine biogeographic units for which EBSAs are being identified are the: Arctic Basin, Western Arctic, Arctic Archipelago, Eastern Arctic, and Hudson Bay Complex. Arctic Bay is within the Eastern Arctic ecoregion. ID 2.10: Baffin Island Coastline (DFO 2011b, 2015e) The EBSAs are also demonstrated in the NBRLUP, Schedule B (see Figure 6 of Appendix 1).

Admiralty Inlet is designated as an EBSA and includes both Baillarge Bay and Berlinguet Inlet IBAs. It is inclusive of Victor Bay and Adams Sound which are just north and south of the Project, respectively

(Schimnowski et al. 2018). Although this area was identified primarily based on narwhal summering stock aggregations, water current interactions between Admiralty Inlet and Lancaster Sound create localized enrichment of nutrients ideal for seabird foraging (M L Mallory & A J Fontaine 2004). Further details on the importance of this EBSA to migratory birds and marine mammals is available in Sections 10.1.4 and Section 12.

7.2.3 Important Bird Areas

IBAs are sites that have been identified as internationally significant for the conservation of birds and biodiversity (Bird Studies Canada 2019). IBAs support birds such as threatened species, large congregations of birds, and birds restricted in range or habitat. These IBAs are identified according to internationally agreed upon, standardized, quantitative, and scientifically defensible criteria. IBAs have been identified for their global and continental significance for species that congregate, and concentrations of waterfowl, and colonial water bird and seabirds. Though IBAs are located outside the Project Study Areas, birds are highly mobile, and most are migratory. Consequently, there is potential for these species to occupy, stop-over, or pass through on their way to nearby IBAs. IBAs have also been identified as Key Bird and Habitat Sites and in some cases are also designated as an EBSA (DFO 2015d; W. W. F. C. Oceans North Conservation Society, and Ducks Unlimited Canada, 2018a).

Baillarge Bay and Berlinguet Inlet are IBAs located approximately 35 km north (northeast shore of Admiralty Inlet) and 72 km south (south shore of Admiralty Inlet) of the Project (Bird Studies Canada 2019).

Nunavut IBAs are provided in Figure 7, Appendix 1.

Refer to Section 10.1.3 for further information relative to migratory birds.

7.2.4 Migratory Bird Sanctuaries

Under the *Migratory Birds Convention Act*, ECCC, through the Canadian Wildlife Service, can establish MBSs on federal, provincial/territorial, or private land to protect terrestrial and marine habitat and provide safe refuge for migratory birds (Government of Canada 2017). Once established, hunting of a listed species is not permitted, and rules and prohibitions are established with respect to taking, injuring, destruction, and molestation of migratory birds, their nests, or eggs. There are no migratory bird sanctuaries near the Project.

Refer to Section 10.1.1 or Table 10-2 for further information relative to migratory and marine birds.

7.3 Polynyas

Sea ice is a fundamental component of Arctic environments that has a significant effect on the spatial and temporal distribution of marine life across all trophic levels. This influence subsequently has shaped socio-economic and cultural practices for the Inuit who depend on the harvest of these animals. Polynyas and ice edge habitat, characteristically areas of higher productivity, have a long history of cultural significance to the Inuit (NPC 2000). A polynya is an area of open-water that remains ice-free all year-round (National Snow & Ice Data Center) (NSIDC 2019). There are 23 polynyas in Canada's Arctic as displayed in Figure 8, Appendix 1. The closest polynya to the Project is the Lancaster Sound polynya which is about 150 km to the north (Canadian Geographic 2019). The presence of polynyas has contributed to some of the EBSA designations described in Section 7.2.2. Canadian Geographic provides an interactive map which provides details on specific polynyas of interest (Canadian Geographic 2019).

7.4 North Baffin Regional Land Use Plan

Existing and proposed protected areas in the NBRLUP are demonstrated in NPC's interactive maps from 2014 and 2016 (NPC 2019):

2014 Interactive Maps

- Schedule A: Land Use Designations Interactive Map
- Schedule B: Direction to Regulators Interactive Map
- Community Priorities and Values Interactive Map

2016 Interactive Maps

- Schedule A: Designations
- Schedule B: Valued Ecosystem and Socio-Economic Components
- Schedule B1: Terrestrial Valued Components
- Schedule B2: Cariboo Ranges Valued Ecosystem Components
- Schedule B3: Marine Valued Components

7.5 National Parks

Nunavut has five national parks, three of which are in the NBRLUP.

7.5.1 Sirmilik National Park

Sirmilik National Park was established in 2001 (The Canadian Encyclopedia 2019) and protects 22,252 km^2 of geological, natural history, and cultural values within the Eastern Arctic Lowlands and North Davis Natural Regions (Parks Canada 2016). It is located on North Baffin Island, extending from the eastern entrance to Admiralty Inlet to west of the Hamlet of Pond Inlet, approximately 200 km east of Arctic Bay (NPC 2016b). The park is divided into four parcels: Bylot Island, Borden Peninsula, Baillarge Bay, and Oliver Sound. With respect to wildlife, Sirmilik hosts the most diverse avian community in the high Arctic with more than 74 species of birds, of which 45 are confirmed breeders. Bylot Island in particular has up to 320,000 thick-billed murres and 50,000 black-legged kittiwakes. In addition to its avian diversity, 19 mammal species inhabit Bylot Island, of which, nine are terrestrial (Université of Laval 2016).

7.5.2 Qausuittuq (Bathhurst Island) National Park

Qausuittuq National Park was established in 2015 and protects 11,000 km^2 of traditional hunting and fishing areas (Parks Canada 2019; The Canadian Encyclopedia 2019).It is located on northern Bathurst Island and smaller surrounding islands, approximately 500 km northwest of Arctic Bay (The Canadian Encyclopedia 2019). It includes the waters of May Inlet and Young Inlet and is boarded to the south by Polar Bear Pass National Wildlife Area. Together these two areas protect a large, ecologically intact area in the Canadian Arctic Archipelago. Much of the landscape is tundra and also varies from wetlands and lowlands to plateaux, bluffs, and hills. Vegetation is sparse and found mostly on irregular surfaces of small hummocks. Terrestrial wildlife are not abundant and marine mammals inhabit the waters off Bathurst Island. The rich ocean life supports abundant seabirds and the wet sedge meadows support nesting grounds for geese and shorebirds (The Canadian Encyclopedia 2019).

7.5.3 Quttinirpaaq National Park

Quttinirpaaq National Park was established in 1988 protects 37,775 km^2 of land with hundreds of archaeological sites (The Canadian Encyclopedia 2019). It is located on northern Ellesmere Island, approximately 1,000 km north of Arctic Bay, and is Canada's second-largest and most northern national park. The landscape is dominated by hundreds of glaciers. Vegetation is sparse in upland areas and relatively lush in lowland areas. Few terrestrial wildlife species are present but species that are present can be abundant. About 30 species of birds nest in meadows of the park (The Canadian Encyclopedia 2019).

7.6 Territorial Parks

The GN-DOE put out a call for people interested in participating in a joint planning and management committee for four territorial parks, which included Kinngaaluk Territorial Park near Sanikiluaq, Aguttinni Territorial Park near Clyde River, Napartulik Territorial Park near Grise Fiord and Kugluk Territorial Park near Kugluktuk. The Committees are composed of six people, based on interest, knowledge, Inuit culture and heritage. Community interest in the development of territorial parks is based on; Inuit rights to continue to use and enjoy parks; protecting culturally significant sites and important wildlife areas; promoting cultural and natural heritage; and developing economic and education benefits (Nunuvut News Online 2019). There is no territorial park near Arctic Bay.

8 Terrestrial Vegetation

Program objectives for vegetation are provided in Section 1.6, Table 1-2. Vegetation studies focused on the terrestrial environment within the HRQ Study Area (Figure 8-1).

8.1 Desktop Review

To support the 2019 field program of the existing conditions of vegetation, a desktop review of existing literature, IQ, and public databases was conducted to determine vegetation species with historical occurrences or the potential to occur within the HRQ Study Area. Desktop information was used to inform the field survey, identify data deficiencies, and focus the information required to complete a baseline study of plant species and communities, and species at risk. For pre-mapping, aerial imagery was reviewed to identify and delineate potential distinct vegetation communities to be confirmed in the field. Prior to field surveys, the Species at Risk Public Registry (Government of Canada 2019p) was searched for rare vascular and non-vascular plants with geographic ranges that occur within the HRQ Study Area. Available research on species distributions and habitats was evaluated to determine the likelihood of occurrence.

Most of Nunavut, is located within the Tundra Biome and the Northern Arctic Ecozone (Ecological Stratification Working Group) (ESWG 1995). This Ecozone incorporates the coldest and driest landscapes in Canada. In addition to the harsh climate, the high winds and shallow soils result in sparse and dwarfed plant life. Herb and lichen communities are the dominant vegetative cover. Lichen communities are associated with rock fields and hilly upland areas. Vegetation cover is higher on wetter sites, sheltered valleys and moist corridors along streams and rivers that typically are more nutrient rich. Specifically, the Project is located within Ecoregion 22 – Borden Peninsula Plateau, which covers north-central Baffin Island and the southwestern coast of Bylot Island along Navy Board Inlet. It has a high arctic ecoclimate and supports a very sparse vegetative cover of moss and mixed low-growing herbs and shrubs. Permafrost is deep and continuous throughout the Ecoregion which is inhibitive to deep-rooted vegetation. Typical species include purple mountain saxifrage (*Saxifraga oppositifolia* L.), avens (*Dryas* spp.), arctic willow (*Salix arctica* Pall.), bog sedges (*Kobresia* spp.), sedges (*Carex* spp.), and arctic poppy (*Papaver* spp.). Other species that may be present in the Northern Arctic Ecozone in no particular order include crustose lichens, cotton grasses (*Eriophorum* spp.), moss campion (*Silene acaulis* [L.] Jacq.), entireleaf daisy (*Hulteniella integrifolia* [Richardson] Tzvelev.), Maydell's oxytrope (*Oxytropis maydelliana* Trautv.), marsh fleabane (*Senecio congestus* [R. Br.] DC.), louseworts (*Pedicularis* spp.), pygmy buttercup (*Ranunculus pygmaeus* Wahlenb.), dwarf fireweed (*Chamerion latifolium* [L.] Holub), mouse-ear chickweed (*Cerastium arcticum* Lange), arctic white mountain heather (*Cassiope tetragona* [L.] D. Don), alpine mountainsorrel (*Oxyria digyna* [L.] Hill), and bog blueberry (*Vaccinium uliginosum* L.) (Aun et al. 2002).

8.1.1 Vegetation Species at Risk

The review of the Species at Risk Public Registry (Government of Canada 2019p) showed one rare plant species whose mapped range overlaps the HRQ Study Area:

- Porsild's Bryum (*Haplodontium macrocarpum* [Hooker] Spence), listed as Threatened under COSEWIC and Schedule 1 under SARA.

Porsild's bryum is a non-vascular bryophyte species. It has a broad, but disjunct distribution in Canada, including sites in Alberta, British Columbia, the island of Newfoundland, and Nunavut (specifically Ellesmere Island). This species has been designated as threatened since 2003, because of its fragmented distribution and few confirmed population locations. There are 19 known populations in Canada, which accounts for about 40% of known global occurrences. Three of the Canadian populations are located in proximity within Quttinirpaaq National Park, Ellesmere Island, Nunavut (2016a, 2016c). Porsild's bryum are found in the high Arctic but also in other treeless vegetation zones such as the sub-alpine and along barren coastlines. Microhabitats for most populations are associated with waterfalls or sheltered calcareous rock crevices or faces near water seepages. Narrow substrate (calcareous rock) and habitat requirements (waterfalls and seepages) limit this species distribution (2016a, 2016c; Government of Canada 2019n).

No historical occurrences of Porsild's bryum have been recorded in the HRQ Study Area, but based on a review of aerial imagery, it may have some microhabitats that could support Porsild's bryum. Therefore, the HRQ Study Area was predicted to have some potential to support populations of Porsild's bryum.

8.1.2 Traditionally-used Vegetation Species

Twenty plant species have been identified as having traditional uses in the high arctic ecoclimate (Baffinland Iron Mines Corporation 2010). Uses for these species include food, medicine, tools, and household items – these species along with their traditional use are identified in Table 8-1.

IQ indicates that there are no specific places that plants are harvested (IQ Workshop 2019 - Jonah Oyukuluk; IQ Workshop 2019 - Olayuk Nagitarvik; IQ Workshop 2019 - Tom Nagitarvik; Mishak Allurut, pers. comm. June 2019). Generally, berry picking occurs outside of the HRQ Study Area and are not a concern because plants can be picked anywhere (Arctic Bay IQ Workshop 2019 - Tom Nagitarvik).

Table 8-1 Traditionally-used Vegetation Species

Latin Name and Authority	Common Name	Traditional Use
Shrubs		
Cassiope tetragona (L.) D. Don	white arctic mountain heather	mattresses, firewood
Empetrum nigrum L. ssp. *Nigrum*	black crowberry	edible
Ledum palustre L. ssp. *decumbens* (Aiton) Hultén	marsh Labrador tea	tea
Salix arctica Pall.	arctic willow	edible, firewood, tools
Salix richardsonii Hook.	Richardson's willow	edible
Saxifraga oppositifolia L.	purple mountain saxifrage	edible, tea
Saxifraga tricuspidata Rottb.	three toothed saxifrage	edible, tea
Vaccinium uliginosum L.	bog blueberry	edible

Latin Name and Authority	Common Name	Traditional Use
Graminoids		
Alopecurus alpinus Lam.	alpine meadow-foxtail	used to make whistling noises
Carex spp.	Sedges	not specified
Eriophorum spp.	arctic cotton grass	lamp wick
Forbs		
Oxytropis maydelliana Traitv.	Maydell's oxytrope	edible
Oxyria digyna (L.) Hill	alpine mountain sorrel	edible
Pedicularis lanata Cham. & Schltdl.	woolly lousewort	edible
Pedicularis sudetica Wild.	sudetic lousewort	not specified
Polygonum viviparum L.	alpine bistort	edible
Pyrola grandiflora Radius	large-flowered wintergreen	tea
Silene uralensis (Rupr.) Bocquet ssp. *uralensis*	apetalous catchfly	not specified
Non-Vasculars		
Dicranum spp.	cushion mosses	used to treat pinworm infections
Racomitrium lanuginosum (Hedw.) Brid.	racomitrium moss	used to construct sleeping shelter

Source: Baffinland Iron Mines Corporation (2010).

8.2 Field Program

8.2.1 Methodology

Field surveys were conducted from August 9–10, 2019 by an experienced vegetation ecologist and a local Inuit field assistant. An ecological land classification survey (ELC) was completed to identify the vegetation communities in the HRQ Study Area. Field surveys also focused on identifying each species encountered to collect an inventory for the area.

8.2.1.1 Ecological Land Classification

During the ELC field survey, quantitative data on ecosystems were collected to classify vegetation communities throughout the HRQ Study Area. As there is no official vegetation classification system used in Nunavut, vegetation communities were grouped based on similar characteristics such as species composition, topographical position, moisture regime, and percent cover of bedrock. Vegetation communities were identified using a combination of field verification and interpretation of desktop aerial imagery (Google Earth 2020).

Within the HRQ Study Area, vegetation plots (0.5 x 0.5 m^2) were sited in each vegetation community identified during pre-mapping and in the field (Ground Plot). Plots were orientated to contain a homogeneous assemblage of plants representative of the typical vegetation community composition. Vegetation data collected at each plot included:

- General site characteristics such as slope, aspect, and surface substrate
- Vegetation species identification and canopy percent cover
- GPS coordinates
- Photographs

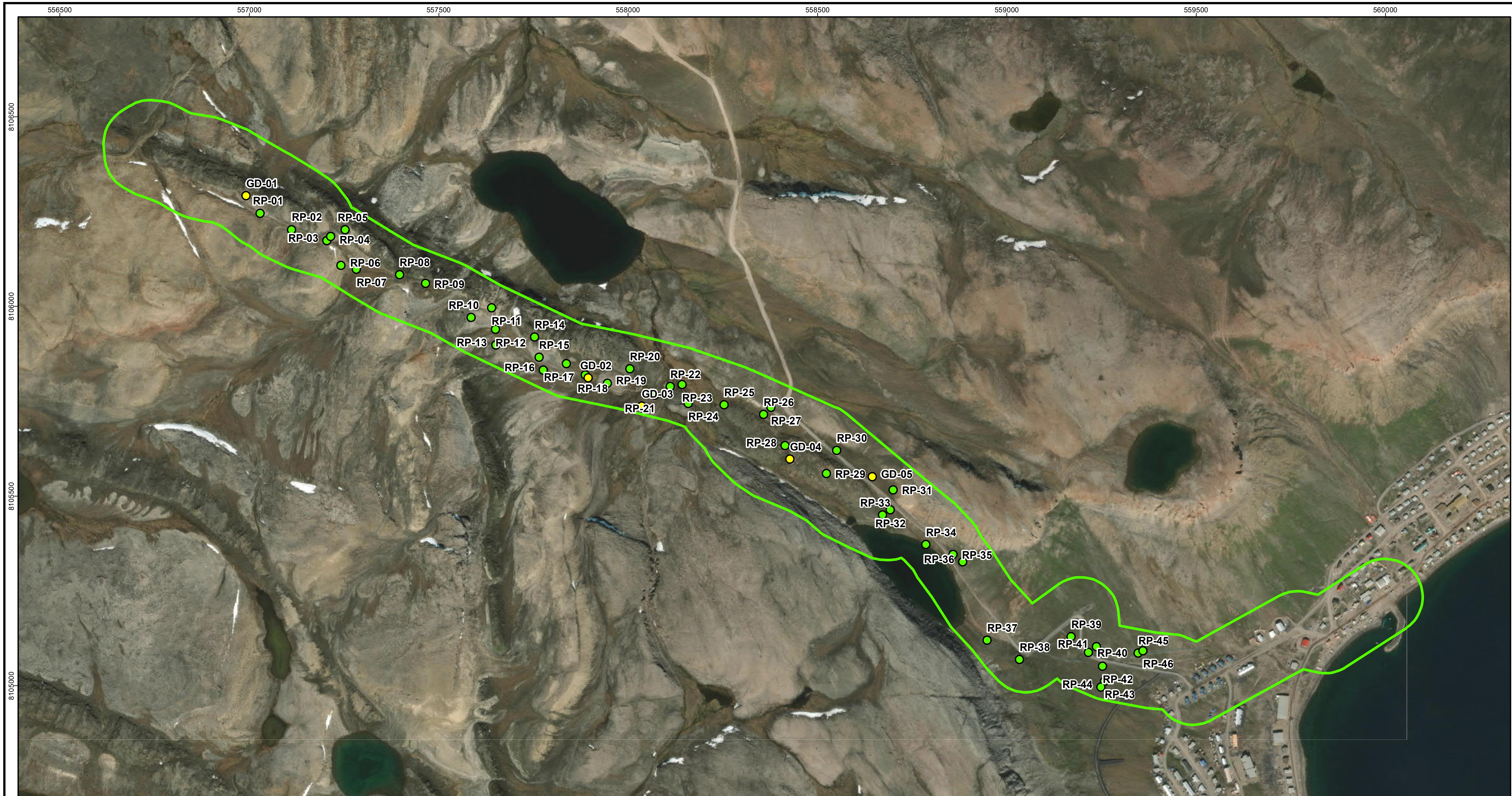
8.2.1.2 Terrestrial Vegetation Inventory and Rare Plant Assessment

A rare plant survey was completed within the HRQ Study Area between August 9-10, 2019. Surveys were targeted in areas where desktop pre-mapping had identified potentially unique habitats or vegetation communities. Each area identified was surveyed using a random meander technique, and all vascular and non-vascular species encountered were inventoried (or collected for identification). Figure 8-1 displays the data points collected along the random meander within the HRQ Study Area (Rare Plant Search). Given that no standards exist for Nunavut, the Alberta Native Plant Council (2012) standards were used as a guideline for survey methodology. The standard states that if rare plants are identified, a 50 m diameter buffer from the plant location is to be investigated to determine the extent and size of the population. Detailed habitat and population information, photographs, and GPS coordinates are further documented, as per the standards, if rare plants are observed.

The following guidebooks were used to identify vegetation species:

- Common Plants of Nunavut (C. Mallory & Aiken 2013)
- Macrolichens of the Pacific Northwest (McCune & Geiser 2000)
- Mosses and Liverworts of Britain and Ireland a Field Guide (Atherton et al. 2010)
- Mosses, Lichens and Ferns of Northwest North America (Vitt et al. 1988)
- Mosses, Liverworts, and Hornworts, a Field Guide to Common Bryophytes of the Northeast (Pope 2016)
- The Arctic Guide: Wildlife of the Far North (Chester 2016)
- Vascular Plants of Continental Northwest Territories (Porsild & Cody 1980)
- Non-native and invasive species were defined according to Government of Nunavut (2010a)

If a species could not be identified in the field, a voucher specimen was collected for identification by a taxa expert. A total of 14 bryophyte samples were collected and sent for identification to Terry McIntosh, Ph.D., and Steven Joya (bryologists) from the Department of Botany at the University of British Columbia. Nomenclature and authorities for each plant species recorded followed the United States Department of Agriculture Plants Database (USDA 2019).



Legend

Vegetation Survey Locations

- Ground Plot
- Rare Plant Search

Haul Road and Quarry (HRQ) Study Area

0 150 300 600

Metres

1:10,000

WGS 1984 UTM Zone 16N

N

Locations approximate.

FISHERIES AND OCEANS CANADA
SMALL CRAFT HARBOURS
ARCTIC BAY

VEGETATION STUDY AREA

Date: 20-MAY-21	Drawn by: JH	Edited by: KR	App'd by: LP
		Project No. 317071-00037	
		FIG No 8-1	REV 0

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Imagery Source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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SAVE DATE & TIME: 5/20/2021 7:52:52 AM

8.2.2 Field Results

During the rare plant survey, 63 vegetation species were identified, including seven shrub, 11 graminoid, 18 forb, and 14 bryophyte and 13 lichen species. A total of 46 rare plant searchers were conducted (Figure 8-1). A list of the species identified is provided in Table 8-2.

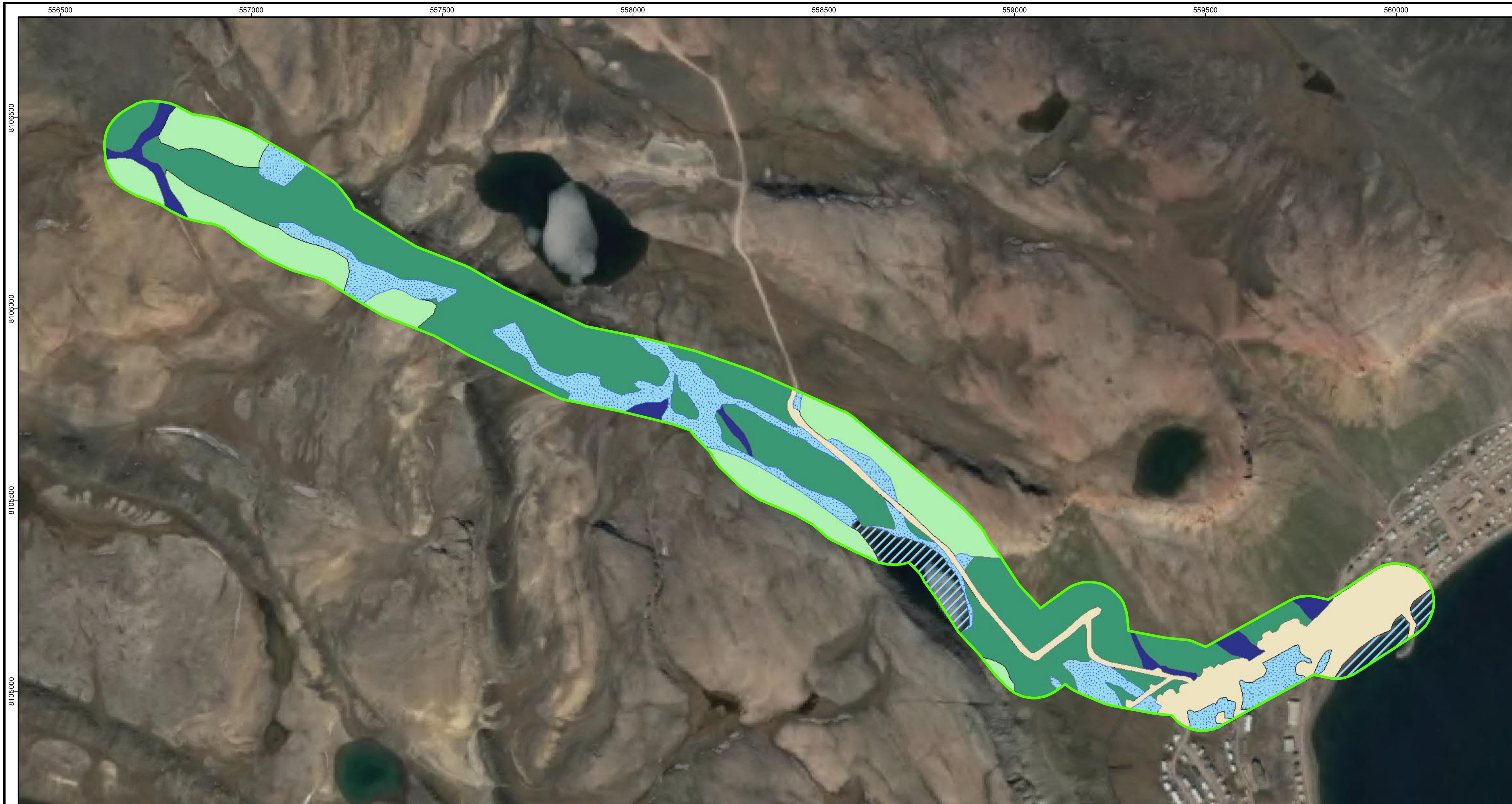
None of the species identified during the field survey are listed as SAR or as invasive. All remaining vegetation data collected in the field are provided in Tables 2 to 4 in Appendix 5.

Six distinct vegetation communities were identified within the HRQ Study Area (Figure 8-2) and five ELC ground plots were assessed to characterize these communities. Vegetation communities identified within the HRQ Study Area included:

- Upland Dwarf Shrub (UDS) – 39 hectares (ha) (44% of the HRQ Study Area)
- Upland Lichen Barren (ULB) – 17 ha (19% of the HRQ Study Area)
- Wetland Graminoid Drainage (WGD) – 15 ha (17% of the HRQ Study Area)
- Disturbed Human-Caused (DHC) – 11 ha (13% of the HRQ Study Area)
- Open Water (OW) – 4 ha (5% of the HRQ Study Area)
- Wetland Dwarf Shrub Drainage (WSD) – 3 ha (4% of the HRQ Study Area)

The HRQ Study Area was covered predominantly by the UDS community. The UDS community was a rolling plateau of frost shattered rocky outcrops and dwarf shrub vegetation. This plateau was interspersed with several drainages, which supports the WGD community. An ELC plot was not conducted in the DHC and ULB communities, but they were mapped, and incidental vegetation species were noted as part of rare plant searches. The DHC community had sparse to no vegetation cover and the ULB community contained talus slopes and sparse vegetation consisting mostly of crustose lichens.

Overall, the HRQ Study Area had a diverse bryophyte (moss) and lichen population, which are common on rock and soil substrates in the Arctic. Descriptions for each community is provided below. The OW was mapped (Figure 8-2) but not surveyed and not described as a vegetation community because it is considered a marine environment, which was out of scope for the terrestrial vegetation assessment.



Legend

Vegetation Communities

- Disturbed Human-Caused
- Open Water
- Upland Dwarf Shrub
- Upland Lichen Barren
- Wetland Dwarf Shrub Drainage
- Wetland Graminoid Drainage

Haul Road and Quarry (HRQ) Study Area

0 150 300 600
Metres
1:10,000
WGS 1984 UTM Zone 16N

N

Locations approximate.

FISHERIES AND OCEANS CANADA
SMALL CRAFT HARBOURS
ARCTIC BAY

VEGETATION COMMUNITIES WITHIN THE HRQ STUDY AREA

Date:	20-MAY-21	Drawn by:	JH	Edited by:	KR	App'd by:	LP

Project No. 317071-00037

FIG No 8-2 | REV 0

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Upland Dwarf Shrub

The UDS community is characterized as a mosaic of vegetated and frost shattered rocky outcrop areas (Photo 8-1). Vegetated areas between rocks are dominated by dwarf shrub species, including white arctic mountain heather, entireleaf mountain-avens (*Dryas integrifolia* Vahl), arctic willow, netleaf willow (*Salix reticulata* L.), purple mountain saxifrage, three toothed saxifrage (*Saxifraga tricuspidata* Rottb.), and bog blueberry (Table 8-2). Forbs included species such as Maydell's oxytrope, alpine mountainsorrel, louseworts, nodding saxifrage (*Saxifraga cernua* L.), alpine saxifrage (*Saxifraga nivalis* L.). Graminoids were sparse and predominantly included alpine sweetgrass (*Anthoxanthum monticola* [Bigelow] Veldkamp), northern woodrush (Juncus albescens [Lange] Fernald), and alpine fescue (*Festuca brachyphylla* Schult. ex Schult. & Schult. f.). Bryophytes were sparse and lichen cover predominantly consisted of witch's hair lichen (*Alectoria ochroleuca* [Hoffm.] A. Massal.) and snow lichens (*Flavocetraria* spp.) (Table 8-2 and Tables 2 to 4 in Appendix 5).

Photo 8-1 Upland Dwarf Shrub Community at GD-01 (August 9, 2019)

Upland Lichen Barren

The ULB community is characterized by barren, rocky areas with crustose lichens being the dominant vegetation type (Photo 8-2). These are typically the higher elevation areas within the HRQ Study Area and also consist rock debris, taluses, and scree slopes. Species identified include Lichens (*Arctoparmelia* spp.), map lichens (*Rhizocarpon* spp.), and navel lichens (*Umbilicaria* spp.) (Table 8-2 and Tables 2 to 4 in Appendix 5).

Photo 8-2 Upland Lichen Barren Community at 556713 m E, 8106364 m N (August 9, 2019)

Wetland Dwarf Shrub Drainage

The WSD community is characterized by saturated ground, permafrost seeps, and sparse vegetation cover in drainage and lowland areas (Photo 8-3). Though mostly bare rock with some surface water, vegetation predominantly included arctic willow, short-leaved sedge (*Carex misandra* R. Br.), and mosses (Table 8-2 and Tables 2 to 4 in Appendix 5).

Photo 8-3 Wetland Dwarf Shrub Drainage Community at GD-03 (August 9, 2019)

Wetland Graminoid Drainage

The WGD community is characterized by saturated ground and vegetation dominated by wetland graminoid species (Photo 8-4). This community type was in drainage draws and lowland areas. Vegetation was dominated by cotton grasses (*Eriophorum* spp.), fragile sedge (*Carex misandra* R. Br.), short-leaved sedge, wideleaf polargrass (*Arctagrostis latifolia* [R. Br.] Griseb.), alpine meadow-foxtail (*Alopecurus magellanicus* Lam.), and bryophytes. Some forbs were present and predominantly included yellow marsh saxifrage (*Saxifraga hirculus* L.), apetalous catchfly (*Silene uralensis* [Rupr.] Bocquet), and mouse-ear (Table 8-2 and Tables 2 to 4 in Appendix 5).

Photo 8-4 Wetland Graminoid Drainage Community at GD-02 (August 9, 2019)

Disturbed Human-Caused

The DHC community is characterized by levelled and graded areas mostly devoid of vegetation (Photo 8-5). DHC areas within the HRQ Study Area consisted of road networks, ditches, and hamlet buildings. Vegetation was sparse, but where present, predominantly included species such as cottongrasses, arctic bluegrass (*Poa arctica* R. Br.), arctic poppy, and nodding saxifrage (Table 8-2 and Tables 2 to 4 in Appendix 5).

Photo 8-5 Disturbed Human-Caused Community at 562010 m E, 8106245 m N (August 10, 2019)

Table 8-2 List of Vegetation Species Identified During Field Program

Species Name	Common Name	DHC	UDS	ULB	WDS	WGD
Shrubs		**0**	**7**	**0**	**1**	**2**
Cassiope tetragona (L.) D. Don *	white arctic mountain heather	---	Y	---	---	---
Dryas integrifolia Vahl	Entireleaf mountain-avens	---	Y	---	---	Y
Rhododendron lapponicum (L.) Wahlenb.	Lapland rosebay	---	Y	---	---	---
Salix arctica Pall. *	arctic willow	---	Y	---	Y	Y
Salix reticulata L.	netleaf willow	---	Y	---	---	---
Saxifraga oppositifolia L. *	purple mountain saxifrage	---	Y	---	---	---
Vaccinium uliginosum L. *	bog blueberry	---	Y	---	---	---
Forbs		**2**	**10**	**0**	**1**	**9**
Cerastium arcticum Lange	mouse-ear chickweed	---	---	---	---	Y
Chamerion latifolium (L.) Holub	dwarf fireweed	---	Y	---	---	Y
Equisetum arvense L.	field horsetail	---	---	---	---	Y
Equisetum variegatum Schleich. ex F. Weber & D. Mohr var. jesupii A.A. Eaton	horsetail	---	---	---	---	Y
Hulteniella integrifolia (Richardson) Tzvelev	entireleaf daisy	---	Y	---	---	---
Oxyria digyna (L.) Hill *	alpine mountainsorrel	---	Y	---	---	---
Oxytropis maydelliana Trautv. *	Maydell's oxytrope	---	Y	---	---	---
Papaver lapponicum (Tolm.) Nordh.	Lapland poppy	Y	Y	---	---	---
Pedicularis capitata M.F. Adams *	capitate lousewort	---	Y	---	---	---
Pedicularis flammea L. *	redrattle	---	Y	---	---	---
Pedicularis hirsuta L. *	hairy lousewort	---	---	---	---	Y
Polygonum viviparum L. *	alpine bistort	---	---	---	---	Y
Saxifraga caespitosa L.	tufted alpine saxifrage	---	---	---	---	Y
Saxifraga cernua L.	nodding saxifrage	Y	Y	---	---	---
Saxifraga hirculus L.	yellow marsh saxifrage	---	---	---	---	Y
Saxifraga nivalis L.	alpine saxifrage	---	Y	---	---	---
Saxifraga tricuspidata Rottb.	three toothed saxifrage	---	Y	---	---	---
Silene uralensis (Rupr.) Bocquet *	apetalous catchfly	---	---	---	Y	Y

Species Name	Common Name	DHC	UDS	ULB	WDS	WGD
Graminoids		**2**	**5**	**0**	**2**	**6**
Alopecurus magellanicus Lam. *	Alpine Meadow-Foxtail	---	---	---	---	Y
Anthoxanthum monticola (Bigelow) Veldkamp	alpine sweetgrass	---	Y	---	---	---
Arctagrostis latifolia (R. Br.) Griseb.	wideleaf polargrass	---	---	---	---	Y
Carex membranacea Hook. *	fragile sedge	---	---	---	---	Y
Carex misandra R. Br. *	shortleaved sedge	---	---	---	Y	Y
Carex nardina Fr. *	spike sedge	---	Y	---	---	---
Eriophorum scheuchzeri Hoppe *	white cottongrass	Y	---	---	---	Y
Festuca brachyphylla Schult. ex Schult. & Schult. f.	alpine fescue	---	Y	---	Y	---
Juncus albescens (Lange) Fernald	northern white rush	---	---	---	---	Y
Luzula confusa Lindeberg	northern woodrush	---	Y	---	---	---
Poa arctica R. Br.	arctic bluegrass	Y	Y	---	---	---
Bryophytes		**0**	**6**	**0**	**1**	**8**
Aulacomnium turgidum (Wahlenb.) SchwÃ¤gr.	turgid aulacomnium moss	---	Y	---	---	---
Campylium stellatum (Hedw.) C.E.O. Jensen	star campylium moss	---	Y	---	---	---
Cinclidium arcticum Bruch & Schimp.	arctic cinclidium moss	---	---	---	---	Y
Dicranum elongatum Schleich. ex SchwÃ¤gr. *	elongate dicranum moss	---	Y	---	---	---
Ditrichum flexicaule (SchwÃ¤gr.) Hampe	ditrichum moss	---	---	---	Y	Y
Hypnum bambergeri Schimp.	Bamberger's hypnum moss	---	Y	---	---	---
Limprichtia cossonii (Schimp.) L.E. Anderson, H.A. Crum & W.R. Buck	Cosson's limprichtia moss	---	---	---	---	Y
Limprichtia revolvens (Sw.) Loeske	limprichtia moss	---	---	---	---	Y
Orthothecium chryseum (SchwÃ¤gr.) Schimp. var. cochlearifolium (Lindb.) Limpr.	orthothecium moss	---	---	---	---	Y
Philonotis fontana (Hedw.) Brid.	philonotis moss	---	---	---	---	Y
Racomitrium lanuginosum (Hedw.) Brid. *	racomitrium moss	---	Y	---	---	---
Scorpidium scorpioides (Hedw.) Limpr.	scorpidium moss	---	---	---	---	Y

Species Name	Common Name	DHC	UDS	ULB	WDS	WGD
Tetraplodon mnioides (Hedw.) Bruch & Schimp.	entireleaf nitrogen moss	---	---	---	---	Y
Tomentypnum nitens (Hedw.) Loeske	tomentypnum moss	---	Y	---	---	---
Lichens		**0**	**13**	**5**	**0**	**0**
Actoparmelia spp.	lichens	---	Y	Y	---	---
Alectoria ochroleuca (Hoffm.) A. Massal.	witch's hair lichen	---	Y	---	---	---
Arctoparmelia centrifuga (L.) Hale	arctoparmelia lichen	---	Y	Y	---	---
Aspicilia spp.	lichens	---	Y	---	---	---
Cetraria tilesii Ach.	lichen	---	Y	---	---	---
Cladina rangiferina (L.) Nyl.	greygreen reindeer lichen	---	Y	---	---	---
Flavocetraria nivalis (L.) Karnefelt & A. Thell	snow lichen	---	Y	---	---	---
Glypholecia scabra (Pers.) MÃ¼ll. Arg.	glypholecia lichen	---	Y	---	---	---
Pertusaria dactylina (Ach.) Nyl.	pore lichen	---	Y	---	---	---
Rhizocarpon spp.	map lichens	---	Y	Y	---	---
Thamnolia subuliformis (Ehrh.) W.L. Culb.	whiteworm lichen	---	Y	---	---	---
Umbilicaria decussata (Vill.) Zahlbr.	navel lichen	---	Y	Y	---	---
Umbilicaria spp.	lichens	---	Y	Y	---	---

Notes:
'Y' denotes species was identified within vegetation community
--- denotes species was not identified within vegetation community
* denotes species has been identified as traditionally used

8.3 Discussion

Vegetation communities identified during field studies (i.e. UDS [44%], ULB [19%], WGD [17%], DHC [13%], WSD [4%]) appear to be typical of the Borden Peninsula Plateau Ecoregion within the Northern Arctic Ecozone of the Tundra Biome (ESWG 1995). Vegetation is overall sparse throughout the HRQ Study Area and dwarfed due to harsh climate conditions, exposure to wind, and frost damage. The WGD community had the highest percent cover of vegetation and the least amount of exposed rock.

Of the 20 traditionally used species identified during desktop review, 14 were identified within the HRQ Study Area during the field surveys. These species include white arctic mountain heather, arctic willow, purple mountain saxifrage, three toothed saxifrage, bog blueberry, alpine mountainsorrel, louseworts, alpine bistort (*Polygonum viviparum* L.), Maydell's oxytrope, apetalous catchfly, alpine meadow-foxtail, sedges, cottongrasses, and racomitrium moss (*Racomitrium lanuginosum* [Hedw.] Brid.) (Table 8-1 and Table 8-2). The UDS community contained the most traditionally-used plants, although there are no specific places within the HRQ Study Area where these plants are harvested or picked (IQ Workshop 2019 -

Jonah Oyukuluk; IQ Workshop 2019 - Olayuk Nagitarvik; IQ Workshop 2019 - Tom Nagitarvik; Mishak Allurut. pers. comm. June 2019). Traditional use of these plants includes berry picking and edibles, lamp wicks, whistle construction, firewood, tool construction, mattress construction, and sleeping shelter construction. Berry picking and plucking leaves for tea still occurs as part of culture in the Arctic though traditional plant use in the HRQ Study Area is likely mostly opportunistic and occurs during travel and when hunting (Baffinland Iron Mines Corporation 2018).

As with any species inventory, some less abundant species may have been missed during the vegetation field survey. However, all species observed are common in the Northern Arctic Ecozone and enabled the characterization of vegetation communities, identification of traditionally use plants, and assessment of rare plant habitat potential.

Based on the Species at Risk Public Registry (Government of Canada 2019p), Porsild's bryum was predicted to be the only potential vegetation SAR within the HRQ Study Area. No individuals were identified during field surveys; however, water seepages, a habitat feature that may support Porsild's bryum, were identified within the WDS community (Government of Canada 2019a). As such, Porsild's bryum has a moderate probability of occurring within the WDS community of the HRQ Study Area.

Overall, the HRQ Study Area was dominated by the UDS community and contains regionally common vegetation communities and plant species. The HRQ Study Area also contains the WDS community that has moderate rare plant habitat potential. The potential quarry locations are in areas dominated by the UDS community, which contain dwarf shrubs, lichens, mosses, and unvegetated rocky outcrops. This is the most common community within the HRQ Study Area and is not limited in the region. A small portion of the potential haul road may disturb the WDS community, which has moderate potential to support Porsild's bryum. However, no Porsild's bryum populations were observed during the field survey and the WDS community occurs in other areas of the HRQ Study Area that would not be impacted by the proposed developments. In addition, the majority of the potential haul road would be sited in the most common UDS community and a pre-disturbed road within the DHC community. As a result, overall Project related disturbances to vegetation communities, traditionally-used plants, and species at risk are considered low.

9 Terrestrial Wildlife

Program objectives for terrestrial wildlife are provided in Section 1.6, Table 1-2. Migratory birds including seabirds are identified in Section 10. Baseline information was determined through historical information gathered as part of a desktop review including a literature review and IQ (see Section 2.3 for methodology). This desktop review was then validated through a field-based habitat assessment and wildlife reconnaissance survey (referred hereafter as the field survey) conducted in conjunction with the vegetation field survey. These results enabled refinement of a list of species likely to inhabit the HRQ Study Area.

9.1 Desktop Review

The desktop review and literature review were conducted to determine species with historical recorded presence near the Project. Furthermore, protected areas or known high value habitats (e.g. Wildlife Sanctuaries) were identified. In addition to identifying historical recorded presence and IQ. a list of species that could potentially occupy the HRQ Study Area was generated. This list was determined by examining available habitat using aerial imagery (Google Earth 2020) and comparing it to habitat requirements for species whose ranges overlap with the Project area. Range maps and habitat information were determined by field guides, peer-reviewed literature, and other reference sources.

Terrestrial wildlife occurrences were primarily based on the NWHS (Priest & Usher 2004). Species identified as having potential to inhabit in the HRQ Study Area were further inferred from range maps, habitat requirements, aerial imagery, and results of the vegetation review and community mapping.

There are nine terrestrial mammal species, ranging from lemmings (*Lemmus* sp. and *Dicrostonyx* sp.) to barren-ground caribou *Rangifer tarandus groenlandicus*) that have historical recorded presence or have the potential to occur within the HRQ Study Area (Table 9-1). Details on each species are provided in the following subsections. Two of these species are listed as a SAR: wolverine (*Gulo gulo*) and barren-ground caribou. Barren-ground caribou are federally-listed as Threatened, and wolverine are federally-listed as Special Concern (Government of Canada 2019p). IQ confirms that lemmings are present within the HRQ Study Area. No dens or burrows of other animals are known within the HRQ Study Area (Arctic Bay IQ Workshop 2019 - Olayuk Nagitarvik).

Table 9-1 Terrestrial Wildlife that have Potential to Inhabit the HRQ Study Area

Common Name	Scientific Name	Habitat[1]
Small Mammals (Rodents and Lagamorphs)		
Brown Lemming	*Lemmus trimucronatus*	• Damp (hydric) tundra dominated by grasses, sedges, and mosses
Peary Land Collared Lemming	*Dicrostonyx groenlandicus*	• Dry (xeric), rocky tundra
Arctic Hare	*Lepus arcticus*	• Typically willow-dominated tundra, but also rocks and broken terrain for cover

Common Name	Scientific Name	Habitat[1]
Medium Mammals (Canids and Mustelids)		
Arctic Fox	*Alopex lagopus*	• Likely determined more by prey availability (i.e. small mammals and geese) than vegetation • Dens are large, complex burrow systems with multiple entrances
Red Fox	*Vulpes vulpes*	• Likely determined more by prey availability (i.e. small mammals and geese) than vegetation • Use pre-existing Arctic fox dens
Baffin Island Wolf	*Canis lupus manningi*	• Likely determined more by prey availability (e.g. caribou) than vegetation • Dens typically located along eskers
Wolverine[2]	*Gulo gulo*	• Wide ranging species whose habitat is likely determined more by prey availability (i.e. carcasses and small mammals) than vegetation • Den within snow or under snow-covered rocks
Ermine	*Mustela ermine*	• Habitat generalist, likely determined more by prey availability than vegetation • Uses subnivean grass nests, rock piles and burrows often commandeered from prey
Large Mammals		
Barren-ground Caribou[3]	*Rangifer tarandus groenlandicus*	• Mesic to xeric tundra with snow-free or shallow snow-covered ridges and other topographical features offering shelter

Notes:

1 Habitat information from: (Chesemore 1969; Chester 2016; COSEWIC 2011, 2014a, 2016a; Duchesne et al. 2011; Garrott et al. 1983; Gauthier & Berteaux 2011; Gray 1993; King 1983; King & Powell 2007; Klein & Bay 1994; McLoughlin et al. 2004; Parker 1977; Sale 2006; Sittler 1995)

2 Wolverine are listed as Vulnerable by the Government of Nunavut, listed by COSEWIC as Special Concern, and are listed on Schedule 1 as Special Concern under SARA (CESCC 2016; Government of Canada 2019p)

3 Barren-ground caribou are listed as Apparently Secure by the Government of Nunavut, are listed by the COSEWIC as Threatened but are not presently listed under the SARA (CESCC 2016; Government of Canada 2019p)

9.1.1 Small Mammals (Rodents and Lagomorphs)

Small mammals are defined in this report as those species belonging to the following mammalian orders: Rodentia (rodents) and Lagomorpha (hares and rabbits). A small-mammal survey was completed between 1990 and 1996 on Baffin Island where brown lemming (*Lemmus trimucronatus*) and Peary Land collared lemming (*Dicrostonyx groenlandicus*) were captured (Carrière 1999). In earlier investigations in the 1950s, Peary Land collared lemmings apparently were more abundant than brown lemmings (Miller 1955). However, the relative abundance of these two species can vary greatly in the same area from year to year (Watson 1956). IQ indicates that lemming burrows are present throughout the HRQ Study Area, confirming their presence (Arctic Bay IQ Workshop 2019 - Olayuk Nagitarvik).

According to the NWHS (Priest & Usher 2004)., arctic hare (*Lepus arcticus*) is the only small mammal reported to be harvested by hunters from the Hamlet, and mean annual harvest was 136 individuals per year (Table 9-2). IQ further confirms that arctic hare are present and harvested throughout the HRQ Study Area but no specific places are necessary to avoid because of arctic hare hunting (IQ Workshop - Olayuk Nagitarvik; IQ Workshop - Tom Nagitarvik).

9.1.2 Medium Mammals (Canids and Mustelids)

Medium-sized mammals have been identified as those species belonging to the following mammalian orders: Canidae (dog family) and Mustelidae (weasel family). The NWHS (Priest & Usher 2004) identified that Baffin Island wolf (*Canis lupus manningi*), red fox (*Vulpes vulpes*), and arctic fox (*Alopex lagopus*) have been harvested by hunters in the Hamlet. However, location data for these species have not been collected. Therefore, it cannot be determined whether these species were distributed and harvested near the HRQ Study Area. On average, 114 arctic fox, one coloured (red) fox, and 13 wolves were harvested each year by hunters from the Hamlet (Table 9-2; (Priest & Usher 2004)).

In addition to foxes and wolves, ermine (*Mustela erminea*), and wolverine could potentially be present in or near the HRQ Study Area. Although no surveys have been conducted near the Hamlet, ermine may be common in coastal lowlands (Miller 1955) Though the mapped distribution for wolverine overlaps with the HRQ Study Area, wolverine have a low probability of occurrence as observations are rare in the region and not documented locally (M. L. Mallory et al. 2001).

9.1.3 Large Mammals (Caribou)

Barren-ground caribou are a main source of country food, and between 1996 and 2001, the mean annual harvest of caribou was 778 individuals per year (Table 9-2). Location data collected as part of the survey revealed that caribou were historically hunted near the Hamlet including near the HRQ Study Area (Figure 9 in Appendix 1). This population of caribou is recognized as the north Baffin Island population (Jenkins et al. 2012). Although historical range may have overlapped, current range does not overlap with the Hamlet and HRQ Study Area, and in recent years, caribou on Baffin Island have declined (Jenkins et al. 2012; Ringrose 2018). The five-year harvest results indicate a similar declining trend (Priest & Usher 2004). Recent studies of caribou density in the Hamlet area report a low density of caribou (M. Campbell et al. 2015). IQ indicates that most caribou are approximately 300 km from the HRQ Study Area, but that the closest caribou were found 80 km east of the HRQ Study Area in 2019 (Arctic Bay IQ Workshop 2019 - Tom Nagitarvik).

Table 9-2 List of Species Harvested by Hunters from Arctic Bay and Nanisivik and their Mean Number Harvested Per Year (1996-2001)

Common Name	Scientific Name	Mean Number Harvested Per Year
Barren-ground caribou	*Rangifer tarandus groenlandicus*	778
Arctic hare	*Lepus arcticus*	136
Arctic fox	*Alopex lagopus*	114
Baffin Island wolf	*Canis lupus manningi*	13
Red fox (coloured fox)	*Vulpes vulpes*	1

Source: Priest and Usher (2004).

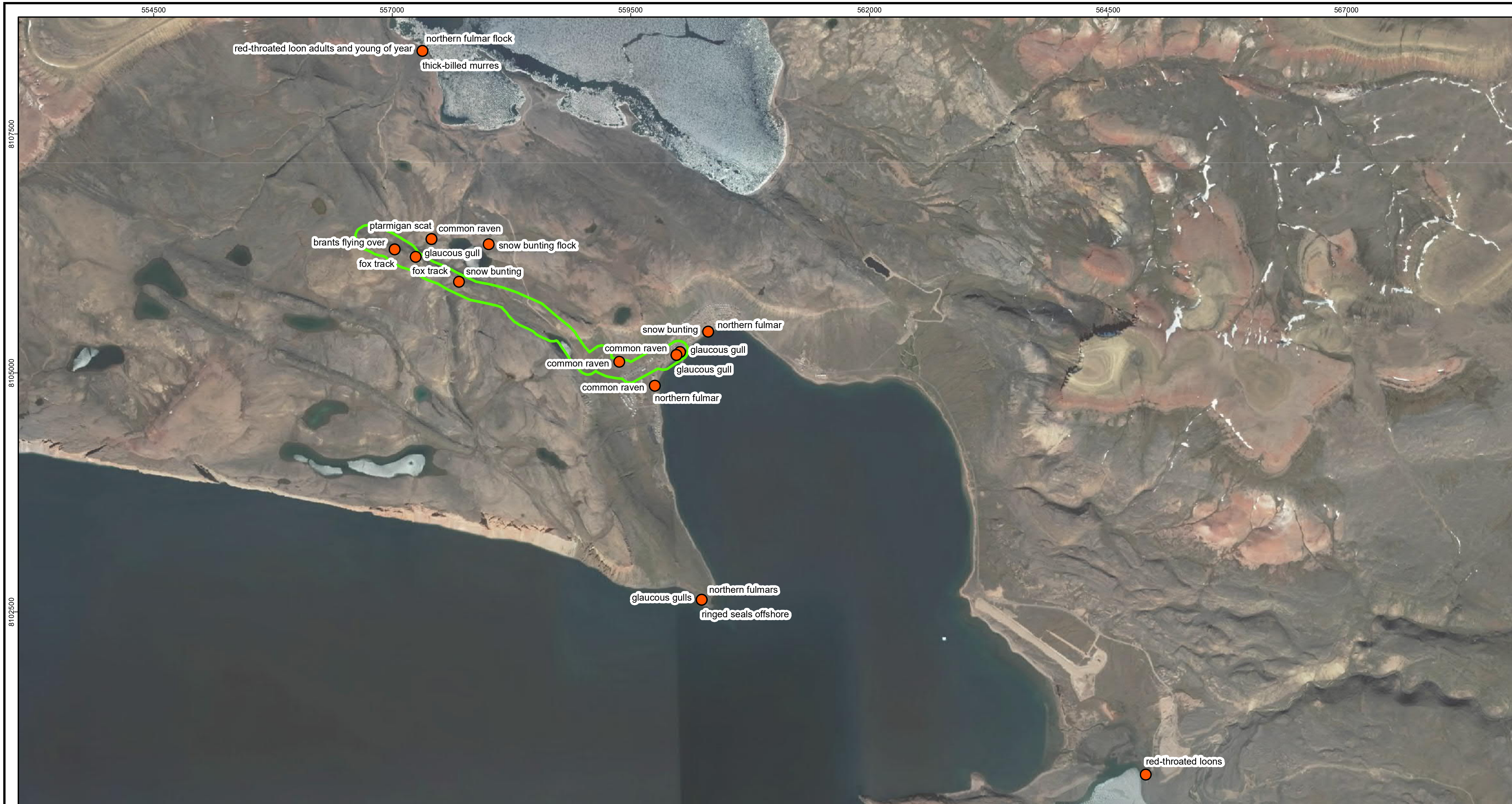
9.2 Field Program

9.2.1 Methodology

Fieldwork was conducted in conjunction with the vegetation survey from August 9–10, 2019. All wildlife species observed or detected by sign (scat, pellets, tracks, etc.) were identified, photographed (if possible), and georeferenced using a handheld GPS. In addition to individual wildlife, all wildlife features (e.g. dens, burrows, diggings) were similarly photographed and georeferenced. The focus of the field survey included the proposed quarry and haul route plus a 100 m buffer. Incidental observations were also recorded outside this area because some terrestrial wildlife are migratory or nomadic and travel long distances and have large home ranges. Terrestrial wildlife can be cryptic and difficult to detect without repeat visits and targeted surveys. As such, a lack of observation does not preclude the potential for species occurrence within the Project Study Area. Given logistical constraints, repeat visits and targeted surveys were not conducted. A general reconnaissance survey was the focus of the wildlife fieldwork and information collected during the vegetation survey were used to further refine the list of species with potential to inhabit the HRQ Study Area. Weather conditions during the field surveys are provided in Section 1.6, Table 1-3.

9.2.2 Results

The only terrestrial wildlife species identified or detected was fox. Two sets of fox tracks (suspected to be made by arctic fox) were identified at the north end and on top of the ridge of the HRQ Study Area (Figure 9-1). All wildlife data collected, including coordinate locations are provided in Tables 5 and 6 in Appendix 5.



Legend

- Incidental Wildlife Observation or Detection
- Haul Road and Quarry (HRQ) Study Area

0 0.5 1 2
Kilometres
1:40,000
WGS 1984 UTM Zone 16N

N

Aerial Image: GoogleEarth, July 2016
Locations approximate.

FISHERIES AND OCEANS CANADA
SMALL CRAFT HARBOURS
ARCTIC BAY

WILDLIFE AND WILDLIFE FEATURES OBSERVED OR DETECTED DURING FIELD SURVEY

Date: 28-MAY-21	Drawn by: JH	Edited by: KR	App'd by: LP
Project No. 317071-00037			
FIG No 9-1		REV 0	

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USER NAME: kenneth.w.ritchie
ISSUING OFFICE: BURNABY GIS
PLOT DATE & TIME: 5/28/2021 9:27:55 AM
SAVE DATE & TIME: 5/28/2021 9:27:43 AM

9.3 Discussion

9.3.1 Habitat Value

In general, habitat near the proposed SCH Study Area is of limited value for terrestrial wildlife. Human development in the Hamlet extends to the edge of the ocean. The beach is developed and has structures and boats along its length. The buildings along the beach may provide cover for small mammals and weasels. At low tide, the intertidal zone may provide limited foraging opportunities. However, the value of these areas for habitat is low given the amount of disturbance and frequent human activity.

As such, habitat available for wildlife in proximity to the HRQ Study Area was considered to be moderate quality. The valley pass is frequented by human traffic crossing over towards Victor Bay from the Hamlet. Much of the terrain was undisturbed and comprised of upland shrubs with graminoids and wetland areas providing cover and foraging opportunities for wildlife. Security, escape, and thermal cover for some small mammals is present, and this may provide foraging opportunities for medium-sized mammals such as arctic fox and ermine. More information about vegetation community types are provided in Section 8.

9.3.2 Small Mammals

9.3.2.1 Arctic Hare Presence in the HRQ Study Area

Arctic hare typically inhabit willow-dominated communities in winter and summer (Klein & Bay 1994) where they typically forage on twigs, bark, and other plant material (Sale 2006) such as willow, avens, graminoids, and forbs (Parker 1977). Willow-dominated communities were not identified in the HRQ Study Area, although willows were present and may provide limited forage opportunities. Parker (1977) suggests that arctic hare also commonly inhabit elevated, dry gravel slopes, which support a sparse but diverse vegetation community. In addition, arctic hare commonly seek shelter behind rocks during winter (Gray 1993). It is believed that this type of broken terrain provides appropriate escape cover and sheltering habitat. Given IQ confirmed presence, portions of the HRQ Study Area, particularly around the proposed quarry location would provide moderate amounts of escape cover for arctic hare.

9.3.2.2 Lemming Presence in the HRQ Study Area

Brown lemmings occupy a variety of tundra types, but with greater abundance on damp tundra dominated by grasses, sedges, and mosses (Sale 2006). Some wetland graminoid areas identified during the ecological land classification may be able to support this species. However, much of the HRQ Study Area is drier and composed of upland, open, and dwarf shrubs dominated areas. Therefore, Peary Land collared lemmings may be more likely to occupy the HRQ Study Area. Peary Land collared lemmings occupy a variety of tundra types, but in contrast to brown lemmings, are more abundant on dry, rocky tundra (Sale 2006). Both species den in complex micro-habitat with an abundance of deciduous shrubs and mosses, which provide opportunities for deep snow cover and thermal protection (Duchesne et al. 2011). Given IQ confirmed presence, lemmings are likely to occur within the HRQ Study Area, but habitat is not limiting in the region for lemmings.

9.3.3 Medium Mammals

9.3.3.1 Ermine Presence in the HRQ Study Area

Ermine are considered to be habitat generalists (King 1983; King & Powell 2007), and like many other mustelids, habitat is likely determined primarily by prey availability rather than vegetation associations (Klemola et al. 1999). In the Arctic, ermine primarily eat lemmings. When lemming populations are low, ermine use other food sources such as ptarmigan and eggs (King & Powell 2007). Therefore, their likelihood of inhabiting the HRQ Study Area depends on the availability of prey. Ermine are known to occupy lemming nests during winter in tundra environments (Sittler 1995), and they also nest in rock piles and burrows (King 1983). Given the rock outcrops in the HRQ Study Area, there may be suitable cover and escape habitat available. Because of the presence of lemming habitat, ermine presence is likely. Home ranges of ermine in the tundra span from 35 to 66 ha for females and 121 to 207 ha for males (King & Powell 2007). Consequently, only one pair (male and female) of weasels are likely to inhabit the HRQ Study Area.

9.3.3.2 Wolverine Presence in the HRQ Study Area

Although federally-listed as Special Concern in Canada, wolverine populations appear to be increasing in Nunavut (COSEWIC 2014b). No wolverines were reported to have been harvested on Baffin Island (Priest & Usher 2004). Wolverine habitat use in the Arctic is likely determined more by prey availability (rodents, hare, and ungulate carcasses) rather than vegetation (COSEWIC 2014b). Wolverines are a wide-ranging, generally nomadic species, found in low densities in remote areas away from human disturbance (COSEWIC 2014b; Sale 2006). As such, wolverine occurrence within the HRQ Study Area is unlikely and would only be transient if present.

