Beluga Habitat Program: Seabed Mooring Deployments in the Tarium Niryutait Marine Protected Area, 2023

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Beluga Habitat Program: Seabed Mooring Deployments in the Tarium Niryutait Marine Protected Area, 2023

by

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ABSTRACT

Westphal, A.M., Scharffenberg, K., Whalen, D., MacPhee, S., Inuvik Hunters and Trappers Committee, Tuktoyaktuk Hunters and Trappers Committee, Aklavik Hunters and Trappers Committee, Marcoux, M., Loseto, L. 2026. Beluga Habitat Program: Seabed Mooring Deployments in the Tarium Niryutait Marine Protected Area, 2023. Can. Data. Rep. Fish. Aquat. Sci. 1493: vii + 16 p.

The Tarium Niryutait Marine Protected Area (TN MPA) was designated as Canada's first Arctic Marine Protected Area in 2010. The goal of designating the TN MPA was to protect beluga whales (*Delphinapterus leucas*) and their habitat in the Mackenzie River estuary. As part of ongoing ecological monitoring efforts in the region, the Beluga Habitat Program has been conducting passive acoustic monitoring complemented with oceanographic data collection since 2014. Key objectives of this program include: 1) to provide a better understanding of oceanographic conditions within the TN MPA; 2) to examine potential environmental drivers of beluga movement and habitat use patterns within the estuary; and 3) to support data accessibility. This addendum builds on previously published metadata associated with the Beluga Habitat Program by providing a detailed description of the 2023 deployment methods and instrument settings. The objective of these metadata reports is to support the full use of data collected as part of the Beluga Habitat Program. In 2023, moorings were deployed in all three parcels of TN MPA: three in Kugmallit Bay (Kittigaryuit MPA), three in Niaqunnaq MPA, and two in Okeevik MPA. With the completion of the 2023 field season, this program has conducted 10 seasons of monitoring in Kugmallit Bay, six in Niaqunnaq MPA, and three in Okeevik MPA.

RÉSUMÉ

Westphal, A.M., Scharffenberg, K., Whalen, D., MacPhee, S., Inuvik Hunters and Trappers Committee, Tuktoyaktuk Hunters and Trappers Committee, Aklavik Hunters and Trappers Committee, Marcoux, M., Loseto, L. 2026. Beluga Habitat Program: Seabed Mooring Deployments in the Tarium Niryutait Marine Protected Area, 2023. Can. Data. Rep. Fish. Aquat. Sci. 1493: vii + 16 p.

La Zone de protection marine Tarium Niryutait (ZPM TN) a été désignée comme la première zone de protection marine de l'Arctique canadien en 2010. L'objectif de la désignation de la ZPM TN était de protéger les bélugas (*Delphinapterus leucas*) et leur habitat dans l'estuaire du fleuve Mackenzie. Dans le cadre des efforts continus de surveillance écologique dans la région, le Programme sur l'habitat du béluga mène depuis 2014 des activités de surveillance acoustique passive, complétées par la collecte de données océanographiques. Les principaux objectifs de ce programme sont les suivants : 1) améliorer la compréhension des conditions océanographiques au sein de la ZPM TN; 2) examiner les facteurs environnementaux susceptibles d'influencer les déplacements des bélugas ainsi que leurs schémas d'utilisation de l'habitat dans l'estuaire; et 3) favoriser l'accessibilité des données. Le présent addenda complète les métadonnées déjà publiées dans le cadre du Programme sur l'habitat du béluga en fournissant une description détaillée des méthodes de déploiement et des paramètres des instruments utilisés en 2023. L'objectif de ces rapports de métadonnées est de soutenir l'utilisation complète des données recueillies dans le cadre du Programme sur l'habitat du béluga. En 2023, des mouillages ont été déployés dans les trois secteurs de la ZPM TN : trois dans la baie Kugmallit (ZPM Kittigaryuit), trois dans la ZPM Niaqunnaq et deux dans la ZPM Okeevik. Après la saison de terrain 2023, ce programme avait totalisait dix saisons de surveillance dans la baie Kugmallit, six dans la ZPM Niaqunnaq et trois dans la ZPM Okeevik.

