WEST KITIKMEOT RESOURCES CORP

Appendix 23A

Marine Mammal Baseline Report

Grays Bay Road and Port Project
Marine Mammal Baseline Report

Prepared for:

West Kitikmeot Resources Corp.

Prepared by:

Nunami Stantec Limited

March 2026

Project No.: 123514868

Sign-off

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Abbreviations

AMAR	Autonomous Multichannel Acoustic Recorder
CBC	Canadian Broadcasting Corporation
CDS	Common Distance Sampling
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DEIS	Draft Environmental Impact Statement
DFO	Department of Fisheries and Oceans
EBSA	Ecologically and Biologically Significant Areas
EC-WG	Eastern Canada-West Greenland
GBEEC	Grays Bay Engineering and Environmental Consultants
GIS	Geographic Information System
GOC	Government of Canada
GN	Government of Nunavut
GN-DOE	Government of Nunavut Department of Environment
IAG	Inuit Advisory Group
IA	Important Area
IS	Impact Statement
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
LAA	Local Assessment Area
MPA	Marine Protected Areas
MMG	Minerals and Metals Group
NOAA Fisheries	National Oceanic and Atmospheric Administration
NTKP	Naonaiyaotit Traditional Knowledge
PDA	Project Disturbance Area
PTS	permanent threshold shifts
RMS	root mean square
RAA	Regional Assessment Area
SARA	Species at Risk Act

SEL .... Sound Exposure Level

SPL .... Sound Pressure Level

TCWR .... Tibbitt to Contwoyto Winter Road

TTS .... temporary threshold shifts

WKR .... West Kitikmeot Resources Corp.

Symbols and Units of Measure

Hz .... hertz

kHz .... Kilohertz

km .... Kilometer

1 Introduction

West Kitikmeot Resources Corporation (WKR) is an Inuit-owned, Inuit-led company focused on the advancement of the Grays Bay Road and Port Project (the “Project”) in the Kitikmeot Region of Nunavut. WKR’s largest shareholder is a wholly-owned subsidiary of the Kitikmeot Inuit Association. The Project is proposed as a multi-user, multi-use transportation infrastructure to be located on a combination of Inuit Owned Land and Crown land in the Kitikmeot Region of western Nunavut. Subject to approval, the Project would result in the establishment of the first deep-water port in the Canadian Central Arctic at Grays Bay, as well as a 230 kilometre (km) all-season access road between Grays Bay and Jericho station near Contwoyto Lake. The Project will connect to the already approved Tibbitt to Contwoyto Winter Road (TCWR). The multi-user, multi-use Project would allow for the establishment of shared infrastructure with many potential users, including the federal and territorial governments, communities, community members, resource companies, and defence agencies.

The Project’s location and current design is based on siting studies and designs previously conducted by Minerals and Metals Group (MMG) for their Izok Corridor Project (a previous iteration of the Project), Government of Nunavut (GN), and Kitikmeot Inuit Association, who were the proponent of the Project until 2020.

WKR benefits from designs, studies, and data previously undertaken by MMG, Kitikmeot Inuit Association, and the GN. Many of the environmental studies are more than 10 years old; therefore, to support the preparation of an Impact Statement (IS), some of the environmental studies have been supplemented with more recent data. Aerial and vessel-based surveys occurred in 2025 as part of the environmental assessment process to help fill these data gaps.

1.1 Inuit Knowledge, Traditional Knowledge, and Community Knowledge

A considerable amount of Inuit Knowledge has been documented for the Project, which has substantially informed WKR’s understanding of baseline environmental and socio-economic conditions in the Project Development Area (PDA). For the purposes of the IS, the focus is placed on the Inuit of the Kitikmeot Region, also known as the Kitikmiut. The Project is located wholly within the Kitikmeot Region; as such, the region and its people are where key Project interactions and effects are most likely to occur.

Verified Inuit Knowledge and perspectives were considered and integrated into the IS, as shared through two primary Project-specific sources.

1. **Naonaiyaotit Traditional Knowledge Project (NTKP):** The Kitikmeot Inuit Association maintains a repository of Inuit Knowledge for the Kitikmeot Region within a Geographic Information System (GIS)-based database called the NTKP. The NTKP is the collective body of documented and verified Inuit Knowledge of the Kitikmeot Region, including, but not limited to, knowledge of birds, fish, terrestrial and marine mammals, water quality, travel routes, gathering places, and heritage. The Kitikmeot Inuit Association compiled a Project-specific report, titled "Kitikmiut Knowledge of the Proposed Kogloktoakyok (Grays Bay) Port and Road Project" (Banci and Spicker 2024), which provides the majority of the Inuit Knowledge shared and integrated in the IS.
2. **Inuit Advisory Group (IAG)**: Initiated in 2018 by the previous Project proponent, WKR re-initiated the IAG in 2025. Through a series of IAG workshops, WKR and Inuit land users, Elders, and Knowledge Holders have met to discuss and document feedback and advice about the Project, including but not limited to dialogue about wildlife, fisheries, land use, archaeology, water, air quality, and access management. Through the IAG, multiple perspectives have been shared, allowing for the integration of knowledge systems (both Inuit Knowledge and Western science), resulting in a more informed and sustainable Project. At the time of filing, four IAG workshops had occurred (GBEEC 2018a, 2018b; IAG 2025a 2025b), with additional workshops planned for the future.

Pertinent baseline information from these sources of Inuit Knowledge is not presented further here; instead, this information is provided in the above-noted reports themselves, the ‘Baseline Conditions’ sections of each assessment section and integrated in the Assessment of Potential Effects on Marine Mammals section (Volume 8, Section 23 of the IS) where appropriate. The same process was applied when integrating baseline information associated with applicable Traditional Knowledge and Community Knowledge shared in publicly available literature and through the Project-specific engagement program.

2 Scope and Objective

This baseline report presents the existing conditions for marine mammals, providing support for the environmental assessment process of the Project. This assessment is based on data collected from previous studies, current project studies, and desktop analysis. For this baseline report, marine mammals have been grouped by parvorder: Pinnipeds, Odontocetes, Mysticetes, and Ursids. Species breakdowns are explained in greater detail in Sections 5.1.1, 5.1.2, 5.1.3, and 5.1.4.

This baseline report includes data and information on marine mammal occurrence, range, abundance, seasonal timing, distribution, and areas of particular sensitivity or importance (e.g., designated key foraging or whelping/breeding areas) from publicly available online resources and available survey data from surveys in the Project assessment and survey Areas (see Section 5). Relevant species acts, regulatory documents, and guidance will be used to advise impact assessment procedures (e.g., Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports; *Species at Risk Act* (SARA); *Fisheries Act* (R.S.C., 1985, c. F-14). These regulatory documents can be utilized as species guidelines to aid in the management recommendations and to help inform pre-construction field surveys, project construction, operation, and monitoring activities. The objectives of the Marine Mammal Baseline Report include:

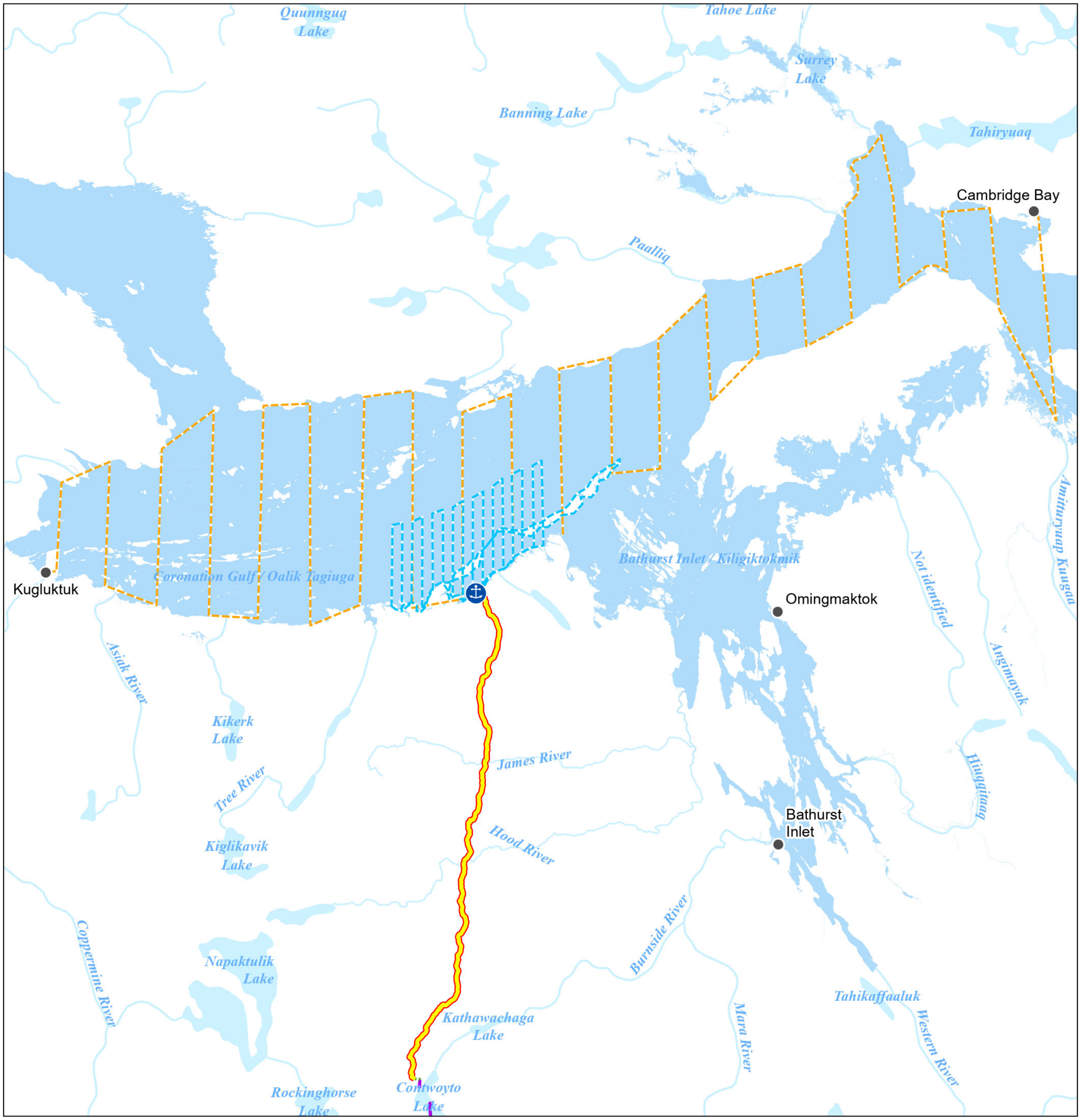
- Provide an overview of the existing information on marine mammals within the Project assessment areas (described in Section 3) as they relate to the Project.
- Describe marine mammal species' distribution, habitat preferences, and likelihood to occur within the Project assessment areas.
- Summarize recent field studies completed in the Project assessment areas.

3 Description of the Assessment Areas

Spatial boundaries were defined to assess the presence and distribution of marine mammals for the Project. The aerial and vessel survey areas were selected to correspond with previous dedicated aerial surveys conducted by LGL Limited in 2012 for comparative purposes (see Figure 3.1;Elliott et al. 2013).

The Regional Assessment Area (RAA) covers where marine mammal aerial surveys were conducted in 2012 and 2025 (i.e., extensive survey grid; see Figure 3.1). The RAA spans the entirety of the Coronation Gulf (see Figure 3.2). More specifically, it is bound at the northwestern end, where the Dolphin and Union Strait enters the Coronation Gulf, and at the northeastern end, where the Dease Strait opens into the Queen Maud Gulf, terminating at the eastern edge of the Kent Peninsula (see Figure 3.2). The RAA was chosen to cover a broad region that encompasses different bathymetry types, Project logistics/plans, geomorphology, and oceanographic features, as well as coverage for the broader-scale movement and usage of several marine mammal species to account for the effects of marine shipping. The Local Assessment Area (LAA) was the focus of the 2025 marine mammal vessel survey (i.e., intensive survey grid) and was previously surveyed in 2012 by an aerial survey conducted by LGL Limited (Elliott et al. 2013; see Figure 3.1). The LAA covers the area of direct effects from construction activities near the marine terminal and the surrounding area, where underwater noise from the proposed Project could be strong enough to cause adverse effects such as subtle to conspicuous changes in behaviour, movement, and displacement (see Figure 3.2).

This baseline report provides a summary of information on marine mammals that may occur in the topic-specific assessment areas, where direct and cumulative effects could potentially occur, referred to as the LAA and RAA, respectively. Additional information outlining the RAA and LAA is located in Section 3.1 of this report.



Marine Mammal Transects

- Aerial Survey
- Vessel Survey

- Grays Bay Port
- Grays Bay Road
- Grays Bay Winter Road
- Community
- Tibbitt to Contwoyto Winter Road
- Watercourse
- Ocean
- Waterbody

0 25 50 Kilometres
(At original document size of 8.5x11)1:2,500,000
N

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Notes
1. Coordinate System: WGS 1984 UTM Zone 12N
2. Data Sources: Government of Canada, Stantec, MMG

Project Location
West Kitikmeot Region
Nunavut

Prepared by SL on 2025-12-04
TR by JB on 2025-12-04

Client/Project
123514868_048
West Kitikmeot Resources Corp
Grays Bay Road and Port

Figure No.
3.1

Title
Aerial and Vessel Survey Transects (2025)

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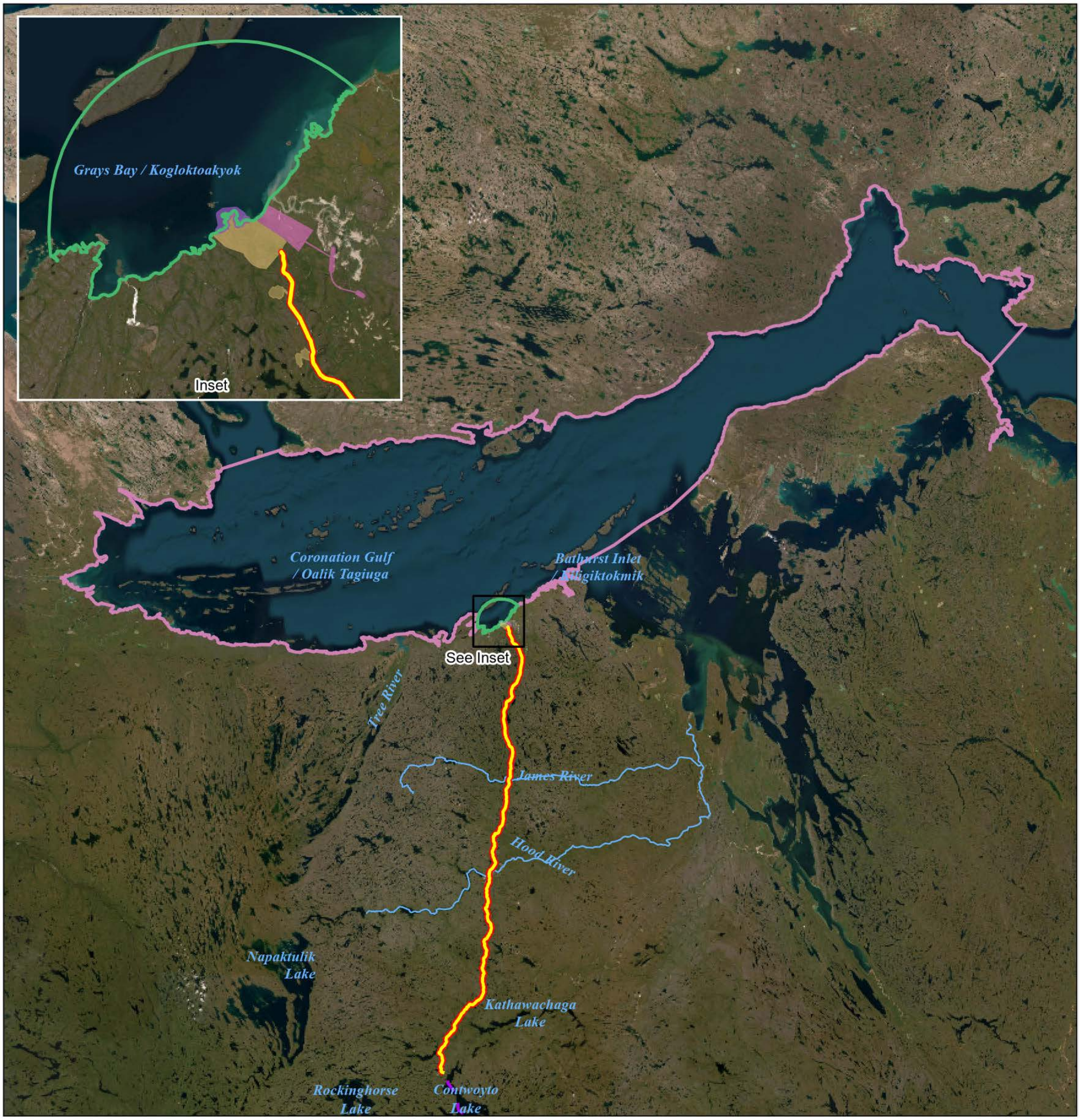

Local Assessment Area (LAA)

Regional Assessment Area (RAA)

Grays Bay Road

Project Development Area (PDA)

Aerodrome

Port (Landside Infrastructure)

Port (Marine-based Infrastructure)

Tibbitt to Contwoyto Winter Road

Watercourse

0 25 50 Kilometres
(At original document size of 8.5x11)
1:2,700,000

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Project Location
West Kitikmeot Region
Nunavut

Prepared by SL on 2025-11-27
TR by EH on 2025-11-27

Client/Project
123514868_030
West Kitikmeot Resources Corp
Grays Bay Road and Port

Figure No.
3.2

Title
Marine Mammal Assessment Areas

Notes
1. Coordinate System: WGS 1984 UTM Zone 12N
2. Data Sources Government of Canada, Stantec
3. Service Layer Credits Earthstar Geographics

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3.1 Local and Regional Assessment Areas

The LAA and RAA represent the areas where data were collected to provide an understanding of the environment, allowing for the assessment of potential direct Project-specific effects and potential cumulative effects of the Project on marine mammals. The Project location and assessment areas are shown in Figure 3.2.

- The **Project Development Area (PDA)**: has been delineated to encompass the physical footprint of all Project components, including both permanent and temporary disturbances (e.g., extent of Project infrastructure, planned clearing and laydown areas). The PDA includes six sub-areas based on the types of components to be developed: the Port (which is further divided into marine and landside infrastructure), Road, Aerodrome, Jericho Station and Winter Road PDAs. The boundaries of the PDAs were created by applying buffers around where the Project components will be sited, and varies by each of the sub-areas depending on necessary flexibility for final siting of certain Project components based on conditions on the ground. For the Port PDA, the areas were subdivided based on the conceptual Project component locations and then buffered approximately 1,000 m for the landside Port PDA, approximately 300 m for the marine Port PDA. For the purposes of the impact assessment, the PDA is the same as the Site Study Area identified in the IS Guidelines.
- The **Local Assessment Area (LAA)** has been developed for marine mammals to represent the area in which project-related effects can be predicted or measured with a level of confidence that allows for the assessment, wherein there is a reasonable expectation that those effects could be of concern. The LAA for marine mammals include a 10 km buffer around the PDA.
- The **Regional Assessment Area (RAA)** has been developed for marine resources to represent the area within which project-specific effects overlap with effects of other past, present, and reasonably foreseeable future projects. The RAA is bound at the northwestern end, where the Dolphin and Union Strait enters the Coronation Gulf, and at the northeastern end, where the Dease Strait opens into the Queen Maud Gulf, terminating at the eastern edge of the Kent Peninsula.

The PDA, LAA and RAA are ice-bound from about November to late June. The proposed in-water construction period coincides with the open-water period (late June to October). However, even during that period, the entire RAA is rarely ice-free (i.e. drifting ice pack). The distribution and abundance of marine mammals in the PDA, LAA and RAA are highly dependent on the extent and nature of the ice cover.

3.2 Marine Mammal Species of Interest

Several marine mammal species are known to occur in the RAA, both seasonally and year-round. The species noted in the literature review that are known to occur in the RAA are described in this section. Historically, cetaceans have been uncommon in RAA. The only mysticete species, or baleen whale, that is known to occur is the bowhead whale (*Balaena mysticetus/akvik*). Two odontocete, or toothed whale, species, the beluga (Delphinapterus leucas/kilalugak) and the narwhal (Monodon monoceros/togaalik), are known to occur in the RAA. Beluga whales have been seen near Kugluktuk at the western end of the RAA (LGL 2013), and narwhals have been seen in Cambridge Bay at the eastern end of RAA (George 2011, 2012). Four pinniped species, bearded seal (*Erignathus barbatus/ugyuk*), harp seal (*Pagophilus groenlandicus/kaigulik*), hooded seal (*Cystophora cristata/nattivak*), and ringed seal (*Pusa hispida/nattik*), are also known to occur in the RAA. Polar bears (*Ursus maritimus/nanui*) are not commonly found in the RAA but have been observed around Kugluktuk approximately every 15–20 years (LGL 2013).

The RAA is generally not considered an Atlantic walrus (*Odobenus rosmarus rosmarus*) habitat (Brown and Fast 2012), although a handful of walrus sightings have been recorded in the Coronation Gulf over 50 years ago (Riewe 1992; GN-DOE 2012). Due to Atlantic walruses being extremely rare in the RAA, they are not included further in this report.

All marine mammal species that are known to occur in the RAA and their respective status under the *Species At Risk Act* (SARA) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) are shown in Table 3.1. Five of the eight marine mammal species that are known to occur in the RAA are considered species of *special concern* by COSEWIC: beluga (E High Arctic/Baffin Bay stock), bowhead whale (E Canada/W Greenland population), narwhal, polar bear, and ringed seal (see Table 3.1). Polar bears and the bowhead whale (Bering-Chukchi-Beaufort population) are also listed as a species of *special concern* on Schedule 1 of SARA (see Table 3.1).

Table 3.1 Status of Marine Mammals Known to Occur Within the RAA

Species[1]	Population	Status				Occurrence
		SARA[2]	COSEWIC[3]	IUCN[4]	Territorial Status[5]	
Mysticetes						
Bowhead whale/*akvik*	Bering-Chukchi-Beaufort	Schedule 1: SC	SC	VU	Vulnerable	Rare
	E Canada/ W Greenland[6]	NS				
Odontocetes						
Beluga/*kilalugak*	E Beaufort Sea	NS	NAR	NT	Secure	Rare
	E High Arctic/ Baffin Bay	NS	SC	NT		Rare
Narwhal/*togaalik*	-	NS	SC	LC	Not Applicable	Uncommon
Pinnipeds						
Ringed seal/*nattik*	-	NS	SC	LC	Apparently Secure	Regular
Bearded seal/ugyuk	-	NS	Cand-1	LC	Unrankable	Common
Harp seal/*kaigulik*	-	NS	Cand-1	LC	Not Applicable	Uncommon
Hooded seal/nattivak	-	NS	NAR: Cand-1	VU	Not Applicable	Uncommon
Ursids						
Polar bear/*nanok*	-	Schedule 1: SC	SC	VU	Vulnerable	Uncommon

Notes:

1 Species names in English/Inuinnaqtun

2 Species at Risk Act (GOC 2023): NS = No status; SC = Special Concern; EN = Endangered

3 Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2023a, 2023b): NAR = Not at Risk; SC = Special Concern; Cand = Candidate Wildlife Species for assessment: 1= high priority, 2= mid priority, 3 = low priority

4 International Union for Conservation of Nature (IUCN 2024): VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient

5 Territorial status is current to 2020 and is presented in the 2020 Wild Species Report (CESCC 2022).

6 In 2009, the Hudson Bay-Foxe Basin and Davis Strait-Baffin Bay populations were considered a single population (COSEWIC 2009).

3.3 Marine Mammal Acoustic Thresholds and Hearing Abilities

Environmental assessments and management plans in Canada primarily rely on acoustic thresholds and regulatory guidance similar to those in the United States. Formal Canadian regulatory underwater acoustic thresholds or standardized national or provincial guidelines are not presently available for mitigation measures and protocols for marine animals exposed to industrial underwater noise-generating activities. Acoustic thresholds are instead provided by the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration (NOAA Fisheries) and offer guidance for assessing the potential for injury or disturbance to marine mammals as a result of underwater sound levels. The National Oceanic and Atmospheric Administration (NOAA Fisheries) acoustic thresholds utilize the onset of permanent threshold shift (PTS) as a proxy for the threshold of injury (NOAA Fisheries 2018). At the same time, an interim NOAA Fisheries' guidance document (2005) included thresholds for broadband underwater root mean square (rms) sound pressure levels (SPLs) anticipated to result in behavioural disruptions in marine mammals. Although NOAA Fisheries updated its guidance on assessing permanent threshold shift (PTS) (i.e., injury) in 2018, the guidance does not address the 2005 NOAA Fisheries interim guidelines in place for behavioural disruptions.

The hearing frequency range and sensitivity of marine mammals differ between species. Southall et al. (2007) identified four marine mammal functional hearing groups and their associated hearing frequency ranges:

- low-frequency cetaceans (hearing frequencies of 7 hertz (Hz) to 22 kilohertz (kHz); baleen whales, including humpback whales, grey whales, and fin whales)
- mid-frequency cetaceans (hearing frequencies of 150 hertz (Hz) to 160 kilohertz (kHz); various odontocetes, including killer whales and Pacific white-sided dolphins)
- high-frequency cetaceans (hearing frequencies of 200 Hz to 180 kHz; various odontocetes, including harbour porpoise and Dall's porpoise) and
- pinnipeds in water (hearing frequencies of 75 Hz to 75 kHz; pinnipeds, including Steller sea lions and harbour seals).

Underwater sound levels above certain received levels have been predicted to cause permanent auditory injury (i.e., PTS) or temporary changes in hearing abilities (i.e., temporary threshold shifts [TTS]) in marine mammals. The onset level of temporary threshold shifts (TTS) has been measured for some marine mammal species (Southall et al. 2007), and PTS-onset thresholds are based on extrapolations from TTS-onset levels.

- Underwater noise from impulsive noise (such as pile driving) is commonly expressed as sound pressure level (SPL), measured in dB re: 1 µPa, and sound exposure level (SEL), a measure of energy in dB re: 1 $\mu Pa^2 s$. The SPL can be an instantaneous value, whereas the sound exposure level (SEL) is the total noise energy over a given time period, typically one second for pulse sources (Theobald et al. 2009). The SPL and SEL are further described using:
- peak SPL (SPL_{peak}): the maximum sound pressure at any given moment produced by a particular activity, capturing the maximum mechanical force that sound receivers will experience

- root mean square SPL (SPL_{RMS}): average root mean square pressure level over a given amount of time and
- cumulative SEL (SEL_{cum}): cumulative energy exposure over multiple pulses for a given period of time.

Southall et al. (2007) and NOAA Fisheries (2018) have estimated thresholds that may induce PTS in marine mammals. Auditory injury thresholds have been estimated using different metrics, some weighted by marine mammal functional hearing groups to emphasize frequencies of greatest sensitivity. NOAA Fisheries' (2018) guidance thresholds are not directly comparable to those of Southall et al. (2007) because they employ different weighting criteria. Table 3.2 summarizes NOAA Fisheries' (2018) current guidance thresholds for the onset of PTS (i.e., auditory injury levels).

Fisheries and Oceans Canada (DFO) will provide Project-specific underwater noise and acoustic recommendations through a Letter of Advice prior to the Project's commencement.

Table 3.2 Marine Mammal Hearing Thresholds

Faunal Group	Impulsive Sound Signals		Non-Impulsive Sound Signals
	Injury (PTS) Exposure Criteria		
	Unweighted PK[1] (dB re 1 µPa)	Frequency Weighted SEL_{cum}[2] (dB re 1 µPa2·s)	Frequency Weighted SEL_{cum}[2] (dB re 1 µPa2·s)
Low-Frequency (LF) Cetaceans	≥219 dB	≥183 dB	≥199 dB
Mid-Frequency (MF) Cetaceans	≥230 dB	≥185 dB	≥198 dB
High-Frequency (HF) Cetaceans	≥202 dB	≥155 dB	≥173 dB
Phocid Pinnipeds in Water (PW)	≥218 dB	≥185 dB	≥201 dB
All Marine Mammals	Behavioural Exposure Criteria (RMS, dB re 1 µPa)		
	≥160 dB		≥120 dB

Notes:

[1] Peak sound pressure level (peak) is expressed in dB re 1 µPa and unweighted (flat weighted).

