Seabed Mooring Deployments in the Tarium Niryutait Marine Protected Area, 2014-2022: A Metadata Report

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2024

Canadian Data Report of
Fisheries and Aquatic Sciences 1393

Fisheries and Oceans Canada Pêches et Océans Canada

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Canadian Data Report of Fisheries and Aquatic Sciences

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Cat. No. Fs97-13/1393E-PDF ISBN 978-0-660-71305-2 ISSN 1488-5395

Correct citation for this publication:

Scharffenberg, K., Whalen, D., MacPhee, S., Loseto, L. 2024. Seabed Mooring Deployments in the Tarium Niryutait Marine Protected Area, 2014-2022: A Metadata Report. Can. Data. Rep. Fish. Aquat. Sci. 1393: v + 32 p.

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Eastern Beaufort Sea beluga whales form one of the largest summering aggregations of the species in the Mackenzie Estuary. In 2010, the Tarium Niryutait Marine Protected Area (TN MPA) was designated to protect beluga whales and their habitats As a part of ongoing ecological monitoring efforts in the TN MPA, passive acoustic monitoring (PAM) was implemented in 2011 to act as continuous monitoring method, filling the temporal gaps associated with historical aerial surveys. Beginning in 2014, PAM effort increased each year, and oceanographic sensors were added to moorings to (1) better understand oceanographic conditions within the TN MPA and (2) examine the environmental parameters that drive beluga movement and habitat use patterns within the estuary. Several studies using this dataset have been completed, and others are ongoing. However, much more can be done with the acoustic and environmental data. The purpose of this report is to outline deployment methods and instrument settings for moorings deployed from 2014-2022 to support the full use of the data collected.

RÉSUMÉ

Scharffenberg, K., Whalen, D., MacPhee, S., Loseto, L. 2024. Seabed Mooring Deployments in the Tarium Niryutait Marine Protected Area, 2014-2022: A Metadata Report. Can. Data. Rep. Fish. Aquat. Sci. 1393: v + 32 p.

Les bélugas de la mer de Beaufort orientale forment l’une des plus grandes agrégations estivales de l’espèce dans l’estuaire du Mackenzie. En 2010, la zone de protection marine (ZPM) de Tarium Niryutait a été désignée pour protéger les bélugas et leurs habitats. Dans le cadre des efforts continus de surveillance écologique dans la ZPM de Tarium Niryutait, la surveillance acoustique passive (PAM) a été mise en place en 2011 comme méthode de surveillance continue, comblant les lacunes temporelles associées aux relevés aériens historiques. À partir de 2014, les efforts de PAM ont augmenté chaque année, et des capteurs océanographiques ont été ajoutés aux amarrages pour (1) mieux comprendre les conditions océanographiques au sein de la ZPM de Tarium Niryutait et (2) examiner les paramètres environnementaux qui influencent les déplacements des bélugas et leurs schémas d’utilisation de l’habitat dans l’estuaire. Plusieurs études utilisant cet ensemble de données ont été achevées, et d’autres sont en cours. Cependant, beaucoup plus peut être fait avec les données acoustiques et environnementales. L’objectif de ce rapport est de décrire les méthodes de déploiement et les paramètres des instruments pour les amarrages déployés de 2014 à 2022 afin de soutenir l’utilisation complète des données collectées.

ACKNOWLEDGEMENTS

This work would not have been possible without the close partnership between Fisheries and Oceans Canada and the communities of Aklavik, Inuvik, and Tuktoyaktuk, who provided guidance on project design and ensured the program was able to continue during the COVID-19 pandemic when field travel was prohibited. This includes the Aklavik, Inuvik, and Tuktoyaktuk Hunters and Trappers Committees, the Aurora Research Institute (G. Elias, E. Amos, J. McAlister), field team leads (J. Kalinek, J. McLeod, J. Keevik), the Inuvialuit Joint Secretariat (C. Gruben) and the Munaqsiyit Monitoring Program (M. Kotokak). We would also like to thank S. Ostertag, E. Way-Nee, F. Malenfant, L. Murray, D. Pokiak, F. van Crimpen, R. Lee, and A. Robertson for logistical support. Funding was provided by Fisheries and Oceans Canada, Natural Resources Canada, the Fisheries Joint Management Committee, the W. Garfield Weston Foundation, the Northern Scientific Training Program and the Polar Continental Shelf Program.

1. INTRODUCTION

1.1 BACKGROUND

Eastern Beaufort Sea beluga whales form one of the world's largest summering aggregations in the Mackenzie Estuary (Harwood and Smith, 2002). They enter the estuary following the breakup of land-fast ice in mid-late June (Fraker et al. 1979, Norton and Harwood 1986) and most vacate the area in mid August. The reasons for summer estuarine use are poorly understood, though several hypotheses have been proposed, including: feeding, calving, moulting, refuge from predators, or socializing (Sergeant 1973, St. Aubin et al. 1990, Smith et al. 1992). These explanations are not mutually exclusive, and it may be that belugas use the estuary for some combination of these factors. Individual whales spend only 3-5 days in the estuary before moving offshore (Richard et al. 2001, Storrie et al. 2022a), and at least some individuals cycle between Amundsen Gulf and the Mackenzie Estuary as the summer progresses (Richard et al. 2001, Storrie et al. 2022b). The distribution pattern of belugas within the estuary is clumped, with belugas using certain locations, or 'hotspots' year after year (Harwood et al. 2014). This aggregation has been hunted by the Inuvialuit for centuries (Fraker et al. 1979) and the hunt remains important today as it provides a nutritionally superior alternative to store-bought products, and an opportunity to pass on traditional hunting and land-based skills to younger generations (Usher 2002, Hoover et al. 2016).

The Tarium Niryutait Marine Protected Area (TN MPA), Canada's first Arctic MPA, was officially designated in August 2010 (Canada Gazette 2010). The TN MPA is made up of three areas called Niaqunnaq, Okeevik, and Kittigaryuit, covering approximately 1,800 square kilometres of the Mackenzie Estuary and surrounding Beaufort Sea (Figure 1). The primary purpose of the TN MPA is to conserve and protect beluga whales and their supporting ecosystem, while preserving the harvesting traditions of the Inuvialuit people (Fisheries and Oceans Canada and Fisheries Joint Management Committee 2013).

With climate driven changes rapidly affecting the Arctic (IPCC 2014, AMAP 2018, Niemi et al. 2019, Druckenmiller et al. 2022), there has been a pressing need to collect near-baseline information on the habitat use of beluga whales within the TN MPA. The Beluga Habitat Study was initially designed to address knowledge gaps regarding the temporal and spatial patterns of beluga habitat use (Simard et al. 2014). Passive acoustic monitoring (PAM) was implemented as part of a larger project involving aerial surveys and documentation of the timing of spring entry of belugas to the Mackenzie Estuary (see Hornby et al. 2016), and was intended to act as continuous monitoring method to fill temporal gaps associated with aerial surveys (Simard et al. 2014). Moored hydrophones were first deployed in Kugmallit Bay in July 2011 and 2012 to demonstrate feasibility; results and instrument settings are outlined in Simard et al. (2014).

Beginning in 2014, the number of moorings deployed in the estuary increased. In addition, moorings were equipped with oceanographic sensors to better understand the oceanographic conditions of Kugmallit Bay (a large bay on the eastern side of the estuary) and to examine key environmental parameters (i.e., wind, waves, temperature, depth, and salinity) that drive beluga movement and habitat use patterns within the estuary. In 2014, we redeployed one hydrophone in the Kittigaryuit Marine Protected Area (MPA) (Kugmallit Bay); the following year (2015) we added oceanographic instruments to moorings to better understand the oceanographic conditions of Kugmallit Bay and to examine the environmental parameters (i.e., wind, waves, temperature, depth, and salinity) that are believed to influence beluga movement and habitat use patterns within the estuary (Scharffenberg et al. 2019). We have deployed a variation of this design in Kugmallit Bay ever since (2015-2022). In 2018, the program was expanded to the Niaqunnaq MPA (Shallow Bay) (2018-2022), and in 2021 it was expanded again to the Okeevik MPA (2021-2022). These observatories have provided new knowledge about drivers of beluga habitat use in the TN MPA, in particular in Kittigaryuit, but more recently in Niaqunnaq and Okeevik.

1.2 KEY FINDINGS TO-DATE

To date, this dataset has allowed us to document the timing of arrival and departure of belugas each year at various locations in the TN MPA. By pairing beluga presence/absence (i.e. vocalization activity) with oceanographic variables, we have also been able to identify key environmental drivers of beluga whale habitat use in the estuary. We have observed that patterns of habitat use align with previously documented high-use locations, or ‘hotspots’ (Harwood et al. 2014), but that patterns can vary throughout the summer and are influenced by temperature, salinity, time of day, wind, and vessel presence (Scharffenberg et al. 2019, 2020, Halliday et al. 2019). We have also documented that high speed wind events, in particular large storms, have a negative effect on beluga habitat use in Kugmallit Bay, and possibly other areas in the delta. In Kugmallit Bay, acoustic monitoring data has shown that whales tend to avoid locations which would typically see high use during high-speed wind events (i.e., their usual ‘hotspots’; Scharffenberg et al. 2019). We detected a time-of-day influence on beluga presence at one of the deployment locations (East Whitefish), with belugas more frequently detected early in the morning (Scharffenberg et al. 2019). The dataset also shows that beluga vocalizations decrease significantly whenever a vessel (i.e. large vessel, for example a barge or tugboat) was within 5 km of a recorder (Halliday et al. 2019). This result suggests belugas avoid vessels or that they reduce their vocalization in response to vessel traffic. The presence of small boats (e.g., harvester boats with outboard motors) also corresponded with reduced presence of beluga vocalizations for several hours (Scharffenberg et al. 2019).