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1. INTRODUCTION

1.1 BACKGROUND

The Eastern Beaufort Sea (EBS) beluga whale (*Delphinapterus leucas,* Qilalugaq) population migrates from overwintering areas in the Bering Sea to summer congregation areas in the Beaufort Sea and Mackenzie River estuary (Fraker et al. 1979, Storrie et al. 2022). The summer aggregations in the Mackenzie River estuary are among the largest globally (Norton and Harwood 1986, Harwood et al. 1996), with thousands of EBS belugas gathering each year to access coastal areas (Harwood et al. 2014, Hornby et al. 2016). The warmer, more turbid waters of the estuary may provide a variety of benefits, including thermal advantages for calves (Sergeant 1973) and conditions that aid moulting processes (St. Aubin et al. 1989, Smith et al. 1992). Beluga distribution within the estuary is not uniform and is often concentrated in specific areas or “hotspots” (Harwood et al. 2014). However, seasonal and interannual variability in beluga distribution suggest that belugas may adjust their habitat use in response to environmental or anthropogenic cues (Halliday et al. 2019, Scharffenberg et al. 2019, Scharffenberg et al. 2020, Scharffenberg et al. 2025a).

The Tarium Niryutait Marine Protected Area (TN MPA) was designated in 2010 with the goal of protecting beluga whales and their habitat in the Mackenzie River estuary (*Tarium Niryutait Marine Protected Areas Regulations*, SOR/2010-190), hereafter ‘Mackenzie Estuary’. The TN MPA encompasses three discrete MPA parcels where EBS beluga whales are known to form large summer aggregations during the ice-free season (Norton and Harwood 1986, Harwood et al. 2014). The boundaries of the three parcels were designed based on beluga harvest management zones and are traditional hunting areas for the communities of Aklavik, Inuvik, and Tuktoyaktuk, respectively (Fisheries Joint Management Committee 2024). Within the TN MPA, there is a need to understand how accelerated environmental change is affecting nearshore oceanography, sediment dynamics, and the shallow marine ecosystem, particularly in areas frequented by beluga whales and along travel routes used by Inuvialuit.

The Beluga Habitat Program is a long-term monitoring program focused on environmental and acoustic conditions within the TN MPA (Scharffenberg et al. 2024). This program has been, and continues to be, developed in partnership with the Aklavik, Inuvik, and Tuktoyaktuk Hunters and Trappers Committees (HTCs). The Beluga Habitat Program has used coastal observatories (i.e., instrumented seabed moorings) to collect acoustic data complemented with oceanographic measurements since 2014 (Scharffenberg et al. 2024), documenting environmental drivers known to influence beluga whale habitat use across the Mackenzie Estuary and TN MPA

(Halliday et al. 2019, Scharffenberg et al. 2019, Scharffenberg et al. 2020, Scharffenberg et al. 2025a). Datasets collected through the program are used to analyze indicators identified in the TN MPA Monitoring Plan, including beluga distribution (Fisheries and Oceans Canada and Fisheries Joint Management Committee 2013a), while providing Inuvialuit community members and the general public with observations of environmental conditions.

With the completion of the 2023 field season, the Beluga Habitat Program has now collected 10 seasons of monitoring data in Kugmallit Bay, including eight consecutive seasons collected from deployments at East Whitefish. Additionally, we have collected six seasons of monitoring data in Niaqunnaq MPA and three seasons in Okeevik MPA. This long-term dataset can be used to monitor the area for environmental change and to assess impacts to beluga habitat use, both within parcels of the TN MPA and across the estuary.

1.2 RECENT FINDINGS

Scharffenberg et al. (2024) provides a comprehensive review of findings associated with the Beluga Habitat Program from 2015 to 2024. Here we provide a summary of findings published since Scharffenberg et al. (2024).