[2] SELcum is expressed in dB re 1 $\mu Pa^2 s$ and weighted according to the relevant weighting function with an accumulation period of 24 hours for marine mammals.

dB = decibels, PTS = permanent threshold shift, SELcum = cumulative weighted sound exposure level, µPa = micropascals, LF = low-frequency cetaceans, MF = mid-frequency cetaceans, HF = high-frequency cetaceans, PW = phocid pinnipeds underwater.

3.4 Designated Areas of Interest

Marine Protected Areas (MPAs) are governed under the *Oceans Act* to protect and conserve marine species, habitats, and ecologically important ecosystems, as well as to address the impacts of climate change (DFO 2024a). In the Canadian Arctic, there are three MPAs: Anguniaqvia niqiqyuam (Ung-u-niak-via Ni-kig-e-um), Tarium Niryutait, and Tuvaijuittuq (DFO 2024a) These MPAs are located outside of the RAA and, therefore, are not discussed further.

Ecologically and Biologically Significant Areas (EBSAs) are areas that have relatively high ecological or biological significance compared to their surrounding areas (DFO 2021). EBSAs are established based on their uniqueness, importance for threatened species, life history, sensitivity to disturbance, biodiversity, and productivity. EBSA information is used to inform marine planning, including environmental assessments of marine-based activities, and is spatially broken down in the Arctic, with three of these areas located partially within or at the boundary of the RAA: Bathurst Inlet, Lambert Channel, and the Southern Victoria Island Coastline (DFO 2021).

A DFO important area (IA) is a specialized EBSA that is specific to one species or feature (Rubidge et al. 2018). The boundaries of these areas depend on the species or feature they are specialized in. No DFO IAs were identified in the RAA (GOC 2024).

Critical habitat is identified for species listed as Endangered or Threatened under the SARA. There is no critical habitat for species at risk that overlaps with the RAA (DFO 2024b). However, the Arctic marine environment beyond the marine mammal habitat LAA includes the following sensitive and protected habitat areas:

- Three Ecologically and Biologically Sensitive Areas: Bathurst Inlet, Lambert Channel, and Southern Victoria Island Coastline (DFO 2021)
- Three Areas of Heightened Ecological Significance: Bathurst Inlet, Lambert Channel, and Southern Victoria Island Coastline (Arctic Council 2009)

While these areas occur in relative proximity to the Project, their spatial boundaries do not overlap with the Project LAA and are either on the boundary or outside of the RAA.

4 Summary of Methods

4.1 Desktop Assessment

A desktop assessment of existing background data and information was conducted to identify potential gaps in the marine mammal datasets, supporting project planning and design, and contributing to the preparation of an IS for the Grays Bay Road and Port Project. A review of available relevant information, including reports, documents, and data, was used to refine the field workplan for marine mammal field surveys.

The review of desktop information included the following:

- High Lake Project (Wolfden 2006)
- Izok Corridor Project (MMG 2012; Elliot et al. 2013; LGL 2013)
- Grays Bay Engineering and Environmental Consultants (GBEEC) Environmental Baseline Studies Review and Gap Analysis (GBEEC 2017)
- Canadian Science Advisory Secretariat Publications
- Scientific peer-reviewed literature
- Publicly available online information on Grays Bay and the Coronation Gulf
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports
- DFO Marine Planning Atlas
- Naonaiyaotit Traditional Knowledge Project Atlas
- Canada's Arctic Marine Atlas (Oceans North 2018)
- DFO Sighting Records

4.2 Field Surveys

In 2025, a marine mammal field program was conducted over two time periods, August 12-17 and August 27 to 29, to obtain information on the marine mammal presence in the LAA and RAA. The field program consisted of an aerial and vessel-based survey. These surveys are outlined below. The aerial and vessel-based marine mammal surveys were conducted under a DFO *Authorization to Disturb a Marine Mammal* (Authorization: A-25-26-004-NU) issued pursuant to Section 28 of the Marine Mammal Regulations.

4.2.1 Aerial Survey

The marine mammal aerial survey was conducted in August 2025 across six survey days (August 12-15 and 17) (see Table 5.1 in Section 5.2.1). Flights were not flown on August 16th due to an aircraft sensor malfunction. Kenn Borek operated the De Havilland Canada Twin Otter aircraft (see Figure 4.1). Five of the six flights were flown to and from Cambridge Bay; on the final day of the survey, the crew left from Cambridge Bay and returned to Kugluktuk.

Figure 4.1 Aircraft and Marine Mammal Aerial Survey Crew 2025(crew left to right: Amy MacKay, Deb Marchione, Erica Smith-Belliveau and Andrea Ahrens).

The volume of fuel the aircraft could carry, along with weather conditions and logistical considerations, constrained the number of transects that could be completed during each flight. The RAA could approximately be flown in its entirety with one pass before needing to refuel. The flight plan each day started with the furthest transect line from the destination and worked back towards either Cambridge Bay or Kugluktuk Air Terminal. Scheduled flying time varied each day, depending on weather conditions.

The aircraft flew at a nominal altitude of 1,000 ft (305 m) above sea level with a cruising speed of approximately 212 km/h. When flying from Cambridge Bay, the aircraft flew to the furthest western transect planned for the day and progressed east on their return. During the flight to Kugluktuk, the pilot flew west, completed the remaining transects while travelling further west across the Coronation Gulf to Kugluktuk.

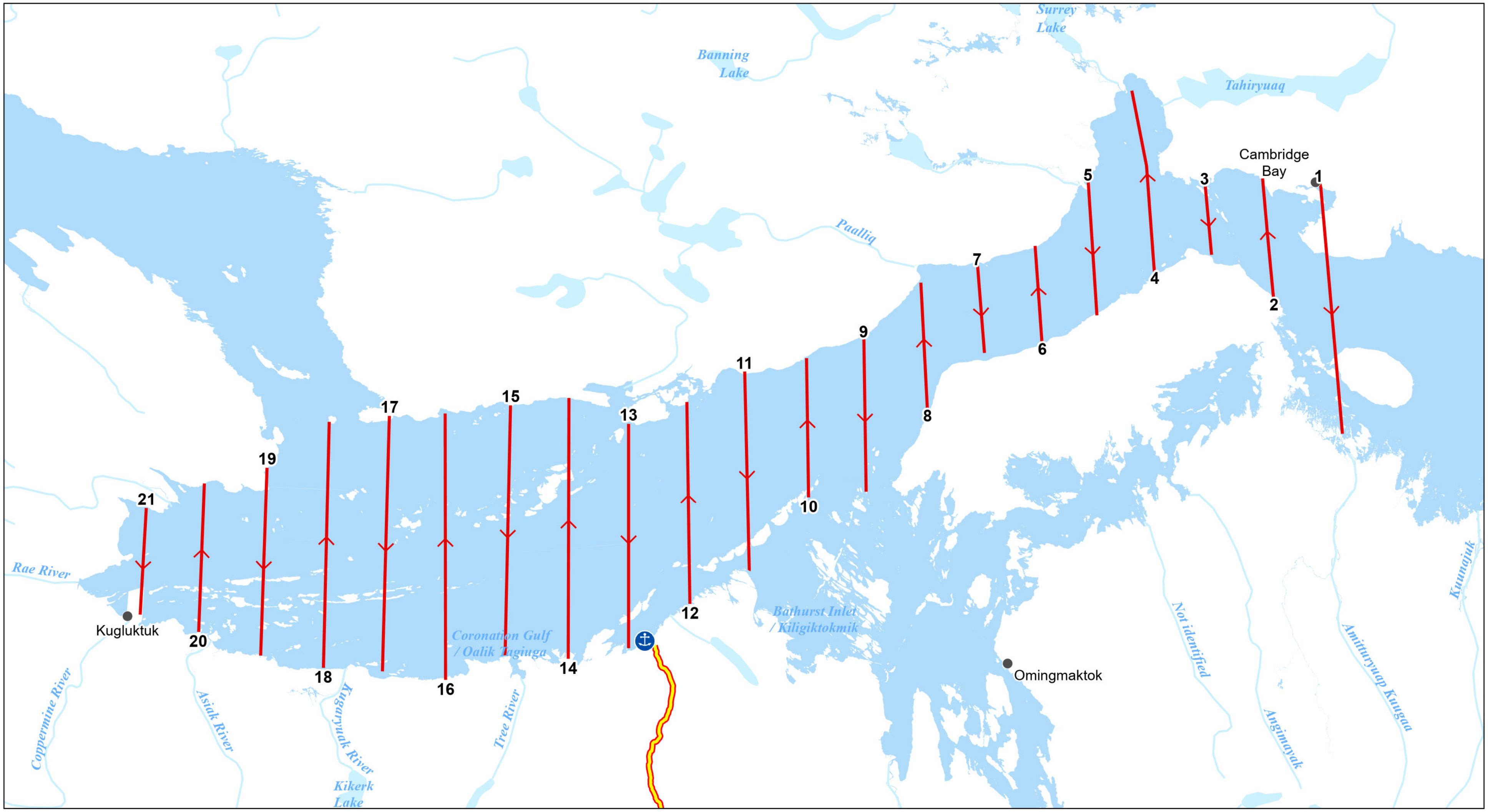
The survey area, previously referred to as the extensive survey grid, included 21 north-to-south transects numbered east to west (see Figure 4.2). Each transect was flown once, except for transect 13 (the transect line adjacent to the proposed Grays Bay port site), which was flown in replicate. Every transect was flown in its entirety, and weather conditions were managed by delaying flight times to accommodate project needs. The transects were designed with 0.5° spacing and ranged from 27.9 to 91.9 km in length. To address observer fatigue, observers rotated positions daily. The transects were organized and flown in either a north-to-south or south-to-north orientation to minimize unnecessary flying over the width of the survey area and to prevent potential disturbance to marine mammals. When a marine mammal was spotted, the aircraft did not break off the transect or perform a loop to avoid potential disturbance to marine mammals, as stipulated under a DFO *Authorization to Disturb a Marine Mammal* (Authorization: A-25-26-004-NU).

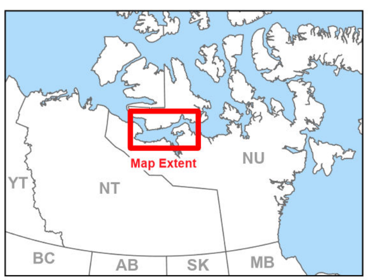
The marine mammal survey crew included four observers, two primary and two secondary. The two primary observers had bubble windows in the front of the passenger seating area. They performed on-effort marine mammal sightings for each transect as well as off-effort observations while travelling to and from the air terminal and in between transects. The primary observer's objective was to focus on a 1,000 m strip on either side of the transect. This position scanned the clockface 12 position, then circled in a C-curve until the view was perpendicular to the craft and directly below it.

During each sighting, the primary observer would speak into the aircraft's communications system and describe their observation to the secondary observer. When the marine mammal was perpendicular to the craft, the primary observer took a clinometer reading, and the secondary observer entered a GPS waypoint and communicated the point's title. The primary observer would then record all findings into the voice recorder, this included: name of observer, time, date, title of waypoint, species of marine mammal and if possible speciation (e.g. ringed seal, bearded seal), clinometer angle reading, direction of travel (e.g. seal spotted travelling towards the seven o'clock position), sighting cue (e.g. splash, swimming, etc.), behaviour (e.g. laying on ice, swimming, etc.), group size, number of juveniles and reliability of identification.

The primary observer recorded environmental conditions at the beginning and end of the transect, which included: Beaufort Sea State, percentage of water coverage and ice cover, type of ice (e.g., pack ice, landfast ice), cloud coverage, sun glare, precipitation, and overall sightability. They would pause the recording after the initial environmental observation and only start a new record if a marine mammal was spotted or the transect ended.

The secondary observers sat behind the primary observers with regular flight windows. They were responsible for supporting the primary observers with their sightings and recording environmental conditions every two minutes. Secondary observers established a flight path when the plane took off, using a handheld GPS and inputting waypoints at the beginning and end of each transect. When the primary observer reported a sighting, the secondary observers would communicate the title of the waypoint, and the primary observer would record this information in their sighting recording.





Extensive Survey Grid Transects (Aerial)
Grays Bay Port
Grays Bay Road
Community
Watercourse
Ocean
Waterbody

0 20 40 Kilometres

(At original document size of 8.5x11) 1:2,000,000

N

NUNAMI STANTEC LIMITED

WEST KITIKMEOT RESOURCES CORP

Notes
1. Coordinate System: WGS 1984 UTM Zone 12N
2. Data Sources: Governments of Canada, Stantec

Project Location
West Kitikmeot Region
Nunavut

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Client/Project
123514868_148
West Kitikmeot Resources Corp
Grays Bay Road and Port

Figure No.
4.2

Title
Aerial Survey Grids

\\Ca0002-ppfss05\geomatics\Clients\Nunami_Stantec\GBRP\Figures\123514868_148_Marine_Mammals_Aerial.pagx Revised: 2026-02-03 By: slemay

An initial recording of the environmental conditions was made for the off-transect transiting to the initial transect of the flight. Conditions between each transect were also recorded; the recording was updated if conditions changed. The following conditions were recorded for each voice recording: Beaufort Sea State, percentage of water and ice coverage, type of ice (e.g., pack ice, landfast ice), cloud coverage, sun glare, precipitation, and overall sightability.

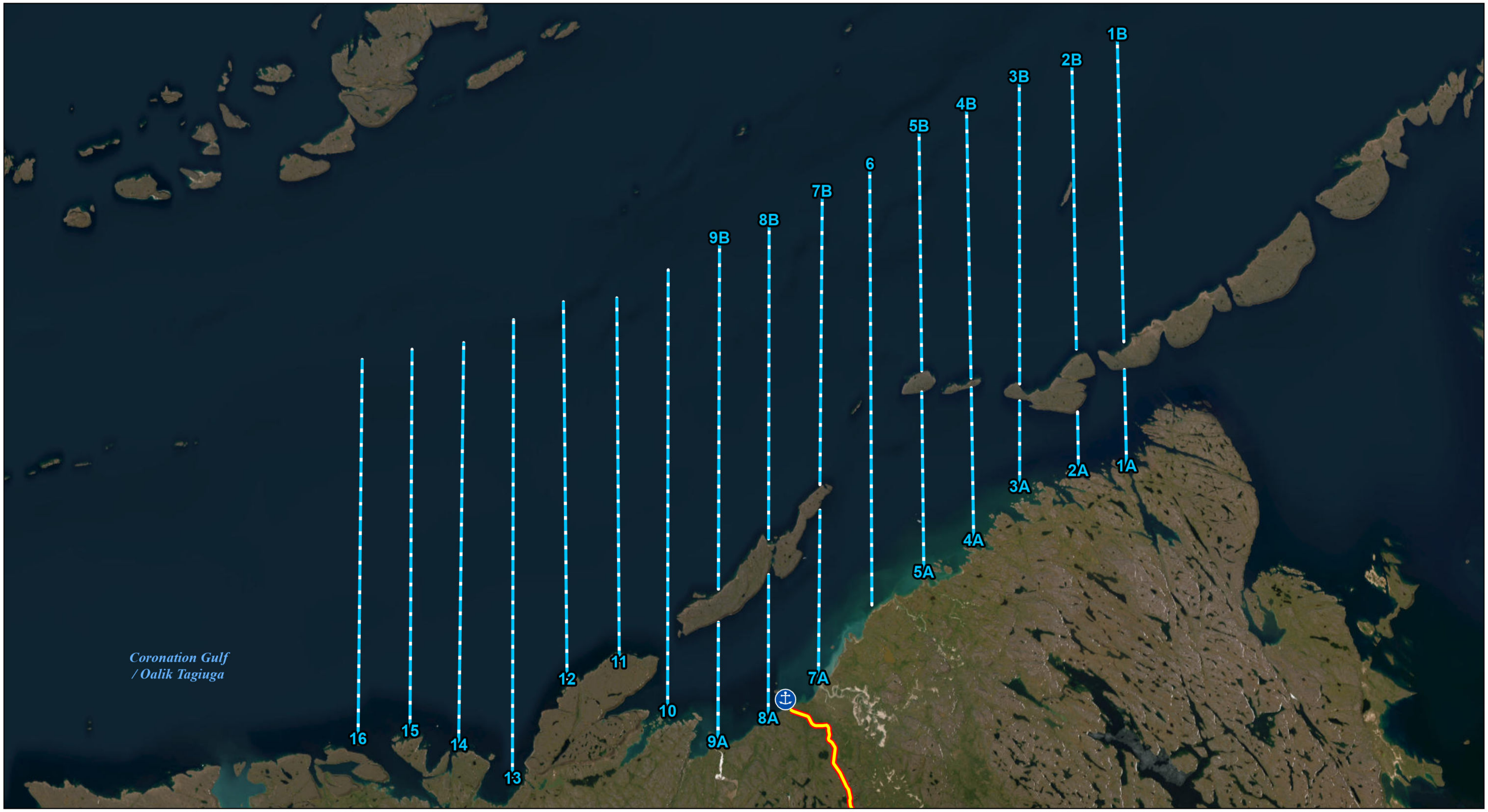
4.2.2 Vessel Survey

Nunami Stantec conducted a marine mammal vessel survey in August 2025 across three survey days (August 27-29). The vessel survey could not be conducted over the last days (August 30-31) of the planned survey dates due to poor weather conditions. The survey area, previously referred to as the intensive survey grid, included 16 north-to-south transects, numbered east to west, of which half were bisected into two line segments due to Hepburn Island and the Jameson Islands (see Figure 4.4). These transect lines were designed using distance sampling methods to potentially enable the calculation of marine mammal density and/or relative abundance, if sufficient observations were made and the analysis was warranted.

The vessel-based survey was completed from the 18.42 m (60 ft) vessel R/V *Martin Bergmann* (see Figure 4.4) during daylight hours when weather conditions were conducive to sighting marine mammals (i.e., Beaufort Sea State less than 4, and visibility >2.5 km). The vessel travelled between 6 and 7 knots on all transects to establish a consistent temporal effort throughout the survey and facilitate observing marine mammals. Four dedicated observers, inclusive of an Inuit observer and a data recorder, were present during the survey. The data recorder recorded information on survey details (i.e., time of transect start and end), marine mammal sightings, behavioural data, and environmental data. This information was collected through the ORCA data collection tool. Observers used 7x50 reticle binoculars to assist with scanning for marine mammals, confirm species identification, and measure distances to the sightings. Observers were positioned on the high vantage point of the vessel, the flying bridge, where one observer was stationed on the port side and another on the starboard side, with the data recorder located in the middle. They continuously scanned for marine mammals at varying distances, focusing primarily on pinnipeds, from the vessel along line transects and during transit between line transects.

When a marine mammal was sighted, the species, distance, and angle from the line transect to the animal were recorded. The distance to the animal was measured using reticle binoculars or sight-estimated by the observer. The angle to the animal from the transect line was measured using a pelorus. Marine mammals observed while the vessel transited along the transect lines were recorded as “on-transect” sightings. Sightings that occurred while the vessel was transiting between survey lines were recorded in the same manner but labelled as “off-transect.”

Behavioural data were recorded for each sighting to provide potential information about habitat use and response to vessel presence. Environmental variables were recorded at the beginning and end of each line transect, as well as when a marine mammal was sighted. Environmental variables were used to determine sightability conditions (i.e., the likelihood of observing an animal, given its presence at the surface, in relation to environmental conditions).



Intensive Survey Grid Transects (Vessel)

Grays Bay Port

Grays Bay Road

0 5 10 Kilometres

(At original document size of 8.5x11) 1:475,000

N

Notes
1. Coordinate System: WGS 1984 UTM Zone 12N
2. Data Sources: Governments of Canada, Stantec
3. Service Layer Credits: Earthstar Geographics

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WEST KITIKMEOT RESOURCES CORP

Project Location
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West Kitikmeot Resources Corp
Grays Bay Road and Port

Figure No.
4.3

Title
Vessel Survey Grid

\\Ca0002-ppfss05\geomatics\Clients\Nunami_Stantec\GBRP\Figures\123514868_149_Marine_Mammals_Vessel.pagx Revised: 2026-02-03 By: slemay

Figure 4.4 Survey Vessel, R/V *Martin Bergmann*

4.2.3 Acoustic Monitoring

JASCO deployed a single Autonomous Multichannel Acoustic Recorder (AMAR) within the LAA to record underwater sounds for approximately one month during the open water season in 2025. An underwater noise monitoring program was completed by JASCO Applied Sciences (JASCO) to provide information on the existing underwater soundscape and document the acoustic presence of marine mammals near the proposed Grays Bay port site. An acoustic recorder was deployed at one location (~500 m from the proposed port site) from July to August 2025. The deployment depth at the recording location was 32 m; a shallow deployment depth that is typically influenced by natural and anthropogenic sound inputs such as wind, waves, precipitation, vessel traffic and industrial processes. The purpose of the study was to characterize the recorded sounds in terms of the frequency distribution of the noise and fluctuations of the sound levels at hourly, daily, and monthly temporal scales. Additionally, the acoustic presence of any anthropogenic sources (e.g., boats) and of marine mammals was characterized.

5 Summary of Results

5.1 Desktop Assessment

The ringed seal is anticipated to be the most abundant marine mammal in the assessment areas (LAA and RAA). Some bowhead whales may be encountered if they migrate through the area; however, observations of bowheads in the RAA are rare. Beluga whales are most likely to be encountered farther offshore than bowheads and have been seen near Kugluktuk at the western end of the RAA (CBC 2012a,b). Narwhals are anticipated to be less common than beluga and bowheads, but they have been observed in Cambridge Bay at the eastern end of the RAA (George 2011, 2012). Bearded seals have been observed in the southern portion of Dolphin and Union Strait, and the western portion of the RAA has been noted as a year-round habitat for bearded seals (GN-DOE 2010; Brown and Fast 2012) despite them typically migrating south as the ice begins to thicken in the fall/early winter. The remaining marine mammal species (polar bears, hooded and harp seals) have mainly been observed around Kugluktuk within the RAA (GN-DOE 2010).

Table 3.1 shows an overview of marine mammal species that are known to occur in the Coronation Gulf, and the following section includes information on each species' general biology, distribution, population status, estimated abundance, and likelihood to occur in the assessment areas (LAA and RAA). Spatial data on marine mammals in the assessment areas (LAA and RAA) is limited, given the lack of recent (within the last 10 years) systematic data surveys. Aerial and vessel-based surveys were conducted in 2025 as part of the environmental assessment process to help fill these data gaps.

5.1.1 Mysticetes

5.1.1.1 Bowhead / Akvik (Balaena mysticetus)

The bowhead whale is a large, slow-moving arctic baleen whale well adapted to living in ice-covered waters. Satellite-tracking data from 27 bowhead whales found that they selected pockets of low sea-ice concentration and small floes during winter and areas with high ice coverage and large floes in summer (Ferguson et al. 2010).

During open-water periods, bowhead distribution is likely driven by prey distribution (COSEWIC 2009; Thomas 1999). Bowheads primarily feed on pelagic zooplankton (mostly copepods and euphausiids) and epibenthic invertebrates (Lowry and Frost 1984; Carroll et al. 1987; Lowry 1993). Two populations of bowhead whale are found in or near the LAA and RAA (1) the Bering-Chukchi-Beaufort (BCB) population (also known as the Western Arctic population) that summers in the Canadian Beaufort Sea and Amundsen Gulf and winters in the Bering Sea (McLaren and Davis 1985; Moore and Reeves 1993); and (2) the Eastern Canada-West Greenland (EC-WG), formerly considered two populations: the Davis Strait-Baffin Bay and Hudson Bay-Foxe Basin populations (COSEWIC 2009). The EC-WG population ranges throughout the eastern and central Canadian High Arctic (Davis and Koski 1980; Finley 2001; IWC 2008).

The BCB bowhead population winters in the central and western Bering Sea, and most of the population summers in the Canadian Beaufort Sea and Amundsen Gulf (Moore and Reeves 1993). Citta et al. (2012) investigated winter movements of bowheads using satellite telemetry during 2008–2010, and found that whales entered the Bering Sea in late November or mid December. While in the Bering Sea, bowheads were found in areas of high ice concentration, away from both the ice edge and polynyas. Bowheads left the Bering Sea in mid April to begin their spring migration (Citta et al. 2012). The timing of the spring migration is determined by ice conditions (Gentleman and Zeh 1987). Whales migrate across the western Beaufort Sea via offshore ice leads from mid April to mid June (Braham et al. 1984; Moore and Reeves 1993). A few bowhead whales arrive in coastal areas off the eastern Beaufort Sea and Amundsen Gulf in late May and June (Fraker et al. 1978; Fraker 1979; Fraker and Bockstoce 1980), but most whales remain in offshore waters (>200 m deep) among the offshore pack ice in the central and eastern Beaufort Sea and Amundsen Gulf until August (Quakenbush et al. 2012).

Satellite telemetry studies have clarified the distribution and movements of the BCB bowhead population in the Canadian Beaufort Sea during June and early July. Most bowheads apparently concentrate along the landfast ice edge between Banks Island and Cape Bathurst, where they probably feed on dense aggregations of zooplankton (Quakenbush et al. 2010). Following breakup of the ice edge, they move into Amundsen Gulf. Bowheads move gradually from offshore Amundsen Gulf or the offshore pack ice in the Beaufort Sea toward coastal and nearshore areas during late July to mid August (Davis et al. 1982). There is size segregation among whales at that time of year (Cubbage and Calambokidis 1987; Koski et al. 1988). Large, adult whales remain in Amundsen Gulf in water depths of 50–200+ m off Bathurst Peninsula. Small (<10 m) subadults move into coastal and nearshore waters at water depths of 10–50 m along the Yukon coast and off the Mackenzie Delta, and large subadults move into nearshore and shelf waters at water depths of 20–200 m off the Yukon coast, Mackenzie Delta, and Tuktoyaktuk Peninsula (Cubbage and Calambokidis 1987). However, not all segments of the population follow these patterns every year. The fall migration of bowheads out of the Canadian Beaufort Sea typically begins in early September with the last animals leaving by late October or early November.

In 2019, a spring ice-based visual survey and a summer aerial line-transect survey were conducted to provide independent estimates of the abundance of the BCB population. For the 2019 ice-based survey, Givens et al. (2021) presented an estimate of abundance of 14,025 whales (CV=0.228), which included a new correction factor to account for disturbance to the migration from powered skiffs. The 2019 aerial line-transect survey data were analyzed using a spatially-explicit density surface model, resulting in an estimated abundance of 17,175 whales (CV = 0.237; Ferguson et al. 2022). Both the ice-based and aerial line-transect abundance estimates from 2019 were endorsed by the International Whaling Commission (IWC) Scientific Committee as Category 1A (acceptable for providing management advice using an Aboriginal Whaling Management Procedure Strike Limit Algorithm; IWC 2021, 2022), despite both of these abundance estimates likely being biased low due to various factors.

The wintering areas, summering areas, and migration routes of the EC-WG bowhead population are not completely understood. The EC-WG bowhead population winter in Hudson Strait and southern Baffin Bay in the pack ice along the coast of western Greenland (Koski et al. 2006). Bowhead whale migration into the eastern and central High Arctic is via Lancaster Sound, and Fury and Hecla Strait. The migration through Lancaster Sound can extend from early/mid May to early August, with a peak in late June (Davis and Koski 1980). From May to early July, bowheads are found at the floe edge and in the pack ice off

Lancaster Sound and Pond Inlet (Reeves et al. 1983; Moore and Reeves 1993). When the pack ice melts, they quickly migrate through Lancaster Sound to the channels of the Canadian Arctic Archipelago. The migration through Fury and Hecla Strait occurs from late June to early July following the breakup of landfast ice in northern Foxe Basin.

A number of EC-WG bowheads summer in the bays and passages of the central and eastern High Arctic islands during August and September (Davis and Koski 1980; Koski and Davis 1980). Principal summering areas include Isabella Bay (eastern Baffin Island), Eclipse Sound (northern Baffin Island), Milne Inlet, Admiralty Inlet, and Prince Regent Inlet; the latter is considered to be a major nursery area (Lubbock 1937). A few bowheads occur in the Peel Sound/Franklin Strait area and in Barrow Strait (Davis and Koski 1980; Davis et al. 1980). They are present in the region from late June through September. Some bowheads summer off northeast Baffin Island (Davis and Koski 1980).