9.3.3.3 Fox Presence in the HRQ Study Area

Fox (suspected to be arctic fox tracks) were confirmed within the HRQ Study Area. Similar to weasels, arctic fox appear to be less closely tied to vegetation associations than to other factors such as prey availability. Cycles in arctic fox populations are closely tied with lemming abundance (Gauthier & Berteaux 2011). Arctic fox home range and movements also increase during periods (or in territories) of low food abundance (Gauthier & Berteaux 2011). The widespread red fox, which is highly adaptable and often associated with human developments and urban areas, has recently been expanding into the arctic (Gauthier & Berteaux 2011). There are likely few places for fox to den within the HRQ Study Area, but abandoned buildings or the underside of other structures near the Hamlet could support denning habitat. Arctic fox home ranges are large and studies in other coastal areas indicated that they may be around 10 km^2 (males) and 4 km^2 (females) (Anthony 1997). Red foxes are likely to have larger home range size than arctic fox because they require larger areas to meet basic metabolic needs (Harestad & Bunnell 1979). As such, based upon expected home range sizes, the HRQ Study Area might only partially support one pair or family group (of either species).

9.3.3.4 Wolf Presence in the HRQ Study Area

Although it is possible that wolves could pass through the HRQ Study Area, it is unlikely. Wolves have large home ranges, and as is with the other carnivores discussed, base their habitat utilization upon prey availability. In the case of wolves on Baffin Island, their primary prey are caribou, which are migratory and have a current density of low near the Hamlet (M. Campbell et al. 2015; McLoughlin et al. 2004). Given that it is expected that wolves follow caribou herds (Krizan 2006), it is unlikely that wolves would frequent this area.

9.3.4 Large Mammals

9.3.4.1 Barren-ground Caribou Presence in the HRQ Study Area

Caribou have declined in the Hamlet area since the late 1990s and have not been reported in proximity since 2004 (Jenkins & Goorts 2011; Priest & Usher 2004), the closest caribou was seen 80 km away in 2019 (Arctic Bay IQ Workshop 2019 - Tom Nagitarvik). Recent density estimates are low, caribou are not likely to occupy the HRQ Study Area.

10 Migratory Birds (including Marine Birds)

Program objectives for migratory and marine birds are provided in Section 1.6, Table 1-2. Although many marine birds are pelagic and spend most of their life at sea, for purposes of the ESES, marine birds are considered together with migratory birds given that they nest terrestrially (a critical life history stage) and most are also migratory. Field survey focused on the SCH and HRQ Study Areas, but incidental observations were also recorded outside this area, which included the DAS Study Area.

10.1 Desktop Review

To support assessment of the existing condition of migratory and marine birds, existing literature, IQ and databases were reviewed to determine species with historical occurrences near the Project. Protected areas (e.g. wildlife sanctuaries) or known high-value habitats (e.g. IBAs) were identified. In addition to identifying historical occurrences, a list of species that could potentially occupy the HRQ, SCH, and DAS Study Areas was generated. This list was determined by examining available habitat using aerial imagery (Google Earth 2020) and comparing it with habitat requirements for species whose ranges overlaps with the Project. Range maps and habitat information were determined by field guides and other reference sources.

10.1.1 Migratory, Marine, and Other Birds Likely to be Present

A review of the NWHS (Priest & Usher 2004), revealed that several bird species and their eggs are harvested by hunters in the Hamlet, confirming their presence and breeding in the surrounding area (Table 10-1). The species most harvested are ptarmigan (*Lagopus muta*), goose eggs, snow goose (*Chen caerulescens*), gull eggs, and eider ducks (*Somateria* spp.), respectively. Location data for harvested birds were not collected for most species. Hunters in the Hamlet hunt both common eiders (*S. mollissima*) and king eiders (*S. spectabilis*) and information on the locations of harvest for these species was collected. Although no bird harvests have been recorded within the HRQ, SCH, and DAS Study Areas, eider hunting has historically occurred (Figure 9 in Appendix 1) in Admiralty Inlet and Adams Sound (see marine corridor locations in Figure 1-3).

There are at least 56 bird species who have potential to be present in the region, but 26 were considered unlikely to nest within or near the Project Study Areas (Table 10-2). Thirteen were considered likely to nest within or near the HRQ Study Area, based on habitat during the breeding season. These include: American pipit (*Anthus rubescens*), arctic tern (*Sterna paradisaea*), Baird's sandpiper (*Calidris bairdii*), common raven (*Corvus corax*), hoary redpoll (*Acanthis hornemanni*), horned lark (*Eremophila alpestris*), northern wheatear (*Oenanthe oenanthe*), purple sandpiper (*Calidris maritim*), red knot (*Calidris canutus*), rock ptarmigan (*Lagopus muta*), snow bunting (*Plectrophenax nivalis*), white-rumped sandpiper (*Calidris fuscicollis*), and willow ptarmigan (*Lagopus lagopus*) (Table 10-2).

IQ indicates that ptarmigan and snow bunting are common throughout the HRQ Study Area (IQ Workshop - Jonah Oyukuluk; IQ Workshop - Olayuk Nagitarvik; IQ Workshop - Tom Nagitarvik). Eider ducks occupy the shoreline during migration and use the DAS Study Area for staging (Arctic Bay IQ Workshop 2019 - Tom Nagitarvik). Gulls and marine birds nest on the cliffs of Admiralty Inlet and common ravens nest near town (Figure 2-1) (Mishak Allurut, pers. comm. June 2019).

Bird SAR that have potential to be present include ivory gull (*Pagophila eburnean*), peregrine falcon (*Falco peregrinus*), red knot, red-necked phalarope (*Phalaropus lobatus*), and Ross's gull (*Rhodostethia rosea*) (Table 10-2). Ivory gull and Ross's gull are not likely to nest within or near the HRQ, SCH, and DAS Study Areas, and the potential for peregrine falcon and red-necked phalarope to nest in the area is low. Red knot is likely to nest in the HRQ Study Area. The territorial and federal status of these SAR are provided in Table 10-2.

Table 10-1 List of Species Harvested by Hunters from Arctic Bay and Nanisivik and their Mean Number Harvested Per Year (1996-2001)

Common Name	Scientific Name	Mean Number Harvested Per Year
Ptarmigan	*Lagopus* spp.	571
Goose eggs	---	556
Snow goose	*Chen caerulescens*	390
Gull eggs	---	33
Eider duck	*Somateria* spp.	16
Brant	*Branta bernicla*	5
Thick-billed murre	*Uria lomvia*	2
Black guillemot	*Cepphus grille*	1
Canada goose	*Branta Canadensis*	1
Red-throated loon	*Gavis stellate*	1
Sandhill crane	*Antigone Canadensis*	1
Arctic (pacific) loon	*Gavia pacifica*	<1
Common loon	*Gavia immer*	<1
Duck eggs	---	<1

Source: Priest and Usher (2004)

Table 10-2 List of Birds, their Federal and Territorial statuses, their Preferred Foraging Strategy, and Potential to Nest (based on season-use) Within or Near the Project Study Areas

Common name	Scientific Name	COSEWIC Status	SARA Status	Territorial Status	Foraging Location	Period of Use	Nesting Resource Requirements	Nesting Likelihood
American golden plover	*Pluvialis dominica*	Not assessed	Not listed	S3	Shoreline	Breeding and Migration	Elevated on sparse, low vegetation, well-drained rocky slopes	Low
American pipit	*Anthus rubescens*	Not assessed	Not listed	SU	Ground forager	Breeding and Migration	Mesic vegetation along streams, grassy meadows, and dry, dwarf shrub matts	Likely
Arctic tern	*Sterna paradisaea*	Not assessed	Not listed	S4	Nearshore	Breeding and Migration	Open country, close to water, no vegetation or low and sparse cover; rocky, gravelly islands, barrier beaches and spits, gravel moraines	Likely
Atlantic puffin	*Fratercula arctica*	Not assessed	Not listed	S3	Offshore	Breeding, Migration, and Overwinter	Burrows on rocky islands with short vegetation and on sea cliffs	Not Likely
Baird's sandpiper	*Calidris bairdii*	Not assessed	Not listed	S5	Shoreline	Breeding and Migration	Dry, well-drained coastal and upland exposed tundra. Beach ridges, terrace banks, bare soil with sparse vegetation	Likely
Black guillemot	*Cepphus grylle*	Not assessed	Not listed	S5	Nearshore	Breeding, Migration, and Overwinter	Colonies on rocky marine coasts of off-shore islands near shallow water	Not Likely
Black-bellied plover	*Pluvialis squatarola*	Not assessed	Not listed	S3	Shoreline	Breeding and Migration	Lowlands in coastal areas and on open, dry, heath tundra, dwarf shrub meadows, and dry exposed ridges, river banks, and beaches	Low
Black-legged kittiwake	*Rissa tridactyla*	Not assessed	Not listed	S5	Nearshore	Breeding and Migration	Colonies on cliff ledges of off-shore islands or inaccessible mainland	Not Likely
Brant	*Branta bernicla*	Not assessed	Not listed	S5	Coastal flats	Breeding and Migration	Colonial near salt marshes, estuaries, and deltas	Not Likely
Cackling goose	*Branta hutchinsii*	Not assessed	Not listed	S5	Ground forager	Breeding and Migration	Variety of low Arctic regions with open view and adjacent to permanent freshwater (ponds, lakes, streams, marshes, and muskeg)	Not Likely
Canada goose	*Branta canadensis*	Not assessed	Not listed	S5	Grassy flats	Breeding and Migration	Broad range of habitats but often adjacent to freshwater	Low
Common eider	*Somateria mollissima*	Not assessed	Not listed	S3	Nearshore	Breeding, Migration, Overwinter	Local colonies along marine coasts, islands, and islets	Not Likely
Common loon	*Gavia immer*	Not at Risk	Not listed	S5	Marine coast	Breeding and Migration	Large lakes	Not Likely
Common raven	*Corvus corax*	Not assessed	Not listed	S5	Ground forager	Breeding and Overwinter	Habitat generalist; often on cliffs, trees, and human structures	Likely
Common redpoll	*Acanthis flammea*	Not assessed	Not listed	SU	Foliage gleaner	Breeding and Migration	Dry, rocky or damp substrates on dry heaths or rocky slopes	Not Likely
Dovekie	*Alle alle*	Not assessed	Not listed	S3	Offshore	Breeding, Migration, and Overwinter	Colonies on rocky marine coasts and cliffs	Not Likely
Glaucous gull	*Larus hyperboreus*	Not assessed	Not listed	S4	Nearshore	Breeding and Migration	Often in mixed colonies on marine and freshwater coasts, tundra, islands, cliffs, shorelines, and ice edges	Not Likely
Gyrfalcon	*Falco rusticolus*	Not at Risk	Not listed	S4	Open terrain	Breeding and Migration	Rocky outcrops, cliffs, and seacoasts	Low
Hoary redpoll	*Acanthis hornemanni*	Not assessed	Not listed	S3	Foliage gleaner	Breeding and Migration	Similar to common redpoll but near dwarf or creeping shrubs	Likely
Horned lark	*Eremophila alpestris*	Not assessed	Not listed	SU	Ground forager	Breeding and Migration	Open habitat on bare ground or short grasses	Likely
Iceland gull	*Larus glaucoides*	Not assessed	Not listed	S5	Nearshore	Migration	Colonies on rocky cliffs and fjords	Not Likely
Ivory gull	*Pagophila eburnean*	Endangered	Endangered	S1	Nearshore	Breeding, Migration, and Overwinter	Rocky islands and cliffs near pack ice	Not Likely
King eider	*Somateria spectabilis*	Not assessed	Not listed	S3	Nearshore	Breeding, Migration, Overwinter	Variety of tundra habitats but often on dry and well-drained in vegetation adjacent to freshwater	Not Likely
Lapland longspur	*Calcarius lapponicus*	Not assessed	Not listed	S5	Ground forager	Breeding and Migration	Wet, hummocky meadows; avoids rocky and bare terrain	Low

Common name	Scientific Name	COSEWIC Status	SARA Status	Territorial Status	Foraging Location	Period of Use	Nesting Resource Requirements	Nesting Likelihood
Long-tailed duck	*Clangula hyemalis*	Not assessed	Not listed	S4	Nearshore	Breeding, Migration, Overwinter	Wetlands or offshore islands with freshwater	Low
Long-tailed jaeger	*Stercorarius longicaudus*	Not assessed	Not listed	S5	Offshore	Migration and Overwinter	Tundra far from sea	Not Likely
Northern fulmar	*Fulmarus glacialis*	Not assessed	Not listed	S5	Offshore	Breeding, Migration, Overwinter	Steep sea cliffs	Not Likely
Northern wheatear	*Oenanthe Oenanthe*	Not assessed	Not listed	SU	Ground forager	Breeding and Migration	Dry, elevated rubble, rocky fields, stony hilltops, and precipices of rocky coasts	Likely
Pacific loon	*Gavia pacifica*	Not assessed	Not listed	SU	Marine coast	Breeding and Migration	Freshwater lakes	Low
Parasitic jaeger	*Stercorarius parasiticus*	Not assessed	Not listed	S4S5	Offshore	Migration and Overwinter	Pelagic bird that nests on low-lying marshy tundra and dry, tussock-heath	Low
Pectoral sandpiper	*Calidris melanotos*	Not assessed	Not listed	S4	Shoreline	Breeding and Migration	Flat, marshy tundra dominated by sedges and grasses	Not Likely
Peregrine falcon	*Falco peregrinus*	Not at Risk	Special Concern	S4	Open terrain	Breeding and Migration	Open landscapes with cliffs or tall human-made structures	Low
Pomarine jaeger	*Stercorarius pomarinus*	Not assessed	Not listed	S5	Offshore	Migration and Overwinter	Pelagic bird that nests irregularly in low-lying marshy tundra near small lakes	Not Likely
Purple sandpiper	*Calidris maritima*	Not assessed	Not listed	S3	Shoreline	Breeding and Migration	Inland on mossy tundra, heath, and moorlands but also low tundra near shores on gravel-sand beaches along rivers	Likely
Red knot	*Calidris canutus*	Endangered	Endangered	S2	Shoreline	Migration	Sparsely vegetated, dry, elevated tundra on ridges or slopes with low shrub cover	Likely
Red phalarope	*Phalaropus fulicarius*	Not assessed	Not listed	S4	Nearshore	Breeding and Migration	Coastal, poorly-drained, hummocky, level terrain on tundra dominated by sedges	Low
Red-breasted merganser	*Mergus serrator*	Not assessed	Not listed	S5	Pursuit Diver	Breeding and Migration	Coastal near fresh, brackish or saltwater wetlands in sheltered bays	Not Likely
Red-necked phalarope	*Phalaropus lobatus*	Special Concern	Special Concern	S3	Nearshore	Breeding and Migration	Mossy hummocks and sedges close to standing water	Low
Red-throated loon	*Gavia stellata*	Not assessed	Not listed	S4	Marine coast	Breeding and Migration	Wetlands and larger ponds, lakes	Low
Rock ptarmigan	*Lagopus muta*	Not assessed	Not listed	S5	Ground forager	Breeding and Overwinter	Well-drained, hummocky tundra with rocky ridges; outcrops and mixed vegetation	Likely
Ross's gull	*Rhodostethia rosea*	Threatened	Threatened	S1	Nearshore	Breeding and Migration	Moist tundra and deltas with dwarf shrubs	Not Likely
Rough-legged hawk	*Buteo lagopus*	Not at Risk	Not listed	SU	Rolling, open terrain	Breeding and Migration	Open tundra including rocky outcrops, escarpments, and cliffs	Low
Ruddy turnstone	*Arenaria interpres*	Not assessed	Not listed	S3	Shoreline	Breeding and Migration	Marshy slopes and flats near freshwater (marshes, streams, ponds) or tidal flats and beaches	Low
Sabine's gull	*Xema sabini*	Not assessed	Not listed	S4S5	Nearshore	Breeding and Migration	Moist tundra near fresh water (ponds and lakes), low-lying sea coasts and coastal islands	Not Likely
Sanderling	*Calidris alba*	Not assessed	Not listed	S3	Shoreline	Breeding and Migration	Islands, peninsulas, and coastal tundra with well-vegetated moist to well-drained slopes, ridges, and alluvial plains	Low
Sandhill crane	*Grus canadensis*	Not assessed	Not listed	S5	Ground forager	Breeding and Migration	Eskers dominated by lichens	Low
Snow bunting	*Plectrophenax nivalis*	Not assessed	Not listed	S3	Ground forager	Breeding and Migration	Rocky areas and boulder screes near vegetated tundra	Likely
Snow goose	*Chen caerulescens*	Not assessed	Not listed	S5	Coastal flats	Breeding and Migration	Colonial near freshwater (ponds, lakes, streams, and braided deltas) often in wet meadows but also undulating terrain, exposed slopes, or cliff edges	Not Likely
Snowy owl	*Bubo scandiacus*	Not assessed	Not listed	S4	Rolling, open terrain	Breeding and Migration	Variety of tundra environments on distinct promontories	Moderate

Common name	Scientific Name	COSEWIC Status	SARA Status	Territorial Status	Foraging Location	Period of Use	Nesting Resource Requirements	Nesting Likelihood
Thayer's gull	*Larus thayeri*	Not assessed	Not listed	S4S5	Marine coast	Breeding and Migration	Colonies on steep cliffs	Not Likely
Thick-billed murre	*Uria lomvia*	Not assessed	Not listed	S5	Offshore	Breeding, Migration, and Overwinter	Large colonies on cliff ledges near deep, offshore waters and land fast ice	Not Likely
Tundra swan	*Cygnus columbianus*	Not assessed	Not listed	S5	Coastal flats	Migration	Tundra lakes, ponds, and coastal deltas	Not Likely
White-rumped sandpiper	*Calidris fuscicollis*	Not assessed	Not listed	S5	Shoreline	Breeding and Migration	Well-vegetated, wet, meadows and low-lying areas near water	Likely
Willow ptarmigan	*Lagopus lagopus*	Not assessed	Not listed	S5	Foliage gleaner	Breeding and Overwinter	Abundant shrubby vegetation, flat terrain, and moist areas	Likely
Yellow-billed loon	*Gavia adamsii*	Not at Risk	Not listed	S4	Marine coast	Breeding and Migration	Near water on ground, partially hidden in tundra vegetation	Not Likely

Notes:

Sources: CESCC (2016); Cornell Lab of Ornithology (2019); Government of Canada (2019p); LePage et al. (1998b); M. L. Mallory and A. J. Fontaine (2004)

Likelihood of nesting within Project Study Areas was based upon a qualitative assessment of results of the ecological land classification and habitat assessment and potential for the habitat to provide suitable nesting requirements. Similarly, other factors such as breeding range, location of known colonies, etc. were incorporated. Likely: the Project is located within the breeding range and the majority of available habitat provides preferred or suitable nesting habitat; Moderate: the Project is located within the breeding range and some of the available habitat may provide suitable nesting habitat; Low: the Project is located within the breeding range and some of the available habitat may provide marginal nesting habitat; Not Likely: the Project is located outside of the breeding range or outside of known colonies (or the species is colonial and such a colony would likely be known to locals given its proximity to the Hamlet), and available habitat is generally not suitable for nesting.

Territorial Rank Descriptions

SX	Presumed Extirpated
SH	Possibly Extirpated
S1	Critically Imperiled
S2	Imperiled
S3	Vulnerable
S4	Apparently Secure
S5	Secure
SU	Unrankable
SNR	Unranked
SNA	Not Applicable

10.1.2 Important Bird Areas and Key Bird and Habitat Sites

IBAs are described in Section 7.2.3 with Baillarge Bay and Berlinquet Inlet being the closest to the Project.

Baillarge Bay in Admiralty Inlet

The coastal cliffs of Baillarge Bay provide important colonial seabird nesting habitat and is one of the largest colonies of northern fulmars (*Fulmarus glacialis*). Over 30,000 (range: 10,000 to 100,000) breeding pairs nest here, representing 13% of the Canadian population (Latour et al. 2008). Likewise, the site offers important breeding grounds for glaucous gulls (*Larus hyperboreus*). During April and October, Baillarge Bay represents important foraging habitat, as northern fulmars and black guillemots (*Cepphus grille*) congregate at the nearby ice floes to feed (Latour et al. 2008; M L Mallory & A J Fontaine 2004). Other species identified in this IBA include long-tailed jaeger (*Stercorarius longicaudus*), black-legged kittiwake (*Rissa tridactyla*), Iceland gull (*Larus glaucoides*), and common raven (Bird Studies Canada 2019). Baillarge Bay is an International Biological Programme site which does not afford additional protections but emphasizes the site's significance. It has been identified as a Key Migratory Bird Terrestrial Habitat site and terrestrial portions of the IBA are also part of Sirmilik National Park (M L Mallory & A J Fontaine 2004).

Berlinguet Inlet in Admiralty Inlet

The Berlinguet Inlet IBA encompasses the coasts and surrounding lowlands of Bernier Bay, Berlinguet Inlet, Gifford River, Jungersen Bay, and Admiralty Inlet. It is predominantly a lowland area, interspersed with some hilly coastal regions, and many small, freshwater lakes. It is the second most important breeding area for snow goose in Canada after Bylot Island, and an estimate of >14,700 snow geese use the area (Bird Studies Canada 2019). Cackling goose (*Branta hutchinsii*) also nest in the area and it is the most northeastern breeding records for this species (IBA Canada 2017). Other birds that nest in this area include Canada goose (*Branta canadensis*), common eider, long-tailed duck (*Clangula hyemalis*), willow ptarmigan, black-bellied plover (*Pluvialis squatarola*), American golden-plover (*Pluvialis dominica*), baird's sandpiper, white-rumped sandpiper, Iceland gull (*Larus glaucoides*), glaucous gull (*Larus hyperboreaus*), red-throated loon (*Gavia stellate*), snowy owl (*Bubo scandiacus*), common raven, horned lark, northern wheatear, Lapland longspur (*Calcarius lapponicus*), snow bunting, and peregrine falcon (Bird Studies Canada 2019). The location has also been identified as a Key Habitat Site for migratory birds by Canadian Wildlife Service, though this carries no protective status (Bird Studies Canada 2019).

10.1.3 Migratory Bird Sanctuaries

MBSs are described in Section 7.2.4.

10.1.4 Ecologically or Biologically Significant Marine Areas

EBSAs are described in Section 7.2.2.

In addition to bird colonies at IBAs, Admiralty Inlet EBSA is a breeding area for glaucous gulls and the area may have large aggregations of marine birds from May to September depending on annual patterns of ice break-up and prey distributions (DFO 2015c; M. L. Mallory & A. J. Fontaine 2004; Schimnowski et al. 2018).

10.2 Field Program

10.2.1 Methodology

Fieldwork was conducted in conjunction with the vegetation survey from August 9-10, 2019. Given logistical constraints (i.e. ice break up), this timing was largely outside the breeding season for migratory and marine birds, which is from approximately June 5 to July 25 in the Arctic (ECCC 2018b). Birds could nest past this period, up until around August 15 in the Arctic, although likelihood is lower (ECCC 2018b). As such, fieldwork focused on gathering habitat data that could be used to generate a list of species with potential to breed within the HRQ, SCH, and DAS Study Areas. All birds observed and features that were detected (e.g. whitewash, pellets, nests, perches) were identified, photographed, and georeferenced using a handheld GPS unit.

In addition, a visual survey with a series of five-minute point counts spaced approximately 400 m apart were conducted by following transects along the shoreline in the SCH Study Area (Figure 10-1). This distance spacing was used to minimize counting the same individual twice. This survey method followed a combination of the BC Coastal Waterbird Survey Protocol (Bird Studies Canada 2013) and Alberta Sensitive Species Inventory Guidelines (Government of Alberta 2013) because no government-recommended protocols exist in Nunavut for migratory or marine bird inventories. Each point count included a wait period of two minutes and listening and observing period of five minutes. Point counts were started no more than 30 minutes before sunrise and were completed before 10:00, when possible (in some cases this was not possible because of poor weather or logistical constraints). All birds observed or heard were identified and recorded. Weather conditions during the field surveys are provided in Table 1-3.

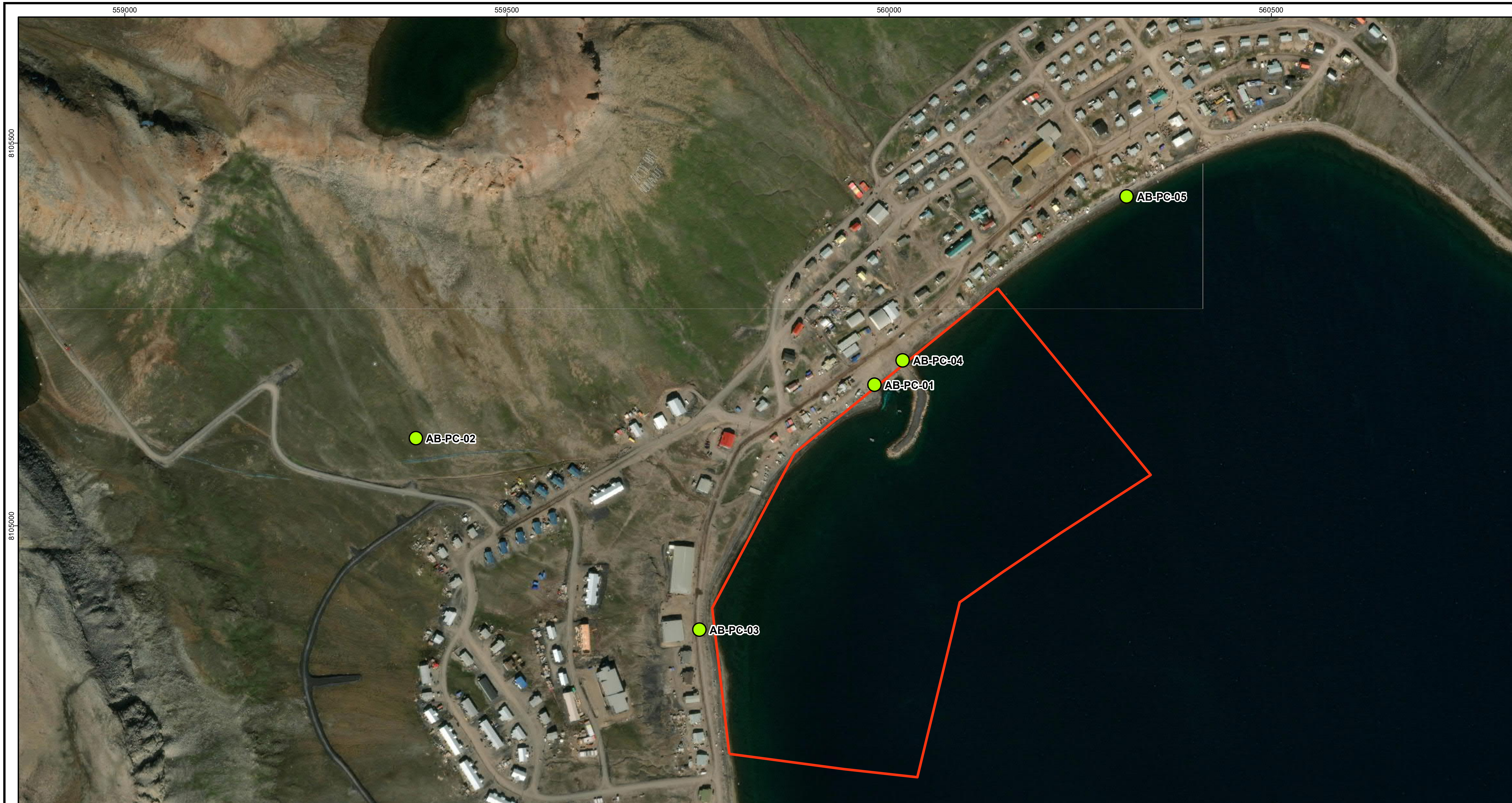
10.2.2 Results

Nine bird species were identified during the field survey from August 9-10, 2019 (Table 10-3). No nesting or breeding behaviour was identified; however, the survey was conducted at the end of the breeding bird season. The lack of breeding behaviour does not preclude the potential for birds to nest in the area.

Flocks of northern fulmars were identified offshore, near the SCH Study Area, and flocks of snow buntings were identified within the HRQ Study Area (Figure 9-1; Tables 5 and 6 in Appendix 5). In addition, a small flock of thick-billed murres (*Uria lomvia*) and a family of red-throated loons were identified in Victor Bay (Figure 9-1). Common ravens were frequent within the Hamlet. Glaucous gulls and Thayer's gulls (*L. thayeri*) were also observed. Field-collected data for migratory and marine birds are included in Tables 5 and 6 in Appendix 5 with other wildlife observations and detections.

Table 10-3 Bird Species Identified or Detected during Point Counts and Field Program

Bird Species	
Common Name	**Species Name**
Point Count Observations	
Common raven	*Corvus corax*
Glaucous gull	*Larus hyperboreus*
Northern fulmar	*Fulmarus glacialis*
Snow bunting	*Plectrophenax nivalis*
Thayer's gull	*Larus thayeri*
Incidental Observations	
Brant	*Branta bernicla*
Ptarmigan species	*Lagopus* sp.
Red-throated loon	*Gavia stellate*
Thick-billed murre	*Uria lomvia*



Legend

- Point Count Location
- SCH Study Area

0 50 100 200

Metres

1:5,000

WGS 1984 UTM Zone 16N

N

Locations approximate.

FISHERIES AND OCEANS CANADA
SMALL CRAFT HARBOURS
ARCTIC BAY

BIRD POINT COUNT LOCATIONS DURING FIELD SURVEY

Date: 28-MAY-21	Drawn by: JH	Edited by: KR	App'd by: LP
Small Craft Harbours / Ports pour petits bateaux	Advisian ᐃᒃᐱᐊᕐᔪᒃ Ikpiaryuk Services Ltd.	Project No. 317071-00037	
		FIG No 10-1	REV 0

"This drawing is prepared solely for the use of our customers as specified in the accompanying report. Worley Canada Services Ltd. assumes no liability to any other party for any representations contained in this drawing."

USER NAME: kenneth.w.ritchie
ISSUING OFFICE: BURNABY GIS
PLOT DATE & TIME: 5/28/2021 9:20:31 AM
SAVE DATE & TIME: 5/28/2021 9:20:19 AM

FILE LOCATION: U:\YVR\317071\00037_PWGS_ArcBayCES\10_Eng\16_Geomatics\01_MXD\Baseline\Fig10-1_AB_BirdPointCounts.mxd

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

10.3 Discussion

10.3.1 Habitat Value

In general, habitat in the SCH Study Area is of limited value to migratory and marine birds. Human development dominates the SCH Study Area with structures and boats along its length. Moreover, teams of dogs were tied up along its length. Species breeding in the SCH Study Area are likely those that nest on bare ground and gravelly areas (e.g. snow buntings) and are relatively tolerant of human disturbance (e.g. common raven). However, human use and dogs likely discourage birds from nesting. At low tide, the intertidal zone provides foraging opportunities, but only for those species tolerant of human activity (e.g. gulls, fulmars, and ravens). Consequently, the value of these habitats is considered low given disturbance and human activity.

The HRQ Study Area offers more natural habitat including wet, freshwater, dry, barren, and vegetated areas. Consequently, the HRQ Study Area offers some value for nesting birds. Ptarmigan scat, identified in the HRQ Study Area, confirms that this species frequents the area. No bird species potentially present would nest in the DAS Study Area. More information about vegetation community descriptions and land cover types are provided in Section 8.

10.3.2 Migratory Birds

The upland dwarf shrub and wetland areas with fresh water identified in the HRQ Study Area (see Section 8) offer nesting and foraging habitat for snow buntings, American pipit, arctic tern, hoary redpoll, horned lark, northern wheatear, purple sandpiper, rock ptarmigan, white-rumped sandpiper, and willow ptarmigan. These species typically require these vegetation communities for nesting (Table 10-2). In addition, eider ducks (Figure 9 in Appendix 1), snow geese, cackling geese, glaucous gulls, and northern fulmars nest in nearby IBAs, so are likely to frequent the area during migration and staging.

According to ECCC, the general nesting season for the region (N10: Arctic Plains and Mountains, Bird Conservation Region 3) is between late-May and mid-August, and the primary season (61-100% of birds nesting) is from early-June to late-July (ECCC 2018b). It should be noted these are estimated breeding dates and that the exact timing can vary according to the species occurrence, climate, elevation, and habitat type. Timing could also vary according to micro-sites or factors such as early or late spring. Because of natural variability in nesting, the timing could vary by up to ten days; moreover, the period above does not include a nest building phase which typically is initiated two weeks prior to the general nesting season (ECCC 2018b).

10.3.3 Marine Birds

The majority of marine birds that have historical occurrences or whose range overlap with the HRQ Study Area are unlikely to nest here. Most of these birds nest in large colonies on remote, precipitous cliffs and remote islands that are inaccessible to predators (Cornell Lab of Ornithology 2015, 2019) In addition, massive lowland areas such as those identified in Berlinguet Inlet, that support aggregations of nesting geese, are not present within the Project Study Areas. Despite the lack of breeding habitat, 26 species of marine birds could potentially use inter-tidal, marine coast, and nearshore habitats in the SCH Area, Adams

Sound, and Victor Bay for foraging and staging. The use of this habitat likely peaks between mid-July and October during ice free periods at the Hamlet (M L Mallory & A J Fontaine 2004).

10.3.4 Species at Risk

10.3.4.1 Ivory Gull

Ivory gulls breed where the ocean is free (or partly free) of ice in late-May and early-June: the Project Study Areas do not support breeding and nesting habitat (COSEWIC 2006b). However, given the proximity to ice edge and availability of food for scavenging, including historical observations, it is probable that ivory gulls forage near the Hamlet, particularly in the fall during migration.

10.3.4.2 Buff-breasted Sandpiper

Buff-breasted sandpiper occur in tundra regions, primarily in wet/lowland habitat, often near a wetland, pond, or lake with sedge-dominated vegetation (COSEWIC 2012a). Habitat use varies depending on breeding stage. In spring, males often display on barren ridges but as the snow melts, they may display in moister areas. Nests have been documented on the drier parts of the tundra including slopes with sedge tussocks and moss-willow-varied grass areas, and in sedge-graminoid meadows close to streams or open-water wetlands (COSEWIC 2012a). Although this type of habitat was present within the HRQ Study Area, the Project is outside the mapped breeding range of this species. Therefore, buff-breasted sandpipers are unlikely to nest near the Project Study Areas.

10.3.4.3 Peregrine Falcon

The likelihood of peregrine falcon being within the Project Study Areas is low. Although they breed in a wide variety of habitats and use coastal areas for hunting avian prey, natural nesting structures capable of supporting this species (cliffs with open gulfs of air) are not present within HRQ and SCH Study Areas. Nevertheless, they are present in nearby Admiralty Inlet and the species have been documented in Berlinguet Inlet (Bird Studies Canada 2019). Peregrine falcons have also been known to nest on human-made structures such as buildings, bridges, and other tall structure, but typically do not nest lower than 50 m (Cornell Lab of Ornithology 2015; COSEWIC 2017c).

10.3.4.4 Red Knot

Three subspecies of red knot (*Calidris canutus*) are considered to be at-risk in Canada: *rufa* (Endangered), *roselaari* (Threatened), and *islandica* (Special Concern). There is unknown overlap of *rufa and islandica* subspecies range with the Project Study Areas, and therefore there is potential for both subspecies to be present (ECCC 2016d). Red knots breed on windswept ridges, slopes, and plateaus with sparse (<5%) vegetation cover, often on south-facing sites in proximity to freshwater such as wetlands and lakes (COSEWIC 2007a). Given that this habitat is present within the HRQ Study Area, it is likely that this species may nest there.

10.3.4.5 Red-necked Phalarope

Red-necked phalarope typically breed in low-Arctic tundra near freshwater (e.g. ponds, lakes, and streams) in vegetation dominated by graminoids (COSEWIC 2014c). This nesting habitat exists within the HRQ Study Area, particularly in the wetland and graminoid communities identified in Section 8. However, this species is considered an accidental visitor to the region (LePage et al. 1998a) and the Hamlet is at the margins of the breeding range. Consequently, the likelihood of red-necked phalarope nesting in the HRQ and SCH Study Areas is low.

10.3.4.6 Ross's Gull

Ross's gulls are distributed across the Arctic, but breed primarily in Siberia and overwinter in the Bering Sea (COSEWIC 2007b) They may nest in a wide variety of habitats including marshy tundra and gravel reefs but always close to water (COSEWIC 2007b). The Project Study Areas do not support their preferred nesting habitat, and it is unlikely that this species would be present.

11 Fish and Fish Habitat

Program objectives for fish and fish habitat are provided in Section 1.6, Table 1-2.

11.1 Desktop Review

Canada's Arctic region is characterized by dramatic shifts in light, temperature and frozen versus open-water states of the ocean (Carmack et al. 2006). Variations in the seasonal or permanent extent of sea ice in the Arctic have a fundamental influence on Arctic ecosystems (W. W. F. C. Oceans North Conservation Society, and Ducks Unlimited Canada, 2018b) and the Inuit (Ford 2009) who harvest marine life.

The coastal marine environment of the Arctic ocean surrounding Nunavut represents an important ecosystem for fish and fish habitat. Intertidal areas are inaccessible throughout periods of the year when the ocean is frozen and when marine vegetation has limited periods of time to facilitate growth due to limited light regimes. These variables have led to uniquely adapted species that have tolerance for extreme climatic regimes (Lindgren et al. 2016). It also represents an important socio-economic function for the people of Nunavut who are dependent on fish and marine mammals for subsistence harvesting.

Information used to summarize desktop information for Nunavut is best managed through a combined approach of available scientific literature, and IQ.

11.1.1 Benthic Habitat

Arctic benthic flora and fauna have adapted to be resilient due to extreme fluctuations in temperature, salinity, light availability, and ice scouring (T. M. Brown et al. 2011; Conlan & Kvitek 2005; Kupper et al. 2016; Wiencke et al. 2007), which varies with depth. For these reasons, vertical zonation is one of the most important variables shaping intertidal and shallow subtidal benthic communities. Disturbance from ice scouring is believed to be the most important 'architect' of Arctic biodiversity (Conlan & Kvitek 2005) in intertidal and shallow subtidal waters. There is limited published information available on the marine benthic habitat of Arctic Bay. Substrate of Arctic shorelines is predominantly sand intermixed with small rocks and gravel (Greenwood 2016) and a barren high intertidal (D. V. Ellis 1955). Seaward of the ice extent (controlled by tide height, slope and ice thickness) subtidal marine vegetation is controlled by availability of hard substrates (e.g. cobble, boulder) for attachment.

Marine vegetation has a large influence on biomass and biodiversity of marine species in temperate and tropical environments (T. M. Brown et al. 2011; Cristie et al. 2003; Warfe et al. 2008; Wikstrom & Kautsky 2007), typically because it provides three-dimensional habitat that can provide a survival function (e.g. habitat, food) for multiple life history stages of marine fish and invertebrates (Radio Canada International 2019). The extent to which seaweed provides three dimensional habitat for marine organisms has not been well studied in the Arctic. Włodarska-Kowalczuk et al. (2009) hypothesize that holdfasts of larger kelps provide refuge for organisms such as amphipods, as they offer protection from ice scour events. It is likely that established seaweed beds are important for a variety of life stages of marine species occurring in the coastal waters of Arctic environments. Furthermore, they are primary producers, and thus play an important role in broader ecosystem productivity during a relatively short open-water season (Glud et al. 2002). How subtidal kelp species that exist below the crush zone (area where ice impact destroys marine life annually) survive is not well understood. It is believed that some kelp species may continue to grow or survive during the iced season (CBC 2019). There are limited site specific studies that exist to document subtidal kelp populations in the region and those that are known have focused in and around northern Baffin Island (Cape Hatt in Eclipse Sound, Kupper et al. (2016), and Pond Inlet [Phillipe Archambault unpublished]).

There is interest in documenting the biomass and biodiversity of Arctic seaweed communities, given that the sea ice season continues to shorten, where it is predicted that the extent and range of seaweeds will change (CBC 2019). Increases in the extent of rockweed have been predicted (Jueterbock et al. 2016) and observed (Norway, Kortsch et al. 2012; Greenland, Weslawski et al. 2010) in the Arctic. The extent to which seaweed extent has changed in Admiralty Inlet has not been studied.

A variety of kelp species (bladder wrack, edible kelp, hollow stemmed kelp, sea colander, spiny sour weed, sea lungwort, dulse) are documented as 'areas of occupation' in and around Arctic Bay, Admiralty Inlet, and the Brodeur Peninsula (Cape Crauford) (see Figure 14 in Government of Nunavut (2010b), see Figure 1-3 for locations). When seaweed harvesting occurs, it is generally in the open water season (July through September). However, seaweeds are not harvested by residents of the Hamlet (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk).

11.1.2 Anadromous River Systems

There is no anadromous river system in or near Arctic Bay.

11.1.3 Focal Fish Species

Focal fish species were selected based on those that are important to the Inuit for harvesting as identified through the Project specific IQ (see Section 11.2.1 for methodology, Section 11.2.3 for results), online IQ, and online and published literature. Species identified as important were Arctic char (*Salvelinus alpinus*), Arctic cod (*Boreogadus saida*), sculpin and the truncate soft shell clam (*Mya truncata*).

11.1.3.1 Arctic char

Typical of salmonid species, Arctic char are ecologically and socio-economically important in Canada's Arctic. Arctic char represent the second-most widely consumed country food (Hurtubise 2016). Arctic char are the northernmost freshwater fish species (Brunner et al. 2001; Evans et al. 2015; W. W. F. C. Oceans North Conservation Society, and Ducks Unlimited Canada, 2018b) with a circumpolar distribution north of 75 °N with documented occurrences throughout Admiralty Inlet (Figure 10 in Appendix 1) and is not necessarily indicative of Arctic char density as more northern areas may be less studied. (W. W. F. C. Oceans North Conservation Society, and Ducks Unlimited Canada, 2018b).

Arctic char exist in both anadromous (referred to as sea run char by Nunavummiut) and lacustrine (land locked) forms, however, the focus of this desktop review is on the anadromous form as the proposed project occurs in the marine environment. Anadromous (sea run) char are not considered to be common in the high Arctic, but they sometimes occur where outflows are substantial enough to ensure a return migration in August (Government of Nunavut 2010b). Arctic char are present in areas in southern Admiralty Inlet, but which river system these fish may originate from is unknown (see Figure 7 from (Government of Nunavut 2010b) for 'areas of occupation'). These locations align with fishery areas identified in Figure 2 of Read (2000) and depicted in the inset of Figure 11-3.

The primary purpose of the seaward migration is to increase energy reserves, at which time they may double their body mass (Jørgensen et al. 1997) over a relatively short summer migration (approximately 20 to 45 days) (Bégout Anras et al. 1999; Klemetsen et al. 2003). Government of Nunavut (2010b) shows anadromous Arctic char being harvested from May through November but does not indicate if these are marine (anadromous) catches, and the earlier part of this range does not align with when the open-water season. Likely the harvesting from mid-July through September may indicate open-water harvesting (Government of Nunavut 2010b). Through the IQ Workshop, several individuals stated that sea run Arctic char are caught occasionally in the Bay (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk) *"Sea run char are not always caught every year, only periodically"* (Mishak Allurut. pers. comm. Nov 2019).

There is limited documented information on the migratory patterns of Arctic char in and around Arctic Bay to confirm where they are migrating from. There are no known tagging studies near Arctic Bay to provide conclusions. During the IQ Workshop one individual stated that the fish come from Marcil Lake (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk) (see Figure 13-1 for location). The extent to which Arctic char migrate, and what habitat features they prefer is poorly understood. From other studies in Nunavut, Arctic char prefer migrating along coastlines as opposed to across water bodies (J. W. Moore 1975; J.-S. Moore et al. 2016), and are typically found within 30 km of their natal rivers (Bégout Anras et al. 1999). Harris et al. (2014) found that coastline distance was the closest genetic link between fish in Cambridge Bay. Therefore, links are closer along coastlines, as opposed to across a bay for example, even if the coastline distance is farther. However, recent research conducted by DFO in Cambridge Bay found that a recently harvested char had migrated nearly 80 km from its 2013 tagging location (Nunatsiaq News 2019a). The most critical harvesting period is considered to be when the fish move from the lakes to the sea and back again (QIA 2018c). Typically, Arctic char return to their natal rivers (Harris et al. 2014; Kristofferson et al. 1984) although some straying does occur.

Despite the primary reason for marine migration to be driven by dietary requirements, very little is known about the diet of anadromous Arctic char, particularly at the local level. Arctic char are likely opportunistic predators, feeding on fish (capelin, northern sand lance), crustaceans (mysids, amphipods, decapods), polychaetes, and insects (Guiguer et al. 2002; Johnson 1989; J. W. Moore & Moore 1974; Rikardsen & Elliot 2000). The preferred prey likely varies between systems depending on availability. There have been no directed studies that exist in published or publicly available data, on the feeding preferences or migratory behaviours of Arctic Bay Arctic char. However, through the IQ Workshop, there is an abundance of amphipods in and around the rock areas in shallow waters of the bay (Arctic Bay IQ Workshop 2019 - Olayuk Nagitarvik). As Arctic char are opportunistic feeders, amphipods may be a component of their diet.

Arctic char spawn in freshwater in September and October over gravel. Eggs incubate under the ice for approximately six months and juveniles spend their early life history in freshwater (DFO 2013). Spawning season in the fall and spring migrations are key life history behaviours of anadromous Arctic char (QIA 2018c). The first migration to the sea occurs at approximately four to five years when they are 150 to 200 mm in length, but this size range likely differs depending on river systems. It is believed that Arctic char do not make their seaward migration the summer before they spawn, indicating this species needs to maintain energy reserves during their fecund period. This, in addition to a short period of energy accumulation during the short summer season, means that Arctic char typically do not spawn in consecutive years (Duitil 1986). Arctic char return to freshwater, regardless of their sexual maturity, likely an adaptation to avoid harsh environmental variables (e.g. freezing temperatures) (Klemetsen et al. 2003).

11.1.3.2 Arctic cod

Arctic cod (*Boreogadus saida*) are a pelagic marine species believed to be the single most important species in the trophic link between plankton, and marine birds and mammals in the Arctic ecosystem (Welch et al. 1992). This species is considered to be inferior to Arctic char in terms of a harvestable species, "*The cods poor diet and high water content leads to poorer tasting meat and shorter preservation*," (Hurtubise 2016; p43, pers comm July 13 2015). However, while they are less important than Arctic char in regard to human consumption, they are more important in consideration of the food chain of marine birds and mammals (Sekerak 1982). Arctic cod are a semelparous (single reproductive episode) highly fecund, fast-growing, short-lived fish species highly specialized to living in cold Arctic waters that are partially frozen for portions of the year (DFO 2016; Lawson et al. 1998). Hatching season for this species depends on the bloom of ice microalgae (January to July, peaks April to May) (Bouchard & Fortier 2011).

Migratory patterns of Arctic cod are not fully understood, with the exception of a pre-spawning late-summer migration to coastal waters (FAO 2017). The floe edge is an important ecological niche for Arctic cod, likely because they are feeding on the abundant sea ice zooplankton (Bradstreet 1982). At the floe edge, Arctic cod are predated on by numerous marine mammal and marine bird species. Arctic cod are known to form large schools in bays and inlets (R. E. Crawford & Jorgensen 1993; Hop et al. 1992), with approximate densities of 80 fish/m^3 and surface areas up to 4.6 hectares (R. E. Crawford & Jorgensen 1996).

Given their importance to the diet of marine mammals such as narwhals, who are known to be present in the fiords Admiralty Inlet in the open-water season (mid June to end of July (QIA 2018c), and given their abundance in nearby Lancaster Sound (Bradstreet 1982), it is probable they are present in the open-water season. IQ interviews confirmed that Arctic cod are present along the southern shore of Admiralty Inlet and at its entrance from Lancaster Sound (see Figure 9 of Government of Nunavut (2010b) for 'areas of occupation'). Arctic cod are caught in the bay, although not fished regularly (Mishak Allurut. pers. comm. Nov 2019). Not many people are catching them and they are considered to possibly be too small and going through the nets (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk).

11.1.3.3 Arctic Sculpin

Sculpins are generally solitary, benthic marine fishes belonging to the family Cottidae. Distinguished by a large broad head with a body that tapers toward the tail, large mouths with small teeth, two dorsal fins, large pectoral fins and one anal fin (University of Guelph 2019). There are five genera (*Artediellus*, *Gymnocanthus*, *Icelus*, *Myoxocephalus*, *Triglops*) and 14 species of sculpin that occur in the Canadian Arctic, the largest of which, those of the genus *Myoxocephalus*, can reach up to 60 cm in length, although most are much smaller (Alfonso et al. 2018).

Sculpins are ubiquitous in the Canadian Arctic and generally inhabit shallow coastal water, however, some are known to range as deep as 2000 m (Mechlenburg & Rask 2018). The Shorthorn sculpin (*Myoxocephalus scorpius*) and Arctic staghorn sculpin (*Gymnocanthus tricuspis*) are reported to be the species most commonly observed in Government of Nunavut (2010b) and so will be the focus of this desktop review (see Figure 10 of Government of Nunavut (2010b) for 'areas of occupation'). The shorthorn and Arctic staghorn sculpin distributions in Nunavut are shown in Figures 157 and 91 of Alfonso et al. (2018). Sculpins are found on all types of substrate, including underneath fronds of large-bladed kelp species (Moeller 2018). However the presence of sculpin were confirmed during the IQ Workshop, and sculpins in Arctic Bay during IQ interviews, and sculpin are listed as one of the key harvested species in Government of Nunavut (2010b). The presence of sculpins was further confirmed during the IQ workshop although they are rarely harvested for food by residents (Mishak Allurut. pers. comm. Nov 2019). (see Section 11.1.4.3).

Sculpins lay demersal eggs and the larvae become planktonic after hatching. These larvae are sometimes guarded by the male (Landry et al. 2018). There is limited information on the feeding habits of sculpins but they tend to be associated with generalist feeding behaviours, preying on larger invertebrates as well as small fish (Landry et al. 2018) Sculpin diet includes benthic molluscs, small fishes, crustaceans and worms. Due to very limited studies regarding sculpin feeding behaviour, there is a lack of quantitative, localized diet information available for Arctic Bay. Sculpins also serve as an important forage fish for larger organisms and are found in the stomachs of narwhal, belugas, bowheads and seals (Government of Nunavut 2010b; QIA 2018c).

11.1.3.4 Truncate Soft Shell Clam

The truncate soft shell clam (*Mya truncata*) is an important infaunal species in the Arctic. The distribution is largely influenced by ice scour events, either by direct mechanical interference, or modification of seafloor topography (Conlan & Kvitek 2005). This clam species is important to Arctic ecosystems for its role in carbon cycling and providing prey for many species of marine mammals. Given their sedentary adult life stage, they are a predictable food source for higher trophic level species (Highsmith & Coyle 1990). As is characteristic of other Arctic bivalves, the truncate soft shell clam has a long life span and low annual growth, which is influenced largely by the length of the open-water season (Piepenburg et al. 2011). Habitat preferences of this particular species have not been studied extensively, but a similar sub-arctic species (*M. arenaria*) showed higher densities in eddies, estuaries, and in slack water adjacent to swift currents (Cristian et al. 2010).

The truncate soft shell clam is known to be present in Arctic Bay (Government of Nunavut 2010b). Through IQ, clams are documented as occurring in Arctic Bay, across from Arctic Bay on the southern shore of Admiralty Inlet, and on Brodeur Peninsula at the Admiralty Inlet entrance (summarized in Figure 13 of Government of Nunavut (2010b) for 'areas of occupancy'). It appears clams are documented as present throughout the spring (May), with higher abundances noted during open-water season (July to September). There are no details to describe how clams are accessed during the time the ocean is frozen. There is no available literature to support that clams in and around the community foreshore are harvested. There are known distributions of clams in Arctic Bay (see Figure 2-1), although they are not harvested for subsistence reasons (see Section 11.1.4.4).

11.1.3.5 Amphipods

Amphipods are common throughout the Arctic in both benthic and pelagic environments, with many species endemic to the Arctic. Their distribution is mainly dictated by habitat type and food resources available (Oceans North Conservation Society et al. 2018). Arctic amphipods tend to be larger than those in lower latitudes, on average 20 mm and no longer than 50 mm in length. There are at least 920 known benthic amphipod species in the Arctic (Census of Marine Life 2017), generally dominated by the Gammaridae family in benthic habitats, and Hyperiidae in pelagic habitats (Oceans North Conservation Society et al. 2018).

Amphipod species within the Arctic Circle occupy a diverse range of habitats, including the sea floor, open water environments, and beneath the sea ice in coastal and offshore areas. Benthic amphipods occupy a variety of substrates such as rocky intertidal and soft bottomed subtidal areas. When amphipods are present in intertidal benthic environment, there is a tendency to be associated with moist habitats, which consist of either rocks (boulder, cobble) or seaweed (typically rockweed). The flexible habitat requirements seen in many benthic amphipod species are likely due to their opportunistic diet strategies. Many are detritivores, scavenging for plant and animal detritus. However, some species found in Nunavut are carnivorous. The common *Themisto libellula* has been observed in both surface and benthic environments, and consumes calanoid copepods (Hobson et al. 2002), and has been noted as a key trophic link in Arctic food webs (Dunbar 1957). Ampeliscid (tube-building amphipods), most commonly *Ampeliscus eschricti*, have a fairly widespread geographic distribution and are a main food source for grey whales (*Eschrictius robustus*) during their residence in the Arctic (Demchenko et al. 2016). Walrus and bowhead whales are known to consume benthic amphipods as a small proportion of their diet, particularly *T. libellula* (Hobson et al. 2002). A diversity of benthic and pelagic fishes, benthic-feeding eider ducks and bearded seals are also known to consume benthic amphipods, however species-specific information is lacking (J. A. Crawford et al. 2015; Whitehouse et al. 2017).

The peer-reviewed literature does not present evidence that benthic amphipods are directly harvested for consumption in the Arctic. Regardless, the evidence is clear that benthic amphipods are a primary food source for higher trophic level animals of commercial and cultural interest, highlighting their importance to the integrity of Arctic food webs. One Arctic specialty is to eat the bearded seal stomach when it is full of amphipods (local knowledge holder pers. comm). In Arctic Bay, 2020 field surveys showed that amphipods were abundant in the low intertidal zone.

11.1.4 Fishery Resource

Fisheries in Nunavut occur as traditional food (subsistence), commercial (inshore traditional and offshore non traditional), and recreational fisheries (Boudreau & Fanning 2016; Nunatsiaq News 2018). Commercial fisheries are managed collaboratively under the Nunavut Agreement (Boudreau & Fanning 2016; Kristofferson & Berkes 2005). Management of commercial fisheries by the Nunavut Agreement, is accomplished with a co-management approach that includes: NWMB, Nunavut Tunngavik Incorporated (NTI), GN, DFO, Regional Wildlife Organizations (RWOs), and Hunters and Trappers Organizations /Associations (HTOs/ HTAs) (GN EFS 2016). Commercial fisheries in Nunavut are considered as offshore and inshore fisheries, with offshore targeting Greenland halibut and northern shrimp, and the inshore targeting Arctic char and Greenland halibut. The potential for clams, scallops and crab are being explored (Nunavut Marine Council 2019). The Nunavut Fisheries Association (NFA) was developed in 2012, and is composed of the four Inuit owned companies which own all of the offshore shrimp and turbot allocations (Arctic Fishery Alliance [AFA], Baffin Fisheries, Pangnirtung Fisheries, Qikiqtaaluk Corporation) (Qikiqtaaluk Corporation 2018). The Hamlet of Arctic Bay is a co-owner of AFA (AFA 2018). The AFA have a vessel (Kiviuq 1) used for exploratory fisheries (AFA 2018) which in recent years has regularly been in the high Arctic Waters, including Admiralty Inlet seeking opportunities for commercial harvests for Greenland halibut and shrimp (Navigator 2015). The AFA works with Memorial University of Newfoundland (MUN) on this endeavor. An exploratory license was first requested from DFO in 2008 by the HTAs of Grise Fiord, Arctic Bay and Resolute Bay for inshore fishing in Jones Sound, Admiralty Inlet, and Parry Sound, respectively (DFO 2008).

Although the Nunavut Agreement came into effect in 1993 and Nunavut was established in 1999, Nunavut fisheries are still managed under the Northwest Territories Fishery Regulations (Government of Canada 2019e, 2019i). Nunavut Fishery Regulations are being developed cooperatively between DFO, NTI, NWMB, the GN and the Makivik Corporation. A consultation period was run from February 11, 2018 to July 31, 2019 (Government of Canada 2019c).

11.1.4.1 Arctic char

Arctic char is a highly valued fish species to the people of Nunavut for subsistence and commercial fisheries, which exist primarily in Cambridge Bay and Cumberland Sound (DFO 2014a). An Integrated Fisheries Management Plan (IFMP) has been developed for the Cambridge Bay fishery (DFO 2014a), and are not developed for subsistence fisheries in the territory. However, there is growing interest in developing commercial fisheries in the territory. There are currently no exploratory fisheries for Arctic char occurring in Arctic Bay. Arctic char fishery stocks in southern Admiralty Inlet are considered 'vulnerable stocks – sustainable fisheries' and 'more vulnerable stocks – less sustainable fisheries' by DFO (2004a). This assessment requires more detailed information on local stocks to confirm DFO's understanding, as many of the category ratings are due to a lack of data. There are currently several collaborative research projects occurring throughout Nunavut between DFO and the relevant HTOs/HTAs to fill these information gaps. Subsistence fisheries are an important component of the diets of the people of Nunavut, who depend on these fisheries for their livelihood. QIA (2018a) converted country foods into a monetary value, where the value of Arctic char country foods fishery for a study which involved six communities (Grise Fiord, Arctic Bay, Pond Inlet, Clyde River, Qikiqtaarjuak, Pangnirtung), provided a substitution value of $1,120,755.

Arctic char fisheries are managed by DFO on the assumption that each river system supports a discrete fish stock (Kristofferson et al. 1984), leading DFO to conclude there are vulnerabilities in assessing the sustainability of Arctic char in the Admiralty Inlet region, as these stocks have not been defined. The Arctic char fisheries to date in close proximity to the SCH Study Area are mainly harvested for subsistence purposes as informed through community consultation (Section 2) and desktop review.

Commercially, Arctic char are harvested using gillnets (DFO 2013), and in some locations subsistence fisheries use angling and snagging (Vangerwen-Toyne et al. 2013). In Arctic Bay, Arctic char are harvested primarily by gillnets with a few individuals using hook-and-line fisheries (see Section 11.1.3.1), and only for subsistence and recreational purposes. Arctic char is an important subsistence fishery with the number of harvesters documented at 175 average from 1996 to 2001 in the Nunavut Wildlife Harvest Study (Priest & Usher 2004).

At the territorial level, efforts are underway to determine the efficacy of expanding the commercial Arctic char fleet, which in 2012 had a landed value of $186,000 (DFO 2014a). GN & NTI (2005) is keen to develop the recreational fishery, which typically has a greater value per fish.

11.1.4.2 Arctic Cod

As indicated earlier in this section, Arctic cod are not considered as valuable as Arctic char, and thus are not a primary subsistence fishery in Nunavut. There is interest in commercial fisheries for this species (CBC 2015b; Nunatsiaq Online 2016). However, there are currently no commercial fisheries or exploratory fishery licenses for fishing Arctic cod in or around Arctic Bay and viability is affected by the lack of local fuelling facilities for large commercial vessels.

11.1.4.3 Arctic Sculpin

There are no commercial fisheries for Arctic sculpins in Nunavut, however, it is considered an important subsistence fishery species (Government of Nunavut 2010b; QIA 2018c). Sculpins are often by-catch to other targeted fisheries, used as bait, or caught for scientific research (Department of Fisheries and Aquaculture 2019).

Although the third most commonly hunted marine species by the Inuit (Hurtubise 2016), sculpins are typically not the primary targets for subsistence fishing and are often caught on accident or recreationally (Priest & Usher 2004). However, (QIA 2018c) list them as one of the most important subsistence fisheries. Over a five year period, an average of five harvesters fished for sculpin in Arctic Bay (Priest & Usher 2004).While sculpins are present in Arctic Bay, as sculpins are caught in the bay (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk). However, the sculpins are not regularly fished for food (Mishak Allurut. pers. comm. Nov 2019).

11.1.4.4 Clams

There is no commercial fishery for benthic species, including clams in Arctic Bay, and this species is not currently harvested for subsistence purposes. Clams are included in the category of sea floor dwellers in QIA (2018) and are considered to be critical for food chain dynamics of larger predators such as marine mammals, fish and marine birds.