In addition to patterns and drivers of beluga habitat use, we established a baseline description of the soundscape of Kugmallit Bay by measuring noise levels and identifying contributors to the summer soundscape (Halliday et al. 2020). Using passive acoustic data and physical variables (i.e., wind and waves) recorded during the summer over four years, we assessed the influence of physical variables, beluga whale vocalizations, and boat noise on sound pressure levels in three frequency bands (low: 0.2–1 kHz; medium: 1–10 kHz; high: 10–48 kHz) to quantify the soundscape. Wind speed, wave height, beluga vocalizations, and boat noise (typically small boats with outboard motors) were all contributors to the soundscape in various frequency bands. The soundscape varied slightly between sites, time of day, and with tide height, but remained relatively constant between years.

Enough consecutive years of continuous monitoring data have been collected from the Beluga Habitat Study to begin to examine historical trends on timing of beluga entry/exit to the estuary, detection frequency, and potential distribution shifts within the MPA. For instance, a hydrophone has been deployed at East Whitefish every summer since 2015, providing 8 years of consecutive ice-free season data. This baseline dataset can be used to monitor for environmental change and to assess impacts of changing conditions and anthropogenic activity (e.g., vessel traffic) on beluga habitat use in the Mackenzie Estuary and TN MPA.

Oceanographic information recorded on these moorings has primarily been analyzed in the context of beluga whale habitat use. However, recently, information from moorings was used in a comparison of wave regimes, temperature and salinity across the three parcels of the TN MPA (Lee et al. in prep). Results suggested there are significant differences in the characteristics of these environmental parameters between and within each MPA parcel. The data act as a baseline of measurements against which future changes in the delta can be measured and contribute to a better understanding of the physical system.

1.3 OBJECTIVES

The purpose of the current metadata report is to provide an overview of data collected from the Beluga Habitat Study, and to provide metadata for all mooring deployments (methods, deployment times, instrument settings etc.) from 2014-2022. This information will support development of a database of indicators for ecological monitoring in the TN MPA. 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 data collected. Oceanographic data collected under the Beluga Habitat Study 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 River and its distributaries flow into the Beaufort Sea west of Tuktoyaktuk, NT. The river system discharges approximately 300 km3 of freshwater annually into the Beaufort Sea and forms the second largest delta in the Arctic at over 13 000 km2 (Emmerton et al. 2007; Yang et al. 2015). The estuary is ice-covered from early October until about mid-June, with peak flow in the spring due to snowmelt and the breakup of river ice (Galley et al. 2008, Yang et al. 2015). River discharge is warm and turbid, forming visible plumes that typically flow eastward along the Tuktoyaktuk Peninsula, though these are heavily influenced by winds (Carmack and Macdonald 2002). Easterly winds, which usually cause upwelling, can push plume waters several hundred kilometers offshore, while westerly winds force plume waters against the coast, enhancing flow along the Tuktoyaktuk Peninsula (Carmack and Macdonald 2002). Sea-surface temperatures in the estuary are generally 5-10°C warmer than the offshore waters (Fraker et al. 1979).

The TN MPA is located within the Mackenzie Estuary, where the Mackenzie River meets the Beaufort Sea. It comprises three locations: Kittigaryuit (Kugmallit Bay), Niaqunnaq (Shallow Bay), and Okeevik (East Mackenzie Bay) (Figure 1). The Kittigaryuit MPA encompasses an approximately 464 km2 portion of the Mackenzie Estuary, primarily in Kugmallit Bay located between Richards Island and the Tuktoyaktuk Peninsula. Like much of the Mackenzie Estuary, Kugmallit Bay is very shallow, with depth rarely exceeding 2 m, except for a deeper channel flowing out from the East Channel into the bay (up to 9 m deep) and the distributary mouth bar at the head (> 1 m of water) (Whalen et al. 2020). This is the only area of the estuary with navigable waters suitable for large marine vessel traffic. As a result, larger boats and barges (>60 tons) pass through a shipping corridor in the area. Ice breakup in Kugmallit Bay occurs in the spring, culminating with the breakup of a landfast ice bridge across the bay in mid-late June, after which belugas have access to the bay. The Kittigaryuit MPA includes several subsistence camps primarily located at East Whitefish and Hendrickson Island and is located near the community of Tuktoyaktuk. From 1980-2009, 64.5% whales harvested in the Mackenzie Estuary were landed in Kugmallit Bay (Harwood et al. 2015).

The Niaqunnaq MPA covers approximately 1041 km2 and located on the west side of the delta at the mouth of Shallow Bay and within West Mackenzie Bay. In general, this area experiences more intense NW storms (since it is not protected by barrier islands) and has earlier timing of ice breakup (longer open water season and exposure to winds) than other parts of the estuary. Water depth in this region varies but in general increases with distance from shore. However water depth in Shallow Bay is consistent between 2-3 m depth with the exception of a narrow channel (up to 20 m deep) that runs down the center of the bay. The area experiences very little marine traffic, though nearby Shingle Point is the location of a traditional subsistence whaling camp and fishing area that at times is a high traffic area as small outboard vessels travel to/from Aklavik and Shingle Point (Worden et al. 2020). Like Kugmallit Bay, ice breakup in Shallow Bay occurs in the spring, ending with the breakup of an ice bridge. Breakup in West Mackenzie Bay typically occurs before the breakup of the Kugmallit Bay ice bridge (Lee et al. in prep).

The Okeevik MPA covers approximately 243 km2 in East Mackenzie Bay, and is surrounded by Pelly, Kendall, and Garry Islands. This region is characterised by shallow seabed (<3 m) with the exception of the narrow channels that extend outward from the outflow of Kumak Channel in the delta front. This is the least frequented area of the MPA with subsistence harvest camps located on Kendall, Baby and Garry Islands. Pelly Island provides some protection from NW winds and open ocean waves to Okeevik, and this is evident in the delayed ice break-up to the region which typically happens after the Niaqunnaq and Kittigaryuit portions have already broke (Lee et al. in prep).

2.2 MOORING DEPLOYMENT

2014-2017 Kugmallit Bay

Between 2014-2017, moorings were only deployed in Kugmallit Bay. Locations were selected to assess persistence of hotspots (see Harwood et al. 2014) and relationships to environmental drivers. In 2014, one acoustic monitoring mooring was deployed in Kugmallit Bay – in the channel, close to the deployment locations used in Simard et al. (2014) – and a second mooring with only oceanographic sensors (waves, conductivity, temperature, depth, and turbidity) was deployed in the middle of Kugmallit Bay. In 2015, moorings were deployed in three locations in Kugmallit Bay: the west side of Hendrickson Island, mid way between Hendrickson Island and East Whitefish, and in the channel (Figure 2). In 2016, five moorings were deployed in Kugmallit Bay: on the east and west side of Hendrickson Island, mid way between Hendrickson Island and East Whitefish, 400m offshore at East Whitefish, and in the Channel (Figure 3). However, in mid-June 2016, following mooring deployment, a large piece of ice broke apart from the landfast ice bridge and moved south, wrapping around west side of Hendrickson Island before moving out to sea. This pushed the East Hendrickson mooring out to sea (it was not recovered) and moved the West Hendrickson mooring several kilometers, dropping it close to the Mid Hendrickson mooring. The event was identified by investigating satellite imagery and listening to acoustic recordings from the mooring that was recovered (the sound of ice is clearly audible). Consequently, in 2016 there are two ‘Mid’ mooring sites (labeled A and B in Figure 3, Table 1, Table 2 and Table 3). In 2017, five moorings were deployed in Kugmallit Bay: on the east and west side of Hendrickson Island, mid way between Hendrickson Island and East Whitefish, 400m offshore at East Whitefish, and in the Channel (Figure 4). This was the most complete dataset at the time and forms the basis of a study identifying environmental drivers of habitat use in Kugmallit Bay (Scharffenberg et al. 2019).

2018-2020 Expansion to Shallow Bay

In 2018, the program was expanded to include moorings in the Niaqunnaq MPA (Figure 5) at the request of the Aklavik Hunters and Trappers Committee (HTC). In 2018 and 2019 two moorings were deployed on either side of Shingle Point (Figure 5 and Figure 6). Unfortunately, during recovery in 2018 an anchor chain broke and the mooring located in the outer bay was not recovered. In 2019, only the outer bay mooring was equipped with a hydrophone due to limited resources. Additionally, two moorings were deployed in Kugmallit Bay in 2018 and 2019: one deployed near East Whitefish, with the second deployed to the west of Hendrickson Island. During an extreme wind event in 2018, the West Hendrickson mooring was moved more than 20 km, it was recovered by a hunter near Tuktoyaktuk, though GPS coordinates were not recorded (Figure 5).

In 2020, moorings were redeployed at Shingle Point, and both moorings were equipped with hydrophones; a third mooring was deployed in the middle of Niaqunnaq (Figure 7). Additionally, three moorings were deployed in Kugmallit Bay: at East Whitefish, to the west of Hendrickson Island, and mid way between Hendrickson Island and East Whitefish (Figure 7).