The fall migration out of the eastern Arctic Archipelago by the EC/WG population occurs during late September to early October (Koski and Davis 1980; Heide-Jørgensen et al. 2006). Whales that summer in Prince Regent Inlet and areas to the west migrate to the north coast of Baffin Island, at which point the migration occurs close to shore. Whales that summer in Eclipse Sound and Milne Inlet proceed north through Navy Board Inlet and then east along Bylot Island (Koski and Davis 1980), and then migrate along the east coast of Baffin Island to Isabella Bay where they join whales that have summered in that area (Finley 1990, 2001). The migration along Bylot Island and northeastern Baffin Island is primarily coastal, but satellite telemetry indicates that some animals move offshore (Heide-Jørgensen et al. 2006). All sightings during 1978–1979 aerial surveys were made within 1.5 km of the coast (Koski and Davis 1980) but those surveys were terminated before the end of the migration. The migration is also quite rapid, with the whales averaging 5 km/h (Koski and Davis 1980).

In August 2013, a large-scale aerial survey was conducted that covered most of the known summer range of the EC-WG population. This survey resulted in a fully corrected abundance estimate for the EC-WG bowhead whale population of 6,446 (95% CI: 3,838–10,827) (Doniol-Valcroze et al. 2020). A more recent abundance estimate of the EC-WG bowhead whale population using genetic mark-recapture analyses through a Jolly-Seber model estimated the total abundance as 5,173 individuals (CI: 3,436–7,788) (Biddlecombe et al. 2023). Despite the Jolly-Seber model's estimated total abundance being slightly less than the estimates from the aerial surveys (Doniol-Valcroze et al. 2020), it does not differ significantly, as they have overlapping confidence intervals. These results confirm earlier indications that the EC-WG stock is continuing to recover from past overexploitation.

The bowhead whale is considered a species of Least Concern by the IUCN (IUCN 2018) and Special Concern by COSEWIC (COSEWIC 2009). The EC-WG population has no status under SARA, but the BCB population is listed under Schedule 1 as Special Concern (GOC 2023).

In the autumn of 2012, there was a documented hunt in the communities of Arctic Bay and Taloyoak, each harvesting a bowhead whale (CBC 2012b; Dawson 2012). There were no other documented hunts within or near the Project assessment areas (LAA/RAA). In addition, there were no bowhead whales sighted during the dedicated 2012 Izok Corridor aerial surveys conducted by LGL Limited covering the Project's LAA and RAA (Elliot et al. 2013; see Figure 5.1).

Cetacean Observation

- Beluga
- Unidentified Whale
- Grays Bay Port
- Grays Bay Road
- Community
- Territorial Boundary
- Tibbitt to Contwoyto Winter Road
- Watercourse
- Ocean
- Waterbody

0 25 50 Kilometres
(At original document size of 8.5x11)
1:2,500,000

N

NUNAMI STANTEC LIMITED

WEST KITIKMEOT RESOURCES CORP

Notes
1. Coordinate System: WGS 1984 UTM Zone 12N
2. Data Sources: Government of Canada, Stantec, MMG

Project Location
West Kitikmeot Region
Nunavut

Prepared by SL on 2025-11-04
TR by JB on 2025-11-04

Client/Project
123514868_045
West Kitikmeot Resources Corp
Grays Bay Road and Port

Figure No.
5.1

Title
Cetaceans detected in the 2012 Aerial Survey

\\Ca0002-ppfss05\geomatics\Clients\Nunami_Stantec\GBRP\Figures\123514868_045_Marine_Mammal_2012_Cetaceans.pagx Revised: 2026-02-03 By: slemay

5.1.2 Odontocetes

5.1.2.1 Beluga / Kilalugak (Delphinapterus leucas)

There are seven recognized populations of belugas in Canadian waters; these divisions are primarily based on summer distributions and genetic differences (COSEWIC 2020a). Two of the populations occur in the Coronation Gulf. The Eastern Beaufort Sea stock summers in the Canadian Beaufort Sea; however, individuals have been reported in Coronation Gulf by hunters from Kugluktuk (Richard et al. 2010). The Eastern High Arctic-Baffin Bay stock summers in the Canadian central High Arctic and winters in Baffin Bay; this population migrates through Lancaster Sound in the spring and fall (Koski et al. 2002; Richard et al. 2010). The population estimates most recently used to provide harvest recommendations to the Nunavut Wildlife Management Board are 41,803 (Eastern Beaufort Sea) and 21,213 (Eastern High Arctic) (DFO 2008).

Belugas feed on a variety of invertebrates and fish, including Greenland halibut, capelin, and saffron cod (Vladykov 1946; Sergeant 1973; Seaman et al. 1982; Stewart et al. 1995). During late summer, belugas feed on coastal concentrations of arctic cod under pan ice and in deep offshore waters (Finley and Johnston 1977; Bradstreet et al. 1986; Koski et al. 2002). Loseto et al. (2009) found size-related dietary differences in Beaufort Sea belugas that suggested larger belugas preferred offshore arctic cod, whereas smaller belugas appeared to feed on nearshore arctic cod.

Belugas are listed as a species of Least Concern by the IUCN (IUCN 2017a), and it has no status under SARA (GOC 2023). COSEWIC lists the Eastern High Arctic-Baffin Bay population as Special Concern (COSEWIC 2020a).

There are a number of historic beluga sightings in and around Coronation Gulf. A beluga was spotted in Cambridge Bay in 1977, and belugas were observed travelling to Klengenberg Bay and Kugluktuk in 1989-1990 (Wolfden 2006; LGL 2013). Five additional sightings (group sizes 1–20) were also made from 1988 to 2000 (GN-DOE 2012). During dedicated aerial surveys conducted from 08-13 September 2012 by LGL Limited, there was a total of one sighting, including 20 individuals, sighted within the Project's RAA (Elliot et al. 2013; see Figure 5.1). The beluga whale sighting of 20 individuals was observed outside of the Project's LAA (10 km buffer around the PDA) and was located to the north of Kugluktuk (Elliot et al. 2013). Independent Quota holders also reported that hunters occasionally harvest belugas in the shallows of Simpson Bay (Riewe 1992; LGL 2013). According to the DFO database, beluga specimen samples were collected near Kugluktuk, including 11 individuals prior to 2014 and 23 individuals in 2021 (Ferguson 2024, pers. comm.).

5.1.2.2 Narwhal / Togaalik (Monodon monoceros)

The narwhal inhabits deep marine waters of the eastern Canadian Arctic from northern Hudson Bay and Davis Strait west to the central Canadian Arctic Archipelago (Reeves et al. 2002). Narwhals are usually seen in small groups of 10-20 individuals segregated by age, sex, and reproductive status (Gonzalez 2001). They can be encountered in herds of up to hundreds or thousands during migration, and concentrations occur along some fast ice edges (Koski and Davis 1980; Strong 1988).

The overall population is estimated to be greater than 161,000 individuals, with ~93,500 mature individuals (COSEWIC 2024). Current levels of hunting are considered sustainable. Abundance may have declined in some areas coincident with increased shipping, but these likely reflect a redistribution of animals rather than a decline in abundance. Threats anticipated to grow in the future include noise pollution from ship traffic, icebreaking, and climate change (COSEWIC 2024).

The Baffin Bay narwhal population occupies Baffin Bay and adjacent waters in winter. In the summer, a large portion of the population congregates in Canadian waters, in areas ranging from the eastern coastal waters of Baffin Island to the High Arctic Archipelago (Richard et al. 2010). The remainder of the population summers along the West Coast of Greenland (DFO 2012). There are four management stocks that summer entirely in Canadian waters: Somerset Island, Admiralty Inlet, Eclipse Sound, and East Baffin Island stocks (Richard et al. 2010).

Narwhals winter in very heavy pack ice throughout the northern Davis Strait and southern Baffin Bay (McLaren and Davis 1982; Koski and Davis 1994). In spring, they move north through the loosening pack ice and first appear near and in Lancaster Sound in April. They enter Pond Inlet and Lancaster Sound in late June and July after the breakup of the ice edge, en route to summering areas farther west (Koski and Davis 1979; Koski 1980). Large congregations can develop in Lancaster Sound during those years when the entrance to the Sound is blocked by fast ice (e.g., Finley et al. 1990). The peak movement of narwhals westward into the central High Arctic from Baffin Bay via Lancaster Sound occurs in late June and July. In summer, narwhals prefer deep-water fiords, inlets, and channels along eastern Baffin Island, Admiralty Inlet, Navy Board Inlet, and Eclipse Sound (Fallis et al. 1983; Smith et al. 1985; Koski and Davis 1994; Richard et al. 1994). During the fall, narwhals return to the open waters of Baffin Bay via Lancaster Sound. Narwhals feed primarily on shrimp and clams, but they also consume arctic cod and halibut (Matley et al. 2015). They usually feed along strong currents, where fish are more prevalent (Gonzalez 2001).

The narwhal is listed as Least Concern by the IUCN (IUCN 2017b). It has no status under SARA (GOC 2023) but is listed as a species of Special Concern by COSEWIC (COSEWIC 2015). Little is known of the reproductive biology of the narwhal (Davis et al. 1980; Kingsley 1989). Narwhal calving generally occurs in bays or inlets within deeper water areas during July and August, although it can begin as early as late May (Mansfield et al. 1975; Gonzalez 2001). There is no calving location within the project RAA (Arctic Portal.org 2023)

The nearest documented hunt of narwhals to the Project's assessment areas (LAA/RAA) is in Cambridge Bay, where approximately 10 animals were harvested each year in 2011 and 2012 (CBC 2012a). This harvest indicates that narwhals are travelling further south of their regular migratory patterns (CBC 2012a). More than 50 narwhals were seen in Cambridge Bay in 2011 (George 2011) and were again observed throughout the bay on one occasion in 2012 (CBC 2012a; George 2012). However, there were no narwhals sighted during the dedicated 2012 Izok Corridor aerial surveys conducted by LGL Limited covering the Project's LAA and RAA (Elliot et al. 2013; see Figure 5.1).

5.1.3 Pinnipeds

5.1.3.1 Bearded Seal / Ugyuk (Erignathus barbatus)

The bearded seal is the largest arctic phocid (Riedman 1990); it is typically spotted alone or in smaller groups. Pups are generally born on pack ice between late April and early May, where they are weaned after 12 to 18 days. Bearded seals are one of the more vocal species, producing long trills, sweeps, ascents, and moans that range from 50 Hz to 60 kHz; males vocalize underwater to establish breeding territories (Stirling et al. 1983; Cleator et al. 1989).

The bearded seal is a benthic feeder in depths of less than 200 m, but also feeds on under-ice biota in pack ice and in deep waters offshore (Burns and Frost 1983; Koski and Davis 1979; Koski 1980). The diet of bearded seals varies regionally. They feed on shrimp, crabs, clams, octopus, gammarid amphipods, isopods, and fish in the Beaufort Sea (Burns and Frost 1983), and primarily Arctic cod in eastern Arctic Canada (Finley and Evans 1983).

The bearded seal has a circumpolar distribution and can extend as far north as the Arctic Ocean 85° N and as far south as Sakhalin Island (45° N) in the western Pacific (Fuirst et al. 2023; Burns 1981) and from southern Hudson Bay and south to northern Newfoundland (~50° N) in the Atlantic (Fuirst et al. 2023).

The size of the global bearded seal population is not known (Kovacs 2009), but it was estimated to range from 500,000 to approximately 1 million (Stirling and Archibald 1979; Blix 2005; Cameron et al. 2010). There are currently no accurate abundance estimates in Canadian waters. Cleator (1996) suggested an estimate of more than 190,000 bearded seals in Canadian waters, based on several indices for different regions over a 35-year period.

Bearded seals are year-round residents of Canadian Arctic waters, preferring drifting ice packs over shallow waters in the summer and pack ice in the winter and spring (Norwegian Polar Institute, n.d.). During the winter months, bearded seals are primarily found along floe edges, as well as in areas of broken and moving pack ice (Ellis 1957; Cleator and Stirling 1990).

Bearded seals are most abundant in shallower waters less than 200 m deep (Burns and Frost 1983; Finley and Evans 1983), prefer less stable ice during breakup, and tend to avoid areas heavily used by predators (Cleator 1987; Cleator and Stirling 1990). During the winter months, this species frequents deeper waters offshore amid the pack ice in the Bering Sea and Baffin Bay, avoiding areas of thick, heavy drifting ice to maintain breathing holes in the relatively thin ice.

The bearded seal is considered a species of Least Concern by the International Union for Conservation of Nature (IUCN 2016a). It has no status under SARA (GOC 2023) and is listed as Not at Risk by COSEWIC (COSEWIC 2024). COSEWIC has designated the bearded seal as a high-priority candidate wildlife species for future assessment (COSEWIC 2024).

Bearded seals have been observed in the southern portion of Dolphin and Union Strait, and the western Coronation Gulf has been noted as a year-round habitat for bearded seals (GN-DOE 2010; Brown and Fast 2012). Despite typically migrating south as the ice begins to thicken in the fall/early winter, bearded seals have been found in this area. During dedicated aerial surveys conducted from 08-13 September 2012 by LGL Limited, there were a total of 4 sightings, including seven individuals detected within the Project's RAA (Elliot et al. 2013; see Figure 5.2). Bearded seal harvests were reported for all communities on the Coronation Gulf except Cambridge Bay from 1996 to 2001 (Priest and Usher 2004). The number of seals harvested was negligible in all communities. Kugluktuk recorded the highest harvest, averaging two bearded seals per year over the five years. Bearded seals were taken from May to September, with the majority (50%) harvested in July (Priest and Usher 2004).

5.1.3.2 Harp Seal / Kaigulik (Pagophilus groenlandica)

There are three distinct populations of harp seals in the Arctic and Northern Atlantic oceans; those that summer in the Canadian Arctic belong to the Northwest Atlantic population. Based on new modelling, the size of this population was recently updated to 4.7 million (Tinker et al. 2023), down from 7.3–7.7 million in 2012 (Hammill et al. 2011). The lower estimate reflects higher and more variable juvenile mortality since 2000 (Tinker et al. 2023).

Harp seals whelp from late February to mid-March (Jefferson et al. 2008) on patches of pack ice. Lactation lasts approximately 12 days (Kovacs and Lavigne 1986; Lydersen and Kovacs 1996; Oftedal et al. 1996). Females remain with their young for the first two to three weeks of life until the young are able to swim (Kovacs and Lavigne 1986). Mating usually takes place in late March or early April, after pups have weaned and before the moult in April and May (King 1983).

The Northwest Atlantic population of harp seals whelp and moult in the Gulf of St. Lawrence and on the ice front in the Strait of Belle Isle from February to May. They migrate north from these areas in April and May to spend the summer in Arctic waters. They are found in summer from northern Hudson Bay, Hudson Strait, and Davis Strait north to northern Baffin Bay and Jones Sound, east to offshore southwestern Greenland, and west through Lancaster Sound to Prince Regent Inlet, Barrow Strait, and Peel Sound (Richard 2001).

Harp seals often travel in groups of up to 100 (Koski and Davis 1979) or even up to 500 when on the summer range (Fallis et al. 1983). Harp seals feed on the arctic cod, which is their primary prey. Harp seals haul out on ice pans while on their summer range.

They remain along the coasts until the outbound migration, which coincides with the formation of pan ice in offshore waters in mid-to-late September (Koski and Davis 1980). Although large numbers can be found in offshore waters, they are widely dispersed (Koski and Davis 1980). The outbound movement along the north shore of Lancaster Sound is protracted, lasting from spring through summer to fall. By October, most harp seals have left Canadian Arctic waters.

The harp seal is considered a species of Least Concern by the IUCN (IUCN 2015a). It has no status under SARA (GOC 2023) and is a high priority by COSEWIC (COSEWIC 2024) due to the decline in pack ice.

Pinniped Observation
- Bearded Seal Observation
- Grays Bay Port
- Grays Bay Road

- Community
- Territorial Boundary
- Tibbitt to Contwoyto Winter Road
- Watercourse
- Ocean
- Waterbody

0 25 50 Kilometres
(At original document size of 8.5x11)
1:2,500,000

N

NUNAMI STANTEC LIMITED
WEST KITIKMEOT RESOURCES CORP

Project Location
West Kitikmeot Region
Nunavut

Prepared by SL on 2025-11-04
TR by JB on 2025-11-04

Client/Project
123514868_046
West Kitikmeot Resources Corp
Grays Bay Road and Port

Figure No.
5.2

Title
Bearded Seals detected in the 2012 Aerial Survey

Notes
1. Coordinate System: WGS 1984 UTM Zone 12N
2. Data Sources: Government of Canada, Stantec, MMG

\\Ca0002-ppfss05\geomatics\Clients\Nunami_Stantec\GBRP\Figures\123514868_046_Marine_Mammal_2012_Bearded_Seals.pagx Revised: 2026-02-03 By: slemay

One independent quota holder reported that harp seals are seen year-round near the islands close to Kugluktuk (GN-DOE 2010; Wolfden 2006; LGL 2013). Harp seals have also been recorded in the Kitikmeot Region near the St. Roch Basin and around the east and west coasts of Peel Sound (Brown and Fast 2012). There are no records of harp seals harvested within the LAA and RAA from 1996 to 2001 (Priest and Usher 2004). No harp seals were sighted during the dedicated 2012 Izok Corridor aerial surveys conducted by LGL Limited covering the Project's LAA and RAA (Elliot et al. 2013).

5.1.3.3 Hooded seal / Nattivak (Cystophora cristata)

Hooded seals are found in the North Atlantic and have four major whelping areas: the "West Ice" near Jan Mayen Island, the pack ice "Front" northeast of Newfoundland, in the Gulf of St. Lawrence, and in the Davis Strait (Sergeant 1974). The combined size of the three herds in the northwest Atlantic was estimated at 593,500 (Hammill and Stenson 2006; NOAA Fisheries 2019).

Hooded seals are highly migratory species (APP 1982) but are limited to arctic and subarctic North Atlantic Ocean waters, usually south of 85° N (Reeves and Ling 1981). They are generally associated with ice and are typically found drifting in offshore pack ice with 25–99% ice cover (McLaren and Davis 1982). Females are known to pup in loose aggregations on the pack ice (Bergflødt 1977; Thompson et al. 1998).

Hooded seals are seen in three main whelping areas in the western North Atlantic Ocean around March and are found along the pack ice edge in the Davis Strait during that time (Sergeant 1976; McLaren and Davis 1982). Females remain with their young for about one week, whereas the pups remain on the pack ice for 7–12 days after birth (Bergflødt 1977). Mating usually takes place in February, after the pups have been weaned and before the moult in April (King 1983).

Hooded seals typically dive to depths of 100–600 m for 5–15 min to forage (Folkow and Blix 1995; Folkow et al. 1996). They are known to eat a variety of fish and invertebrates, including Greenland halibut, redfish, arctic cod, Atlantic herring and squid (Ross 1992). Male hooded seals, also known as bladdernose seals, are easily distinguished when they inflate a red balloon-like sac from one nostril (Riedman 1990).

The hooded seal is considered Vulnerable by the IUCN (IUCN 2015b). It has no status under SARA (GOC 2023) and is listed as not at Risk by COSEWIC (COSEWIC 1986).

There have been very few sightings of hooded seals in the Coronation Gulf: one hooded seal was observed near Kugluktuk in 1996 (GN-DOE 2012); one hooded seal was harvested in Kugluktuk in October 1998 (Priest and Usher 2004); one hooded seal was sighted in Simpson Bay in 2005 (GN-DOE 2010a); and from November 2007 to June 2008, a hooded seal was observed at the mouth of Admiralty Inlet (GN-DOE 2010). No hooded seals were sighted during the dedicated 2012 Izok Corridor aerial surveys conducted by LGL Limited covering the Project's LAA and RAA (Elliot et al. 2013).

5.1.3.4 Ringed Seal / Nattik (Pusa hispida)

Ringed seals have a continuous northern circumpolar distribution. In Canada, their distribution is centred in the Arctic Archipelago and offshore Baffin Bay but ranges from Newfoundland to the Beaufort Sea. Ringed seals are year-round residents and one of the most abundant marine mammal species in the Canadian Arctic, and are highly adapted to living in arctic conditions. Population estimates are difficult to obtain because the species' range includes ice-covered regions, and its movements are poorly understood. The overall number of ringed seals is very uncertain, but various estimates (Kovacs et al. 2021; NOAA Fisheries 2024) indicate a total number of about 3.5 million seals, of which a little more than 3 million are of the Arctic subspecies *Pusa hispida hispida*. Some of the uncorrected and partially corrected population estimates of Canadian regional populations are: *(1)* at least 40,000 ringed seals in the Canadian Beaufort Sea (Stirling et al. 1982); *(2)* 52,000 in the northern Amundsen Gulf (Kingsley 1990); *(3)* 49,000 in Prince Albert Sound (Kingsley 1990); and *(4)* 90,000 in the Canadian High Arctic (Kingsley 1990).

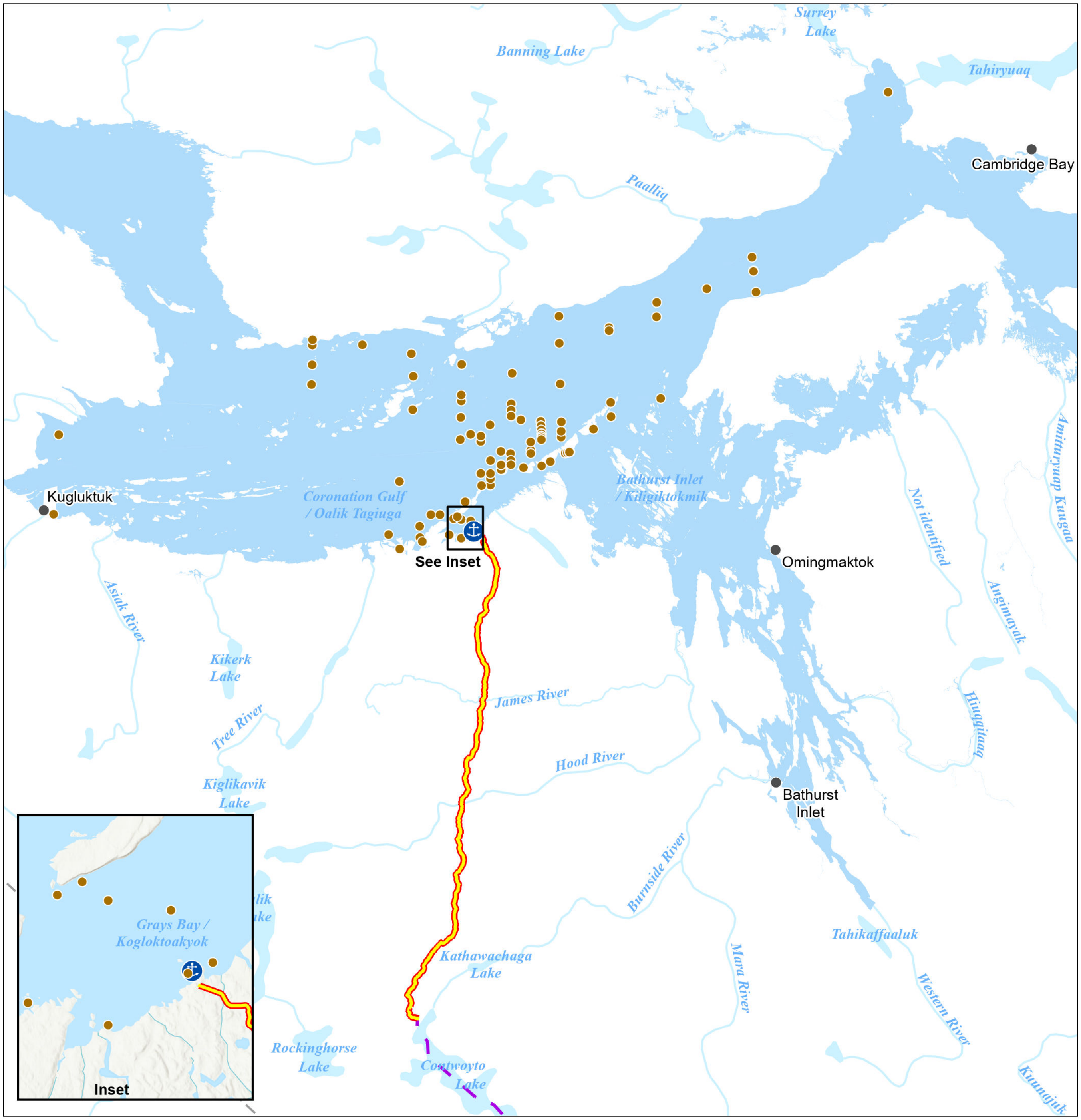
During the summer, ringed seals are dispersed throughout open-water areas and sometimes undergo substantial migrations (Harwood et al. 2012). Ice conditions influence ringed seal distribution and abundance from late autumn to late spring (Smith and Stirling 1975, 1978; Moulton et al. 2002), as they do not haul out on land but depend on sea ice to moult and rest. Ringed seals typically give birth to young on the landfast ice in subnivean lairs. However, they may also give birth on the offshore pack ice (Finley and Evans 1983; Kelly 1988). In autumn, as the ice begins to form, ringed seals open breathing holes in the sea ice and maintain them through the ice-covered season.

Ringed seals feed primarily on fish, especially arctic (or polar) cod, and crustaceans such as amphipods, euphausiids, epibenthic mysids, and decapods (Lowry et al. 1980; Bradstreet et al. 1986; Smith 1987).

The ringed seal is considered a species of Least Concern by the IUCN (IUCN 2016b). It has no status under SARA (GOC 2023) and has been listed as Special Concern by COSEWIC (COSEWIC 2020b). However, COSEWIC has recently designated the ringed seal a high-priority candidate wildlife species, given that it is threatened by expected losses of summer sea ice associated with climate change (COSEWIC 2023a, 2023b).

From 1996 to 2001, ringed seal harvests were reported for all four communities on the Coronation Gulf (Kugluktuk, Cambridge Bay, Bathurst Inlet, and Umingmaktok) (Priest and Usher 2004). Harvest levels are highest in Kugluktuk and Taloyoak. Most ringed seals are harvested in August and September, but smaller numbers are harvested every other month (Priest and Usher 2004). Capelin peak in the area of Dolphin and Union Strait and Coronation Gulf in the latter part of August, which attracts ringed seals to the area. Annual harvests in some of the smaller communities surrounding the Coronation Gulf are often much less than 20 individuals (Priest and Usher 2004). According to the DFO database, ringed seal specimen samples were collected near Kugluktuk, including four in 2020 and nine in 2021 (Ferguson 2024, pers. comm.).

During dedicated aerial surveys conducted from 08-13 September 2012 by LGL Limited, there was a total of 56 sightings of 86 individuals within the Project's RAA (Elliot et al. 2013; see Figure 5.3). Ringed seal detections within the Project's RAA were primarily in the central region of the assessment area (Elliot et al. 2013; see Figure 5.3).



- Ringed Seal Observation
- Grays Bay Port
- Grays Bay Road
- Community
- Territorial Boundary
- Tibbitt to Contwoyto Winter Road
- Watercourse
- Ocean
- Waterbody

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1:2,500,000

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Notes
1. Coordinate System: WGS 1984 UTM Zone 12N
2. Data Sources: Government of Canada, Stantec, MMG Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NRCan, Parks Canada, Esri, USGS

Project Location
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Grays Bay Road and Port

Figure No.
5.3

Title
Ringed Seals detected in the 2012 Aerial Survey

5.1.4 Ursids

5.1.4.1 Polar Bear / Nanuak (Ursus maritimus)

Polar bears are the largest land-based carnivores and are considered an apex predator, spending the majority of their lives near the ice. They have a circumpolar Arctic distribution and are seen worldwide. They are divided into 19 subpopulations, 14 of which occur in Canada (COSEWIC 2018). Densities of populations are linked to the presence of sea ice habitat. Polar bear distribution varies throughout the year and is strongly influenced by the presence, distribution, and quality of sea ice, as the ice provides them access to their primary prey species (COSEWIC 2018). During winter and spring, most polar bears are found on the sea ice and spend approximately 50% of their time hunting when there are suitable sea ice conditions (Amstrup et al. 2000). They tend to concentrate along pressure ridges that parallel the coast and in the vicinity of floe edges, where they can hunt seals more effectively in areas of thinner ice (Stirling et al. 1984). Males and non-breeding animals feed offshore along ice edges and in the transition zone where bearded seals and non-breeding ringed seals concentrate. In summer, they tend to remain with the multi-year pack ice, which usually retreats north at that time (Stirling et al. 1975, 1981; DeMaster and Stirling 1981; Amstrup 1995).