There is interest in expanding commercially exploited fisheries in Nunavut, some of which include soft shell clam, soft corals, amphipods, brittle stars, and brown sea cucumber (*Cucumaria frondosa*) (Boudreau & Fanning 2016). However, at this time, there are no known exploratory fisheries occurring in the vicinity of Arctic Bay. The number of harvesters documented was a total of three from 1996 to 2001 in the NWHS (Priest & Usher 2004). While clams are present in Arctic Bay, harvesting them is rare as it requires SCUBA equipment or long poles (Arctic Bay IQ Workshop 2019 - Tom Nagitarvik). There is one person who used to dive for them but no longer does (Mishak Allurut. pers. comm. Nov 2019).

Table 11-1 Number of Hunters harvesting each Species in Arctic Bay (June 1996 to May 2001)

Species	Year					Total
	Y1 (June 1996 – May 1997)	Y2 (June 1997 – May 1998)	Y3 (June 1998 – May 1999)	Y4 (June 1999 – May 2000)	Y5 (June 2000 – May 2001)	
Arctic char	95	84	92	90	106	467
Cod	5	5	3	5	1	19
Sculpin	7	4	9	7	2	29
Clams		1	1	1		3

Source: Table 34 from Priest and Usher (2004)

11.2 Field Program – Marine

Quantitative surveys were undertaken in 2019 (August 9, 10) and 2020 (September 19 to 24) to characterize the seabed conditions of the intertidal and subtidal areas. The 2019 survey targeted SCH and DAS Study Areas and the 2020 survey was focused on the SCH Study Area.

11.2.1 Methodology

Habitat was characterized in the Study Areas (SCH, DAS) using a combination of intertidal and subtidal habitat survey techniques. The survey zones are defined as follows:

- Intertidal: High water mark (HWM) to the low water mark (LWM)
- Subtidal: All water below LWM

11.2.1.1 Survey Location

Surveys were focused within the Study Areas (SCH, DAS, see Table 11-2, Figure 11-1, Figure 11-2, Figure 11-3).

Table 11-2 Marine Field Studies Fish and Fish Habitat Surveys

Survey Type	Study Area	Date (2019)	Date (2020)
Intertidal (quadrat)	SCH	10 August 2019	19 September 2020
Subtidal (ROV, transect)	SCH, DAS	09 August 2019	NA
Subtidal (Snorkel, quadrat)	SCH	NA	21 September 2020

Legend

SCH Footprint

SCH Study Area

Transects

Start

End

Subtidal (2019)

Intertidal (2019 & 2020)

0 20 40 80

Metres

1:3,000

WGS 1984 UTM Zone 16N

Imagery Source: CHS, July 2017

FISHERIES AND OCEANS CANADA
SMALL CRAFT HARBOURS
ARCTIC BAY

SMALL CRAFT HARBOUR

2019 & 2020 INTERTIDAL AND SUBTIDAL TRANSECT SURVEYS

Date: 28-MAY-21	Drawn by: KR	Edited by: KR	App'd by: VB
		Project No. 317071-00037	
		FIG No 11-1	REV 0

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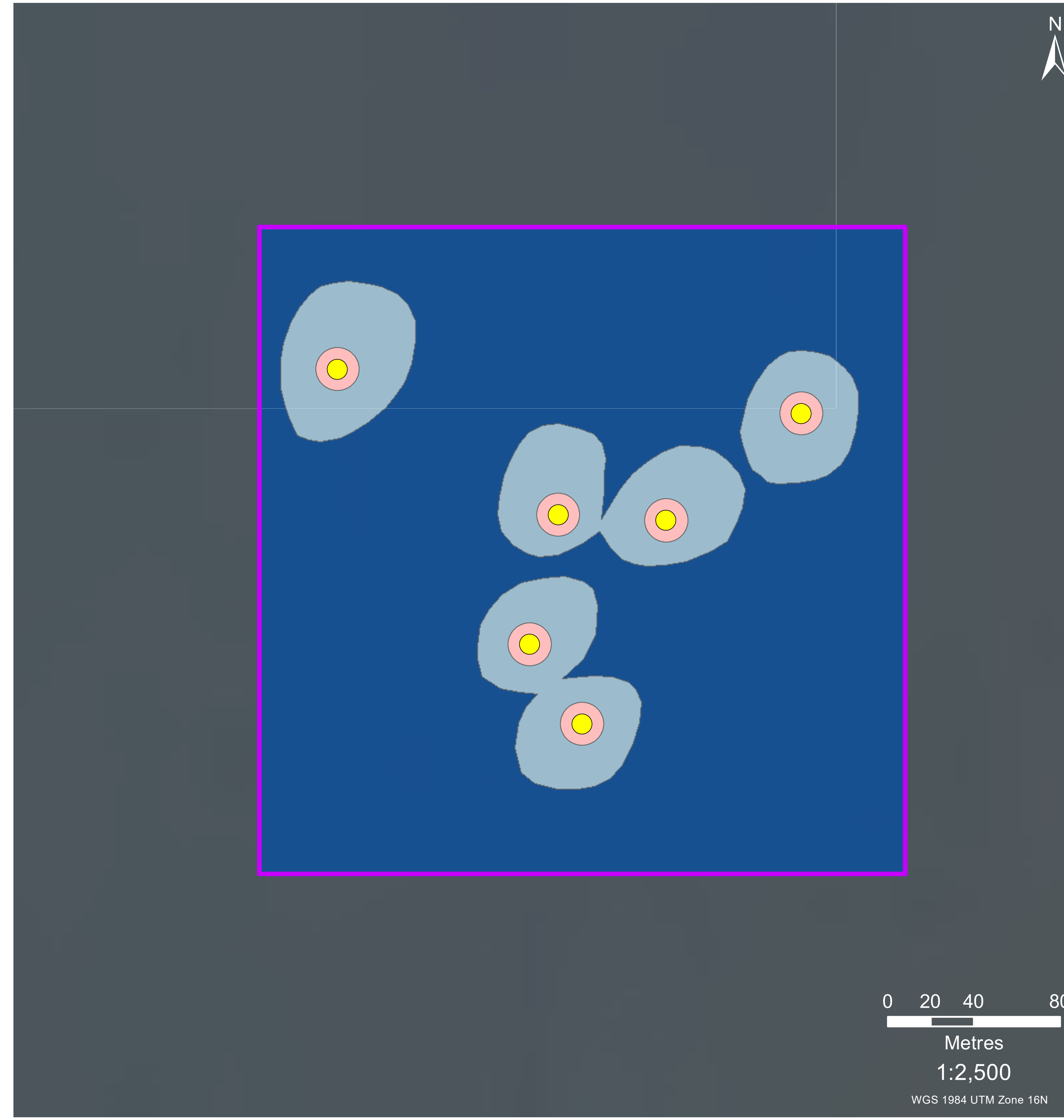

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Study Area
- SCH
- DAS

- ROV Start Location
- ROV Observation Area
- Brittle Stars Surveyed Habitat (20 - 50 per sq m)
- Brittle Stars Interpreted Habitat

Locations approximate.

FISHERIES AND OCEANS CANADA
SMALL CRAFT HARBOURS
ARCTIC BAY

DISPOSAL AT SEA
2019 SUBTIDAL TRANSECT SURVEYS

Date: 20-MAY-21	Drawn by: KR	Edited by: KR	App'd by: VB
		Project No. 317071-00037	
		FIG No 11-2	REV 0

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11.2.1.2 Field Survey Techniques

Intertidal (SCH Study Area) and subtidal (SCH, DAS Study Areas) transects were conducted to determine habitat characteristics along the foreshore of the Study Areas(see Section 1.4 for Study Area definitions). 'Control' or reference areas were selected for the fish habitat study, which will be areas that are not impacted by the construction of the SCH, and thus outside of the Project footprint. These areas will serve for future studies to compare 'natural' changes to the seabed habitat. Tidal conditions on the date of the survey are provided in Table 1-4. Transect locations for the field surveys are provided in Table 11-3 for the intertidal surveys and in Table 11-4 and Table 11-5 for the subtidal project footprint and DAS site surveys. Photographs and video recordings from the field surveys were later analyzed by the enumeration techniques described in Table 11-7 for substrate and Table 11-8 for categorizations of marine fauna/flora. Habitat was categorized by the quality definitions provided in Table 11-9. Sessile and motile fauna abundance estimates are counts, percent cover, or relative estimates, depending on the particular organism being assessed. Sessile and motile fauna observed abundance estimates are counts, percent cover, or relative estimates, depending on the particular organism being assessed. Marine vegetation was assessed through a percent cover estimate and sessile invertebrates were assessed through a combination of counts and aerial coverage in square metres (m^2), depending on their abundance. Mobile organisms were assessed with a count.

Intertidal Habitat

Transects were established perpendicular to the shoreline at regular intervals from the HWM to the water line, both within and adjacent to the SCH Study Area. Perpendicular transects facilitate the identification of transitions between habitat types, as zonation is a strong feature of intertidal communities for both rocky and sandy communities. A total of five transects were set in the intertidal zone for the SCH Study Area (Figure 11-1). Transect start and stop points and habitat band transitions were delineated with a GPS. A habitat band was defined as an observable differentiation of biophysical features (substrate, fauna, flora) across a vertical gradient. The same transect locations were used during both years (see Table 11-3). A total of 29 quadrats were assessed during the 2019 field survey, and a total of 58 quadrats were assessed during the 2020 field survey as the tide was greater at the time of the survey.

Photographs were taken of each habitat band within each transect, and individual photographs were taken of identified taxa. Observed flora and fauna were identified to the lowest possible taxonomic level.

Table 11-3 Intertidal Transects Conducted at the Arctic Bay SCH Study Area on August 10, 2019 and September 19, 2020

Transect #	Start		Stop		2019		2020		Quadrat Spacing (m)	Distance from Previous Transect (m)
	Latitude	Longitude	Latitude	Longitude	Transect Length (m)	Number of Quadrats	Transect Length (m)	Number of Quadrats		
Transect 1	73° 2.069'N	85° 9.364'W	73° 2.062'N	85° 9.359'W	11	6	22	12	2	
Transect 2	73° 2.036'N	85° 9.455'W	73° 2.032'N	85° 9.450'W	8	6	9	7	1.5	80
Transect 3	73° 2.014'N	85° 9.562'W	73° 2.008'N	85° 9.557'W	9.5	5	18	10	2	80
Transect 4	73° 1.970'N	85° 9.726'W	73° 1.966'N	85° 9.715'W	10	6	34	18	2	120
Transect 5	73° 1.916'N	85° 9.838'W	73° 1.910'N	85° 9.831'W	10	6	20	11	2	120

Subtidal Habitat – 2019

Subtidal habitat transects were conducted using a VideoRay Pro 4 ROV. Survey methodology varied between the SCH and DAS Study Area due to depths as the ROV is more difficult to manoeuvre in deeper waters.

Within the SCH Study Area, parallel (east-west) and perpendicular (north-south) to shore transects were conducted. Parallel to shore transects were initiated on the eastern or western side of the SCH Study Area, depending on currents and wind direction. The boat was anchored at the start position, and the ROV travelled for 10 m to 60 m in a parallel to shore direction. The distance was estimated by the length of tether that had been run out. A GPS position was taken at the start position, and the end position was estimated using the AvenaPDF measuring application. The transects conducted outside of the footprint served as a control. Twenty-two and two parallel and perpendicular to shore transects were conducted. One transect was conducted along the western edge of the existing breakwater.

Within the DAS Study Area, the ROV was deployed on auto depth to a setting that was 2 m above the seabed, as determined by the use of a Lowrance depth sounder. Once on the bottom, the ROV travelled in a 10 m circumference. Five transects were conducted in the DAS Study Area and 1 control transect was conducted at a nearby reference location.

Video recordings were later analyzed by the enumeration techniques described in Section 11.2.1.3) A subset of images were analyzed which were considered representative of the relevant transect. Images were taken during the survey, as the ROV can record and photograph simultaneously. Additional images were taken as video snapshots using the program Adobe Premiere Pro CC 2019. Where possible, exact counts were provided, but were otherwise in relative abundance. When there was uncertainty in the species identification, an indication of ‘possible’ (poss) or ‘probable’ (prob) is provided.

Table 11-4 Subtidal Transects Conducted at the Arctic Bay SCH Study Area on August 9, 2019

Transect #	Type	Start		Stop		Time	Tide Height (m)	Depth (m)		Length (m)
		Latitude (N)	Longitude (W)	Latitude	Longitude	Start		Sounder (m)	CD (m)	
T1	PL	73° 1.814'N	85° 9.841'W	73° 1.837'N	85° 9.837'W	8:56	1.7	2.4	0.7	10
T2	PL	73° 1.819'N	85° 9.811'W	73° 1.828'N	85° 9.812'W	9:00	1.5	4.5	3.0	10
T3	PL	73° 1.814'N	85° 9.661'W	73° 1.836'N	85° 9.652'W	9:13	1.5	2.0	10.5	40
T4	PL	73° 1.884'N	85° 9.760'W	73° 1.901'N	85° 9.710'W	9:34	1.5	2.5	1.0	40
T5	PL	73° 1.926'N	85° 9.641'W	73° 1.941'N	85° 9.590'W	9:57	1.5	3.5	2.0	40
T6	PL	73° 1.885'N	85° 9.630'W	73° 1.905'N	85° 9.541'W	9:59	1.5	8.1	6.6	60
T7	PL	73° 1.940'N	85° 9.519'W	73° 1.967'N	85° 9.423'W	10:11	1.3	6.2	4.9	70
T8	PL	73° 1.969'N	85° 9.382'W	73° 1.983'N	85° 9.303'W	10:20	1.3	7.8	6.5	50
T9	PL	73° 1.985'N	85° 9.270'W	73° 1.997'N	85° 9.205'W	10:32	1.3	11	9.7	40
T10	PL	73° 2.001'N	85° 9.187'W	73° 2.018'N	85° 9.092'W	10:41	1.3	12.7	11.4	60
T11	PL	73° 2.039'N	85° 9.294'W	73° 2.057'N	85° 9.200'W	10:59	1.3	2.1	0.8	60
T12	BW	73° 2.042'N	85° 9.349'W	73° 1.983'N	85° 9.452'W	11:08	1.0	1.2	0.2	120
T13	PL	73° 1.977'N	85° 9.519'W	73° 1.942'N	85° 9.584'W	11:33	1.0	13	12.0	75
T14	PL	73° 1.923'N	85° 9.705'W	73° 1.953'N	85° 9.643'W	11:52	1.0	20	19.0	65
T15	PR	73° 2.009'N	85° 9.540'W	73° 1.993'N	85° 9.468'W	13:00	0.6	0.5	0.1	50
T16	PL	73° 1.907'N	85° 9.521'W	73° 1.922'N	85° 9.448'W	15:17	0.6	12	11.4	50
T17	PL	73° 1.952'N	85° 9.379'W	73° 1.967'N	85° 9.326'W	13:28	0.6	10.1	9.5	40
T18	PL	73° 1.950'N	85° 9.299'W	73° 1.960'N	85° 9.247'W	15:43	0.6	15	14.4	30

Transect #	Type	Start		Stop		Time	Tide Height (m)	Depth (m)		Length (m)
		Latitude (N)	Longitude (W)	Latitude	Longitude	Start		Sounder (m)	CD (m)	
T19	PL	73° 2.048'N	85° 9.095'W	73° 2.068'N	85° 8.976'W	15:55	0.6	14.9	14.3	70
T20	PR	73° 2.016'N	85° 9.470'W	73° 2.027'N	85° 9.425'W	16:10	0.8	1.0	0.2	30
T21	PL	73° 1.947'N	85° 9.719'W	73° 1.923'N	85° 9.787'W	16:35	0.8	1.4	0.6	55
T22	PL	73° 1.959'N	85° 9.601'W	73° 1.961'N	85° 9.501'W	16:46	0.8	4	3.2	55
T23	PR	73° 2.037'N	85° 9.468'W	73° 2.027'N	85° 9.403'W	19:35	1.6	0.5	+1.1	40
T24	PR	73° 2.028'N	85° 9.478'W	73° 2.012'N	85° 9.418'W	19:44	1.6	1	+0.6	40
T25	PR	73° 1.972'N	85° 9.594'W	73° 1.993'N	85° 9.662'W	20:00	1.8	1.5	+0.3	55

Note : PL= Parallel, PR= perpendicular, BW=breakwater

Table 11-5 Information on Subtidal Transects Conducted at the DAS Study Area. August 09, 2019

Transect #	Start		Time	Tide Height (m)	Depth (m)	
	Latitude (N)	Longitude (W)	Start		Sounder (m)	CD (m)
T1	73° 1.512'N	85° 8.776'W	13:19	0.6	60.5	59.9
T2	73° 1.456'N	85° 9.015'W	13:38	0.6	57.1	56.5
T3	73° 1.488'N	85° 8.987'W	13:58	0.6	57.4	56.8
T4	73° 1.525'N	85° 9.156'W	14:11	0.6	54	53.4
T5	73° 1.486'N	85° 8.895'W	14:26	0.6	58.1	57.5
T6	73° 1.436'N	85° 8.972'W	14:56	0.6	59	58.4
T7	73° 1.594'N	85° 8.740'W	17:05	1.1	60	58.9

Subtidal Habitat – 2020

A more quantitative subtidal habitat survey was planned for 2020 to build on the 2019 information. Subtidal habitat transects were conducted through snorkelling with hand-held video footage from a GoPro 8 camera.

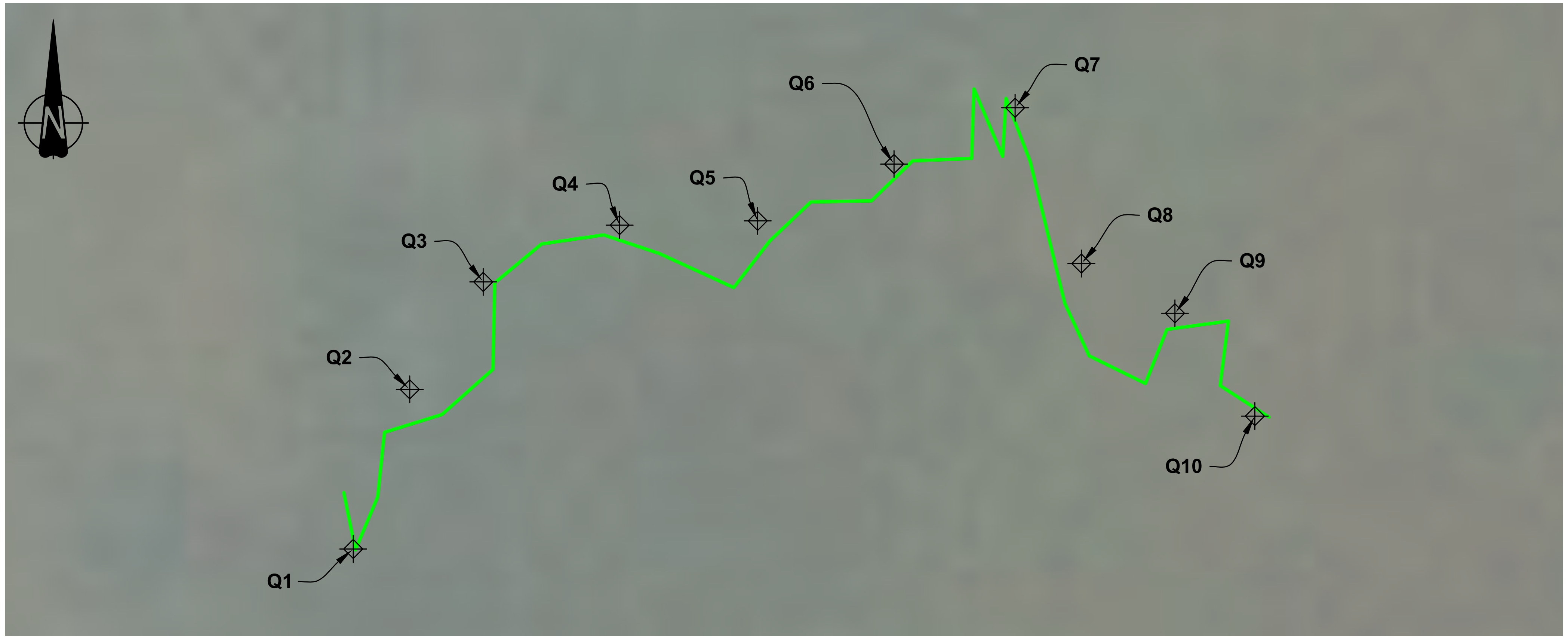
Within the SCH Study Area, the survey focused on the rockweed habitat west of the existing breakwater (see Figure 11-5). The snorkel survey was carried out in three phases, with Phase 1, 2 and 3 occurring on 21, 23 and 24 of September 2020 respectively. For all phases, the swim track was GPS referenced by towing an iPad on a float and running the Avenza PDF program in track mode. When the GoPro was used for videos or photographs, the GPS position can be confirmed by aligning the time stamp of the GPS with the GoPro footage The snorkeller towed the float to maintain an accurate track.

Phase 1 had the intention to map the spatial boundaries of the rockweed bed. The rockweed bed was considered to be an area with a minimum aerial coverage of 80% rockweed, where rockweed patches were less than 2 m apart. If more than 2 m apart, rockweed beds would be considered separate patches. The snorkeller swam around the rockweed to generate rockweed polygons.

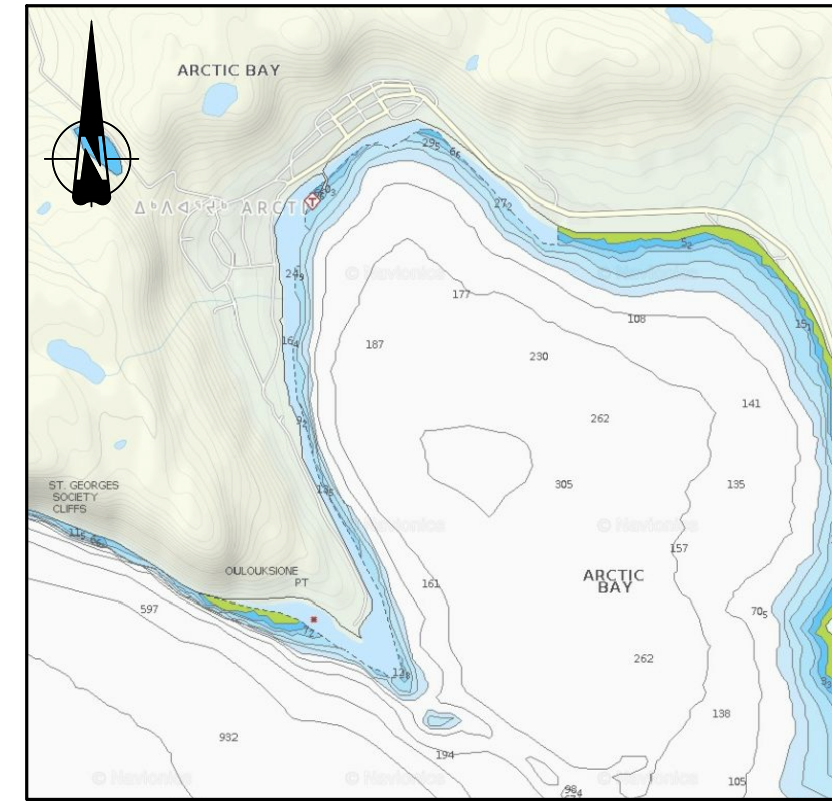
Phase 2 of the survey was a swim through the defined rockweed bed (polygons from Phase 1) with the GoPro in video mode. Post field, representative photographs were extracted as screenshots. Similar to Phase 1, a track was maintained of the swim to provide the opportunity to geo-reference photographs and video. The polygon, video transect, quadrat transect and quadrat locations are depicted in Figure 11-3.

Phase 3 consisted of a random quadrat survey in the Phase 1 rockweed bed. The snorkeller swam though the rockweed polygon, and randomly placed a 0.25 m^2 quadrat on the seabed. Once the snorkeller placed the quadrat, the float (and GPS) were pulled as close as possible to be immediately overhead. This enabled an accurate GPS position to be taken as described for the Phase 2 survey. A total of 10 quadrats were assessed (see Table 11-4) using the same techniques as the intertidal survey.

Video recordings and photographs were later analyzed by the enumeration techniques described in Section 11.2.1.3. Additional images were taken as video snapshots using the program VLC media player 2020. Where possible, exact counts were provided, but were otherwise in relative abundance.



PLAN - QUADRAT SURVEY
1:200



PLAN - CHART
NTS

PLAN - ROCKWEED BED
1:1500

LEGEND:

- ROCKWEED BED
- ROCKWEED - PHASE 1
- ROCKWEED - PHASE 2
- ROCKWEED - PHASE 3

GOVERNMENT OF NUNAVUT
ARCTIC BAY

SNORKEL SURVEY
ROCKWEED MAPPING AND QUADRAT LOCATIONS

Date: 17-DEC-20	Drawn by: JLC	Edited by: JLC	App'd by: HGK
Advisian Worley Group; Ikpiaryuk Services Ltd.		WorleyParsons Project No. 317071-00037	
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USER NAME: tania.muller
ISSUING OFFICE: VANCOUVER
PLOT DATE & TIME: 31/5/2021 4:39:51 PM
SAVE DATE & TIME: 31/5/2021 4:35:24 PM

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Table 11-6 Subtidal Habitat Transects Conducted at the Arctic Bay SCH Study Area on September 24, 2020

Quadrat #	Latitude	Longitude	Time	Gauge Depth (m)	Tide height (m)	CD (m)
Quadrat 1	73° 1.895'N	85° 9.796' W	8:19	2.2	0.5	1.7
Quadrat 2	73° 1.898'N	85° 9.792'W	8:21	2.1	0.5	1.6
Quadrat 3	73° 1.900'N	85° 9.787'W	8:24	1.8	0.5	1.3
Quadrat 4	73° 1.901'N	85° 9.778'W	8:27	1.6	0.5	1.1
Quadrat 5	73° 1.901'N	85° 9.769'W	8:30	1.5	0.5	1.0
Quadrat 6	73° 1.902'N	85° 9.760'W	8:32	1.4	0.5	0.9
Quadrat 7	73° 1.903'N	85° 9.752'W	8:33	1.1	0.5	0.6
Quadrat 8	73° 1.900'N	85° 9.748'W	8:34	1.1	0.5	0.6
Quadrat 9	73° 1.899'N	85° 9.742'W	8:35	1.0	0.5	0.5
Quadrat 10	73° 1.897'N	85° 9.737'W	8:37	1.0	0.5	0.5

11.2.1.3 Habitat Characterization

Substrate categories for both surveys were as defined by (DFO 1990) (see Table 11-7). Marine plant observations were recorded as a percent areal cover (DFO 1990). The addition of the 'infrequent' category is specific to the fish and fish habitat survey and was added to address the patchy and ephemeral nature of marine habitats. Sessile and motile fauna observed abundance estimates are counts, percent cover, or relative estimates, depending on the particular organism being assessed. When using relative estimates, the categories defined in Table 11-8 are used.

Table 11-7 Substrate Categories for the Marine Fish and Fish Habitat Field Assessment

Substrate	Definition	Size (mm)
Silt, clay, mud	Loose sedimentary deposit	<0.0625
Sand	Loose granular material	0.0625 – 2
Gravel	Loose fragments of rock	2 – 64
Cobble	Loose stone larger than gravel, smaller than a boulder	64 – 256
Boulder	Detached mass of rock	>256
Bedrock	Solid rock underlying unconsolidated surface material	
Shell hash	Shell fragments of various organisms	

Source: DFO (1990)

Table 11-8 Categorizations of Marine Fauna when Enumerated with Estimates

Category	Definition	Quantified Area Estimate	
		Percent Cover	Area (m^2) estimates
Abundant	Organisms distributed as the primary flora or fauna	Distribution that covered an area >60% of available suitable habitat	20 to 50
Moderate	Organisms either clustered in groups or sporadic within the habitat zone	Distribution covering 25% to 50% of available habitat	10 to 20
Infrequent	Combination of moderate and trace, patchy and ephemeral in nature, occurring in more frequent clusters than trace		
Trace	Relatively small cluster of colonizing organisms	(<10% to 25%) of assessed area.	5 to 10

Source: DFO (1990), exception is 'Infrequent' this was specific to this survey

Table 11-9 Habitat Categories

Category	Description
High	High value habitat that contribute to a critical life stage or function (e.g. feeding, nursery, reproductive, migratory route) of a marine species, or that are of high social or cultural significance. Additionally, loss of the habitat in question is limited or could result in decreased connectivity of a marine species or population.
Moderate	Habitat that may contribute to critical life stages or function of a marine species but is not limited.
Low	Habitat does not contribute to life stages and functions of marine species and is not limited. Habitat may be used as, or is likely to be used for migratory purposes of marine species, but alternative migratory routes are available.

11.2.1.4 Quality Assurance/Quality Control

Subtidal Snorkel and ROV Survey

- Subtidal towed video surveys were recorded and backed up on field laptops, providing a copy both to the Advisian network and a back up drive of the data for review at a later date.
- The video feed was monitored throughout the survey to verify the camera was not obstructed and that the recording was of sufficient quality for later analysis.

11.2.2 Drone Survey

A drone survey was conducted by ArcticUAV on August 22, 2019 on the Arctic Bay foreshore area during a separate field survey (see Figure 11-4). The purpose of the survey was to support the feasibility phase of the Project and was commissioned by DFO-SCH. The imagery was provided to Advisian to support the fish and fish habitat program. Georeferencing information was not available at the time of this report, and the spatial coverage was not sufficient to encompass the SCH Study Area, so this map was not used to support habitat mapping. It does, however, provide demonstrative habitat of the intertidal and shallow subtidal characteristics and has therefore been used as reference material in the discussion.

11.2.3 Results

Details from the fish habitat survey are provided in Tables 7 to 11 in Appendix 5, for the 2019 SCH intertidal and subtidal, DAS subtidal, and the 2020 SCH intertidal and subtidal snorkel survey respectively.

Representative photos of the 2019 and 2020 intertidal surveys are provided in Photo 11-1 and Photo 11-2. Overview and quadrat photo panels of each transect are provided in Photos 2 through 6 of Appendix 3 (2019) and Photos 7 through 11 of Appendix 3 (2020).

Photo panels of the parallel and perpendicular to shore transects for the 2019 SCH subtidal survey, broken down by transect number are provided in Photo 12 of Appendix 3. A representative photo of the SCH Study Area subtidal zone is provided in Photo 11-3.

Photo panels of the transects for the 2019 DAS Study Area subtidal survey, broken down by transect number are provided in Photo 13 of Appendix 3, with representative photos provided in Photo 11-5.

Photo panels of the transects for the 2020 snorkel survey in the subtidal zone are provided in Photo 14, Appendix 3 with representative photos provided in Photo 11-4.

11.2.3.1 Intertidal

In 2019, the tidal range of the SCH intertidal was 1.2 m and in 2020 was 2.1 m. Characteristics of the intertidal area between 2019 and 2020 were very similar, even with a greater tidal extent in 2020.

SCH Study Area – 2019 and 2020

The intertidal shoreline observed in Arctic Bay was a largely rocky substrate which was primarily cobble and gravel (see demonstrative view in Photo 11-1 [2019], Photo 11-2 [2020]). Observations of marine vegetation were minimal with trace coverage of rockweed. The exception to this in 2020 was at Transect 4 where quadrats 17 and 18 were 90% cover by rockweed. No invertebrates were observed in 2019, however amphipods were observed in 2020 in trace to moderate amounts and generally under large cobble. There were no observations of fish in either year. Observations between years were similar, although a larger tidal range was observed in 2020 versus 2019, with the slope distance ranging between 8 m to 11 m in 2019 and between 9 m to 22 m in 2020 (see Table 11-3).

Photo 11-1 Arctic Bay Intertidal Foreshore. Photos taken on August 10, 2019

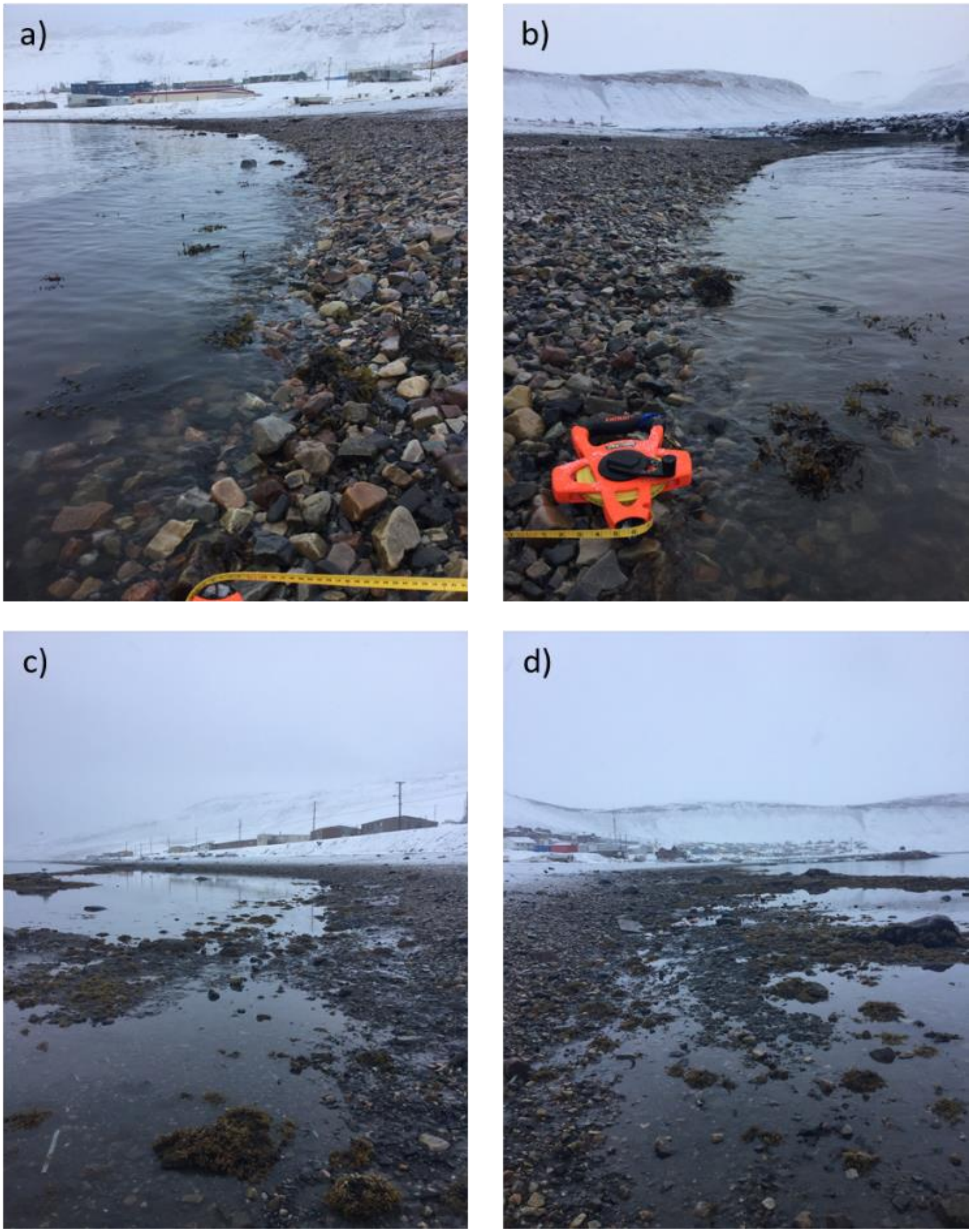

Photo 11-2 Arctic Bay Intertidal Foreshore. Photos taken on September 19, 2020

11.2.3.2 Subtidal

SCH Study Area – 2019

The depth range of the area observed during the subtidal field survey ranged from 0.5 m to 9 m CD. Substrates observed within the SCH Study Area were primarily soft substrates (sand) with occasional boulder, which were at times in clusters. Other substrates observed on top of the sand were cobble and shell hash. Substrate was similar throughout the SCH Study Area, with the exception of Transects 23 and 24 where there is a silty deep area in the inner harbour of the existing breakwater. This area was difficult to observe due to the easily mobilized silt sediment.

When hard substrates were present, higher densities of marine vegetation were observed. The marine vegetation that was most abundant was rockweed (*Fucus sp.*), which was typically present in densities which ranged from 40% to 80% in depths less than 4 m CD. Other types of marine vegetation observed included occasional patches of kelp (sugar wrack kelp, *Saccharina latissima*, ~<5% in clusters; sea colander, *Agarum clathratum*, <10% on occasional boulder). When observed, kelp species were between 2 m to 7 m CD depth. A brown filamentous algae, which is possibly thread brown algae (*Chordaria sp*.), was observed throughout the site as a thin layer on both hard (boulders) and soft substrates (sand).

The two most abundant marine invertebrates observed during 2019 Remote Operated Vehicle (ROV) surveys were the truncate soft-shell clam (*Mya truncata*), and brittle stars (*Ophiocton or Ophiura sp.*). Brittle stars occurred in densities that ranged from 5/m^2 to upwards of 50/m^2, and soft-shell clams occurred in densities up to 40/m^2. The categorization range of the truncate soft shell clam (see Table 11-8) ranged from infrequent to moderate (observed on 17 of 25 transects), and from infrequent to abundance for brittle stars (observed on 12 of 25 transects). Other marine invertebrates observed included:

- Green sea urchins (*Strongylocentrotus drobachiensis*, when present, 1 to 10 per transect, trace to infrequent, observed on 11 of 25 transects)
- Seastars (sun star, *Solaster sp.,* rose star, *Crossater papposus*, blood star, unidentified [UNID], trace to infrequent, observed on 9 of 25 transects)
- Tube dwelling anemones (*Pachycerianthus borealis*, <5/m^2, trace, observed on one of 25 transects)
- Anemones (*Hormatia rugosa, Cribrinopsis sp.,* UNID, trace, observed on four of 25 transects)

Observations of marine fish were limited to several different sculpin species which were frequently associated with anthropogenic debris.

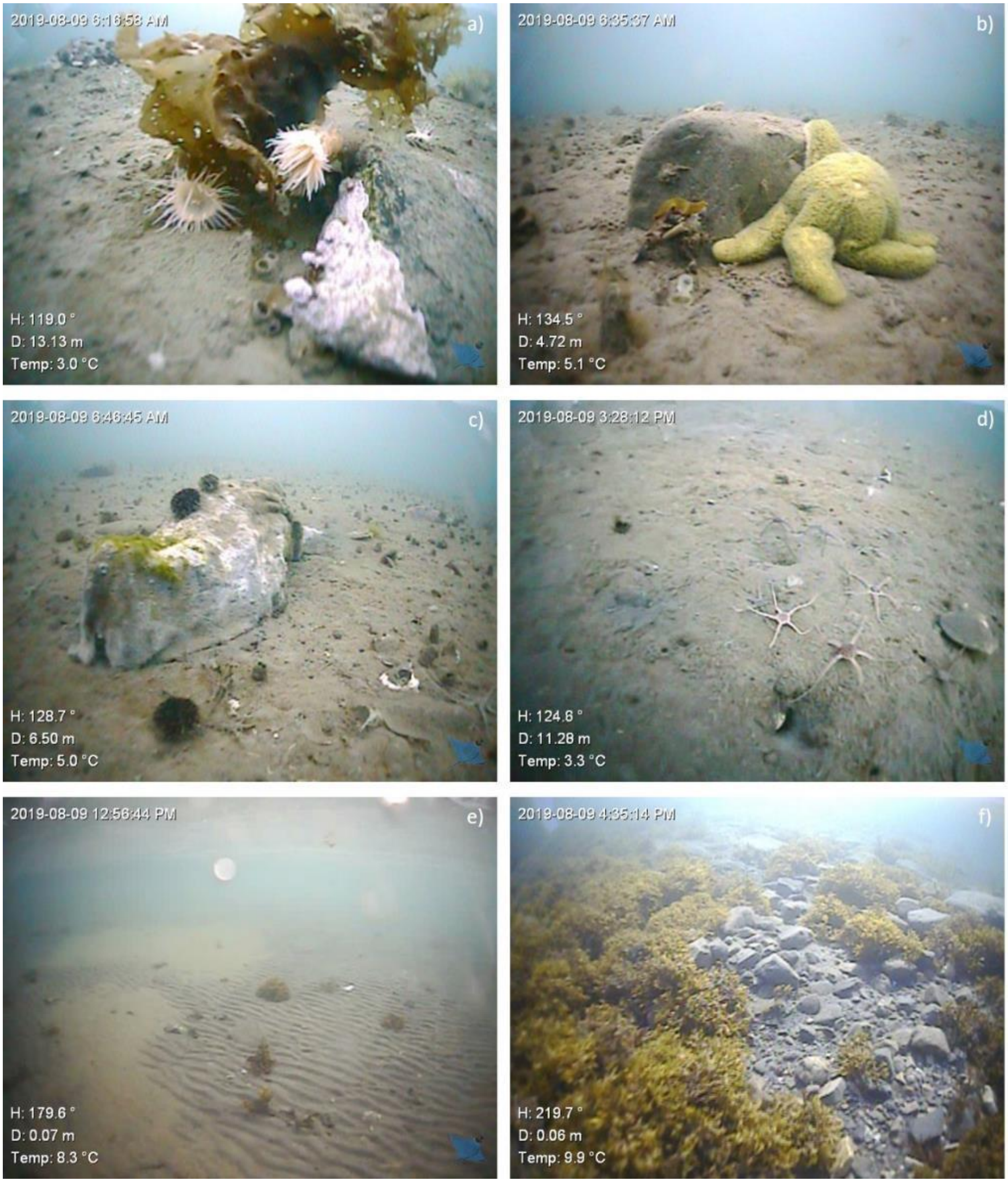

Photo 11-3 Demonstrative Photo Panel of SCH Study Area taken on August 9, 2019: a) T3, anemones b) T4, sun star c) T5, green sea urchins and clam siphons d) T9, brittle stars e) T15, overview f) T21, overview

SCH Study Area – 2020

The depth range of the rockweed patch observed during the snorkel survey ranged from 0.5 m to 1.7 m CD. Substrates observed within the random quadrat survey were cobble and sand only, however the GoPro video footage of the SCH Study Area also showed sand and occasional boulder.

In the random quadrat survey, rockweed was present in every quadrat, and was present in densities which ranged from 30% to 100%. No other marine vegetation was observed in the random quadrat survey. The GoPro video footage showed brown filamentous algae in some parts of the SCH Study Area.

The most abundant marine invertebrate were limpets (*Gastropod* sp.). One individual was counted in four of ten quadrats, and the categorization range of the limpets (see Table 11-8) is trace. No other marine invertebrates were observed in the random quadrat survey. The GoPro video footage showed comb jellies (*Mertensia ovum*) in infrequent abundance, a lion's mane jellyfish (*Cyanea capillata*), and a common clione (*Clione limacina*). There were no observations of marine vertebrates during the 2020 snorkel survey, however three sculpin were incidentally observed during the sediment collection program.

Photo 11-4 Demonstrative Photo Panel of SCH Study Area from GoPro footage taken on September 21, 2020: a) overview of subtidal habitat, b) rockweed, c) comb jelly, d) rockweed and brown filamentous algae

DAS Study Area – 2019

Substrates observed within the DAS Study Area were primarily soft substrates (silt) with occasional boulder, which were at times in clusters. When hard substrates were present, higher densities of marine sessile marine invertebrates were observed.

The most abundant marine invertebrates were brittle stars which occurred in very high densities throughout the DAS Study Area (*Ophiocten* or *Ophiura sp*, 20 to 60/m^2 when observed). The categorization range of the brittle stars (see Table 11-8) ranged from moderate to abundant (observed on 7 of 7 transects). Other marine invertebrates observed included:

- Green sea urchin (*Strongylocentrotus drobachiensis*, 1 observed in 1 transect, trace)
- Burrowing sea cucumber (*Psolus* sp., 1 per transect, trace, observed on 1 of 7 transects)
- Barnacle (*Balanus* sp., 10 observed on 1 transect, trace, observed on 1 of 7 transects)
- Snails (*Buccinum* sp., 1 observed on 1 transect, trace, observed on 1 of 7 transects)
- Finger sponge/Encrusting sponge (UNID, 1 to 4 observed per transect, observed on 2 of 7 transects, trace)
- Soft coral (*Alcyonium* sp., 1 to 10 observed per transect, observed on 6 transects, trace to infrequent)
- Sea spider (*Nymphon* sp., 3 observed on 1 transect, trace)
- Tube worm (*Echone papillosa* [poss], 5 to 20/m^2, observed on 6 of 7 transects, trace to infrequent)
- Crinoids (*Heliometra glacialis* [poss], 1 to 6 observed per transect, observed on 2 of 7 transects, trace)
- Snail dwelling anemone (*Allantactis parasitica*, 1 to 5 observed per transect, observed on 6 of 7 transects, trace)
- Calcareous tube worm (UNID, 5 to 10 m^2, observed on 1 of 7 transects, trace to moderate)
- Tunicate (*Halocynthia sp*. [poss]| UNID, 1 to 6 observed per transect, observed on 7 of 7 transects, trace)
- Tube dwelling anemone (*Pachycerianthus borealis*, observed in densities of < 5/m^2, observed on 4 of 7 transects, trace)
- Sea whip (UNID, 1 observed on 1 transect, trace)

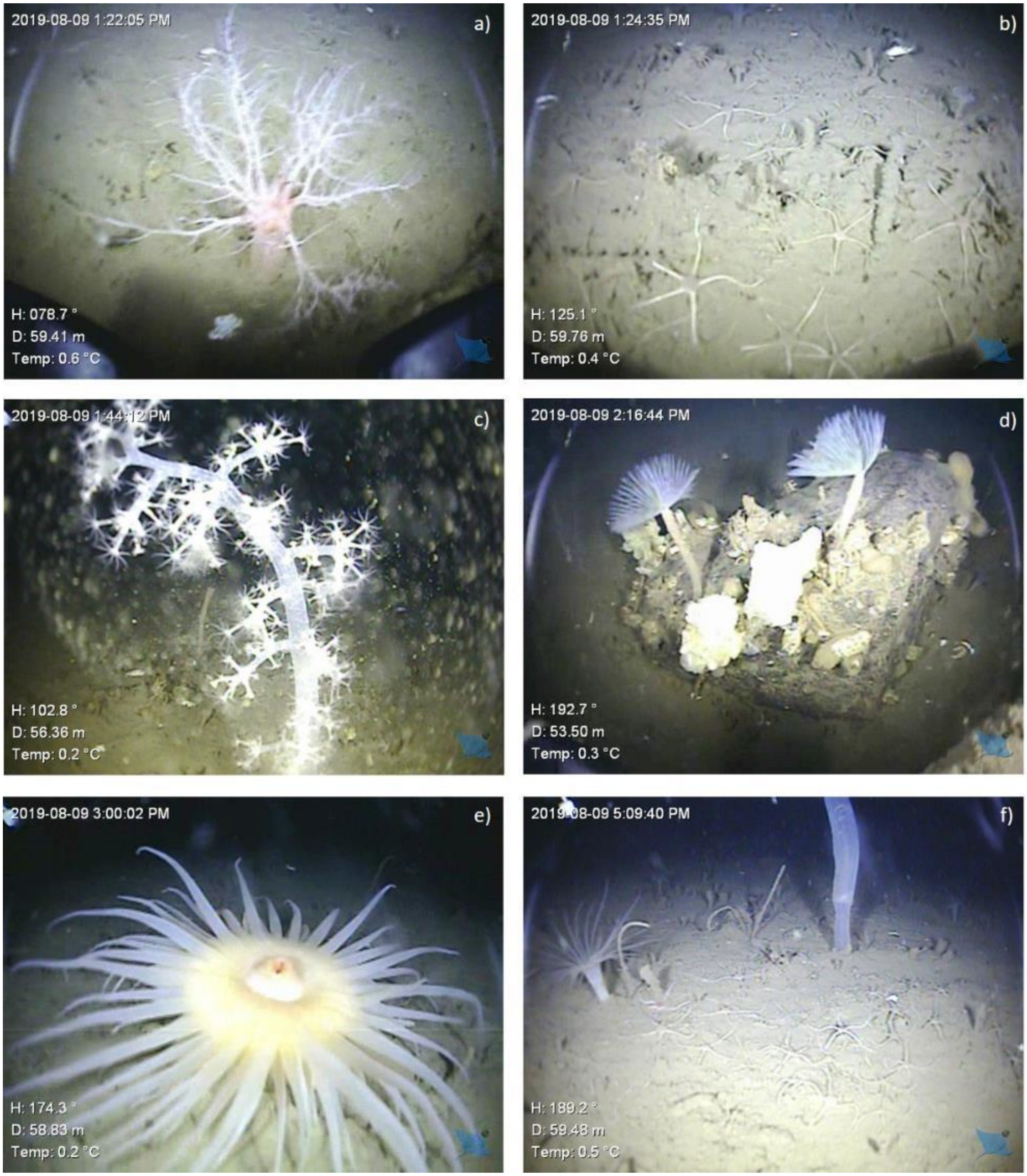

Photo 11-5 Demonstrative Photo Panel of the DAS Study Area taken on August 9, 2019: a) T1, peachy burrowing sea cucumber b) T1, brittle stars c) T2, soft coral d) T4, tube worms e) T6, snail-dwelling anemone f) T7, large tunicate, brittle stars, and sea anemone

11.2.4 Drone Survey

The drone survey was performed for half an hour on August 22, 2019 at approximately 12:00–12:30 when the tide height was 0.8–0.9 m. Low and High tide on the date of the drone survey was 0.5 m (11:14) and 1.7 m (5:09, 17:47) respectively. The rockweed observed during the ROV surveys is visible in the drone image (Figure 11-4).

Figure 11-4 Rockweed visible from Arctic Bay Drone Survey (August 22, 2019)

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SAVE DATE & TIME: 5/20/2021 9:09:06 AM ISSUING OFFICE: BURNABY GIS

Legend

- SCH Footprint
- SCH Study Area
- Rockweed Bed

Substrate

- Existing Breakwater
- Intertidial - Sand with Intermettient Cobble
- Sand with Trace Boulder

Brittle Star Habitat

- Low - 5-10 per square metre
- Moderate - 10-20 per square metre
- High - 20-40 per square metre

Clam Habitat

- Low - 5-10 per square metre
- Moderate - 10-20 per square metre
- Clam Bed - as confirmed from IQ Workshop

Locations approximate.

FISHERIES AND OCEANS CANADA
SMALL CRAFT HARBOURS
ARCTIC BAY

ARCTIC BAY SMALL CRAFT HARBOUR STUDY AREA HABITAT MAP

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11.3 Field Program – Fresh Water

11.3.1 Methodology

During the 2019 field program, a qualitative survey on nearby freshwater courses and lakes was conducted, including observations of the two lakes (Dead Dog Lake, Alternate Water Supply Lake – see Figure 1-1 for lake locations) that are in proximity to the proposed quarry. Photographs and GPS positions were documented.

11.3.2 Results

11.3.2.1 SCH Study Area

One small creek was observed within the western portion of the SCH Study Area during the field survey as well as in the drone imagery and is identified as Creek 2 in Figure 11-6. The creek is west of the existing breakwater and extends north through two culverts (Culvert 1, 73° 1.952'N, 85° 9.879'W, Culvert 2, 73° 1.987'N, 85° 10.111'W) in the existing roads north of the foreshore (see Photo 11-6). The creek bed can then be observed to divert northwest. The creek was dry at the time of the field survey and the drone survey. The creek is unlikely to be fish bearing and is likely for surface drainage based on observation of the drone and Google earth imagery. This was confirmed as not to be fish bearing (Mishak Allurut. pers. comm. Nov 2019).

Figure 11-6 Small Craft Harbour Study Area Small Creek

11.3.2.2 HRQ Study Area

If the Alternate Quarry is selected for the Quarry a culvert crossing will be required over a small creek (73° 2.390'N, 85° 12.918'W, Photo 11-6) that is north of Dead Dog Lake and south of the Alternate Water Supply Lake (see Figure 1-2). There is limited information on the presence of fish in either of the lakes or the creek, however, a local knowledge holder stated that there is land locked Arctic char in both of the lakes and no fish in the creeks in that area (Mishak Allurut. pers. comm. Nov 2019).

Photo 11-6 Possible Creek for Haul Road Crossing to the Alternate Quarry Culvert

11.4 Discussion

The tidal range during the SCH intertidal field survey was 1.2 m during the 2019 field study, and 2.1 m during the 2020 field study, with maximum tidal range presented in Table 3-3. Habitat quality within the SCH Study Area is generally considered low quality, however the rockweed bed is considered moderate quality in addition to a narrow patch of low intertidal habitat where amphipods occur. Observed substrate were consistent between the 2019 and 2020 field surveys, both consisting primarily of cobble and gravel. Rockweed was present in both surveys; however, the 2020 field survey had more instances of >5% cover, which was observed with gravel or bedrock. Marine invertebrates, specifically amphipods, were only observed during the 2020 field survey and were generally under cobble. It is expected that this is due to a wider area of intertidal being exposed in 2020 not due to differential species presence between years. Studies to determine the diets of Arctic char in the surrounding area may provide more insight into the benthic invertebrates that may be expected in the area. If Arctic char are utilizing these intertidal areas, it is likely that they are feeding on amphipods.

Habitat quality within the subtidal SCH Study Area is considered low quality, with the exception of the shallow subtidal areas where the rockweed bed is present. The depth ranged observed was from 0.5 m to 9 m CD in 2019, and from 0.5 m to 1.7 m CD in 2020. Substrates observed in the 2020 random quadrat survey within the shallow subtidal SCH Study Area were dominated by sand and cobble, however GoPro footage also showed presence of boulder. Substrate was similar throughout the SCH Study Area. Rockweed densities were consistent regardless of depth (80 to 100% aerial coverage), except for at 2.1 m (30%) and 1.6 m (40%). Scattered throughout the area was the brown filamentous algae (thread brown algae), observed in the GoPro footage. During the 2019 field study, echinoderms were observed in trace to abundant densities in the subtidal SCH Study Area. The dominant species present were truncate soft shell clam and brittle stars. Other invertebrates included other echinoderm species (sea stars, green sea urchins, brittle stars, and sea cucumbers [*Cucumaria sp.*]). Brittle stars were in unusually high densities for shallow water with some transects observed to be upwards of 50 individuals/m^2. Bivalve siphons occurred in infrequent to abundant densities, and bivalve patches ranged from 10 to 40 siphons/m^2. Bivalves were present in greatest densities between 3 m to 8 m CD, which may be due to the iced season scour area. There was not a predictable pattern (other than depth) to attribute to the densities of clams throughout the site. It is not known how these densities compare to nearby areas, although the SCH Study Area does not appear to be unique in comparison to other foreshore areas in Admiralty Inlet. In the 2020 field study, limpets were also observed between depths of 1.4 m and 2.1 m and was the only marine invertebrate species present. GoPro footage revealed comb jellies, a jellyfish, and a clione in the water column.

Observations of marine fish in 2019 were limited to several sculpin species which were frequently associated with anthropogenic debris; however, it is not known how mobile species may react to the presence of the ROV, and mobile species may take shelter behind rocks or under seaweed. Sculpins are known to be in Arctic Bay (IQ Workshop - Jonah Oyukuluk, Mishak Allurut. pers. comm., June 2019). No marine fish were observed during the 2020 survey; however a sculpin was observed incidentally during the sediment quality field program. Further to this, Facebook postings in January 2020 reveal that sculpin are caught in this area in the winter months. An 'ugly fish' competition occurred in close proximity to the existing breakwater where both sculpin and Arctic cod were caught.

Species diversity within the DAS Study Area from the 2019 field study was considered moderate, but not dissimilar from nearby areas for that depth. The depths ranged from 54 m to 61 m. Species diversity and biomass was similar along all seven transects.

12 Marine Mammals

Program objectives for marine mammals are provided in Section 1.6, Table 1-2. A comprehensive desktop review was conducted for all Arctic marine mammal species in Lancaster Sound, and when possible the waters of Admiralty Inlet and Arctic Bay (see Figure 1-3). Marine mammals are an integral component of the Canadian Arctic and hold ecological, socio-economic, and cultural importance. Lancaster Sound is recognized for its importance as a migratory corridor for beluga whales, narwhal, bowhead whales, walrus, harp seals and polar bears which contributes to its designations as both an EBSA (DFO 2015b, 2015d) and an NMCA (Government of Canada 2019q) (see Section 7.2.2). Marine mammals are considered in a broader context than the SCH and DAS Study Areas defined in Section 1.4 as no directed studies were conducted and desktop information is often general in nature. Marine mammals are highly mobile and are generally not restricted to small geographical areas. Marine corridors that connect Lancaster Sound, Baffin Bay and Davis Strait are available to marine mammal species seasonally and throughout the year, depending primarily on sea ice conditions. The IQ program (see Section 2) provided valuable insight and local knowledge into the seasonal changes, distributions and habitat use of marine mammals in Arctic Bay. Species specific habitat preferences were considered, so that information presented is as focused as possible to the waters of Arctic Bay. For reference, the commonly referred to place names are identified in Figure 1-3.

12.1 Desktop Review

The desktop review was initiated with a review of the IUCN website for global species ranges, conservation statuses and general risk factors. From this, a candidate species list was compiled, and then filtered for those with a coastal distribution, or those that are known to move into coastal waters for part of their life history, with special emphasis on High Arctic waters. A range of additional scientific, government, natural history and IQ sources were then reviewed to refine the species-specific information. Information relevant to Canadian populations was taken from the COSEWIC and SARA websites, including Canadian conservation statuses, Species Status Reports and other information. Local information was obtained from online resources related to Arctic marine mammals, the marine wildlife of Nunavut and IQ websites and documents. Social media posts were also evaluated for community specific information.

12.1.1 Species Spatial Categories

From a broad review of marine mammals including the desktop research and IQ, ten species were identified with Arctic ranges that included Arctic Bay (Table 7-1) and were categorized as either Arctic Residents or Seasonal Visitors, as defined below:

- Arctic Resident: species that resides in the Arctic year-round
- Seasonal Visitor: species that predictably resides within the Arctic region for a portion of the year, which most typically is the open-water season

Many of the marine mammal species ranges are international, and therefore can have different global and Canadian conservation statuses (see Table 7-1).

12.2 Arctic Residents

12.2.1 Beluga

Beluga whales (*Delphinapterus leucas*) are circumpolar in distribution, and can be found throughout Arctic and subarctic waters, as far south as the Gulf of Saint Lawrence (COSEWIC 2004a; L. Lowry et al. 2017). Their range includes Canada, Greenland, the Russian Federation, Svalbard and Jan Mayen, and the United States (i.e. Alaska), though occasional sightings have been reported in areas such as Japan, New Jersey, Scotland and France, among others (Jefferson et al. 2012a). Globally, there is only one species of beluga whale and it is listed by the IUCN as *Least Concern* (L. Lowry et al. 2017). In Canada, there are seven identified populations by COSEWIC (COSEWIC 2004a). Arctic Bay is within the range of the Eastern High Arctic Baffin Bay population (see Table 7-1), with a COSEWIC status of Special Concern and no listing under SARA (Government of Canada 2019p).

The Eastern High Arctic/Baffin Bay population may actually consist of two separate populations: the North Water population numbering around 15,000, and the West Greenland population of around 5,000 (COSEWIC 2004a). Innes et al. (2002) found an estimated 21,123 whales during an aerial survey of the Canadian High Arctic. The TI NMCA provides essential habitat for up to 20% of the Canadian beluga population (Government of Canada 2019m).

In Canada, there are seven identified populations by COSEWIC (COSEWIC 2004a). The Eastern High Arctic/Baffin Bay population is found from the eastern Canadian Arctic to Greenland (COSEWIC 2004a; Jefferson et al. 2012a). These animals summer around Somerset Island in Barrow Strait, Lancaster Sound, Prince Regent Inlet and Peel Sound, and winter amongst the heavy pack ice and in the North Water Polynya in northern Baffin Bay and off Greenland (COSEWIC 2004a; DFO 2015f; Lowry 2016b; Weber Arctic 2019) (see locations on Figure 1-3). Arctic Bay, on northern Baffin Island, is within the summer range of beluga whales (Arctic Bay Adventures 2017; Vard Marine Inc. 2016).