2021-2022 Expansion to Okeevik and Atkinson Point

In 2021, the program was expanded to Okeevik MPA at the request of the Inuvik HTC. Two new moorings were deployed in Okeevik, just off the coasts of Garry and Kendall islands (Figure 8). Moorings were repositioned in Niaqunnaq with one off the coast of Shingle Point (farther offshore than previous years), and three others in the north, south and east parts of the Niaqunnaq MPA (Figure 8). In Kugmallit Bay moorings were redeployed at East Whitefish, to the west of Hendrickson Island, and mid way between Hendrickson Island and East Whitefish. The hydrophone at West Hendrickson Island failed to record in 2021. The 2022 deployment locations were similar to 2021, except the northernmost mooring in Niaqunnaq was moved southeast to the middle of a previously identified beluga hotspot (Harwood et al. 2014), and the Kendall Island mooring was moved farther from shore (Figure 9).

Also in 2022, a tenth mooring was added off Atkinson Point, along the Tuktoyaktuk Peninsula, outside the TN MPA (Figure 9). Placement of this mooring was suggested by the Tuktoyaktuk HTC to record the presence of whales that have been reported by community members to have a different movement pattern than previously tagged belugas. Belugas tagged in the Mackenzie Estuary typically move hundreds of kilometres offshore within a few days of being tagged (Richard et al. 2001, Storrie et al. 2022a). However, community members observe belugas along the Tuktoyaktuk Peninsula in August through October and wanted to record vocalisations to document these occurrences.

2.3 WEATHER STATION

Weather stations were manufactured and monitored by Campbell Scientific Canada Inc. (Edmonton, AB, Canada). A station was first installed at East Whitefish in 2015 and was upgraded in 2016 and 2017 to take hourly photos and video. The station was installed to collect more precise weather data in Kugmallit Bay, and data are made publicly accessible in near-real-time to provide weather updates for local travellers. Weather stations were later installed at Toker Point (2017), Shingle Point (2018) and Kendall Island (2021), forming a network of coastal observatories. Historical data are available via an FTP link monitored by Campbell

Scientific Inc accessible by request to D. Whalen (dustin.whalen@NRCan-RNCan.gc.ca). All weather stations monitor wind parameters (i.e., speed and direction) and air temperature, but additional metadata are not reported here due to inconsistencies in recording times. As weather stations are updated and improved we will include this information in future reports.

2.4 MOORING DESIGN

2014-2019

All moorings deployed prior to 2020, except those deployed at East Whitefish (see below), were designed following Figure 10, with the acoustic recording device fixed in the center of a metal frame (using a plastic collar and hose clamps) with the hydrophone facing up, and oceanographic instruments attached to the four posts using electrical tape and hose clamps. The instruments used for each mooring varied by year and location (see Table 3). Each mooring was fixed with up to 72lbs of weight and had a 15m groundline attached to a 30lb weight, which was attached to a buoy at the surface (Figure 10). The mooring at the channel in Kugmallit Bay in 2015 differed slightly, with the buoy attached directly to the top of the mooring. In 2017, and subsequent years, each mooring was also equipped with a sediment trap to investigate sedimentation rates (Figure 10). A unique mooring design was used for the East Whitefish station due to shallower conditions compared to other mooring locations in Kugmallit Bay. The acoustic recorder was attached on its side to a metal plate using two plastic collars, with various oceanographic sensors as depicted in Figure 11. A 400m cable ran from the oceanographic instruments to the East Whitefish weather station (Figure 11), which transmitted data to a publicly accessible feed in near real-time.

2020

In 2020, scientists from southern Canada were unable to travel to the Northwest Territories due to public health restrictions related to the COVID-19 global pandemic. The deployment plan was adjusted such that field work could be conducted entirely by Northern community partners. Part of this approach included the redesign of moorings to facilitate easier assembly and deployment by non-experts (though instrument configurations were similar to years prior; Figure 12). Mooring frames consisted of a weighted, circular aluminum base with vertical rods that instruments could be attached to. Additionally, new satellite-linked ‘smart’ Spotter buoys (Sofar Ocean) were added to each mooring, which transmitted position, sea surface temperature and wind and wave conditions on an hourly basis. The configuration of the groundline and buoy remained the same as in previous years. The cable system at East Whitefish was replaced in favour of the new frame style and smart buoy system used at the other locations. Unfortunately, the weld on some of the rods failed and an RBR CTD was lost from both the Mid Kugmallit and West Hendrickson moorings during recovery.

2021-2022

Following the loss of instruments in 2020, mooring frames were redesigned yet again in 2021. The frames were custom made aluminium tripods, similar to those deployed in 2014-2019, but were shorter so instruments sat lower in the water column near the seabed (Figure 13). Field crews reported that the new mooring design was easy to deploy and recover and resulted in no instrument loss. The ground line-buoy line system remained unchanged and smart buoys were deployed again in both years. Due to limited quantity of frames, an older style yellow frame (Figure 10) was used for the Atkinson Point deployment.

2.5 ACOUSTIC RECORDINGS

Prior to 2020, each mooring was equipped with a Song Meter SM2M (except the East Hendrickson mooring in 2017, which was equipped with an SM3M) Submersible Marine

Recorder (Wildlife Acoustics, Maynard, MA, USA) with either a standard or ultrasonic hydrophone which determined sample rate (96 kHz or 384 kHz, respectively; Table 2). A 96-kHz sample rate provided a recording bandwidth of 2 Hz-48 kHz, sufficient to capture beluga social calls, broadband calls, and low frequency echolocation clicks (Belikov and Bel'kovich 2006), while the 384 kHz sample rate provided recording bandwidth of 2Hz-192 kHz, covering the entire vocal range of beluga, including ultrasonic echolocation clicks (Ford 1977, Au et al. 1985). All recordings were made with a 16-bit sample size. Duty cycle was chosen to maximize recording effort, using the highest possible sample rate for the longest possible duration. As such, moorings equipped with a standard hydrophone had a 50% duty cycle (15 min on, 15 min off), while moorings with an ultrasonic hydrophone used a 25% duty cycle (15 min on, 45 min off). Beginning in 2019 recorders with ultrasonic capabilities were programmed to record at a 96kHz sample rate for 15 min and 384 kHz sample rate for 2 min. Different recording bandwidths were used as new technology enabling a high-frequency sample rate was made available. Until 2019, recorders were set with a 180 Hz high-pass filter (or 220 Hz filter on the SM3M at East Hendrickson in 2017) to filter out low frequency sounds which do not propagate in such shallow water. A 16000 Hz high-pass filter was set unintentionally at the Mid Kugmallit mooring in 2016. In 2020, Sound Trap acoustic recorders (Ocean Instruments, NZ) were used in addition to the SM2Ms (Table 2). In 2021 and 2022 the Wildlife Acoustics units began to be phased out in favour of Sound Traps. Three different Sound Trap models have been used with varying configurations: ST300 STD models were programmed with a 144 kHz sample rate and 25% duty cycle (15 min on, 45 min off); ST300 HF models were programmed with a 192 kHz sample rate and 25% duty cycle (15 min on, 45 min off); ST400 models were programmed with a 96 kHz sample rate and 8.3% duty cycle (5 min on; 55 min off). Acoustic data files can be made available by request to K. Scharffenberg (DFO) and pending approval of co-management bodies.

2.6 OCEANOGRAPHIC DATA

The configuration of oceanographic instruments varied by mooring and year. 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. In 2017, oceanographic sensors at East Whitefish recorded samples every 10 min and transmitted data in near real-time via the weather station. 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). Oceanographic datasets 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.

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INSTRUMENT METADATA

Table 1: Locations of mooring deployments and variables recorded during the summers of 2014-2022.. NR = Not recorded.

Year	Location	Latitude	Longitude	Bottom Depth (m)	Deploy Date	Recovery Date	Water Temp. bottom (°C)	SST (°C)	Salinity (PSU)	Depth (m)	Current	Turbidity (NTU)	pH	Waves (m)	Acoustics
2014	Channel	69.4857	-133.7553	NR	16-Jun	21-Aug									X
2014	Mid Hendrickson	69.4425	-133.7338	2	16-Jun	NR	X		X			X		X	
2015	West Hendrickson	69.5067	-133.6982	2.5	16-Jun	21-Aug	X		X	X					X
2015	Mid Kugmallit	69.4465	-133.6124	2.5	16-Jun	21-Aug	X		X	X					X
2015	Channel	69.3940	-133.8675	9	18-Jun	23-Aug	X			X					X
2016	Mid Kugmallit A	69.4447	-133.6121	2	13-Jun	22-Aug	X				X		X		X
2016	Mid Kugmallit B	69.4591	-133.5650	2.5	16-Jun	22-Aug	X		X	X	X			X	X
2016	Channel	69.3981	-133.8560	9.1	13-Jun	22-Aug	X			X					X
2016	East Whitefish	69.3804	-133.6344	1.4	14-Jun	22-Aug	X		X	X	X			X	X
2017	Mid Kugmallit	69.4448	-133.6113	1.6	20-Jun	19-Aug	X		X	X		X	X	X	X
2017	Channel	69.3947	-133.8620	8	20-Jun	19-Aug	X			X					X
2017	East Whitefish	69.3804	-133.6344	1.1	21-Jun	19-Aug	X			X					X
2017	West Hendrickson	69.5077	-133.6980	1.6	21-Jun	19-Aug	X		X	X	X			X	X
2017	East Hendrickson	69.4984	-133.4346	2.2	21-Jun	19-Aug	X		X	X				X	X