In December, pregnant females give birth in snow dens in coastal areas or on the ice. Dens are concentrated in some areas, but denning habitat appears to be unlimited throughout the Arctic Archipelago, and denning occurs at low densities along most coastlines that have been investigated (Stirling et al. 1979, 1981; Schweinsburg et al. 1981). In late March and early April, females with cubs return to the sea ice to hunt seals, typically concentrating in areas where ringed seals are pupping (Davis et al. 1980). In the western Arctic, females and cubs hunt along coastal fast ice after emerging from coastal denning sites. Bays in which ice remains longer than other areas are especially important hunting areas for females with cubs and pregnant females (Stirling et al. 1979). Polar bears usually exhibit fidelity to spring feeding and denning areas (Ramsay and Stirling 1990; Wiig 1995; Born et al. 1997).

Canadian populations are poorly understood, and survey estimates have not been conducted within the last 15 years; however, global estimates of 20,000-26,000 have been completed. The Polar Bear Technical Committee assessed 13 managed subpopulations, two of which encompass portions of the Coronation Gulf, the Northern Beaufort Sea (western side) and the M’Clintock Channel (eastern side) (Polar Bear Technical Committee 2022). The current population estimate for the Northern Beaufort Sea population is 1,291, which accounts for the boundary change with the Southern Beaufort subpopulation (Conference of Management Authorities 2022; Crockford 2021). However, current harvest rates are based on a managed subpopulation size of 1,710 bears, reflecting *(1)* the revised subpopulation boundary, which increased the geographic area of the Northern Beaufort Sea subpopulation (Griswold et al. 2017; Crockford 2021) and *(2)* potential negative bias in the current abundance resulting from incomplete sampling of the subpopulation during the 2006 count (Stirling et al. 2011). Results of a three-year genetic mark-recapture assessment estimated the M’Clintock Channel subpopulation size to be 716 (95% Credible Interval [CRI] = 545–955; Dyck et al. 2020; Crockford 2021). Numbers of both males and females are predicted to have increased due to reduced hunting and ‘improved habitat quality’ (i.e. less thick multiyear ice; Crockford 2021). The subpopulation is considered stable by the Inuit Knowledge assessment but is listed as ‘likely increased’ by the Polar Bear Specialist Group (Polar Bear Technical Committee 2022).

The polar bear is considered Vulnerable by the IUCN (IUCN 2015c), a species of special concern status under SARA (GOC 2023), and Not at Risk by COSEWIC (COSEWIC 2018). Nunavut currently allows an annual hunt of 500 polar bears, which includes defence kills.

Inuit Knowledge reports that polar bears are not common in the Coronation Gulf, but they have been seen around Kugluktuk every 15–20 years (Wolfden 2006; LGL 2013). Their distribution is variable and strongly influenced by the presence and quality of sea ice, which provides them access to their primary prey species, the ringed seal. No polar bears were sighted during the dedicated 2012 Izok Corridor aerial surveys conducted by LGL Limited covering the Project's LAA and RAA (Elliot et al. 2013).

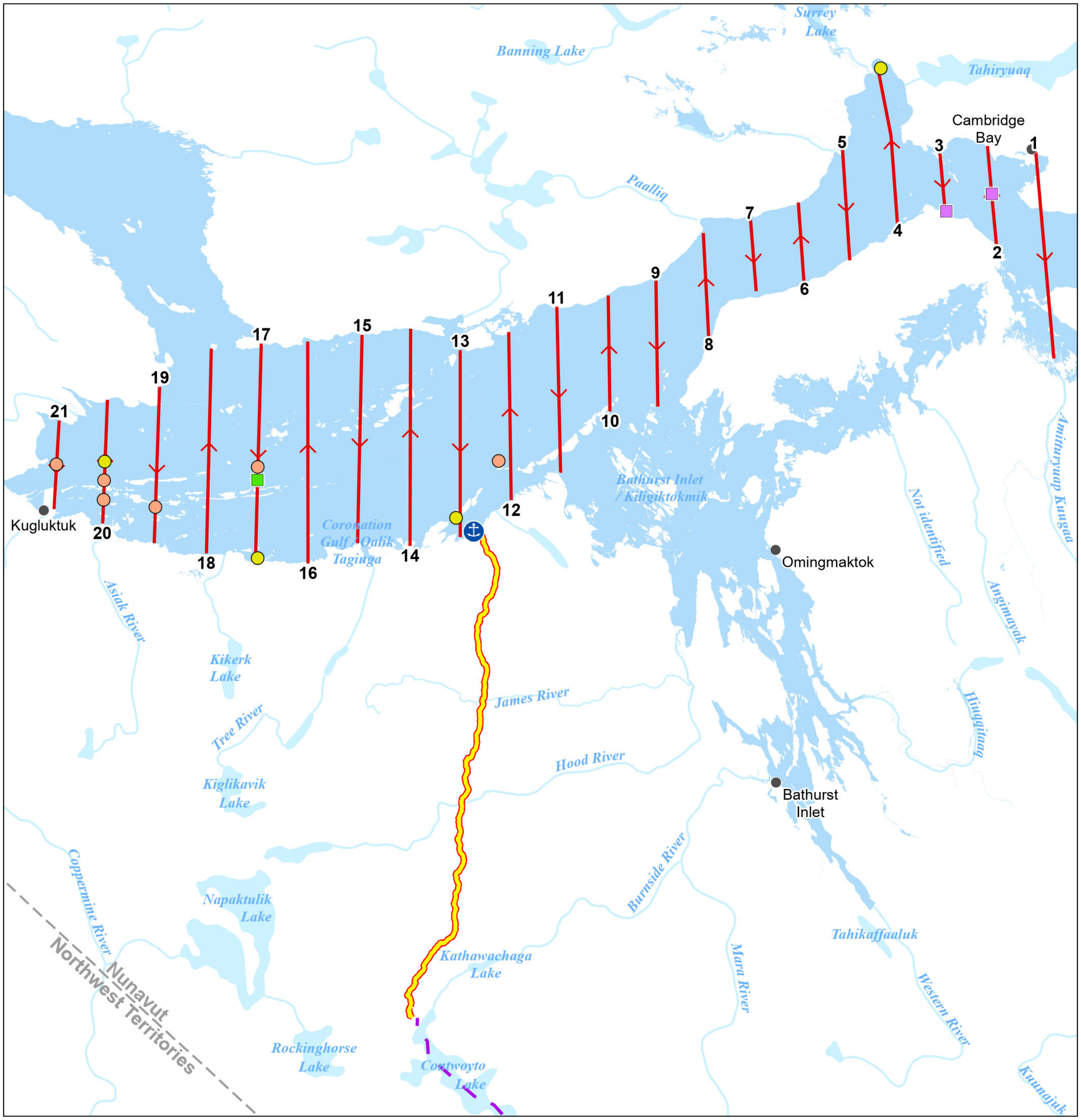
5.2 Field Based Study

5.2.1 Aerial Survey

The proposed 21 transects of the survey were completed in entirety and flown once; transect 13 was flown twice in replicate because of its critical position adjacent to the proposed port site at Grays Bay (see Figure 4.2). Observer sightability throughout the survey area was mostly good to excellent, which was attributed to a Beaufort Sea State ≤4, overcast to clear skies, light to no precipitation, weak to moderate sun glare, low percentages of pack ice and mostly water coverage. The survey had infrequent bouts of poor sightability; these conditions included a Beaufort Sea State ≥4, strong glare, moderate precipitation and strong sun glare.

The sightability varied slightly from the port and starboard sides of the craft. The starboard side of the craft, on average, had better sightability than port. This was due to the time of day of the surveys, the initial transect flown, and whether there was a north-to-south or south-to-north flying route.

There were 14 seal sightings with 66 individuals (see Table 5.1). Three sightings had a 'poor' or 'possible' reliability of identification; one of them involved a pinniped, and the other two involved a swirl or splash of water. The other 11 sightings had a reliability of ID of likely or definite, and this comprised 65 ringed seal individuals. No cetacean sightings were recorded. There were too few to perform a density and abundance analysis (see Figure 5.4). Each sighting was observed with a sightability of either 'good' (14% of sightings) or 'excellent' (86% of sightings).



2025 Sighting
(definite, possibly, likely, poor = Reliability of ID)

- Definite, Ringed Seal
- Likely, Ringed Seal
- Possibly, Unknown ID
- Poor, Unknown ID
- Extensive Survey Grid (Aerial)

- Grays Bay Port
- Grays Bay Road
- Community
- Territorial Boundary
- Tibbitt to Contwoyto Winter Road
- Watercourse
- Ocean
- Waterbody

0 25 50 Kilometres
(At original document size of 8.5x11)
1:2,500,000

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NUNAMI STANTEC LIMITED

WEST KITIKMEOT RESOURCES CORP

Notes
1. Coordinate System: WGS 1984 UTM Zone 12N
2. Data Sources: Government of Canada, Stantec, MMG

Project Location
West Kitikmeot Region
Nunavut

Prepared by SL on 2025-11-04
TR by ESB on 2025-11-04

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123514868_121
West Kitikmeot Resources Corp
Grays Bay Road and Port

Figure No.
5.4

Title
Marine Mammal Aerial Survey Sightings (2025), On and Off-Transect

Table 5.1 Marine Mammal Aerial Survey Sightings On and Off-Transect.

Date	Transect #	Species	Group Size	Cue	ID Reliability	Sightability
August 13, 2025	2	Unknown	Unknown	Footprint	Poor	Excellent
August 13, 2025	3	UnID pinniped	1	Surfacing	Poor	Excellent
August 13, 2025	4	Ringed seal	1	Body	Likely	Excellent
August 14, 2025	17	UnID pinniped	1	Splash	Possible	Excellent
August 14, 2025	16	Ringed seal	2	Body	Likely	Good
August 14, 2025	17	Ringed seal	3	Body	Definite	Excellent
August 14, 2025	Off-Transect	Ringed seal	17	Body	Definite	Excellent
August 14, 2025	Off-Transect	Ringed seal	8	Body	Definite	Excellent
August 15, 2025	13	Ringed seal	2	Body	Likely	Excellent
August 17, 2025	19	Ringed seal	2	Splash	Definite	Excellent
August 17, 2025	20	Ringed seal	5	Body	Definite	Excellent
August 17, 2025	20	Ringed seal	4	Body	Definite	Excellent
August 17, 2025	20	Ringed seal	1	Splash	Likely	Excellent
August 17, 2025	21	Ringed seal	19	Body	Definite	Good

5.2.2 Vessel Survey

The objective of the vessel-based marine mammal surveys was to determine if seals, specifically ringed seals, were abundant in the nearshore area surrounding the proposed port site. The highest priority lines were assessed as those in the nearshore environment within or adjacent to the LAA (Transect# 1A-9A; see Figure 4.3) to accommodate the potential direct impacts to seals from future planned noise-generating construction activities (e.g., pile-driving, casing advancement, and nearshore blasting). The offshore lines were designed to be secondary, covering potential cetacean (i.e., bowhead, narwhal, and beluga) presence, as well as gaining a comparative perspective on overall seal preference between nearshore and offshore areas.

Due to unsuitable weather conditions for conducting survey activities, the marine mammal vessel survey only occurred over portions of three days, August 27-29. With the reduced survey period, the survey team was only able to complete approximately 40% (9.5 out of 24 transect line segments) of the total number of transect lines. However, the survey team was able to complete all of the high-priority lines in the nearshore area within the LAA (Transect # 1A-9A) under ‘good’ sighting conditions with a Beaufort Sea State ≤4 and Visibility ≥ 2.5km. A limited portion of the offshore area (Transect #5B and the northern part of Transect #6) was also completed, for comparative purposes, but under ‘poor’ sighting conditions due to an increased sea state (Beaufort Sea State ≥4). The data collected during the vessel survey will be used along with the information collected from our aerial surveys, Inuit Knowledge, and historical data, to provide the most complete understanding of the assessment area as possible.

During the 2025 marine mammal vessel program, the observers recorded six sightings of six individual seals from the vessel while operating in the nearshore environment within or adjacent to the LAA (see Table 5.2 and Figure 5.5). Ringed seal was the only seal species observed. All seal sightings were observed during either 'good' or 'excellent' sighting conditions (Beaufort Sea State ≤4 and Visibility ≥2.5 km). The six seals observed during the vessel survey demonstrated either a diving type (i.e., dive and flipper slapping) or milling initial behaviour. Seal sightings were too few to perform a density and abundance analysis.

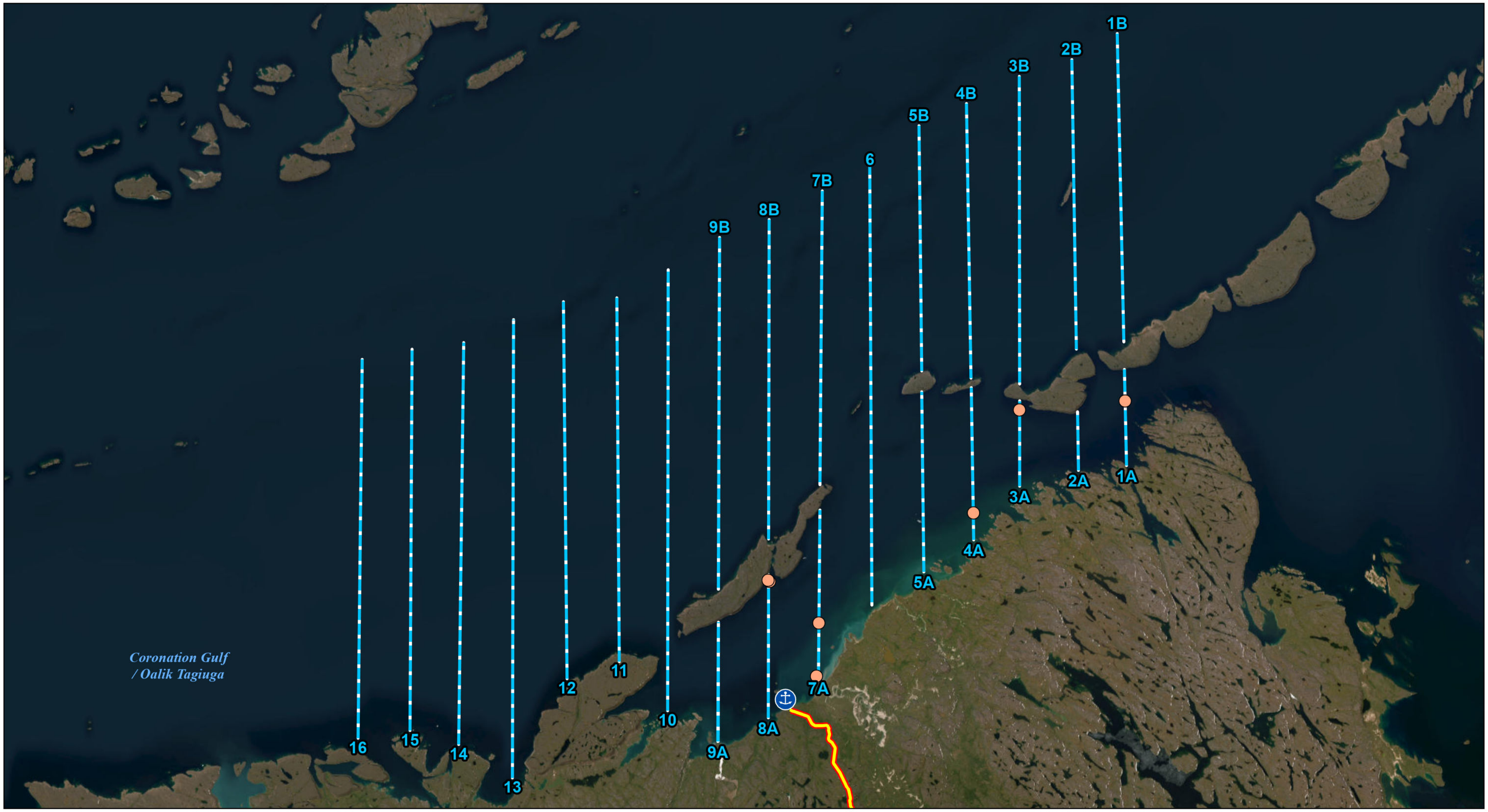
Table 5.2 Marine Mammal Vessel Survey Sightings On and Off-Transect.

Date	Transect #	Species	Group Size	Distance to Observer (m)	Initial Behaviour	Sightability
August 27	Off-Transect	Ringed Seal	1	50	Milling	Good
August 27	8A	Ringed Seal	1	100	Flipper-slap	Good
August 27	7A	Ringed Seal	1	50	Dive	Excellent
August 27	7A	Ringed Seal	1	10	Dive	Excellent
August 29	3A	Ringed Seal	1	100	Milling	Good
August 29	1A	Ringed Seal	1	100	Dive	Excellent

5.2.3 Acoustic Monitoring

A soundscape is comprised of the cumulative contributions from abiotic (geophonic), biotic (biophonic), and human (anthrophonic) sound sources (Krause 2008). To better understand the existing soundscape within the LAA, JASCO was contracted to collect Project-specific data. Underwater ambient noise levels were recorded from late July to late August 2025 using an AMAR. Specifically, the recorder was located at 67°48.547'N 110°52.1261'W, just south of the sediment sampling site SED06. This is a deep site located approximately 500 m off the peninsula of the proposed port. Daily broadband recorded sound pressure levels ranged from 81 to 147 dB re 1 µPa. The mean broadband sound pressure level was 110 dB re 1 µPa, and the median level was 91 dB re 1 µPa.

The main contributors to the soundscape were weather and flow noise (water movement along the surfaces of the hydrophone pressure transducers). Wind speeds during the recording period were obtained from Copernicus Climate Data Service. Wind and the resulting waves cause increases in sound levels primarily from 100-1000 Hz, with some broadband impacts as well. The first half of the deployment has higher overall wind speeds than the second half, and that is reflected as higher sound levels. The three events with wind speeds exceeding 9 m/s are also reflected clearly across most decade bands. Flow noise was the primary soundscape contributor below 100 Hz, elevating pressure over the hydrophone due to water movement caused by tides and weather.



Ringed Seal Sighting
Intensive Survey Grid (Vessel)
Grays Bay Port
Grays Bay Road

0 5 10 Kilometres

(At original document size of 8.5x11) 1:475,000

N

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WEST KITIKMEOT RESOURCES CORP

Notes
1. Coordinate System: WGS 1984 UTM Zone 12N
2. Data Sources: Governments of Canada, Stantec
3. Service Layer Credits: Earthstar Geographics

Project Location
West Kitikmeot Region
Nunavut

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123514868_150

West Kitikmeot Resources Corp
Grays Bay Road and Port

Figure No.
5.5

Title
Marine Mammal Vessel Survey Sightings (2025), On and Off-Transect

The only vessel detections occurred during the first three days of the recording period, while the deployment vessel *Martin Bergmann* and its accompanying small boat were in the area collecting water quality samples. Aside from the deployment vessel and sampling boat, vessels did not contribute to the soundscape during the recording period. Due to an overall quiet soundscape as well as a shallow deployment depth, an increase in vessel traffic in the future would likely result in increased sound levels recorded up to approximately 2 kHz.

Analysis of acoustic signals to determine the presence of sounds produced by marine mammals was conducted using a combination of automated detector-classifiers (referred to as automated detectors) and manual review by experienced analysts. All acoustic recordings were processed with automated detectors designed to target the calls of Arctic marine mammal species. A subset of 100 sound files (2.3% of the dataset) was then manually reviewed to validate potential automated detections. A single pinniped detection (most likely from a ringed seal) was recorded on 14 August 2025 at 05:03 UTC. Detailed information on underwater acoustic monitoring can be found in Appendix A.

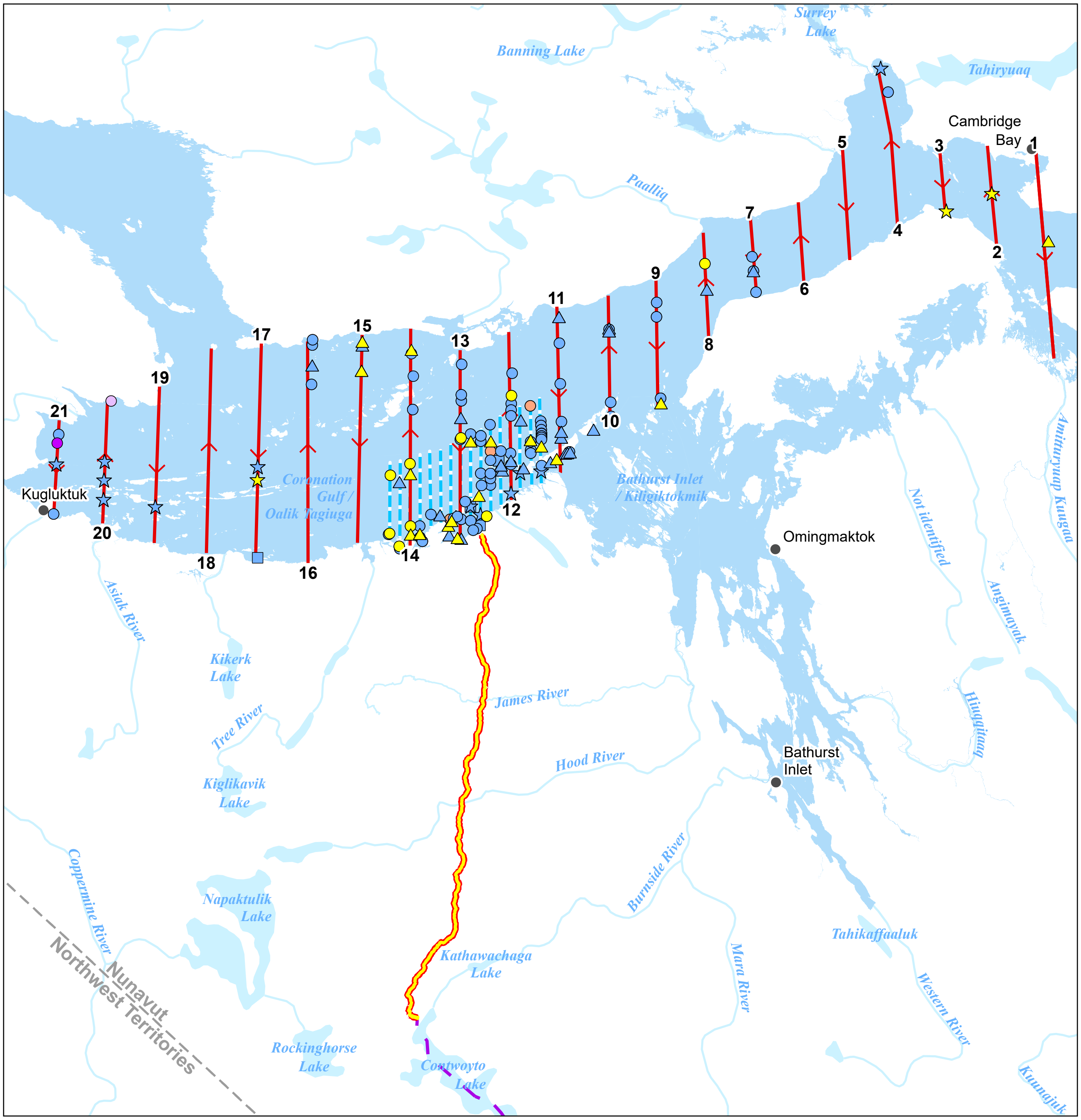
6 Summary of Results

Marine mammal surveys conducted by LGL Limited in 2012 were completed using a similar survey design as those implemented in the 2025 marine mammal field program (Elliott et al. 2013; see Figure 3.1). However, LGL Limited surveyed its entire survey area exclusively using aerial surveys. In contrast, Nunami Stantec's 2025 field program conducted the previously designed extensive survey grid, covering the RAA, through aerial surveys and the intensive survey grid, covering and extending beyond the LAA, through a vessel-based survey. LGL Limited was also able to perform two replicate surveys of the intensive and extensive survey grid (Elliot et al. 2013; see Figure 3.1). Nunami Stantec's 2025 marine mammal field program was only able to do one replicate of the extensive survey area through aerial surveys and was limited to the nearshore area (i.e., LAA) of the intensive survey grid with a vessel-based survey, due to timing, weather, and equipment availability. Nunami Stantec's flight altitude (305 m) was also twice as high as LGL Limited's (152 m) because of the stipulations under Nunami Stantec's *Authorization to Disturb a Marine Mammal* (Authorization: A-25-26-004-NU) issued by DFO.

LGL Limited, in 2012, observed 120 sightings (155 individuals) of seals during their survey covering the LAA and RAA. Ringed seals (124 individuals) and bearded seals (7 individuals) were the only seal species positively identified during the surveys. Twenty-four seals were not identified to species level. Most seal sightings occurred in the central part of the RAA (see Figure 5.3). In comparison, there were 14 seal sightings of 66 individuals during Nunami Stantec's 2025 aerial survey covering the RAA (see Table 5.2). Ringed seals were the only species identified to species (n= 11 of 65 individuals). The remaining three sightings of three individuals were not identified to a species level. During Nunami Stantec's 2025 vessel survey, covering the Project's LAA, there were an additional six ringed seal sightings of six individual seals. LGL Limited, based on the common distance sampling (CDS) estimation method, was able to use its survey effort and the 92 seal sightings during Beaufort ≤2 to produce an estimate of seal abundance at 13,381 and an estimate of seal density (0.53/km^2) for the RAA (Elliot et al. 2013). In contrast, Nunami Stantec in 2025 were not able to calculate abundance or density estimates for any marine mammal species group for either the aerial or vessel-based surveys because the number of sightings was too low.

LGL Limited in 2012 observed a sighting of 20 beluga whales and 5 sightings of unidentified whales north of Kugluktuk. In 2025, Nunami Stantec had no sightings of cetaceans during the aerial or vessel-based surveys. For both LGL's 2012 survey and Nunami Stantec's 2025 surveys, density estimates were not calculated for whales because the number of sightings was too low.

Despite the altitude flown during the aerial surveys being higher than preferred for seal surveys in 2025, along with the incomplete coverage of the vessel-based survey area, there were favourable sighting conditions for the majority of the survey effort. Results from the LGL Limited and Nunami Stantec (aerial and vessel) datasets were consistent with each other and with Inuit Knowledge and other historical data compiled for this baseline study report. Ringed seals were the predominant seal species observed within the assessment areas (LAA/RAA), and there was a limited cetacean presence within the LAA/RAA, as expected. Nunami Stantec's aerial and vessel survey sighting data from 2025 and LGL Limited's aerial survey data from 2012 are shown in Figure 6.1.



Aerial Sightings

2012

- Off-transect
- On-transect

2025

- Off-transect
- On-transect

Species

- Bearded Seal
- Beluga
- Ringed Seal
- Seal
- Unkown ID
- Unknown Whale ID

- Extensive Survey Grid (Aerial)- 2012 & 2025
- Intensive Survey Grid- 2012 (Aerial) & 2025 (Vessel)
- Grays Bay Road
- Community
- Territorial Boundary
- Tibbitt to Contwoyto Winter Road
- Watercourse
- Ocean
- Waterbody

0 25 50 Kilometres
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Notes

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West Kitikmeot Resources Corp
Grays Bay Road and Port

Figure No.
6.1

Title
Marine Mammal Survey Sightings from 2012 and 2025 Field Surveys

7 References

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Appendix A JASCO Acoustic Monitoring Report

Grays Bay Port Facility

Baseline Underwater Noise Monitoring

JASCO Applied Sciences (Canada) Ltd

9 December 2025

Submitted to:

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Report approved by:

Version	*Role*	*Name*	*Date*
1.0	Project Manager	Melanie Austin	December 9, 2025

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1. Introduction

The Grays Bay Road and Port project will link the Canadian Arctic, providing road access from southern Canada to the Kitikmeot. The first phase of this vital corridor will connect a deepwater port in the center of the Northwest Passage to Contwoyto Lake—the northern terminus of the Tibbit to Contwoyto winter road. When combined with the Slave Geological Province Corridor project, it will provide all-season road access from southern Canada to the Coronation Gulf. In support of the preparation of an impact statement evaluating the project's potential environmental effects, Stantec Consulting contracted JASCO Applied Sciences (JASCO), on behalf of West Kitikmeot Resources Corp, to conduct an underwater baseline noise monitoring study in the area of the proposed Port facility.