Belugas are seen less frequently around Baffin Island as the ice forms and with the species returning in the spring as the fast ice breaks up (COSEWIC 2004a). As the sea ice breaks up in the late spring, beluga whales follow leads in the ice to river estuaries. They are found throughout the summer in the coastal shallows and at glacier fronts (COSEWIC 2004a). In mid-August they move away from land to deeper waters then overwinter in areas with loose pack ice or polynyas (COSEWIC 2004a). Mating and parturition occur between *Upirngaaq* (June and July) and *Aujaq* (July to September), with calves observed during the same time (QIA 2018b). Calves are born between June and September, with the peak from mid-June to early-July (Higdon 2017; Stewart et al. 1995). Beluga whales are believed to calve offshore, and coastal habitats are understood to be important for rearing and nursing (Higdon 2017). Lancaster Sound is likely a calf rearing habitat as females have been observed returning in the summer with calves, rather than having their calves there (Higdon 2017). Though hunters have identified known birthing areas in Admiralty Inlet (QIA 2018b). They have also observed that moulting takes place in the area in *Aujaq* (mid-July - end of September) (QIA 2018b). Migrating beluga whales pass through this area in the late summer and early winter as they shift to their winter habitats of the North Water polynya near the coast of Greenland. These seasonal movements are heavily influenced by both ice cover and prey species availability (COSEWIC 2004a).

The beluga whale diet is diverse (R. Ellis 1994), and includes a variety of benthic and pelagic prey species including fish, squid, octopus, crustaceans, molluscs, and polychaete worms (Bluhm & Gradinger 2008, in Vard Marine Ltd., 2016). Beluga habitat use is likely related to prey species distribution. Their close association with the ice floe edges may be related to the presence of Arctic cod, which is an important prey species (Kilabuk 1998). Beluga whales commonly use the waters near Devon, Cornwallis and Somerset islands (Higdon 2017). The importance of these high arctic waters for beluga whale survival was recognised in the formation of TI NMCA which includes essential habitat for beluga whales (Government of Canada 2019q).

Beluga whales are a social and highly vocal species that make a wide range of underwater calls and echolocation clicks (R. Ellis 1994). The frequency range is broad for this species, ranging from 0.1 – 120 kHz (Todd et al. 2015), and they have been called the "sea canaries" because of their frequent use of underwater acoustics (R. Ellis 1994). This species can remain submerged for up to about 15 minutes (Ridgeway et al. 1984), and can make forays under ice. Beluga whales often use the same coastal habitats from year to year and have long been targeted by hunters throughout their distribution.

Beluga whale harvesting is reported to occur throughout Nunavut, with harvests from Arctic Bay in May to October (Priest & Usher 2004). Inter-annual variability in the numbers taken and the monthly effort is evident in harvest data (Priest & Usher 2004). Areas within Admiralty Inlet, Prince Regent Inlet and Lancaster Sound have been noted as among the highest value beluga whale hunting grounds for Inuit communities (QIA 2012) (see locations in Figure 1-3).

IQ reports indicate that beluga whales are present near Arctic Bay in Admiralty Inlet and Lancaster Sound between *Upirngasaaq* (mid-March through end of May) and *Ukiassaaq* (end of September to mid-October) and that the arrival of beluga whales coincides with the arrival of harp seals (QIA 2018b). IQ research conducted in the 1970s indicates that beluga whales were not common in the northern Baffin Island region and therefore, the Inuit of the region did not have specialized hunting practices for them (QIA 2018b). IQ also informs that beluga whales are generally not present near Arctic Bay during *Ukiaq* (mid-October – beginning of November) and *Ukiuq* (November – mid March) (QIA 2018b). According to IQ if beluga whales remain in the area longer than by late September, they can get stuck in ice (QIA 2018b). Local harvester knowledge also informs that the beluga whales which have been harvested in the fall have empty stomachs (QIA 2018b). During the IQ Workshop, sites of beluga whale harvests in Arctic Bay were identified on the north and west sides of the bay (see Figure 2-1).

Based on this species' life history, ecology, habitat use, IQ, and monthly harvest reports, beluga whales can occur in the waters of Arctic Bay during the open-water season with presence at the mouth of Admiralty Inlet near the floe edge in late spring before break-up. They are seen at numerous sites throughout Admiralty Inlet from April to September (Government of Nunavut 2010b). Presence in Arctic Bay is determined by the ice extent, and likely mediated by food chain interactions, such as chasing Arctic cod, an important prey item, or avoidance of killer whales.

Threats include: harvesting (less than 100 animals per year in the Canadian High Arctic; likely overharvested in Greenland (COSEWIC 2004a)); climate change (loss of sea ice); human activities (oil and gas development, shipping) (DFO 2014c); pollution and disease (COSEWIC 2004a; L. Lowry et al. 2017). The Eastern High Arctic/Baffin Bay population is heavily harvested in west Greenland (COSEWIC 2004a). Natural predators include killer whales and polar bears (COSEWIC 2004a). Belugas travel closer to shore in Arctic

Bay when killer whales are in the area (NWMB 2000), and killer whale predation is likely to increase as more ice-free areas become available (DFO 2010a).

12.2.2 Narwhal

Narwhal (*Monodon monoceros*) are the most northerly of all cetaceans (R. Ellis 1994), and occur in Arctic waters throughout Canada, Greenland, Russian Federation, and Svalbard and Jan Mayen (Jefferson et al. 2012b). Only one species of narwhal has been identified globally, though 12 sub-populations exist (Jefferson et al. 2012b). Narwhal are globally listed by the IUCN as *Least Concern* (L. Lowry et al. 2017). Narwhals summering in the Eastern Arctic are listed as *Special Concern* by COSEWIC (COSEWIC 2004b), and have no status under SARA (Government of Canada 2019p). Approximately 45,000–50,000 narwhals from the Baffin Bay population are estimated to summer in Canadian waters of the High Arctic (COSEWIC 2004b). This population consists of five summering stocks including Admiralty Inlet, which is likely to be seen around Arctic Bay (DFO 2010b; C. A Watt et al. 2012). A 2013 estimate showed 35,043 animals in the Admiralty Inlet subpopulation, which is considered stable (L. Lowry et al. 2017). The waters of the TI NMCA provides essential habitat for up to 75% of the global narwhal population (Government of Canada 2019m).

Narwhal are reported to occur throughout the Lancaster region including areas of Prince Regent Inlet, Barrow Strait, Peel and Eclipse Sounds and Admiralty Inlet (QIA 2012). Arctic Bay is located within the Admiralty Inlet EBSA, identified in part due to its importance to the summer stock of Baffin Bay narwhal (DFO 2015a) and contains a marine mammal migration pathway and is within the narwhal general range (DFO 2011a; NPC 2008a). Found in spring at the floe edge, they summer near the Inlet and winter in Baffin Bay (L. Lowry et al. 2017) and are seen around Arctic Bay and Admiralty Inlet from April to October, calving, nursing and rearing their young (Arctic Bay Adventures 2017; Canadian Northern Economic Development Agency 2019; DFO 2010b; Government of Nunavut 2010b). The migration peaks in mid-July and they do not move into the fiords and bays until after ice breaks-up (QIA 2018b). Local information on the timing of narwhal reproduction comes from IQ with parturition occurring from *Upirngaaq* to *Aujaq* (mid-June to September) when the water is warm and silty and occurring in Admiralty Inlet, Navy Board Inlet, Eclipse Sound, Baffin Bay, Home Bay, and Cumberland Sound (QIA 2018b). Hunters have also observed that narwhal both mated and gave birth in Admiralty Inlet and fiords from *Upirngaaq* to *Aujaq* (mid-June to September) (QIA 2018b).

It has been reported that narwhal are not using the same habitats as they had previously with the whales entering the inlets later in *Upirngaaq* (June and July) and leaving the inlets during *Ukiassaaq* (end of September to mid-October) (QIA 2018b). It has been speculated that this be due to increases in underwater noise from vessels (QIA 2018b). Arctic Bay hunters note that narwhal have recently been spending more time in the middle of the inlet, possibly due to increased harvesting pressure, and that they arrive later in the season when the ice is unsafe for travel (COSEWIC 2004b). However, narwhal have also been known to travel closer to shore in Arctic Bay when killer whales are in the area (NWMB 2000), and killer whale predation is likely to increase as more ice-free areas become available (DFO 2010a; C. A Watt et al. 2012).

Like beluga whales, harvesters in Arctic Bay, Lancaster Sound, and Pond Inlet have described that narwhal are at risk of entrapment in ice, and that this species is predated upon by killer whales, polar bear, and Greenland sharks (QIA 2018c). In 2005, a killer whale attack on a large group of narwhals was observed in Admiralty Inlet (Laidre et al. 2006). Narwhal are not present in Arctic Bay from *Ukiaq* (November and December) through *Ukiuq* (January and February) (QIA 2018b).

Radio telemetry research suggests a high degree of summer residency with low movement patterns by narwhal in nearby Eclipse Sound (Dietz et al. 2001). Satellite tracking of the Admiralty Inlet and Eclipse Sound stocks by DFO from 2009 to 2011 determined that Eclipse Sound narwhals were present in nearby Pond Inlet from August to November (C A. Watt et al. 2012). Prior to this, narwhal are present at the floe edge (Bradstreet 1982; DFO 2015a; Dietz et al. 2001; Lee & Wenzel 2004; NWMB 2000). Narwhal used to occur in Arctic Bay but have not been observed in the bay for over the past decade or so (IQ Workshop - Tom Nagitarvik).

Over ten years ago, narwhal used to be harvested from boats in the bay (see Figure 2-1), however they have not come in that close again since (IQ Workshop - Jonah Oyukuluk). Larger groups of narwhal are known to occur at Victor Bay (sometimes more than 100) (see Figure 3-1), it is thought that the noise from town may keep them away (IQ Workshop - Tom Nagitarvik). This year had more narwhal than normal at Victor Bay, it changes depending on the year (IQ Workshop - Olayuk Nagitarvik). Inter-annual changes in distribution may also be related to prey species fluctuations.

The deep diving narwhal has a broad diet that includes benthic and pelagic fish, squid, and crustaceans (Bluhm & Gradinger 2008), where diet varies seasonally with a winter emphasis on benthic prey (Jefferson et al. 2012b). Narwhals likely target ice edges for foraging, based on comparison of stomach samples taken at the ice edge or from ice cracks, compared with those from open-water (Bradstreet 1982; COSEWIC 2004b). Narwhal are a social and vocal species with a diversity of calls and clicks (R. Ellis 1994). The frequency range is broad, ranging from 0.3 to 48 kHz (Todd et al. 2015). DFO has expressed concerns about potential masking of shipping sounds and the effect that would have on narwhal in the area, especially in narrow bodies of water (DFO 2014b). Narwhal can remain submerged for up to about 15 minutes (Martin et al. 1994), and can make forays under the ice.

Narwhal are currently harvested by some Indigenous communities in Canada and Greenland (Lowry 2016a; NWMB 2013), including in Nunavut (QIA 2018c). Areas within Admiralty Inlet, Prince Regent Inlet and Lancaster Sound have been noted as among the highest value narwhal harvesting grounds for Inuit communities (QIA 2012). Narwhal are harvested in this area during the summer (Arctic Bay News Faebookgroup 2019), and there are hunting camps overlooking Lancaster Sound near Arctic Bay (Innuit Heritage Trust 2016; Innuit Places 2019). Hunting for narwhal has been reported from June to October, with inter-annual variation in the timing and numbers taken (Priest & Usher 2004).

Most of Admiralty Inlet, and other sites in Prince Regent Inlet, and Eclipse Sound were identified through IQ as Arctic Bay Inuit Land Use for narwhal (QIA 2012). Narwhal are considered a shared species with Greenland by the Inuit living in Arctic Bay (QIA 2018b). Arctic Bay harvesters distinguish the different populations by the scars from Greenlandic harpoons, and chipped tusks and other wounds from being in shallow waters as compared to the deep waters of Admiralty Inlet (QIA 2018b). Killer whales are known to avoid areas with ice, thus IQ studies indicate narwhals may congregate in these areas to avoid being hunted (Ferguson et al. 2012; Science 2012). Marcoux et al. (2009) also suggest summering grounds of narwhals may be related to avoidance of killer whales.

Based on this species' life history, ecology, habitat use, IQ, habitat designations, and harvest reports, narwhal can be expected throughout Arctic Bay and Admiralty Inlet during the open-water season, leaving the area by mid-October. Threats to this species include harvesting, climate change (both loss and timing of sea ice), human activities (oil and gas development, commercial shipping, commercial fishing), pollution, and disease (L. Lowry et al. 2017).

12.2.3 Bowhead Whales

Bowhead whales (*Balaena mysticetus*) inhabit the Arctic and subarctic waters of Canada, Greenland, and the United States (i.e. Alaska) (Reilly et al. 2012). There is only one species of bowhead whale, listed globally as *Least Concern* (Reilly et al. 2012) by IUCN. Of the four recognized sub-populations, two are located in Canada; the Eastern Canada-West Greenland population is relevant to Lancaster Sound (Cooke & Reeves 2018; COSEWIC 2009). The Eastern Canada – West Greenland population has Special Concern status by COSEWIC and is not listed under the SARA, but is currently under consideration for addition to Schedule 1 (COSEWIC 2005, 2009; Government of Canada 2019o).

The Eastern Canada–West Greenland subpopulation was heavily hunted from the 1500s until the early 1900s. The population is thought to be over 4,000 animals and is increasing but still well below pre-whaling levels of over 25,000 (Cooke & Reeves 2018). This population summers in western Baffin Bay, northwestern Hudson Bay, Foxe Basin, and the Lancaster Sound region, and winters in Davis Strait and Hudson Strait (Cooke & Reeves 2018; COSEWIC 2009).

Arctic Bay is located within the Admiralty Inlet EBSA and contains a marine mammal migration pathway and bowhead whale feeding area (DFO 2011a). Arctic Bay is also within the identified critical habitat identified for bowhead whales (NPC 2017a). The seasonal migration path follows the eastern shore of Baffin Island, into and out of Lancaster Sound and Admiralty and Prince Regent Inlets, where they can be seen in late spring to early fall (COSEWIC 2009) (DFO 2010a) Thomas et al. (2016). There are reports of bowheads over-wintering in polynyas at the far end of the inner Inlet (Government of Nunavut 2010b). Calves are frequently reported in Admiralty Inlet later in the summer (Higdon 2017).

Bowhead whales use a variety of habitats during the summer and have been observed in northern Hudson Bay and Foxe Basin, along the eastern coast of Baffin Island, and south of Lancaster Sound in Pond Inlet, Eclipse Sound, Navy Board Inlet, Admiralty Inlet, Prince Regent Inlet, Isabella Bay, and the Gulf of Boothia (Finley 1990; QIA 2012) (see locations in Figure 1-3). Thomas et al. (2016) observed variability in densities of bowhead whales during the 2015 aerial surveys for the Baffinland project. DFO conducted a High Arctic Cetacean Survey in August 2013 to quantify summering areas of the Eastern Canada-Western Greenland bowhead whale stock, which noted were visual observations of bowhead whales in the area (Doniol-Valcroze et al. 2015).

IQ informs that bowhead whales occur at the floe edge off Admiralty Inlet in the *Upirngasaaq* (early spring) and *Upirngaaq* (late spring), then occur along the coast and congregate in open waters throughout Admiralty Inlet in the *Aujaq* (summer), and move toward the open-water before freeze-up during the *Ukiassaaq* (early fall) (QIA 2018b). Bowhead whales are not present in Arctic Bay from *Ukiaq* (fall/early winter) through *Ukiuq* (winter) (QIA 2018b). According to elders in Arctic Bay, sightings of bowhead whales were rarer during their childhood but increased considerably from the 1960s onwards, with cow-calf pairs often spotted in the area in the summer (NWMB 2000). The whales tend to travel closer to shore in Arctic Bay when killer whales are in the area (NWMB 2000). In recent years, bowhead whales occur only *"once in a blue moon"* in Arctic Bay (Arctic Bay IQ Workshop 2019 - Tom Nagitarvik).

Bowhead whales forage during the open-water season, taking advantage of the productive arctic waters. The main prey are pelagic zooplankton (Bluhm & Gradinger 2008; R. Ellis 1994; Reilly et al. 2012). Bowhead whales can remain submerged for up to an hour and will swim under ice (R. Ellis 1994; Krutzikowski & Mate 2000). Bowhead whales are capable of breaking through ice that is several inches thick due to their large skulls and powerful bodies (WWF 2019). Bowhead whales can communicate over large distances and use a frequency range from 0.02 to 5 kHz (Todd et al. 2015). The seasonal distribution is dependent upon timing and distribution of sea ice (Cooke & Reeves 2018).

Based on this species' life history, ecology, habitat use, and IQ, bowhead whales can be expected at the floe edge in the spring and can congregate in Admiralty Inlet during the open-water season and will leave the in the early fall. Threats to bowhead whale conservation include increased human activity, vessel strikes, pollution, and climate change (COSEWIC 2009).

12.2.4 Ringed Seal

Ringed seals (*Pusa hispida*), the most common seal in the Arctic, have a circumpolar distribution (Godwin 1990; Kingsley 1989). Native to Canada, Estonia, Finland, Greenland, Japan, Latvia, Norway, Russian Federation, Svalbard and Jan Mayen, Sweden, and the United States, these are the smallest pinnipeds in the world (Kingsley 1989; Lowry 2016b). The five recognized subspecies of ringed seal have been assessed individually by the IUCN, with a global listing of *Least Concern* (Lowry 2016b).

The Arctic ringed seal subspecies (*P. h. hispida*) (Lowry 2016b) can be spotted near every community in Nunavut in the spring (Canadian Northern Economic Development Agency 2019). Ringed seals are listed as *Not at Risk* under COSEWIC, with no status under SARA (Government of Canada 2019p). A 2016 IUCN Red List assessment found 1,450,000 mature individuals in the Arctic population, with a likely total population greater than three million animals (Lowry 2016b).

Ringed seals are a non-migratory species that remain in Arctic waters year-round and can be found throughout Lancaster Sound and the contiguous waterways, including Admiralty Inlet and in Arctic Bay (Godwin 1990; Kingsley 1989; Natures Edge 2015). IQ informs that ringed seals have been observed from Arctic Bay in all months of the year, but that there have been times when the seals have been scarce (i.e. in the 1950s and 1960s) in Admiralty Inlet – though the cause of this was unknown (QIA 2018b). Arctic Bay is located just south of the known high-density area for this species (NPC 2008c). Local areas where hunters wait for seals are identified in Figure 2-1.

Ringed seals are known utilize a variety of feeding habitats including shallow coastal waters, as well as offshore waters as deep as 150 m (McLaren 1958). They eat a variety of fish and invertebrates, and planktonic, nektonic, and benthic prey (Bluhm & Gradinger 2008; Godwin 1990; McLaren 1958). The seasonal distribution of this species is highly influenced by the ice. Bradstreet (1982) observed in Lancaster Sound that seals were in noticeably higher densities within 24 km of the ice edge than farther away. Ringed seals use landfast ice and pack ice during the winter, maintaining breathing holes (Kingsley, 1989), and can also be found in multi-year ice (Government of Nunavut 2010b).

In *Ukiuq* (mid-November to mid-March) ringed seals are found at breathing holes, especially in areas where cracks appear within Admiralty Inlet (QIA 2018b). The habitat use of the seals is influenced by these open areas, and the distribution of different sizes of seals also varies by location and ice conditions (QIA 2018b). In *Upirngasaaq* (mid-March to May), ringed seals are found at breathing holes and in birthing lairs (QIA, 2018b). Pups are born in lairs on fast ice around April and are nursed for 30 days, and parental care lasts until break-up (Kingsley 1989; McLaren 1958). Most mating also occurs in April shortly after pups are born (Godwin 1990). In mid-May, ringed seals haul out to moult, fasting during this time (McLaren 1958). In *Upirngaaq* (June-July) they are found at breathing holes, at the floe edge, and in birthing lairs (QIA

2018b). From *Aujaq* (mid-July to September) through *Ukiassaaq* (September to mid-October) they use the open waters, and for the remainder of the year, this species is found at the floe edge (QIA 2018b).

The ringed seal produces sounds that range from 0.4 to 16 kHz (Todd et al. 2015), with vocalizations consisting of barks and yelps heard during the breeding season, but the species is relatively silent otherwise (Kingsley 1989). This species can remain submerged for up to 17 minutes (Lydersen 1991).

Ringed seals are harvested year round with variation in the monthly effort and numbers taken (Priest & Usher 2004). Natural predators include killer whales, walrus, polar bears and Arctic foxes, and predation on pups by birds such as gulls and ravens has been observed (Kingsley 1989). Threats include pollution, climate change (habitat loss with reduced sea ice and snow cover), and anthropogenic disturbance (Lowry 2016b).

Based on this species' life history, ecology, habitat use, and IQ, and harvest reports, ringed seals can be expected year-round. Ringed seals are present in Arctic Bay (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk; Arctic Bay IQ Workshop 2019 - Olayuk Nagitarvik; Arctic Bay IQ Workshop 2019 - Tom Nagitarvik) (Mishak Allurut. pers. comm. June 2019) and are a staple diet item (IQ Workshop - Jonah Oyukuluk).

12.2.5 Bearded Seal

Bearded seals (*Erignathus barbatus*) inhabit Arctic and sub-Arctic waters year-round, and are native to Canada, Greenland, Iceland, Norway, Russian Federation, Svalbard and Jan Mayen, and the United States (COSEWIC 2007d; Kovacs 2016b). Two separate subspecies, the Atlantic and the Pacific, can be found in the Canadian Arctic (Kovacs 2016b). The Atlantic bearded seal (*E. b. barbatus*) is listed by the IUCN as *Least Concern* (Kovacs 2016b). Bearded seals are present in the Arctic year-round and are the largest of the Arctic seals (Godwin 1990; Natures Edge 2015). This species is listed as *Data Deficient* in Canada, (COSEWIC 2007d).

There are few data for bearded seals, but Arctic Bay and adjacent waters are within the known spring-summer distribution as this species can be seen during excursions in this region (Arctic Bay Adventures 2017). Bearded seals are also known to winter in Lancaster Sound and Davis Strait (COSEWIC 2007d), and can be seen in this area year-round (DFO 2015f; QIA 2018b) but there is some variability in the records as the natural history suggests that this species leaves the area as fast ice begins to form and move to areas with moving pack ice (QIA 2012). According to the NPC, Arctic Bay is proximal to an identified high-density area for bearded seals (NPC 2017c). This species shows a preference for open water less than 200 m deep with broken ice, and their seasonal movements depend upon prey availability and ice distribution (Kovacs 2016b). Some of the highest densities of bearded seals are found east of Arctic Bay, in Eclipse Sound, Oliver Sound and Milne Inlet (Koski & Davis 1980).

The seasonal distribution based on IQ of this species indicates that the local distribution is highly influenced by the ice. Bearded seals are not always present in Arctic Bay, but when they are there, it is during ice break-up, when the ice is moving out (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk). This species is reported to occur very occasionally in Arctic Bay (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk; Arctic Bay IQ Workshop 2019 - Olayuk Nagitarvik; Arctic Bay IQ Workshop 2019 - Tom Nagitarvik) (Mishak Allurut. pers. comm. June 2019).

When bearded seals do occur, they are reported as being present along the shoreline of Arctic Bay by *Upirngaaq* (June-July) (QIA 2018b). From *Aujaq* (mid July to September) through *Ukiassaaq* (September to mid-October) they are reported to use the open waters (QIA 2018b). When they are available they are harvested (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk). Areas where hunters wait for seals are identified in Figure 2-1.

Pups are born in the spring (April–May), and are nursed for around 24 days, maintaining a close bond with their mothers even after weaning (COSEWIC 2007c). Mating occurs in the water following weaning, followed by a period of moulting (COSEWIC 2007d; Godwin 1990). Bearded seals also use waters northwest from Bylot Island in Lancaster Sound, with pupping sites identified along north and east coasts of Bylot Island (Baffinland Iron Mines Corporation 2012).

Bearded seals are primarily benthic feeders but have a varied diet which includes pelagic fishes, crustaceans and molluscs (COSEWIC 2007c). When not feeding, they will haul out on the ice, and they are one of the few species to use pack ice for resting, pupping, and moulting (COSEWIC 2007d). Bearded seals are reported to be closely associated with drifting ice floes and in shallower waters that provide feeding opportunities (Government of Nunavut 2010b). They can be found at numerous sites throughout Admiralty Inlet year-round, concentrating at the mouth of the Inlet in late spring (Government of Nunavut 2010b). Large aggregations of bearded seals are not often encountered (Godwin 1990).

Bearded seals typically are not social animals, occurring alone or in small groups (COSEWIC 2007d). Their vocalizations range from 0.02 to 11 kHz (Todd et al. 2015). In the spring, the calls of bearded seals can be audible under the water for up to 25 km likely as part of courtship behaviours (COSEWIC 2007d). Dives are usually a few minutes in length and to depths shallower than 100 m, but they have been recorded longer than 20 minutes and up to 450 m (COSEWIC 2007c).

Bearded seals are harvested year-round in Nunavut where they are available, with the majority killed June–October (COSEWIC 2007c). This species is recorded being harvested from Arctic Bay from March through to December, with variation in the timing and monthly numbers taken per year (Priest & Usher 2004). Natural predators include polar bears and walrus (COSEWIC 2007c).

Based on this species' life history, ecology, habitat use, IQ, and harvesting reports, bearded seals could occur year-round, but are much more likely to occur from mid-March through to mid-October. Threats include harvesting, climate change (reduction of sea ice), anthropogenic disturbance, entanglement in fisheries gear, and pollution (contaminants and spills) (COSEWIC 2007c; Kovacs 2015).

12.2.6 Walrus

Walrus (*Odobenus rosmarus*) can be found in Arctic and sub-Arctic waters, usually around the shallow continental shelf (Lowry 2016a). They are native to Canada, Greenland, Russian Federation, Svalbard and Jan Mayen, and the United States (i.e. Alaska) (Lowry 2016a). This species is globally listed as *Vulnerable* by the IUCN (Lowry 2016a). Based on the SARA registry there are two populations of walrus that occur in the Canadian Arctic (i.e., Central Low Arctic population, and the High Arctic population). Both are listed as *Special Concern* by COSEWIC (2017a), with no status under SARA (Government of Canada 2019a). However, the Central Low Arctic and High Arctic populations are under consideration for addition to Schedule 1 (Government of Canada 2019p).

The Central/Low Arctic population can be found in Foxe Basin, Hudson Bay, south and east Baffin, southern Hudson Strait-Ungava Bay-Labrador Bay, and James Bay (COSEWIC 2017a). The High Arctic population can be found in Penny Strait-Lancaster Sound, western Jones Sound, and Baffin Bay (COSEWIC 2006a). A 2009 survey resulted in an estimate of 2,481 animals in the High Arctic population (COSEWIC 2006a), and a minimum of 18,900 animals in the Central/Low Arctic population, though survey coverage is incomplete in the latter case, and trends are unknown (COSEWIC 2017a).

Walrus are year-round residents in the Arctic, though seasonal changes in distribution are noted in relation to ice cover (COSEWIC 2006a). Walrus spend about two-thirds of their lives at-sea, with the rest of their time hauled out on drifting pack ice or land to rest, pup, or moult (Godwin 1990). Walrus typically prefer near-shore areas during the open-water season that provide haul out locations and shallow water (less than 100 m) suitable for providing access to prey (Outridge et al. 2003 cited in QIA 2012). Walrus require shallow, coastal, ice-free waters with significant bivalve growth as well as haul out sites close by (Lowry 2016a) and are often seen at the mouth of Admiralty Inlet in the winter, near the edge of the ice floe (Government of Nunavut 2010b). Walrus devote a large proportion of the day (8 to 12 hours) foraging (Godwin 1990), and can remain submerged for nearly half an hour (COSEWIC 2006a). Though walrus have a diverse diet ranging from clams and worms, to fish, squid, sea birds, and occasionally seals, they are primarily benthic feeders and use soft substrate coastal waters that range from 10 to 80 m in depth. This is a gregarious species, that are often found in groups (Lowry 2016a). Males establish territories in winter during the mating season, with pups born in May the following year (Lowry 2016a). This species has an extended pup weaning period of about two years (Godwin 1990).

Walrus are known to aggregate in Lancaster Sound near northwestern Bylot Island (Baffinland Iron Mines Corporation 2012). However, in the general vicinity of Arctic Bay, "*Walrus - very rare to see them in the bay*". – Oyaluk.' (Arctic Bay IQ Workshop 2019 - Olayuk Nagitarvik). Summer concentrations of walrus are known to occur along the southern coast of Devon Island, across Lancaster Sound from Arctic Bay (NPC 2008b). Most migration activity has been observed in mid-October (Koski & David 1994 cited in QIA 2012), when walrus leave as the ice forms and move to areas with open-water and mobile ice. Walrus are known to winter in several locations in Lancaster Sound (DFO 2015e), including Jones Sound, Devon Island, the floe edge of Lancaster and Jones Sounds, and the North Water polynya (Born et al. 1995 cited in QIA 2012). Walrus are seen at numerous sites throughout Admiralty Inlet through the spring, summer and fall, and at the mouth of the Inlet during the winter months (Government of Nunavut 2010b). Wintering habitats in the Lancaster region include the east and west ends of Jones Sound (Cardigan Strait-Fram Sound and around Dundas Island), the west end of Devon Island (south of Grinnell Peninsula), the floe edge of Lancaster and Jones and Sounds, and the North Water polynya (Born et al. 1995).

The seasonal distribution of walrus is influenced by the ice. In *Ukiaq* (fall to early winter), *Ukiua* (winter) and *Upirngasaaq* (early spring), walrus are found in the pack ice in the Davis Strait, by *Upirngaaq* (late spring) they are distributed at the floe edge, and are in the open waters, inlets and fiords during the *Aujaq* (summer) (QIA 2018b). By *Ukiassaaq* (early fall) the walrus departs for their wintering grounds (QIA 2018b). Harvest records indicate that walrus inhabit areas of Pond, Milne, and Admiralty Inlets, Bathurst and Cornwallis Islands, and Jones Sound in the Lancaster area in summer (Priest & Usher 2004).

Walrus have been historically used for food, hides, ivory and bones by Indigenous communities, but the commercial hunts of the 1700s to the mid-1800s depleted the population significantly (Lowry 2016a). Walrus are harvested in Nunavut, with harvests recorded to occur in most months from March to October from Arctic Bay, with inter-annual variation in the numbers taken and the months harvested (Priest &

Usher 2004). Areas within Admiralty Inlet, Prince Regent Inlet and Lancaster Sound have been noted as among the high value walrus harvesting grounds for Inuit communities (QIA 2012). A concern with increased shipping is disturbance to walrus causing them to move further away from hunting communities, as happened in Resolute Bay in the 1990s (Arctic Council 2009).

Based on this species' life history, ecology, habitat use, and IQ, and harvest reports walrus are could occur from spring through fall. Natural predators include polar bears and killer whales (Lowry 2016a). Threats include harvesting, degradation of feeding areas (e.g. disturbance by benthic trawl fisheries, industrial development), anthropogenic disturbance (including vessel and aircraft traffic), oil and gas exploration, and climate change (and effects on ice conditions) (COSEWIC 2006a).

12.2.7 Polar Bear

Polar bears (*Ursus maritimus*) are circumpolar and can be found throughout the Arctic, with a preference for shallow, ice-covered areas of productive upwelling (Wiig et al. 2015). Habitat selection is most closely related to sea ice concentration. Polar bears are native to Canada, Greenland, Norway, the Russian Federation, Svalbard and Jan Mayen, and the United States (i.e. Alaska), and are occasionally also spotted in Iceland (Wiig et al. 2015). Globally classified as *Vulnerable* under the IUCN, there are 19 recognized subpopulations of polar bears (Wiig et al. 2015), 14 of which can be found in Canada (COSEWIC 2018; Government of Canada 2018c). (see Figure 11, Appendix 1). The Lancaster Sound and Baffin Bay subpopulations can be found within the TI NMCA (COSEWIC, 2018; Government of Canada, 2019n). Polar bears are listed as *Special Concern* under COSEWIC (COSEWIC 2018) and *Special Concern* on Schedule 1 of SARA (Government of Canada 2019p).

Polar bears are found throughout the high Arctic and be found along the entire Baffin, Devon, and Ellesmere Islands coastlines (QIA 2018c). IQ indicates that polar bears are found throughout the TI NMCA including at Arctic Bay (Arctic Bay IQ Workshop 2019 - Tom Nagitarvik; IQ Workshop - Olayuk Nagitarvik). Summer habitats include the south and east coasts of Devon Island, the east side of the Brodeur Peninsula, Borden Peninsula, and Bylot Island (QIA 2012, 2018c). High densities of polar bears can be seen in the central and eastern TI NMCA, and these animals spend the summers to the west where they can find multi-year pack ice (McLoughlin et al. 2007). A 1997 estimate of bears in Lancaster Sound found a population of between 2,000-3,000 adults (Government of Canada 2018c; McLoughlin et al. 2007; Taylor et al. 2013). However, there is insufficient data to determine a current trend for the Lancaster Sound population, (Wiig et al. 2015). The Tallurutiup Imanga NMCA provides essential habitat for polar bears in Canada (Government of Canada 2019m).

Polar bears occur at low densities and have a very low reproductive rate, with mating occurring in the spring and implantation delayed until autumn (Wiig et al. 2015). Female bears move to dens in late autumn and pups (usually twins) are born in December or January, leaving the den in early spring (Wiig et al. 2015). Polar bears with cubs are present in the Arctic Bay region during the summer (Arctic Bay Adventures 2017) and denning sites occur along the shorelines in nearby Lancaster Sound along the shores of Baffin and Devon islands (NPC 2017b).The preferred diet of polar bears consists of ringed seals, as well as bearded, harp and hooded seals, walrus, narwhal and beluga (COSEWIC 2018; Wiig et al. 2015). The life history of polar bears is closely tied to that of the ringed seal (their primary prey species) (QIA 2018b). Polar bears have their cubs in dens before ringed seals give birth and hunt ringed seal pups in their dens, or out on open ice (QIA 2018b).

Polar bears show site fidelity to feeding and denning areas, based on sea-ice concentration, type, bathymetry, distance to edge, and distance to land (COSEWIC 2018). Bear migration patterns show deliberate movements on drifting ice to stay within productive habitats (Vard Marine Inc. 2016). The Baffin Bay region has seen significant decline in sea-ice habitat and the polar bears have shifted northward and landward (COSEWIC 2018).

The allowable harvest for 2018 was 85 bears/year in the Lancaster Sound Management Unit (COSEWIC 2018). More bears are seen now than in the past, with many reports of bears in poor condition (Government of Nunavut 2010b). Polar bears are seen throughout Admiralty Inlet year-round, especially in January and February (Government of Nunavut 2010b). In the spring, polar bears concentrate at the mouth of Admiralty Inlet, an important spring habitat for hunting and breeding (Government of Nunavut 2010b). The Borden Peninsula (upon which Arctic Bay is situated) is used for maternity denning during the fall and winter months and is used as a summer sanctuary during the ice free period (Government of Nunavut 2010b).

In Nunavut, only Inuit (or an assignee) can harvest polar bears (based on set restrictions), and polar bears can also be killed in defense of human life or property (COSEWIC 2018). Areas throughout Admiralty Inlet, Prince Regent Inlet, Lancaster Sound and northern Baffin Bay have been noted as among the highest value polar bear hunting grounds for Inuit communities (QIA 2012). Records from Arctic Bay show that polar bears have been harvested throughout the year, with records in March, June, October, November, December, and January (Priest & Usher 2004). Harvest sites are located in Admiralty Inlet, Lancaster Sound, Prince Regent Inlet, and throughout the contiguous waterways of the high Arctic (QIA 2018b). The IQ workshop identified a polar bear harvest site on the west side of Arctic Bay (Figure 2-1).

Based on this species' life history, ecology, habitat use, IQ, and harvest reports, polar bears can occur in this region throughout the year. At Arctic Bay, polar bears are attracted to the food boxes for the dogs (Arctic Bay IQ Workshop 2019 - Tom Nagitarvik) which can increase the potential for human-polar bear conflict.

12.3 Arctic Seasonal Visitors

Three species of marine mammals are considered to be seasonal visitors, moving northwards into Arctic waters during the open-water season.

12.3.1 Killer Whales

Killer whales (*Orcinus orca*) are a cosmopolitan species found throughout the world's oceans, and are known to be native to more than 150 countries (Reeves et al. 2017). Globally listed as *Data Deficient* by the IUCN (Reeves et al. 2017), the species consists of many distinct populations or ecotypes which do not interbreed. It is important to note, that taxonomic complexity exists, and the classification of this species may be refined as research continues (Taylor et al. 2013). As the taxonomic uncertainties are resolved, global conservation statuses may change accordingly.

Five separate killer whale populations are recognized in Canada, with four occurring in the Pacific off British Columbia. The fifth, the Northwest Atlantic / Eastern Arctic population, which is likely to be found around Lancaster Sound is listed as *Special Concern* (COSEWIC 2008; NPC 2017a), but has no listing under the SARA (considered *Data Deficient*) (COSEWIC 2008; Government of Canada 2019p). The small size of this population (fewer than 1000, and likely less than 250 mature individuals), as well as their susceptibility to disturbance, contributes to their COSEWIC designation. Relatively little is known about the range and distribution of the Northwestern Atlantic/Eastern Arctic killer whales, and there is no population estimate available (COSEWIC 2008).

Killer whales are seen throughout the Lancaster Sound region, generally in small pods, with occasional sightings of single animals (Westdal et al. 2009). Killer whales are reported in the summer in the Arctic Bay area (NWMB, 2000), with a pod of around 30 found in Admiralty Inlet (Arctic Bay Adventures 2017). An attack on a large group of narwhals was observed in the Inlet in 2005 (Laidre et al. 2006). Jeff W. Higdon et al. (2012) compiled historical data to document the occurrence of killer whales in the Arctic. Higdon (2007) notes that the highest number of killer whale sightings to date are from southwest Greenland and Lancaster Sound, with notable areas in the Lancaster region being in the Pond Inlet/Bylot Island area, Lancaster Sound, and Admiralty Inlet (cited in QIA 2012).

Given their predatory nature, there is interest in determining killer whale abundance and distribution in the Arctic. Ferguson et al. (2012) conducted a series of IQ interviews, and it is believed that these killer whales are predators primarily of marine mammals, as no interviewees have observed them eating fish. The results of this survey state that killer whales are predators of narwhals, beluga whales, bowhead whales, and ringed and bearded seals as well as immature walrus (Government of Nunavut 2010b). Arctic Bay residents do not harvest killer whales (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk; Arctic Bay IQ Workshop 2019 - Olayuk Nagitarvik; Arctic Bay IQ Workshop 2019 - Tom Nagitarvik) (Mishak Allurut .pers. comm. June 2019). Orcas came into the Bay once 'about six years ago, and they were there when there were no narwhal around (Arctic Bay IQ Workshop 2019 - Tom Nagitarvik).

Reported predation events on narwhals and beluga whales far outnumber those on bowhead whales or pinnipeds, with the majority reported in Lancaster Sound. Bowhead whale predation is more frequently reported in Davis Strait-Baffin Bay, and most sightings of killer whales occur in the late spring, summer and early fall (J. W. Higdon et al. 2012), often near groups of marine mammals (Laidre et al. 2006). Arctic Bay is located within the Admiralty Inlet EBSA and contains a marine mammal migration pathway; killer whales are known to use this area during the open-water period (DFO 2015a). Killer whale sightings from the Lancaster Sound region represent 24.2% of all reported sightings (J. W. Higdon et al. 2012). Killer whales are reported throughout Admiralty Inlet in the summer with a couple of sightings as late as October (Government of Nunavut 2010b).

Killer whales are social animals capable of communicating over large distances underwater, using a variety of clicks and whistles. The frequency range is broad, ranging from 0.5 to 75 kHz (Todd et al. 2015). Killer whales that eat marine mammals have relatively short dive times of less than about 15 minutes (Morton 1990) and tend to vocalise less frequently than fish eating killer whales.

Killer whales have recently had an increased presence and range expansion in the Arctic, likely as the climate changes and sea ice declines, making new areas available to them (Ferguson et al. 2010; J. W. Higdon et al. 2012; Reeves et al. 2017). This may also influence the distribution of other marine mammals. They are usually seen in the summer ice-free months, often near groups of marine mammals (Laidre et al. 2006).

Based on this species' life history, ecology, habitat use, and IQ, killer whales can occur in this region from the late spring through the summer months. Threats include harvesting (in Greenland), anthropogenic disturbance (acoustic and physical), prey depletion, vessel strikes, interaction with commercial fisheries, and contaminants (COSEWIC 2008).

12.3.2 Harp Seal

Harp seals (*Pagophilus groenlandicus*) can be found in the North Atlantic and Arctic oceans, and are native to Canada, Greenland, Iceland, Norway, Russian Federation, and Svalbard and Jan Mayen (Kovacs 2015). Globally, harp seals are listed as *Least Concern* by the IUCN, with the stipulation that climate change could seriously affect this species and it should be reassessed within a decade (Kovacs 2015). While they are considered a single species, there is some taxonomic uncertainty related to breeding populations (Kovacs 2015). Harp seals have not yet been assessed by COSEWIC.

The most abundant pinniped in the northern hemisphere, the Northwest Atlantic population is stable at around 7.5 million animals (Kovacs 2015). Commercial hunting for oil and later pelts drastically reduced the numbers and led to a low of 1.8 million in the early 1970s, but the population has since recovered (Kovacs 2015). Yearly quotas are set at 400,000 however only half of this number is actually killed in Greenland and Canada combined (Kovacs 2015). Currently, harp seals can be killed in subsistence harvests without permit by Indigenous people as well as anyone living north of 53 degrees latitude (Kovacs 2015).

This is a truly marine seal, as they live their entire lives (approximately 30 years) at sea – never touching land (Godwin 1990). Harp seals are highly migratory, traveling about 4,800 km per year – one of the longest known animal migrations (Godwin 1990). This species travels to the Arctic during the open-water season to access feeding grounds each year, and returns south to the Gulf of St. Lawrence, southern Labrador and northern Newfoundland for the winter (DFO 2012; Godwin 1990; Kovacs 2015). Their annual movements appear to follow fluctuations of the ice pack, as they forage at the ice edge during the year (Stenson 2015). Their diet consists of pelagic and benthic invertebrates and fish (Bluhm & Gradinger 2008).

Harp seals are the most abundant marine mammal species in the North Atlantic (Stenson 2015), and Arctic Bay is just south of a recognized high-density area for this species (NPC 2017c). This species is in numerous places throughout Nunavut, including in Lancaster Sound along the coast of Devon Island (INAC, 1983 cited in QIA 2012). It is possible that seasonal presence of harp seals in Arctic Bay changes from year to year and depends on a number of environmental factors given this species large annual habitat range.

In the summer and fall, several thousand harp seals can be seen travelling along the east side of Admiralty Inlet (Government of Nunavut 2010b). Harp seals occur near Arctic Bay during the summer (Arctic Bay Adventures 2017), with several hundred in the southern part of the inlet, including around Peter Richards Islands just around the corner from Arctic Bay (Government of Nunavut 2010b). High density areas are known to be in Jones Sound, Lancaster Sound, Navy Board, Eclipse and Pond Inlets, and down the east coast of Baffin Island (DFO 1994). Harp seals are seen throughout Lancaster Sound during the open-water season (DFO 2015f).

IQ informs that harp seals are observed from Arctic Bay from July to September/October, and arrive each year at the same time as the narwhal (QIA 2018b). Their association with the narwhal has led to the local name which translates to "the dog team of the narwhal" (QIA 2018b). Harp seals sometimes go into the bay for feeding (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk), and are observed to be present (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk; Arctic Bay IQ Workshop 2019 - Olayuk Nagitarvik; Arctic Bay IQ

Workshop 2019 - Tom Nagitarvik). One participant stated harp seals are sometimes only present during the open-water season (Mishak Allurut. pers. comm. June 2019). Areas where hunters wait for seals are identified in Figure 2-1.

Harp seals are a gregarious species, with the exception of the first year of life, when the pups must migrate alone (Godwin 1990). Pups are born from late-February to early-March on the pack ice in their southern wintering grounds (DFO 2012; Godwin 1990; Stenson 2015). Pupping is followed by the annual moult, which occurs from April to May (DFO 2012). Coastal locations of Bylot Island in Lancaster Sound and Baffin Bay have been identified by Inuit as harp seal pupping sites (Baffinland Iron Mines Corporation 2012).

This species local distribution is highly influenced by the ice. In *Upirngasaaq* (mid-March to May), they are associated with the floe edge, and by *Upirngaaq* (June-July) they can be found along the shoreline of Arctic Bay (QIA 2018b). From *Aujaq* (mid-July to September) through *Ukiassaaq* (September to mid-October) they use the open waters, and for the remainder of the year, this species is not present in Arctic Bay (QIA 2018b).

Harp seals have a variety of calls including growls, grunts, squeaks and knocks in a frequency range <16 kHz (Todd et al. 2015). The dive times are relatively short for this species at less than 15 minutes (Lydersen & Kovacs 1993).

Harp seals are harvested in Nunavut, with harvests occurring out of Arctic Bay in during the summer to fall months of July through to October, with variation in the monthly timing and numbers taken annually (Priest & Usher 2004).

Based on this species' life history, ecology, habitat use, IQ, and harvest reports harp seals occur in this region during the summer and fall months. Predators include polar bears, killer whales and Greenland sharks (Kovacs 2015). Threats include reduction of prey availability, entanglement, oil spills, vessel traffic, contamination, and climate change.

12.3.3 Hooded Seal

Hooded seals (*Cystophora cristata*) can be found in the North Atlantic and seasonally in the Arctic ocean, and are native to the waters of Canada, Greenland, Iceland, and Norway (Kovacs 2016a). Globally, hooded seals are listed as *Vulnerable* by the IUCN (Kovacs 2016a), due in part to changing sea ice conditions, and are recommended for re-evaluation once new data become available. Three separate breeding populations are recognized; Lancaster Sound is within range of the Davis Strait (R. R. Campbell 1986; Kovacs 2016a). Last assessed in Canada in 1986 and determined to be *Not At Risk* (R. R. Campbell 1986), hooded seals have been identified by COSEWIC as a Candidate Priority Species to be scientifically re-assessed (COSEWIC 2016b). The global population is thought to be in the hundreds of thousands, though no recent estimate is available, and the population is likely declining due to reduction in pack ice required for breeding (Kovacs 2016a). One of four main pupping areas is located in central Davis Strait, and was assessed in 1984 at 19,000 pupas and again in 2005 at 3,346 indicating a significant decline (Kovacs 2016a).

Hooded seals were heavily targeted for commercial trade in the 1800s and 1900s (R. R. Campbell 1986; Kovacs 2016a). Total allowable catch in the Northwest Atlantic is 8,200 animals yearly in Canada, and a few thousand animals per year are also killed in Greenland (some of which are likely from the Davis Strait population) (Kovacs 2016a).

Hooded seals distribution is influenced by sea ice availability and they tend to move south in winter and north in summer (R. R. Campbell 1986; Kovacs 2016a). The hooded seal is considered uncommon in the Lancaster and north Baffin Bay region (Koski & Davis 1979, 1980) Hooded seals are not observed to be present in Arctic Bay (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk; Arctic Bay IQ Workshop 2019 - Olayuk Nagitarvik; Arctic Bay IQ Workshop 2019 - Tom Nagitarvik), (Mishak Allurut. pers. comm. June 2019); however, in recent years there have been some sightings with one caught recently (Arctic Bay IQ Workshop 2019 - Tom Nagitarvik).

Hooded seals have a preference for drifting on ice floes and deep water and are solitary animals outside the breeding season (Godwin 1990). In February, mature individuals congregate near the ice prior to pupping and mating (R. R. Campbell 1986). Pups are born on pack ice (in Davis Strait) in the late spring, when break-up has begun (R. R. Campbell 1986; Godwin 1990; Kovacs 2016a). Pups nurse for only four days—the shortest lactation period of any mammal—before transitioning to an adult diet (Godwin 1990). This is followed by a compressed breeding season lasting only about 2.5 weeks, with mating occurring in the water (R. R. Campbell 1986; Kovacs 2016a). Animals move northward after the mating season (R. R. Campbell 1986), congregating again for the summer moult (R. R. Campbell 1986; Godwin 1990; Kovacs 2016a). These seals can remain submerged for up to 30 minutes, though longer dives have been recorded (Kovacs 2016a). Hooded seals are generalists and eat a diverse range of prey that includes zooplankton, benthic and pelagic fish, crustaceans, molluscs, and squid (Kovacs 2016a). The vocal frequency range for this species is <6 kHz (Todd et al. 2015).

Hooded seals are a harvested species in Nunavut but are not reported in the Arctic Bay harvest statistics collated by Priest and Usher (Priest & Usher 2004). However, one hooded seal was reported harvested more recently than these previous data (IQ Workshop - Tom Nagitarvik). IQ indicates that this is a relatively rare species in Arctic Bay (IQ Workshop - Jonah Oyukuluk; IQ Workshop - Mishak Allurut; IQ Workshop - Olayuk Nagitarvik; IQ Workshop - Tom Nagitarvik).

Based on this species' life history, ecology, habitat use, IQ, and harvest reports hooded seals are not expected to occur in this region with any regularity, however if they were to occur it would likely be during the open water season. Natural predators include polar bears, killer whales and Greenland sharks (Kovacs 2016a). Threats include harvesting, by-catch/entanglement, competition for food with local fisheries, pollution, and climate change and associated reduced pack ice habitat required for pupping and molting.

12.4 Discussion

The desktop review for marine mammals identified ten marine mammal species that could occur differentially throughout the year in Arctic Bay. All of which have also been identified as Valued Ecosystem Components (VEC) in Nunavut (NGMP 2012). These marine mammal VECs include: beluga whale, narwhal, bowhead whales, killer whales, walrus, and ringed, bearded, harp, and hooded seals and polar bears (NGMP 2012). Marine mammals are an integral component of the Arctic ecosystem, with an important role as both predators and prey. Marine mammals also represent an important cultural significance to the people of Arctic Bay, who most consistently harvest ringed and bearded seals (Arctic Bay IQ Workshop 2019 - Jonah Oyukuluk), narwhals (when they are in the bay) and on one occasion a bowhead whale (Arctic Bay IQ Workshop 2019 - Tom Nagitarvik). The arctic ecosystem of Lancaster Sound and Admiralty Inlet is particularly important to marine mammals during the open-water season and is a migratory corridor for many marine mammal species. During this time period, beluga whales, narwhal, bowhead whales, killer whales, ringed, harp, hooded and bearded seals, walrus and polar bears use the area for a variety of fundamental life functions. In addition to the marine mammal Arctic residents and seasonal visitors, IQ informs that on occasion rare events can also occur. For instance a North Atlantic Right Whale (*Eubalaena glacialis*) was also reported from the Arctic Bay area (QIA 2018b). Occurrences like this are notable and are considered rare events.

The importance of the TI NMCA biodiversity is evident through the information provided by IQ and through the diversity of marine mammal species that reside in or seasonally visit the region. Further to this, the ecological importance of the local waters is recognized as Arctic Bay is located within the TI NMCA and the Admiralty Inlet EBSA and in close proximity to the Lancaster Sound EBSA.

The arctic ecosystem is integrally linked with a strong connection to food chain dynamics through predators and the prey species, which includes Arctic char and sculpin (see Section 11). Marine mammal predators e.g., ringed seal, bearded seal, harp seal, walrus, narwhal and beluga all congregate where the Arctic char are in abundance (QIA 2018b). Seals are also drawn to aggregations of Greenland halibut (QIA 2018b). Similarly, the capelin migration signals the return of whales (QIA 2018b). Habitat use by narwhal and beluga whales is influenced by the presence of killer whales, and some distributional changes in the Arctic ecosystem are related to anthropogenic noise. There is also a concern that noise from town may influence marine mammals use of the nearshore area of Arctic Bay (IQ Workshop - Jonah Oyukuluk).

Of the identified ten species, most are likely to occur in the SCH and DAS Study Area throughout the year depending on their life histories and the variation that has been observed and documented both within and between years, see Table 7-1. The occurrence of killer whales is unpredictable, and the presence of hooded seals appears to be relatively uncommon. Bowhead whales, walrus and bearded seals appear to have more substantial variability in their presence near Arctic Bay than the other species identified as either Arctic residents or seasonal visitors. Some, such as the ringed seal, are abundant and more predictable in their occurrence and distribution. IQ provided regionally specific details for the different marine mammal species and it is clear that the waters of Arctic Bay are seasonally important to both the marine mammals and the Inuit who live near them.

The importance to Inuit harvesting was also evident for all of the identified species except killer whales, with hooded seals and bowhead whales also not being reported harvested out of Arctic Bay with any regularity. The direct connections between the marine mammals of the Arctic and the Inuit who call this region home is clear through the comprehensive review conducted and was further enhanced by the details provided by the IQ program.

13 Socio-Economic Environment

Program objectives for the Socio-Economic survey as outlined in Section 1.6, Table 1-2. This section provides an overview of the existing socio-economic environment of the Hamlet of Arctic Bay including demographics; housing and accommodation; labour force and economic activity; community infrastructure and services; local businesses; and land and resource use. Its main objective is to describe the socio-economic conditions that may interact with the construction of the proposed SCH.

13.1 Desktop Review

Data collection for this socio-economic baseline survey was obtained through a combination of field research (primary data) and desktop research (secondary data). Field research involved interviews and meetings with community leaders and key stakeholders including: Mayor and Council, the local Senior Administrative Officer (SAO), local outfitters, business owners, Royal Canadian Mounted Police (RCMP), and health centre personnel. A local interpreter was hired to facilitate discussions as required.

Desktop sources used are described in Section 1.8.

Please note that in order to ensure the confidentiality of an individual's census response, Statistics Canada rounds values up or down, including totals, to a multiple of '5' or '10'. As stated by Statistics Canada, "as a result, when these data are summed or grouped, the total value may not match the individual values since totals and sub-totals are independently rounded" (Statistics Canada 2019). For example, Table 13-1 indicates under the topic 'Highest Educational Attainment' that the total population 15 years and over is 540 individuals yet under 'Labour Force Activity' the total population 15 years and older is reported as 535. This discrepancy is due to random rounding and does not affect the accuracy of the data set in a significant way. Similarly, percentages may not necessarily add up to 100% because they are calculated on rounded data.

13.2 Socio-Economic Profile

The community of Arctic Bay is located on the north shore of Adams Sound off the coast of Admiralty Inlet on northern Baffin Island. It is also known as 'Ikpiarjuk' meaning pocket in Inuktitut, referring to the way it is nestled among high hills and cliffs. The nearest communities are Pond Inlet, Resolute Bay and Grise Fiord.

13.2.1 Demographics

13.2.1.1 Population

According to Statistics Canada 2016 census data, the total population of Arctic Bay is 868, representing an increase of 5.5% since 2011. The population is young with children aged 0–14 years representing over a third of the total population (38.0% or 330 individuals) and a median age of 22.3 years old for the total population (Statistics Canada 2017). A breakdown of key population statistics provided by Statistics Canada for Arctic Bay is presented in Table 13-1 below. The Nunavut Bureau of Statistics estimated the population of Arctic Bay as of July 1, 2019 to be 967 (Government of Nunavut 2020).

13.2.1.2 Aboriginal Identity

The total self-declared Inuit population is 825 or 95.0% of the total population according to Statistics Canada 2016 census data (Table 13-1).

13.2.1.3 Educational Attainment and Language

Table 13-1 shows that in 2016, of the total population 15 years old and over in Arctic Bay: 15.7% (85 individuals) held a secondary school diploma (or equivalent) as their highest educational attainment and 22.2% (120 individuals) held a postsecondary certificate, diploma or degree. Of the 120 individuals with postsecondary accreditations, 25.0% (30 individuals) held apprenticeship or trades certificates or diploma; 58.3% (70 individuals) held college, CEGEP or other non-university certification; and 12.5% (15 individuals) graduated from a University with a bachelor level degree or higher. In the census results 330 individuals (61.1%) held no certificate, diploma or degree.

Lack of basic literacy and numeracy present a challenge to labour force development in Arctic Bay and across Nunavut (Government of Nunavut & Nunavut Tunngavik Incorporated 2006). Individuals with low levels of literacy are prevented from gaining meaningful employment, "*while others are dead-ended in positions from which they can't progress without additional education and training*" (Government of Nunavut & Nunavut Tunngavik Incorporated 2006).Often, the lack of child care in the community also becomes a barrier to employment, "*It makes it difficult for people to work. It's very much an economic development issue because in order for family members to get jobs, they need someone to look after their children.*" (CBC 2015a).

Inuktitut is the prevalent language in Arctic Bay, reported as the mother tongue for 93.0% of residents. Nearly 1-in-2 Inuit (48.5%) work in settings where Inuktitut is the language most often used at work (Statistics Canada 2017). Additionally, large numbers of people speak English in Arctic Bay – 760 residents or 87.6% of the population (Statistics Canada 2017).

13.2.2 Housing and Accommodation

The 2016 Statistics Canada Census reported Arctic Bay having a total of 227 private dwellings, of which 210 were occupied by their usual residents. Of the 210 occupied dwellings, 85.7% (180) were rented. Of the 180 rented dwellings, 86.1% were public (subsidized) housing. Nearly one in five occupied dwellings were also in need of major repairs.

According to the Nunavut Housing Needs Survey, approximately 45.0% of occupied dwellings in Arctic Bay in 2011 were classified as crowded based on the lack of enough bedrooms (Government of Nunavut 2011a). In about half of the crowded dwellings, respondents indicated that they regularly used the living room to sleep because there were no other rooms available (Government of Nunavut 2011a).The Nunavut Housing Corporation's (NHC) Annual report for 2018-2019 listed Arctic Bay's housing stock at 43.0%, indicating a critical need for housing (NHC 2019).

Hotel accommodation in Arctic Bay is limited and is currently provided by the Tangmaarvik Inn and the Tangmaarvik Bed and Breakfast with a total capacity for 31 guests (GN-EDT 2018).

13.2.3 Labour Force and Economic Activity

Table 13-1 presents the participation, employment and unemployment rates in Arctic Bay according to the 2016 census. Of the population 15 years old and over (535), 280 people or 52.3% participate in the labour force. The unemployment rate was reported as 21.4% in Arctic Bay compared to 17.3% for Baffin (Statistics Canada 2017). The employment rate was reported as 42.1%.

At the territorial level, according to Nunavut's Bureau of Statistics' Annual Labour Force Update, Inuit employment and non-Inuit employment increased in Nunavut between 2018 and 2019. Although Inuit accounted for about 80.0% of the working-age population in Nunavut, on average, they accounted for only 66.0% of the total employed individuals in the territory that year. This disparity is also represented with an employment rate of 44.3% for Inuit compared to 90.2% for non-Inuit (Nunavut Bureau of Statistics 2020).

According to 2016 census data, the median income reported in Arctic Bay for recipients 15 years and over with income was $21,696 in 2015 with 20.0% of total income attributed to government transfers.

The economy of Arctic Bay is characterized by traditional subsistence activities (hunting, fishing, trapping and gathering) mixed with wage-based activities. Despite the high costs associated with harvesting (such as equipment, fuel and materials), participation rates in the traditional economy remain high (Government of Nunavut 2011c). According to Statistics Canada's Aboriginal Peoples Survey in 2006, 83.0% of respondents from Arctic Bay reported having hunted, 86.0% fished, and 79.0% gathered wild plants in the 12 months preceding the survey (Statistics Canada 2006). Many residents continue to rely heavily on fish, seal and whale hunting, both for subsistence and as a cultural activity, including customary resource sharing practices.

The largest employers in Arctic Bay are the Hamlet, the Northern store and the school. A breakdown of how the labour force in Arctic Bay is allocated across various industries is provided in Table 13-2. Public administration, retail trade and educational services collectively occupied nearly half (47.3%) of the total labour force activity in Arctic Bay in 2016 (Statistics Canada 2017). Of interest to the SCH project for potential local hiring is that 15 individuals worked in construction; 20 in transportation and warehousing; and 10 in accommodation and food services.

More recently, Baffinland's Mary River iron ore mining project has had an impact on the local economy. According to Baffinland's 2019 Socio-Economic Monitoring Report, a total of 60 local Inuit residents were employed by either the Baffinland Corporation or its contractors at the Mary River mine site in 2019 (Baffinland 2020).