Table 1 continued

Year	Location	Latitude	Longitude	Bottom Depth (m)	Deploy Date	Recovery Date	Water Temp. bottom (°C)	SST (°C)	Salinity (PSU)	Depth (m)	Current	Turbidity (NTU)	pH	Waves (m)	Acoustics
2018	East Whitefish	69.3804	-133.6344	1.4	20-Jun	31-Aug	X			X					X
2018	Hendrickson to Tuktoyaktuk	NR	NR[e]	N/A	1-Jul	30-Jul	X		X	X				X	X
2018	Shingle Point Inner Bay	NR	NR	1.7	13-Jul	27-Jul									X
2019	West Hendrickson	69.5053	-133.7183	1.8	20-Jun	13-Aug	X		X	X					X
2019	Mid Kugmallit	69.4434	-133.5902	1.8	20-Jun	13-Aug	X		X	X				X	
2019	East Whitefish	69.3804	-133.6344	1.4	21-Jun	8-Aug	X			X					X
2019	Shingle Point Inner Bay	68.9874	-137.4044	1.7	17-Jun	12-Aug	X		X	X		X			
2019	Shingle Point Outer Bay	69.0060	-137.4166	5.2	16-Jun	12-Aug	X		X	X		X			X
2020	East Whitefish	69.3820	-133.6323	2.1	24-Jun	8-Sep				X				X	X
2020	Mid Kugmallit	69.4434	-133.5902	NR	24-Jun	8-Sep		X						X	X
2020	West Hendrickson	69.5053	-133.7183	1.6	24-Jun	8-Sep		X		X				X	X
2020	Niaqunnaq	69.0649	-136.5642	1.7	26-Jun	13-Sep	X	X	X	X				X	X
2020	Shingle Point Inner Bay	68.9874	-137.4044	1.7	26-Jun	13-Sep	X			X		X		X	X
2020	Shingle Point Outer Bay	69.0060	-137.4166	4.9	26-Jun	13-Sep	X	X	X	X		X		X	X

Table 1 continued

Year	Location	Latitude	Longitude	Bottom Depth (m)	Deploy Date	Recovery Date	Water Temp. bottom (°C)	SST (°C)	Salinity (PSU)	Depth (m)	Current	Turbidity (NTU)	pH	Waves (m)	Acoustics
2021	Shingle Point Ocean	69.0429	-137.3933	5.2	27-Jun	16-Sep	X	X	X	X	X	X		X	X
2021	Niaqunnaq East	68.9697	-136.4443	1.9	27-Jun	16-Sep	X	X	X			X		X	X
2021	Niaqunnaq West	68.9960	-136.9714	2.5	27-Jun	16-Sep	X	X	X					X	X
2021	Niaqunnaq North	69.0888	-136.9912	3.0	27-Jun	16-Sep	X	X	X	X				X	X
2021	Mid Kugmallit	69.4430	-133.5902	1.7	25-Jun	23-Sep	X		X	X				X	X
2021	West Hendrickson	69.5047	-133.7192	1.7	25-Jun	23-Sep	X		X	X				X	
2021	East Whitefish	69.3824	-133.6324	2.3	25-Jun	23-Sep	X			X				X	X
2021	Garry Island	69.5132	-135.6673	1.4	28-Jun	16-Sep	X	X	X		X	X		X	X
2021	Kendall Island	69.5147	-135.3733	1.7	28-Jun	16-Sep	X	X	X	X		X		X	X
2022	Shingle Point Ocean	69.0368	-137.3794	5.2	22-Jul	23-Sep	X	X	X					X	X
2022	Niaqunnaq East	68.9700	-136.4424	1.9	30-Jun	23-Sep	X		X	X		X		X	X
2022	Niaqunnaq West	69.0002	-136.9437	2.5	30-Jun	23-Sep	X		X	X	X			X	X
2022	Niaqunnaq North	69.0556	-136.7187	2.2	30-Jun	23-Sep	X	X	X	X				X	X
2022	Mid Kugmallit	69.4157	-133.5228	2.4	25-Jun	19-Sep	X		X	X				X	X

Table 1 continued

Year	Location	Latitude	Longitude	Bottom Depth (m)	Deploy Date	Recovery Date	Water Temp. bottom (°C)	SST (°C)	Salinity (PSU)	Depth (m)	Current	Turbidity (NTU)	pH	Waves (m)	Acoustics
2022	West Hendrickson	69.5037	-133.7180	1.7	25-Jun	19-Sep	X	X	X					X	X
2022	East Whitefish	69.3832	-133.6322	2.6	25-Jun	19-Sep	X	X		X		X		X	X
2022	Garry Island	69.5134	-135.6605	1.4	26-Jun	19-Sep	X		X	X				X	X
2022	Kendall Island	69.5274	-135.3702	1.3	26-Jun	19-Sep	X	X	X	X	X	X		X	X
2022	Atkinson Point	69.7750	-132.1063	5.6	17-Jul	11-Sep	X	X	X	X		X		X	X

Definitions:

Bottom Depth: In 2015-2019 this was the bottom depth recorded using a depth sounder at the time of deployment. In 2020-2022, bottom depth was not recorded at deployment time, so this 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

Current: Direction and magnitude of water currents.

Turbidity (NTU) : A measure of the cloudiness of a fluid. Turbidity sensors detect light scattered by solid particles suspended in water.

pH: The hydrogen ion concentration in environmental water, yielding its relative acidity or alkalinity.

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 2014-2022. NP = Not Provided

Year	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)
2014	Channel	681077	SM2M	19-Jun	23-Jul	15/5	96	15.5	-164.4	NP	180
2015	West Hendrickson	681125	SM2M	16-Jun	29-Jul[a]	15/15	96	15.5	-165.1	NP	180
2015	Mid Kugmallit	681126	SM2M	16-Jun	21-Aug	15/15[b]	96	15.5	-165.2	NP	180
2015	Channel	681077	SM2M	18-Jun	16-Jul[c]	15/15	96	15.5	-164.4	NP	180
2016	Mid Kugmallit A	681707	SM2M	13-Jun	1-Aug	15/45	384	15.5	-164.2	NP	16000
2016	Mid Kugmallit B	681126	SM2M	16-Jun	12-Aug	15/15	96	15.5	-165.2	NP	180
2016	Channel	681125	SM2M	13-Jun	12-Aug	15/15	96	15.5	-165.1	NP	180
2016	East Whitefish	681694	SM2M	14-Jun	22-Aug	15/45	384	15.5	-164.1	NP	180
2017	Mid Kugmallit	681707	SM2M	20-Jun	19-Aug	15/45	384	15.5	-164.2	NP	180
2017	Channel	681125	SM2M	20-Jun	18-Aug	15/15	96	15.5	-165.1	NP	180
2017	East Whitefish	681694	SM2M	21-Jun	19-Aug	15/45	384	15.5	-164.1	NP	180
2017	West Hendrickson	681126	SM2M	21-Jun	7-Aug	15/15	96	15.5	-165.2	NP	180
2017	East Hendrickson	681897	SM3M	21-Jun	19-Aug	15/45	384	12	-164.5	NP	220
2018	East Whitefish	681694	SM2M	30-Jun	19-Aug	15/45	384	15.5	-164.1	NP	180
2018	Hendrickson to Tuktoyaktuk	681707	SM2M	1-Jul	30-Jul	15/45	384	15.5	-164.2	NP	180
2018	Shingle Point Inner Bay	681126	SM2M	13-Jul	27-Jul	15/15	96	15.5	-165.2	NP	180
2019	West Hendrickson	681707	SM2M	20-Jun	13-Aug	15/2/43	96/384	15.5	-164.2	NP	0
2019	East Whitefish	681694	SM2M	21-Jun	8-Aug	15/2/43	96/384	15.5	-164.1	NP	0

Table 2 continued

Year	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)
2019	Shingle Point Outer Bay	681126	SM2M	16-Jun	7-Aug	15/15	96	15.5	-165.2	NP	0
2020	East Whitefish	5269	ST300 (STD)	24-Jun	7-Sep	15/45	144	"High"	NP	176.1	0
2020	Mid Kugmallit	5262	ST300 (STD)	24-Jun	8-Sep	15/45	144	"High"	NP	176.5	0
2020	West Kugmallit	681707	SM2M	24-Jun	8-Sep	15/2/43	96/384	15.5	-164.2	NP	0
2020	Niaqunnaq	681126	SM2M	26-Jun	28-Aug	15/15	96	15.5	-165.2	NP	0
2020	Shingle Point Inner Bay	5230	ST300 (HF)	26-Jun	13-Sep	15/45	192	"High"	NP	176.6	0
2020	Shingle Point Outer Bay	681694	SM2M	26-Jun	13-Sep	15/2/43	96/384	15.5	-164.1	NP	0
2021	Shingle Point Ocean	5262	ST300 (STD)	27-Jun	16-Sep	15/45	144	"High"	NP	176.5	0
2021	Niaqunnaq East	6048	ST300 (STD)	27-Jun	16-Sep	15/45	144	"High"	NP	176	0
2021	Niaqunnaq West	681694	SM2M	27-Jun	9-Sep	15/2/43	96/384	15.5	-164.1	NP	0
2021	Niaqunnaq North	681126	SM2M	5-Jul	20-Jul	15/15	96	15.5	-165.2	NP	0
2021	Middle Hendrickson	5230	ST300 (HF)	25-Jun	23-Sep	15/45	192	"High"	NP	176.6	0
2021	East Whitefish	5269	ST300 (STD)	25-Jun	23-Sep	15/45	144	"High"	NP	176.1	0
2021	Garry Island	6067	ST300 (HF)	28-Jun	16-Sep	15/45	192	"High"	NP	175.2	0
2021	Kendall Island	6065	ST300 (HF)	28-Jun	29-Jul	15/45	192	"High"	NP	176.4	0
2022	East Whitefish	6048	ST300 (STD)	25-Jun	19-Sep	15/45	144	"High"	NP	176	0
2022	Mid Kugmallit	6839	ST400 (STD)	25-Jun	19-Sep	5/55	96	"High"	NP	176.4	0
2022	West Hendrickson	681707	SM2M	25-Jun	19-Sep	15/45	96	15.5	-164.2	NP	0
2022	Atkinson	681694	SM2M	17-Jul	11-Sep	15/45	96	15.5	-164.1	NP	0