JASCO deployed a single autonomous underwater acoustic recorder in Coronation Gulf near the proposed Port facility (Figure 1), to record underwater sounds for approximately one month during the open water season in 2025. The purpose for the study was to characterize the recorded sounds in terms of the frequency distribution of the noise and fluctuations of the sound levels at hourly, daily, and monthly temporal scales. Additionally, JASCO sought and characterized the acoustic presence of any anthropogenic sources (e.g. boats) and marine mammals. This report summarizes the methods used to collect the data and presents the results from the acoustic analysis.

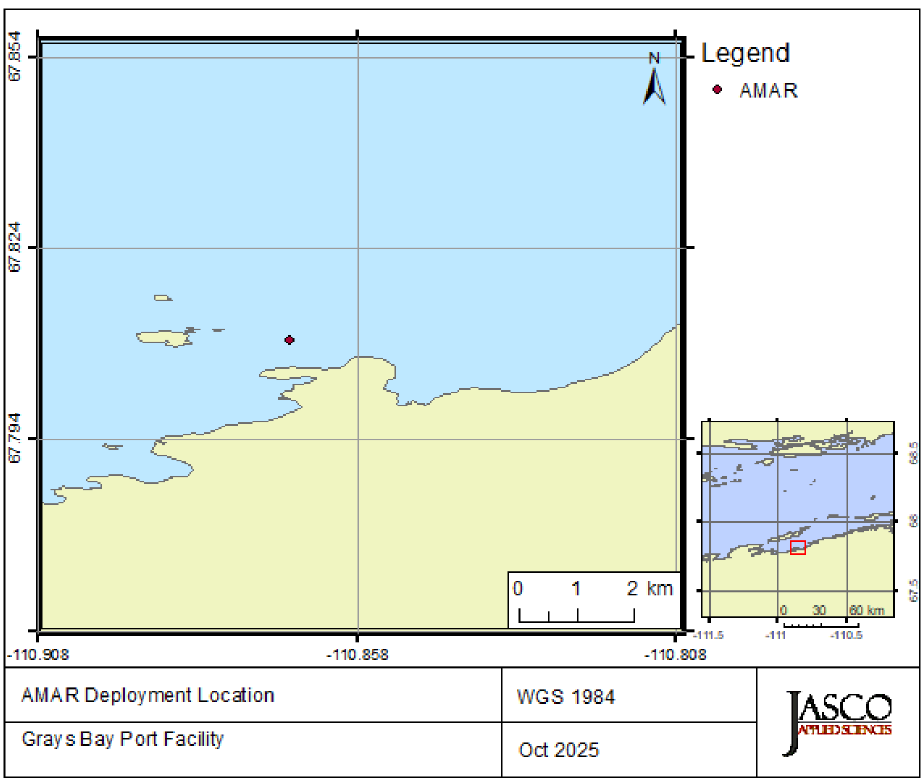


Figure 1 Map showing the Autonomous Multichannel Acoustic Recorder (AMAR) location used to collect baseline underwater sound data.

1.1. Ambient Ocean Soundscape

The soundscape of a location is the characterization of its ambient sound in terms of its spatial, temporal, and frequency attributes, as well as the types of sources contributing to the sound field (ISO 18405:2017a). Ambient sound is usually a composite of sound from many sources near and far. These include environmental sources such as precipitation, sea ice and wave action (geophony), biological sources such as fish and marine mammals (biophony), and anthropogenic sources such as vessels and construction activities (anthropophony). The Wenz (1962) curves in Figure 2 show the typical frequencies and spectral levels of contributions from distant sources associated with these activities.

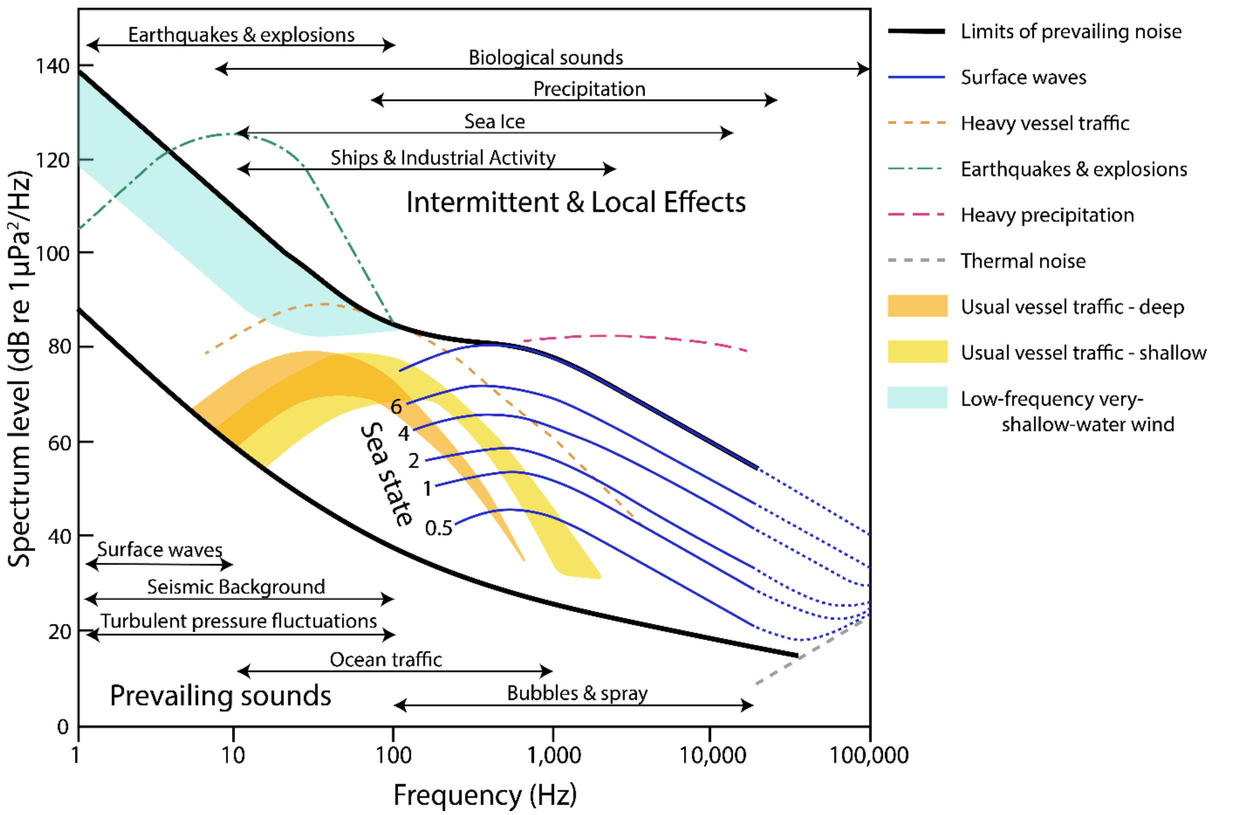


Figure 2. Wenz curves describing pressure spectral density levels of marine ambient sound from weather, wind, geologic activity, and commercial shipping (adapted from NRC 2003, based on Wenz 1962). The thick lines are the limits of prevailing ambient sound, which are included in some of the results plots to provide context.

In the marine environment, the geophonic elements of a soundscape can act as proxies for oceanographic conditions. Knudsen et al. (1948) and Wenz (1962) demonstrated that increased sea state and wind speed commonly correlate with higher sound intensities across frequencies from 500 Hz to 30 kHz due to breaking whitecaps, surface flow noise, wave generation, cavitation, and pressure change (Urick 1983). Rainfall can elevate sound levels in the 1–15 kHz frequency range via sound from surface impacts and bubble entrainment (Heindsmann et al. 1955, Bom 1969, Scrimger et al. 1987).

In high latitude areas, ice can be a prominent feature of a soundscape. The contribution of sea ice is usually highest when it is forming and breaking up. Under established sea ice, sound levels are usually lower than in open water areas because the ice attenuates or even eliminates the effects of wind and waves on the soundscape (Menze et al. 2017). Given the timing of the study (August) and the conditions observed by JASCO's field team during the deployment and retrieval of the instrument, sea ice was not expected to be a factor in the acoustic measurements presented here. Waves, currents, and seismic activity (such as earth movement and subsea landslides) can also be loud, though short-duration, geophonic contributors.

Biophonic sources of sound are diverse, and many marine taxa produce sounds. Animals that are known to produce acoustic signals include crustaceans, fish, and marine mammals. Biophonic signals include those generated for communicating, navigating, breeding, and foraging by sound-producing species. Marine mammals have received the most attention in terms of the description of their vocal repertoire and acoustic behaviour.

While geophonic and biophonic contributors comprise the natural soundscape, the total soundscape also includes anthropogenic (related to human activity) sounds. Human sound sources are diverse and can have large underwater acoustic footprints. The main sources are vessel noise, which is primarily caused by global shipping vessels, and seismic exploration for hydrocarbon deposits. The development of offshore wind farms and other coastal construction projects are also important sound sources, although more restricted in their impact areas. Given the remote location of the study area, vessel and boat noise is the only expected anthropogenic noise contributor during the time of this study.

Measuring ambient sound and characterizing the soundscape of an area is complicated by non-acoustic processes that often appear in acoustic recordings. One such issue is flow noise, which is caused by pressure eddies and vortices produced by water moving along the surfaces of hydrophone pressure transducers. This is similar to the buffeting sounds recorded by microphones in the wind. Flow noise is not part of a marine soundscape (Strasberg 1979, Urick 1983), but its intensity may indicate current strength (Willis and Dietz 1961). Current or wave action can also induce mooring noise when non-stationary components of a mooring create sound as they move or strum.

1.2. Anthropogenic Contributors to the Soundscape

Anthropogenic (human-generated) sound can be a by-product of vessel operations, such as engine sound radiating through vessel hulls and cavitating propulsion systems, or it can be a product of active acoustic data collection with seismic surveys, military sonar, and depth sounding as the main contributors. Marine construction projects often involve nearshore blasting and pile driving that can produce high levels of impulsive-type noise. The contribution of anthropogenic sources to the ocean soundscape has increased from the 1950s to 2010, largely driven by greater maritime shipping traffic (Ross 1976, Andrew et al. 2011). Recent trends suggest that global sound levels are leveling off or potentially decreasing in some areas (Andrew et al. 2011, Miksis-Olds and Nichols 2016). Oil and gas exploration with seismic airguns, marine pile driving, and oil and gas production platforms elevate sound levels over radii of 10 to 1000 km when present (Bailey et al. 2010, Miksis-Olds and Nichols 2016, Delarue et al. 2018).The extent of seismic survey sounds has increased substantially following the expansion of oil and gas exploration into deep water, and seismic sounds can now be detected across ocean basins (Nieukirk et al. 2004).

The main anthropogenic contributor to ambient sound in the present study was vessel sounds and associated echosounder use during the first day of recording.

1.3. Biological Contributors to the Marine Soundscape and Acoustic Monitoring

Given that most marine mammals produce sounds underwater, acoustic monitoring is generally an effective way to monitor for the presence of multiple species of marine mammals in remote environments year-round. Compared to visual techniques, acoustic monitoring depends less on weather conditions and is unaffected by visibility. However, acoustic monitoring requires animals to make sounds and those sounds must be sufficiently loud to be detected. Because not all species vocalise regularly, and vocalisation activity often depends on season, acoustic monitoring effectiveness varies by species and seasonally.

One cetacean (bowhead whale, *Balaena mysticetus)* and two pinniped (ringed seal (*Phoca hispida)* and bearded seals (*Erignathus barbatus*)) species have presumed ranges that overlap with the Project area (Table 1). Current knowledge on marine mammal presence and distribution in the study area is limited. Given the inshore location of the monitoring site, it is unclear whether bowhead whales could actually be present and detected there.

Table 1. List of cetacean and pinniped species known to occur (or possibly occur) in or near the Project area and their Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and Species at Risk Act (SARA) status.

Species	Scientific name	COSEWIC status	SARA status
Cetaceans			
Bowhead whales	*Balaena mysticetus*	Special concern[1]	Special Concern[1]
Pinnipeds			
Ringed seals	*Phoca hispida*	Special concern	Not listed
Bearded seals	*Erignathus barbatus*	Data deficient	Not listed

[1] Status of the Bering-Chukchi-Beaufort population

Although species differ widely in their vocal behaviour, most can be reasonably expected to produce sounds on a regular basis. Passive acoustic monitoring (listening) with long-duration recorders is therefore an efficient survey method. However, this approach produces huge data sets that must be analyzed, either manually or with computer programs that can automatically detect and classify sounds produced by different species. Seasonal and sex- or age-based differences in sound production, as well as signal frequency, source level, and directionality all influence the applicability and success rate of acoustic monitoring, and its effectiveness must be considered separately for each species and season.

Understanding of the acoustic signals produced by the marine mammals expected in the Project area varies by species. Marine mammal sounds can be broadly divided into two broad categories: narrow-band signals including baleen whale moans and pinniped vocalizations, and echolocation clicks produced by all odontocetes mainly for foraging and navigating. The signals of three species in the Project area have been sufficiently described for reliable, systematic identification and to design automated acoustic signal detectors to process large data sets (Table 2).

Table 2. Acoustic signals used for identification and automated detection of the species expected in Milne Inlet and supporting references.

Species	Sound production frequency range (kHz)[1]	Identification signal	Automated detection signal	Reference
Bowhead whales	0.02 (moan) – 6 (warble)	Moan	Moan	Clark and Johnson (1984) Delarue et al. (2009)
Ringed seals	0.4 (howl) – 0.7 (howl)	Grunt, yelp, bark	Grunt	Stirling et al. (1987) Jones et al. (2011)
Bearded seals	0.08 (groan) – 22 (moan)	Trill	Trill	Risch et al. (2007)

1 (Southall et al. 2019)

1.4. Weather

Weather conditions, including wind speeds (Figure 3) and precipitation (Figure 4), can influence the soundscape. Weather data for this report was obtained from Copernicus ERA5 reanalysis (https://cds.climate.copernicus.eu).

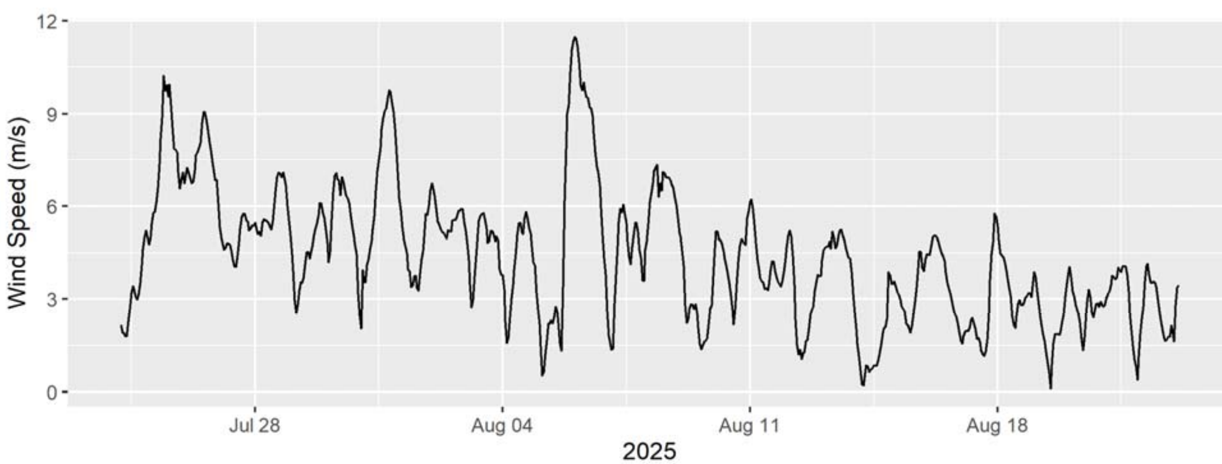


Figure 3. Hourly wind speeds during the recording period.

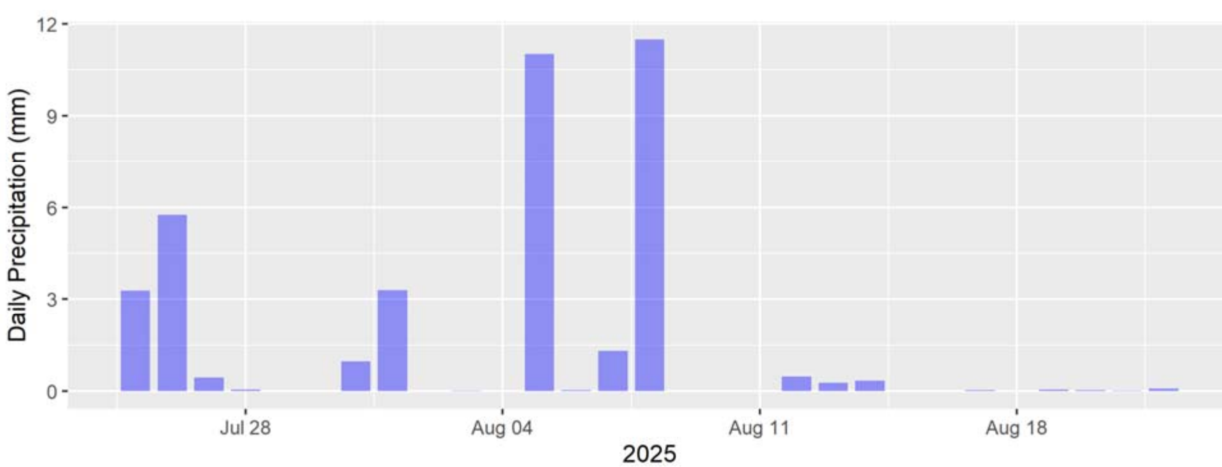


Figure 4. Daily precipitation during the recording period.

2. Methods

2.1. Acoustic Data Acquisition

2.1.1. Underwater Acoustic Recorders

Underwater sound was recorded with one Autonomous Multichannel Acoustic Recorder Generation 4 (AMAR G4, JASCO; Figure 5) in an acetal housing. The AMAR was fitted with an M36 omnidirectional hydrophone (GeoSpectrum Technologies Inc., −165 ± 3 dB re 1 V/µPa sensitivity). The AMAR hydrophone was protected by a hydrophone cage, which was covered with an open-cell foam shroud to minimize non-acoustic noise caused by water flowing over the hydrophone transducer; this noise is often referred to as ‘flow noise’. The AMAR recorded continuously at 128,000 samples per second for a recording bandwidth of 10 Hz to 64 kHz. The recording channel had 24-bit resolution with a spectral noise floor of 32 dB re 1 µPa^2/Hz and a nominal ceiling of 165 dB re 1 µPa. Acoustic data were stored on 2.6 TB of internal solid-state flash memory. Appendix A describes the calibration procedure.

Figure 5. The Autonomous Multichannel Acoustic Recorder Generation 4 ACE (AMAR; JASCO) used to measure underwater sound in Grays Bay, NU.

2.1.2. Deployment Locations

The AMAR was deployed at one location shown in Figure 1 between 24 Jul and 23 Aug 2025 (Table 3). The AMAR was retrieved as planned using a pop-up acoustic release and recorded as planned from deployment until retrieval, for a recording duration of 30 days. Appendix A provides details about the mooring design.

Table 3. Operation period, location, and water depth of the Autonomous Multichannel Acoustic Recorders (AMARs) deployed for the Grays Bay study.

Station	Latitude (°N)	Longitude (°E)	Depth (m)	Deployment	Retrieval	Duration (days)
AMAR861	67.80953333	-110.86645	32	24 Jul 2025	23 Aug 2025	30

2.2. Automated Data Analysis

The AMAR collected approximately 930 GB of acoustic data during this study. All acoustic data were processed with JASCO’s PAMlab software suite, which processes acoustic data hundreds of times faster than real time. PAMlab performed automated analysis of total ocean noise and sounds from vessels and marine mammal vocalizations. The following sections describe each type of analysis, and Appendix B provides an overview of the processing algorithms.

2.2.1. Ambient Data Analysis

2.2.1.1. Soundscape and Time Series Analysis

The data collected at Grays Bay span 30 days over the 10–64 Hz frequency band. The goal of the total ocean sound analysis is to present this expansive data set in a manner that documents the baseline underwater sound conditions in Grays Bay and allows comparison over time and with external factors that affect sound levels, such as weather and human activities.

The first stage of the total sound level analysis involves computing the peak sound pressure level (PK) and sound pressure level (SPL) for each minute of data. This reduces the data to a manageable size without compromising its value for characterizing the soundscape (ISO 2017b, Ainslie et al. 2018, Martin et al. 2019). SPL analysis was performed by averaging 120 fast-Fourier transforms (FFTs) that each included 1 s of data with a 50 % overlap that use the Hann window to reduce spectral leakage. The 1 min average data were stored as power spectral densities (1 Hz resolution up to 455 Hz and millidecades frequency bands above 455 Hz) and summed over frequency to calculate decidecade band SPL. Appendix B.2 lists the frequencies of the decidecade band levels. (Decidecade bands are similar to 1/3-octave-bands.)

The millidecade band analysis approach is described in Martin et al. (2021). Millidecades are logarithmically spaced frequency bands but have a bandwidth equal to 1/1000th of a decade. Using millidecades instead of 1 Hz frequency bands reduced the size of the spectral data by a large factor without compromising the usefulness of the data.

The decidecade analysis sums as many frequencies as contained in the recorded bandwidth and reduces them to a manageable set of up to 45 bands that approximate the critical bandwidths of mammal hearing. The decade bands further summarize the sound levels into four frequency bands for manageability. Appendices B.1 and B.2 contain detailed descriptions of the acoustic metrics and decidecade analysis, respectively.

In Section 3, the total sound levels are presented as:

- **Band-level plots**: These strip charts show the averaged received SPL as a function of time within a given frequency band. We show the total sound levels (across the entire recorded bandwidth from 10–16,000 Hz) and the levels in the decade bands of 8.9–89.1 Hz (Decade A); 89.1–891.3 Hz (Decade B); 891.3–8,913 Hz (Decade C); and 8,913–16,000 Hz (Decade D), depending on the recording bandwidth. The 8.9–89.1 Hz band is generally associated with fin and blue whales, large shipping vessels, flow and mooring noise, and seismic survey impulses. Sounds within the 89.1–891.3 Hz band are generally associated with the physical environment, such as wind and wave conditions, but can also include both biological and anthropogenic sources such as minke and humpback whales, fish, smaller vessels, seismic surveys, and pile driving. Sounds above 1000 Hz include high-frequency components of humpback whale sounds, odontocete whistles and echolocation signals, wind- and wave-generated sounds, and sounds from human sources at close range including pile driving, vessels, seismic surveys, and sonars.
- **Long-term Spectral Averages (LTSAs)**: These colour plots show power spectral density levels as a function of time (*x* axis) and frequency (*y* axis). The frequency axis uses a logarithmic scale, which provides equal vertical space for each decade increase in frequency and equally shows the contributions of low- and high-frequency sound sources. The LTSAs are excellent summaries of the temporal and frequency variability in the data.

- **Decidecade box-and-whisker plots**: The ‘boxes’ in these figures represent the middle 50 % of the range of SPL, so that the bottom of the box is the sound level 25th percentile (L_{25}) of the recorded levels, the bar in the middle of the box is the median (L_{50}), and the top of the box is the level that exceeded 75 % of the data (L_{75}). The whiskers indicate the maximum and minimum ranges of the data.
- **Spectral density level percentiles**: While the decidecade box-and-whisker plots represent the histogram of each band’s sound pressure levels, the power spectral density data have too many frequency bins for a similar presentation. Instead, coloured lines represent the L_{eq}, L_5, L_{25}, L_{50}, L_{75}, and L_{95} percentiles of the histograms. Shading underneath these lines indicate the relative probability distribution. It is common to compare the power spectral densities to the results from Wenz (1962), which documented the variability of ambient spectral levels off the US Pacific coast as a function of frequency of measurements for a range of weather, vessel traffic, and geologic conditions (see Figure 2). The Wenz levels are only appropriate for approximate comparisons because those data were collected in deep water, largely before an increase in low-frequency sound levels (Andrew et al. 2011).
- **Daily rhythm plots**: The data from each month are examined in 10-minute steps over one day (i.e., from 0:00–0:10, 0:10–0:20, …, 23:50–24:00). Each 10-minute step is comprised of ten 1-minute bins. For each month, the median value is calculated from these bins for a given time each day. For example, in a 30-day month, the daily L_{50} for 12:00–12:10 is the median of the ten 1-minute samples each day for all 30 days (from 300 1-minute samples). Plotting the daily cadences can reveal patterns associated with human activity, such as from ferries and other regularly scheduled vessel passages.
- **Weekly rhythm plots**: Similar to the daily rhythm plot, the data are examined in 30-minute steps over a week. The thirty 1-minute bins in each step are combined over multiple weeks, so over four weeks there are 120 samples. Mean values are calculated from the samples. Plotting the weekly cadences can reveal patterns associated with human activity that vary on a weekly schedule, such as work-week versus weekend differences.
- **Tidal rhythm plots**: Similar to the weekly rhythm plots, the decade band SPL are examined in 10-minute steps over each tidal cycle. Median values are calculated from the sample of tidal cycles across the recording period and plotted in reference to time at low tide for a full tidal cycle (from low to high to low tide). Plotting the tidal cadences can reveal the influence of tidal currents on sound level measurements.

2.2.2. Vessel Detections

The vessel detector searches the acoustic data for signals that indicate a ship is passing the recorder. The detector considers two factors: the sound pressure level in a defined frequency band and the presence of tonal sounds (i.e., sounds from rotating machinery that are stable at a single frequency for extended periods of time (minutes)). The vessel detector operates in the following three steps

1. Determine the number of tonals and SPL per minute;
2. Identify minutes where a vessel could be present; and
3. Review all the minutes to determine when the vessel passed, referred to as determining the closest point of approach (CPA) of the vessel.

When the shipping band SPL is greater than the average background and there are sufficient tonals present, the minute with the highest shipping band SPL is identified as the CPA. However, the shipping band SPL and tonals present condition can last for many hours, especially near a shipping lane. The following additional conditions for detecting other vessels passing are needed:

1. While the tones are present and the shipping band SPL is above background, a CPA is identified if the shipping band SPL reaches a relatively sharp local maximum (such as a small vessel passing quickly).
2. If the shipping band SPL slowly reaches local maximum that does not overlap with the previously detected CPA, then an additional CPA is detected.
3. If the shipping band SPL is no longer above background, but there is a local peak in the number of tonals detected, an additional CPA can be detected.

For each CPA detected, the spectrum at the moment of the CPA is analyzed to determine which decidecade band has the strongest peak. If the peak occurs at or below 100 Hz, the vessel is identified as low frequency, which is typical of large single screw vessels such as container ships, bulkers, and tankers. If the peak occurs at or above 100 Hz, the vessel is identified as high frequency, which include fish vessels, passenger ships or other vessels with azipod thrusters, and many other two screwed vessels. If the frequency is equal to or above 100 Hz, the detection duration is shorter than 20 minutes, and the maximum shipping band SPL is at least 115 dB, the vessel is identified as fast and high frequency, which primarily include small pleasure crafts.

The algorithm supports two operational modes: the normal mode and a set of conditions for very shallow coastal water, lakes, or rivers where there are small fast craft passing regularly. In this configuration, the minimum duration of a vessel passage becomes 3 minutes, the difference between the maximum shipping band SPL minute and the SPL average of its neighbours can be 20, and the minimum value for the shipping band SPL is 95 dB re 1 μPa². The shallow mode was used in this study.

Appendix C provides further details on the detector.