Table 13-1 Arctic Bay Demographics

Characteristics: 2016 Census Data	Total
Population	
Population in 2016	868
Population in 2011	823
Median age of the population	22.3
% of the population < 15 years of age	38
Percent population change (from 2011)	5.5
Aboriginal Population	
Inuk (Inuit)	825
Non-Aboriginal identity population	35
Highest Educational Attainment	
Total population 15 years and over	540
No certificate, diploma or degree	330
Secondary (high) school diploma or equivalency certificate	85
Postsecondary certificate, diploma or degree	120
Apprenticeship or trades certificate or diploma	30
College; CEGEP or other non-university certificate or diploma	70
University certificate or diploma below the bachelor level	0
University certificate or degree at bachelor level or above	15
Labour force activity	
Total population 15 years and over	535
In the labour force	280
Employed	225
Unemployed	60
Not in the labour force	255
Participation rate %	52.3

Characteristics: 2016 Census Data	Total
Employment rate %	42.1
Unemployment rate %	21.4
Income in 2015	
Median income ($) for total population 15 years and over with income	21,696
Composition of total income (100%)	
Earnings - As a % of total income:	100
Government transfers %	20
Market Income %	80

Source: 2016 Census: Statistics Canada (2017)

Table 13-2 Total Labour Force population aged 15 years and over by Industry- North American Industry Classification System (NAICS) 2012

NAICS Category	Total
11 Agriculture, forestry, fishing and hunting	10
21 Mining, quarrying, and oil and gas extraction	25
22 Utilities	10
23 Construction	15
44-45 Retail trade	50
48-49 Transportation and warehousing	20
53 Real estate and rental and leasing	10
56 Administrative and support, waste management and remediation services	10
61 Educational services	35
62 Health care and social assistance	15
71 Arts, entertainment and recreation	10
72 Accommodation and food services	10
81 Other services (except public administration)	15
91 Public administration	50

Source: 2016 Census Statistics Canada (2017)

13.2.4 Community Infrastructure and Services

13.2.4.1 Hamlet-owned Infrastructure

According to the GN-CGS, the Hamlet of Arctic Bay currently owns the following infrastructure:

- Hamlet office
- Fire Hall
- Community Hall
- Arena
- Heritage building
- Two three-bay parking garages
- Four-bay parking garage
- Dumpsite
- Cold storage building
- Floating dock
- Breakwater
- Water treatment plant
- Sewage wetlands facility and lagoon
- Three staff housing units

13.2.4.2 Hamlet Equipment and Vehicle Inventory

According to the SAO, the Hamlet currently owns the following equipment and vehicles (in addition to the vehicles discussed in the following sections) (Deborah Johnson, SAO pers. comm. Dec 2019):

- One grader
- One front-end loader
- One backhoe
- One dump truck
- One bulldozer

13.2.4.3 Utilities and Communications

The Hamlet of Arctic Bay is responsible for water, sewage and solid waste collection.

Water

Water is collected from Marcil Lake (see Figure 13-1 for location)., located approximately 10 km from town, a short distance from the community airport. Marcil Lake is the only potable water source for the community. Water is treated with chlorine at the truck fill station and loaded into trucks for distribution to holding tanks in each building and dwelling.

Figure 13-1 Location of Marcil Lake – Arctic Bay's Potable Water Source

Source: (Google Earth 2020)

Currently, there are two water trucks that deliver potable water daily to residences and commercial operations and one spare truck (Deborah Johnson, SAO. pers. comm. Nov 2019). The Hamlet reports no issues with water capacity or quality but notes that delivery is at times effected when a truck or driver is down (Deborah Johnson, SAO. pers. comm. Nov 2019). The water truck fill station is expected to be replaced in the next five years (Deborah Johnson, SAO. pers. comm. Nov 2019).

The Hamlet recently applied to renew their Nunavut Water Board (NWB) water licence and requested a water withdrawal of 183.22 cubic metres per day or 66,875 cubic metres annually based on the projected estimated population of 925 in 2029 (Hamlet of Arctic Bay 2019a).

Sewage

A new sewage lagoon was commissioned in 2012 and is now in operation. The single cell sewage lagoon receives trucked sewage from holding tanks for each building. The sewage lagoon is located approximately 4 km from the centre of the Hamlet where sewage is naturally treated before being disposal in a wetland where it eventually reaches the sea (Hamlet of Arctic Bay 2019b).

Sewage and municipal wastewater are collected by two trucks daily. A spare truck is used when needed. As with the water trucks, an ongoing issue with consistent service is truck maintenance and availability of drivers (Deborah Johnson, SAO. pers. comm. Nov 2019).

Solid Waste Management

The municipal waste management facility, located 3 km from the centre of town, includes domestic wastes, construction wastes, metal wastes and hazardous goods. The Hamlet operates one garbage truck three days a week to collect solid wastes within the community and transfer them to the facility. Metals/hazardous wastes are separated from domestic wastes by being placed on either side of the access road heading towards the new sewage lagoon (Hamlet of Arctic Bay 2019c). Hazardous wastes are further segregated from metals by storage in a sea can for disposal to the South. The bulk metals/hazardous waste storage area is not bermed or lined and runoff from the facility currently flows into the sewage treatment wetland (Hamlet of Arctic Bay 2019c).

The Hamlet reports no issues with the current capacity of the waste management facility (Deborah Johnson. SAO. pers. comm. Nov 2019). However, installing fencing around the landfill site to prevent garbage debris from "flying from the site" is a priority listed on the Hamlet's 2019-2020 Infrastructure Plan (Hamlet of Arctic Bay 2019c).

Electricity and Fuel

Electricity through diesel generators is provided by the Qulliq Energy Corporation (QEC), a territorial corporation that is 100% owned by the Government of Nunavut. QEC is the only generator, transmitter and distributor of electrical energy in Nunavut. All electricity needs in Nunavut are met by imported fossil fuel supplies. The Arctic Bay power plant was constructed in 1974 and its capacity is no longer adequate to meet the community's current capacity requirements. Construction of a new diesel generated power plant including two new 90,000 L horizontal fuel tanks for bulk fuel storage is currently under construction in the community.

The GN Petroleum Products Division (GN-PPD) is responsible for the import, storage and distribution of Nunavut's fuel products. The Taqqut Co-op is contracted by GN-PPD to deliver fuel to the community. Fuel is stored at a tank farm located approximately 1.5 km from the community and delivered to residents and businesses with one fuel truck. Fuel storage capacity and delivery quantities for 2017/2018 for Arctic Bay are provided in Table 13-3 and Table 13-4. The Hamlet reports that in recent years, the supply of fuel tends to run low just prior to the arrival of sealift (Deborah Johnson, SAO. pers. comm. Nov 2019). Recent discussions in November 2020 with GN-PPD confirms this statement and expects this trend to continue as community fuel demand increases.

Table 13-3 Bulk Fuel Storage Capacity for Arctic Bay

Total Diesel (L)	Total Reserve (L)	Total Gasoline (L)	Total Jet A-1 (L)
3,188,704	377,640	641,555	1,376,516

Table 13-4 GN-PPD Fuel Delivery for Arctic Bay 2017/2018

Diesel (L)	Gasoline (L)	Jet A-1 (L)
2,869,580	498,317	1,037,248

Source: (Legislative Assembly of Nunavut 2018)

Communications

Landline and mobile phone services are provided by NorthwesTel/Bell Mobility while internet service has historically been provided by Qiniq. However, as of 2019, a new open-access network by NorthwesTel and Bell called Tamarmik Nunaliit now delivers 15 megabits per second (Mbps) Internet and LTE wireless service to Arctic Bay and all Nunavut communities. Operating on Telesat ka-Band satellite technology, the network provides up to 20 times more Internet capacity than previously available, making high-speed Internet and wireless service possible in the community.

The local community radio (Atta Suvaguuq Radio Society) broadcasts daily in Inuktitut and English. There is a Post Office located in the Northern Store.

13.2.4.4 Education Services

Arctic Bay is home to the following educational institutions:

- Inuujaq School (K to 12)
- Arctic Bay Daycare
- Nunavut Arctic College

Inuujaq School houses classrooms, a community library and gym, a kitchen, computer lab, and workshop. Repairs costing ~$295,000 were made to the school gymnasium in 2011–2012, funded by the GN (Government of Nunavut 2011c).

Classes are offered in Inuktitut up to Grade 3, 4, or 5 depending on staffing, after which education is in English. ESL is taught to all students learning in Inuktitut in the classroom and similarly, Inuktitut is taught to all students learning in English during the school day.

The 2019-2020 Community Infrastructure Plan for Arctic Bay identifies the need for a new school due to lack of space. There is also an urgent need for a new day care facility. As stated in the 2019-2020 plan, *"Building 83 was slated for a daycare, a study is required to determine what is required to bring it up to code and expand. There is upwards of 65 kids ages 1-4, a daycare is needed to free up mothers to work and provide for their families"*(Government of Nunavut 2011c).

An Aboriginal Head Start program is in place to offer early childhood education. Due to lack of space the program is offered in Inuujaq School, adding additional pressures to the limited space in the school.

The Arctic Bay Infrastructure Plan (2019–2020) indicates the need for a Youth and Elder Centre where youth and elders can gather to talk and spend time on projects and cultural activities. It is viewed as a much needed centre that could be an effective way for elders to help youth learn about their culture. It would also allow Elders to provide assistance for youth dealing with the problems of drug and alcohol abuse, self-harm and crime (Government of Nunavut 2011a).

Nunavut Arctic College runs a community learning centre in Arctic Bay. Two courses are being offered in the community this school year (2020–2021): PreTrade sand Adult Basic Education (Nunavut Arctic College 2020). The college also offers free community internet services.

13.2.4.5 Transportation

Arctic Bay is serviced daily by scheduled commercial flights provided by Canadian North through Iqaluit. Koonoo Taxi and J.E Taxi provide service to and from the airport and the Tangmaarvik Inn offers a free airport shuttle.

The roads in Arctic Bay are gravel surface with no walkways. Pedestrians, all-terrain vehicles, snow machines, cars, and trucks all share the road. Although dust control on roads is provided by the Hamlet, dust in the community is a concern. Investments in dust control and in a road resurfacing project using fine shale to combat dust were among the priorities listed for the community in their 2019–2020 Infrastructure Plan (Government of Nunavut 2011c).

The Nanisivik Naval Facility (NNF) is a refueling port for navy patrol ships that is linked to Arctic Bay by a 40 km road, the only highway in Nunavut. The NNF is near completion of construction. It is expected to be operational by 2021 when the new Arctic and Offshore Patrol Ships (AOPS) are commissioned and are stationed in the Arctic for the summer shipping season. It is anticipated that the NNF will be operationally linked to Arctic Bay for personnel and equipment support. The road between Arctic Bay and NNF was upgraded in 2019 by the GN in preparation for operations at NNF.

Sealift is a vital link for all communities in Nunavut that supply residents with their annual cargo of goods and materials needed for the year. Sealift ships travel from several southern Canadian ports with a variety of goods ranging from housewares, non-perishable items, construction materials, vehicles, and heavy equipment. The current providers of sealift carriage and associated services are Nunavut Sealink and Supply Inc. (NSSI) and Nunavut Eastern Arctic Shipping Inc. (NEAS). Sealift ships usually arrive in Arctic Bay at the end of August, with the last boat of the year leaving sometime around middle to late September.

The GN-EDT is considering the relocation of sealift operations to the industrial area of Arctic Bay, adjacent the tank farm. This will mitigate the safety concerns and congestion caused by sealift during delivery operations at the existing community ramp (Frank May, former Mayor and current councillor of Arctic Bay. pers. comm. Nov 2018).

13.2.4.6 Emergency and Protection Services

Fire protection is the responsibility of the Hamlet and currently relies on 19 volunteer firefighters, led by a Fire Chief. A new 2,430 ft^2 fire hall is currently being built and is expected to be finished by summer 2021. The new fire hall will feature training areas, space for gear, equipment, and office space (Nunavut News Online 2019). The Hamlet currently has one firetruck and one ambulance.

The RCMP detachment office has a staff of two full time officers. According to the constable in charge, the detachment is strained with the current staffing level (RCMP constable. pers. comm. Nov 2018). A surge in hiring by Baffinland Corporation in 2018 resulted in a 30% increase in calls (RCMP officer. Pers. comm. Nov 2018).

13.2.4.7 Public Health

A new Arctic Bay Health Centre was opened in September 2017, replacing the original health centre that was built in 1983. The old building was too small to meet the health demands of the community and needed significant repairs. The new centre has a modern design to meet the current and future needs of Arctic Bay. It features new radiology and diagnostic systems and has a five-plex residential unit to accommodate staff (Government of Nunavut 2017).

A non-emergency sick clinic is open Monday to Friday from 9:00 am to 12:15 pm. The Health Centre provides a 24-hour on-call emergency service. The Arctic Bay Health Centre is staffed by a supervising nurse, three full time nurses and a mental health nurse. (Gail Redpath, Supervising Nurse, pers. comm. Dec 2019). Arctic Bay also utilizes tele-med services.

The Health Centre delivers community programs that include but are not limited to: Pre-natal and Post-natal Care, Well Woman, Well Man, Well Child and Chronic Disease Clinics.

There are visiting specialists who fly into the community, including the following:

- Dentists: Visit four to six times a year and stay for three weeks per visit
- Doctors: Visits every six to eight weeks for three days (arrive Monday evening and leave Friday morning)
- Physiotherapists, speech therapists, occupational therapists, psychiatrists and dieticians visit the community once or twice a year
- LPN or Public Health Nurse: available at times to assist with specific programs such as immunization

The Arctic Bay Health Centre is not equipped to allow overnight stays and patients who require that level of care are flown by medevac to the hospital in Iqaluit.

The Health Clinic had a total of 10,470 visits in 2016 and 13.3 visits per capita (Government of Nunavut 2018b). The Supervising Nurse said that they are adequately staffed to meet the current health care demands of the community (Gail Redpath, Supervising Nurse, pers. comm. Dec 2019). She indicated that the construction activities of the NNF did not create any significant demands on their resources.

13.2.5 Local Businesses

The following businesses in Table 13-5 are registered with the Hamlet for the current financial year (list provided by Julian Oyukuluk. Economic Development Officer for Arctic Bay, December 2020).

Table 13-5 Registered Business for Current Financial Year

Business	Owner
Arctic Bay Adventure	ABA
Arvaqtuq Service	Moses Oyukuluk
Bohlender Richard	Not available
Photography	Clair Kines
ERC Store	Eunice & Rubin
Ikpiarjuk Service	Frank May
Ilaksatarvik	Isaiah Oyukuluk
Harry Iyerak	Harry Iyearak
Katiqsivik	Martha Willie
Northern	Northwest Company
AB Taxi	Nicola Arnayujumaju
Siqniq	Jonah Oyukuluk
J.E. Taxi	Jimmy
Naqitarvik Outfitting	Tom Naqitarvik
Taqqut Co-op	Co-operative
Taqqut Inns North	Hotel B&B
Inuk Sway	Marlene Willi
5027 LTD	David Swoboda
ULU	Martha Qaunaq
Iglurjuat Outfitting	Moses Koonoo
Uniuti	Sakiasie Qaunaq

13.2.6 Land and Resource Use

13.2.6.1 Harvesting and Food Security

Food security is a problem in Inuit communities throughout northern Canada but especially in Nunavut. Food security, as defined by the United Nation's Food and Agriculture Organization (FAO), exists *"when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life"* (FAO 2002). Nearly half (46.8%)

of Nunavut households were reported to be food insecure in 2014 compared with 12% of households across Canada (Tarasuk et al. 2016). Additionally, results from the 2007/2008 International Polar Year Inuit Health Survey indicated that 70% of Inuit preschoolers in Nunavut resided in food insecure households (Egeland et al. 2010) and that the Inuit in Nunavut had the highest documented food insecurity rate for any Indigenous population in a developed country (Egeland 2011; Egeland et al. 2010; FAO 2002).

The availability of traditionally harvested foods (country food) is therefore crucial because it lowers the demand for imported food which is very costly and most often less nutritious. Additionally, the harvesting, preparation, and sharing of meat and skins offers important opportunities to maintain and enhance Inuit culture.

Residents in Arctic Bay obtain food resources from harvesting, purchasing at stores, and through sealift. Harvesting remains an essential part of life in Arctic Bay.

Harvesting locations (fishing, hunting, and berry picking) identified during the IQ workshop have been provided in the Land Use and Occupancy map (Figure 2-1). With the exception of fishing and the occasional seal or beluga, harvesting is limited in Arctic Bay (IQ workshop June 2019). Narwhal used to be hunted from boats in Arctic Bay (see Figure 2-1) *"but that was over 10 years and they haven't come in that close since"* (IQ Workshop - Jonah Oyukuluk).

Victor Bay is an important area for hunting, especially in the spring and summer (IQ workshop June 2019) (see Figure 2-1). Many cabins and tents are dotted around the Victor Bay area and it is very busy there all summer long (HTA design workshop Nov 2018).

> *"When the ice is forming the seals come close to town but there's really nothing much in the bay when it's open water season."* (IQ Workshop - Olayuk Nagitarvik)

> *"We know there will be noise to construct the harbour but most of the hunters will be on the other side (Victor Bay) where the animals are anyway."* (IQ Workshop - Tom Nagitarvik)

Fishing (nets and casting/jigging) occurs all along the shoreline in the harbour area in Arctic Bay and also at Victor Bay (see Figure 2-1). Fishing is primarily with the use of gillnets however some people *"maybe only five people now"* (IQ Workshop - Tom Nagitarvik) occasionally cast with rods along the beach (IQ Workshop - Jonah Oyukuluk).

Clams and mussels, although present in the bay, are not harvested (see Figure 2-1).

> *"It's very rare for anyone to harvest clams or mussels in the bay because you need scuba equipment or long poles. The area where they are found is too deep."* (IQ Workshop - Tom Nagitarvik)

> *"There was just one person that used to dive for them but he's no longer doing this anymore." (*Mishak Allurut, pers. comm. June 2019)

Although berry harvesting sites have been noted (Figure 2-1) they are not located anywhere near any of the proposed development areas. Additionally, there is very limited harvesting of any other plants in the community (IQ workshop June 2019). Knowledge holders remarked during the IQ and verification workshops that there are no important areas for harvesting plants or berries that should be avoided or protected. Additionally, there is no harvesting of any kelp or seaweed in Arctic Bay (IQ workshop 2019).

There are no particular areas for ptarmigan or arctic hare hunting in Arctic Bay (IQ workshop June 2019).

"People have certain favourite spots they like to hunt for ptarmigan and arctic hare, but there are no areas that are restricted for this, there are no areas to avoid because of this." (IQ Workshop - Olayuk Nagitarvik)

Similarly, a few people still trap in Arctic Bay but there are no particular areas for setting traps, they place them anywhere (IQ workshop June 2019).

Knowledge holders stated that although polar bear sightings can occur anywhere in and around the community, they most often happen at Victor Bay (see Figure 2-1). Polar bears also tend to be attracted to the boxes used to store food for the sled dogs (IQ Workshop - Tom Nagitarvik).

There are several sources of carving stone in the community (see Figure 2-1). Several community members requested that the Project, during quarry operations, considers producing a stockpile of carving stone. It was noted that carvers from Arctic Bay and from Igloolik who travel to Arctic Bay for stone, would really appreciate having a stockpile of carving stone (IQ workshop June 2019, HTA design workshop Nov 2019, Hamlet meeting Nov 2019. Other than the carving stone areas noted, no other culturally important areas were identified by the knowledge holders (IQ workshop June 2019).

13.2.6.2 Travel Routes and Access

Boats and skidoos are critical for subsistence harvesting in the Arctic. Most hunting and fishing in Arctic Bay is done far from the community and requires boats and skidoos to access (HTA Design Workshop Nov 2018). The community's existing harbour has one small breakwater providing a semi-sheltered area for small craft moorage.

"We, the hunters, have lost a lot of expensive harvesting equipment from boats being flipped over in this harbour. Many boats get tipped over, it's not safe." (HTA member. pers. comm. Nov 2018)

There is only one ramp in the community from which to launch boats during the open water season. Dry cargo from the sealift is lightered to shore in the conventional manner using small tugs and barges that are carried on board the arriving ship. The barges are brought into the ramp that is also used for launching boats. Most of the upland area at the ramp is used for dry cargo storage temporarily until it is delivered to the community. Congestion and conflicts with boating exist until the cargo is cleared several days after the delivery. There is no access to the ramp for hunters during sealift delivery. The ramp and surrounding shoreline area become extremely congested and hunters are unable to use the ramp to launch their boats to access harvesting areas (HTA member, pers. comm. Nov 2018).

Additionally, several community members expressed safety concerns associated with the congestion caused by sealift:

"The road is very busy during sealift, there is too much congestion, and many kids playing around heavy equipment such as front-end loaders" (HTA member. pers. comm. June 2019); and

"There are serious safety concerns with sealift. It causes too much congestion. We need to move sealift or ensure the design accommodates for it." (Frank May, former mayor and current councillor. pers. comm. Nov 2018).

In addition to traffic concerns at the shoreline, water safety is also an ongoing concern in the Hamlet, especially considering that many children enjoy playing on the beach and around the shoreline during the summer (Hamlet councillor. pers. comm. Nov 2019).

During the winter, ice access in Arctic Bay is considered very good. As stated by an active hunter during the first HTA design workshop (Nov 2018):

> *"Ice access is not a problem. There are no boulders and the ice is usually nice and flat. We can easily access the ice from many areas to travel to our hunting grounds far away from town"*

Ice break up occurs later at Victor Bay than Arctic Bay. In late spring "even up until July some years" the ice is still accessible to hunters at Victor Bay (see Figure 2-1) (HTA member pers. comm. Nov 2018). There are well traveled skidoo trails from the community to Victor Bay that mainly follow the sides of the road and use the smoother ice provided by the creeks in some areas (Interview – Tom Nagitarvik March 2021). The road to Victor Bay is also heavily travelled during the open water season.

> *"The road to Victor Bay is very busy all summer. It is an important area for harvesting and people enjoy their cabins and tents there"* (Hamlet councillor pers. comm. Nov 2018)

13.2.6.3 TI NMCA: Arctic Bay Nauttiqsuqtiit (Guardian) Program

In July 2018, QIA launched the TI Nauttiqsuqtiit pilot program (otherwise known as the pilot Guardian Program) in Arctic Bay as an early benefit from the IIBA required to establish the TI NMCA. The Nauttiqsuqtiit program is made possible through funding from Parks Canada (QIA 2019). The Nauttiqsuqtit Program aims to provide local stewardship of TI NMCA to monitor the ecological health of the region and maintain cultural sites. Guardians have been hired from Arctic Bay to be the stewards of the marine areas. Their activities include the following:

- Monitor sea ice, snow conditions, wildlife and ship traffic near Arctic Bay
- Assist with search and rescue efforts
- Harvest marine mammals to provide country food for the community
- Contribute to land and marine planning and management
- Promote intergenerational sharing of IQ by taking youth out on the land and sea
- Engage the community members and act as a bridge between Elders and youth
- Act as cultural liaisons and interpreters for the TI NMCA
- Gather IQ (Nunatsiaq News 2019b; QIA 2019)

The pilot project is already making a difference in the community. As stated by QIA President P.J. Akeeagok in June 2019 "Although the Nauttiqsuqtiit have only been working for a few months, they are already making a huge difference and demonstrating the need for similar programs in the other four TI communities. Their job is not only monitoring the region but also harvesting to feed the community" (QIA 2019).

On June 16, 2020, The QIA and Baffinland Iron Mines signed *The Mary River Project Inuit Certainty Agreement* providing Inuit additional benefits related to the expansion of the Mary River Project (QIA

2020). As part of the benefits agreement, the Nauttiqsuqtiit Program will be expanded to all communities affected by the Mary River mine. It will be funded by Baffinland and run by the QIA (QIA 2020).

13.2.6.4 Recreation and Tourism

The Hamlet offers community residents the following recreational facilities:

- West Side Community Hall
- Qaggivik Hall
- Ice arena
- School Gymnasium
- School library

The Arctic Bay 2019-2020 Infrastructure Plan states that the arena needs renovations. The plan also indicates the need for more recreational infrastructure, including a skateboard park, curling rink and another playground area (presently the only playground is located in the school yard). There is public interest in building a community swimming pool, however the municipality must assess the costs and liabilities associated with a pool.

Arctic Bay also hosts an annual community Terry Fox run and participates in events such as Nunavut Quest, a popular dog sledding race that attracts the best teams from across Nunavut. Arctic Bay was also home to an annual 84 km ultramarathon race that was held between Nanisivik and Arctic Bay until 1998.

Arctic Bay offers tourists a unique opportunity to visit a vibrant and traditional community. The Hamlet is located on the western boundary of Sirmilik National Park. The terrain around Arctic Bay is comprised of a variety of geological formations, including glacial carved fiords, hoodoos, flat-topped pillars of stone and sheer red rock cliffs as high as 180 m (600 feet). The wildlife in the vicinity are a tourist attraction. Arctic Bay's sheltered shores and steep cliffs provide nesting habitat for many unique species of High Arctic birds. Its sea waters are home to narwhals and bowhead whales.

Two cruise ships visited the Hamlet in the summer of 2019: L'Austral, (July 2019) with approximately 224 passengers and M/V Ocean Adventurer Quark Expeditions with approximately 128 passengers (September 2019). Additionally, the sheltered harbour is also an ideal landing site for yachts in the summer.

Arctic Bay Adventures Ltd. is an award-winning community owned tourism business established with funding from Kakivak, CanNor, and the GN-EDT (CBC 2018). In 2018, just three years after getting started, Arctic Bay Adventures Ltd. won a national tourism award for maximizing social benefits and running an environmentally-friendly business (CBC 2018). Using local Inuit guides, it offers packages in and around Arctic Bay with activities that include camping, floe edge tours, dog sledding, fishing and birding (Arctic Bay Adventures 2017). Other outfitters based in the community include: the Ikajutit HTA; Nagitarvik Outfitting; Iglurjuat Outfitting; and Siqiniq Outfitting (Julian Oyukuluk. EDO. Pers. comm. Dec 2020).

The Hamlet is exploring the opportunity to renovate the old health centre to create an Arctic Bay Visitor and Heritage Centre. Its purpose is to provide tourist information and a location to keep Arctic Bay's cultural heritage alive and relevant (Government of Nunavut 2011c). The study is being funded by the Kakivak Association.

The Qimatuligvik Heritage Centre & Gift Shop sells traditional arts and crafts and provides tourist information (Travel Nunavut 2019). Tikiq, a local retail store, sells custom clothing, both traditional and modern.

14 Archaeological and Culturally Significant Sites

An Archaeological Impact Assessment (AIA) was conducted in 2019 by Lifeways of Canada in support of the Project in Arctic Bay. Objectives for the AIA are provided in Table 1-2. The following section provides a high-level summary of the methodology and baseline conditions discussed in the AIA. The AIA was submitted to the Territorial Archaeologist at the Government of Nunavut Department of Culture & Heritage (GN-CH) on February 11, 2020 (Lifeways 2019).

14.1 Desktop Review

A desktop review of existing knowledge of archaeological resources and available IQ was conducted to assess landforms for their heritage resource potential. Information on previously recorded sites within 20 km of the Project sites was reviewed, as well as available relevant archaeological reports, studies and published academic articles. Based on the desktop study, through review of the database of significant paleontological sites that the Canadian Museum of Natures maintains on behalf of the Territory of Nunavut, there were no known archaeological or paleontological sites within the Project Study Areas.

IQ has been shared as part of the community consultation program for the Project and is ongoing. Results to date have included the importance of archaeological sites to the community, function of site types and features that have been recorded and the importance of having Elders and/or knowledgeable land users involved in archaeological field studies.

The data collected during the desktop study and literature review was used to inform the field studies for the project.

14.2 Field Program

14.2.1 Methodology

The archaeological field program was conducted on August 9 and 10, 2019 (see Table 1-4 for permit). Fieldwork included pedestrian surveys to assess areas of elevated archaeological potential within the Project Study Areas. The SCH Study Area was limited to the accessible foreshore and intertidal portions.

Sites and related features were recorded are evaluated based on perceived heritage resource value and community cultural value as well as the predicted impact from the Project construction and operation. Community input plays an important role in the evaluation of site value. The addition of a local knowledge holder on the field crew supported the in-field discussions regarding site significance. This individual participated in the AIA, assisted with site interpretation, and acted as a wildlife monitor.

Inventory and assessment techniques followed established practices and, when appropriate, consisted of the following for when archaeological sites of interest are observed:

- Visual examination of the Project Study Areas to determine the presence of surficial features such as stone cache pits, house or tent rings, standing or collapsed buildings, and exposed Precontact cultural materials such as stone tool making debris and tools;
- Visual examination of bedrock exposures or gravels for Precontact quarrying activity;

- Documentation of the location (GPS coordinates), nature, size, and complexity of each identified site; and
- Documentation of individual site features to record content, context, potential identity, and to provide information required to develop a mitigation program.

14.2.2 Results

14.2.2.1 Quarry Study Area

Planned

The pedestrian survey found the entire area to consist of exposed bedrock, boulders, and gravel with sparse vegetation. Although no archaeological sites, artifacts, or features were observed within the Study Area, several modern features were observed.

Modern land use sites, although not meeting the technical requirements to be classified as archaeological sites, are cultural markers of recent occupation and activity and as such are briefly described in the AIA. These included a stone cairn, inuksuit and several hearths as well as stone circles adjacent to Dead Dog Lake. Adjacent to the quarry footprint there is also an outcrop where local carvers have been collecting a white 'marble' for carvings.

Alternate

The pedestrian survey found the entire area to consist of exposed bedrock, boulders, and gravel with very sparse vegetation. No archaeological sites, artifacts, or features were observed.

14.2.2.2 Haul Road Study Area

No archaeological sites, artifacts, or features were observed during the pedestrian survey of the Haul Road Study Area. However, there was a modern inukshuk overlooking the reservoir and the outcrop of carving stone mentioned above is within the haul road right-of-way.

14.3 Discussion

No archaeological or paleontological sites were observed within the Project Study Area and thus there are no mitigation requirements, other than chance find procedures required during the construction and operation of the Project. While the Project Study Area included a 100 m buffer, archaeological mitigation (should features have been observed) would only have been required for a 30 m buffer relative to the Project footprints.

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Appendix 1 Supporting Figures

Appendix 1 – Supporting Figures

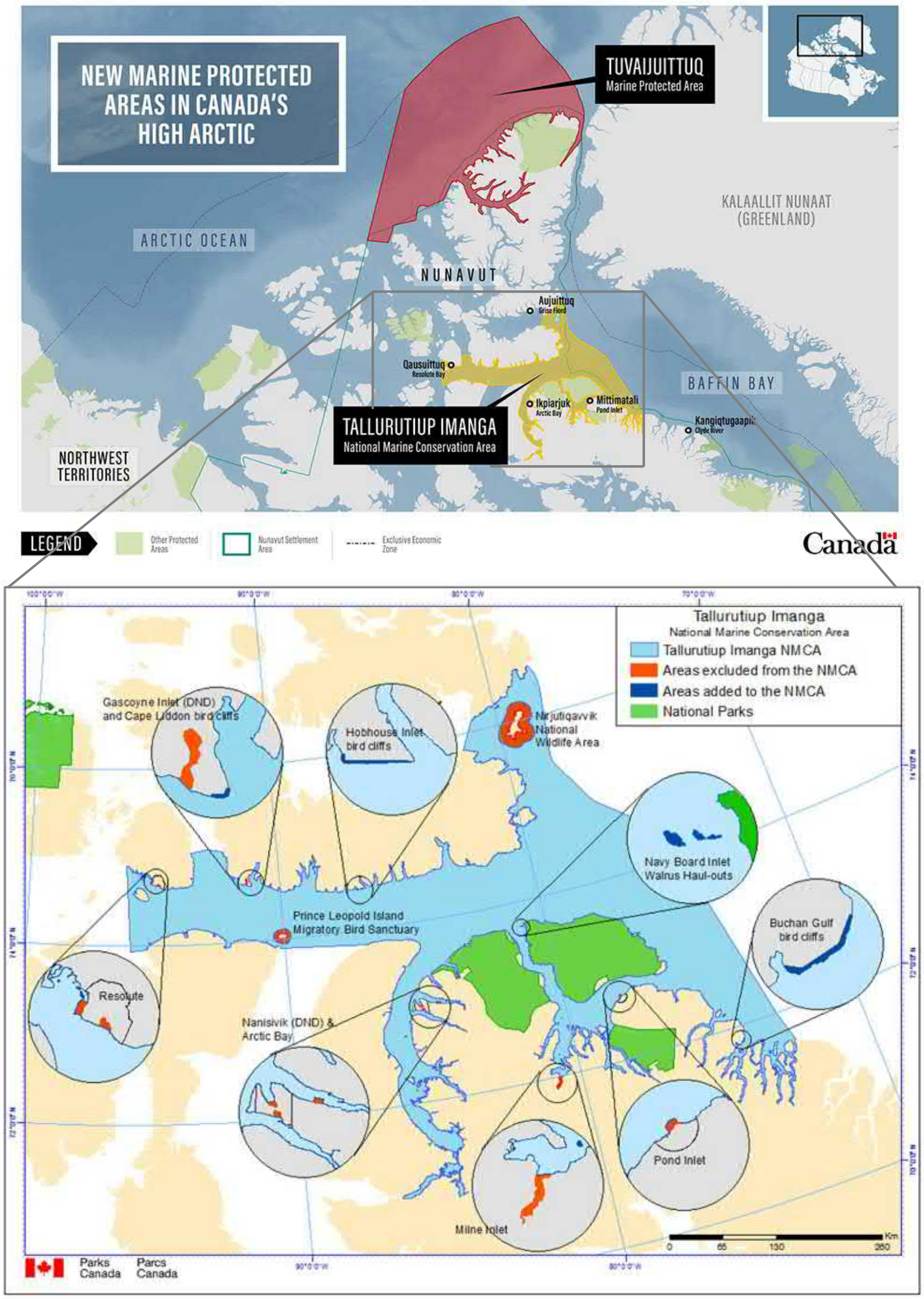


Figure 1 Tallurutiup Imanga National Marine Conservation Area and Tuvaijuittuq Marine Protected Area

Source: (Justin Trudeau 2019; Parks Canada 2020)

Arctic Bay Ice Charts

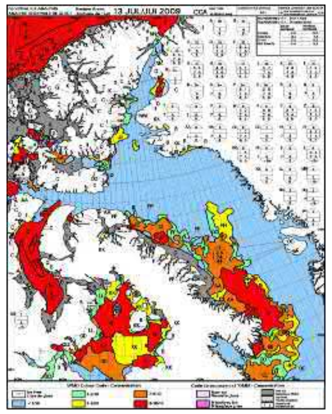
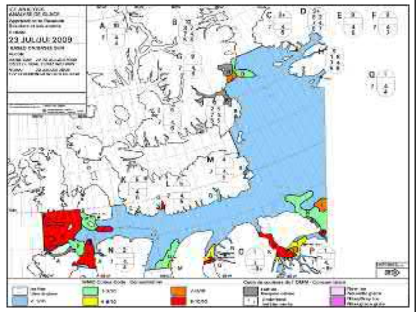
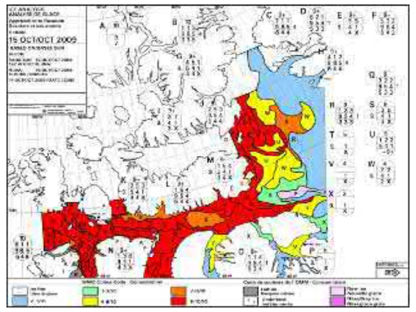
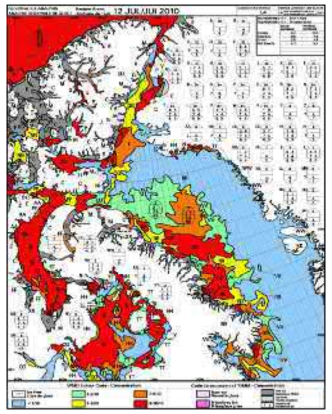
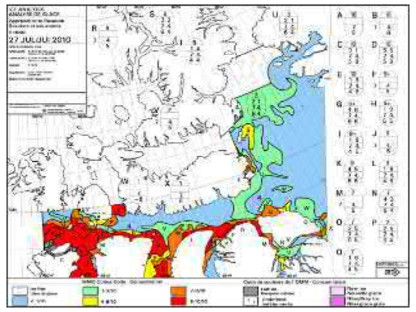
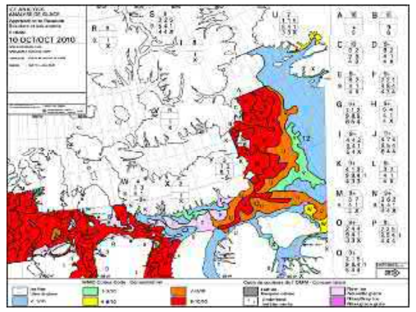
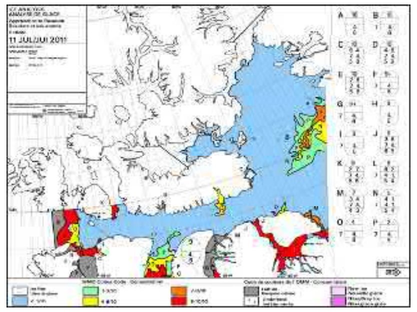
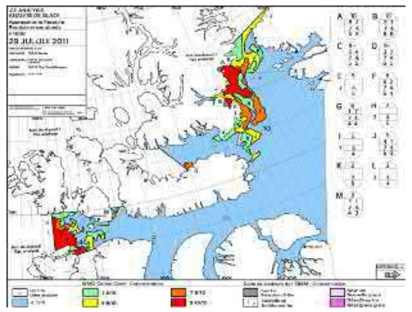
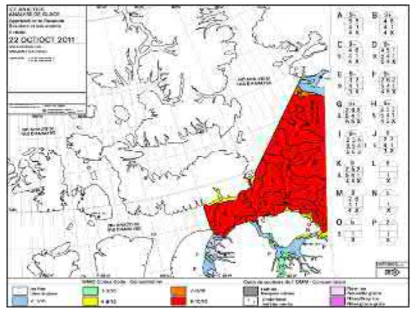
	Ice Charts		Satellite Imagery		Freeze up	Comments
	Ice Break Up	Ice Free	Ice Break Up	Ice Free		
2009	13-jul 	23-Jul 	13-Jul 	23-Jul 	15-Oct 	The ice charts show breakige of ice the week of 23-Jul. By this date, the bay is already free of ice as shown in the satellite image. 10 days after, the bay and creek are ice free and will remain with ice-free conditions until freeze up in mid October
2010	12-Jul 	27-Jul 	07-Jul 	27-Jul 	10-Oct 	Ice Breakage begins the last week of July. It can be observed from the satellite images hat breakage commences from the bay and from south of the inlet. Satellite images show the first ice-free day on 09-Jul, floes will go into the bay in the fallowing weeks. Ice charts show ice-free conditions on 27- Jul. freeze up begins around 10-Oct.
2011	11-Jul 	29-Jul 	N/A		27-Oct 	As the previous year, brake up begins from south of the inlet. The satellite images show the bay free of ice on 06-Jul, but some big floes will eventually go into the inlet and the bay as shown by ice charts and satellite images. Ice-free conditions from 29-July to late October

Figure 2A Arctic Bay Annual Variability in Ice, 2009 to 2011

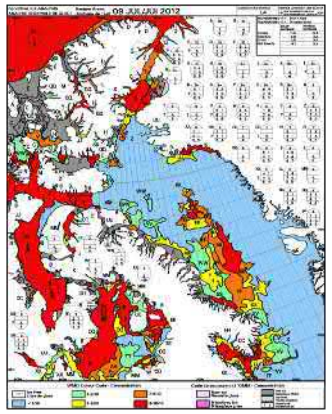
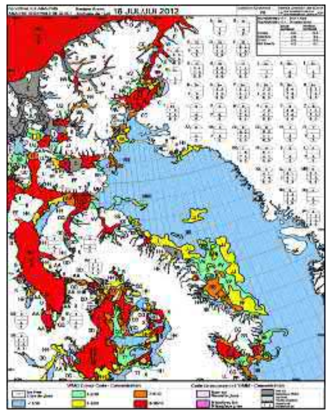
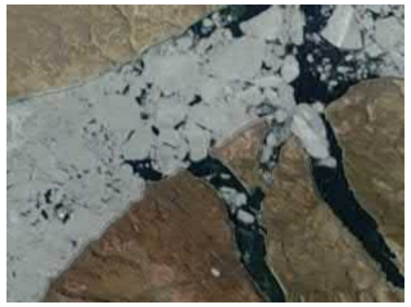
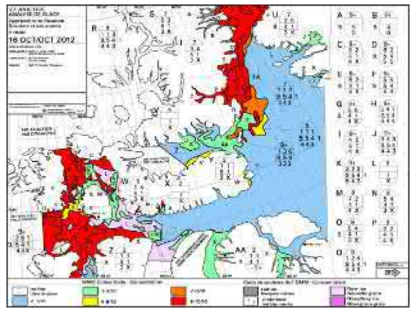
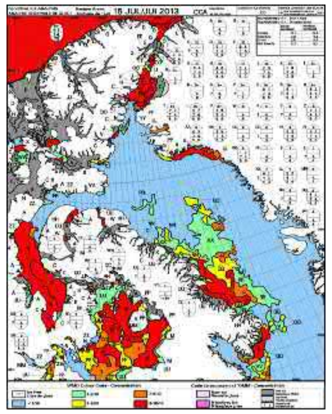
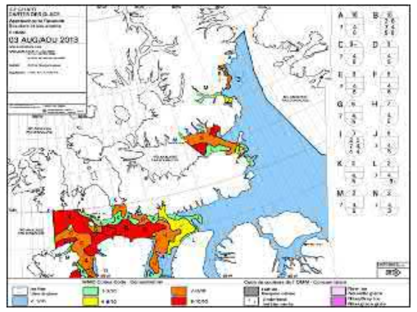
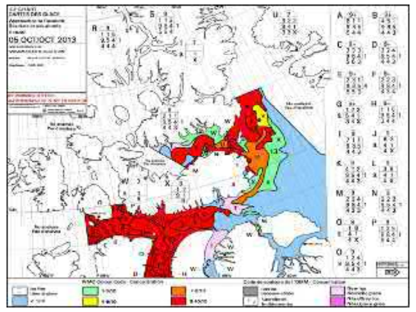
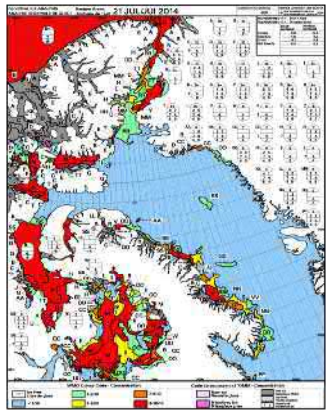
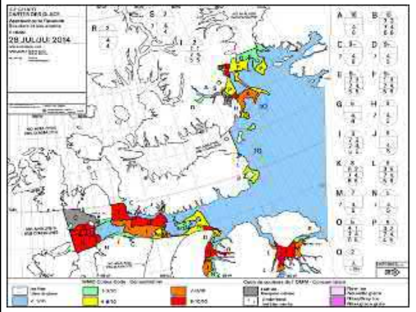
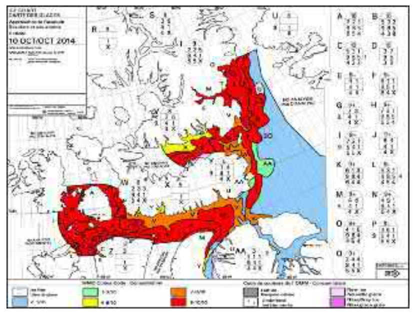
	Ice Charts		Satellite Imagery		Freeze up	Comments
	Ice Break Up	Ice Free	Ice Break Up	Ice Free		
2012	09-Jul 	16-Jul 	02-Jul 	17-Jul 	16-Oct 	Brake up commences the first week of July and begins from south the inlet and form the bay itself. Two weeks after that, the bay is free from ice, but some big floes remain in the inlet. Ice-free conditions from 23-Jul to mid October
2013	15-Jul 	03-Aug 	18-Jul 	04-Aug 	05-Oct 	Ice breakage begins on mid July following the same mechanism as the previous year. Two weeks after, the bay is free from ice
2014	21-Jul 	28-Jul 	12-Jul 	06-Aug 	10-Oct 	Brake up follows same mechanism as 2013. According to daily ice charts, Ice-free conditions from 28-jul to 02-Aug and from 06-Aug to 09-Oct (freeze up)

Figure 2B Arctic Bay Annual Variability in Ice, 2012 to 2014

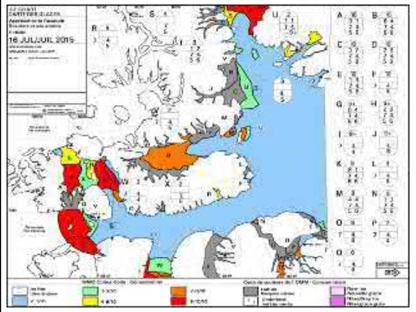
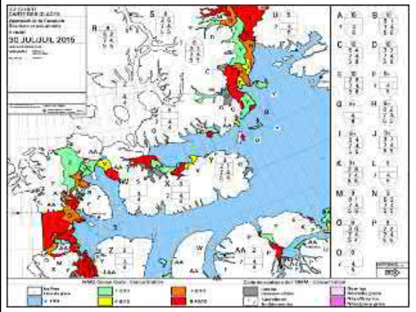
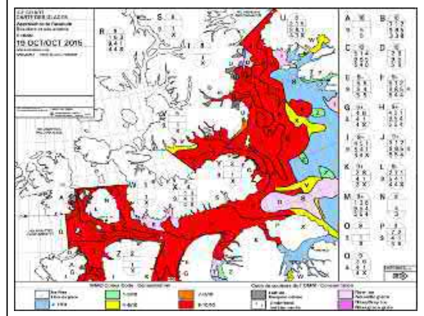
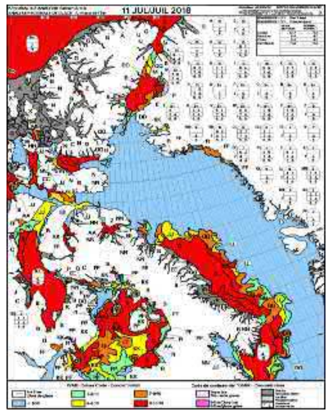
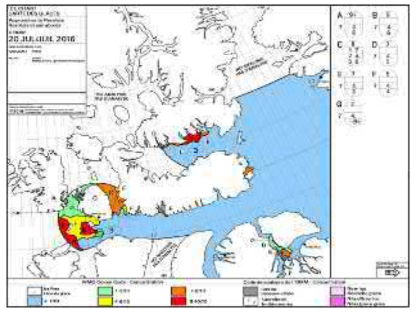
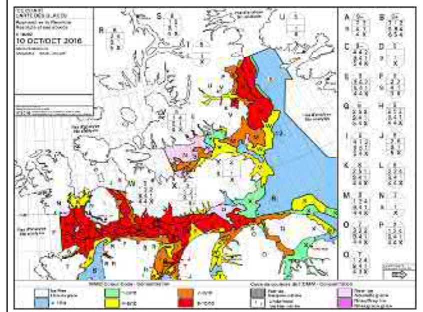
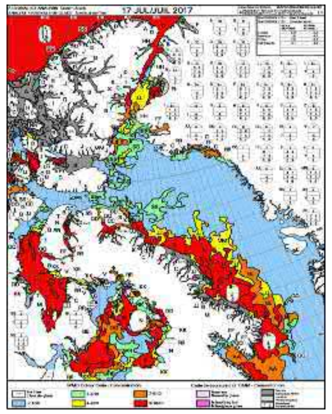
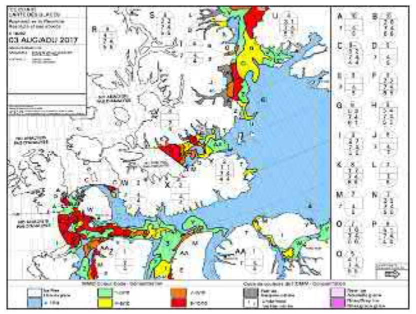
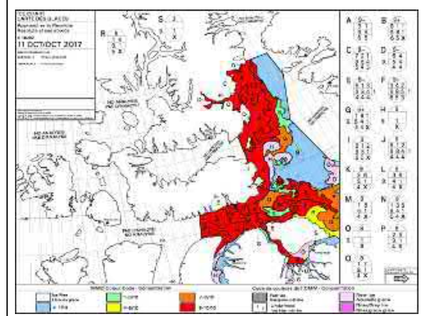
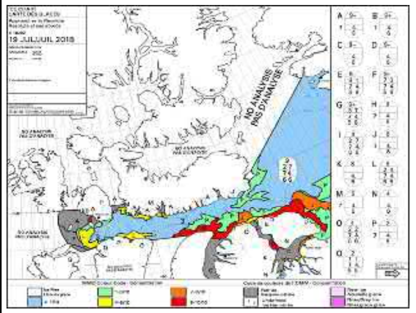
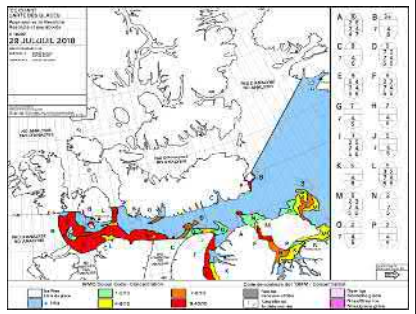
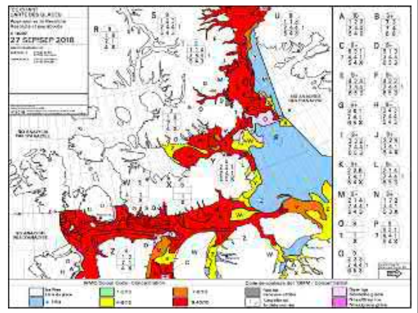
	Ice Charts		Satellite Imagery		Freeze up	Comments
	Ice Break Up	Ice Free	Ice Break Up	Ice Free		
2015	16-Jul 	30-Jul 	11-Jul 	30-Jul 	19-Oct 	Satellite images show brake up at the bay around July 11. Daily ice charts do not really show what is happening exactly at Artic bay. Well defined period of ice-free conditions from 30-Jul to 18-Oct (freeze up)
2016	11-Jul 	20-Jul 	04-Jul 	21-Jul 	10-Oct 	Initial breakage of the bay commences the first week of July. It follows the same pattern as previous years. Two weeks after, the bay is free from ice until 07-Oct (freeze up)
2017	17-Jul 	03-Aug 	04-Jul 	19-Jul 	11-Oct 	Initial breakage of the bay commences the first week of July. It follows the same pattern as previous years. Two weeks after, the bay is free from ice, but some big floes with small concentrations (20%) will get into the creek and the bay in the fallowing 2 weeks.
2018	19-Jul 	29-Jul 	09-Jul 	30-Jul 	27-Sep 	It can be observed from the satellite images that brake up at the bay begins around 09-July. 20 days after, the bay is free from ice for about a week. Ice-free conditions from 29-jul to 04-Aug and from 11-Aug 23 Sep.

Figure 2C Arctic Bay Annual Variability in Ice, 2015 to 2018

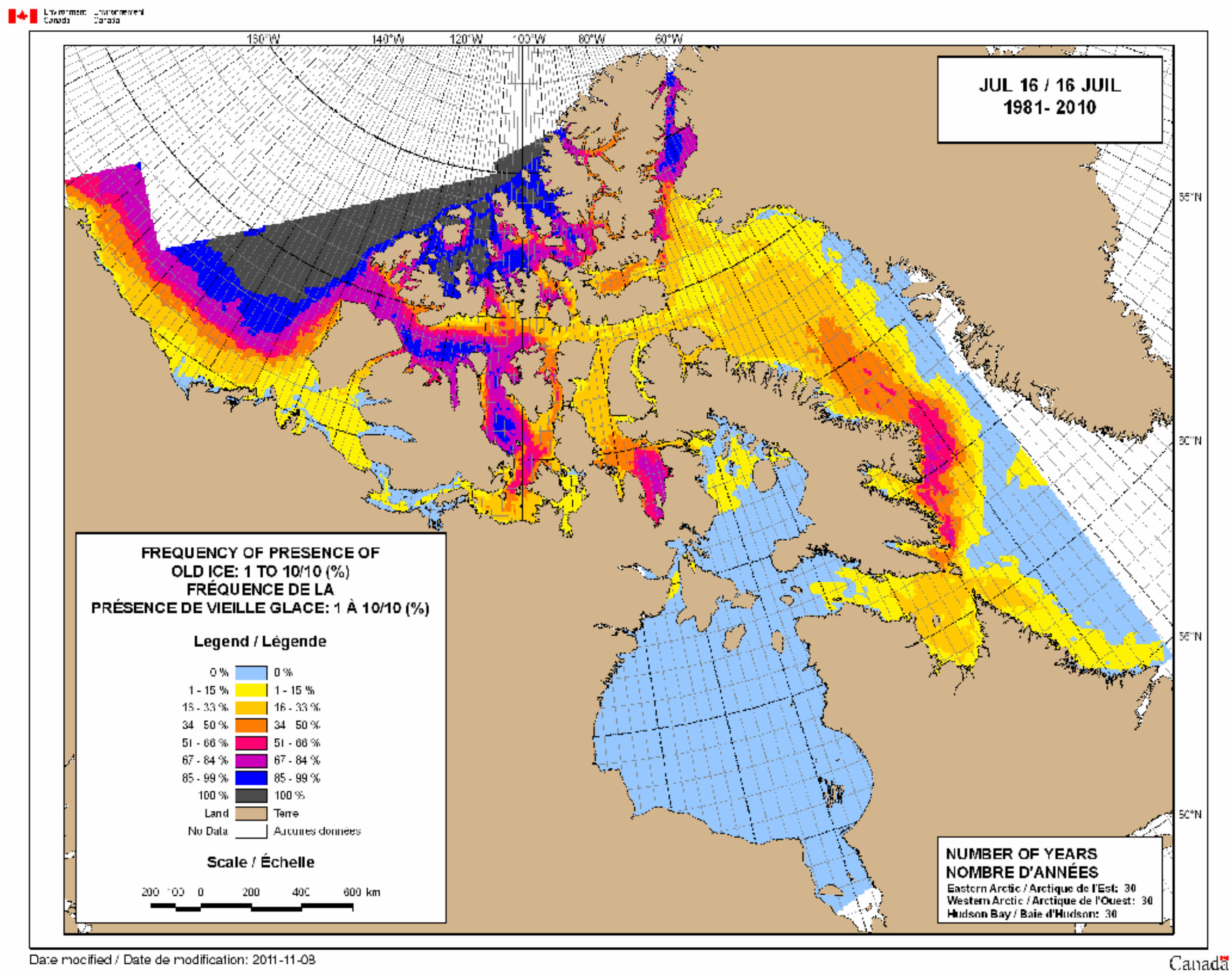
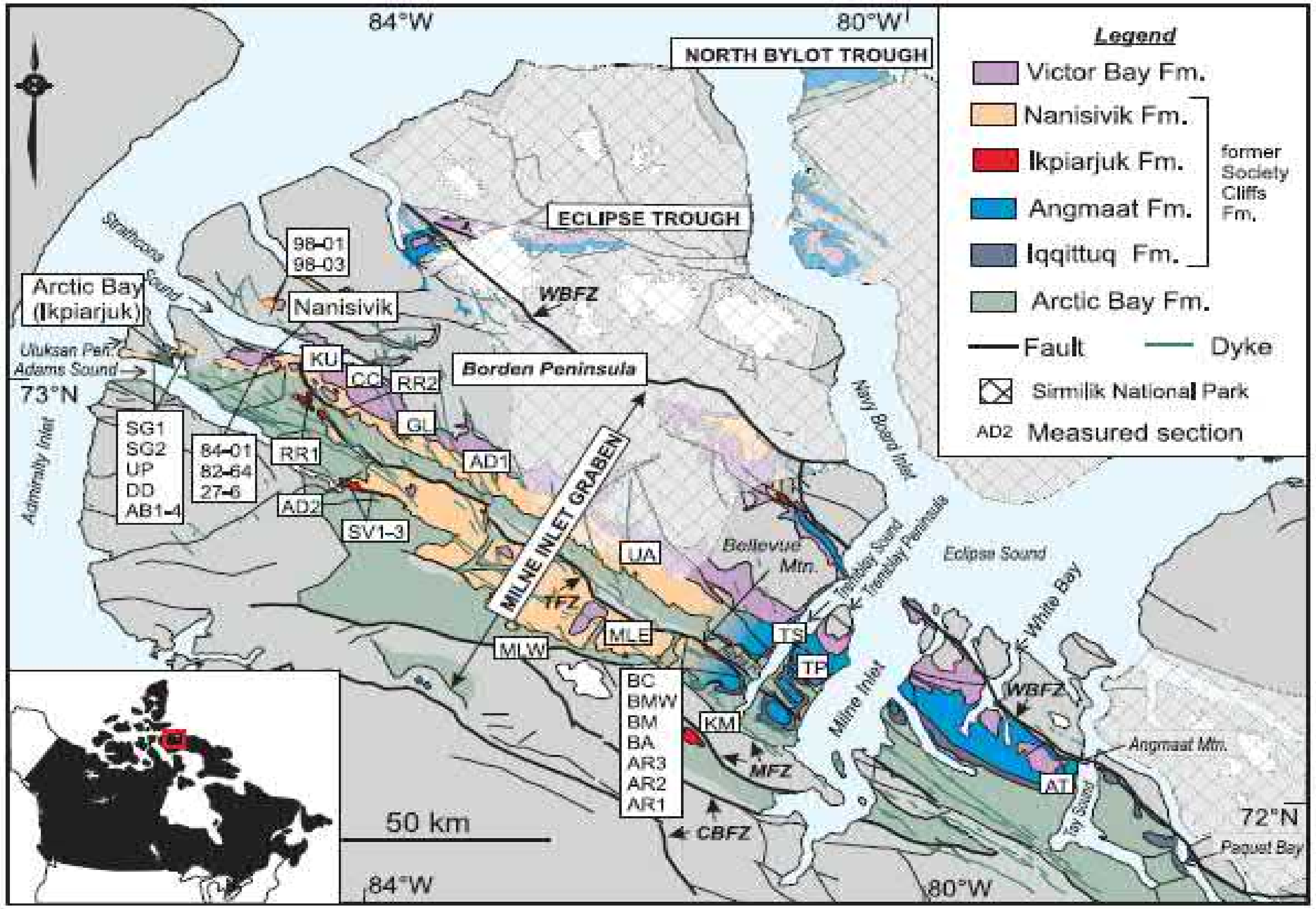
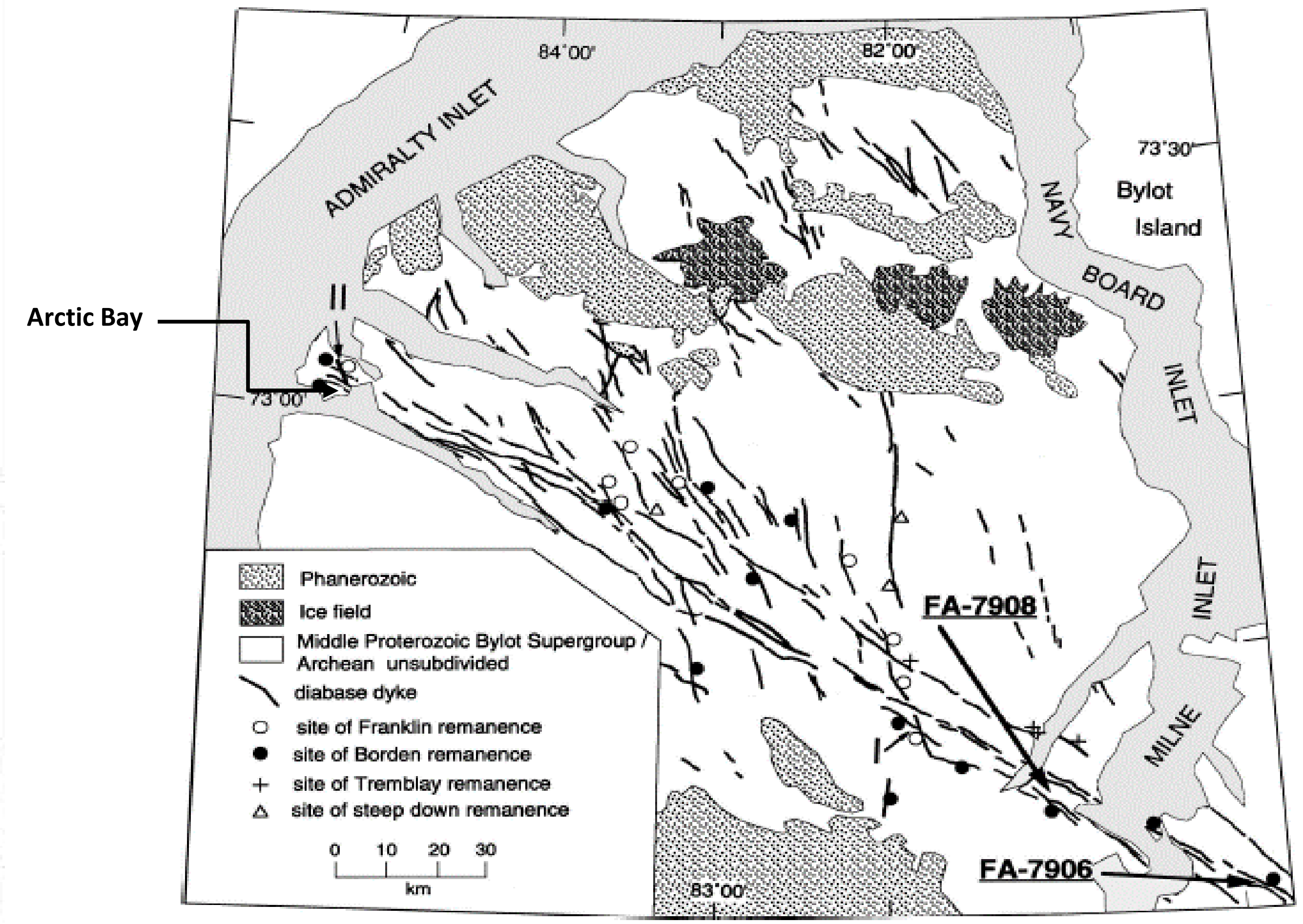


Figure 3 Presence of Multi-Year Ice in Canadian Arctic Regions

Source: Government of Canada (2020)

Arctic Bay - Bedrock Geology





Source: E.C. Turner, 2009. Mesoproterozoic carbonate systems in the Borden Basin, Nunavut. Canadian Journal Earth Science, 46: 915-938.