Table 2 continued

Year	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)
2022	Garry Island	5269	ST300 (STD)	26-Jun	19-Sep	15/45	144	"High"	NP	176.1	0
2022	Kendall Island	5262	ST300 (STD)	26-Jun	19-Sep	15/45	144	"High"	NP	176.5	0
2022	Niaqunnaq East	5230	ST300 (HF)	30-Jun	23-Sep	15/45	192	"High"	NP	176.6	0
2022	Niaqunnaq West	6065	ST300 (HF)	30-Jun	23-Sep	15/45	192	"High"	NP	176.4	0
2022	Niaqunnaq North	6067	ST300 (HF)	30-Jun	23-Sep	15/45	192	"High"	NP	175.2	0
2022	Shingle Point Ocean	6840	ST400 (STD)	22-Jul	23-Sep	5/55	96	"High"	NP	175.7	0

[a]Data missing from 06/27 to 06/30. [b]Occasional stretches of time where alternating recordings began late, resulting in recordings that are only 00:09:24. [c]Data missing from 07/03 to 07/08.

Definitions:

Year: The year in which the hydrophone was deployed
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 which 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.
HPF (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 2014-2022. For hydrophone settings and locations see Table 2. NR = Not Recorded

Year	Location	Record Start Date	Record End Date	Variables	Serial Number	Model	Settings
2014	Mid Hendrickson	16-Jun	21-Aug	waves	21561	RBR TWR-2050	3:45 min sample rate
2014	Mid Hendrickson	16-Jun	21-Aug	Conductivity, Temperature	NR	Star-ODDI	1 min period
2014	Mid Hendrickson	16-Jun	21-Aug	Turbidity	10040	RBR XR-420	1 min period
2015	West Hendrickson	16-Jun	21-Aug	Conductivity, Temperature, Depth	60234	RBR Concerto	30s period
2015	Mid Kugmallit	16-Jun	21-Aug	Conductivity, Temperature, Depth	60219	RBR Concerto	2s period
2015	Channel	18-Jun	23-Aug	Temperature, Depth	16242	RBR TDR-2050	15s period
2016	Mid Kugmallit A	13-Jun	22-Aug	pH, Temperature	52622	RBR Duo	1s period
2016	Mid Kugmallit A	13-Jun	22-Aug	Currents	AQD12218	Nortek Aquadopp Profiler	10 min period
2016	Mid Kugmallit B	16-Jun	22-Aug	Conductivity, Temperature, Depth	60273	RBR Concerto	5s period
2016	Mid Kugmallit B	16-Jun	22-Aug	Waves	15454	RBR TWR-2050	4Hz rate, 512 samples, 24min period
2016	East Whitefish	14-Jun	22-Aug	Conductivity, Temperature, Depth	60234	RBR Concerto	15s period
2016	East Whitefish	14-Jun	22-Aug	Waves	50760	RBR Duo	4Hz rate, 512 samples, 30min period
2016	Channel	13-Jun	22-Aug	Temperature, Depth	16242	RBR TDR-2050	15s period
2017	East Hendrickson	21-Jun	19-Aug	Waves, Depth	55172	RBR Virtuoso	6Hz rate, 512 samples, 5min period

Table 3 continued

Year	Location	Record Start Date	Record End Date	Variables	Serial Number	Model	Settings
2017	East Hendrickson	21-Jun	19-Aug	Conductivity, Temperature, Depth	60524	RBR Concerto	5s period
2017	West Hendrickson	21-Jun	19-Aug	Waves, Depth	55171	RBR Virtuoso	6Hz rate, 512 samples, 5min period
2017	West Hendrickson	21-Jun	19-Aug	Conductivity, Temperature, Depth	60234	RBR Concerto	5s period
2017	West Hendrickson	21-Jun	19-Aug	Currents	AQD12218	Nortek Aquadopp Profiler	10min period
2017	Mid Kugmallit	20-Jun	19-Aug	Conductivity, Temperature, Depth	60273	RBR Concerto	5s period
2017	Mid Kugmallit	20-Jun	19-Aug	Turbidity	52587	RBR Duo	30s period
2017	Mid Kugmallit	20-Jun	19-Aug	pH, Temperature	52622	RBR Duo	5s period
2017	Mid Kugmallit	20-Jun	19-Aug	Waves	15454	RBR TWR-2050	4Hz rate, 512 samples, 32min period
2017	East Whitefish	21-Jun	19-Aug	Temperature, Depth	NR	RBR Duo	10min period (live feed)
2017	Channel	20-Jun	19-Aug	Temperature, Depth	16240	RBR TDR-2050	5s period
2018	East Whitefish	20-Jun	31-Aug	Temperature, Depth	NR	RBR Duo	10min period (live feed)
2018	Hendrickson to Tuktoyaktuk[b]	1-Jul	30-Jul	Conductivity, Temperature, Depth	NR	NR	NR
2018	Hendrickson to Tuktoyaktuk[b]	1-Jul	30-Jul	Waves	55171	RBR Virtuoso	6Hz rate, 512 samples, 5min period
2019	Mid Kugmallit	20-Jun	13-Aug	Waves, Depth	41489	RBR Solo	16Hz rate, 512 samples, 5min period
2019	Mid Kugmallit	20-Jun	25-Jun	Conductivity, Temperature, Depth	60708	RBR Concerto	1min period
2019	East Whitefish	21-Jun	8-Aug	Temperature, Depth	NR	RBR Duo	1 sample per day (noon)

Table 3 continued

Year	Location	Record Start Date	Record End Date	Variables	Serial Number	Model	Settings
2019	West Hendrickson	20-Jun	29-Jun	Conductivity, Temperature, Depth	60709	RBR Concerto	1min period
2019	Shingle Point Inner Bay	17-Jun	12-Aug	Turbidity, Depth	51225	RBR Duo	2min period
2019	Shingle Point Inner Bay	17-Jun	12-Aug	Conductivity, Temperature	NR	Star-ODDI	1min period
2019	Shingle Point Outer Bay	16-Jun	12-Aug	Turbidity	79992	RBR Solo	2min period
2019	Shingle Point Outer Bay	16-Jun	12-Aug	Conductivity, Temperature, Depth	60273	RBR	1min period
2019	Shingle Point Outer Bay	16-Jun	12-Aug	Currents	AQD14871	Nortek Aquadopp	10min period
2020	East Whitefish	24-Jun	22-Aug	Waves, Depth	41464	RBR Solo	4Hz, 512 samples, 5min period
2020	East Whitefish	24-Jun	8-Sep	Waves, SST	0184	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2020	Mid Kugmallit	24-Jun	8-Sep	Waves, SST	0532	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2020	West Hendrickson	24-Jun	8-Sep	Waves, Depth	204449	RBR Virtuoso	4Hz continuous
2020	West Hendrickson	24-Jun	8-Sep	Waves, SST	0536	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2020	Niaqunnaq	26-Jun	25-Jul	Conductivity, Temperature, Depth	60709	RBR Concerto	2Hz rate, 10 samples, 10min period
2020	Niaqunnaq	26-Jun	26-Jul	Waves	41489	RBR Solo	4Hz, 512 samples, 5min period
2020	Niaqunnaq	26-Jun	13-Sep	Waves, SST	0528	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2020	Shingle Point Inner Bay	26-Jun	13-Sep	Turbidity	79992	RBR Solo	2min period
2020	Shingle Point Inner Bay	26-Jun	13-Sep	Temperature, Depth	204451	RBR Duo	4Hz continuous
2020	Shingle Point Inner Bay	26-Jun	13-Sep	Waves	0183	Sofar Spotter	Waves: 2.5Hz continuous; averaged and transmitted hourly