We have recently published the first comprehensive long-term analysis of beluga distribution within the estuary since the 1970s and 1980s, detailing aggregation and core residency periods in addition to assessing temporal and spatial patterns in vocalization rates within the estuary (Scharffenberg et al. 2025a). Acoustic data collected through the Beluga Habitat Program has also been used to provide additional context to concurrent aerial surveys within Kugmallit Bay (Scharffenberg et al. 2025b). Both of these publications continue to build on our understanding of seasonal variation in beluga vocalization and distribution patterns and the influence of oceanographic and environmental conditions. Observations to date suggest that while this beluga population exhibits a high degree of site fidelity (Harwood et al. 2014), they can be flexible and shift their usage of available habitat in response to environmental and anthropogenic cues (Noel et al. 2022, Scharffenberg et al. 2025a, Scharffenberg et al. 2025b). Additionally, it suggests that beluga distributions within the estuary could be sensitive to climate-driven changes that affect estuary conditions, including water temperatures, salinity, and the timing of ice break-up (Lee et al. 2025).

Multi-year oceanographic datasets collected through the Beluga Habitat Program have been used to compare wave regimes, temperature, and salinity across all three parcels of TN MPA (Lee et al. 2025). Wave heights and water temperature were linked with wind direction and proximity to river mouths. However, relationships between salinity and other environmental variables depended on proximity to freshwater influences (Lee et al. 2025). Water temperature and salinity were directly correlated at sites outside the boundary of freshwater influence, however, in other areas this relationship was only present during northwesterly wind events (Lee et al. 2025). These findings suggest that ecological monitoring should be conducted in all three parcels of the TN MPA to provide a more comprehensive understanding of the area. On-going data collection will provide opportunities to further examine spatial and temporal trends across the TN MPA in greater depth, thus providing a better understanding of oceanographic conditions across the area.

1.3 OBJECTIVES

The Beluga Habitat Program was designed to address knowledge gaps relating to temporal and spatial patterns of beluga habitat use in the Mackenzie River estuary (Simard et al. 2014, Scharffenberg et al. 2024). Key objectives of this program include: 1) to provide a better

understanding of oceanographic conditions within the TN MPA; 2) to examine potential environmental drivers of beluga movement and habitat use patterns within the estuary; and 3) to support data accessibility. This addendum builds on an earlier publication encompassing all moorings associated with the Beluga Habitat Program that were deployed from 2014 to 2022 (Scharffenberg et al. 2024). A detailed summary of the background and rationale for the Beluga Habitat Program can be found in that earlier report by Scharffenberg et al. (2024). Here we provide an overview of data collected through the Beluga Habitat Program in 2023 and provide metadata associated with mooring deployments (methods, deployment times, instrument settings, etc.).

In addition, it is the wish of the authors that making the metadata publicly accessible will stimulate new research questions and facilitate the full utilization of the dataset. Oceanographic data collected under the Beluga Habitat Program are available for download under the Government of Canada's Open Government Portal: https://open.canada.ca/data/en/dataset/ce02d6bc-af2e-11ee-bd12-d17b9d44bf6a. Acoustic data files can be made available by request to K. Scharffenberg (DFO) and pending approval of co-management bodies.

2. MATERIALS AND METHODS

2.1 STUDY AREA

The Mackenzie Estuary encompasses the region where freshwater from the Mackenzie River meets the Beaufort Sea in the Inuvialuit Settlement Region, western Canadian Arctic (Figure 1). The TN MPA encompasses 1800 km^2 within the estuary (*Tarium Niryutait Marine Protected Areas Regulations*, SOR/2010-190) and was designed with the conservation objective of protecting beluga whales and their habitat (Fisheries and Oceans Canada and Fisheries Joint Management Committee 2013b). The TN MPA is comprised of three distinct MPA parcels: Kittigaryuit (Kugmallit Bay), Niaqunnaq (West Mackenzie Bay), and Okeevik (East Mackenzie Bay). Fresh sediment-rich water from several outflows of the Mackenzie River mix with cool salt water of the estuary creates a dynamic environment where water temperature, salinity, and turbidity can fluctuate spatially and temporally throughout the area (Lee et al. 2025). Waters within the MPA boundaries are generally shallow, with many areas less than 2-3 m in depth with the exception of a deep, narrow channel in both Niaqunnaq MPA (Canadian Hydrographic Service Nautical Chart 'Mackenzie Bay 7662') and Kittigaryuit MPA (Canadian Hydrographic Service Nautical Chart 'Kugmallit Bay 7663', Whalen et al. 2020). The study area for the Beluga Habitat Program is described in detail in a previously published metadata report (Scharffenberg et al. 2024).