2.2.3. Marine Mammal Detection Overview

This analysis used a combination of automated detector-classifiers (referred to as automated detectors) and manual review by experienced analysts to determine the presence of any sounds (tonals or clicks) produced by marine mammals in the acoustic data. First, a suite of automated detectors was applied to the full data set (see Appendices D.1 and D.2). Second, a subset (100 files, 2.5 %) of acoustic data was selected for manual analysis of marine mammal acoustic occurrence. The analysis sample was selected based on automated detector results via our Automatic Data Selection for Validation (ADSV) algorithm (Kowarski et al. 2021) (see Appendix D). Typically, manual analysis results are compared to automated detector results to determine automated detector performance, and marine mammal occurrence plots that incorporate both manual and automated detections are created to characterize marine mammal presence in the acoustic data. Because a single marine mammal call was detected in these data, these steps were not necessary and are not described further.

2.2.3.1. Automated Click Detection

Odontocete clicks are high-frequency impulses ranging from 1 to over 150 kHz (Au et al. 1999, Møhl et al. 2000). We applied an automated click detector to the high-frequency data (audio bandwidth up to 128 or 256 kHz, depending on the recorders) to identify clicks from sperm whales, beaked whales, porpoises, and delphinids. This automated detector is based on zero-crossings in the acoustic time series. Zero-crossings are the rapid oscillations of a click's pressure waveform above and below the signal's normal level (e.g., see Figure D-1). Zero-crossing-based features of automatically detected events are then compared to templates of known clicks for classification (see Appendix D for details).

2.2.3.2. Automated Tonal Signal Detection

Tonal signals are narrowband, often frequency-modulated signals produced by many species across a range of taxa (e.g., baleen whale moans, delphinids whistles). They range predominantly between 15 Hz and 4 kHz (Berchok et al. 2006, Risch et al. 2007), thus automated detectors for these species were applied to the low-frequency data (audio bandwidth up to 8 or 32 kHz depending on the recorder). In contrast, the automated detector for small dolphin tonal acoustic signals was applied to the high-frequency data, as these whistles can reach 20 kHz (Steiner 1981). The automated tonal signal detector identified continuous contours of elevated energy and classified them against a library of marine mammal signals (see Appendix D for details).

3. Results

3.1. Sound Levels

The band-level plots, spectrograms (Long-term Spectral Averages), decidecade box-and-whisker plots, and spectral density level percentiles (Figure 6) provide an overview of the sound variability in time and frequency, presenting an overview of presence and level of contribution from different sources. Short-term events appear as vertical stripes on the spectrograms and spikes on the band level plots. The deployment depth at the recording location was 32 m; a shallow deployment depth that is typically influenced by natural and anthropogenic sound inputs such as wind, waves, precipitation, vessel traffic, and industrial processes. The decade band level statistics appear in Table 4.

The most substantial soundscape influences during this deployment period are from weather and flow noise. Wind speeds during the recording period were obtained from Copernicus Climate Data Service, as shown in Figure 3. Wind and the resulting waves cause increases in sound levels primarily from 100–1000 Hz, with some broadband impacts as well. The first half of the deployment has higher overall wind speeds than the second half, and that is reflected as higher sound levels. The three events with wind speeds exceeding 9 m/s are also reflected clearly across most decade bands. Flow noise was the primary soundscape contributor below 100 Hz, elevating pressure over the hydrophone due to water movement caused by currents and weather.

Precipitation is also a contributing factor to the soundscape, due to the shallow deployment depth and overall quiet soundscape. Rainfall is depicted most prominently in the LTSA (Figure 6) as intermittent events above 10 kHz, primarily in the first half of the recording period. The most prominent events are on 5 and 8 Aug, which corresponds to precipitation in Figure 4.

The only vessel detections occurred during the first three days of the recording period (Figure 10), while the deployment vessel *Martin Bergmann* and its accompanying small boat were in the area collecting water quality samples (contributing to the LF Vessel and HF vessel detections in Figure 10, respectively). Analysts also noted the presence of small pleasure crafts around 1800 UTC on 22 Aug and 1600 UTC on 23 Aug. Aside from the deployment vessel and sampling boat, vessels did not contribute to the soundscape during the recording period. Due to an overall quiet soundscape as well as a shallow deployment depth, an increase in vessel traffic in the future would likely result in increased sound levels recorded up to approximately 2 kHz.

The first day of deployment also recorded high frequency sounds from an echosounder, likely from the vessel detected. These high frequency sounds elevate the highest frequencies of the LTSA, and appear as a spike in the power spectral density figure.

At the beginning of the deployment, Grays Bay experienced 24 hours per day of daylight, and by the end of the deployment there were 18 hours of daylight and 6 hours of twilight. Therefore, daily patterns of surface temperature and biological activity changes that are typical in lower latitudes are less pronounced in this study area. Grays Bay also experiences only one high tide and one low tide per day, with a maximum daily tidal range of approximately 0.45 m and a spring-neap cycle, with a minimum tidal range of approximately 0.15 m. Tidal information was obtained from WebTide model (www.bio.gc.ca). Figure 7 shows the sound levels across all frequencies relative to high and low tide. In regions with high tidal flow, there is typically an increase of flow noise (below 100 Hz) after high or low tide, peaking in the middle when flow is highest. This deployment in Grays Bay does not demonstrate a relationship typical of a high-flow environment, which corroborates with the relatively minimal tidal range and long tidal period over which change occurs.

Figures 8 and 9 show the decade band SPL by time of day/day of week and time relative to high tide, respectively, excluding the dates at the beginning when the vessel and echosounder were detected. Both the time of day and time relative to high tide plots show an increase in SPL at bands above 100 Hz beginning around 16:00 UTC (noon local) and 8 hours after high tide (approaching low tide). Generally in a shallow environment, sound level increases occurring in the afternoon could be related to higher wind speeds, warmer waters, or increased daytime vessel traffic, while sound level increases surrounding low tide could be related to tidal flow and shallower water, which allow sound to more easily reach the bottom. Given this deployment's location, colder environment with relatively minimal daily temperature range, near-absence of vessels, and minimal tidal range, the most likely candidate for the daily/24 hour tidal aligned fluctuations is the higher wind in the afternoon vs overnight or morning. A sound source not featured during this deployment due to time of year is ice noise. This would be a substantial soundscape contribution during formation and breakup periods of the year.

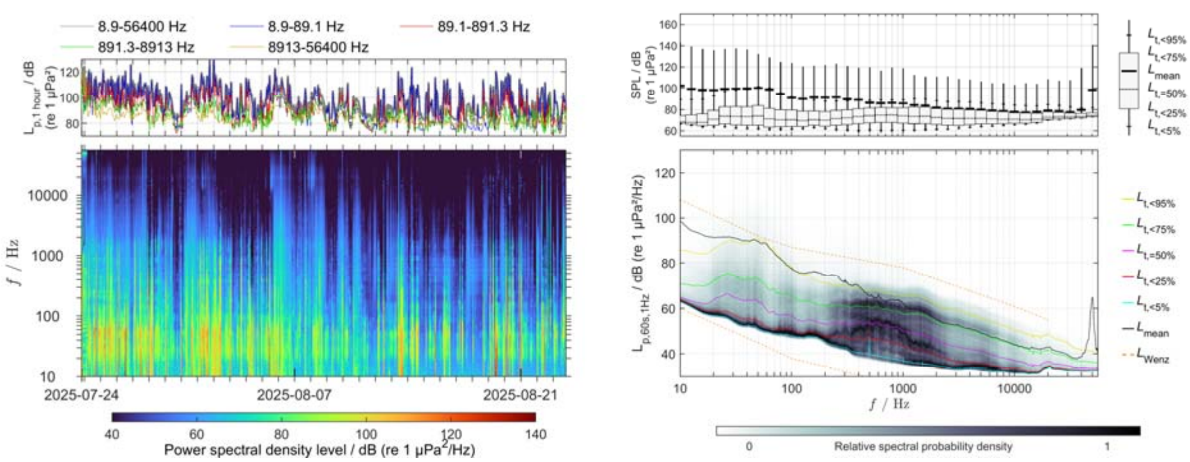


Figure 6. (Left) In band sound pressure levels and long term spectrogram of received sound; (right) Decidecade boxplot showing the distribution of sound pressure level within a decidecade band and power spectral density percentile plot.

Table 4. Band level statistics over the full deployment.

Sound level statistic	8.9–56400 Hz	8.9–89.1 Hz	89.1–891.3 Hz	891.3–8913 Hz	8913–56400 Hz
Min	81.2	73.4	70.0	72.1	79.3
L_{95}	82.2	74.3	72.2	73.5	79.5
L_{75}	85.1	76.5	77.3	77.4	80.1
L_{50}	91.1	83.6	83.7	83.4	82.3
L_{25}	98.0	92.4	90.8	91.4	87.0
L_{5}	109.5	108.3	99.3	98.9	93.7
Max	146.5	146.5	129.7	123	141.0
Mean	110.1	109.3	99.9	93.3	98.7

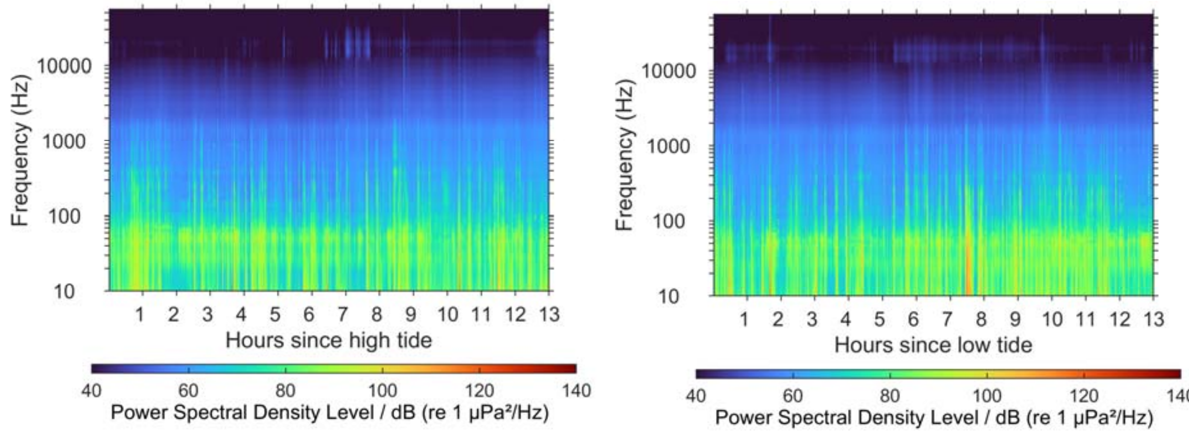


Figure 7. Spectrogram by time since (left) high tide and (right) low tide.

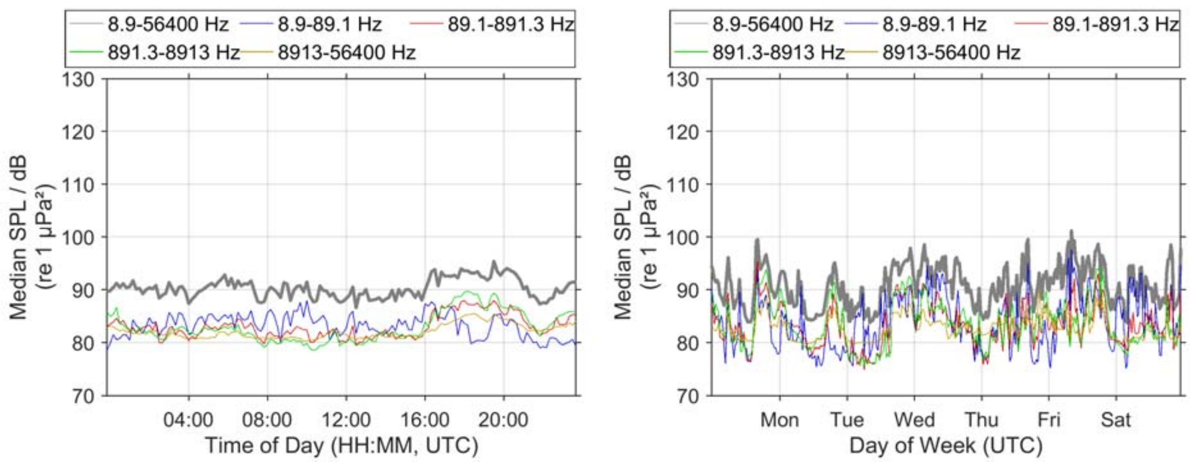


Figure 8. In band sound pressure levels by (left) time of day and (right) day of week.

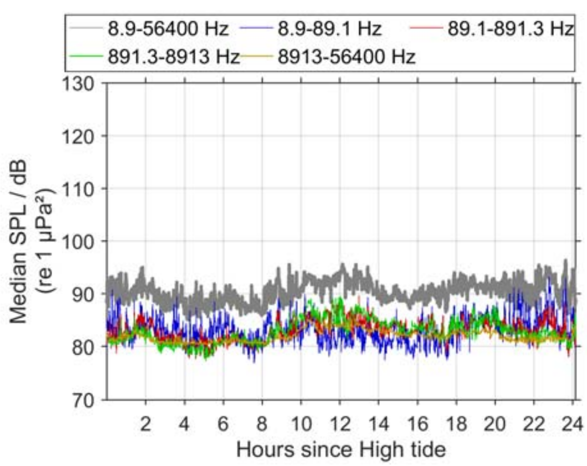


Figure 9. In band sound pressure levels by hours relative to high tide.

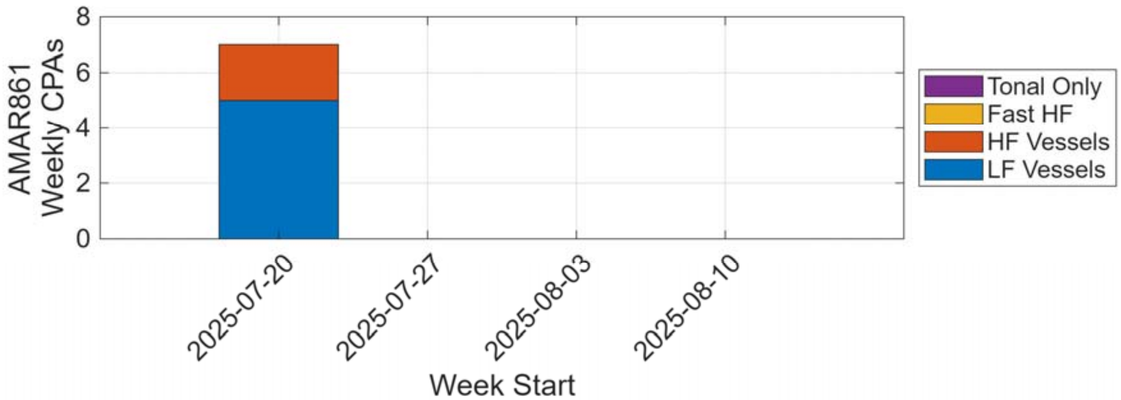


Figure 10. Vessel detections by week during the recording period.

3.2. Marine Mammal Detections

The only marine mammal detections in the data were a few ringed seal calls on 14 Aug at 05:00 UTC (Figure 11). Analysts also noted the occasional presence of grunt-like sounds that were tentatively attributed to fish.

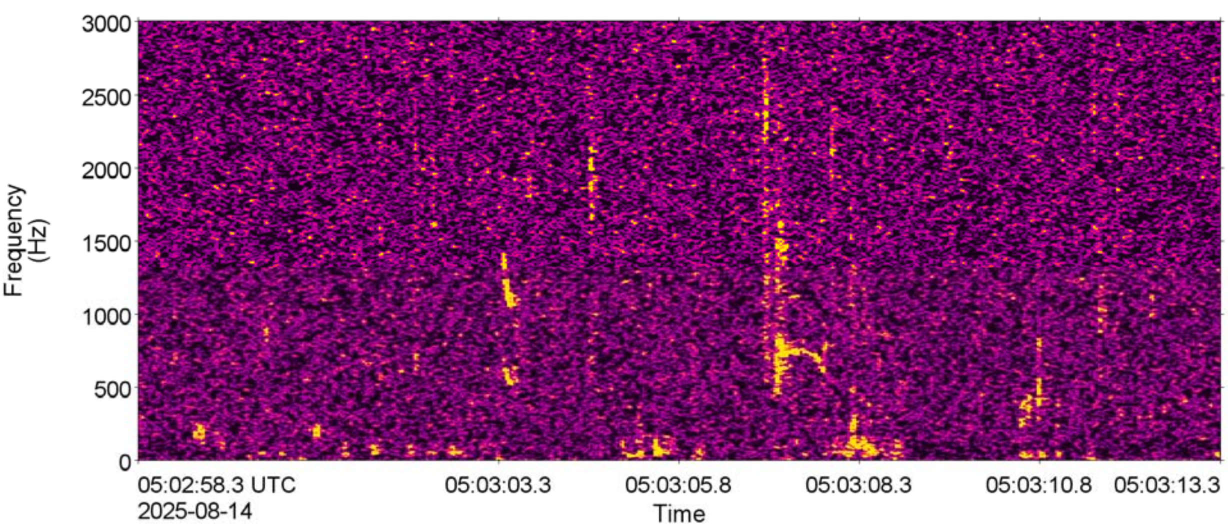


Figure 11. Ringed seal calls. (2 Hz discrete Fourier Transform (DFT) frequency step, 0.125 s DFT temporal observation window (TOW), 0.03125 s DFT time advance, and Hann window). The spectrogram is 15 s long.

4. Discussion and Conclusion

The most substantial consistent contributions to the soundscape were from weather and flow over the hydrophone. The shallow deployment depth caused the recorder to be susceptible to detection of variations in wind speed as well as rainfall events. Flow over the recorder, primarily from wind waves but also partially from tidal changes, elevated sound levels at low frequencies. A vessel with an echosounder was present at the beginning of the recording, which substantially elevated sound levels. Ice noise was not present during this recording but would be a substantial soundscape contribution at other times of the year.

The lack of marine mammal detections was not surprising, given the inshore location of the recorder in an area with limited marine mammal species diversity. The project area is on the edge of the range of bowhead whales from the Bering-Chukchi-Beaufort population and it is unclear if and to what extent they use the Grays Bay area. Bearded seals are primarily vocally active from fall to spring (Frouin-Mouy et al. 2016). The recording period took place when acoustic detections are least likely, which may explain the lack of records for this species. Ringed seals were presumably the species most likely to be detected in the area. However, this species is not as vocally active as other Arctic pinnipeds such as bearded seals or walruses. Their vocal activity outside of the spring breeding season (Jones et al. 2011) is limited, which may explain the low number of detections. Information regarding the presence of haul-out sites in Grays Bay would be informative to assess the likelihood of detecting ringed seal sounds in this area.

Acknowledgements

The underwater acoustic recorders used to collect the data in this report were deployed and retrieved by JASCO field scientists Allison Richardson, Colin Belanger, and Seamus Garvey with skillful support from the Captain and crew of the research vessel *Martin Bergmann*.

Glossary of Acoustics Terms

1/3-octave

One third of an octave. A 1/3-octave is approximately equal to one decidecade (1/3 oct ≈ 1.003 ddec).

1/3-octave-band

Frequency band whose bandwidth is one 1/3 octave. The bandwidth of a 1/3-octave-band increases with increasing centre frequency.

acoustic noise

Sound that interferes with an acoustic process.

acoustic self-noise

Sound at a receiver caused by the deployment, operation, or recovery of a specified receiver and its associated platform (ISO 18405:2017).

ambient sound

Sound that would be present in the absence of a specified activity (ISO 18405:2017). It is usually a composite of sound from many sources near and far, e.g., shipping vessels, seismic activity, precipitation, sea ice movement, wave action, and biological activity.

automated detection

The output of an automated detector.

automated detector

An algorithm that includes both the automated detection of a sound of interest (e.g., vessel noise, marine mammal call) based on how it stands out from the background noise, and its automated classification based on similarities to templates in a library of reference signals.

background noise

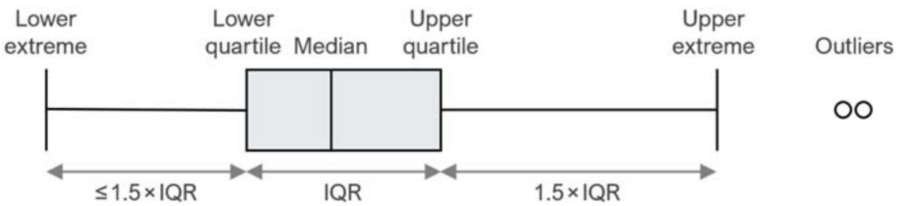
Combination of ambient sound, acoustic self-noise, and, where applicable, sonar reverberation (ISO 18405:2017) that is detected, measured, or recorded with a signal.

bandwidth

A range within a continuous band of frequencies. Unit: hertz (Hz).

box-and-whisker plot

A statistical data plot that illustrates the centre, spread, and overall range of data as a visual 5-number summary. The box is the interquartile range (IQR), which shows the middle 50 % of the data—from the lower quartile (25th percentile) to the upper quartile (75th percentiles). The line inside the box is the median (50th percentile). The whiskers show the lower and upper extremes excluding outliers, which are data points that fall more than 1.5 × IQR beyond the upper or lower quartiles.



broadband level

The total level measured over a specified frequency range. If the frequency range is unspecified, the term refers to the entire measured frequency range.

candidate detection

An acoustic signal that has been flagged by an automated detector in real time but has not been validated by a human analyst. A term commonly used in real-time or near-real-time monitoring and mitigation.

cavitation

A rapid formation and collapse of vapor cavities (i.e., bubbles or voids) in water, most often caused by a rapid change in pressure. Fast-spinning vessel propellers typically cause cavitation, which creates a lot of noise.

cetacean

Member of the order Cetacea. Cetaceans are aquatic mammals and include whales, dolphins, and porpoises.

decade

Logarithmic frequency interval whose upper bound is ten times larger than its lower bound (ISO 80000-3:2006). For example, one decade up from 1000 Hz is 10,000 Hz, and one decade down is 100 Hz.

decibel (dB)

Unit of level used to express the ratio of one value of a power quantity to another on a logarithmic scale. Especially suited to quantify variables with a large dynamic range.

decidecade

One tenth of a decade. Approximately equal to one third of an octave (1 ddec ≈ 0.3322 oct), and for this reason sometimes referred to as a 1/3 octave.

decidecade band

Frequency band whose bandwidth is one decidecade. The bandwidth of a decidecade band increases with increasing centre frequency.

ensonified

Exposed to sound.

frequency

The rate of oscillation of a periodic function measured in cycles per unit time. The reciprocal of the period. Unit: hertz (Hz). Symbol: f. 1 Hz is equal to 1 cycle per second.

hertz (Hz)

Unit of frequency defined as one cycle per second. Often expressed in multiples such as kilohertz (1 kHz = 1000 Hz).

hydrophone

An underwater sound pressure transducer. A passive electronic device for recording or listening to underwater sound.

level

A measure of a quantity expressed as the logarithm of the ratio of the quantity to a specified reference value of that quantity. For example, a value of sound pressure level with reference to 1 μPa^2 can be written in the form x dB re 1 μPa^2.

manual analysis

Human examination of acoustic data via visual review of spectrograms and/or aural inspection of data.

manual detection

The output of manual analysis as recorded in an annotation.

median

The 50th percentile of a statistical distribution.

mysticete

Member of the Mysticeti, a suborder of cetaceans. Also known as baleen whales, mysticetes have baleen plates (rather than teeth) that they use to filter food from water (or from sediment as for grey whales). This group includes rorquals (Balaenopteridae, such as blue, fin, humpback, and minke whales), right and bowhead whales (Balaenidae), and grey whales (*Eschrichtius robustus*).

octave

The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

odontocete

Member of Odontoceti, a suborder of cetaceans. These whales, dolphins, and porpoises have teeth (rather than baleen plates). Their skulls are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

otariid

Member of the family Otariidae, one of the three groupings of pinnipeds (along with phocids and walrus). These eared seals, commonly called fur seals and sea lions, are adapted to semi-aquatic life; they use their large fore flippers for propulsion underwater and can walk on all four limbs on land.

peak sound pressure level (PK), zero-to-peak sound pressure level

The level (L_{pk}) of the squared maximum magnitude of the sound pressure (p^2_{pk}) in a stated frequency band and time window. Defined as L_{pk} = 10log$_{10}$(p^2_{pk}/p^2_0) = 20log$_{10}$(p_{pk}/p_0). Unit: decibel (dB). Reference value (p^2_0) for sound in water: 1 μPa^2.

peak-to-peak sound pressure

The difference between the maximum and minimum sound pressure over a specified frequency band and time window. Unit: pascal (Pa).

percentile level

The sound level not exceeded *N* % of the time during a specified time interval. The *N*th percentile level is equal to the (100−*N*) % exceedance level.

phocid

Member of the family Phocidae, one of the three groupings of pinnipeds (along with otariids and walrus). These true/earless seals are more adapted to in-water life than are otariids, which have more terrestrial adaptations. Phocids use their hind flippers to propel themselves underwater.

pinniped

Member of the superfamily Pinnipedia, which is composed of phocids (true seals or earless seals), otariids (eared seals or fur seals and sea lions), and walrus.

power spectral density

Generic term, formally defined as power in a unit frequency band. Unit: watt per hertz (W/Hz). The term is sometimes loosely used to refer to the spectral density of other parameters such as squared sound pressure. Ratio of energy spectral density, E_f, to time duration, Δt, in a specified temporal observation window. In equation form, the power spectral density P_f is given by $P_f = E_f/\Delta t$. Power spectral density can be expressed in terms of various field variables (e.g., sound pressure, sound particle displacement).

power spectral density level

The level ($L_{P,f}$) of the power spectral density (P_f) in a stated frequency band and time window. Defined as: $L_{P,f}$ = 10log$_{10}$($P_f / P_{f,0}$). Unit: decibel (dB).

As with power spectral density, power spectral density level can be expressed in terms of various field variables (e.g., sound pressure, sound particle displacement). The reference value ($P_{f,0}$) for power spectral density level depends on the nature of the field variable.

received level

The level of a given field variable measured (or that would be measured) at a given location.

reference value

Standard value of a quantity used for calculating underwater sound level. The reference value depends on the quantity for which the level is being calculated:

Quantity	Reference value
Sound pressure	$p_0{}^2$ = 1 μPa^2 or p_0 = 1 μPa
Sound exposure	E_0 = 1 μPa^2 s
Sound particle displacement	$\delta_0{}^2$ = 1 pm^2
Sound particle velocity	$u_0{}^2$ = 1 nm^2/s^2
Sound particle acceleration	$a_0{}^2$ = 1 μm^2/s^4

sound

A time-varying disturbance in the pressure, stress, or material displacement of a medium propagated by local compression and expansion of the medium. In common meaning, a form of energy that propagates through media (e.g., water, air, ground) as pressure waves.

sound exposure level (SEL)

The level (L_E) of the sound exposure (E) in a stated frequency band and time window: L_E = 10log$_{10}$(E/E_0) (ISO 18405:2017). Unit: decibel (dB). Reference value (E_0) for sound in water: 1 μPa^2 s.

sound pressure

The contribution to total pressure caused by the action of sound (ISO 18405:2017). Unit: pascal (Pa). Symbol: p.

sound pressure level (SPL), rms sound pressure level

The level (L_p) of the time-mean-square sound pressure (p^2_{rms}) in a stated frequency band and time window: L_p = 10log$_{10}$(p^2_{rms}/p^2_0) = 20log$_{10}$(p_{rms}/p_0), where rms is the abbreviation for root-mean-square. Unit: decibel (dB). Reference value (p^2_0) for sound in water: 1 μPa^2. SPL can also be expressed in terms of the root-mean-square (rms) with a reference value of p_0 = 1 μPa. The two definitions are equivalent.

soundscape

The characterization of the ambient sound in terms of its spatial, temporal, and frequency attributes, and the types of sources contributing to the sound field (ISO 18405:2017).

spectrogram

A visual representation of acoustic amplitude over time and frequency. A spectrogram's resolution in the time and frequency domains should generally be stated as it determines the information content of the representation.

spectrum

Distribution of acoustic signal content over frequency, where the signal's content is represented by its power, energy, mean-square sound pressure, or sound exposure.

wavelength

Distance over which a wave completes one cycle of oscillation. Unit: meter (m). Symbol: λ.