Table 3 continued

Year	Location	Record Start Date	Record End Date	Variables	Serial Number	Model	Settings
2020	Shingle Point Outer Bay	26-Jun	13-Sep	Conductivity, Temperature, Depth	204386	RBR Concerto	4Hz, 40 samples, 5min period
2020	Shingle Point Outer Bay	26-Jun	13-Sep	Turbidity, Waves	51225	RBR Duo	4Hz, 512 samples, 10min period
2020	Shingle Point Outer Bay	26-Jun	13-Sep	Waves, SST	0529	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2021	Shingle Point Ocean	27-Jun	16-Sep	Turbidity	206575	RBR Solo	5min period
2021	Shingle Point Ocean	27-Jun	16-Sep	Conductivity, Temperature, Depth (Seabed)	60709	RBR Concerto	2Hz rate, 20 samples, 30min period
2021	Shingle Point Ocean	27-Jun	16-Sep	Conductivity, Temperature	10945	Star-ODDI	2min period
2021	Shingle Point Ocean	27-Jun	16-Sep	Currents	0060	Nortek Eco	1mHz carrier frequency, 30min interval
2021	Shingle Point Ocean	27-Jun	16-Sep	Waves	1079	Sofar Spotter (Cabled)	Waves: 2.5Hz continuous; averaged and transmitted hourly
2021	Niaqunnaq East	27-Jun	16-Sep	Turbidity	79992	RBR Solo	10min period
2021	Niaqunnaq East	27-Jun	16-Sep	Conductivity, Temperature	10946	Star-ODDI	2min period
2021	Niaqunnaq East	27-Jun	16-Sep	Waves, SST	0528	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2021	Niaqunnaq West	27-Jun	16-Sep	Conductivity, Temperature	10944	Star-ODDI	2min period
2021	Niaqunnaq West	27-Jun	16-Sep	Waves, SST	0971	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2021	Niaqunnaq North	27-Jun	20-Aug	Waves, Depth	41464	RBR Solo	4Hz rate, 512 samples, 5min period
2021	Niaqunnaq North	27-Jun	16-Sep	Conductivity, Temperature, Depth	60524	RBR Concerto	1Hz rate, 10 samples, 10min period
2021	Niaqunnaq North	27-Jun	16-Sep	Waves, SST	0529	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2021	Middle Kugmallit	25-Jun	23-Sep	Waves, Depth	204449	RBR Virtuoso	4Hz rate, 512 samples, 5min period

Table 3 continued

Year	Location	Record Start Date	Record End Date	Variables	Serial Number	Model	Settings
2021	Middle Kugmallit	25-Jun	23-Sep	Conductivity, Temperature	10947	Star-ODDI	2min period
2021	Middle Kugmallit	25-Jun	23-Sep	Waves	0183	Sofar Spotter	Waves: 2.5Hz continuous; averaged and transmitted hourly
2021	West Hendrickson	25-Jun	23-Sep	Conductivity, Temperature, Depth	206639	RBR Concerto	2Hz rate, 20 samples, 10min period
2021	West Hendrickson	25-Jun	10-Aug	Waves	41489	RBR Solo	4Hz rate, 1024 samples, 10min period
2021	West Hendrickson	25-Jun	23-Sep	Waves, SST	0536	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2021	East Whitefish	25-Jun	23-Sep	Temperature, Depth	204451	RBR Duo	4Hz rate, 512 samples, 5min period
2021	East Whitefish	25-Jun	23-Sep	Waves	0184	Sofar Spotter	Waves: 2.5Hz continuous; averaged and transmitted hourly
2021	Garry Island	28-Jun	16-Sep	Turbidity	206574	RBR Solo	5min period
2021	Garry Island	28-Jun	16-Sep	Conductivity, Temperature	10948	Star-ODDI	2min period
2021	Garry Island	28-Jun	7-Sep	Currents	0022	Nortek Eco	1mHz carrier frequency, 30min interval
2021	Garry Island	28-Jun	16-Sep	Waves, SST	1006	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2021	Kendall Island	28-Jun	16-Sep	Conductivity, Temperature, Depth	205124	RBR Concerto	2Hz rate, 20 samples, 10min period
2021	Kendall Island	28-Jun	16-Sep	Turbidity, Waves	51225	RBR Duo	4Hz rate, 512 samples, 30min period
2021	Kendall Island	28-Jun	16-Sep	Waves, SST	0532	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2022	Shingle Point Ocean	22-Jul	23-Sep	Conductivity, Temperature (surface)	10948	Star-ODDI	10min period
2022	Shingle Point Ocean	22-Jul	23-Sep	Conductivity, Temperature (Seabed)	10947	Star-ODDI	10min period
2022	Shingle Point Ocean	22-Jul	23-Sep	Waves	1079	Sofar Spotter (Cabled)	Waves: 2.5Hz continuous; averaged and transmitted hourly

Table 3 continued

Year	Location	Record Start Date	Record End Date	Variables	Serial Number	Model	Settings
2022	Niaqunnaq East	30-Jun	23-Sep	Conductivity, Temperature	10944	Star-ODDI	10min period
2022	Niaqunnaq East	30-Jun	23-Sep	Turbidity, Waves, Depth	51225	RBR Duo	4Hz rate, 512 samples, 30min period
2022	Niaqunnaq East	30-Jun	23-Sep	Waves	1728	Sofar Spotter	Waves: 2.5Hz continuous; data averaged and transmitted hourly
2022	Niaqunnaq West	30-Jun	23-Sep	Conductivity, Temperature, Depth	206639	RBR Concerto	2Hz rate, 20 samples, 10min period
2022	Niaqunnaq West	30-Jun	23-Sep	Currents	0060	Nortek Eco	1mHz carrier frequency, 30min interval
2022	Niaqunnaq West	30-Jun	23-Sep	Waves	0183	Sofar Spotter	Waves: 2.5Hz continuous; averaged and transmitted hourly
2022	Niaqunnaq North	30-Jun	23-Sep	Conductivity, Temperature, Depth	205124	RBR Concerto	2Hz rate, 20 samples, 10min period
2022	Niaqunnaq North	30-Jun	23-Sep	Waves, SST	1006	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2022	Middle Kugmallit	25-Jun	19-Sep	Conductivity, Temperature, Depth	60709	RBR Concerto	2Hz rate, 20 samples, 10min period
2022	Middle Kugmallit	25-Jun	19-Sep	Waves, Depth	41489	RBR Solo	4Hz rate, 512 samples, 20min period
2022	Middle Kugmallit	25-Jun	19-Sep	Waves	0536	Sofar Spotter	Waves: 2.5Hz continuous; averaged and transmitted hourly
2022	West Hendrickson	25-Jun	19-Sep	Conductivity, Temperature	10945	Star-ODDI	10min period
2022	West Hendrickson	25-Jun	19-Sep	Waves, SST	0971	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2022	East Whitefish	25-Jun	19-Sep	Temperature, Depth	204451	RBR Duo	1Hz rate, 30 samples, 10min period
2022	East Whitefish	25-Jun	19-Sep	Turbidity	206575	RBR Solo	10min period
2022	East Whitefish	25-Jun	19-Sep	Waves, SST	0528	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2022	Garry Island	26-Jun	19-Sep	Conductivity, Temperature	10946	Star-ODDI	10min period

Table 3 continued

Year	Location	Record Start Date	Record End Date	Variables	Serial Number	Model	Settings
2022	Garry Island	26-Jun	19-Sep	Waves Depth	204449	RBR Virtuoso	4Hz rate, 512 samples, 5min period
2022	Garry Island	26-Jun	19-Sep	Waves	0184	Sofar Spotter	Waves: 2.5Hz continuous; averaged and transmitted hourly
2022	Kendall Island	26-Jun	19-Sep	Conductivity, Temperature, Depth	60524	RBR Concerto	1Hz rate, 10 samples, 10min period
2022	Kendall Island	26-Jun	19-Sep	Turbidity	79992	RBR Solo	10min period
2022	Kendall Island	26-Jun	6-Sep	Currents	0022	Nortek Eco	1mHz carrier frequency, 30min interval
2022	Kendall Island	26-Jun	19-Sep	Waves, SST	0532	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly
2022	Atkinson Point	17-Jul	11-Sep	Conductivity, Temperature, Depth	207096	RBR Concerto	2Hz rate, 20 samples, 10min period
2022	Atkinson Point	17-Jul	11-Sep	Waves, Depth	41464	RBR Solo	4Hz rate, 512 samples, 20min period
2022	Atkinson Point	17-Jul	11-Sep	Turbidity	207256	RBR Solo	10min period
2022	Atkinson Point	17-Jul	11-Sep	Waves, SST	0529	Sofar Spotter	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted hourly

Definitions:

Year: The year in which the instrument was deployed
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.
Conductivity: A measure of the water's capability to pass electrical flow. This is used to calculate salinity.
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
pH: The hydrogen ion concentration in environmental water, yielding its relative acidity or alkalinity.
Currents: Direction and magnitude of water currents.
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