2.2 MOORING DEPLOYMENT

In 2023, we continued to build on a long-term, baseline description of the soundscape in the TN MPA (refer to Scharffenberg et al. 2024 for a description of 2014-2022 program activities). We deployed instrumented moorings equipped with acoustic and environmental sensors in all three parcels of the TN MPA (Figure 1, Table 1).

We deployed moorings at three locations in Kittigaryuit MPA: offshore from East Whitefish subsistence camp, west of Hendrickson Island, and midway between Hendrickson Island and East Whitefish. We deployed three moorings in Niaqunnaq MPA, positioned into a roughly linear east-west configuration parallel to the southern shoreline of the MPA. Finally, we deployed one mooring in Okeevik MPA, just off the coast of Garry Island. In addition to moorings deployed

within the TN MPA, we deployed a mooring approximately 10 kilometres east of Pelly Island, just outside of the Okeevik MPA (Figure 1). The location of this deployment was based on recommendations from the Inuvik HTC to collect information on belugas moving north of Pelly Island. We also deployed a mooring off of Atkinson Point along the Tuktoyaktuk Peninsula (Figure 1). The location of the Atkinson Point mooring was suggested by the Tuktoyaktuk HTC and first deployed in 2022.

2.3 MOORING DESIGN

In 2023, we continued using the mooring design first deployed in 2021 (Scharffenberg et al. 2024). This design included a custom-made aluminum tripod designed with attachment points to place instruments low in the water column near the seabed (Figure 2). These moorings used the same ground line-buoy line system from earlier program years (Scharffenberg et al. 2024). Finally, each mooring was also equipped with a satellite linked Sofar Spotter buoy (Sofar Ocean, San Francisco, CA, USA). These are GPS buoys which record and transmit their position, wave parameters, and sea surface temperatures on an hourly basis.

Unfortunately, in 2023 a beluga was observed to be entangled in the mooring at the East Whitefish deployment location (Figure 1). The beluga was alive when discovered by a local community member and mooring lines were cut to release the entangled whale. The buoy was returned, but the mooring frame and attached instrumentation were not recovered. The community member who released the whale noted the entanglement might have been caused by too much slack in the rope. Rope lines are pre-measured in Inuvik and designed to include some slack to allow for storm surges and tidal fluctuation. It is possible that extremely low water levels in the area during the 2023 ice-free season contributed to additional slack in the line (CBC News, 25 July 2023).

A communication detailing the whale entanglement was sent to the Inuvik, Aklavik, and Tuktoyaktuk HTCs, the Inuvialuit Game Council, and the Inuvialuit Joint Secretariat immediately following the incident. In fall 2023, we hosted collaborative discussions between DFO scientists and the Inuvik, Aklavik, and Tuktoyaktuk HTCs to assess the current mooring design and discuss modifications to reduce the likelihood of future entanglements. Modifications developed from these discussions were implemented during the 2024 field season, including the addition of tubing to prevent surface lines from looping and implementation of a geofencing feature on the Sofar Spotter buoys to provide real-time alerts of buoy movement. All modifications and final mooring designs were approved by the HTCs prior to deployment.

2.4 ACOUSTIC RECORDINGS

Moorings deployed in 2023 were equipped with a Song Meter SM2M Submersible Marine Recorder (Wildlife Acoustics, Maynard, MA, USA), Song Meter SM3M Submersible Marine Recorder (Wildlife Acoustics, Maynard, MA, USA), Sound Trap acoustic recorder (Ocean Instruments, NZ), or Loggerhead acoustic recorder (Loggerhead Instruments, FL, USA) (Table 1). Song Meter SM2M and SM3M devices (Wildlife Acoustics, Maynard, MA, USA) were equipped with either a standard or ultrasonic hydrophone and were programmed to record at a 96 kHz sample rate with 25% duty cycle (15 min on, 45 min off) (Table 2). Two models of Sound Trap acoustic recorders (Ocean Instruments, NZ) were used in 2023: ST300 STD models were programmed with a 144 kHz sample rate and 25% duty cycle (15 min on, 45 min off); and ST300 HF models were programmed with a 192 kHz sample rate and 25% duty cycle (15 min on, 45 min off). A Loggerhead acoustic recorder (Loggerhead Instruments, FL, USA) was

deployed at one site in 2023. The Loggerhead was programmed with a 96 kHz sample rate and 25% duty cycle (15 min on, 45 min off).