Source: S.J. Pehrsson and K.L. Buchan, 1999. Boreden dykes of Baffin Island, Northwest Territories: a Franlin U-Pb baddeleyite age and a paleomagnetic reinterpretation. Canadian Journal Earth Science, 36: 65-75.

Notes: Not to Scale (NTS)

Phase	Date	Originator	Checker	Approver	Project Number	Figure Number	REV
NA	9-May-19	JRG	JRG	JRG	307071-01306 / 317071-00037	4	

Figure Name

Arctic Bay - Bedrock Geology

Client

0 100 200 400
Kilometres
1:9,000,000

N

Data Sources:
Tallurutiup Imanga (Lancaster Sound) NMCA from Protected Planet
(provided by Environment Canada)
Tuvaijuittuq MPA from DFO

Location approximated.

Imagery Source: NOAA National Centers for Environmental Information (NCEI); International Bathymetric Chart of the Arctic Ocean (IBCAO); General Bathymetric Chart of the Oceans (GEBCO)

FISHERIES AND OCEANS CANADA - SMALL CRAFT HARBOURS
ARCTIC BAY HARBOUR DEVELOPMENT
ENVIRONMENTAL AND SOCIO-ECONOMIC BASELINE

TALLURUTIUP IMANGA NATIONAL MARINE CONSERVATION AREA AND TUVAIJUITTUQ MARINE PROTECTED AREA

Date: 28-OCT-20	Drawn by: KR	Edited by: KR	App'd by: VB
Advisian ᐃᑉᐱᐊᕐᔪᒃ ᐃᖅᑲᓇᐃᔭᕐᑦ Ikpiaryuk Services Ltd.		Project No. 317071-00037	
		FIG No 5	REV 0

PLOT DATE & TIME: 28/10/2020 3:04:08 PM USER NAME
SAVE DATE & TIME: 28/10/2020 3:04:00 PM ISSUING OFFICE: BURNABY GIS

FILE LOCATION: U:\YVR\317071\00037_PWGS_ArcBayCES\10_Eng\16_Geomatics\01_MXD\Baseline\Fig4_AB_MarineProtectedAreas.mxd

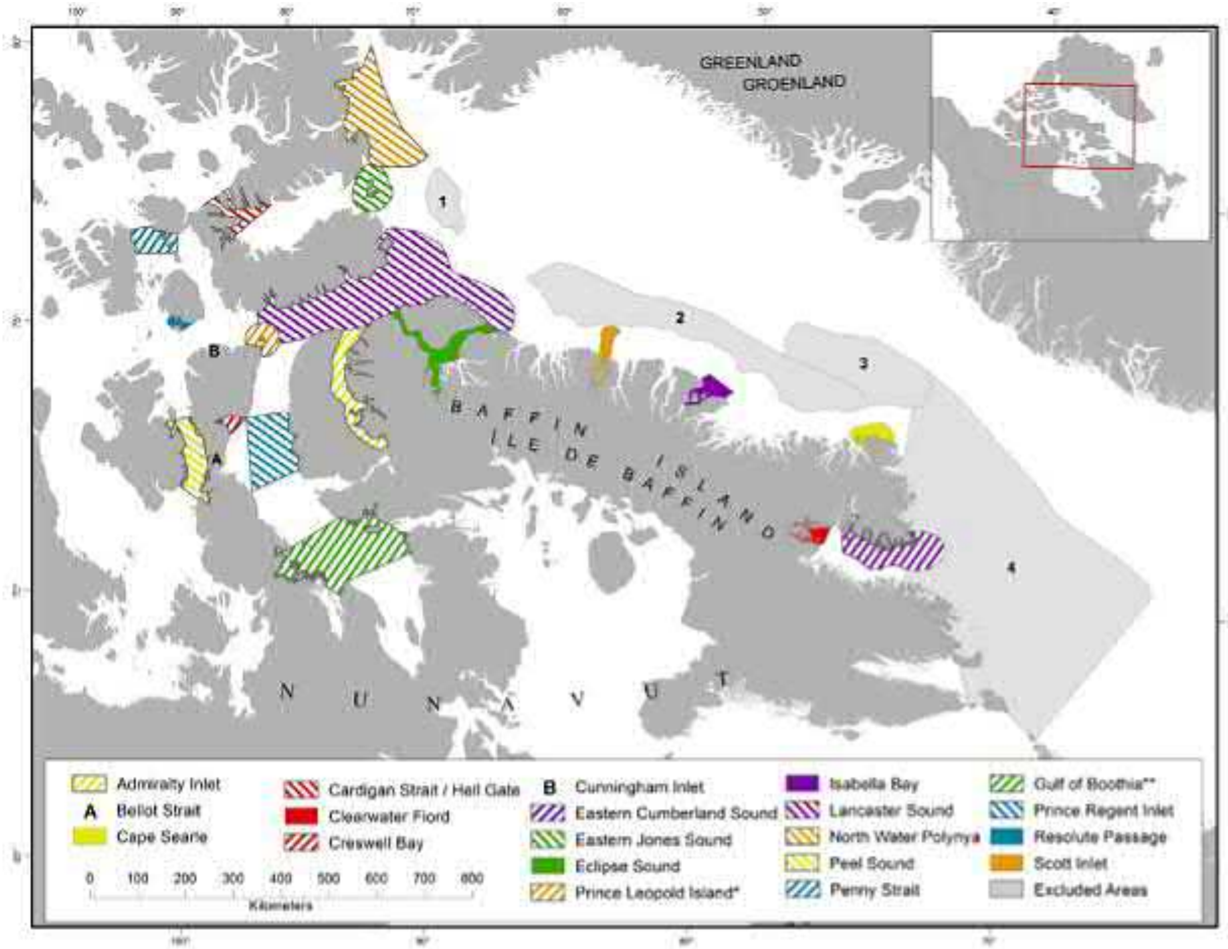
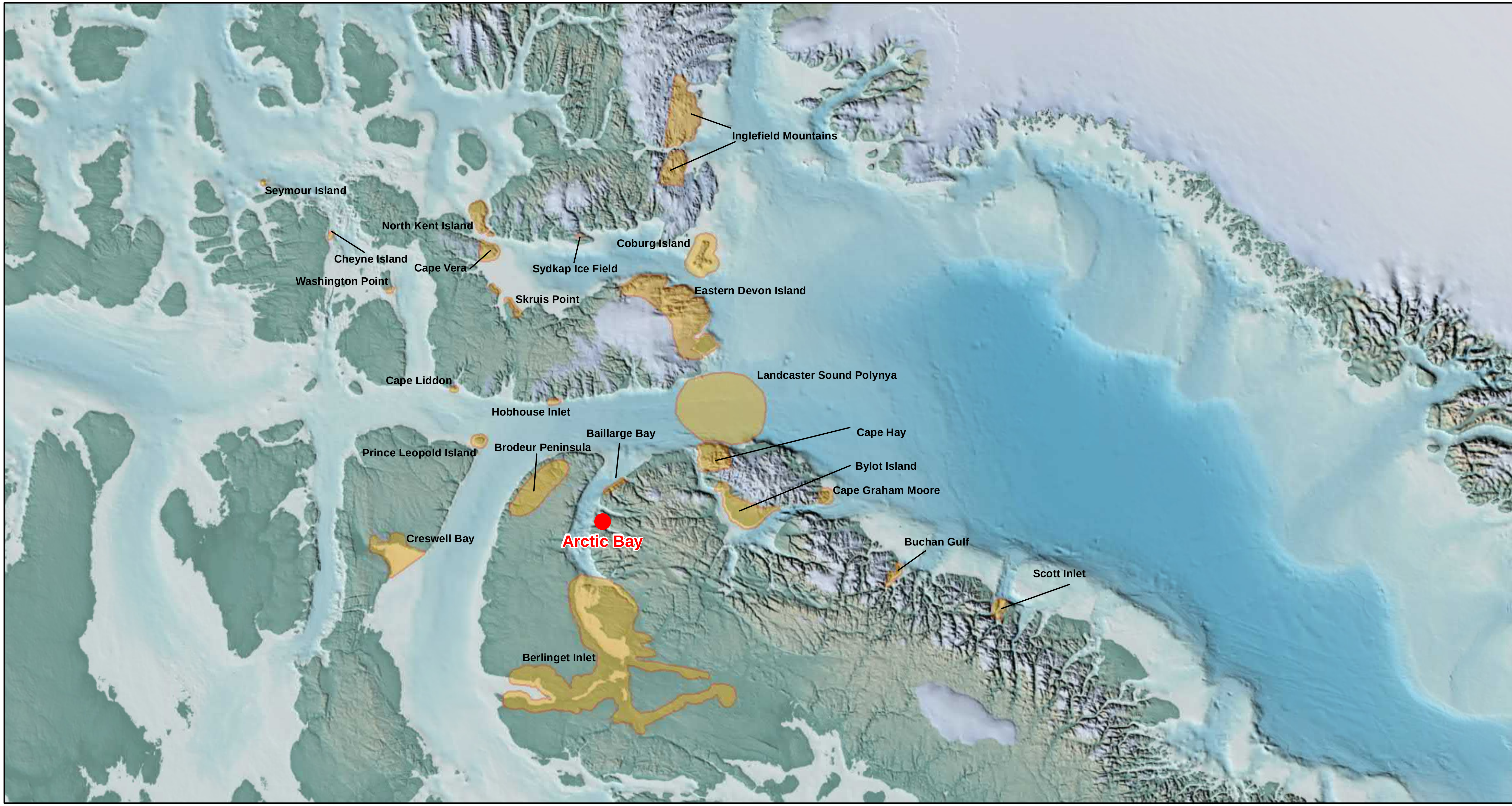


Figure 6 EBSAs in the Eastern Arctic Biogeographic Region

Source: (DFO 2015); Schimnowski et al. (2018)



Legend

- Site Location
- Important Bird Areas

0 50 100 200
Kilometres
1:5,000,000

N

FISHERIES AND OCEANS CANADA - SMALL CRAFT HARBOURS
ARCTIC BAY HARBOUR DEVELOPMENT
ENVIRONMENTAL AND SOCIO-ECONOMIC BASELINE

IMPORTANT BIRD AREAS IN NUNAVUT

Date: 28-OCT-20	Drawn by: JH	Edited by: KR	App'd by: VB
Advisian Ikpiaryuk Services Ltd.		Project No. 317071-00037	
		FIG No 7	REV 0

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PLOT DATE & TIME: 28/10/2020 3:03:17 PM USER NAME: kenneth.ritchie
SAVE DATE & TIME: 28/10/2020 3:03:11 PM ISSUING OFFICE: BURNABY GIS

Imagery Source: NOAA National Centers for Environmental Information (NCEI); International Bathymetric Chart of the Arctic Ocean (IBCAO); General Bathymetric Chart of the Oceans (GEBCO)

FILE LOCATION: U:\YVR\317071\00037_PWGS_ArcBayCES\10_Eng\16_Geomatics\01_MXD\Baseline\Fig6_AB_ImportantBirdAreas.mxd

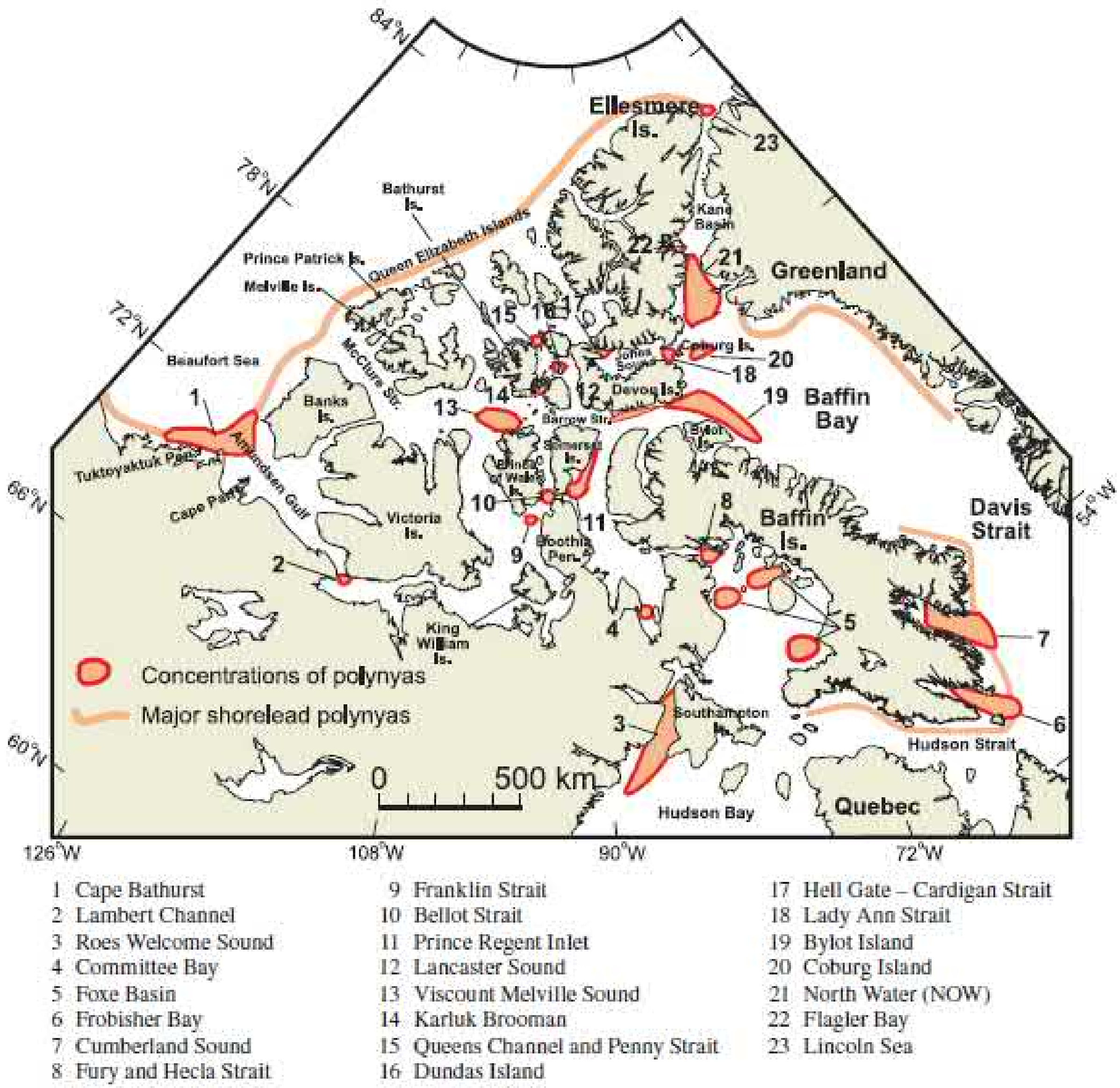
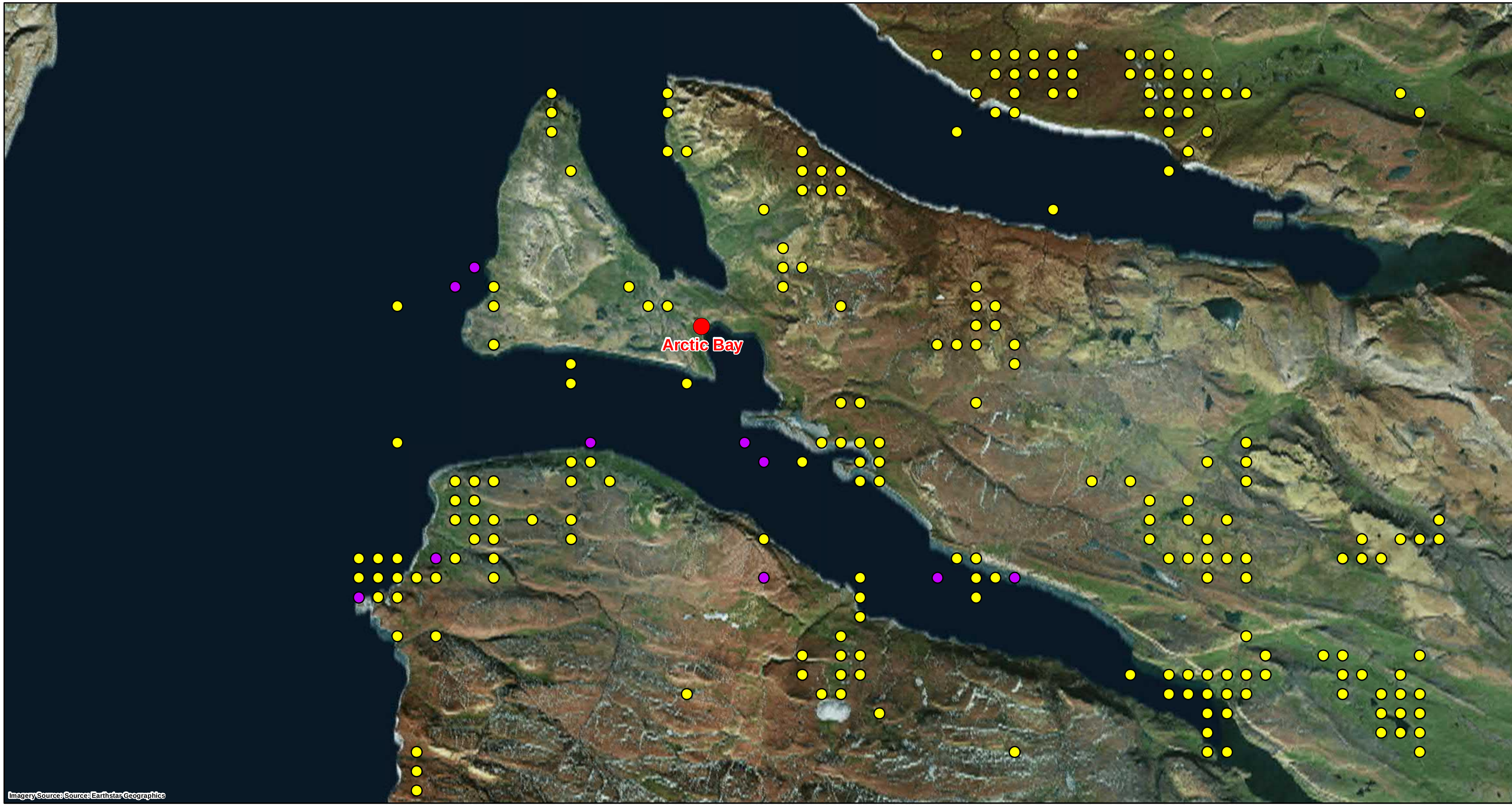


Figure 8 Known polynyas in Canada's Arctic

Source: Figure 1 in Hannah et al (2009).



Legend

Animal Species

- Barren-ground Caribou
- Common Eider

0 1.25 2.5 5
Kilometres
1:200,000
WGS 1984 UTM Zone 16N

N

Locations approximate.

FISHERIES AND OCEANS CANADA - SMALL CRAFT HARBOURS
ARCTIC BAY HARBOUR DEVELOPMENT
ENVIRONMENTAL AND SOCIO-ECONOMIC BASELINE

NWHS HARVESTED CARIBOU, COMMON EIDER DUCK AND EGG LOCATIONS IN ARCTIC BAY (1996-2001)

Date: 29-OCT-20	Drawn by: JH	Edited by: KR	App'd by: LP

Advisian ᐃᒃᐱᐊᕐᔪᒻᒥ ᐃᖅᑲᓇᐃᔨᑦ Ikpiaryuk Services Ltd.

Project No. 317071-00037

FIG No 9 | REV 0

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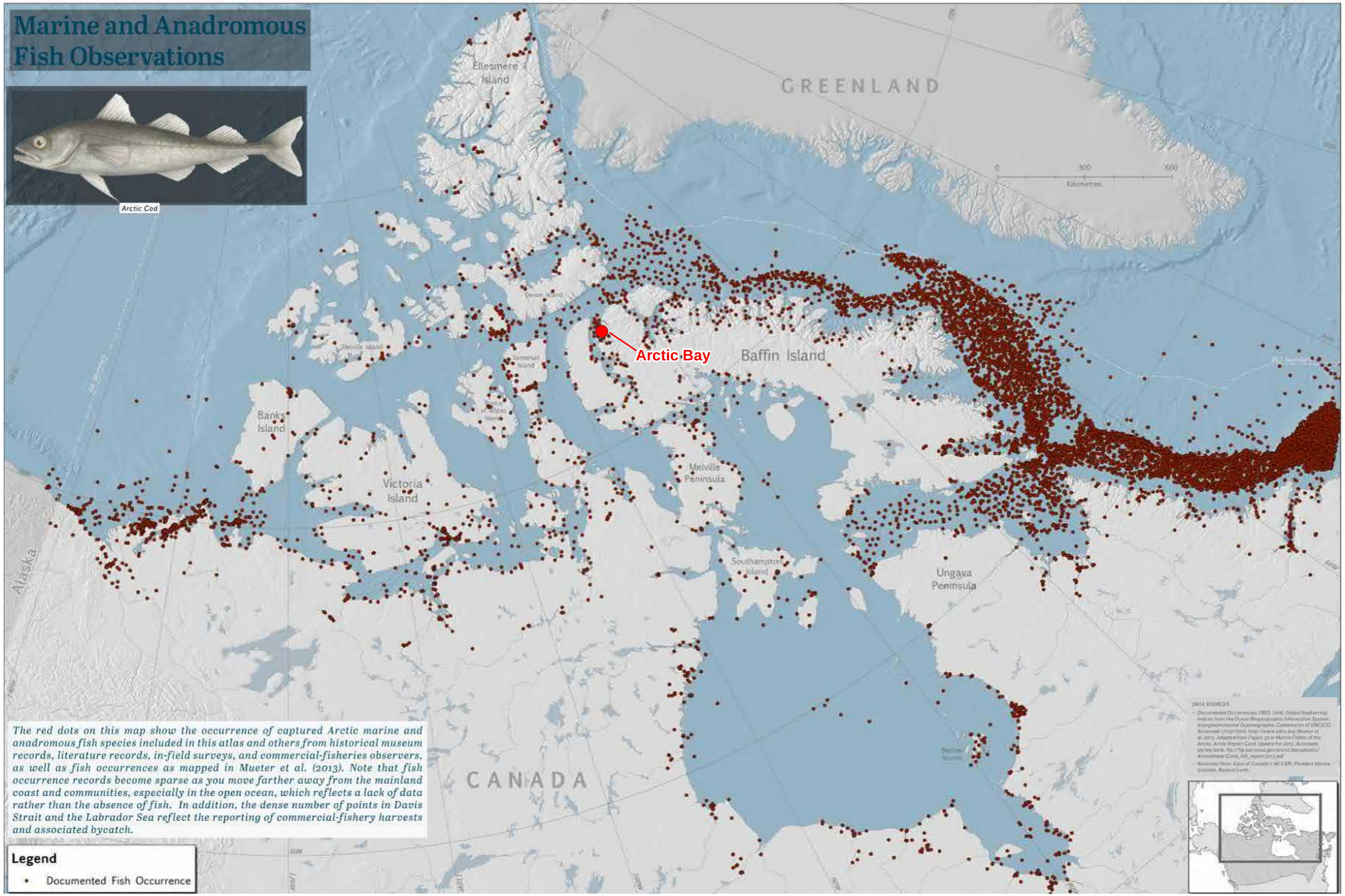
PLOT DATE & TIME: 29/10/2020 7:34:01 AM USER NAME: kenneth.w.ritchie
SAVE DATE & TIME: 29/10/2020 7:32:43 AM ISSUING OFFICE: BURNABY GIS

FILE LOCATION: U:\YVR\317071\00037_PWGS_ArcBayCES\10_Eng\16_Geomatics\01_MXD\Baseline\Fig7_AB_Eider_Caribou_Locations.mxd



FISHERIES AND OCEANS CANADA - SMALL CRAFT HARBOURS
ARCTIC BAY HARBOUR DEVELOPMENT
ENVIRONMENTAL AND SOCIO-ECONOMIC BASELINE

ANADROMOUS FISH DISTRIBUTION IN CANADA

Date: 28-OCT-20	Drawn by: KR	Edited by: KR	App'd by: VB
Advisian ᐃᒃᐱᐊᕐᔪᒃ ᐃᖅᑲᓇᐃᔩᑦ Ikpiaryuk Services Ltd.		Project No. 317071-00037	
		FIG No 10	REV 0

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USER NAME: kenneth.w.ritchie
ISSUING OFFICE: BURNABY GIS
PLOT DATE & TIME: 28/10/2020 3:02:25 PM
SAVE DATE & TIME: 28/10/2020 3:02:16 PM

FILE LOCATION: U:\YVR\317071\00037_PWGS_ArcBayCES\10_Eng\16_Geomatics\01_MXD\Baseline\Fig8_AB_AnadromousFish.mxd

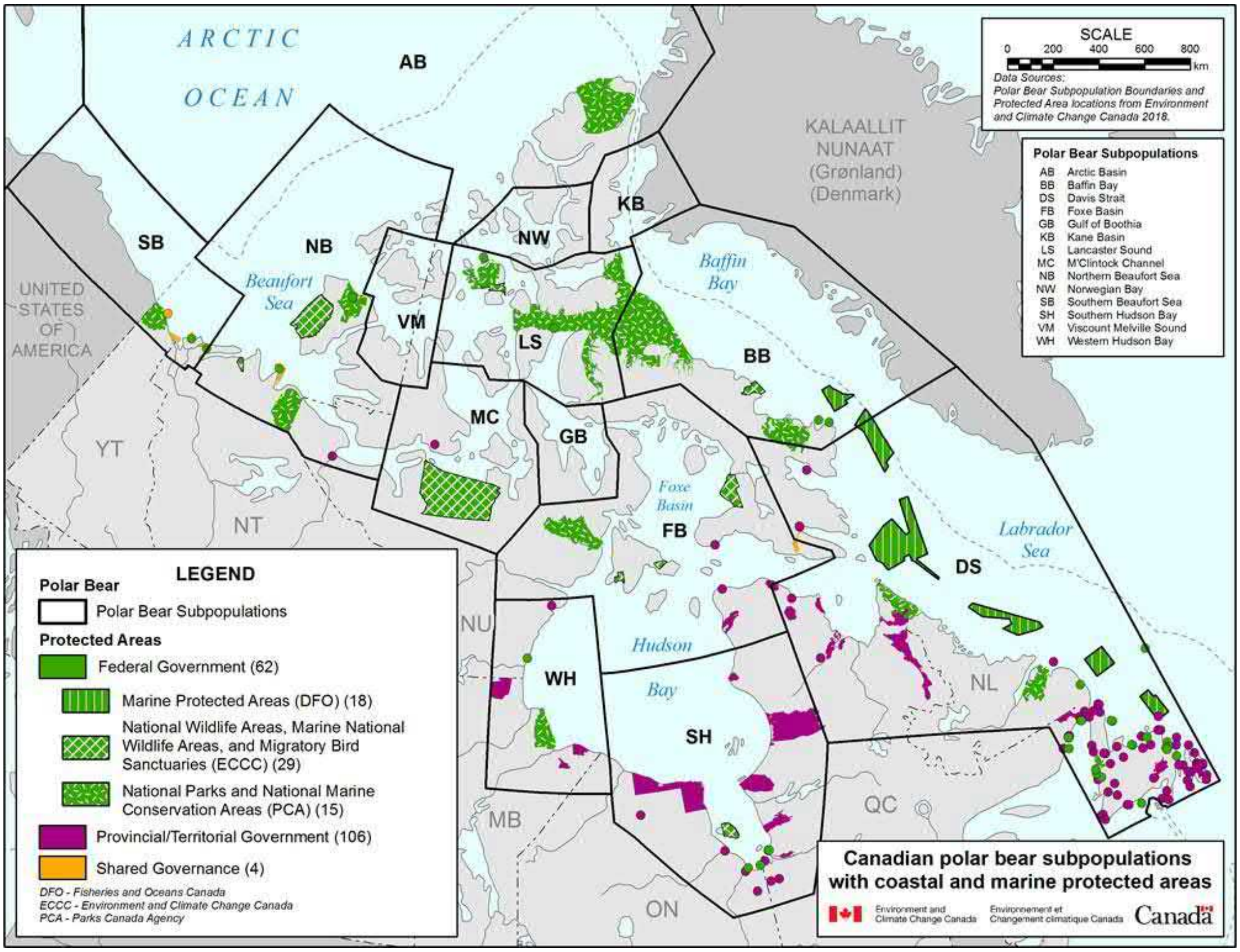

Figure 11 Map of Subpopulations of Polar Bears and Protected Areas

Source: Government of Canada, 2019

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Schimnowski, Paulic, & Martin. (2018). Information in support of the evaluation of Ecologically and Biologically Significant Areas (EBSA) in the Eastern Arctic Biogeographic Region. *DFO Can. Sci. Advis. Sec. Res. Doc., 2017/080*, v + 109 p. Available at: https://waves-vagues.dfo-mpo.gc.ca/Library/40656123.pdf Accessed: October 40652019.

Appendix 2 Laboratory Data Tables

Advisian ᐃᒃᐱᐊᕐᔪᒃ ᐃᖅᑲᓇᐃᔭᕐᑦ Ikpiaryuk Services Ltd.

Table 1

Water Quality Results: Indicator Analysis Parameters

PROJECT No.: 317071-00037

Monitoring Station	Date (dd-mmm-yyyy)	pH (pH units)	Hardness (as CaCO3)-Total Calculated (mg/L)	Hardness (as CaCO3)-Dissolved (mg/L)	Total Organic Carbon (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Nitrate as N (mg/L)	Nitrate plus nitrite as N (mg/L)	Nitrite as N (mg/L)	Ammonia as N (mg/L)	Orthophosphate (mg/L)	Sulphur-Dissolved (mg/L)	Sulphur-Total (mg/L)
CCME Marinewater Aquatic Life, 2007		**(7 - 8.7)**	**---**	**---**	**---**	**---**	**---**	**3.6**	**---**	**---**	**---**	**---**	**---**	**---**
Arctic Bay														
AB WQ1 DEEP	10-Aug-2019	7.92	5440	5240	63 [#3]	0.10 [#4]	7.2	< 0.020	< 0.020 [#2]	< 0.0050 [#2]	0.60 [#1]	0.022	777	830
AB WQ1 SHALLOW	10-Aug-2019	7.99	4180	4200	44 [#3]	< 0.030 [#4]	6.6	< 0.020	< 0.020	< 0.0050	0.45 [#1]	0.0072	630	636
	22-Sep-2020	7.93	4890	5100	0.95	---	< 2.0	< 0.050	< 0.0510	< 0.010	< 0.0050	0.0175	1010	984
AB WQ 2 DEEP	10-Aug-2019	7.98	5310	5140	65 [#3]	0.039 [#4]	2.7	< 0.020	< 0.020	< 0.0050	0.78 [#1]	0.020	770	803
(Duplicate)	10-Aug-2019	8.00	5070	5100	62 [#3]	0.035 [#4]	3.0	< 0.020	< 0.020	< 0.0050	0.11 [#1]	0.020	776	771
	22-Sep-2020	7.90	4900	4720	0.93	---	< 2.0	< 0.050	< 0.0510	< 0.010	0.0064	0.0188	926	989
AB WQ 2 SHALLOW	10-Aug-2019	8.00	4340	4290	47 [#3]	< 0.030 [#4]	4.3	< 0.020	< 0.020	< 0.0050	0.28 [#1]	0.0073	648	661
(Duplicate)	10-Aug-2019	8.00	4430	4280	50 [#3]	< 0.030 [#4]	1.7	< 0.020	< 0.020	< 0.0050	0.54 [#1]	0.0079	669	669
	22-Sep-2020	7.91	4770	4950	0.97	---	< 2.0	< 0.050	< 0.0510	< 0.010	< 0.0050	0.0175	987	962
AB WQ4	10-Aug-2019	8.02	4270	4390	54 [#3]	0.025 [#4]	1.3	< 0.020	< 0.020	< 0.0050	0.67 [#1]	0.0081	667	652
	22-Sep-2020	7.92	4620	5010	0.98	---	< 2.0	< 0.050	< 0.0510	< 0.010	< 0.0050	0.0190	953	954
AB WQ5	10-Aug-2019	7.98	4130	4160	51 [#3]	0.079 [#4]	2.2	< 0.020	< 0.020	< 0.0050	< 0.010 [#1]	0.0073	617	633
	22-Sep-2020	7.87	4680	4730	1.53	---	38.9	< 0.050	< 0.0510	0.013	< 0.0050	0.0174	945	949
AB WQ6	22-Sep-2020	7.92	4660	5060	0.88	---	5.9	< 0.050	< 0.0510	< 0.010	< 0.0050	0.0176	986	964
AB WQ7	22-Sep-2020	7.92	4760	5320	0.90	---	6.3	< 0.050	< 0.0510	< 0.010	< 0.0050	0.0166	1010	984
(Duplicate)	22-Sep-2020	7.92	5030	5130	1.10	---	< 2.0	< 0.050	< 0.0510	< 0.010	< 0.0050	0.0169	993	1000

Relative Percent Difference (RPD) Report														
AB WQ2 DEEP	10-Aug-2019	7.98	5310	5140	65 [#3]	0.039 [#4]	2.7	< 0.020	< 0.020	< 0.0050	0.78 [#1]	0.020	770	803
(Duplicate)	10-Aug-2019	8.00	5070	5100	62 [#3]	0.035 [#4]	3.0	< 0.020	< 0.020	< 0.0050	0.11 [#1]	0.020	776	771
RPD(%)			**4.6%**	**0.8%**	**4.7%**	**10.8%**	**10.5%**	**---**	**---**	**---**	**150.6%**	**0.0%**	**0.8%**	**4.1%**
AB WQ2 SHALLOW	10-Aug-2019	8.00	4340	4290	47 [#3]	< 0.030 [#4]	4.3	< 0.020	< 0.020	< 0.0050	0.28 [#1]	0.0073	648	661
(Duplicate)	10-Aug-2019	8.00	4430	4280	50 [#3]	< 0.030 [#4]	1.7	< 0.020	< 0.020	< 0.0050	0.54 [#1]	0.0079	669	669
RPD(%)			**2.1%**	**0.2%**	**6.2%**	**---**	**86.7%**	**---**	**---**	**---**	**63.4%**	**7.9%**	**3.2%**	**1.2%**
AB WQ5	22-Sep-2020	7.92	4760	5320	0.90	---	6.3	< 0.050	< 0.0510	< 0.010	< 0.0050	0.0166	1010	984
(Duplicate)	22-Sep-2020	7.92	5030	5130	1.10	---	< 2.0	< 0.050	< 0.0510	< 0.010	< 0.0050	0.0169	993	1000
RPD(%)			**5.5%**	**3.6%**	**20.0%**	**---**	**---**	**---**	**---**	**---**	**---**	**1.8%**	**1.7%**	**1.6%**

NOTES:

1. --- in guideline row(s) denotes no criteria for that parameter.
2. --- in detail data row(s) denotes parameter not analyzed.
3. Highlighting indicates non-detect parameters above applied guideline/criteria.
4. Highlighting indicates parameters at applied guideline/criteria.
5. Denotes values exceeding

   (Canadian Environmental Quality Guidelines for the Protection of Aquatic Life (CCME, 1999 and Updates, last update

   Nitrate as N:

   Guideline for NO3 as N, for reporting as just "NO3", the guideline is 3.6 mg/L
6. Superscript [#1] - Detection limits raised due to dilution to bring analyte within the calibrated range.
7. Superscript [#2] - Matrix spike exceeds acceptance limits due to suspected matrix interference.
8. Superscript [#3] - Detection limits raised due to sample matrix.
9. Superscript [#4] - Due to the sample matrix, sample required dilution. Detection limit was adjusted accordingly.

Table 2

Water Quality Results: Total Metals and Trace Elements

PROJECT No.: 317071-00037

General / Total Metals and Trace Elements (Aluminum – Lead)

Monitoring Station	Date (dd-mmm-yyyy)	pH (pH units)	Aluminum (ug/L)	Antimony (ug/L)	Arsenic (ug/L)	Barium (ug/L)	Beryllium (ug/L)	Bismuth (ug/L)	Boron (ug/L)	Cadmium (ug/L)	Calcium (ug/L)	Chromium (ug/L)	Cobalt (ug/L)	Copper (ug/L)	Iron (ug/L)	Lead (ug/L)
CCME Marinewater Aquatic Life, 2007		**(7 - 8.7)**	**---**	**---**	**12.5**	**---**	**---**	**---**	**---**	**0.12**	**---**	**1.5**	**---**	**---**	**---**	**---**
Arctic Bay																
AB WQ1 DEEP	10-Aug-2019	7.92	59	< 0.50	2.01	9.1	< 1.0	< 1.0	3730	< 0.050	352000	< 0.50	0.16	0.61	26	< 0.10
AB WQ1 SHALLOW	10-Aug-2019	7.99	66	< 0.50	0.75	4.7	< 1.0	< 1.0	2850	< 0.050	277000	< 0.50	0.12	1.22	29	0.41
	22-Sep-2020	7.93	12.6	< 1.0	1.38	7.5	< 0.50	< 0.50	2840	0.041	324000	< 0.50	< 0.050	0.74	13	0.121
AB WQ 2 DEEP	10-Aug-2019	7.98	34	< 0.50	1.60	9.4	< 1.0	< 1.0	3650	< 0.050	348000	< 0.50	0.14	< 0.50	15	< 0.10
(Duplicate)	10-Aug-2019	8.00	34	< 0.50	1.65	10.0	< 1.0	< 1.0	3590	< 0.050	335000	< 0.50	0.13	< 0.50	18	< 0.10
	22-Sep-2020	7.90	18.3	< 1.0	1.44	7.5	< 0.50	< 0.50	2840	0.040	327000	< 0.50	< 0.050	< 0.50	33	0.056
AB WQ2 SHALLOW	10-Aug-2019	8.00	46	< 0.50	0.89	4.7	< 1.0	< 1.0	3000	< 0.050	285000	< 0.50	0.10	0.71	30	0.12
(Duplicate)	10-Aug-2019	8.00	38	< 0.50	1.41	5.0	< 1.0	< 1.0	3090	< 0.050	291000	< 0.50	0.13	0.68	25	< 0.10
	22-Sep-2020	7.91	5.5	< 1.0	1.40	7.3	< 0.50	< 0.50	2960	0.038	322000	< 0.50	< 0.050	< 0.50	< 10	< 0.050
AB WQ4	10-Aug-2019	8.02	38	< 0.50	1.20	5.6	< 1.0	< 1.0	3020	< 0.050	284000	< 0.50	0.14	< 0.50	25	< 0.10
	22-Sep-2020	7.92	14.5	< 1.0	1.37	7.2	< 0.50	< 0.50	2680	0.038	312000	< 0.50	< 0.050	< 0.50	14	0.166
AB WQ5	10-Aug-2019	7.98	49	< 0.50	1.20	5.4	< 1.0	< 1.0	2880	< 0.050	275000	< 0.50	0.12	0.92	27	< 0.10
	22-Sep-2020	7.87	752	< 1.0	1.68	13.7	< 0.50	< 0.50	3000	0.048	321000	1.31	0.808	2.29	1430	1.65
AB WQ6	22-Sep-2020	7.92	12.5	< 1.0	1.39	7.6	< 0.50	< 0.50	2840	0.052	323000	< 0.50	< 0.050	< 0.50	17	0.082
AB WQ7	22-Sep-2020	7.92	5.4	< 1.0	1.38	7.4	< 0.50	< 0.50	2820	0.038	328000	< 0.50	< 0.050	< 0.50	< 10	< 0.050
(Duplicate)	22-Sep-2020	7.92	6.6	< 1.0	1.44	7.7	< 0.50	< 0.50	2820	0.042	315000	< 0.50	< 0.050	< 0.50	< 10	0.053
Relative Percent Difference (RPD) Report																
AB WQ2 DEEP	10-Aug-2019	7.98	34	< 0.50	1.60	9.4	< 1.0	< 1.0	3650	< 0.050	348000	< 0.50	0.14	< 0.50	15	< 0.10
(Duplicate)	10-Aug-2019	8.00	34	< 0.50	1.65	10.0	< 1.0	< 1.0	3590	< 0.050	335000	< 0.50	0.13	< 0.50	18	< 0.10
RPD(%)		**0.3%**	**0.0%**	**---**	**3.1%**	**6.2%**	**---**	**---**	**1.7%**	**---**	**3.8%**	**---**	**7.4%**	**---**	**18.2%**	**---**
AB WQ2 SHALLOW	10-Aug-2019	8.00	46	< 0.50	0.89	4.7	< 1.0	< 1.0	3000	< 0.050	285000	< 0.50	0.10	0.71	30	0.12
(Duplicate)	10-Aug-2019	8.00	38	< 0.50	1.41	5.0	< 1.0	< 1.0	3090	< 0.050	291000	< 0.50	0.13	0.68	25	< 0.10
RPD(%)		**0.0%**	**19.0%**	**---**	**45.2%**	**6.2%**	**---**	**---**	**3.0%**	**---**	**2.1%**	**---**	**26.1%**	**4.3%**	**18.2%**	**---**
AB WQ7	22-Sep-2020	7.92	5.4	< 1.0	1.38	7.4	< 0.50	< 0.50	2820	0.038	328000	< 0.50	< 0.050	< 0.50	< 10	< 0.050
(Duplicate)	22-Sep-2020	7.92	6.6	< 1.0	1.44	7.7	< 0.50	< 0.50	2820	0.042	315000	< 0.50	< 0.050	< 0.50	< 10	0.053
RPD(%)		**0.0%**	**20.0%**	**---**	**4.3%**	**4.0%**	**---**	**---**	**0.0%**	**10.0%**	**4.0%**	**---**	**---**	**---**	**---**	**---**

Total Metals and Trace Elements (Lithium – Zirconium)

Monitoring Station	Date (dd-mmm-yyyy)	Lithium (ug/L)	Magnesium (ug/L)	Manganese (ug/L)	Mercury (ug/L)	Molybdenum (ug/L)	Nickel (ug/L)	Phosphorus (ug/L)	Potassium (ug/L)	Selenium (ug/L)	Silicon (ug/L)	Silver (ug/L)	Sodium (ug/L)	Strontium (ug/L)	Sulphur (ug/L)	Thallium (ug/L)	Tin (ug/L)	Titanium (ug/L)	Uranium (ug/L)	Vanadium (ug/L)	Zinc (ug/L)	Zirconium (ug/L)
CCME Marinewater Aquatic Life, 2007		**---**	**---**	**---**	**0.016**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**
Arctic Bay																						
AB WQ1 DEEP	10-Aug-2019	162	1110000	0.86	< 0.0020	10.1	1.26	< 50	335000	0.52	< 1000	< 0.050	9810000	7310	830000	< 0.10	< 1.0	< 10	2.99	< 10	7.7	---
AB WQ1 SHALLOW	10-Aug-2019	123	846000	1.31	< 0.0020	7.9	1.05	< 50	260000	< 0.50	< 1000	< 0.050	7620000	5590	636000	< 0.10	< 1.0	< 10	2.30	< 10	33.4	---
	22-Sep-2020	117	990000	0.78	< 0.0050	9.40	< 0.50	< 50	327000	< 0.50	< 1000	< 0.10	9330000	6760	984000	< 0.050	< 1.0	< 5.0	2.21	1.41	17.9	< 0.50
AB WQ 2 DEEP	10-Aug-2019	157	1080000	< 0.50	< 0.0020	10.0	1.07	< 50	329000	< 0.50	< 1000	< 0.050	9470000	7040	803000	< 0.10	< 1.0	< 10	2.82	< 10	6.0	---
(Duplicate)	10-Aug-2019	155	1030000	0.75	< 0.0020	9.6	1.27	< 50	318000	< 0.50	< 1000	< 0.050	8960000	6820	771000	< 0.10	< 1.0	< 10	2.78	< 10	< 5.0	---
	22-Sep-2020	111	991000	1.27	< 0.0050	9.30	< 0.50	< 50	319000	< 0.50	< 1000	< 0.10	9230000	7100	989000	< 0.050	< 1.0	< 5.0	2.25	1.50	< 3.0	< 0.50
AB WQ2 SHALLOW	10-Aug-2019	130	882000	1.21	< 0.0020	8.0	1.10	< 50	268000	< 0.50	< 1000	< 0.050	7740000	5660	661000	< 0.10	< 1.0	< 10	2.30	< 10	6.7	---
(Duplicate)	10-Aug-2019	134	900000	1.62	< 0.0020	8.4	1.03	< 50	275000	< 0.50	< 1000	< 0.050	7720000	5780	669000	< 0.10	< 1.0	< 10	2.35	< 10	5.6	---
	22-Sep-2020	128	962000	0.76	< 0.0050	9.09	< 0.50	< 50	302000	< 0.50	< 1000	< 0.10	8930000	6560	962000	< 0.050	< 1.0	< 5.0	2.34	1.40	15.2	< 0.50
AB WQ4	10-Aug-2019	128	865000	2.73	< 0.0020	8.2	1.40	< 50	272000	< 0.50	< 1000	< 0.050	7730000	5650	652000	< 0.10	< 1.0	< 10	2.27	< 10	6.2	---
	22-Sep-2020	109	934000	0.69	< 0.0050	9.06	< 0.50	< 50	320000	< 0.50	< 1000	< 0.10	9200000	6630	954000	< 0.050	< 1.0	< 5.0	2.22	1.40	< 3.0	< 0.50
AB WQ5	10-Aug-2019	124	837000	2.10	< 0.0020	7.8	1.07	< 50	258000	< 0.50	< 1000	< 0.050	7490000	5460	633000	< 0.10	< 1.0	< 10	2.23	< 10	6.8	---
	22-Sep-2020	120	941000	25.3	< 0.0050	9.01	1.55	< 50	317000	< 0.50	< 1000	< 0.10	8780000	6800	949000	< 0.050	< 1.0	15.2	2.39	3.18	5.0	0.60
AB WQ6	22-Sep-2020	112	935000	0.71	< 0.0050	9.51	< 0.50	< 50	322000	< 0.50	1100	< 0.10	9310000	7010	964000	< 0.050	< 1.0	< 5.0	2.25	1.38	7.4	< 0.50
AB WQ7	22-Sep-2020	122	956000	0.58	< 0.0050	9.52	< 0.50	< 50	317000	< 0.50	< 1000	< 0.10	9320000	6810	984000	< 0.050	< 1.0	< 5.0	2.26	1.42	< 3.0	< 0.50
(Duplicate)	22-Sep-2020	110	1030000	0.61	< 0.0050	9.88	< 0.50	< 50	334000	< 0.50	< 1000	< 0.10	9530000	7310	1000000	< 0.050	< 1.0	< 5.0	2.31	1.55	< 3.0	< 0.50
Relative Percent Difference (RPD) Report																						
AB WQ2 DEEP	10-Aug-2019	157	1080000	< 0.50	< 0.0020	10.0	1.07	< 50	329000	< 0.50	< 1000	< 0.050	9470000	7040	803000	< 0.10	< 1.0	< 10	2.82	< 10	6.0	---
(Duplicate)	10-Aug-2019	155	1030000	0.75	< 0.0020	9.6	1.27	< 50	318000	< 0.50	< 1000	< 0.050	8960000	6820	771000	< 0.10	< 1.0	< 10	2.78	< 10	< 5.0	---
RPD(%)		**1.3%**	**4.7%**	**---**	**---**	**4.1%**	**17.1%**	**---**	**3.4%**	**---**	**---**	**---**	**5.5%**	**3.2%**	**4.1%**	**---**	**---**	**---**	**1.4%**	**---**	**---**	**---**
AB WQ2 SHALLOW	10-Aug-2019	130	882000	1.21	< 0.0020	8.0	1.10	< 50	268000	< 0.50	< 1000	< 0.050	7740000	5660	661000	< 0.10	< 1.0	< 10	2.30	< 10	6.7	---
(Duplicate)	10-Aug-2019	134	900000	1.62	< 0.0020	8.4	1.03	< 50	275000	< 0.50	< 1000	< 0.050	7720000	5780	669000	< 0.10	< 1.0	< 10	2.35	< 10	5.6	---
RPD(%)		**3.0%**	**2.0%**	**29.0%**	**---**	**4.9%**	**6.6%**	**---**	**2.6%**	**---**	**---**	**---**	**0.3%**	**2.1%**	**1.2%**	**---**	**---**	**---**	**2.2%**	**---**	**17.9%**	**---**
AB WQ7	22-Sep-2020	122	956000	0.58	< 0.0050	9.52	< 0.50	< 50	317000	< 0.50	< 1000	< 0.10	9320000	6810	984000	< 0.050	< 1.0	< 5.0	2.26	1.42	< 3.0	< 0.50
(Duplicate)	22-Sep-2020	110	1030000	0.61	< 0.0050	9.88	< 0.50	< 50	334000	< 0.50	< 1000	< 0.10	9530000	7310	1000000	< 0.050	< 1.0	< 5.0	2.31	1.55	< 3.0	< 0.50
RPD(%)		**10.3%**	**7.5%**	**5.0%**	**---**	**3.7%**	**---**	**---**	**5.2%**	**---**	**---**	**---**	**2.2%**	**7.1%**	**1.6%**	**---**	**---**	**---**	**2.2%**	**8.8%**	**---**	**---**

NOTES:

1. --- in guideline row(s) denotes no criteria for that parameter.
2. --- in detail data row(s) denotes parameter not analyzed.
3. Highlighting indicates non-detect parameters above applied guideline/criteria.
4. Highlighting indicates parameters at applied guideline/criteria.
5. Denotes values exceeding
   (Canadian Environmental Quality Guidelines for the Protection of Aquatic Life (CCME, 1999 and Updates, last update v7 2007))

Chromium:
Standard is for Chromium VI as it is the most conservative value.

Table 3

Water Quality Results: Dissolved Metals and Trace Elements

PROJECT No.: 317071-00037		General	Dissolved Metals and Trace Elements																																		
Monitoring Station	Date (dd-mmm-yyyy)	pH (pH units)	Aluminum (ug/L)	Antimony (ug/L)	Arsenic (ug/L)	Barium (ug/L)	Beryllium (ug/L)	Bismuth (ug/L)	Boron (ug/L)	Cadmium (ug/L)	Calcium (ug/L)	Chromium (ug/L)	Cobalt (ug/L)	Copper (ug/L)	Iron (ug/L)	Lead (ug/L)	Lithium (ug/L)	Magnesium (ug/L)	Manganese (ug/L)	Mercury (ug/L)	Molybdenum (ug/L)	Nickel (ug/L)	Phosphorus (ug/L)	Potassium (ug/L)	Selenium (ug/L)	Silicon (ug/L)	Silver (ug/L)	Sodium (ug/L)	Strontium (ug/L)	Sulphur (ug/L)	Thallium (ug/L)	Tin (ug/L)	Titanium (ug/L)	Uranium (ug/L)	Vanadium (ug/L)	Zinc (ug/L)	Zirconium (ug/L)
CCME Marinewater Aquatic Life, 2007		**(7 - 8.7)**	---	---	**12.5**	---	---	---	---	**0.12**	---	**1.5**	---	---	---	---	---	---	---	**0.016**	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Arctic Bay																																					
AB WQ1 DEEP	10-Aug-2019	7.92	13	< 0.50	2.89	8.3	< 1.0	< 1.0	3780	< 0.050	346000	< 0.50	< 0.10	< 0.50	< 10	< 0.10	156	1060000	< 0.50	< 0.0020	9.8	0.98	< 50	328000	< 0.50	< 1000	< 0.050	9190000	7130	777000	< 0.10	< 1.0	< 10	2.82	< 10	< 5.0	---
AB WQ1 SHALLOW	10-Aug-2019	7.99	28	< 0.50	2.50	4.2	< 1.0	< 1.0	2930	< 0.050	283000	< 0.50	0.11	0.92	< 10	0.22	123	849000	0.69	< 0.0020	8.0	0.94	< 50	262000	< 0.50	< 1000	< 0.050	7260000	5570	630000	< 0.10	< 1.0	< 10	2.17	< 10	30.0	---
	22-Sep-2020	7.93	< 5.0	< 1.0	1.41	7.7	< 0.50	< 0.50	2910	0.038	348000	1.00	< 0.050	0.44	< 10	0.058	117	1030000	0.50	< 0.0050	9.36	< 0.50	< 50	346000	< 0.50	< 1000	< 0.10	8660000	6940	1010000	< 0.050	< 1.0	< 5.0	2.18	1.40	7.8	< 0.50
AB WQ2 DEEP	10-Aug-2019	7.98	20	< 0.50	2.60	7.8	< 1.0	< 1.0	3790	< 0.050	340000	< 0.50	0.12	< 0.50	< 10	< 0.10	154	1040000	< 0.50	< 0.0020	9.7	0.86	< 50	322000	< 0.50	< 1000	< 0.050	8790000	6750	770000	< 0.10	< 1.0	< 10	2.70	< 10	< 5.0	---
(Duplicate)	10-Aug-2019	8.00	22	< 0.50	2.59	8.2	< 1.0	< 1.0	3820	< 0.050	331000	< 0.50	0.12	< 0.50	< 10	< 0.10	154	1040000	< 0.50	< 0.0020	9.3	0.72	< 50	315000	< 0.50	< 1000	< 0.050	8880000	6860	776000	< 0.10	< 1.0	< 10	2.67	< 10	< 5.0	---
	22-Sep-2020	7.90	< 5.0	< 1.0	1.29	7.5	< 0.50	< 0.50	2760	0.042	325000	0.64	< 0.050	< 0.20	< 10	< 0.050	110	949000	1.00	< 0.0050	8.93	< 0.50	< 50	310000	< 0.50	< 1000	< 0.10	8660000	6460	926000	< 0.050	< 1.0	< 5.0	2.22	1.32	2.1	< 0.50
AB WQ2 SHALLOW	10-Aug-2019	8.00	18	< 0.50	2.14	4.2	< 1.0	< 1.0	3110	< 0.050	284000	< 0.50	< 0.10	< 0.50	21	< 0.10	129	869000	0.75	< 0.0020	8.2	1.13	< 50	267000	< 0.50	< 1000	< 0.050	7490000	5710	648000	< 0.10	< 1.0	< 10	2.21	< 10	< 5.0	---
(Duplicate)	10-Aug-2019	8.00	22	< 0.50	2.34	5.6	< 1.0	< 1.0	3150	< 0.050	283000	< 0.50	0.10	< 0.50	10	< 0.10	131	868000	1.39	< 0.0020	8.0	0.61	< 50	267000	< 0.50	< 1000	< 0.050	7450000	5660	669000	< 0.10	< 1.0	< 10	2.18	< 10	< 5.0	---
	22-Sep-2020	7.91	< 5.0	< 1.0	1.32	7.3	< 0.50	< 0.50	2980	0.035	333000	0.64	< 0.050	0.22	< 10	< 0.050	119	1000000	0.69	< 0.0050	8.77	< 0.50	< 50	329000	< 0.50	< 1000	< 0.10	8530000	6460	987000	< 0.050	< 1.0	< 5.0	2.21	1.32	8.0	< 0.50
AB WQ 4	10-Aug-2019	8.02	18	< 0.50	2.25	4.7	< 1.0	< 1.0	3190	< 0.050	288000	0.59	0.10	< 0.50	< 10	< 0.10	130	891000	2.28	< 0.0020	8.0	0.68	< 50	272000	< 0.50	< 1000	< 0.050	7560000	5810	667000	< 0.10	< 1.0	< 10	2.29	< 10	< 5.0	---
	22-Sep-2020	7.92	< 5.0	< 1.0	1.43	7.7	< 0.50	< 0.50	2850	0.044	334000	0.86	< 0.050	0.38	< 10	0.053	115	1010000	0.47	< 0.0050	9.31	< 0.50	55	328000	< 0.50	< 1000	< 0.10	8420000	6930	953000	< 0.050	< 1.0	< 5.0	2.24	1.38	2.2	< 0.50
AB WQ5	10-Aug-2019	7.98	19	< 0.50	2.56	5.1	< 1.0	< 1.0	3070	< 0.050	279000	< 0.50	< 0.10	< 0.50	< 10	< 0.10	125	842000	1.91	< 0.0020	7.8	0.93	< 50	260000	< 0.50	< 1000	< 0.050	7070000	5570	617000	< 0.10	< 1.0	< 10	2.09	< 10	< 5.0	---
	22-Sep-2020	7.87	5.4	< 1.0	1.28	9.1	< 0.50	< 0.50	2690	0.030	316000	0.71	0.136	0.24	< 10	0.054	112	958000	7.96	< 0.0050	9.10	< 0.50	< 50	307000	< 0.50	< 1000	< 0.10	8570000	6840	945000	< 0.050	< 1.0	< 5.0	2.22	1.01	2.1	< 0.50
AB WQ6	22-Sep-2020	7.92	5.0	< 1.0	1.36	7.6	< 0.50	< 0.50	2840	0.048	331000	< 0.50	< 0.050	0.23	< 10	0.051	112	1030000	0.55	< 0.0050	9.78	< 0.50	< 50	336000	< 0.50	< 1000	< 0.10	8700000	7080	986000	< 0.050	< 1.0	< 5.0	2.22	1.38	3.4	< 0.50
AB WQ7	22-Sep-2020	7.92	< 5.0	< 1.0	1.43	7.8	< 0.50	< 0.50	3020	0.037	336000	0.51	< 0.050	0.24	< 10	< 0.050	117	1090000	0.51	< 0.0050	9.42	< 0.50	< 50	334000	< 0.50	< 1000	< 0.10	8400000	7010	1010000	< 0.050	< 1.0	< 5.0	2.31	1.41	3.3	< 0.50
(Duplicate)	22-Sep-2020	7.92	< 5.0	< 1.0	1.43	7.8	< 0.50	< 0.50	2920	0.035	340000	0.55	< 0.050	0.27	< 10	< 0.050	115	1040000	0.52	< 0.0050	9.26	< 0.50	< 50	339000	< 0.50	< 1000	< 0.10	8800000	6780	993000	< 0.050	< 1.0	< 5.0	2.26	1.42	2.2	< 0.50
Relative Percent Difference (RPD) Report																																					
AB WQ2 DEEP	10-Aug-2019	7.98	20	< 0.50	2.60	7.8	< 1.0	< 1.0	3790	< 0.050	340000	< 0.50	0.12	< 0.50	< 10	< 0.10	154	1040000	< 0.50	< 0.0020	9.7	0.86	< 50	322000	< 0.50	< 1000	< 0.050	8790000	6750	770000	< 0.10	< 1.0	< 10	2.70	< 10	< 5.0	---
(Duplicate)	10-Aug-2019	8.00	22	< 0.50	2.59	8.2	< 1.0	< 1.0	3820	< 0.050	331000	< 0.50	0.12	< 0.50	< 10	< 0.10	154	1040000	< 0.50	< 0.0020	9.3	0.72	< 50	315000	< 0.50	< 1000	< 0.050	8880000	6860	776000	< 0.10	< 1.0	< 10	2.67	< 10	< 5.0	---
RPD(%)		**0.3%**	**9.5%**	**---**	**0.4%**	**5.0%**	**---**	**---**	**0.8%**	**---**	**2.7%**	**---**	**0.0%**	**---**	**---**	**---**	**0.0%**	**0.0%**	**---**	**---**	**4.2%**	**17.7%**	**---**	**2.2%**	**---**	**---**	**---**	**1.0%**	**1.6%**	**0.8%**	**---**	**---**	**---**	**1.1%**	**---**	**---**	**---**
AB WQ2 SHALLOW	10-Aug-2019	8.00	18	< 0.50	2.14	4.2	< 1.0	< 1.0	3110	< 0.050	284000	< 0.50	< 0.10	< 0.50	21	< 0.10	129	869000	0.75	< 0.0020	8.2	1.13	< 50	267000	< 0.50	< 1000	< 0.050	7490000	5710	648000	< 0.10	< 1.0	< 10	2.21	< 10	< 5.0	---
(Duplicate)	10-Aug-2019	8.00	22	< 0.50	2.34	5.6	< 1.0	< 1.0	3150	< 0.050	283000	< 0.50	0.10	< 0.50	10	< 0.10	131	868000	1.39	< 0.0020	8.0	0.61	< 50	267000	< 0.50	< 1000	< 0.050	7450000	5660	669000	< 0.10	< 1.0	< 10	2.18	< 10	< 5.0	---
RPD(%)		**0.0%**	**20.0%**	**---**	**8.9%**	**28.6%**	**---**	**---**	**1.3%**	**---**	**0.4%**	**---**	**---**	**---**	**71.0%**	**---**	**1.5%**	**0.1%**	**59.8%**	**---**	**2.5%**	**59.8%**	**---**	**0.0%**	**---**	**---**	**---**	**0.5%**	**0.9%**	**3.2%**	**---**	**---**	**---**	**1.4%**	**---**	**---**	**---**
AB WQ7	22-Sep-2020	7.92	< 5.0	< 1.0	1.43	7.8	< 0.50	< 0.50	3020	0.037	336000	0.51	< 0.050	0.24	< 10	< 0.050	117	1090000	0.51	< 0.0050	9.42	< 0.50	< 50	334000	< 0.50	< 1000	< 0.10	8400000	7010	1010000	< 0.050	< 1.0	< 5.0	2.31	1.41	3.3	< 0.50
(Duplicate)	22-Sep-2020	7.92	< 5.0	< 1.0	1.43	7.8	< 0.50	< 0.50	2920	0.035	340000	0.55	< 0.050	0.27	< 10	< 0.050	115	1040000	0.52	< 0.0050	9.26	< 0.50	< 50	339000	< 0.50	< 1000	< 0.10	8800000	6780	993000	< 0.050	< 1.0	< 5.0	2.26	1.42	2.2	< 0.50
RPD(%)		**0.0%**	**---**	**---**	**0.0%**	**0.0%**	**---**	**---**	**3.4%**	**5.6%**	**1.2%**	**7.5%**	**---**	**11.8%**	**---**	**---**	**1.7%**	**4.7%**	**1.9%**	**---**	**1.7%**	**---**	**---**	**1.5%**	**---**	**---**	**---**	**4.7%**	**3.3%**	**1.7%**	**---**	**---**	**---**	**2.2%**	**0.7%**	**40.0%**	**---**

NOTES:

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4. Highlighting indicates parameters at applied guideline/criteria.
5. Denotes values exceeding

(Canadian Environmental Quality Guidelines for the Protection of Aquatic Life (CCME, 1999 and Updates, last update v7 2007))

Chromium:

Standard is for Chromium VI as it is the most conservative value.