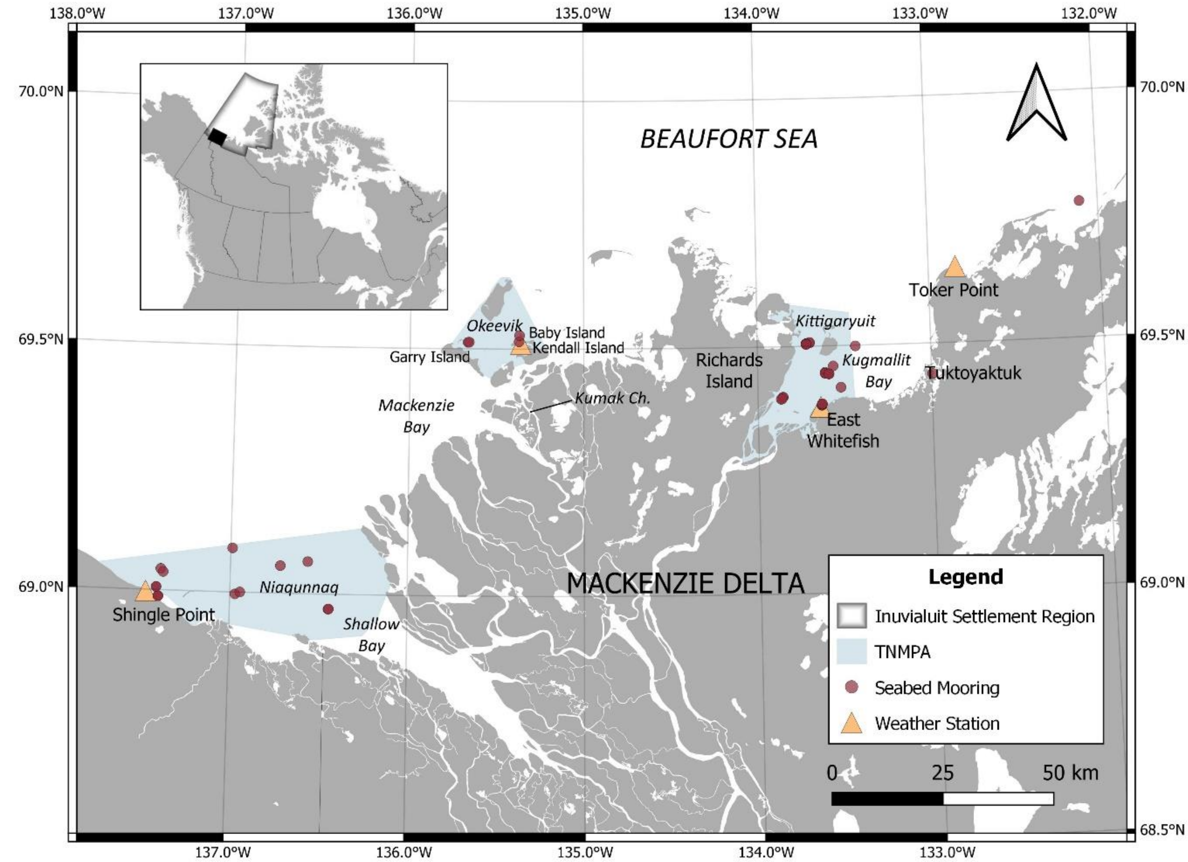

Figure 1: Map of the Mackenzie Delta region showing the location of the three parcels of the TN MPA and each mooring deployed and weather station installed between 2014 and 2022.

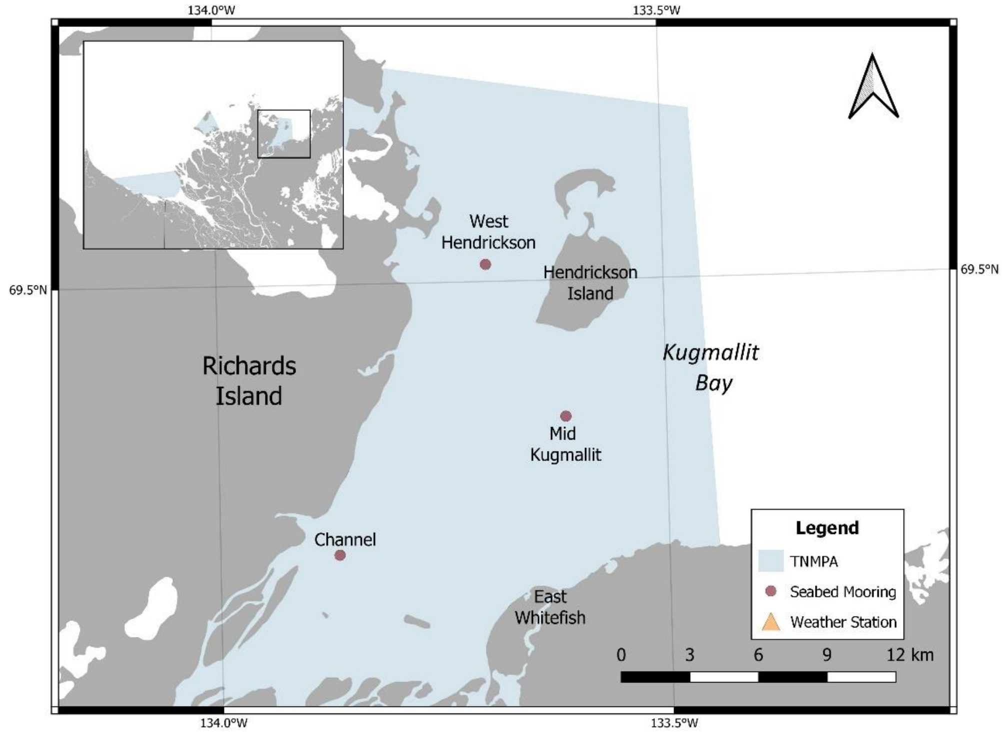

Figure 2: Map of Kugmallit Bay, showing mooring deployment locations in 2015.

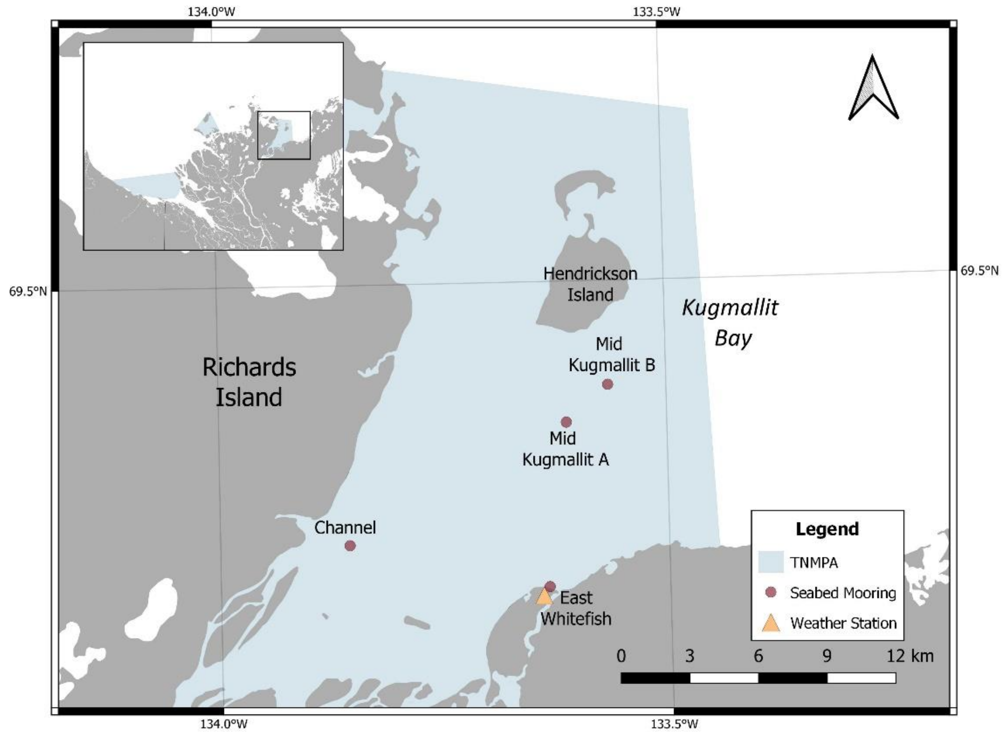

Figure 3: Map of Kugmallit Bay, showing mooring deployment locations in 2016.

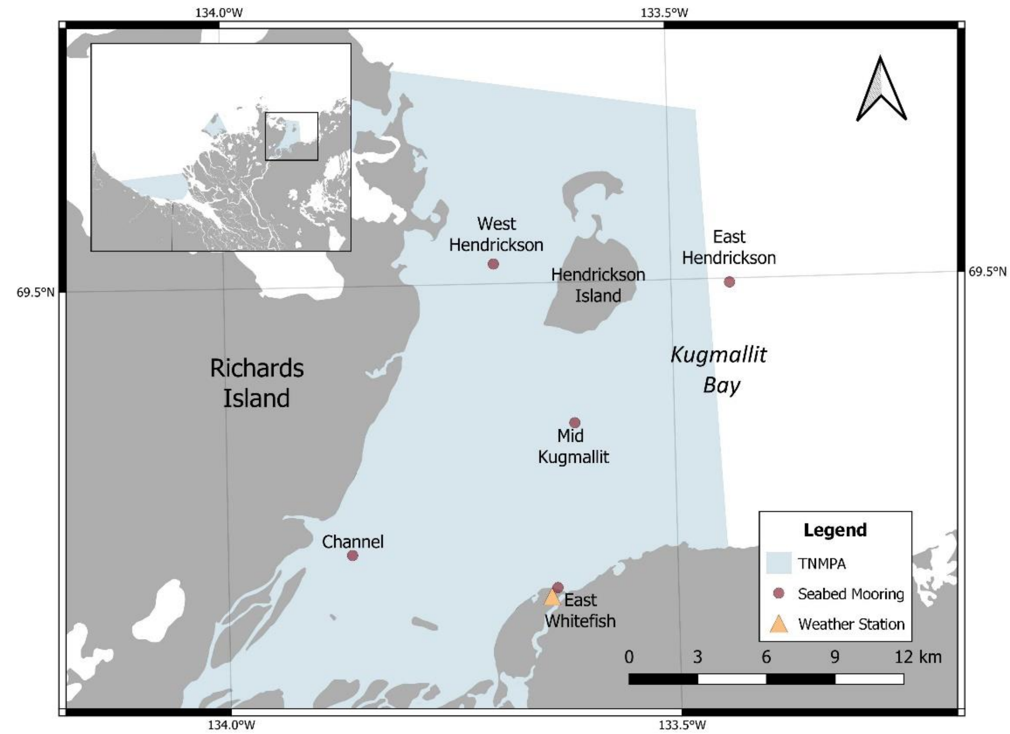

Figure 4: Map of Kugmallit Bay, showing mooring deployment locations in 2017.