2.5 OCEANOGRAPHIC DATA

The configuration of oceanographic instruments varied by mooring (Table 3). All moorings were equipped with a Sofar Spotter buoy (Sofar Ocean, San Francisco, CA, USA) and at least one RBR (RBR Concerto, Duo, and Solo models; RBR Ltd., Kanata, Canada) or Star-ODDI (Star-Oddi Ltd., Gardabaer, Iceland) CTD instrument. Instrument configuration was designed to maximize coverage for collecting temperature, depth, conductivity, and wave condition measurements while targeting specific deployments for turbidity measurements (Table 1). Locations closer to river mouths or highlighted as potential sites of interest for future projects were prioritized for deployment with turbidity sensors, while aiming to have at least one sensor in each MPA parcel. For each instrument, sampling rate was chosen to maximize sampling frequency, while ensuring the instrument recorded for the entire study period. As such, the settings for each instrument varied depending on individual power requirements. Sampling rate and other relevant settings are outlined in Table 3. Note: wave loggers recorded wave characteristics in bursts, which had a pre-set number of samples per burst (e.g., 512 samples), sample rate (e.g., 6 Hz), and sample period (e.g., one burst every 5 min).

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INSTRUMENT METADATA

Table 1: Locations of mooring deployments and variables recorded during the summer of 2023. Note: the East Whitefish mooring equipment was lost at sea; the Sofar Spotter buoy was recovered, however, the mooring and attached instruments were not. Greyed out squares refer to measurements recorded by instruments that were not recovered from the field.

Location	Latitude	Longitude	Bottom Depth (m)	Deploy Date	Recovery Date	Water Temp. bottom (°C)	SST (°C)	Salinity (PSU)	Depth (m)	Turbidity (NTU)	Waves (m)	Acoustics
East Whitefish[a]	69.3856	-133.6347		19-Jun	30-Jul		X				X	
Mid Kugmallit	69.4254	-133.4870	2.2	19-Jun	10-Sep	X		X	X		X	X
West Hendrickson	69.5037	-133.7162	1.7	19-Jun	10-Sep	X	X	X	X		X	X
Atkinson Point	69.7697	-132.1291	5.4	14-Jul	13-Sep		X		X		X	X
Garry Island	69.5147	-135.6565	1.2	22-Jun	20-Sep	X		X	X		X	X
Pelly Island	69.6078	-135.1884	2.8	22-Jun	20-Sep	X	X	X	X	X	X	X
Niaqunnaq Mid	69.0092	-136.7447	2.2	28-Jun	24-Sep	X		X	X	X	X	X
Niaqunnaq East	68.9780	-136.4311	1.8	28-Jun	24-Sep	X		X	X	X	X	X
Escape Reef	69.0347	-137.1189	NR	28-Jun	24-Sep	X	X	X			X	X

[a] Mooring was lost at sea. Sofar Spotter buoy was recovered; mooring frame and other instruments were not recovered.

Definitions:

Bottom Depth: In 2023, bottom depth was not recorded at deployment time, the value provided here is the average bottom depth at each location for the duration of the deployment as recorded by the mooring.
Water Temp. bottom (°C): Temperature in degrees Celsius, recorded just above the seafloor.
SST (°C): Sea Surface Temperature; the water temperature at the position of the instrument, typically recorded ~10 cm below the surface. SST recorded here may differ slightly from the "skin" temperature (typically to a depth of 10–20 µm) measured by satellites.
Salinity (PSU): The ratio of the mass of dissolved material to the mass of seawater. It is impossible to measure absolute salinity directly, however, practical salinity is derived from measurable properties: electrical conductivity, temperature, and pressure.