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Appendix A. Recorder Calibration and Mooring Design

A.1. Recorder Calibrations

Each AMAR was calibrated before deployment and upon retrieval (battery life permitting) with a pistonphone type 42AC precision sound source (G.R.A.S. Sound & Vibration A/S; Figure A-1). The pistonphone calibrator produces a constant tone at 250 Hz at a fixed distance from the hydrophone sensor in an airtight space of known volume. The recorded level of the reference tone on the AMAR yields the system gain for the AMAR and hydrophone. To determine absolute sound pressure levels, this gain was applied during data analysis. Typical calibration variance using this method is less than 0.7 dB absolute pressure.

Figure A-1. Split view of a G.R.A.S. 42AC pistonphone calibrator with an M36 hydrophone.

A.2. Recorder Mooring Design

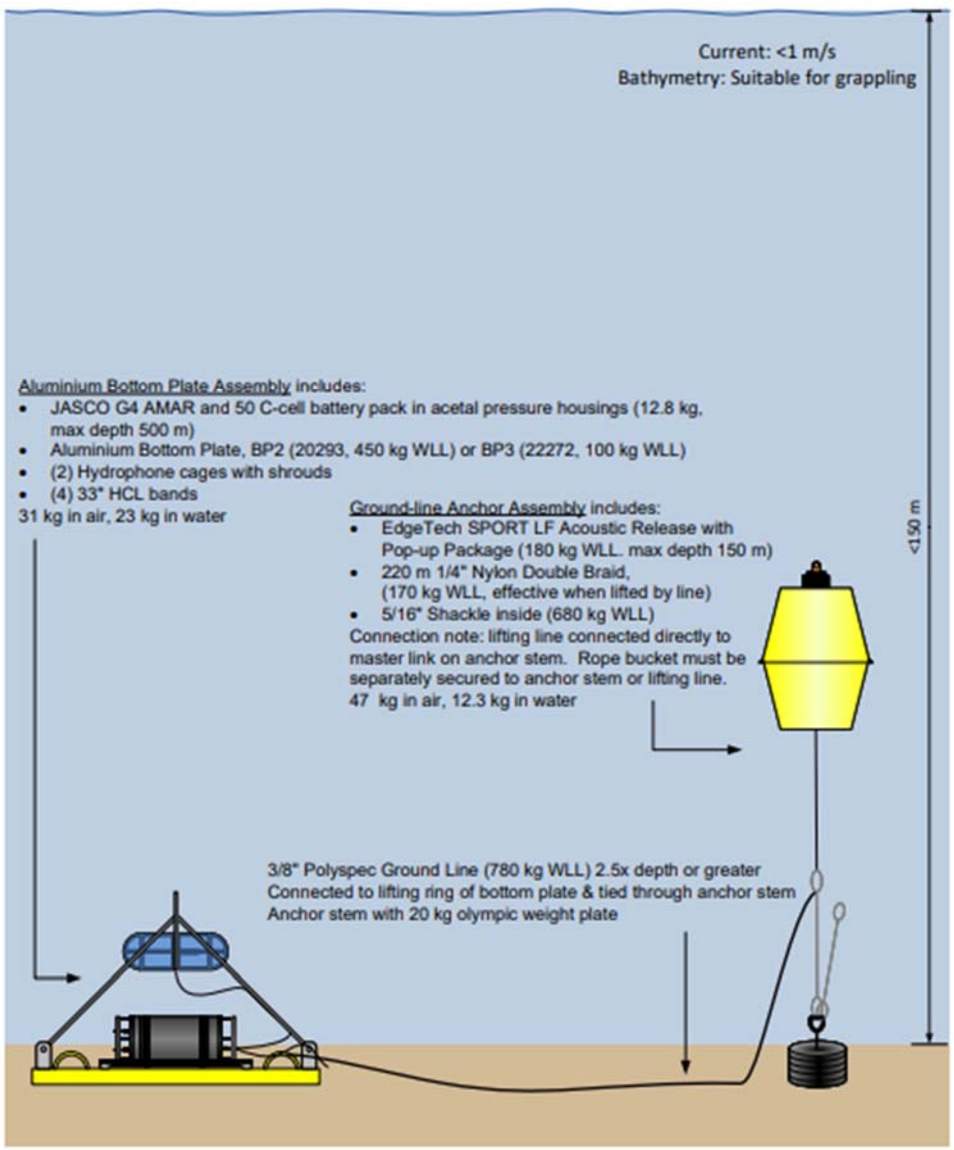

Figure A-2. Shallow mooring design with one acetal housing Autonomous Multichannel Acoustic Recorder Generation 4 (AMAR G4) attached to a bottom plate with a pop-up acoustic release.

Appendix B. Acoustic Data Analysis

The sampled data were processed for ambient sound analysis, vessel noise detection, and detection of all marine mammal vocalizations with JASCO's PAMlab acoustic analysis software suite. The major processing stages are outlined in Figure B-1. The results are calclutaed in terms of various acoustics metrics, defined in Appendix B.1, and in various frequency bands, defined in Appendix B.2.

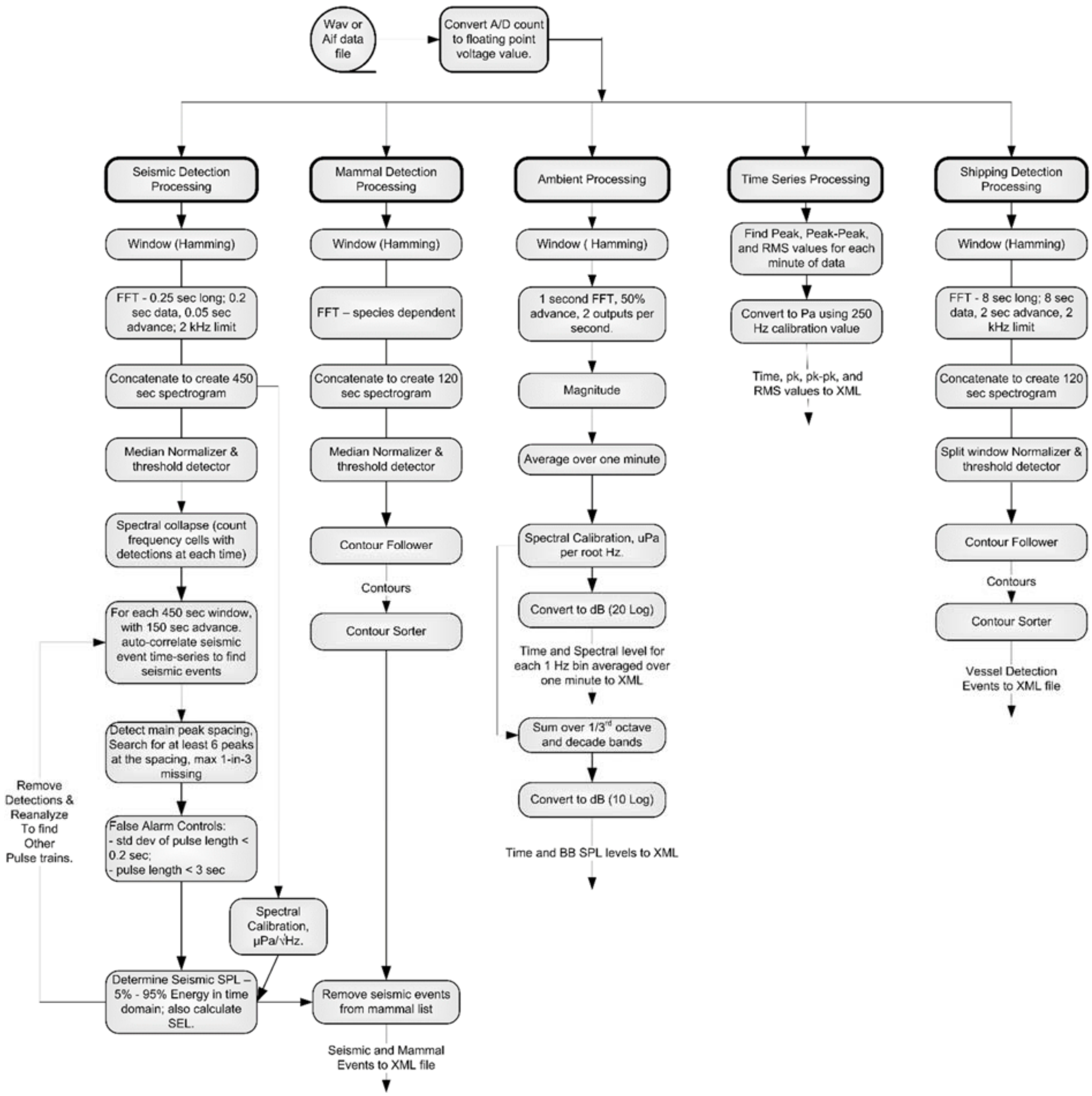

Figure B-1. Major stages of the automated acoustic analysis process performed with JASCO's PAMlab software suite.

B.1. Acoustic Metrics

Underwater sound pressure amplitude is quantified in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa. Because the perceived loudness of sound, especially pulsed sound such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate sound and its effects on marine life. Here we provide specific definitions of relevant metrics used in the accompanying report. Where possible, we follow International Organization for Standardization definitions and symbols for sound metrics (e.g., ISO 18405:2017a, ANSI S1.1-2013).

The zero-to-peak sound pressure, or peak sound pressure (PK or L_{pk}; dB re 1 μPa), is the decibel level of the maximum instantaneous sound pressure in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

$$L_{\text{pk}} = 10\log_{10}\frac{p_{\text{pk}}^2}{p_0^2} = 20\log_{10}\frac{p_{\text{pk}}}{p_0} = 20\log_{10}\frac{\max|p(t)|}{p_0}. \tag{B-1}$$

PK is often included as a criterion for assessing whether a sound is potentially injurious; however, because it does not account for the duration of an acoustic event, it is generally a poor indicator of perceived loudness.

The peak-to-peak sound pressure level (PK-PK or $L_{\text{pk-pk}}$; dB re 1 μPa) is the level of the difference between the maximum and minimum instantaneous sound pressure, possibly filtered in a stated frequency band, attained by an impulsive sound, $p(t)$:

$$L_{\text{pk-pk}} = 10\log_{10}\frac{(p_{\max}-p_{\min})^2}{p_0^2} = 10\log_{10}\frac{\{\max[p(t)]-\min[p(t)]\}^2}{p_0^2}. \tag{B-2}$$

The sound pressure level (SPL or L_p; dB re 1 μPa) is the root-mean-square (rms) pressure level in a stated frequency band over a specified time window (T; s):

$$L_p = 10\log_{10}\frac{p_{\text{rms}}^2}{p_0^2} = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)\,dt\Big/p_0^2\right). \tag{B-3}$$

It is important to note that SPL always refers to an rms pressure level (i.e., a quadratic mean over a time interval) and therefore not instantaneous pressure at a fixed point in time. The SPL can also be defined as the *mean-square* pressure level, given in decibels relative to a reference value of 1 μPa^2 (i.e., in dB re 1 μPa^2). The two definitions of SPL are numerically equivalent, differing only in reference value.

B.2. Decidecade Band Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the power spectral density of the sound. These values directly compare to the Wenz curves, which represent typical deep ocean sound levels (see Figure 2) (Wenz 1962). This splitting of the spectrum into passbands of a constant width of 1 Hz, however, does not represent how animals perceive sound.

Animals perceive exponential increases in frequency rather than linear increases, so analyzing a sound spectrum with passbands that increase exponentially in size better approximates real-world scenarios. In underwater acoustics, a spectrum is commonly split into decidecade bands, which are one tenth of a decade wide. A decidecade is sometimes referred to as a “1/3-octave” because one tenth of a decade is approximately equal to one third of an octave. Each decade represents a factor of 10 in sound frequency. Each octave represents a factor of 2 in sound frequency. The centre frequency of the ith decidecade band, $f_c(i)$, is defined as:

$$f_{\mathrm{c}}(i) = 10^{\frac{i}{10}}\ \mathrm{kHz}\,, \tag{B-4}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the ith decidecade band are defined as:

$$f_{\mathrm{lo},i} = 10^{\frac{-1}{20}} f_{\mathrm{c}}(i) \text{ and } f_{\mathrm{hi},i} = 10^{\frac{1}{20}} f_{\mathrm{c}}(i)\,. \tag{B-5}$$

The decidecade bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure B-2).

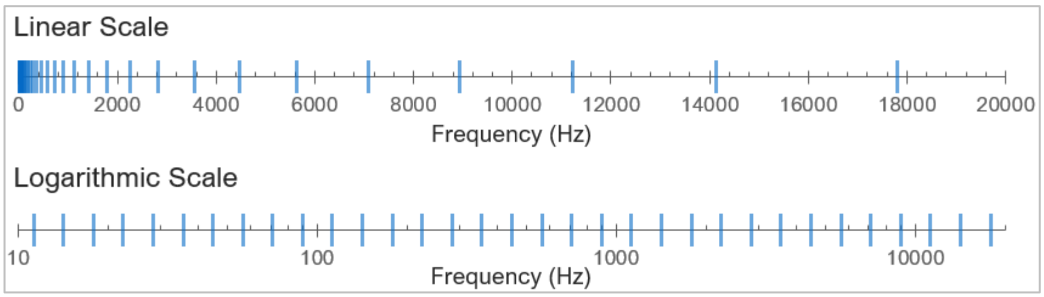

Figure B-2. Decidecade frequency bands (vertical lines) shown on (top) a linear frequency scale and (bottom) a logarithmic scale. On the logarithmic scale, the bands are equally spaced.

The sound pressure level in the ith band ($L_{p,i}$) is computed from the spectrum $S(f)$ between $f_{lo,i}$ and $f_{hi,i}$:

$$L_{p,i} = 10 \log_{10} \int_{f_{\mathrm{lo},i}}^{f_{\mathrm{hi},i}} S(f)\, \mathrm{d}f \ \mathrm{dB}\,. \tag{B-6}$$

Summing the sound pressure contributions of all the decidecade bands in the specified passband yields the sound pressure level in that passband:

$$\mathrm{SPL} = 10 \log_{10} \sum_i 10^{\frac{L_{p,i}}{10}}\ \mathrm{dB}\,. \tag{B-7}$$

Figure B-3 shows an example of how the decidecade band sound pressure levels compare to the sound pressure spectral density levels of an ambient sound signal. Because the decidecade bands are wider than 1 Hz, the decidecade band SPL is higher than the spectral levels at higher frequencies. Decidecade band analysis can be applied to continuous and impulsive sound sources. For impulsive sources, the decidecade band SEL is typically reported.

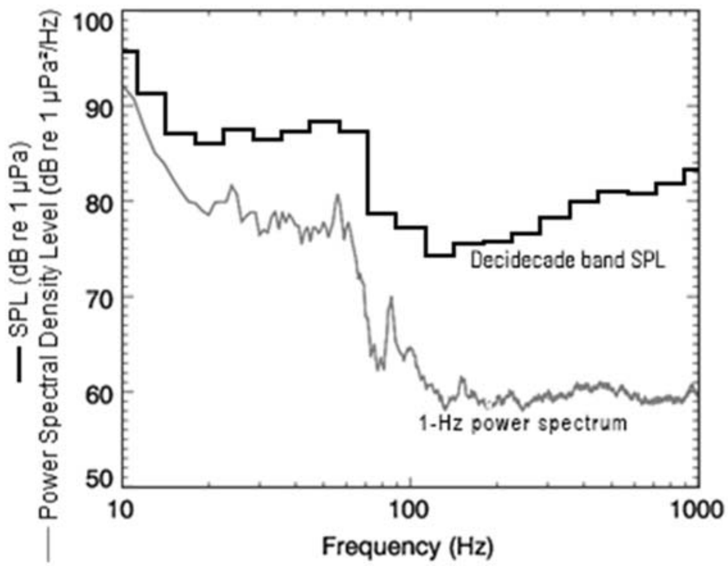

Figure B-3. Sound pressure spectral density levels and the corresponding decidecade band sound pressure levels of example ambient sound shown on a logarithmic frequency scale. Because the decidecade bands are wider with increasing frequency, the decidecade band SPL is higher than the power spectrum, which is based on bands with a constant width of 1 Hz.

Table B-1. Decidecade band centre and limiting frequencies (Hz).

Band	Lower frequency	Nominal centre frequency	Upper frequency		Band	Lower frequency	Nominal centre frequency	Upper frequency
10	8.9	10.0	11.2		33	1778	1995	2239
11	11.2	12.6	14.1		34	2239	2512	2818
12	14.1	15.8	17.8		35	2818	3162	3548
13	17.8	20.0	22.4		36	3548	3981	4467
14	22.4	25.1	28.2		37	4467	5012	5623
15	28.2	31.6	35.5		38	5623	6310	7079
16	35.5	39.8	44.7		39	7079	7943	8913
17	44.7	50.1	56.2		40	8913	10000	11220
18	56.2	63.1	70.8		41	11220	12589	14125
19	70.8	79.4	89.1		42	14260	16000	17952
20	89.1	100.0	112.2		43	17825	20000	22440
21	112	126	141		44	22281	25000	28050
22	141	158	178		45	28074	31500	35344
23	178	200	224		46	35650	40000	44881
24	224	251	282		47	44563	50000	56101
25	282	316	355		48	56149	63000	70687
26	355	398	447		49	71300	80000	89761
27	447	501	562		50	89125	100000	112202
28	562	631	708		51	111406	125000	140252
29	708	794	891		52	142600	160000	179523
30	891	1000	1122		53	178250	200000	224404
31	1122	1259	1413		54	222813	250000	Above Nyquist
32	1413	1585	1778					

Table B-2. Decade band centre and limiting frequencies (Hz).

Decade band	Lower frequency	Nominal centre frequency	Upper frequency
A	8.9	50	89.1
B	89.1	500	891
C	891	5,000	8913
D	8913	50,000	89125

Appendix C. Vessel Noise Detection

To find tonals, the spectrum of the data is found using an 8-second long fast Fourier transform (FFT), as recommended by Arveson and Vendittis (2000). A 120-second spectrogram is generated using a 4-second overlap between FFTs. The spectrogram is then normalized across frequencies using a split window normalizer with a 0.75 Hz notch and a 2 Hz window. A single frequency must be present for at least 20 seconds, and at least two frequencies must be present simultaneously for the algorithm to declare a tonal detection. The total number of tones per minute is recorded.

The frequency bands considered are the decidecades between 40 and 400 Hz. The SPL per minute is summed from the decidecades to obtain the SPL used in the analysis. To determine if the SPL in each minute may have a passing vessel, it must exceed an estimate of the background level by 3 dB. The background estimate is an exponential average of the previous shipping band SPL:

$$background(t) = \alpha \cdot background(t-1) + newValue(t)(1-\alpha)$$
$$\alpha = 1/720 \tag{C-1}$$
$$newValue(t) = \min\left(shippingSPL(t), background(t-1)+3\right)$$

This approach allows the background estimate to increase slowly when wind or vessel activity increases, but to decrease more quickly when sound levels decrease so that the detector can become sensitive to distant shipping again.

To identify minutes when vessels may be present, the following three criteria must be met (see Figure C-1):

- The shipping band SPL is at least 3 dB above the background.
- At least three shipping tonals are present; the average number of tonals in the previous 11 minutes is employed to smooth effects from noise and propagation, which can cause the number of detected tones to fluctuate.
- The shipping band SPL is within 9 dB of the total sound pressure level for the minute, i.e., shipping is a significant component of the recorded soundscape.

Internally, the algorithm identifies these minutes with a shipping detection flag value of 1.

Once the periods with possible vessel detections are identified (i.e., shipping detection flag set to 1), the periods with continuous detections are found, and the minute with the maximum shipping band SPL is identified as the closest point of approach. Additional checks are then performed to remove periods that are likely not vessels, according to the following criteria:

- The duration of the detection must be at least 5 minutes and less than 20 minutes.
- The maximum shipping band SPL must be at least 95 dB re 1 μPa^2.
- To be identified as the CPA, the difference between the minute with the shipping band SPL maximum and the average of its two neighbours must be less than 10 dB. This avoids issues with short noise events being falsely labelled as the CPA.

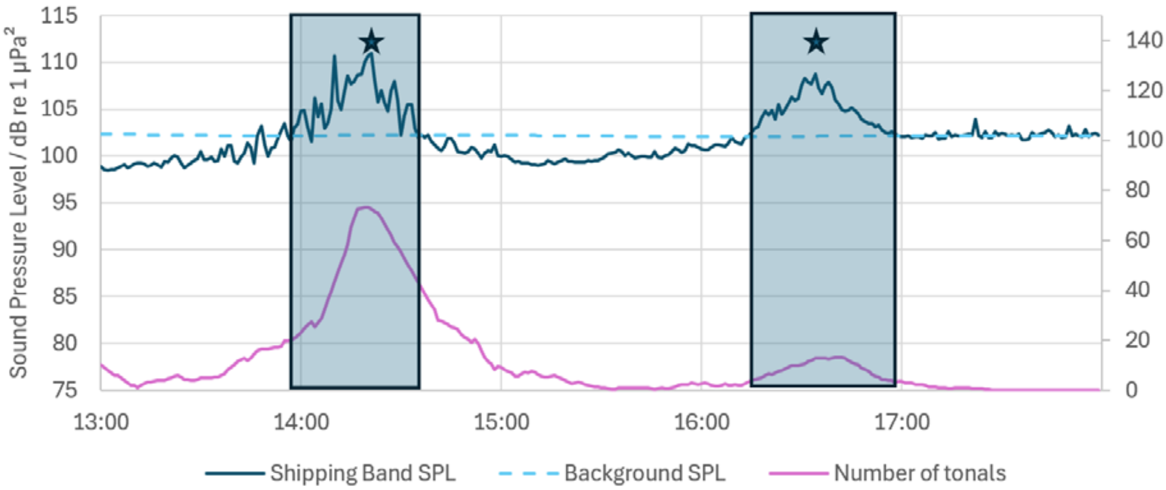

Figure C-1. Example of broadband and 40–400 Hz band sound pressure level (SPL), as well as the number of tonals detected per minute as two vessels passed the recorder in succession. The shaded area is the period of shipping detection. The stars mark the detected closest points of approach.

In the case of typical vessel CPA shown in Figure C-1, the vessel CPA flag is set to 1. The algorithm includes additional passes through the data to find times when there is likely a second vessel passing without triggering the standard CPA detection. The conditions for additional CPAs are the following:

- *Vessel CPA Flag 2*: A second rapid peak in SPL, identified when:
  - It has been at least 20 minutes since the previous CPA.
  - A local maximum in the shipping band SPL is found.
  - The difference between the local maximum and the average of its two adjacent minutes is at least 1 (but still less than 10).
  - The slopes of the shipping band sound pressure level, over the 10 minutes before the maximum and after the maximum (in dB/minute) sums to at least 0.5.
  - For this case, the detection flag must be set (i.e., the shipping band SPL is at least 3 dB above the background and at least three tones are detected).
- *Vessel CPA Flag 3*: There is a slow peak in SPL, identified when:
  - There are no CPAs within 20 minutes.
  - A local maximum in the shipping band SPL is found.
  - The difference between the local maximum and the average of the SPL 20 min before and 20 min after the peak is at least 4 dB.
  - For this case. the detection flag must be set (i.e., the shipping band SPL is at least 3 dB above the background and there are at least three tones detected).
- *Vessel CPA Flag 4*: There is no peak in SPL, but there is a peak in the number of tones, identified when:
  - There is period of at least 1 h without the detection flag set to 1.
  - There is a peak within that period where the maximum number of tones detected is at least 6 tones.

- The duration of the peak where there are at least three tones is at least 30 minutes.

For each minute where a vessel may be present, a metric to describe the spectral shape of the detection is computed. For every decidecade starting at 40 Hz, the average of that decidecade and one decidecade higher are summed, then the sum of the decidecades two below and three above the decidecade of interest is subtracted. For example, at 40 Hz, the value is $SPL_{ddec,40Hz} + SPL_{ddec,50Hz} - (SPL_{ddec,25Hz} + SPL_{ddec,80Hz})$. The maximum value between 40 and 400 Hz is stored as an indication of the spectral peak. Vessels are identified as low frequency if this peak less than 100 Hz. They are identified as a high frequency if it is equal to or greater than 100 Hz. If the frequency is equal to or greater than 100 Hz, the detection duration is shorter than 20 minutes, and the maximum shipping band SPL is at least 115 dB, they are identified as fast and high frequency. Low-frequency vessels include container ships, bulkers, tankers, etc. High-frequency ships are either smaller vessels such as fishers or vessels with specialized propulsion systems typical of passenger ships (MacGillivray and de Jong 2021). The total number of ships of each type per week is found and plotted as an indication of the volume and type of shipping in an area (see Figure C-2).

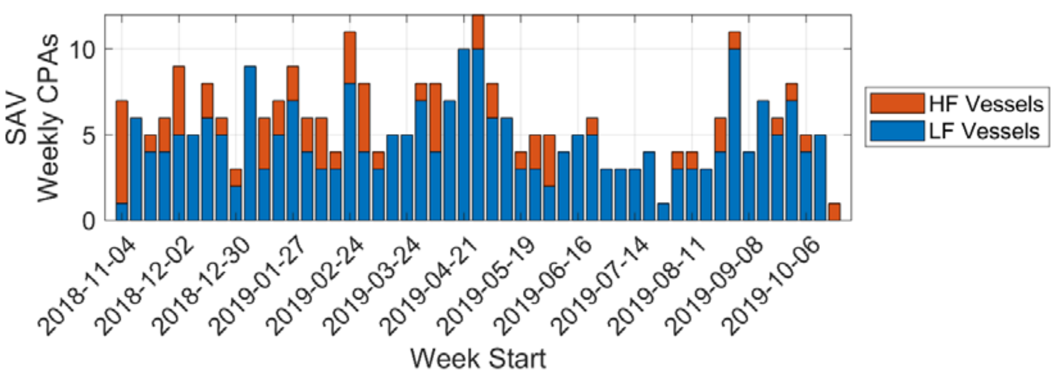

Figure C-2. Example of the types of vessels passing a recorder in deep water of the US Outer Continental Shelf. No high-frequency fast vessels were detected.

The performance of the vessel detector depends on the distance vessels pass by the recorder, propagation conditions, how fast the vessels travel (directly relates to how loud they are), and the number of ships passing, as they can mask each other. Performance was evaluated using AIS records for a recorder in deep water off the US East Coast. 411 AIS tracks were recorded in a 1-eyar period. Of those, 188 were associated with an acoustic CPA. 1018 acoustic CPAs were detected for which no AIS track was associated—this seems to be common—a significant proportion of acoustic CPAs do not have AIS tracks. Reliable detection of events in this location was only to 10 km, with better than 50 % detection out to 20 km (Figure C-3).

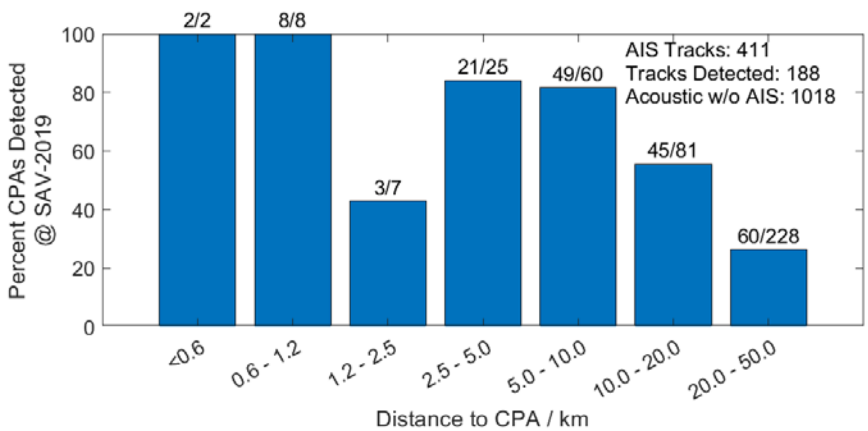

Figure C-3. Probability of detecting passing vessels from a recorder near shipping lanes in the Gulf of St. Lawrence, Canada. The numbers above each bar indicate the total number of vessels passing at each distance bracket. A 10 kn speed restriction was in effect during this recording.

The algorithm supports two modes of operation: the normal mode and a set of conditions for very shallow coastal water, lakes, or rivers where there are small fast craft passing regularly. In this configuration, the minimum duration of a vessel passage becomes 3 minutes, and the difference between the maximum shipping band SPL minute, the average of its neighbours can be 20, and the minimum value for the shipping band SPL is 95 dB re 1 μPa².