Table 4

Sediment Analytical Results: General and Salinity Parameters

PROJECT No.: 317071-00037

Sampling Location	Date	% Moisture	Clay	Gravel	Silt	Sand	Fine Sand (0.2mm - 0.063mm)	Sand (0.06-2.00 mm)	Sieve - Pan	Coarse Sand (2.00mm - 0.2mm)	Organic Matter	pH	Sieve #10 (<2.0mm)	Sieve #100 (<0.149mm)	Sieve #120 (<0.125mm)	Sieve #18 (<1.00mm)	Sieve #20 (<0.85mm)	Sieve #250 (<0.063mm)	Sieve #270 (<0.053mm)	Sieve #35 (<0.5mm)	Sieve #4 (<4.75mm)	Sieve #40 (<0.42mm)	Sieve #60 (<0.250mm)	Sieve #625 (<0.020mm)	Sieve (<0.0020mm)	Sieve (<0.0039mm)	Sieve (<0.0050 mm)	Sieve (<0.0078mm)	Sieve (<0.016mm)	Sieve (<0.031mm)	Sieve (<19 mm)	Sieve (<25.4 mm)	Sieve (<38.1 mm)	Sieve (<50.8 mm)	Sieve (<76.2 mm)	Sieve (<9.5 mm)	Carbon by Combustion	Sulphur	Inorganic Carbon (as CaCO3 Equivalent)	Total Inorganic Carbon	Total Organic Carbon	Total Organic Carbon
	(dd-mmm-yyyy)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(pH units)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(mg/kg)	(%)	(%)	(%)	(mg/kg)
Arctic Bay																																										
AB LS1	10-Aug-2019	31 26	11	4.0	27	58	---	---	---	---	---	7.75	96	---	64	95	---	38	---	94	---	---	90	---	8.8	11	---	12	19	26	---	---	---	---	---	---	---	---	---	---	---	5200
AB LS2	10-Aug-2019	32 27	41	11	27	21	---	---	---	---	---	8.34	89	---	77	87	---	68	---	85	---	---	82	---	36	41	---	44	54	60	---	---	---	---	---	---	---	---	---	---	---	8000
ABLS. SQ_1	19-Sep-2020	17.3	< 1.0	44.8	3.4	51.8	13.4	51.8	3.9	38.4	0.47	8.09	---	10.1	6.2	51.6	50.5	3.4	2.8	47.1	61.0	40.1	21.8	1.7	< 1.0	< 1.0	< 1.0	---	---	2.0	69.7	75.5	100	100	100	63.9	0.326	< 1000	0.45	0.054	0.272	---
ABLS. SQ_2	19-Sep-2020	15.3	< 1.0	32.7	3.5	63.8	14.6	63.8	4.5	49.2	0.41	8.59	---	12.1	8.5	52.4	49.6	3.5	2.5	41.3	84.3	36.1	22.6	1.6	< 1.0	< 1.0	< 1.0	---	---	1.8	100	100	100	100	100	93.1	0.318	< 1000	0.65	0.078	0.240	---
ABLS. SQ_3	19-Sep-2020	21.1	1.2	21.8	2.7	74.3	24.9	74.3	4.4	49.4	0.41	8.23	---	14.8	6.5	72.8	72.3	3.9	3.4	70.8	83.6	62.1	39.4	2.2	1.1	1.2	1.2	---	---	2.4	100	100	100	100	100	89.4	0.290	< 1000	0.44	0.052	0.238	---
ABLS. SQ_4	19-Sep-2020	21.8	3.4	9.0	16.1	71.5	46.4	71.5	24.3	25.1	0.84	8.09	---	52.5	44.5	89.4	89.1	19.5	14.2	88.0	93.5	84.7	76.1	8.7	2.8	3.4	3.8	---	---	10.2	100	100	100	100	100	97.2	0.569	< 1000	0.69	0.083	0.486	---
ABLS. SQ_5	19-Sep-2020	26.1	3.9	31.4	12.4	52.3	19.7	52.3	18.2	32.6	1.76	7.91	---	29.8	26.1	61.0	58.7	16.3	14.2	51.8	82.7	48.8	40.7	9.0	3.4	3.9	4.2	---	---	10.3	100	100	100	100	100	93.2	1.10	3200	0.69	0.082	1.02	---
ABLS. SQ_6	19-Sep-2020	16.0	1.6	15.2	16.2	67.0	33.5	67.0	22.7	33.5	0.75	7.94	---	46.0	42.8	78.4	76.3	17.8	12.6	69.9	90.6	65.8	55.3	6.2	1.3	1.6	1.7	---	---	7.5	96.5	100	100	100	100	94.3	0.498	< 1000	0.54	0.064	0.434	---
ABLS. SQ_7	21-Sep-2020	16.6	1.7	27.1	4.1	67.1	13.8	67.1	6.6	53.2	0.47	8.39	---	13.5	9.8	64.7	62.2	5.8	5.0	54.9	83.3	46.4	24.3	3.3	1.6	1.7	1.8	---	---	3.7	100	100	100	100	100	90.0	0.329	< 1000	0.46	0.055	0.274	---
ABLS. SQ_8	21-Sep-2020	20.6	2.1	38.1	10.9	48.9	25.5	48.9	15.3	23.4	0.89	8.47	---	30.0	24.9	57.0	56.3	13.0	10.5	54.1	71.2	51.5	45.0	6.0	1.8	2.1	2.3	---	---	7.1	93.7	100	100	100	100	76.6	0.587	< 1000	0.59	0.071	0.516	---

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Table 5

Sediment Analytical Results: Metals and Trace Elements

PROJECT No.: 317071-00037

Sampling Location	Date (dd-mmm-yyyy)	pH (pH units)	Aluminum (mg/kg)	Antimony (mg/kg)	Arsenic (mg/kg)	Barium (mg/kg)	Beryllium (mg/kg)	Bismuth (mg/kg)	Boron (mg/kg)	Cadmium (mg/kg)	Calcium (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Lead (mg/kg)	Lithium (mg/kg)	Magnesium (mg/kg)	Manganese (mg/kg)	Mercury (mg/kg)	Molybdenum (mg/kg)	Nickel (mg/kg)	Phosphorus (mg/kg)	Potassium (mg/kg)	Selenium (mg/kg)	Silver (mg/kg)	Sodium (mg/kg)	Strontium (mg/kg)	Thallium (mg/kg)	Tin (mg/kg)	Titanium (mg/kg)	Tungsten (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Zinc (mg/kg)	Zirconium (mg/kg)
CCME Marine Sediment (ISQG), 1999		---	---	---	7.24	---	---	---	---	0.7	---	52.3	---	18.7	---	30.2	---	---	---	0.13	---	---	---	---	---	---	---	---	---	---	---	---	---	---	124	---
CCME Marine Sediment (PEL), 1999		---	---	---	41.6	---	---	---	---	4.2	---	160	---	108	---	112	---	---	---	0.7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	271	---
BC-Environment Canada Disposal at Sea Regulations		---	---	---	---	---	---	---	---	0.6	---	---	---	---	---	---	---	---	---	0.75	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Arctic Bay																																				
AB LS1	10-Aug-2019	7.75	16800	0.23	5.12	96.7	1.01	0.25	19.5	0.155	1860	28.7	13.1	37.4	33500	21.8	---	7290	231	< 0.050	2.06	27.4	353	2400	< 0.50	0.070	4330	20.4	0.140	1.06	105	< 0.50	---	40.9	77.0	12.4
AB LS2	10-Aug-2019	8.34	16200	0.15	3.59	306	0.81	0.16	30.9	0.100	4850	36.9	15.2	44.3	33400	12.7	---	9970	276	< 0.050	1.44	34.1	369	3440	< 0.50	< 0.050	6320	29.0	0.125	0.60	177	< 0.50	---	54.7	51.6	17.6
ABLS. SQ_1	19-Sep-2020	8.09	11400	0.12	3.94	64.6	0.52	< 0.20	10.2	< 0.020	1610	18.4	8.99	16.4	25200	8.80	16.0	5450	196	0.0053	0.76	18.4	234	1290	< 0.20	< 0.10	2250	10.2	0.080	< 2.0	244	< 0.50	0.602	47.4	47.7	6.8
ABLS. SQ_2	19-Sep-2020	8.59	11000	0.12	3.60	182	0.47	< 0.20	11.9	0.024	2620	17.8	9.01	29.0	25300	7.58	13.9	5580	216	0.827	0.55	17.8	284	1400	< 0.20	< 0.10	2030	14.6	0.089	< 2.0	599	< 0.50	0.582	75.5	47.3	6.9
ABLS. SQ_3	19-Sep-2020	8.23	12500	0.14	3.81	104	0.62	< 0.20	15.4	0.030	2300	20.5	9.30	20.5	25500	9.73	15.6	5570	205	0.0058	0.79	20.6	288	1790	< 0.20	< 0.10	3310	14.8	0.089	< 2.0	379	< 0.50	0.682	55.5	51.0	8.0
ABLS. SQ_4	19-Sep-2020	8.09	12600	0.21	5.68	198	0.63	2.20	19.1	0.050	2780	21.1	8.30	20.2	23500	29.9	16.0	6270	181	0.0128	1.03	19.3	324	2120	< 0.20	< 0.10	3860	20.6	0.111	7.0	142	< 0.50	0.735	41.2	50.5	8.1
ABLS. SQ_5	19-Sep-2020	7.91	19100	0.44	5.29	53.2	1.03	0.29	17.3	0.098	1560	28.5	12.5	36.5	35000	18.1	21.1	7710	239	0.0096	1.28	27.8	360	2560	< 0.20	< 0.10	4460	24.9	0.115	< 2.0	59.3	< 0.50	1.17	36.4	88.3	11.5
ABLS. SQ_6	19-Sep-2020	7.94	15400	0.24	4.57	106	0.89	0.24	12.0	0.041	1700	23.9	11.6	28.3	30400	17.1	18.8	6510	312	0.0070	0.96	24.1	261	2010	< 0.20	< 0.10	2520	15.0	0.089	< 2.0	84.4	< 0.50	0.880	35.9	67.9	8.3
ABLS. SQ_7	21-Sep-2020	8.39	12400	0.14	4.18	57.1	0.56	< 0.20	12.1	0.028	1840	20.3	9.56	19.7	25200	8.67	17.5	6320	189	< 0.0050	0.72	19.7	278	1460	< 0.20	< 0.10	2440	11.8	0.084	< 2.0	270	< 0.50	0.630	48.7	45.7	7.2
ABLS. SQ_8	21-Sep-2020	8.47	12800	121	4.99	137	0.66	0.52	14.2	0.054	2280	21.3	9.55	23.1	24100	12100	17.0	6160	205	0.0086	1.14	21.1	311	1690	< 0.20	0.21	3460	30.9	0.182	< 2.0	134	< 0.50	0.784	42.4	57.1	6.4

NOTES:

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   (Canadian Environmental Quality Guidelines for Marine Sediment (ISQGs), (CCME, 1999))
6. Denotes values exceeding
   (Canadian Environmental Quality Guidelines for Marine Sediment (PEL), (CCME, 1999))
7. Denotes values exceeding
   (BC-Environment Canada Disposal at Sea Regulations)

Table 6

Sediment Analytical Results: Polycyclic Aromatic Hydrocarbons (PAHs)

PROJECT No.: 317071-00037

Sampling Location	Date (dd-mmm-yyyy)	1- & 2-Methylnaphthalene (mg/kg)	1-Methylnaphthalene (mg/kg)	2-Methylnaphthalene (mg/kg)	Acenaphthene (mg/kg)	Acenaphthylene (mg/kg)	Acridine (mg/kg)	Anthracene (mg/kg)	Benzo[a]anthracene (mg/kg)	Benzo[a]pyrene (mg/kg)	Benzo[a]pyrene Total Potency Equivalent (mg/kg)	Benzo[b&j]fluoranthene (mg/kg)	Benzo[b,j,k]fluoranthene (mg/kg)	Benzo[g,h,i]perylene (mg/kg)	Benzo[k]fluoranthene (mg/kg)	Chrysene (mg/kg)	Dibenzo[a,h]anthracene (mg/kg)	Fluoranthene (mg/kg)	Fluorene (mg/kg)	IACR-COARSE (none)	IACR-FINE (none)	Indexed Value of Additive Cancer Risk (IACR) (mg/kg)	Indexed Value of Additive Cancer Risk (IACR) (none)	Naphthalene (mg/kg)	Phenanthrene (mg/kg)	Indeno[1,2,3-cd]pyrene (mg/kg)	Pyrene (mg/kg)	Quinoline (mg/kg)	Polycyclic Aromatic Hydrocarbons (heavy) (mg/kg)	Polycyclic Aromatic Hydrocarbons (light) (mg/kg)	PAHs, total (EPA 16) (mg/kg)	Total PAHs (mg/kg)
CCME Marine Sediment (ISQG), 1999		---	---	0.0202	0.00671	0.00587	---	0.0469	0.0748	0.0888	---	---	---	---	---	0.108	0.00622	0.113	0.0212	---	---	---	---	0.0346	0.0867	---	0.153	---	---	---	---	---
CCME Marine Sediment (PEL), 1999		---	---	0.201	0.0889	0.128	---	0.245	0.693	0.763	---	---	---	---	---	0.846	0.135	1.494	0.144	---	---	---	---	0.391	0.544	---	1.398	---	---	---	---	---
BC-Environment Canada Disposal at Sea Regulations		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2.5
Arctic Bay																																
AB LS1	10-Aug-2019	---	---	**0.051**	< 0.00050	0.00095	---	0.0018	0.0012	< 0.0010	< 0.010	0.0019	---	0.0022	< 0.0010	0.0039	< 0.00050	0.0050	0.0054	---	---	---	< 0.10	0.026	0.012	< 0.0020	0.0061	---	0.016	0.098	---	0.11
AB LS2	10-Aug-2019	---	---	0.0077	< 0.00050	< 0.00050	---	< 0.0010	< 0.0010	< 0.0010	< 0.010	0.0014	---	< 0.0020	< 0.0010	0.0038	< 0.00050	0.0018	0.0019	---	---	---	< 0.10	0.0036	0.0082	< 0.0020	0.0038	---	0.0095	0.021	---	0.031
ABLS. SQ_1	19-Sep-2020	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.060	< 0.050	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.033	< 0.062	< 0.59	---	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	---	---	< 0.20	< 0.2
ABLS. SQ_2	19-Sep-2020	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.060	< 0.050	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.033	< 0.062	< 0.59	---	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	---	---	< 0.20	< 0.2
ABLS. SQ_3	19-Sep-2020	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.060	< 0.050	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.033	< 0.062	< 0.59	---	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	---	---	< 0.20	< 0.2
ABLS. SQ_4	19-Sep-2020	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.060	< 0.050	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.033	< 0.062	< 0.59	---	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	---	---	< 0.20	< 0.2
ABLS. SQ_5	19-Sep-2020	< 0.075	< 0.050	**0.068**	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.060	< 0.050	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.033	< 0.062	< 0.59	---	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	---	---	< 0.20	< 0.2
ABLS. SQ_6	19-Sep-2020	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.060	< 0.050	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.033	< 0.062	< 0.59	---	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	---	---	< 0.20	< 0.2
ABLS. SQ_7	21-Sep-2020	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.060	< 0.050	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.033	< 0.062	< 0.59	---	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	---	---	< 0.20	< 0.2
ABLS. SQ_8	21-Sep-2020	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.060	< 0.050	< 0.075	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.033	< 0.062	< 0.59	---	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	---	---	< 0.20	< 0.2

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7. Denotes values exceeding
   (BC-Environment Canada Disposal at Sea Regulations)

Table 7

Sediment Analytical Results: PCBs

PROJECT No.: 317011-00037

Sampling Location	Date (dd-mmm-yyyy)	2,2',3,3',4,4',5,6-Octachlorobiphenyl (ug/kg)	2,2',3,3',4,4',6-Heptachlorobiphenyl (ug/kg)	2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl (ug/kg)	2,2',3,3',4,5,5',6'-Octachlorobiphenyl (ug/kg)	2,2',3,3',4,5',6'-Heptachlorobiphenyl (ug/kg)	2,2',3,3',4-Pentachlorobiphenyl (ug/kg)	2,2',3,4,4',5,5'-Heptachlorobiphenyl (ug/kg)	2,2',3,4,4',5',6-Heptachlorobiphenyl (ug/kg)	2,2',3,5,5',6-Hexachlorobiphenyl (ug/kg)	2,2',3,5'-Tetrachlorobiphenyl (ug/kg)	2,2',4,4',5,5'-Hexachlorobiphenyl (ug/kg)	2,2',4,4',5-Pentachlorobiphenyl (ug/kg)	2,2',4-Trichlorobiphenyl (ug/kg)	2,2',5-Trichlorobiphenyl (ug/kg)
CCME Marine Sediment, 1999		---	---	---	---	---	---	---	---	---	---	---	---	---	---
CCME Marine Sediment (PEL), 1999		---	---	---	---	---	---	---	---	---	---	---	---	---	---
BC-Environment Canada Disposal at Sea Regulations		---	---	---	---	---	---	---	---	---	---	---	---	---	---
Arctic Bay															
AB LS1	10-Aug-2019	---	---	---	---	---	---	---	---	---	---	---	---	---	---
AB LS2	10-Aug-2019	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ABLS. SQ_1	19-Sep-2020	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	0.0150	0.0110	< 0.0060	< 0.0060
ABLS. SQ_2	19-Sep-2020	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	0.0110	< 0.0060	< 0.0060	< 0.0060
ABLS. SQ_3	19-Sep-2020	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	0.0270	0.0100	< 0.0060	< 0.0060
ABLS. SQ_4	19-Sep-2020	< 0.0070	< 0.0070	< 0.0070	< 0.0070	0.0090	< 0.0070	0.0410	< 0.0070	0.0100	0.0220	0.0700	0.0290	< 0.0070	< 0.0070
ABLS. SQ_5	19-Sep-2020	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080	0.0360	0.0080	0.0170	0.0290	0.128	0.0650	< 0.0080	< 0.0080
ABLS. SQ_6	19-Sep-2020	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	0.0110	< 0.0060	0.0090	0.0290	0.0570	0.0310	< 0.0060	< 0.0060
ABLS. SQ_7	21-Sep-2020	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060
ABLS. SQ_8	21-Sep-2020	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	0.0150	< 0.0060	< 0.0060	0.0160	0.0390	0.0210	< 0.0060	< 0.0060

Sampling Location	Date (dd-mmm-yyyy)	2,3,3',4,4',5',6-Heptachlorobiphenyl (ug/kg)	2,3,3',4,4',5-Hexachlorobiphenyl (ug/kg)	2,3,3',4',6-Pentachlorobiphenyl (ug/kg)	3,3',4,4',5,5'-Hexachlorobiphenyl (ug/kg)	Decachlorobiphenyl (ug/kg)	PCB 105/127 (ug/kg)	PCB 118/106 (ug/kg)	PCB 128/167 (ug/kg)	PCB 132/168 (ug/kg)	PCB 139/149 (ug/kg)	PCB 158/160 (ug/kg)	PCB 163/164/138 (ug/kg)	PCB 170/190 (ug/kg)	PCB 182/187 (ug/kg)	PCB 20/33/21 (ug/kg)
CCME Marine Sediment, 1999		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
CCME Marine Sediment (PEL), 1999		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
BC-Environment Canada Disposal at Sea Regulations		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Arctic Bay																
AB LS1	10-Aug-2019	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
AB LS2	10-Aug-2019	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ABLS. SQ_1	19-Sep-2020	< 0.0060	< 0.0060	0.0180	< 0.0060	< 0.0060	< 0.0060	0.0170	< 0.0060	< 0.0060	0.0080	< 0.0060	0.0190	< 0.0060	< 0.0060	< 0.0060
ABLS. SQ_2	19-Sep-2020	< 0.0060	< 0.0060	0.0090	< 0.0060	< 0.0060	< 0.0060	0.0080	< 0.0060	< 0.0060	< 0.0060	< 0.0060	0.0130	< 0.0060	< 0.0060	< 0.0060
ABLS. SQ_3	19-Sep-2020	< 0.0060	< 0.0060	0.0220	< 0.0060	< 0.0060	< 0.0060	0.0190	< 0.0060	< 0.0060	0.0120	< 0.0060	0.0290	< 0.0060	< 0.0060	< 0.0060
ABLS. SQ_4	19-Sep-2020	< 0.0070	< 0.0070	0.0450	< 0.0070	< 0.0070	0.0210	0.0520	0.0120	0.0150	0.0330	0.0100	0.0670	0.0220	0.0180	< 0.0070
ABLS. SQ_5	19-Sep-2020	< 0.0080	< 0.0080	0.0430	< 0.0080	< 0.0080	0.0160	0.0650	0.0160	0.0210	0.0430	< 0.0080	0.113	0.0210	0.0290	< 0.0080
ABLS. SQ_6	19-Sep-2020	< 0.0060	< 0.0060	0.0280	< 0.0060	< 0.0060	0.0130	0.0380	< 0.0060	0.0100	0.0230	< 0.0060	0.0420	< 0.0060	0.0090	< 0.0060
ABLS. SQ_7	21-Sep-2020	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060
ABLS. SQ_8	21-Sep-2020	< 0.0060	0.0060	0.0300	< 0.0060	< 0.0060	< 0.0060	0.0300	< 0.0060	0.0060	0.0160	< 0.0060	0.0350	< 0.0060	0.0080	< 0.0060

NOTES:

1. --- in guideline row(s) denotes no criteria for that parameter.
2. --- in detail data row(s) denotes parameter not analyzed.
3. Highlighting indicates non-detect parameters above applied guideline/criteria.
4. Highlighting indicates parameters at applied guideline/criteria.
5. Denotes values exceeding
   (Canadian Environmental Quality Guidelines for Marine Sediment (ISQGs), (CCME, 1999))
6. Denotes values exceeding
   (Canadian Environmental Quality Guidelines for Marine Sediment (PEL), (CCME, 1999))
7. Denotes values exceeding
   (BC-Environment Canada Disposal at Sea Regulations)

Sediment Analytical Results: PCBs

PROJECT No.: 317011-00037

Sampling Location	Date (dd-mmm-yyyy)	PCB 31/28 (ug/kg)	PCB 43/49 (ug/kg)	PCB 70/76 (ug/kg)	PCB 73/52 (ug/kg)	PCB 74/61 (ug/kg)	PCB 84/90/101/89 (ug/kg)	PCB 86/111/125/117/87/116/115 (ug/kg)	PCB 95/93 (ug/kg)	Total Heptachlorobiphenyls (ug/kg)	Total Hexachlorobiphenyls (ug/kg)	Total Octachlorobiphenyls (ug/kg)	Total Pentachlorobiphenyls (ug/kg)	Total Tetrachlorobiphenyls (ug/kg)	TOTAL Tri to Deca CB (ug/kg)	TOTAL NONA CB (ug/kg)	Total DeCB (ug/kg)	Total TriCB (ug/kg)
CCME Marine Sediment, 1999		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
CCME Marine Sediment (PEL), 1999		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
BC-Environment Canada Disposal at Sea Regulations		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Arctic Bay																		
AB LS1	10-Aug-2019	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
AB LS2	10-Aug-2019	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ABLS. SQ_1	19-Sep-2020	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	0.0260	< 0.0060	0.0160	< 0.0060	0.0420	< 0.0060	0.0880	< 0.0060	0.130	< 0.0060	< 0.0060	< 0.0060
ABLS. SQ_2	19-Sep-2020	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	0.0090	< 0.0060	0.0080	< 0.0060	0.0240	< 0.0060	0.0340	< 0.0060	0.0580	< 0.0060	< 0.0060	< 0.0060
ABLS. SQ_3	19-Sep-2020	< 0.0060	< 0.0060	0.0240	< 0.0060	0.0090	0.0170	0.0090	0.0160	< 0.0060	0.0680	< 0.0060	0.0930	0.0460	0.207	< 0.0060	< 0.0060	< 0.0060
ABLS. SQ_4	19-Sep-2020	< 0.0070	0.0200	0.0360	0.0390	0.0140	0.0560	0.0200	0.0300	0.0990	0.227	< 0.0070	0.267	0.171	0.764	< 0.0070	< 0.0070	< 0.0070
ABLS. SQ_5	19-Sep-2020	< 0.0080	0.0240	0.0330	0.0810	0.0290	0.0810	0.0260	0.0590	0.0940	0.361	< 0.0080	0.381	0.245	1.08	< 0.0080	< 0.0080	< 0.0080
ABLS. SQ_6	19-Sep-2020	< 0.0060	0.0180	0.0400	0.0620	0.0150	0.0510	0.0170	0.0360	0.0200	0.147	< 0.0060	0.231	0.235	0.633	< 0.0060	< 0.0060	< 0.0060
ABLS. SQ_7	21-Sep-2020	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060
ABLS. SQ_8	21-Sep-2020	< 0.0060	0.0110	0.0310	0.0400	0.0100	0.0380	0.0130	0.0290	0.0230	0.102	< 0.0060	0.161	0.154	0.440	< 0.0060	< 0.0060	< 0.0060

Sampling Location	Date (dd-mmm-yyyy)	Aroclor 1016 (ug/kg)	Aroclor 1221 (ug/kg)	Aroclor 1232 (ug/kg)	Aroclor 1242 (ug/kg)	Aroclor 1248 (ug/kg)	Aroclor 1254 (ug/kg)	Aroclor 1260 (ug/kg)	Aroclor 1262 (ug/kg)	Aroclor 1268 (ug/kg)	PCBs-TOTAL (ug/kg)
CCME Marine Sediment, 1999		---	---	---	---	---	**63.3**	---	---	---	**21.5**
CCME Marine Sediment (PEL), 1999		---	---	---	---	---	**709**	---	---	---	**189**
BC-Environment Canada Disposal at Sea Regulations		---	---	---	---	---	---	---	---	---	**100**
Arctic Bay											
AB LS1	10-Aug-2019	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
AB LS2	10-Aug-2019	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
ABLS. SQ_1	19-Sep-2020	---	---	---	---	---	---	---	---	---	---
ABLS. SQ_2	19-Sep-2020	---	---	---	---	---	---	---	---	---	---
ABLS. SQ_3	19-Sep-2020	---	---	---	---	---	---	---	---	---	---
ABLS. SQ_4	19-Sep-2020	---	---	---	---	---	---	---	---	---	---
ABLS. SQ_5	19-Sep-2020	---	---	---	---	---	---	---	---	---	---
ABLS. SQ_6	19-Sep-2020	---	---	---	---	---	---	---	---	---	---
ABLS. SQ_7	21-Sep-2020	---	---	---	---	---	---	---	---	---	---
ABLS. SQ_8	21-Sep-2020	---	---	---	---	---	---	---	---	---	---

NOTES:

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6. Denotes values exceeding (Canadian Environmental Quality Guidelines for Marine Sediment (PEL), (CCME, 1999))
7. Denotes values exceeding (BC-Environment Canada Disposal at Sea Regulations)

Appendix 3 Site Photos

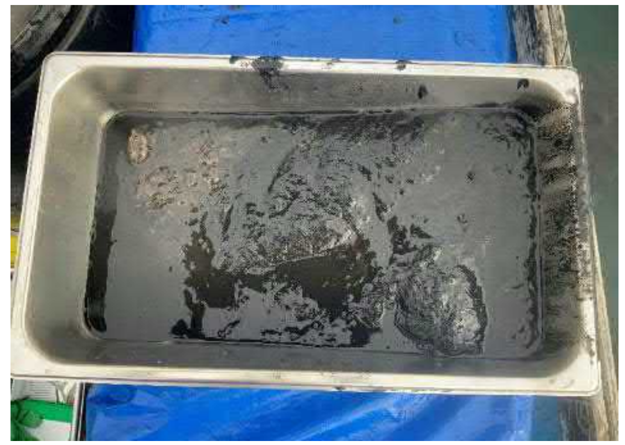
Appendix 3 – Arctic Bay Marine Study Photos

Photo 1 Raw Sediment Samples Photo Panel

AB LS1

No photo

AB LS2



AB LS3

ABLS SQ1

ABLS SQ2

ABLS SQ3

ABLS SQ4

No photo

ABLS SQ5

ABLS SQ6

ABLS SQ7

ABLS SQ8

Photo 2 Transect 1 Overview and Quadrats (2019)

Transect 1	
Seaward Overview	**Landward Overview**
	

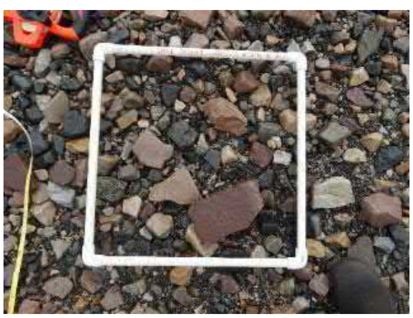
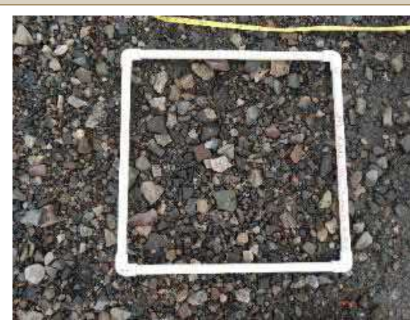
Quadrats		
Quadrat 1	**Quadrat 2**	**Quadrat 3**
		
Quadrat 4	**Quadrat 5**	**Quadrat 6**
		

Photo 3 Overview and Quadrats (2019)

Transect 2

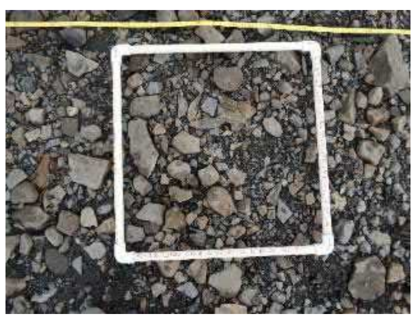
Seaward Overview

Landward Overview

Quadrats

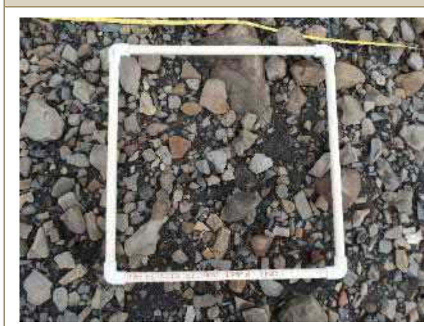
Quadrat 1

Quadrat 2

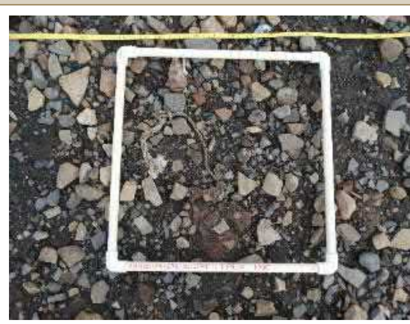


Quadrat 3

Quadrat 4



Quadrat 5



Quadrat 6

Photo 4 Transect 3 Overview and Quadrats (2019)

Transect 3		
Seaward Overview	**Landward Overview**	
		
Quadrats		
Quadrat 1	**Quadrat 2**	**Quadrat 3**
		
Quadrat 4	**Quadrat 5**	
		

Photo 5 Transect 4 Overview and Quadrats (2019)

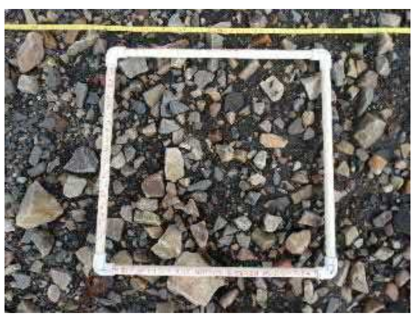
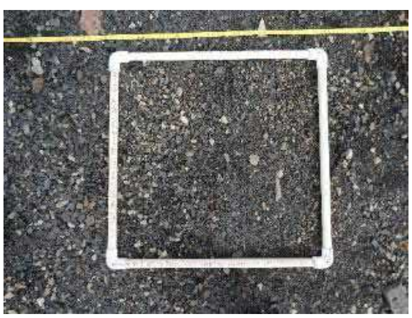
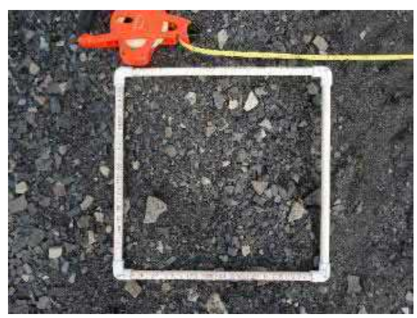
<table>
<tr><th colspan="3">Transect 4</th></tr>
<tr><td>Seaward Overview</td><td colspan="2">Landward Overview</td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><th colspan="3">Quadrats</th></tr>
<tr><td>Quadrat 1</td><td>Quadrat 2</td><td>Quadrat 3</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Quadrat 4</td><td>Quadrat 5</td><td>Quadrat 6</td></tr>
<tr><td></td><td></td><td></td></tr>
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Photo 6 Transect 5 Overview and Quadrats (2019)

Transect 5

Seaward Overview	Landward Overview
	

Quadrats

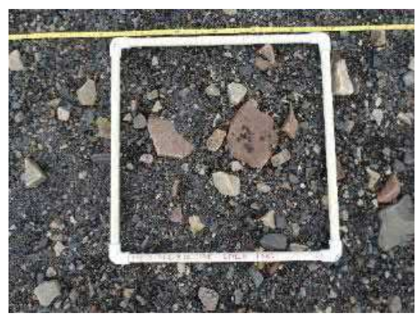
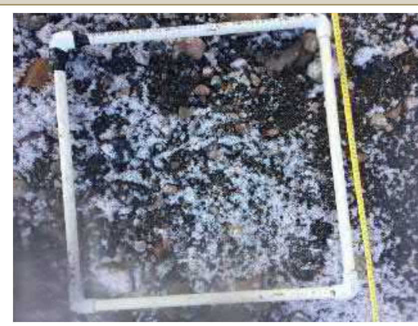
Quadrat 1	Quadrat 2	Quadrat 3
		
Quadrat 4	**Quadrat 5**	**Quadrat 6**
		

Photo 7 Transect 1 Overview and Quadrats (2020)

Transect 1		
Seaward Overview	**Landward Overview**	
		
Quadrats		
Quadrat 1	**Quadrat 2**	**Quadrat 3**
		
Quadrat 4	**Quadrat 5**	**Quadrat 6**
		

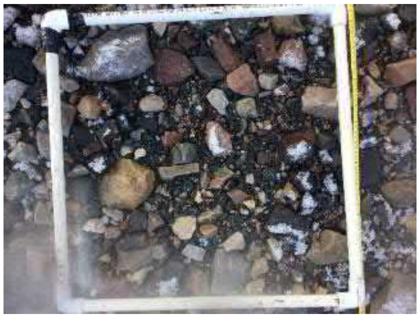
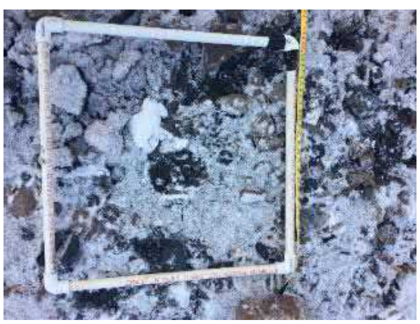
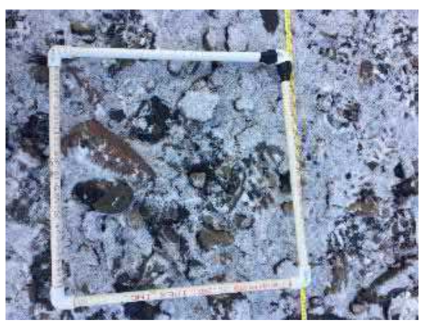
Quadrat 7	Quadrat 8	Quadrat 9
		
Quadrat 10	**Quadrat 11**	**Quadrat 12**
		

Photo 8 Transect 2 Overview and Quadrats (2020)

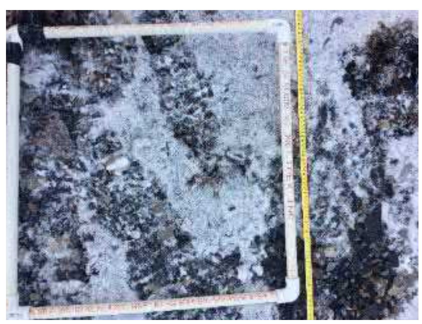
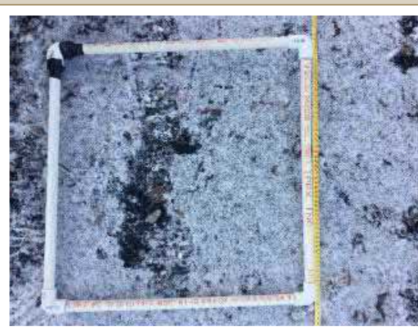
Transect 2	
Seaward Overview	**Landward Overview**
	

Quadrats		
Quadrat 1	**Quadrat 2**	**Quadrat 3**
		
Quadrat 4	**Quadrat 5**	**Quadrat 6**
		

Quadrat 7		
		

Photo 9 Transect 3 Overview and Quadrats (2020)

Transect 3	
Seaward Overview	**Landward Overview**
	

Quadrats		
Quadrat 1	**Quadrat 2**	**Quadrat 3**
		
Quadrat 4	**Quadrat 5**	**Quadrat 6**
		

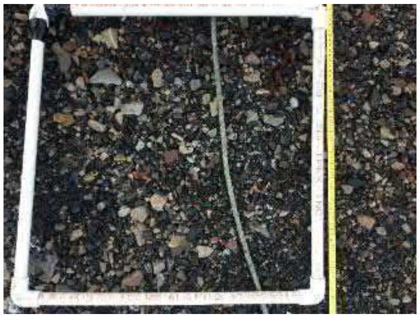
Quadrat 7	Quadrat 8	Quadrat 9
		
Quadrat 10		
		

Photo 10 Transect 4 Overview and Quadrats (2020)

<table>
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<tr><th>Seaward Overview</th><th>Landward Overview</th></tr>
<tr><td></td><td></td></tr>
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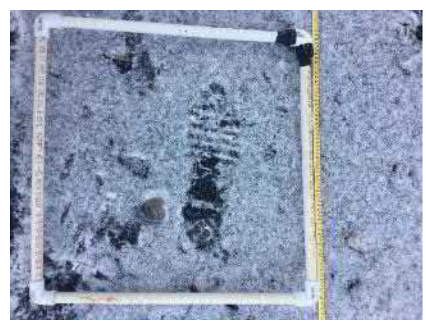
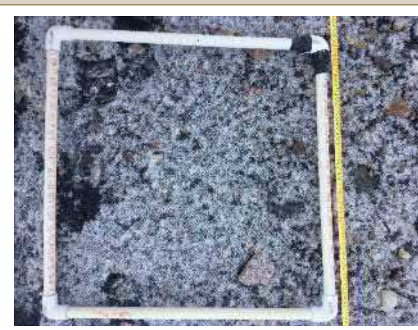
<tr><td></td><td></td><td></td></tr>
<tr><th>Quadrat 4</th><th>Quadrat 5</th><th>Quadrat 6</th></tr>
<tr><td></td><td></td><td></td></tr>
</table>

Quadrat 7	Quadrat 8	Quadrat 9
		
Quadrat 10	**Quadrat 11**	**Quadrat 12**
		
Quadrat 13	**Quadrat 14**	**Quadrat 15**
		
Quadrat 16	**Quadrat 17**	**Quadrat 18**
		

Photo 11 Transect 5 Overview and Quadrats (2020)

Transect 5

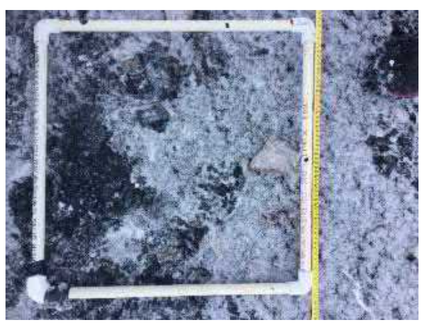
Seaward Overview

Landward Overview

Quadrats

Quadrat 1

Quadrat 2



Quadrat 3

Quadrat 4

Quadrat 5

Quadrat 6

Quadrat 7	Quadrat 8	Quadrat 9
		
Quadrat 10	**Quadrat 11**	
		

Photo 12 2019 Subtidal ROV SCH Transect Images

Transect 1 – Photo 1

Transect 1 – Photo 2

Transect 1 – Photo 3

Transect 1 – Photo 4 (Rockweed)

Transect 2 – Photo 1 (Anthropogenic)

Transect 2 – Photo 2 (Rockweed)

Transect 2 – Photo 3

Transect 2 – Photo 4 (Clams)

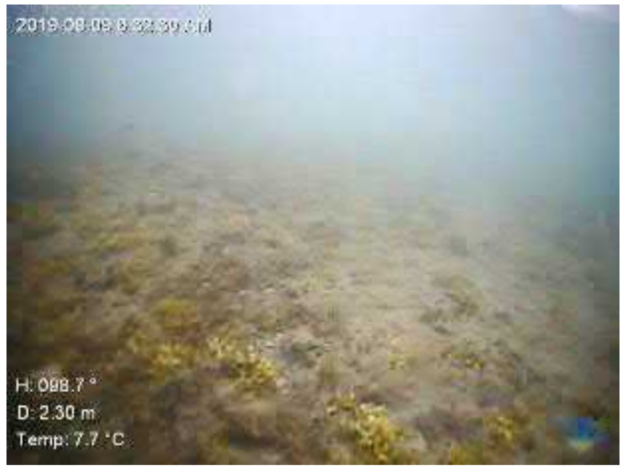
Transect 3 – Photo 1

Transect 3 – Photo 2 (Brittle stars)

Transect 3 – Photo 3 (Clams)

Transect 3 – Photo 4 (anemone)

Transect 4 – Photo 1 (Rockweed)



Transect 4 – Photo 2 (Clams)

Transect 4 – Photo 3 (Anthropogenic)

Transect 4 – Photo 4 (Sun star)

Transect 5 – Photo1 (Rockweed)

Transect 5 – Photo 2 (Clams)

Transect 5 – Photo 3 (Green sea urchins)

Transect 5 – Photo 4 (Sun star, brittle stars)

Transect 6 – Photo 1 (Sculpin)

Transect 6 – Photo 2 (Clams)

Transect 6 – Photo 3 (Green sea urchins)

Transect 6 – Photo 4 (Anemones)

Transect 7 – Photo 1 (Sun star, brittle stars)

Transect 7 – Photo 2 (Anthropogenic)

Transect 7 – Photo 3

Transect 7 – Photo 4 (Thread brown algae)

Transect 8 – Photo 1 (Anemones)

Transect 8 – Photo 2 (Clams)

Transect 8 – Photo 3 (Sun star)

Transect 8 – Photo 4 (Green Sea Urchins)

Transect 9 – Photo 1 (Brittle stars)

Transect 9 – Photo 2

Transect 9 – Photo 3 (Rose star)

Transect 9 – Photo 4 (Green sea urchins)

Transect 10 – Photo 1 (Arctic blood star)	Transect 10 – Photo 2 (Sculpin, brittle stars)	Transect 10 – Photo 3 (Sun star)	Transect 10 – Photo 4 (Green sea urchins)
			
Transect 11 – Photo 1 (Rockweed)	**Transect 11 – Photo 2 (Thread brown algae)**	**Transect 11 – Photo 3 (Clams)**	**Transect 11 – Photo 4**
			
Transect 12 – Photo 1 (Rockweed)	**Transect 12 – Photo 2**	**Transect 12 – Photo 3**	**Transect 12 – Photo 4 (Anthropogenic)**
			

Transect 13 – Photo 1 (Rockweed)

Transect 13 – Photo 2 (Coralline algae)

Transect 13 – Photo 3 (Clams)

Transect 13 – Photo 4

Transect 14 – Photo 1 (Pteropod, rockweeds)

Transect 14 – Photo 2 (Rockweed)

Transect 14 – Photo 3

Transect 14 – Photo 4 (Anthropogenic)

Transect 15 – Photo 1

Transect 15 – Photo 2 (Rockweed)

Transect 15 – Photo 3

Transect 15 – Photo 4 (At breakwater)

Transect 16 – Photo 1 (Brittle stars)

Transect 16 – Photo 2 (Green sea urchin)

Transect 16 – Photo 3 (Clam siphons)

Transect 16 – Photo 4 (Anthropogenic)

Transect 17 – Photo 1 (Green sea urchins)

Transect 17 – Photo 2 (Shorthorn sculpin)

Transect 17 – Photo 3 (Anthropogenic, clams)

Transect 12 – Photo 4 (Brittle stars)

Transect 18 – Photo 1 (Sea colander)

Transect 18 – Photo 2 (Sun star, brittle stars)

Transect 18 – Photo 3 (Green sea urchin)

Transect 18 – Photo 4 (Sea cucumber)

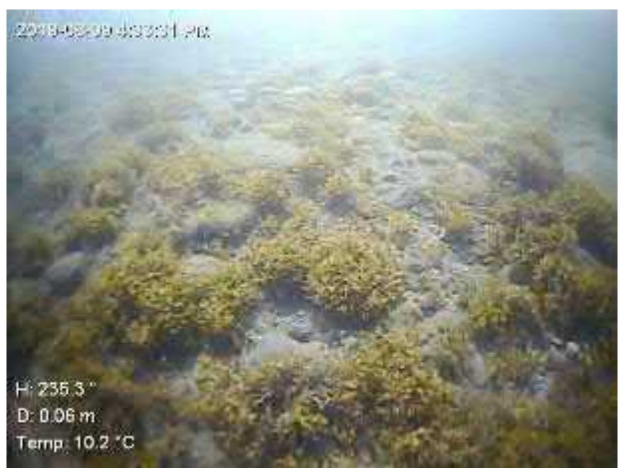
Transect 19 – Photo 1 (Brittle stars)

Transect 19 – Photo 2 (Green sea urchin)

Transect 19 – Photo 3

Transect 19 – Photo 4

Transect 20 – Photo 1 (Rockweed)



Transect 20 - Photo 2

Transect 20 – Photo 3

Transect 20 – Photo 4

Transect 21 – Photo 1 (Rockweed)

Transect 21 – Photo 2

Transect 21 – Photo 3

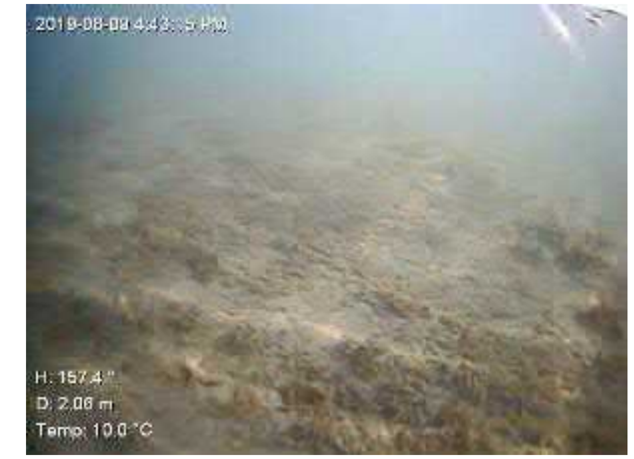
Transect 21 – Photo 4

Transcect 22 – Photo 1

Transect 22 – Photo 2 (Shorthorn sculpin)

Transect 22 – Photo 3 (Crinoid)

Transect 22 – Photo 4



Transect 23 – Photo 1 (Rockweed)

Transect 23 – Photo 2

Transect 23 – Photo 3 (At breakwater)

Transect 23 – Photo 4 (Rockweed)

Transect 24 – Photo 1 (Rockweed)

Transect 24 – Photo 2

Transect 24 – Photo 3 (At breakwater)

Transect 24 – Photo 4

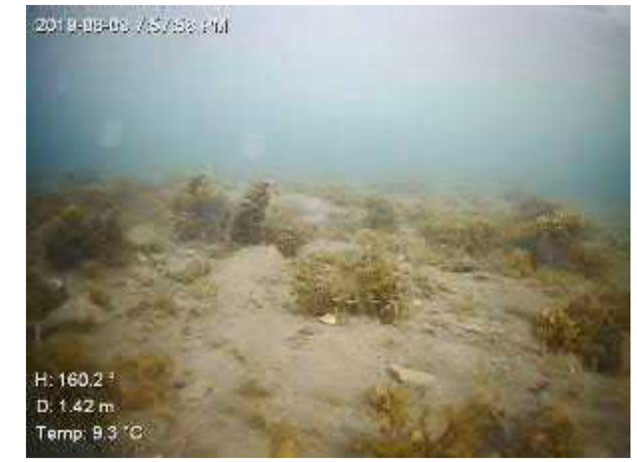
Transect 25 – Photo 1 (Rockweed)	Transect 25 – Photo 2	Transect 25 – Photo 3	Transect 25 – Photo 4
			

Photo 13 2019 Subtidal ROV DAS Transect Images Panel

Transect 1 – Photo 1 (Snail-dwelling anemone)

Transect 1 – Photo 2 (Sea cucumber)

Transect 1 – Photo 3 (Tunicate)

Transect 1 – Photo 4 (Brittle stars)

Transect 2 – Photo 1 (Anemone, soft coral)

Transect 2 – Photo 2 (Brittle stars, worm)

Transect 2 – Photo 3 (Tube-dwelling anemone)

Transect 2 – Photo 4 (Tunicate)

Transect 3 – Photo 1 (Brittle stars)

Transect 3 – Photo 2 (Sea whip)

Transect 3 – Photo 3 (Tunicate)

Transect 3 – Photo 4 (Tube-dwelling anemone)

Transect 4 – Photo 1 (Snail-dwelling anemone)

Transect 4 – Photo 2 (Tube worms)

Transect 4 – Photo 3 (Soft coral)

Transect 4 – Photo 4 (Brittle stars, worm)

Transect 5 – Photo 1 (Ribbon worm)

Transect 5 – Photo 2 (Snail-dwelling

Transect 5 – Photo 3 (Brittle stars)

Transect 5 – Photo 4 (Tube worm)

Transect 6 – Photo 1 (Tube-dwelling anemone)

Transect 6 – Photo 2 (Snail-dwelling

Transect 6 – Photo 3 (Anthropogenic)

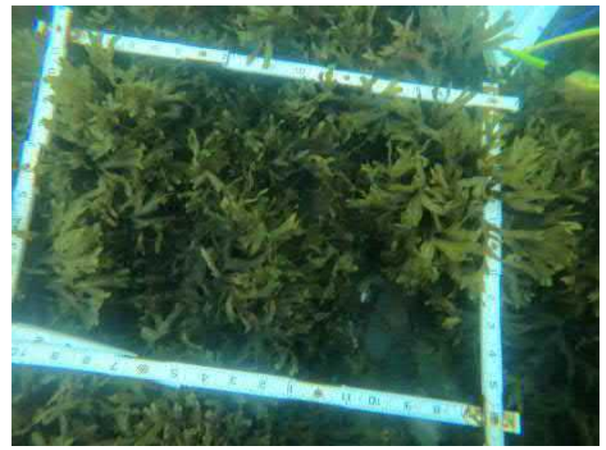
Transect 6 – Photo 4 (Snail-dwelling anemone)

Transect 7 – Photo 1 (Tube worms)	Transect 7 – Photo 2 (Brittle stars)	Transect 7 – Photo 3 (Tunicate, anemone)	Transect 7 – Photo 4 (Snail-dwelling anemone)
			

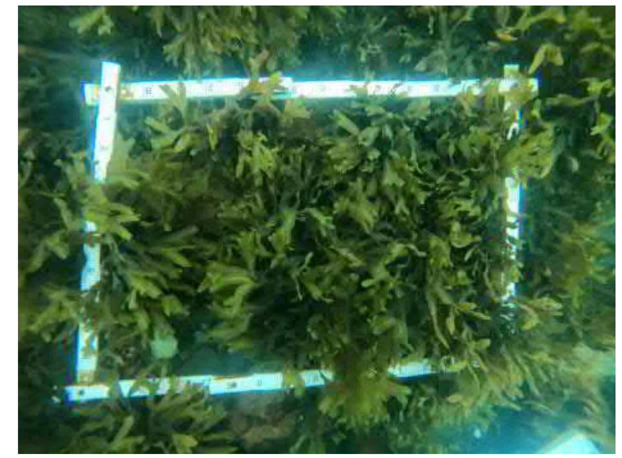
Photo 14 2020 Snorkel Survey Random Quadrat Images

Quadrat 1

Quadrat 2

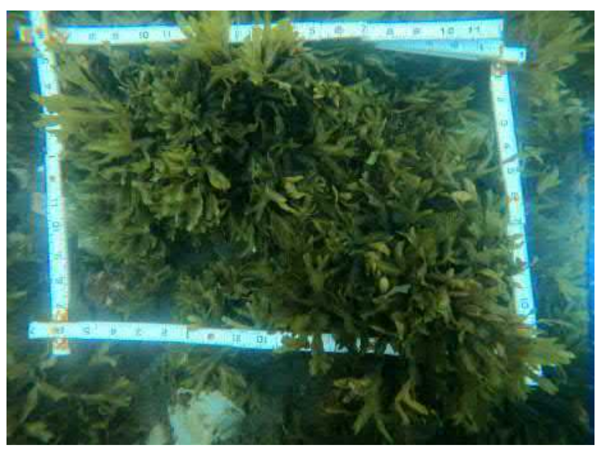


Quadrat 3

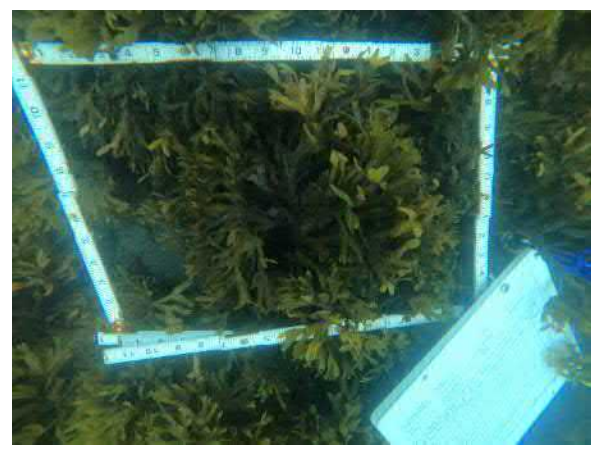


Quadrat 4

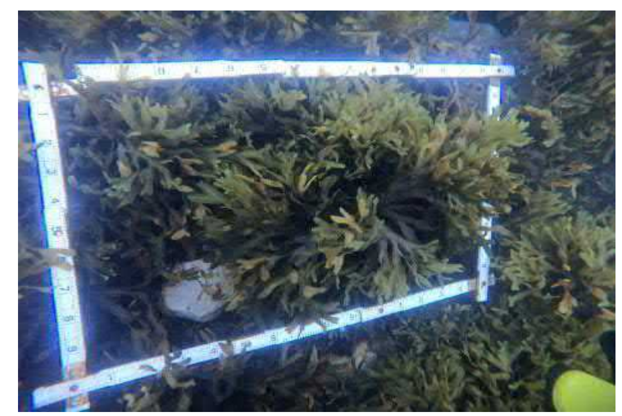
Quadrat 5



Quadrat 6



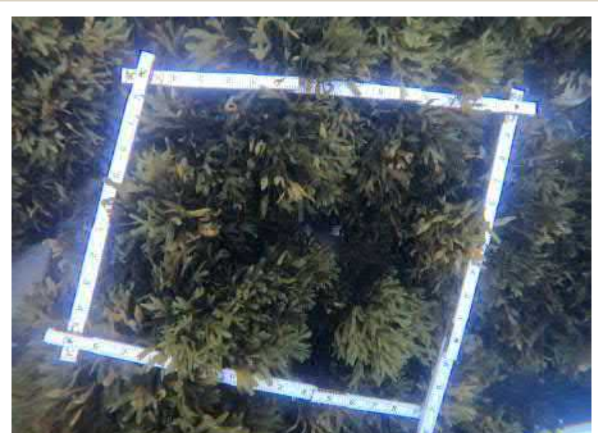
Quadrat 7



Quadrat 8

Quadrat 9

Quadrat 10



Appendix 4 Arctic Bay Rock Laboratory Certificates

STANDARD TEST METHOD FOR AGGREGATE DURABILITY INDEX
ASTM D3744

October 4, 2019
Project Number: 19130550-1000

ADVISIAN
Suite 500, 4321 Still Creek Drive
Burnaby, BC
V5C 6S7

ATTENTION: Mr. Jeffrey Gibson

PROJECT: Lancaster Sound 4 Ports

Sample:	**Arctic Bay Rock (Laboratory Crushed to Minus 19 mm)**
Source:	**Arctic Bay**

Date sampled: September 2019 **Sampled by:** Client
Date tested: September 30, 2019 **Tested by:** KS

PROCEDURE	**SEDIMENT HEIGHT (in.)**		**DURABILITY INDEX (D_c)**
A (Coarse Aggregate)	Trial 1	0.4	87
	Trial 2	0.4	87
	Trial 3	0.4	87
	Average	**0.4**	**87**

Reported by: K. Scribner

Reviewed by: ______________________
S. John, AScT

Notice: The test data given herein pertain to the samples provided and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

RESISTANCE TO DEGRADATION OF SMALL-SIZE COARSE AGGREGATE BY ABRASION & IMPACT IN THE LOS ANGELES MACHINE

ASTM C131

October 7, 2019
Project Number: 19130550-1000

ADVISIAN
Suite 500, 4321 Still Creek Drive
Burnaby, BC
V5C 6S7

ATTENTION: Mr. Jeffrey Gibson

PROJECT: Lancaster Sound 4 Ports

Sample:	**Arctic Bay Rock (Laboratory Crushed to Minus 19 mm)**
Source:	**Arctic Bay**

Date sampled: September 2019 **Sampled by:** Client
Date tested: October 4, 2019 **Tested by:** KS

Grading	**B**
Number of Revolutions	500
Loss After 500 Revolutions (%)	**24.1**

Reported by: K. Scribner

Reviewed by: ______________________
S. John, AScT

Notice: The test data given herein pertain to the sample provided and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

RELATIVE DENSITY (SPECIFIC GRAVITY) AND ABSORPTION OF COARSE AGGREGATE

ASTM C127

October 4, 2019
Project Number: 19130550-1000

ADVISIAN
Suite 500, 4321 Still Creek Drive
Burnaby, BC
V5C 6S7

ATTENTION: Mr. Jeffrey Gibson

PROJECT: Lancaster Sound 4 Ports

Sample:	Arctic Bay Rock (Laboratory Crushed to Minus 19 mm)
Source:	**Arctic Bay**

Date sampled: September 2019 **Sampled by:** Client
Date tested: September 25, 2019 **Tested by:** KS

Trial No.	Mass (g)	Relative Density (Dry Basis)	Relative Density (SSD Basis)	Apparent Relative Density	Absorption (%)
1	2039.2	2.943	2.962	3.002	0.68
2	2266.4	2.940	2.959	2.997	0.64
AVERAGE		**2.941**	**2.961**	**3.000**	**0.66**

Reported by: K. Scribner

Reviewed by: ______________________
S. John, AScT

Notice: The test data given herein pertain to the sample provided and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATE
ASTM C136

ADVISIAN
Suite 500, 4321 Still Creek Drive
Burnaby, BC
V5C 6S7

October 4, 2019
Project Number: 19130550-1000

ATTENTION: Mr. Jeffrey Gibson

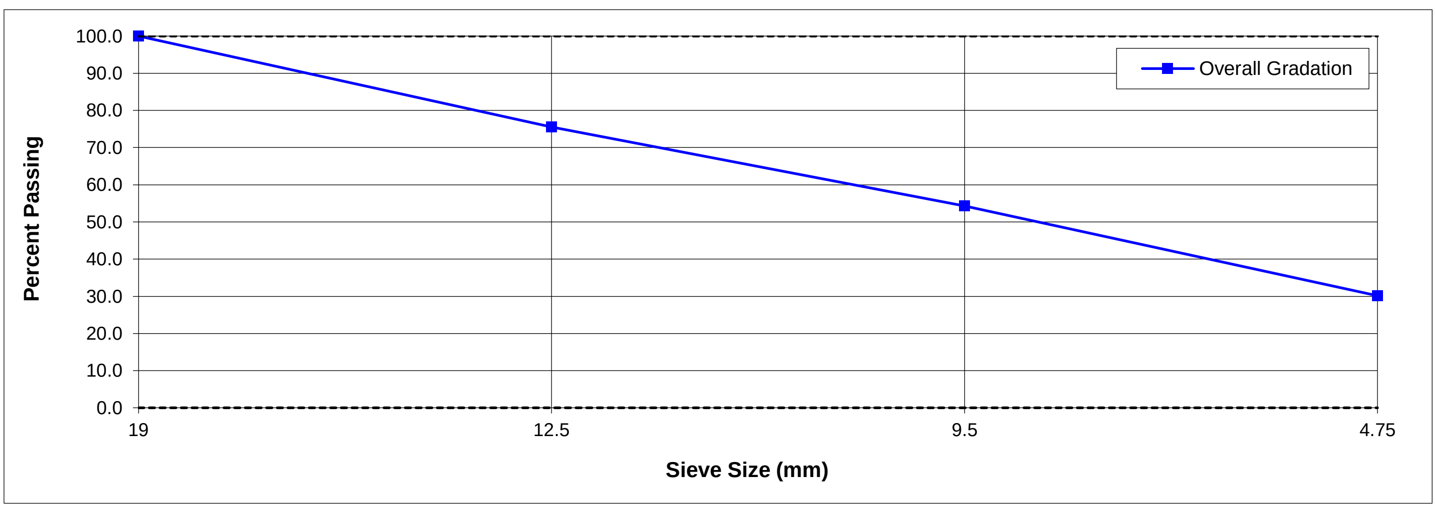
PROJECT: Lancaster Sound 4 Ports

Sample:	**Arctic Bay Rock (Laboratory Crushed to Minus 19 mm)**
Source	**Arctic Bay**

DATE SAMPLED: September 2019
DATE TESTED: September 25, 2019

SAMPLED BY: Client
TESTED BY: KS

SIEVE ANALYSIS					MATERIAL SPECIFICATION: NONE	
Sieve Size (mm)	% Retained	% Passing	Individual % Retained (Split values)			
			+ 4.75	- 4.75		
19	0.0	100.0	0.0			
12.5	24.4	75.6	35.0			
9.5	21.3	54.3	30.4			
4.75	24.2	30.2	34.6			
PAN	30.2	0		100.0		
Total	100.0		100.0	100.0		



Reported by: K. Scribner

Reviewed by: S. John, AScT

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other zones/depths. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

SOUNDNESS OF AGGREGATE BY USE OF MAGNESIUM SULFATE

ASTM C88

October 4, 2019
Project Number: 19130550-1000

ADVISIAN
Suite 500, 4321 Still Creek Drive
Burnaby, BC
V5C 6S7

ATTENTION: Mr. Jeffrey Gibson

PROJECT: Lancaster Sound 4 Ports

Sample:	**Arctic Bay Rock (Laboratory Crushed to Minus 19 mm)**
Source:	**Arctic Bay**

Date sampled: September 2019 **Sampled by:** Client
Date tested: September 26 - October 3, 2019 **Tested by:** KS

Sieve Fraction (mm)	Original Grading (%)	Mass/Fraction Before Test (g)	Loss (%)	Weighted Loss (%)
19 × 12.5 12.5 × 9.5	65.4	1002.0	0.1	0.1
9.5 × 4.75	34.6	303.1	0.9	0.3
	100.0		**TOTAL**	**0.4**

Reported by: K. Scribner

Reviewed by: ______________________
S. John, AScT

Notice: The test data given herein pertain to the sample provided and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

Appendix 5 Field Data Tables

Appendix 5 – Field Survey Data

Table list

Advisian ᐃᑉᐱᐊᕐᔪᒃ ᐱᕙᓪᓕᐊᔪᑦ Ikpiaryuk Services Ltd.