Depth (m): The water depth of the instrument, which is typically fixed to seabed mooring (unless otherwise specified). This relates to the depth of the water at each location, but each instrument is held just above the seafloor. The height above seafloor was not measured and varied by location and year but remained consistent throughout each season. It is a function of sea pressure and seawater density.
Turbidity (NTU): A measure of the cloudiness of a fluid. Turbidity sensors detect light scattered by solid particles suspended in water.
Waves: Various wave parameters including amplitude (height), period, and direction.
Acoustics: Audio recordings of underwater sounds, typically recorded for 15 minutes every hour.

Table 2: Settings and location of all hydrophones deployed in the TN MPA during the 2023 field season. NP = Not Provided by manufacturer. NA = Not Applicable, hydrophone was not recovered at the end of the field season. For oceanographic instrument settings and locations see Table 3. Note: East Whitefish mooring equipment was lost at sea; hydrophone settings are included here for reference.

Location	Serial Number	Model	Recording Start	Recording Finish	Duty Cycle (min on/off)	Sampling Rate (kHz)	Gain Settings (+dB)	Hydrophone sensitivity (dB re 1V/uPa)	End-to-End Calib. (dB)	High Pass Filter (Hz)
East Whitefish[a]	6048	ST300 (STD)	19-Jun	-	NA	NA	“High”	NP	176.0	0
Mid Kugmallit	-	Loggerhead	19-Jun	10-Sep	15/45	96	12.4	-169.9	NP	0
West Hendrickson	681707	SM2M	19-Jun	10-Sep	15/45	96	15.5	-164.2	NP	0
Atkinson Point	681694	SM2M	14-Jul	13-Sep	15/45	96	15.5	-164.1	NP	0
Garry Island	5269	ST300 (STD)	22-Jun	20-Sep	15/45	144	“High”	NP	176.1	0
Pelly Island	5262	ST300 (STD)	22-Jun	20-Sep	15/45	144	“High”	NP	176.5	0
Niaqunnaq Mid	5230	ST300 (HF)	28-Jun	24-Sep	15/45	192	“High”	NP	176.6	0
Niaqunnaq East	6065	ST300 (HF)	28-Jun	24-Sep	15/45	192	“High”	NP	176.4	0
Escape Reef	681897	SM3M	28-Jun	24-Sep	15/45	96	12.0	-164.5	NP	0

[a] Mooring was lost at sea. Sofar Spotter buoy recovered; mooring frame and other instruments were not recovered.

Definitions:

Location: The location where the hydrophone was deployed.
Serial Number: The identification number of each individual hydrophone.
Model: The type of hydrophone used.
Recording Start: The date of the first underwater recording.
Recording Finish: The date of the last underwater recording.
Duty Cycle (min on/off): The 'on/off' schedule for hydrophone recordings. For example, a hydrophone that recorded for 15 minutes, followed by 45 minutes off would have a 25% duty cycle (it is recording 25% of the time).

Sampling Rate (kHz): The number of instantaneous measurements of sound amplitude that are taken per second. This frequency is double the highest frequency that is recorded in the audio file. For example, a sampling rate of 96 kHz can record sounds up to 48 kHz.
Gain Settings (+dB): The amount of amplification applied to the received signal.
Hydrophone sensitivity (dB re 1vu/uPa): The amount of voltage generated per unit of sound pressure. This value is needed to retrieve the original measurement of sound pressure from audio files generated by recorders where the end-to-end calibration is not provided.
End-to-End Calib.: Calibration that is carried out by inputting a known signal into the transducer.
High Pass Filter (Hz): A filter used to remove low-frequency sounds from an audio signal.

Table 3: Settings and location of all oceanographic instruments (except hydrophones) deployed in the TN MPA during the 2023 field season. For hydrophone settings and locations see Table 2. NA = Not Applicable, instrument was not recovered at the end of the field season. Note: East Whitefish mooring equipment was lost at sea; the Sofar Spotter buoy was recovered, and other oceanographic instrument settings are included here for reference.