Appendix D. Marine Mammal Detection Methodology

D.1. Automated Click Detector for Odontocetes

Figure D-1 shows how JASCO applies an automated click detector/classifier to the data to detect clicks from odontocetes. This detector/classifier is based on the zero-crossings in the acoustic time series. Zero-crossings are the rapid oscillations of a click's pressure waveform above and below the signal's normal level. Clicks are detected by the following steps:

1. The raw data are high-pass filtered to remove all energy below 5 kHz. This removes most energy from sources other than odontocetes (such as shrimp, vessels, wind, and cetacean tonal calls) yet allows the energy from all marine mammal click types to pass.
2. The filtered samples are summed to create a 0.334 ms rms time series. Most marine mammal clicks have a 0.1–1 ms duration.
3. Possible click events are identified with a split-window normalizer that divides the 'test' bin of the time series by the mean of the 6 'window' bins on either side of the test bin, leaving a 'notch' that is 1-bin wide.
4. A Teager-Kaiser energy detector identifies possible click events.
5. The high-pass filtered data are searched to find the maximum peak signal within 1 ms of the detected peak.
6. The high-pass filtered data are searched backwards and forwards to find the time span when the local data maxima are within 9 dB of the maximum peak. The algorithm allows for two zero-crossings to occur where the local peak is not within 9 dB of the maximum before stopping the search. This defines the time window of the detected click.
7. The classification parameters are extracted. The number of zero crossings within the click, the median time separation between zero crossings, and the slope of the change in time separation between zero-crossings are computed. The slope parameter helps identify beaked whale clicks, because beaked whales can be identified by the increase in frequency (upsweep) of their clicks.
8. The Mahalanobis distance between the extracted classification parameters and the templates of known click types is computed. The covariance matrices for the known click types (computed from thousands of manually identified clicks for each species) are stored in an external file. Each click is classified as a type with the minimum Mahalanobis distance unless none of them are less than the specified distance threshold.

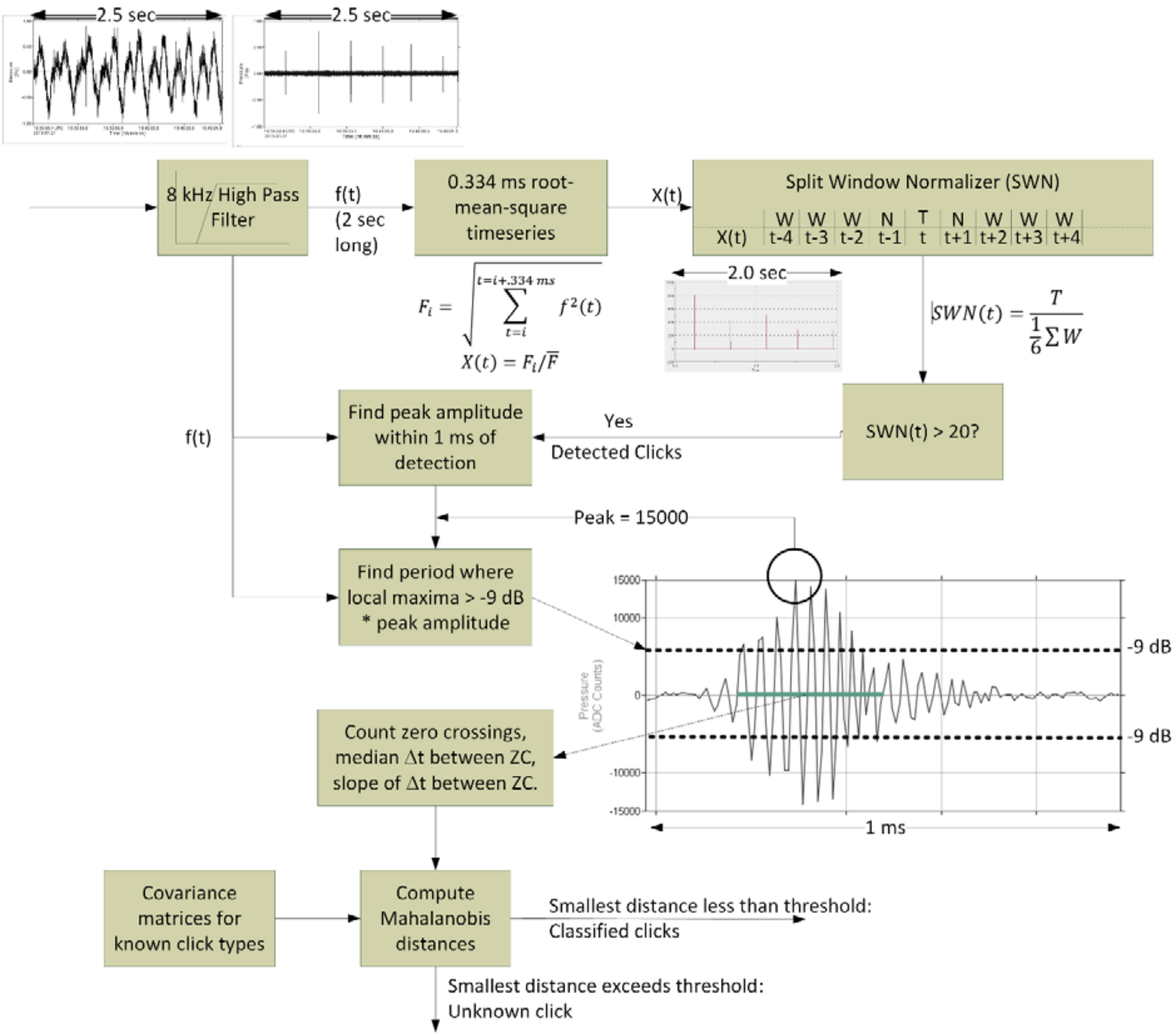

Figure D-1. Flowchart of the automated click detector/classifier process.

Odontocete clicks occur in groups called click trains. Each species has a characteristic inter-click-interval (ICI) and number of clicks per train. As shown in Figure D-2, the automated click detector includes a second stage that associates individual clicks into trains. The automated click train detector performs the following steps:

1. Queue clicks for N seconds, where N is twice the maximum number of clicks per train times the maximum ICI.
2. Search for all clicks within the window that have Mahalanobis distances less than 11 for a species of interest (this finds 80 % of all clicks for the species as defined by the template).
3. Create a candidate click train if:
    a. The number of clicks is greater or equal to the minimum number of clicks in a train;
    b. The maximum time between any two clicks is less than 2.5 times the maximum ICI, and
    c. The smallest Mahalanobis distance for all clicks in the candidate train is less than 4.1.

4. Create a new ‘time series’ with a value of 1 at the time of arrival for each click and zero everywhere else (using a ‘time series’ with a bin duration of 0.5 ms).
5. Apply a Hann window to the time series, and then compute the cepstrum.
6. A click train is classified if a peak in the cepstrum with an amplitude greater than five times the standard deviation of the cepstrum occurs at a quefrency between the minimum maximum ICI.
7. For each click related to the previous N cepstrum, create a new time series and compute ICI. If there is a good match, then extend the click train.
8. Output a species_click_train detection if the click features, total clicks, and mean ICI match the species.

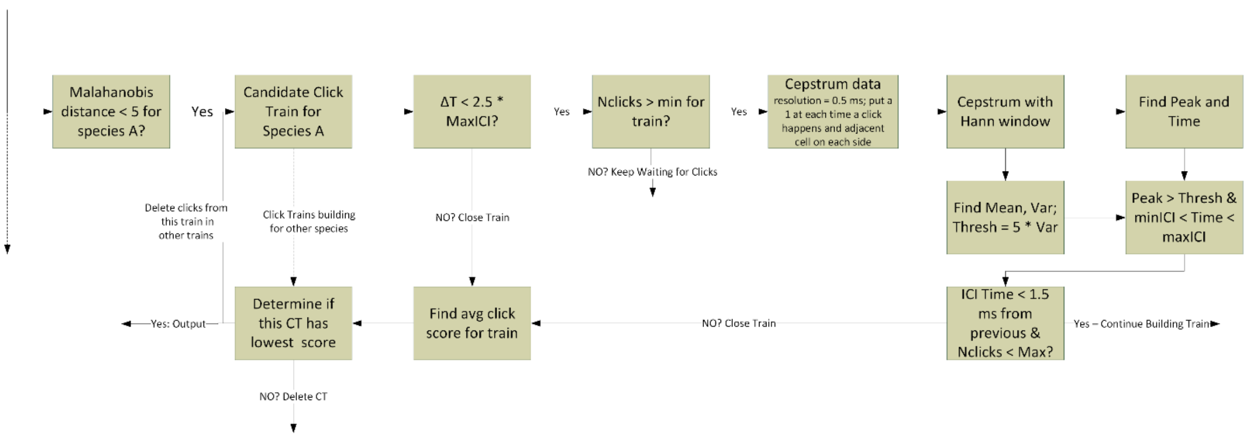

Figure D-2. Flowchart of the click train automated detector/classifier process.

D.2. Automated Tonal Signal Detection

Marine mammal tonal acoustic signals are automatically detected using the contour detection and following algorithm depicted in Figure D-3. The algorithm has the following steps:

1. Create spectrograms of the appropriate resolution for each mammal vocalization type that were normalized by the median value in each frequency bin for each detection window (Table D-1).
2. Join adjacent bins and create contours via a contour-following algorithm (Figure D-4).
3. Apply a sorting algorithm to determine if the contours match the definition of a marine mammal vocalization (Table D-2).

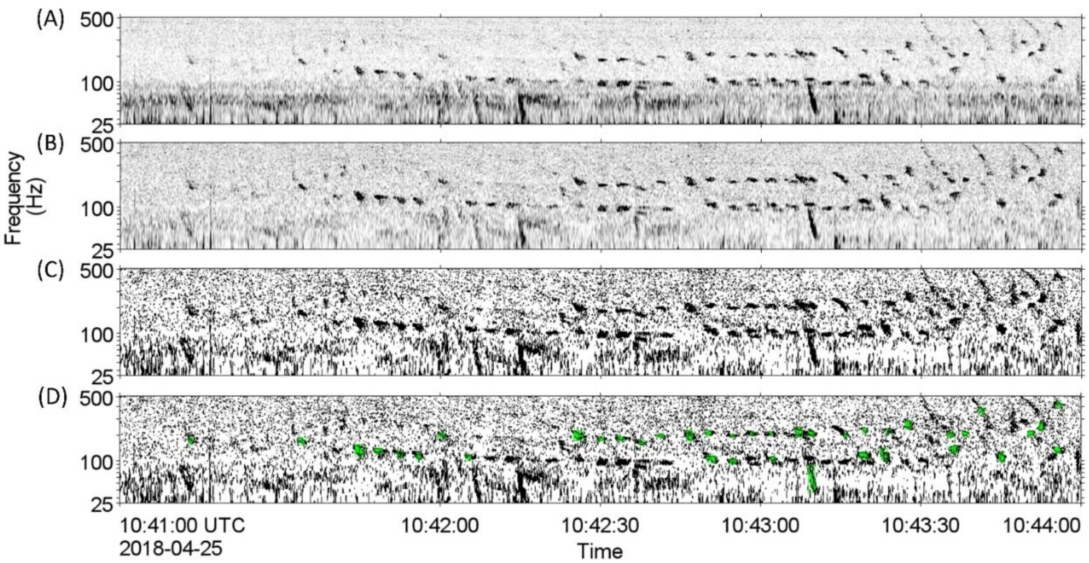

Figure D-3. Illustration of the contour detection process. (A) A spectrogram is generated at the frequency and time resolutions appropriate for the tonal calls of interest. (B) A median normalizer is applied at each frequency. (C) The data are turned into a binary representation by setting all normalized values less than the threshold to 0 and all values greater than the threshold to 1. (D) The regions that are ‘1’ in the binary spectrogram are connected to create contours, which are then sorted to detect signals of interest, shown here as green overlays.

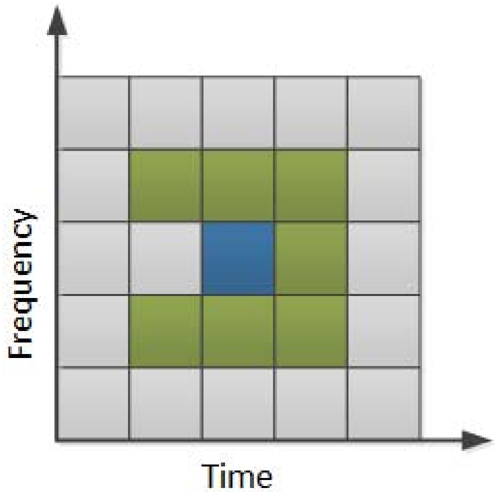

Figure D-4. Illustration of the search area used to connect spectrogram bins. The blue square represents a bin of the binary spectrogram equalling 1, and the green squares represent the potential bins it could be connected to. The algorithm advances from left to right, so grey cells left of the test cell need not be checked.

Table D-1. Discrete Fourier Transform (DFT) and detection window settings for all automated contour-based detectors used to detect tonal vocalizations of marine mammal species expected in the data. Values are based on JASCO's experience and empirical evaluation of various data sets. Due to the overlapping characteristics of some species' signals, automated detectors developed for a particular signal (Primary species (signal) targeted), can also effectively detect the signals of other species (Other species (signal) targeted). For some signals, JASCO applies many automated detectors and during manual validation determines which perform best.

Automated detector	Primary species (signal) targeted	Other species (signal) targeted	Discrete Fourier transform			Detection window (s)	Detection threshold
			Frequency step (Hz)	Temporal observation window (s)	Time advance (s)		
Atl_BW_GL_IM	Blue whale (A-B song)	NA	0.125	2	0.5	40	4
Atl_BW_IM1_TH4			0.125	2	0.5	40	4
Atl_BW_IM1_TH6			0.125	2	0.5	40	6
Atl_BW_IM2_TH4			0.125	2	0.5	120	4
Atl_BW_IM2_TH6			0.125	2	0.5	120	6
Atl_BW_IM3			0.125	8	2	40	4
BWBaleen1_Down_TH2 BWBaleen7_NZDown_TH2 BWBaleen11_UpDown_TH2 BWBaleen12_UpDown_HF_TH2	Blue whale (non-song call)	Sei whale (downsweep)	2	0.3	0.1	30	2
BWBaleen2_Down_TH3 BWBaleen5_NZDown_TH3 BWBaleen8_EIODown_TH3 BWBaleen13_UpDown_TH3			2	0.3	0.1	30	3
BWBaleen3_Down_TH5 BWBaleen4_AUDown_TH5 BWBaleen10_EIODown_TH5 BWBaleen15_UpDown_TH5			2	0.3	0.1	30	5
BWBaleen6_NZShortDown_TH4 BWBaleen9_EIODown_TH4 BWBaleen14_UpDown_TH4			2	0.3	0.1	30	4
BWBaleen16_Down_TH2			2	0.25	0.05	10	2
BWBaleen17_Down_TH2			2	0.25	0.05	10	4
FW1_20Hz_TH1.7 FW 7_20Hz_TH1.7	Fin whale (20 Hz pulse)	NA	1	0.2	0.05	5	1.7
FW 2_20Hz_TH4			1	0.2	0.05	5	4
FW3_20Hz_TH2			1	0.3	0.1	30	2
FW4_20Hz_TH3.7			1	0.2	0.05	5	3.7
FW5_20Hz_TH6			1	0.2	0.05	5	6
FW 6_20Hz_TH5			1	0.2	0.05	5	5
VLFMoan			2	0.2	0.05	15	4
NAtl_FW_130_TH2	Fin whale (130 Hz call)	Humpback whale (moan), Right whale (moan)	2	0.5	0.1	30	2
NAtl_FW_130_TH3			2	0.2	0.05	5	3
LFMoan	Bowhead, humpback (moan)	Blue whale (D call), fin whale (40 Hz call)	2	0.25	0.05	10	3
HB		Right whale (moan)	4	0.128	0.032	30	3
MFMoanLow_TH3			4	0.2	0.05	5	3
MFMoanLow_TH5			4	0.2	0.05	5	5
MFMoanHigh_TH3			8	0.125	0.05	5	3

MFMoanHigh_TH5		Killer whale, (whistle), Beluga (whistle)	8	0.125	0.05	5	5
ShortLow		Pinnipeds (moan), fish (grunt)	7	0.17	0.025	10	3
RW1_Upcall_TH3 RW3_Upcall_HF_TH3	Right whale (upcall)	Humpback whale (moan)	4	0.128	0.032	10	3
RW 2_Upcall_TH2 RW4_Upcall_TH2 RW6_UpcallCatchEmAll_TH 2			4	0.128	0.032	10	2
RW5_UpcallCatchEmAll_TH 4			4	0.128	0.032	10	4
RW7_UpcallCatchEmAll_TH 3			4	0.128	0.032	10	3
SWBaleen1_ShortDown_TH 3.5	Sei whale (downsweeps)	Blue whale (non-song call)	3.25	0.2	0.035	5	3.5
SWBaleen2_ShortDown_TH 5.5			3.25	0.2	0.035	5	5.5
SWBaleen3_ShortDown_TH 2.5			3.25	0.2	0.035	5	2.5
SWBaleen4_ShortDown_TH 5			3.25	0.2	0.035	5	5
SWBaleen5_ShortDown_TH 3			2	0.5	0.1	30	3
SWBaleen6_ShortDown_TH 3			3.25	0.2	0.035	5	3
SWBaleen7_ShortDown_TH 2			3.25	0.2	0.035	5	2
Atl_MWPulseTrain	Minke whale (pulse train)	NA	8	0.1	0.025	40	3.5
NW_LFbuzz	Narwhal (buzz)	Beluga (buzz)	16	0.03	0.015	5	2
NW_HFbuzz			64	0.01	0.005	5	2.5
NW_KnockTrain	Narwhal (knock)	NA	64	0.01	0.005	40	2
NW_Whistle	Narwhal (whistle)	Beluga (whistle)	4	0.05	0.01	5	3.5
BeardedSeal1_downsweep Beardedseal3_upsweep	Bearded seal (trill)	NA	2	0.2	0.05	10	3
Beardedseal2_fulltrill			4	0.25	0.125	10	3
HbrS_1	Harbour seal (roar)	NA	8	0.128	0.032	30	3
HbrS_2			20	0.06	0.03	35	2.2
RibbonSeal	Ribbon seal (downsweep)	Beluga, narwhal (whistle), Bowhead whale (moan)	4	0.1	0.05	5	3
RingedSeal	Ringed seal (double thump)	NA	20	0.05	0.025	5	4
Walrus	Walrus (knock)	NA	32	0.03125	0.016	5	4
WhistleHighSuppress	Small dolphin (whistle with energy between 4-20 kHz)	Killer whale (whistle)	64	0.015	0.005	10	1.5
WhistleHigh_TH1.5			64	0.015	0.005	10	1.5
WhistleHigh_TH4.5			64	0.015	0.005	10	4.5
WhistleLowSuppress	Pilot, killer whale (whistle with energy between 1-10 kHz)	Small dolphin, narwhal, beluga (whistle)	8	0.125	0.05	10	1.5
WhistleLow_TH1.5			8	0.125	0.05	10	1.5
WhistleLow_TH4.5			8	0.125	0.05	10	4.5

Table D-2. A sample of vocalization sorter definitions for the tonal vocalizations of cetacean species expected in the area. Automated detectors are capable of triggering on species and signals beyond those targeted.

Automated detector	Frequency (Hz)	Duration (s)	Bandwidth (Hz)	Other parameters
Alt_BW_GL_IM	14-22	8.00-30.00	1-5	f_{min} <18 Hz, 16.5< f_{peak} <17.5Hz, -500<SR<0 Hz/s
Atl_BW_IM1_TH4 Atl_BW_IM1_TH6	14-22	8.00-30.00	1-5	f_{min} <18 Hz, 16.5< f_{peak} <18 Hz, -500<SR<0 Hz/s
Atl_BW_IM2_TH4 Atl_BW_IM2_TH6	15-22	8.00-30.00	1-5	f_{min} <18 Hz
Atl_BW_IM3	14-22	7.00-30.00	0.375-6	f_{min} <18 Hz, 16.5< f_{peak} <18.5 Hz, -10<SR<10 Hz/s
BWBaleen1_Down_TH2	19-150	1.50-5.00	30-131	f_{min} <40 Hz, MIB <30 Hz, -20<SR<-5 Hz/s
BWBaleen2_Down_TH3	10-100	1.90-5.00	30-80	f_{min} <40 Hz, MIB <30 Hz, -30<SR<-5 Hz/s
BWBaleen3_Down_TH5	19-150	1.80-5.00	35-180	f_{min} <30 Hz, MIB <30 Hz, -20<SR<-10 Hz/s
BWBaleen4_AUDown_TH5	19-150	1.60-3.50	0.40-131	f_{min} <60 Hz, MIB <40 Hz, -30<SR<-10 Hz/s
BWBaleen5_NZDown_TH3 BWBaleen7_NZDown_TH2	25-80	1.50-4.00	15-60	f_{min} <40 Hz, MIB <20 Hz, -20<SR<-5 Hz/s
BWBaleen6_NZShortDown_TH4	25-60	1.00-2.70	20-30	f_{min} <40 Hz, MIB <20 Hz, -15<SR<-2 Hz/s
BWBaleen8_EIODown_TH3 BWBaleen9_EIODown_TH4 BWBaleen10_EIODown_TH5	10-80	1.30-5.00	30-80	f_{min} <40 Hz, MIB <30 Hz, -20<SR<-5 Hz/s
BWBaleen11_UpDown_TH2	10-90	2.00-7.00	30-80	f_{min} <40 Hz, MIB <30 Hz
BWBaleen12_UpDown_HF_TH2	40-100	1.80-10.00	20-60	f_{min} <60 Hz, MIB <25 Hz
BWBaleen13_UpDown_TH3	10-90	2.00-10.00	30-80	f_{min} <40 Hz, MIB <30 Hz
BWBaleen14_UpDown_TH4	10-90	2.00-7.00	30-80	f_{min} <40 Hz, MIB <30 Hz
BWBaleen15_UpDown_TH5	10-90	2.00-10.00	30-90	f_{min} <40 Hz, MIB <30 Hz
BWBaleen16_Down_TH2	20-100	2.00-10.00	10-15	MIB <30 Hz, -15<SR<-5 Hz/s
BWBaleen17_Down_TH2	20-100	2.00-10.00	>15	MIB <30 Hz, -15<SR<-5 Hz/s
FW1_20Hz_TH1.7	10-40	0.40-3.00	>6	f_{min} <17 Hz, 20< f_{peak} <22 Hz, -100<SR<0 Hz/s
FW2_20Hz_TH4	8-40	0.30-3.00	>6	f_{min} <17 Hz, -100<SR<0 Hz/s
FW3_20Hz_TH2 FW4_20Hz_TH3.7	10-40	0.40-3.00	>6	f_{min} <17 Hz, 20< f_{peak} <22 Hz, -30<SR<0 Hz/s
FW5_20Hz_TH6	8-40	0.30-3.00	>6	f_{min} <17 Hz, -30<SR<0 Hz/s
FW 6_20Hz_TH5 FW7_20Hz_TH1.7	3-50	0.40-3.00	>6	f_{min} <17 Hz, MIB <30 Hz, 20< f_{peak} <23.5 Hz, -30<SR<0 Hz/s
NAtl_ FW_130_TH2	110-140	0.70-3.00	>3	f_{min} <130 Hz
NAtl_ FW_130_TH3	110-150	0.30-1.50	>6	f_{min} <125 Hz
VLFMoan	10-100	0.30-10.00	>10	f_{min} <40 Hz
LFMoan	40-250	0.50-10.00	>15	MIB <50 Hz
HB	100-700	0.50-8.00	>50	f_{min} <500 Hz, MIB <200 Hz
MFMoanLow_TH3 MFMoanLow_TH5	100-700	0.50-5.00	>50	f_{min} <450 Hz, MIB <200 Hz
MFMoanHigh_TH3 MFMoanHigh_TH5	500-2500	0.50-5.00	>150	f_{min} <1500 Hz, MIB <300 Hz
ShortLow	30-400	0.08-0.60	>25	None
RW1_Upcall_TH3	50-300	0.45-1.70	80-180	f_{min} <110 Hz, MIB <90 Hz, 50<SR<130 Hz/s
RW 2_Upcall_TH2	60-300	0.55-1.70	120-300	f_{min} <110 Hz, MIB <70 Hz, 80< f_{peak} <140 Hz, 100<SR<145 Hz/s
RW3_Upcall_HF_TH3	100-300	0.50-1.20	80-195	f_{min} <180 Hz, MIB <90 Hz, 120<SR<150 Hz/s
RW4_Upcall_TH2	50-300	0.45-1.70	50-180	f_{min} <150 Hz, MIB <90 Hz, 50<SR<240 Hz/s
RW5_UpcallCatchEmAll _TH4 RW7_UpcallCatchEmAll_TH3	50-400	0.35-2.00	<350	f_{min} <150 Hz, 20<SR<240 Hz/s

SWBaleen1_ShortDown_TH3.5	20-150	0.50 1.70	19-120	MIB <120 Hz, -60<SR<-10 Hz/s
SWBaleen2_ShortDown_TH5.5	20-150	0.50 1.70	19-120	MIB <70 Hz, -60<SR<-10 Hz/s
SWBaleen3_ShortDown_TH2.5	20-100	1.00-1.70	30-80	MIB <100 Hz, -60<SR<-10 Hz/s
SWBaleen4_ShortDown_TH5	20-80	1.00-1.70	30-80	MIB <100 Hz, -60<SR<-10 Hz/s
SWBaleen5_ShortDown_TH3	20-120	1.00-4.00	30-100	MIB <35 Hz, -50<SR<-10 Hz/s
SWBaleen6_ShortDown_TH3	20-120	0.50-1.70	30-95	f_{min} <110 Hz, MIB <70 Hz, 80< f_{peak} <140 Hz, -60<SR<-20 Hz/s
SWBaleen7_ShortDown_TH2	20-120	0.50-1.70	30-95	f_{min} <40 Hz, MIB <30 Hz, 20< f_{peak} <60 Hz, -60<SR<-20 Hz/s
Atl_MWPulseTrain	50-500	0.025-0.30	NA	0.25-2 s pulse gap, 10-100 s train length
NW_LFbuzz	1000-10,000	0.50-5.00	>1000	f_{min} <5000 Hz
NW_HFbuzz	14,000-100,000	0.10-10.00	>3000	None
NW_KnockTrain	1000-8000	0.005-0.04	NA	0.03-0.5 s pulse gap, 0.5-30 s train length
NW_Whistle	1000-20,000	0.50-5.00	20-1000	f_{min} <9000 Hz, MIB <800 Hz
BeardedSeal1_downsweep	200-1500	1.00-10.00	>100	f_{min} <1500 Hz, MIB <200 Hz, -250<SR<-5 Hz/s
BeardedSeal2_fulltrill	125-8200	10.00-90.00	>500	-150<SR<-5 Hz/s
BeardedSeal3_upsweep	150-2000	1.00-6.00	>100	f_{min} <2000 Hz, MIB <200 Hz, 40<SR<250 Hz/s
HbrS_1	75-1200	0.75-2.00	250-1000	f_{min} <150 Hz
HbrS_2	75-1200	0.50-2.00	100-1000	f_{min} <150 Hz
RibbonSeal	200-2000	0.60-2.50	400-1800	-1500<SR<-500 Hz/s
RingedSeal	10-250	0.20-1.00	>20	f_{min} <50 Hz
Walrus	20-8000	0.03-0.30	>1200	f_{min} <750 Hz
WhistleHigh_TH1.5 WhistleHigh_TH4.5	4000-20,000	0.30-5.00	>700	MIB <2000 Hz
WhistleHighSuppress	4000-12,000	0.30-5.00	>700	MIB <2000 Hz, suppress detections for SPL >125 dB from 50-1000 Hz
WhistleLow_TH1.5 WhistleLow_TH4.5	1000-10,000	0.80-5.00	>300	f_{min} 5000 Hz, MIB <1000 Hz
WhistleLowSuppress	1000-10,000	0.80-5.00	>300	f_{min} <5000 Hz, MIB <1000 Hz, suppress detections for SPL >125 dB from 50-1000 Hz

f = frequency, MIB = median instantaneous bandwidth, SR = sweep rate; HT = high threshold; BW = bandwidth