TABLE 1: FIELD POINT LOAD TESTING RESULTS

PROJECT NAME	Lancaster Sound	PROJECT NUMBER	307071-01306
CLIENT	Fisheries and Oceans Canada	DATE	30-Sep-19
PROJECT LOCATION	Arctic Bay	REV	0

Date	Sample Number	Location	Test Type[1] (D/A)	Width (mm)	Diameter (mm)	Failure Load (kN)	D_e^2 (mm^2)	D_e (mm)	I_s[3] (MPa)	F[4]	Is_{50}[3] (MPa)	Test Validity	Comments
06-Sep-19	AB01	1	L	122	64.0	39.949	9941	99.7	4.02	1.36	5.48	Valid	(c3)
06-Sep-19	AB02	1	L	50.5	62.0	26.468	3987	63.1	6.64	1.11	7.37	Invalid	e2
06-Sep-19	AB03	1	L	61.5	46.0	16.543	3602	60.0	4.59	1.09	4.99	Valid	(c1)
06-Sep-19	AB04	1	L	105	42.0	18.420	5615	74.9	3.28	1.20	3.94	Valid	(c1)
06-Sep-19	AB05	1	L	57.5	88.0	15.367	6443	80.3	2.39	1.24	2.95	Valid	(c1)
06-Sep-19	AB01	2	L	63	82.0	38.508	6578	81.1	5.85	1.24	7.28	Valid	(c1)
06-Sep-19	AB02	2	L	74	80.0	37.531	7538	86.8	4.98	1.28	6.38	Valid	(c1)
06-Sep-19	AB01	3	L	91	42.0	49.808	4866	69.8	10.24	1.16	11.89	Valid	(c1)
06-Sep-19	AB02	3	L	74.5	52.0	18.695	4933	70.2	3.79	1.17	4.42	Valid	(c1)

1. L -Lump Test
2. I_s - Uncorrected point load strength (MPa), $I_{s(50)}$ - Corrected Point Load Strength (MPa)
3. F - Size Correction Factor

ASTM D5731 – 08

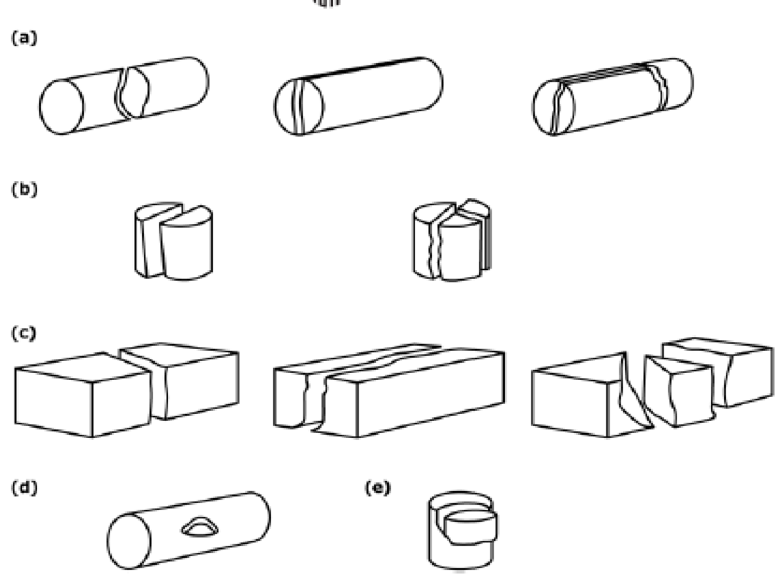


FIG. 5 Typical Modes of Failure for Valid and Invalid Tests—(a) Valid diametral tests; (b) valid axial tests; (c) valid block tests; (d) invalid core test; and (e) invalid axial test (point load strength index test).[3]

ROCK MATERIAL STRENGTH

Grade	Term	Uniaxial Comp. Strength (MPa)	Point Load Index (MPa)	Field Estimate of Strength	Field Estimate of Strength
R6	Extremely strong	> 250	> 10	Specimen can only be shipped with a geological hammer	Fresh basalt, chert, diabase, gneiss, granite, quartzite
R5	Very strong	100 - 250	4 - 10	Specimen requires many blows of a geological hammer to fracture it	Amphibolite, sandstone, basalt, gabbro, gneiss, granodiorite, peridotite, rhyolite, tuff
R4	Strong	50 - 100	2 - 4	Specimen requires more than one blow of a geological hammer to fracture it	Limestone, marble, sandstone, schist
R3	Medium strong	25 - 50	1 - 2	Cannot be scraped or peeled with a pocked knife, specimen can be fractured with a single blow from a geological hammer	Concrete, phyllilte, schist, siltstone
R2	Weak	5 - 25	***	Can be peeled with a pocket knife with difficulty, shallow indentation made by a firm blow with the point of a geological hammer	Chalk, claystone, potash, marl, siltstone, shale, rocksalt
R1	Very weak	1 - 5	***	Crumbles under firm blows with point of a geological hammer, can be peeled with a pocket knife	Highly weathered or altered rock, shale
R0	Extremely weak	0.25 - 1	***	Indented by thumbnail	Stiff fault gouge

Notes:

1. All rock types exhibit a broad range of uniaxial compressive strength reflecting heterogeneity in composition and anisotropy in structure. Strong rocks are characterized by well-interlocked crystal fabric at few voids.
2. Rocks with uniaxial compressive strength below 25 MPa are likely to yield highly ambiguous results under point load testing.

Table 2 Abiotic Data collected during Ecological Land Classification

Date	Plot	Biome	Ecozone	Ecoregion	Community Type	Slope	Aspect	Soil Moisture Regime	Soil Nutrient Regime	Meso Slope Position	Exposure Type	Drainage	Mineral Soil Texture	Organic Soil Texture	Humus Form	Surface Shape	Coarse Fragment Content	Surficial Material
09-Aug-19	GD-01, GD-04	Tundra	Northern Arctic	Borden Peninsula Plateau	Upland Dwarf Shrub	0->5%	Rolling, mostly level	Xeric	Poor	Upper Slope	Wind, Frost, Cold Air Drainage	Imperfectly	NA	Fibric	Mor	Convex, Straight	>70%	Till Veneer
09-Aug-19	GD-02, GD-05	Tundra	Northern Arctic	Borden Peninsula Plateau	Wetland Graminoid-Moss Drainage	0-2%	Mostly level	Hydric	Poor	Middle Slope, Lower Slope	Wind, Frost, Cold Air Drainage	Poorly	DNC	Fibric	Mor	Concave, Straight	20-35%	Till Veneer
09-Aug-19	GD-03	Tundra	Northern Arctic	Borden Peninsula Plateau	Wetland Dwarf Shrub Drainage	0-2%	Mostly level	Hydric	Poor	Middle Slope, Lower Slope	Wind, Frost, Cold Air Drainage	Poorly	DNC	Fibric	Mor	Straight	35-70%	Till Veneer
09-Aug-19	NA	Tundra	Northern Arctic	Borden Peninsula Plateau	Disturbed Human-Caused	0->5%	Mostly level though variable	Very Xeric	Very Poor	Level	Wind, Frost, Cold Air Drainage	Moderately Well	DNC	NA	NA	Straight	>70%	Till Veneer
09-Aug-19	NA	Tundra	Northern Arctic	Borden Peninsula Plateau	Upland Lichen Barren	0->5%	Rolling, steep, variable	Very Xeric	Very Poor	Middle, Upper	Wind, Frost, Cold Air Drainage	Well	DNC	NA	NA	Straight	>70%	Till Veneer

Notes:

NA – means not applicable
DNC – means did not collect

Categories for abiotic conditions that were considered included the following:

- Slope: 0%, 1%, 2%, 2-5%, >5%
- Aspect: level, mostly level, rolling, variable, northernly, southerly, easterly, westerly
- Soil Moisture Regime: very xeric, xeric, subxeric, submesic, mesic, subhygric, hygric, subhydric, hydric
- Soil Nutrient Regime: very poor, poor, medium, rich, very rich
- Meso Slope Position: crest, upper slope, middle slope, lower slope, toe, depression, level
- Exposure Type: wind, insolation, frost, cold air drainage, toxicity (atmospheric or soil), not applicable
- Drainage: very rapidly, rapidly, well, moderately well, imperfectly, poorly, very poorly
- Mineral Soil Texture: sandy, loamy, silty, clayey
- Organic Soil Texture: fibric, mesic, humic
- Humus Form: mor, moder, mull
- Surface Shape: concave, convex, straight

Coarse Fragment Content: <20%, 20-35%, 35-70%, >70%

Table 3 Vegetation Ground Plot Data

Date	Plot	Community Type	Total Tree Layer %	Total Shrub Layer %	Total Forb Layer %	Total Graminoid Layer %	Total Non-vascular Layer %	Litter %	Water %	Mineral Soil %	Rock %	Species Name and Author	Common Name	Percent Foliar Cover
09-Aug-19	GD-01	Upland Dwarf Shrub	0	1	5	3	5	1	0	0	85	*Alectoria ochroleuca* (Hoffm.) A. Massal.	witch's hair lichen	2
												Carex nardina Fr.	spike sedge	3
												Dryas integrifolia Vahl	entireleaf mountain-avens	1
												Flavocetraria nivalis (L.) Karnefelt & A. Thell	snow lichen	3
												Hulteniella integrifolia (Richardson) Tzvelev	entireleaf daisy	3
												Oxytropis maydelliana Trautv.	Maydell's oxytrope	1
												Salix arctica Pall.	arctic willow	1
09-Aug-19	GD-02	Wetland Graminoid-Moss Drainage	0	1	5	80	5	10	5	0	0	*Arctagrostis latifolia* (R. Br.) Griseb.	wideleaf polargrass	1
												Carex membranacea Hook.	fragile sedge	40
												Carex misandra R. Br.	shortleaved sedge	10
												Eriophorum scheuchzeri Hoppe	white cottongrass	30
												Limprichtia revolvens (Sw.) Loeske	limprichtia moss	1
												Limprichtia cossonii (Schimp.) L.E. Anderson, H.A. Crum & W.R. Buck	Cosson's limprichtia moss	1
												Scorpidium scorpioides (Hedw.) Limpr.	scorpidium moss	1
												Cinclidium arcticum Bruch & Schimp.	arctic cinclidium moss	1
												Salix arctica Pall.	arctic willow	1
09-Aug-19	GD-03	Wetland Dwarf Shrub Drainage	0	3	1	1	2	1	30	1	70	*Carex misandra* R. Br.	shortleaved sedge	1
												Festuca brachyphylla Schult. ex Schult. & Schult. f.	alpine fescue	1
												Ditrichum flexicaule (SchwÃ¤gr.) Hampe	ditrichum moss	*2*
												Salix arctica Pall.	arctic willow	3
												Saxifraga cernua L.	nodding saxifrage	1
												Silene uralensis (Rupr.) Bocquet	apetalous catchfly	1
09-Aug-19	GD-04	Upland Dwarf Shrub	0	1	5	3	5	1	0	0	85	*Alectoria ochroleuca* (Hoffm.) A. Massal.	witch's hair lichen	15
												Dryas integrifolia Vahl	entireleaf mountain-avens	1
												Flavocetraria cucullata (Bellardi) Karnefelt & A. Thell	snow lichen	5
												Flavocetraria nivalis (L.) Karnefelt & A. Thell	snow lichen	8

Date	Plot	Community Type	Total Tree Layer %	Total Shrub Layer %	Total Forb Layer %	Total Graminoid Layer %	Total Non-vascular Layer %	Litter %	Water %	Mineral Soil %	Rock %	Species Name and Author	Common Name	Percent Foliar Cover
												Hypnum bambergeri Schimp.	Bamberger's hypnum moss	1
												Oxytropis maydelliana Trautv.	Maydell's oxytrope	3
												Pedicularis capitata M.F. Adams	capitate lousewort	1
												Polygonum viviparum L.	alpine bistort	2
												Salix arctica Pall.	arctic willow	1
												Tomentypnum nitens (Hedw.) Loeske	tomentypnum moss	3
												Vaccinium uliginosum L.	bog blueberry	25
09-Aug-19	GD-05	Wetland Graminoid-Moss Drainage	0	1	5	80	5	10	5	0	0	*Arctagrostis latifolia* (R. Br.) Griseb.	wideleaf polargrass	5
												Carex membranacea Hook.	fragile sedge	20
												Carex misandra R. Br.	shortleaved sedge	10
												Eriophorum scheuchzeri Hoppe	white cottongrass	25
												Limprichtia revolvens (Sw.) Loeske	limprichtia moss	3
												Pedicularis flammea L.	redrattle	1
												Salix arctica Pall.	arctic willow	5
												Salix nivalis Hook.	snow willow	1
												Saxifraga oppositifolia L.	purple mountain saxifrage	1
												Silene uralensis (Rupr.) Bocquet	apetalous catchfly	1
09-Aug-19	NA	Disturbed Human-Caused	0	0	0	0	0	0	0	5	95	NA	NA	NA
09-Aug-19	NA	Upland Lichen Barren	0	0	0	0	0	0	0	0	0	NA	NA	NA

Table 4 Vegetation Rare Plant Survey Data

Date	Community Type	Strata	Species Name and Authority	Common Name
09-Aug-19	Disturbed Human-Caused	Forbs	*Papaver lapponicum* (Tolm.) Nordh.	Lapland poppy
09-Aug-19	Disturbed Human-Caused	Forbs	*Saxifraga cernua* L.	nodding saxifrage
09-Aug-19	Disturbed Human-Caused	Graminoids	*Eriophorum scheuchzeri* Hoppe	white cottongrass
09-Aug-19	Disturbed Human-Caused	Graminoids	*Poa arctica* R. Br.	arctic bluegrass
09-Aug-19	Upland Dwarf Shrub	Shrubs	*Cassiope tetragona* (L.) D. Don	white arctic mountain heather
09-Aug-19	Upland Dwarf Shrub	Shrubs	*Dryas integrifolia* Vahl	entireleaf mountain-avens
09-Aug-19	Upland Dwarf Shrub	Shrubs	*Rhododendron lapponicum* (L.) Wahlenb.	Lapland rosebay
09-Aug-19	Upland Dwarf Shrub	Shrubs	*Salix arctica* Pall.	arctic willow
09-Aug-19	Upland Dwarf Shrub	Shrubs	*Salix reticulata* L.	netleaf willow
09-Aug-19	Upland Dwarf Shrub	Shrubs	*Saxifraga oppositifolia* L.	purple mountain saxifrage
09-Aug-19	Upland Dwarf Shrub	Shrubs	*Saxifraga tricuspidata* Rottb.	three toothed saxifrage
09-Aug-19	Upland Dwarf Shrub	Shrubs	*Vaccinium uliginosum* L.	bog blueberry
09-Aug-19	Upland Dwarf Shrub	Forbs	*Chamerion latifolium* (L.) Holub	dwarf fireweed
09-Aug-19	Upland Dwarf Shrub	Forbs	*Oxyria digyna* (L.) Hill	alpine mountainsorrel
09-Aug-19	Upland Dwarf Shrub	Forbs	*Oxytropis maydelliana* Trautv.	Maydell's oxytrope
09-Aug-19	Upland Dwarf Shrub	Forbs	*Papaver lapponicum* (Tolm.) Nordh.	Lapland poppy
09-Aug-19	Upland Dwarf Shrub	Forbs	*Pedicularis capitata* M.F. Adams	capitate lousewort
09-Aug-19	Upland Dwarf Shrub	Forbs	*Pedicularis flammea* L.	redrattle
09-Aug-19	Upland Dwarf Shrub	Forbs	*Saxifraga cernua* L.	nodding saxifrage
09-Aug-19	Upland Dwarf Shrub	Forbs	*Saxifraga nivalis* L.	alpine saxifrage
09-Aug-19	Upland Dwarf Shrub	Graminoids	*Anthoxanthum monticola* (Bigelow) Veldkamp	alpine sweetgrass
09-Aug-19	Upland Dwarf Shrub	Graminoids	*Carex nardina* Fr.	spike sedge
09-Aug-19	Upland Dwarf Shrub	Graminoids	*Festuca brachyphylla* Schult. ex Schult. & Schult. f.	alpine fescue
09-Aug-19	Upland Dwarf Shrub	Graminoids	*Luzula confusa* Lindeberg	northern woodrush
09-Aug-19	Upland Dwarf Shrub	Graminoids	*Poa arctica* R. Br.	arctic bluegrass
09-Aug-19	Upland Dwarf Shrub	Bryophytes	*Aulacomnium turgidum* (Wahlenb.) SchwÃ¤gr.	turgid aulacomnium moss
09-Aug-19	Upland Dwarf Shrub	Bryophytes	*Campylium stellatum* (Hedw.) C.E.O. Jensen	star campylium moss
09-Aug-19	Upland Dwarf Shrub	Bryophytes	*Dicranum elongatum* Schleich. ex SchwÃ¤gr.	elongate dicranum moss
09-Aug-19	Upland Dwarf Shrub	Bryophytes	*Hypnum bambergeri* Schimp.	Bamberger's hypnum moss
09-Aug-19	Upland Dwarf Shrub	Bryophytes	*Racomitrium lanuginosum* (Hedw.) Brid.	racomitrium moss

Date	Community Type	Strata	Species Name and Authority	Common Name
09-Aug-19	Upland Dwarf Shrub	Bryophytes	*Tomentypnum nitens* (Hedw.) Loeske	tomentypnum moss
09-Aug-19	Upland Dwarf Shrub	Lichens	*Actoparmelia* spp.	lichens
09-Aug-19	Upland Dwarf Shrub	Lichens	*Alectoria ochroleuca* (Hoffm.) A. Massal.	witch's hair lichen
09-Aug-19	Upland Dwarf Shrub	Lichens	*Arctoparmelia centrifuga* (L.) Hale	arctoparmelia lichen
09-Aug-19	Upland Dwarf Shrub	Lichens	*Aspicilia* spp.	lichens
09-Aug-19	Upland Dwarf Shrub	Lichens	*Cetraria tilesii* Ach.	lichen
09-Aug-19	Upland Dwarf Shrub	Lichens	*Cladina rangiferina* (L.) Nyl.	greygreen reindeer lichen
09-Aug-19	Upland Dwarf Shrub	Lichens	*Flavocetraria nivalis* (L.) Karnefelt & A. Thell	snow lichen
09-Aug-19	Upland Dwarf Shrub	Lichens	*Glypholecia scabra* (Pers.) MÃ¼ll. Arg.	glypholecia lichen
09-Aug-19	Upland Dwarf Shrub	Lichens	*Pertusaria dactylina* (Ach.) Nyl.	pore lichen
09-Aug-19	Upland Dwarf Shrub	Lichens	*Rhizocarpon* spp.	map lichens
09-Aug-19	Upland Dwarf Shrub	Lichens	*Thamnolia subuliformis* (Ehrh.) W.L. Culb.	whiteworm lichen
09-Aug-19	Upland Dwarf Shrub	Lichens	*Umbilicaria decussata* (Vill.) Zahlbr.	navel lichen
09-Aug-19	Upland Dwarf Shrub	Lichens	*Umbilicaria* spp.	lichens
09-Aug-19	Upland Lichen Barren	Lichens	*Actoparmelia* spp.	lichens
09-Aug-19	Upland Lichen Barren	Lichens	*Arctoparmelia centrifuga* (L.) Hale	arctoparmelia lichen
09-Aug-19	Upland Lichen Barren	Lichens	*Rhizocarpon* spp.	map lichens
09-Aug-19	Upland Lichen Barren	Lichens	*Umbilicaria decussata* (Vill.) Zahlbr.	navel lichen
09-Aug-19	Upland Lichen Barren	Lichens	*Umbilicaria* spp.	lichens
09-Aug-19	Wetland Dwarf Shrub Drainage	Shrubs	*Salix arctica* Pall.	arctic willow
09-Aug-19	Wetland Dwarf Shrub Drainage	Forbs	*Silene uralensis* (Rupr.) Bocquet	apetalous catchfly
09-Aug-19	Wetland Dwarf Shrub Drainage	Graminoids	*Carex misandra* R. Br.	shortleaved sedge
09-Aug-19	Wetland Dwarf Shrub Drainage	Graminoids	*Festuca brachyphylla* Schult. ex Schult. & Schult. f.	alpine fescue
09-Aug-19	Wetland Dwarf Shrub Drainage	Forbs	*Saxifraga cernua* L.	nodding saxifrage
09-Aug-19	Wetland Dwarf Shrub Drainage	Bryophytes	*Ditrichum flexicaule* (SchwÃ¤gr.) Hampe	ditrichum moss
09-Aug-19	Wetland Graminoid-Moss Drainage	Shrubs	*Dryas integrifolia* Vahl	entireleaf mountain-avens
09-Aug-19	Wetland Graminoid-Moss Drainage	Shrubs	*Salix arctica* Pall.	arctic willow
09-Aug-19	Wetland Graminoid-Moss Drainage	Forbs	*Cerastium arcticum* Lange	mouse-ear chickweed
09-Aug-19	Wetland Graminoid-Moss Drainage	Forbs	*Chamerion latifolium* (L.) Holub	dwarf fireweed
09-Aug-19	Wetland Graminoid-Moss Drainage	Forbs	*Equisetum arvense* L.	field horsetail
09-Aug-19	Wetland Graminoid-Moss Drainage	Forbs	*Equisetum variegatum* Schleich. ex F. Weber & D. Mohr var. jesupii A.A. Eaton	horsetail
09-Aug-19	Wetland Graminoid-Moss Drainage	Forbs	*Pedicularis hirsuta* L.	hairy lousewort

Date	Community Type	Strata	Species Name and Authority	Common Name
09-Aug-19	Wetland Graminoid-Moss Drainage	Forbs	*Polygonum viviparum* L.	alpine bistort
09-Aug-19	Wetland Graminoid-Moss Drainage	Forbs	*Saxifraga caespitosa* L.	tufted alpine saxifrage
09-Aug-19	Wetland Graminoid-Moss Drainage	Forbs	*Saxifraga hirculus* L.	yellow marsh saxifrage
09-Aug-19	Wetland Graminoid-Moss Drainage	Forbs	*Silene uralensis* (Rupr.) Bocquet	apetalous catchfly
09-Aug-19	Wetland Graminoid-Moss Drainage	Graminoids	*Alopecurus magellanicus* Lam.	Alpine Meadow-Foxtail
09-Aug-19	Wetland Graminoid-Moss Drainage	Graminoids	*Arctagrostis latifolia* (R. Br.) Griseb.	wideleaf polargrass
09-Aug-19	Wetland Graminoid-Moss Drainage	Graminoids	*Carex membranacea* Hook.	fragile sedge
09-Aug-19	Wetland Graminoid-Moss Drainage	Graminoids	*Carex misandra* R. Br.	shortleaved sedge
09-Aug-19	Wetland Graminoid-Moss Drainage	Graminoids	*Eriophorum scheuchzeri* Hoppe	white cottongrass
09-Aug-19	Wetland Graminoid-Moss Drainage	Graminoids	*Juncus albescens* (Lange) Fernald	northern white rush
09-Aug-19	Wetland Graminoid-Moss Drainage	Bryophytes	Cinclidium arcticum Bruch & Schimp.	arctic cinclidium moss
09-Aug-19	Wetland Graminoid-Moss Drainage	Bryophytes	Ditrichum flexicaule (SchwÃ¤gr.) Hampe	ditrichum moss
09-Aug-19	Wetland Graminoid-Moss Drainage	Bryophytes	Limprichtia cossonii (Schimp.) L.E. Anderson, H.A. Crum & W.R. Buck	Cosson's limprichtia moss
09-Aug-19	Wetland Graminoid-Moss Drainage	Bryophytes	*Limprichtia revolvens* (Sw.) Loeske	limprichtia moss
09-Aug-19	Wetland Graminoid-Moss Drainage	Bryophytes	*Orthothecium chryseum* (SchwÃ¤gr.) Schimp. var. cochlearifolium (Lindb.) Limpr.	orthothecium moss
09-Aug-19	Wetland Graminoid-Moss Drainage	Bryophytes	*Philonotis fontana* (Hedw.) Brid.	philonotis moss
09-Aug-19	Wetland Graminoid-Moss Drainage	Bryophytes	*Scorpidium scorpioides* (Hedw.) Limpr.	scorpidium moss
09-Aug-19	Wetland Graminoid-Moss Drainage	Bryophytes	*Tetraplodon mnioides* (Hedw.) Bruch & Schimp.	entireleaf nitrogen moss

Table 5 Incidental Wildlife Species Observed for Detected during Field Survey

Date	Species Code	Species Name	Common Name	Count	Type	Easting	Northing	Coordinate System	Zone
09-Aug-19	BRANT	*Branta bernicla*	brant	2	flyover	557027	8106287	UTM NAD83	16X
09-Aug-19	CORA	*Corvus corax*	common raven	1	call	557414	8106398	UTM NAD83	16X
09-Aug-19	NOFU	*Fulmarus glacialis*	northern fulmar	6	on water	560246	8102624	UTM NAD83	16X
09-Aug-19	NOFU	*Fulmarus glacialis*	northern fulmar	20	on water + 500 m	557318	8108363	UTM NAD83	16X
09-Aug-19	RETL	*Gavia stellata*	red-throated loon	6	on water + 500 m	557318	8108363	UTM NAD83	16X
09-Aug-19	RETL	*Gavia stellata*	red-throated loon	2	on water	564898	8100796	UTM NAD83	16X
09-Aug-19	PTSP	*Lagopus* sp.	ptarmigan species	1	scat	557414	8106398	UTM NAD83	16X
09-Aug-19	GLGU	*Larus hyperboreus*	glaucous gull	1	on water	557414	8106398	UTM NAD83	16X
09-Aug-19	GLGU	*Larus hyperboreus*	glaucous gull	2	on water	560246	8102624	UTM NAD83	16X
09-Aug-19	THGU	*Larus thayeri*	Thayer's gull	1	foraging	559981	8105184	UTM NAD83	16X
09-Aug-19	SNBU	*Plectrophenax nivalis*	snow bunting	6	flock	558013	8106343	UTM NAD83	16X
09-Aug-19	SNBU	*Plectrophenax nivalis*	snow bunting	1	foraging	557701	8105950	UTM NAD83	16X
09-Aug-19	RISE	*Pusa hispida*	ringed seal	2	in water	560246	8102624	UTM NAD83	16X
09-Aug-19	TBMU	*Uria lomvia*	thick-billed murre	3	on water + 500 m	557318	8108363	UTM NAD83	16X
09-Aug-19	FOSP	*Vulpes* sp.	fox species	1	track	557027	8106287	UTM NAD83	16X
09-Aug-19	FOSP	*Vulpes* sp.	fox species	1	track	557246	8106211	UTM NAD83	16X

Table 6 Bird Species Observed or Detected during Field Migratory Bird Point Count Survey

Point Count Name	Date	Time start (5 min)	Wind (km/hour)	Cloud Cover (%)	Temp (°C)	Precipitation (mm)	Species Name	Common Name	Count	Easting	Northing	Coordinate System	Zone
AB-PC-01	09-Aug-19	8:00	2	90	10	0	*Corvus corax*	common raven	3	559981	8105184	UTM NAD83	16X
AB-PC-01	09-Aug-19	8:00	2	90	10	0	*Larus hyperboreus*	glaucous gull	6	559981	8105184	UTM NAD83	16X
AB-PC-01	09-Aug-19	8:00	2	90	10	0	*Fulmarus glacialis*	northern fulmar	5	559981	8105184	UTM NAD83	16X
AB-PC-02	10-Aug-19	10:40	5	95	11	0	*Corvus corax*	common raven	4	559381	8105114	UTM NAD83	16X
AB-PC-03	10-Aug-19	10:56	2	95	11	0	*Corvus corax*	common raven	2	559752	8104864	UTM NAD83	16X
AB-PC-03	10-Aug-19	10:56	2	95	11	0	*Fulmarus glacialis*	northern fulmar	2	559752	8104864	UTM NAD83	16X
AB-PC-04	10-Aug-19	11:30	3	95	11	0	*Corvus corax*	common raven	2	560018	8105216	UTM NAD83	16X
AB-PC-04	10-Aug-19	11:30	3	95	11	0	*Larus hyperboreus*	glaucous gull	1	560018	8105216	UTM NAD83	16X
AB-PC-04	10-Aug-19	11:30	3	95	11	0	*Plectrophenax nivalis*	snow bunting	2	560018	8105216	UTM NAD83	16X
AB-PC-04	10-Aug-19	11:30	3	95	11	0	*Larus thayeri*	Thayer's gull	1	560018	8105216	UTM NAD83	16X
AB-PC-05	10-Aug-19	11:50	2	95	11	0	*Fulmarus glacialis*	northern fulmar	8	560311	8105430	UTM NAD83	16X
AB-PC-05	10-Aug-19	11:50	2	95	11	0	*Plectrophenax nivalis*	snow bunting	5	560311	8105430	UTM NAD83	16X

Table 7 2019 Arctic Bay Intertidal Transect Data

Transect No. (n)	Transect Distance (m)	Quadrat No. (n)	Substrate (%)		Vegetation (%)		Invertebrates			Fish (n)	
			Type	Percent	Species	Abundance	Species	Abundance	Measure	Species	Abundance
1	0	1	CO	80							
			GR	20							
	2	2	CO	40	RW	<5%					
			GR	30							
			SA	30							
	4	3	CO	20							
			GR	50							
			SA	30							
	6	4	CO	5							
			GR	30							
			SA	65							
	8	5	CO	20							
			GR	40							
			SA	40							
	10	6	CO	20							
			GR	80							
2	0	1	BO	30							
			CO	60							
			SA	10							
	1.5	2	CO	20							
			GR	70							
			SA	10							
	5	3	CO	30	RW (D)	10%					
			GR	40							
			SA	30							
	4.5	4	CO	20							
			GR	50							
			SA	30							
	6	5	CO	5							
			GR	60							
			SA	35							
	7.5	6	CO	5							
			GR	40							
			SA	55							
3	0	1	GR	20	RW (D)	<5%					
			SA	80							
	2	2	GR	10	RW (D)	<5%					
			SA	90							
	4	3	GR	20	RW (D)	5%					
			SA	80							
	6	4	GR	10							
			SA	90							
	8	5	GR	20							
			SA	80							
4	0	1	CO	20							
			GR	40							
			SA	40							
	2	2	CO	5							
			GR	40							
			SA	55							
	4	3	CO	5	RW (D)	<5%					
			GR	10							

Transect No. (n)	Transect Distance (m)	Quadrat No. (n)	Substrate (%)		Vegetation (%)		Invertebrates			Fish (n)	
			Type	Percent	Species	Abundance	Species	Abundance	Measure	Species	Abundance
			SA	85							
	6	4	GR	90							
			SA	10							
	8	5	CO	5							
			GR	50							
			SA	45							
	10	6	CO	5							
			GR	80							
			SA	15							
5	0	1	CO	60							
			GR	40							
	2	2	CO	60							
			GR	40							
	4	3	CO	20							
			GR	80							
	6	4	CO	5	RW	<5%					
			GR	95							
	8	5	CO	5							
			GR	95							
	10	6	CO	10							
			GR	90							

Notes:

Substrate: BO=boulder, CO=cobble, GR=gravel, SA=sand, MU=mud

Vegetation: (D) = detached, gfa = green filamentous algae

Table 8
2019 Arctic Bay ROV Subtidal Results

Survey Time	Transect No	ROV Depth (m) Minimum	ROV Depth (m) Maximum	Sounder Depth (m)	Tide Height (m)	Datum (CD, m)	Temperature (° C)	Substrate Type	Substrate Percent	Vegetation (%) Species name Common	Vegetation (%) Species name Latin	Vegetation Abundance	Invertebrates Species name Common	Invertebrates Species name Latin	Invertebrates Abundance	Measure	Cateogorization Range (Table 9-6)	Fish (n) Species Common	Fish (n) Species Latin	Fish Abundance
								sand	90 to 100	rockweed	*Fucus sp*	10 to 30								
								boulder	<10											
								cobble	5 to 10											
8:56	1	0.5	1.7	2.4	1.7	0.7	7.1	shellhash	5 to 10											
								sand	60 to 90	rockweed	*Fucus sp*	10 to 30	truncate soft shell tun	*Mya truncata*	10 - 20 / m2	count	infrequent			
9:00	2	3.5	4.5	4.5	1.5	3	4.7	shellhash	10 to 40											
								sand	60 to 90	kelp	*Agarum*	<5%	tube-dwelling anemor	*Pachycerianthus borealis*	2	count	trace			
								shellhash	10 to 40	encrusting coralline algae	*Corallina sp*	30 to 40	anemone	*Hormathia rugosa*	2 to 5/m2	density	trace to infrequent			
								boulder	<10	kelp	*UNID*	<5%	anemone	*UNID*	1	count	trace			
													anemone	*Cribrinopsis (prob)*	8	count	trace			
													brittle stars	*Ophiocten or Ophiura sp*	10-50/m2	density	moderate to abundant			
													truncate soft shell tun	*Mya truncata*	10 - 20 / m2	density	infrequent to moderate			
9:13	3	11.5	15	2	1.5	0.5	3.1						green sea urchin	*Strongylocentrotus drobachiensis*	2	count	trace			
								sand	90 to 100	rockweed	*Fucus sp*	10 to 70	truncate soft shell tun	*Mya truncata*	5 - 10 / m2	density	trace			
								cobble	5 to 10	thread brown algae	*Chordaria (poss)*	10 to 40	green sea urchin	*Strongylocentrotus drobachiensis*	1	count	trace			
9:34	4	2	4.5	2.5	1.5	1	6.1			sugarwrack kelp	*Saccharina latissima*	<5%	sun star	*Solaster sp*						
								sand	80 to 100	rockweed	*Fucus sp*	10	truncate soft shell tun	*Mya truncata*	10 to 20/m2	count	trace			
								cobble	5 to 20	thread brown algae	*Chordaria (poss)*	10 to 40	sun star	*Solaster sp*	1	count	trace			
													brittle stars	*Ophiocten or Ophiura sp*	10 to 15 /m2	density	trace to moderate			
9:57	5	2.3	5	3.5	1.5	2	7.1						green sea urchin	*Strongylocentrotus drobachiensis*	2 to 5/m2	density	trace to moderate			
								sand	80 to 100				green sea urchin	*Strongylocentrotus drobachiensis*	10	count	infrequent	sculpin	*Myoxocephalus sp (prob)*	1
								cobble	5 to 20				anemones	*Hormathia rugosa*	8	count	infrequent			
								shell debris	5 to 20				brittle stars	*Ophiocten or Ophiura sp*	5 - 40 / m2	density	infrequent to moderate			
9:59	6	7	9	8.1	1.5	6.6	4.1						truncate soft shell tun	*Mya truncata*	10-30 / m2	density	infrequent to moderate			
								sand	90 to 100	thread brown algae	*Chordaria (poss)*	10 to 30	sun star	*Solaster sp*	1	count	infrequent to moderate			
								shell debris	5 to 10				truncate soft shell tun	*Mya truncata*	20 to 30 /m2	density	moderate to abundant			
10:11	7	5.5	7	6.2	1.3	4.9	4.5						brittle stars	*Ophiocten or Ophiura sp*	5 - 40 / m2	density	infrequent to moderate			
								sand	90 to 100	encrusting coralline algae	*Corallina sp*	10 to 30	truncate soft shell tun	*Mya truncata*	10-30 / m2	density	infrequent to moderate			
								cobble	5 to 10				brittle stars	*Ophiocten or Ophiura sp*	2 to 5/m2	density	trace			
								shell debris	5 to 10				sun star	*Solaster sp*	1	count	trace			
													green sea urchin	*Strongylocentrotus drobachiensis*	5	count	trace			
10:20	8	9.5	11	7.8	1.3	6.5	3.4						anemones	*Hormathia rugosa*	10	count	infrequent			
								sand	90 to 100	rockweed (D)	*Fucus sp*	5 to 10	sun star	*Solaster sp*	3	count	trace			
								cobble	5 to 10				truncate soft shell tun	*Mya truncata*	5 to 10/m2	density	trace to moderate			
													tube dwelling anemor	*Pachycerianthus borealis*	<5/m2	density	trace			
													brittle stars	*Ophiocten or Ophiura sp*	5 - 40 / m2	density	moderate to abundant			
10:32	9	12	12	11	1.3	9.7	3.1						green sea urchin	*Strongylocentrotus drobachiensis*	12	count	infrequent			
								sand	90 to 100	encrusting coralline algae	*Corallina sp*	10	truncate soft shell tun	*Mya truncata*	10-30 / m2	density	infrequent to moderate	sculpin	*Myoxocephalus sp (prob)*	1
								cobble	5 to 10				burrowing sea cucum	*Psolus sp. (poss)*	2	count	trace			
													sun star	*Solaster sp*	3	count	trace			
													green sea urchin	*Strongylocentrotus drobachiensis*	5	density	trace			
													brittle stars	*Ophiocten or Ophiura sp*	5 - 40 / m2	density	moderate to abundant			
10:41	10	11	13	12.7	1.3	11.4	3.2						rose star	*Crossater papposus*	1	count	trace			
								sand	90 to 100	rockweed	*Fucus sp*	10 to 70	truncate soft shell tun	*Mya truncata*	10-30 / m2	density	infrequent to moderate			
10:59	11	1.5	2.5	2.1	1.3	0.8	6.1	cobble	5 to 10	thread brown algae	*Chordaria (poss)*	10 to 40								
11:08	12	0.5	1.5	1.2	1	0.2	6.3	rip rap	50 to 90	rockweed	*Fucus sp*	10 to 30								
								sand	90 to 100	rockweed	*Fucus sp*	10 to 30	truncate soft shell tun	*Mya truncata*	10-30 / m2	density	sparse			
								cobble	5 to 10	encrusting coralline algae	*Corallina sp*		brittle stars	*Ophiocten or Ophiura sp*	5 m2	density	sparse			
								boulder	5 to 10											
11:33	13	3	5	13	1	12	5	shell debris	5 to 10											
								sand	90 to 100	rockweed	*Fucus sp*	40 to 100								
11:52	14	0.5	2.5	20	1	19	5.7	cobble	5 to 10											
13:00	15	0.5	0.8	0.5	0.6	-0.1	8	sand	90 to 100	rockweed (D)	*Fucus sp*	5 to 10	truncate soft shell tun	*Mya truncata*						
								sand	90 to 100				blood star (poss)	*UNID*	1	count	trace			
								cobble	5 to 10				brittle stars	*Ophiocten or Ophiura sp*	5 - 40 / m2	density	moderate to abundant			
													green sea urchin	*Strongylocentrotus drobachiensis*	1	count	trace			
15:17	16	11.54	13	12	0.6	11.4	2.3						truncate soft shell tun	*Mya truncata*	5 - 10 / m2	density	sparse			
								sand	90 to 100	sea collander	*agarum clathratum*	<5	truncate soft shell tun	*Mya truncata*	10 to 20/m2	density	moderate	shorthorn sculpin	*Myoxocephalus scorpius*	1
								cobble	5 to 10				brittle stars	*Ophiocten or Ophiura sp*	5 - 40 / m2	density	moderate to abundant			
													green sea urchin	*Strongylocentrotus drobachiensis*	2 to 5/m2	density	trace			
13:28	17	10.5	12	10.1	0.6	9.5	3.3						sun star	*Solaster sp*	1	count	trace			
								sand	90 to 100	sea collander	*agarum clathratum*	<5	brittle stars	*Strongylocentrotus drobachiensis*	5 - 40 / m2	density	abundant			
													truncate soft shell tun	*Mya truncata*	<5/m2	density	trace			
								cobble	5 to 10				green sea urchin	*Strongylocentrotus drobachiensis*	10	count	trace			
								shell debris	5 to 20				burrowing sea cucum	*Psolus sp. (poss)*	1	count	trace			
													anemones	*Hormathia rugosa*	1	count	trace			
													blood star (poss)	*UNID*	1	count	trace			

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Table 8
2019 Arctic Bay ROV Subtidal Results

Survey Time	Transect No	ROV Depth (m)		Sounder Depth (m)	Tide Height (m)	Datum (CD, m)	Temperature (° C)	Substrate		Vegetation (%)			Invertebrates					Fish (n)		
		Minimum	Maximum					Type	Percent	Species name		Abundance	Species name		Abundance	Measure	Cateogorization Range (Table 9-6)	Species		Abundance
										Common	Latin		Common	Latin				Common	Latin	
15:43	18	12.5	14.5	15	0.6	14.4	2.4						sun star	*Solaster sp*	1	count	trace			
								sand	90 to 100	rockweed (D)	*Fucus sp*	5 to 10	brittle stars	*Strongylocentrotus drobachiensi*	5 - 40 / m2	density	abundant			
								cobble	5 to 10				green sea urchin	*Strongylocentrotus drobachiensis*	4	count	trace			
													truncate soft shell tun	*Mya truncata*	<5/m2	density	trace			
15:55	19	14	15	14.9	0.6	14.3	2.7	shell debris	5 to 20				burrowing anemone	*Psolus sp*	10	count	trace			
								sand	90 to 100	rockweed	*Fucus sp*	40 to 100								
16:10	20	0.6	0.5	1	0.8	0.2	11.6	cobble	5 to 10											
								sand	90 to 100	rockweed	*Fucus sp*	40 to 100								
								cobble	5 to 10											
								shell debris	5 to 20											
16:35	21	0.5	0.2	1.4	0.8	0.6	9.9	boulder	<5											
								sand	90 to 100	rockweed	*Fucus sp*	40 to 100	truncate soft shell tun	*Mya truncata*	<5/m2	density	trace	shorthorn sculpin	*Myoxocephalus scorpius*	1
16:46	22	1	3.5	4	0.8	3.2	6.2	cobble	5 to 10											
								cobble	5 to 10	rockweed	*Fucus sp*	40 to 100								
19:35	23	0.5	0.5	0.5	1.6	-1.1	9.2	shell debris	5 to 20											
								sand	90 to 100	rockweed (D)	*Fucus sp*	40 to 100								
19:44	24	0.5	1	1	1.6	-0.6	10.2	cobble	5 to 10	rockweed	*Fucus sp*	40 to 100								
								cobble	30 to 50	rockweed (D)	*Fucus sp*	5 ro 30								
20:00	25	0.21	2.9	1.5	1.8	-0.3		sand	90 to 100	rockweed	*Fucus sp*	40 to 100								

Table 9
2019 Arctic Bay DAS subtidal data

Survey Time	Transect No	ROV Depth (m)		Sounder Depth (m)	Tide Height (m)		Temperature (° C)	Substrate		Invertebrates					Fish (n)	
		Minimum	Maximum			Depth (CD,m		Type	Percent	Species common	Species latin	Abundance	Measure	Cateogorization Range (Table 9-6)	Species	Abundance
								silt	100	brittle stars	*Ophiocten or Ophiura sp*	20 to 50 /m2	density	moderate to abundant		
										tunicate	*UNID*	3	count	trace		
										crinoid	*Heliometra glacialis (poss)*	6	count	trace		
										sea spider	*Nymphon sp*	3	count	trace		
										Tube worm	*Echone papillosa (poss)*	<5/m2	density	trace		
										snail dwelling anemone	*Allantactis parasitica*	4	count	trace		
										soft coral	*Alcyonium sp*	1	count	trace		
										burrowing sea cucumber	*Psolus phantapus*	1	count	trace		
13:19	1	58	60	60.5	0.6	59.9	0.9			tube dwelling anemone	*Pachycerianthus borealis*	5 / m2	density	trace		
								silt	90 to 100	brittle stars	*Ophiocten or Ophiura sp*	30 to 60 /m2	density	abundant		
								boulder	<10	tunicate	*UNID*	1	count	trace		
										tube dwelling anemone	*Pachycerianthus borealis*	5 / m2	density	trace		
										Tube worm	*Echone papillosa (poss)*	10 to 20/m2	density	infrequent		
										soft coral	*Alcyonium sp*	10	count	infrequent		
										snail dwelling anemone	*Allantactis parasitica*	3	count	trace		
										finger sponge (poss)	*UNID*	1	count	trace		
13:38	2	54	56	57.1	0.6	56.5	0.2			encrusting sponge or bryoz	*UNID*	2	count	trace		
								silt	90 to 100	brittle stars	*Ophiocten or Ophiura sp*	20 to 40 /m2	density	moderate to abundant		
								boulder	<10	tunicate	*UNID*	2	count	trace		
										tube dwelling anemone	*Pachycerianthus borealis*	<5/m2	density	trace		
										sea whip	*UNID*	1	count	trace		
										Tube worm	*Echone papillosa (poss)*	<5/m2	density	trace		
13:58	3	55	56	57.4	0.6	56.8	0.4			soft coral	*Alcyonium sp*	2	count	trace		
								silt	90 to 100	brittle stars	*Ophiocten or Ophiura sp*	20 to 50 /m2	density	moderate to abundant		
										green sea urchin	*Strongylocentrotus drobachie*	1	count	trace		
										barnacle	*Balanus sp.*	10	count	trace		
										bivalve siphons	*Mya sp. or Hiatella sp.*	1	count	trace		
										snail dwelling anemone	*Allantactis parasitica*	5	count	trace		
								boulder	<10	Tube worm	*Echone papillosa (poss)*	5/m2	density	trace		
										soft coral	*Alcyonium sp*	3	count	trace		
										tunicate	*Halocynthia (poss)*	6	count	trace		
										sponge	*UNID*	4	count	trace		
										lyre crab	*Hyas sp*	1	count	trace		
										tube dwelling anemone	*Pachycerianthus borealis*	5/m2	density	trace		
14:11	4	52	53	54	0.6	53.4	0.4									
								silt	100	brittle stars	*Ophiocten or Ophiura sp*	20 to 50 /m2	density	moderate to abundant		
										Calcarious tube worm	*Spirorbis (poss)*	5 to 10/m2	density	trace to moderate		
										snail	*Buccinum sp*	1	count	trace		
										snail dwelling anemone	*Allantactis parasitica*	1	count	trace		
										spoon worm	*family Echioroidia*	1	count	trace		
										ribbon worm	*Cerebratulus sp.*	1	count	trace		
										tube dwelling anemone	*Pachycerianthus borealis*	5	count	trace		
										crinoid	*Heliometra glacialis (poss)*	1	count	trace		
14:26	5	57	58	58.1	0.6	57.5	0.2			tunicate	*UNID*	1	count	trace		
								silt	100	tube dwelling anemone	*Pachycerianthus borealis*	3	count	trace		
										soft coral	*Alcyonium sp.*	2	count	trace		

Table 9
2019 Arctic Bay DAS subtidal data

Survey Time	Transect No	ROV Depth (m) Minimum	ROV Depth (m) Maximum	Sounder Depth (m)	Tide Height (m)	Depth (CD,m)	Temperature (° C)	Substrate Type	Substrate Percent	Invertebrates Species common	Invertebrates Species latin	Abundance	Measure	Cateogorization Range (Table 9-6)	Fish (n) Species	Fish (n) Abundance
										stalked jelly	*Haliclystus auricula (poss)*	1	count	trace		
										Tube worm	*Echone papillosa (poss)*	5/m2	density	trace		
										snail dwelling anemone	*Allantactis parasitica*	5	count	trace		
										brittle stars	*Ophiocten or Ophiura sp*	30 to 50 /m2	density	moderate to abundant		
14:56	6	57	58	59	0.6	58.4	0.3			tunicate	*Halocynthia (poss)*	1	count	trace		
								silt	100	brittle stars	*Ophiocten or Ophiura sp*	20 to 40 /m2	density	moderate to abundant		
										hydroid	*Hydractina (poss)*	20	count	trace to moderate		
										tube dwelling anemone	*Pachycerianthus borealis*	8	count	trace		
										snail-dwelling anemone	*Allantactis parasitica*	1	count	trace		
										lyre crab	*Hyas sp*	1	count	trace		
										clam	*Mya truncata (prob)*	5	count	trace		
										Tube worm	*Echone papillosa (poss)*	5 to 10/m2	density	trace		
										tunicate	*UNID*	5	count	trace		
17:05	7	58	59	60	1.1	58.9	0.7			soft coral	*Alcyonium sp.*	1	count	trace		

Table 10 2020 Arctic Bay Intertidal Transect Table

Transect No. (n)	Transect Distance (m)	Quadrat No. (n)	Substrate (%)		Vegetation (%)		Invertebrates			Fish (n)		Notes
			Type	Percent	Species	Abundance	Species	Abundance	Measure	Species	Abundance	
1	0	1	GR	100								
	2	2	GR	80								
			CO	20								
	4	3	GR	100								
	6	4	GR	80								
			SA	20								
	8	5	GR	80								
			CO	20								
	10	6	GR	80								
			CO	20								
	12	7	CO	50								
			GR	50								
	14	8	CO	70								
			SA	30								
	16	9	CO	60								
			SA	40								
	18	10	CO	60			amphipod	1				
			SA	40								
	20	11	CO	5	rockweed	5						
			SA	95								
	22	12	SA	100								
2	0	1	CO	20								
			GR	80								
	1.5	2	CO	30								
			GR	70								
	3	3	CO	20								
			GR	80								
	4.5	4	CO	50								
			GR	50								
	6	5	BO	20								
			CO	30								
			SA	50								
	7.5	6	CO	15								
			SA	85								
	9	7	BO	5								
			CO	5								
			SA	90								
3	0	1	GR	100	rockweed, loose	30						
	2	2	GR	100	rockweed, loose	20						
	4	3	GR	100								
	6	4	GR	100	rockweed, loose	5						
	8	5	GR	100								
	10	6	GR	100								
	12	7	CO	20								
			GR	80								
	14	8	CO	40								
			GR	60								
	16	9	CO	70			amphipod	10				
			GR	30								

Transect No. (n)	Transect Distance (m)	Quadrat No. (n)	Substrate (%)		Vegetation (%)		Invertebrates			Fish (n)		Notes
			Type	Percent	Species	Abundance	Species	Abundance	Measure	Species	Abundance	
	18	10	CO	60	rockweed	5	amphipod	10				
			GR	10								
			SA	20								
4	0	1	GR	100								
	2	2	GR	100								
	4	3	GR	100								
	6	4	GR	80								
			SA	20								
	8	5	GR	80								
			SA	20								
	10	6	GR	80								
			SA	20								
	12	7	CO	20								
			GR	60								
			SA	20								
	14	8	CO	60								
			GR	10								
			SA	20								
	16	9	BO	30			amphipod	40				generally under cobble
			CO	50								
			GR	10								
			SA	10								
	18	10	BO	10			amphipod	5				
			CO	70								
			GR	10								
			SA	10								
	20	11	CO	20	rockweed, loose	<5	amphipod	5				
			GR	70								
			SA	10								
	22	12	CO	40			amphipod	5				inch of water
			GR	40								
			SA	20								
	24	13	CO	30								
			GR	20								
			SA	50								
	26	14	CO	15	rockweed	5						
			SA	85								
	28	15	BR	60								
			SA	40								
	30	16	BR	30	rockweed	<5						
			CO	20								
			SA	20								
			SI	30								
	32	17	BR	80	rockweed	90						
			CO	10								
			SA	10								
	34	18	BR	80	rockweed	90						
			CO	10								
			SA	10								
5	0	1	GR	100								
	2	2	GR	80								
			SA	20								

Transect No. (n)	Transect Distance (m)	Quadrat No. (n)	Substrate (%)		Vegetation (%)		Invertebrates			Fish (n)		Notes
			Type	Percent	Species	Abundance	Species	Abundance	Measure	Species	Abundance	
	4	3	CO	10								
			GR	60								
			SA	20								
	6	4	CO	5								
			GR	80								
			SA	5								
	8	5	CO	10								
			GR	20								
			SA	70								
	10	6	GR	30								
			SA	70								
	12	7	CO	5								
			GR	25								
			SA	70								
	14	8	CO	25								
			GR	15								
			SA	60								
	16	9	CO	80	rockweed, loose	<5	amphipod	50-100				always under boulder
			GR	20								
	18	10	CO	30			amphipod	50				always under boulder
			SA	20								
			SI	50								
	20	11	CO	20								
			SA	40								
			SI	40								

Table 11 2020 Arctic Bay Subtidal Snorkel Data

Quadrat No. (n)	Quadrat Distance (m)	Depth (m)	Substrate (%)		Vegetation (%)		Invertebrates			Fish (n)	
			Type	Percent	Species	Abundance	Species	Abundance	Measure	Species	Abundance
1	3	2.2	CO	50	rockweed	30					
			SA	50							
2	5	2.1	CO	50	rockweed	80	limpet	1	count		
			SA	50							
3	8	1.8	CO	50	rockweed	100	limpet	1	count		
			SA	50							
4	11	1.6	CO	50	rockweed	40	limpet	1	count		
			SA	50							
5	14	1.5	CO	50	rockweed	100					
			SA	50							
6	16	1.4	CO	50	rockweed	80					
			SA	50			limpet	1	count		
7	17	1.1	CO	50	rockweed	80					
			SA	50							
8	18	1.1	CO	50	rockweed	100					
			SA	50							
9	19	1.0	CO	50	rockweed	80					
			SA	50							
10	20	1.0	CO	50	rockweed	90					
			SA	50							