Location	Record Start Date	Record End Date	Variables	Serial Number	Model	Settings
East Whitefish[a]	19-Jun	30-Jul	Waves, SST	0528	Sofar Spotter Buoy	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted every 30min
East Whitefish[a]	19-Jun	-	Turbidity	206575	RBR Solo	NA
East Whitefish[a]	19-Jun	-	Temperature, Depth	204451	RBR Duo	NA
Mid Kugmallit	19-Jun	10-Sep	Waves	0536	Sofar Spotter Buoy	Waves: 2.5Hz continuous; data averaged and transmitted every 30min
Mid Kugmallit	19-Jun	10-Sep	Waves, Depth	41489	RBR Solo	4Hz rate, 512 samples, 20min period
Mid Kugmallit	19-Jun	10-Sep	Conductivity, Temperature, Depth	60709	RBR Concerto	2Hz rate, 20 samples, 10min period
West Hendrickson	19-Jun	10-Sep	Waves, SST	0971	Sofar Spotter Buoy	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted every 30min
West Hendrickson	19-Jun	10-Sep	Conductivity, Temperature, Depth	214426	RBR Concerto	2Hz rate, 60 samples, 10min period
Atkinson Point	14-Jul	13-Sep	Waves, Depth	41464	RBR Solo	4Hz rate, 512 samples, 20min period
Atkinson Point	14-Jul	13-Sep	Waves, SST	31145C	Sofar Spotter Buoy	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted every 30min
Garry Island	22-Jun	20-Sep	Conductivity, Temperature, Depth	214427	RBR Concerto	2Hz rate, 60 samples, 10min period
Garry Island	22-Jun	20-Sep	Waves	0184	Sofar Spotter Buoy	Waves: 2.5Hz continuous; data averaged and transmitted every 30min
Pelly Island	22-Jun	20-Sep	Conductivity, Temperature, Depth	60524	RBR Concerto	1Hz rate, 10 samples, 10min period

Pelly Island	22-Jun	20-Sep	Turbidity	79992	RBR Solo	10min period
Pelly Island	22-Jun	20-Sep	Waves, SST	0532	Sofar Spotter Buoy	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted every 30min
Niaqunnaq Mid	28-Jun	24-Sep	Conductivity, Temperature	10944	Star-ODDI	5min period
Niaqunnaq Mid	28-Jun	24-Sep	Turbidity, Waves, Depth	51225	RBR Duo	4Hz rate, 512 samples, 30min period
Niaqunnaq Mid	28-Jun	24-Sep	Waves	1728	Sofar Spotter Buoy	Waves: 2.5Hz continuous; data averaged and transmitted every 30min
Niaqunnaq East	28-Jun	24-Sep	Conductivity, Temperature, Depth	206639	RBR Concerto	2Hz rate, 20 samples, 10min period
Niaqunnaq East	28-Jun	24-Sep	Turbidity	207256	RBR Solo	10min period
Niaqunnaq East	28-Jun	24-Sep	Waves	0183	Sofar Spotter Buoy	Waves: 2.5Hz continuous; data averaged and transmitted every 30min
Escape Reef	28-Jun	24-Sep	Waves, SST	1006	Sofar Spotter Buoy	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted every 30min
Escape Reef	28-Jun	24-Sep	Conductivity, Temperature, Depth	10946	Star-ODDI	5min period

[a] Mooring was lost at sea. Sofar Spotter buoy recovered; mooring frame and other instruments were not recovered.

Definitions:

Location: The location where the instrument was deployed.
Record Start Date: The date of the first underwater measurement.
Record End Date: The date of the last underwater measurement.
Waves: Various wave parameters including amplitude (height), period, and direction.
Turbidity: A measure of the cloudiness of a fluid. Turbidity sensors detect light scattered by solid particles suspended in water.
Temperature: The subsurface temperature of the water in degrees Celsius recorded just above the seafloor.
Depth: The water depth of the instrument, which is typically fixed to seabed mooring (unless otherwise specified). This relates to the depth of the water at each location, but each instrument is held just above the seafloor. The height above seafloor was not measured

and varied by location and year but remained consistent throughout each season. It is a function of sea pressure and seawater density.
SST: Sea Surface Temperature; the water temperature at the position of the Spotter buoy recorded ~10 cm below the surface. SST recorded here may differ slightly from the "skin" temperature (typically to a depth of 10–20 μm) measured by satellites.

DEPLOYMENT CONFIGURATIONS

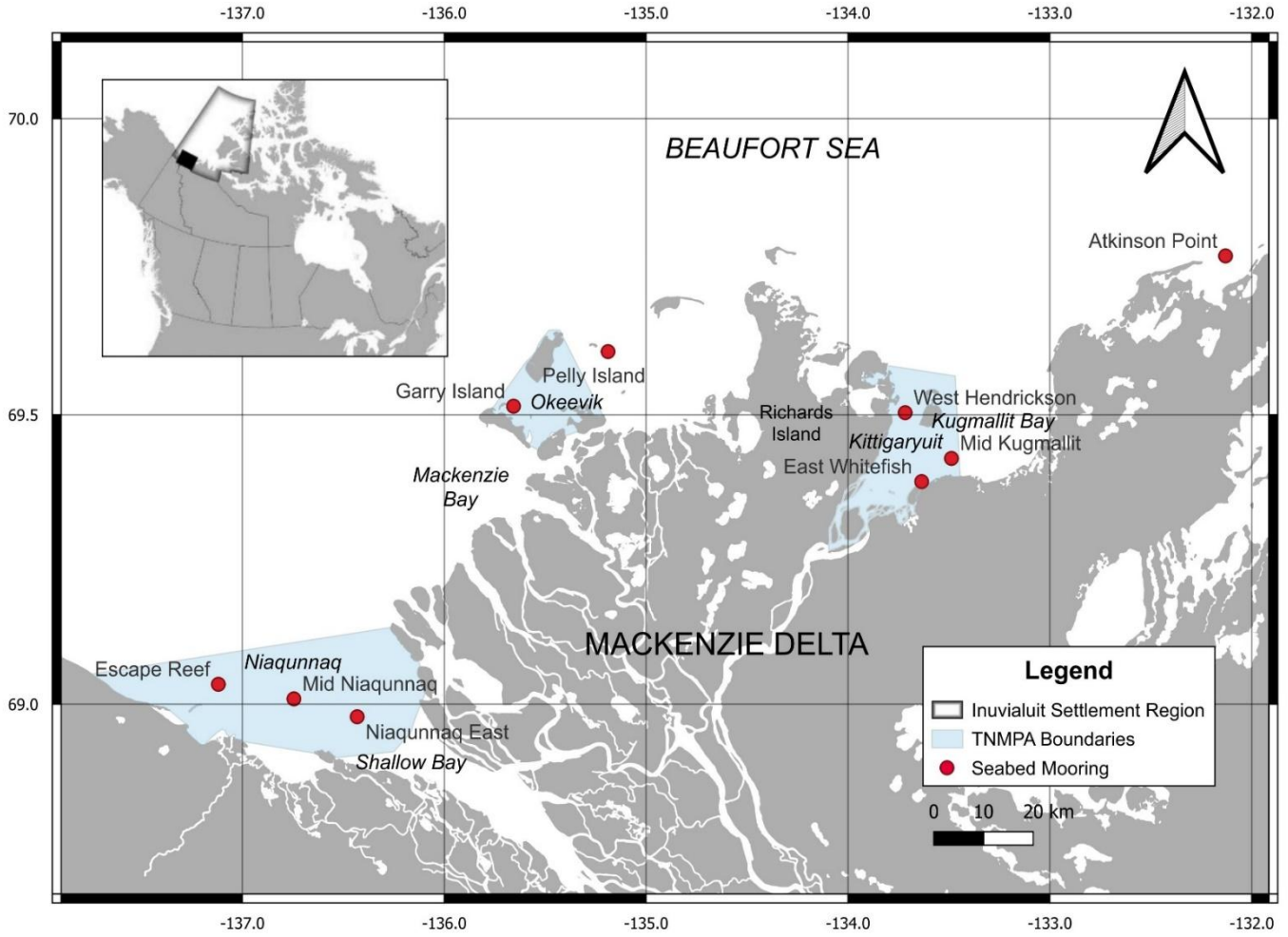


Figure 1: Map of the Mackenzie Delta and estuary showing the location of the three parcels of the TN MPA and each mooring deployed in 2023.



Figure 2: Mooring frame design used in 2023. This mooring design was also used in 2021 and 2022 (Scharffenberg et al. 2024).