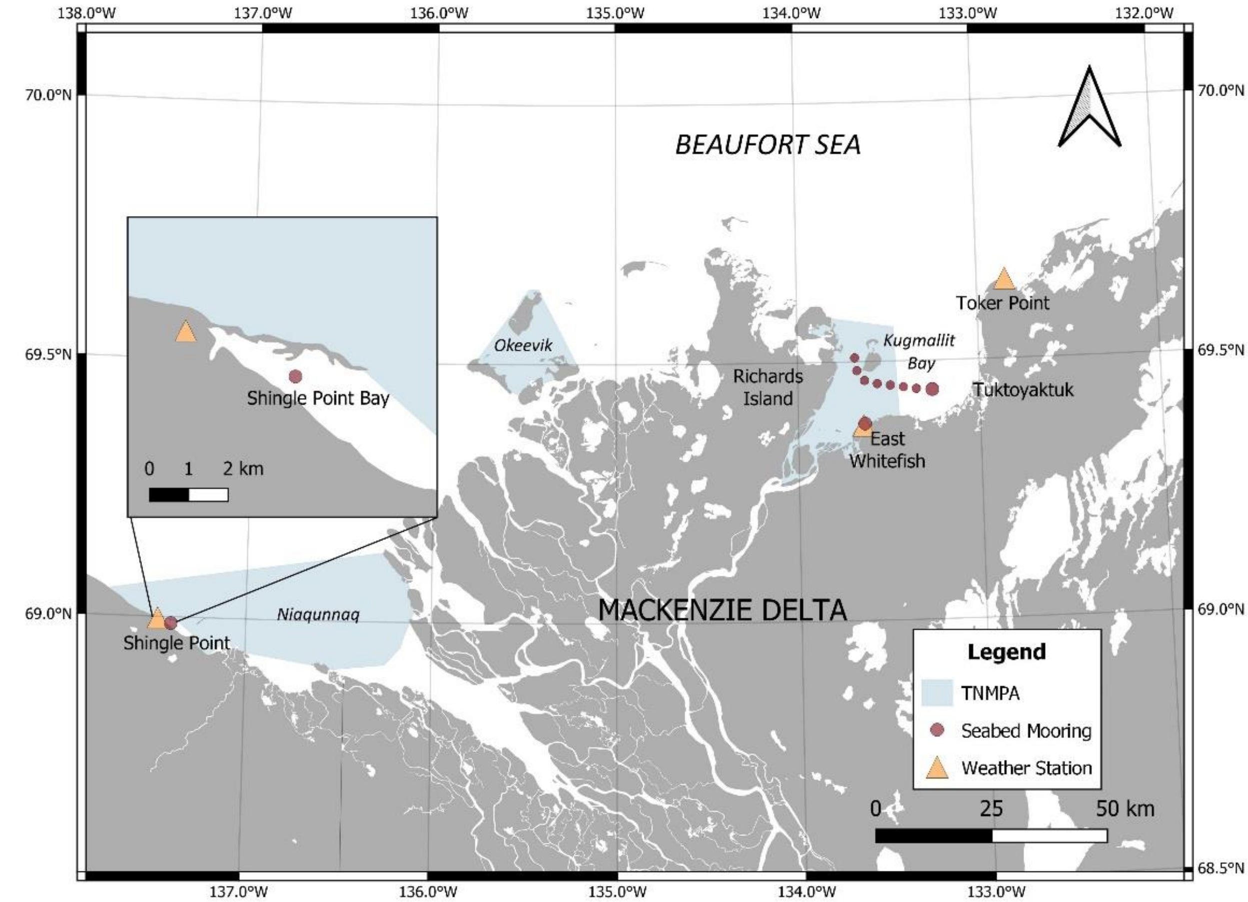

Figure 5: Map of the Mackenzie Delta region, showing mooring deployment locations in 2018. The dotted line represents the assumed movement trajectory of the West Hendrickson mooring. It was recovered near Tuktoyaktuk, though coordinates were not taken.

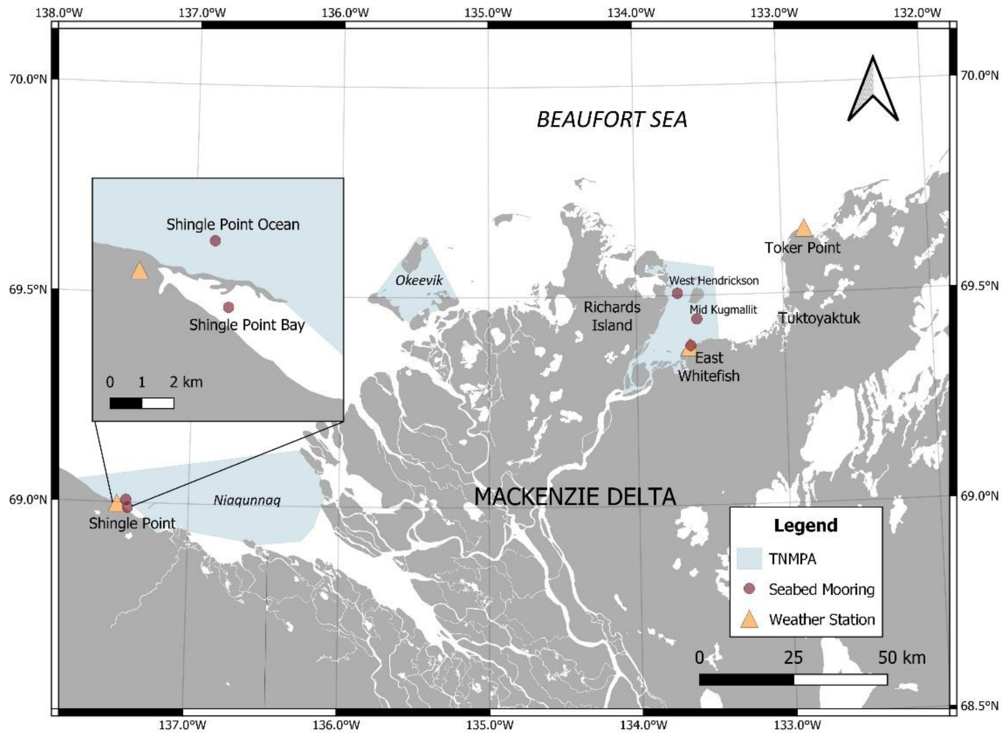

Figure 6: Map of the Mackenzie Delta region, showing mooring deployment locations in 2019.

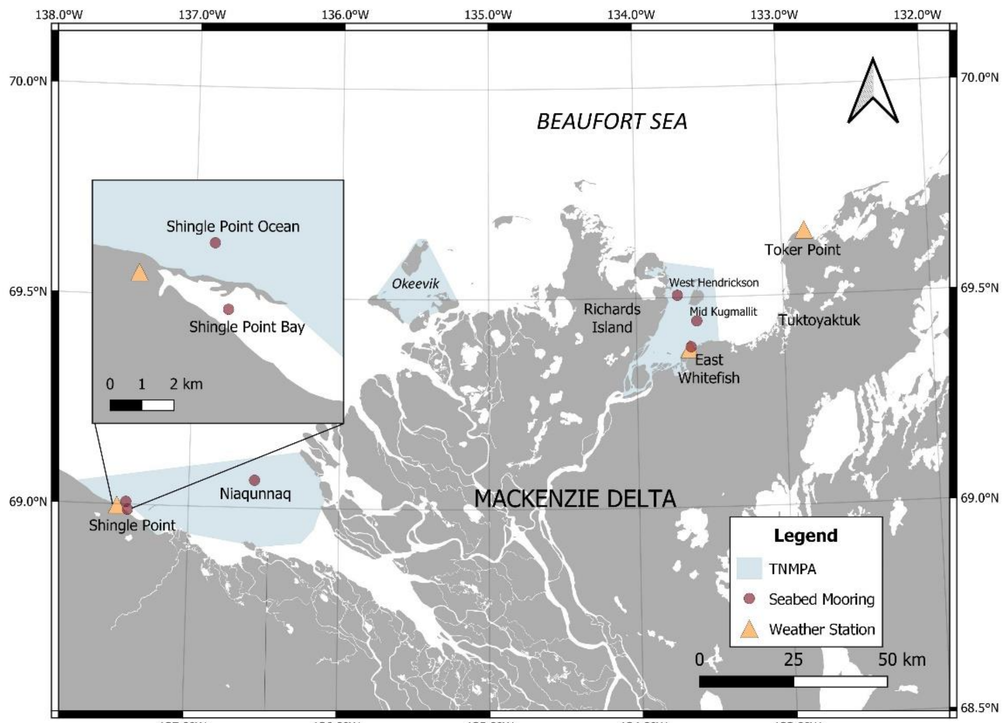

Figure 7: Map of the Mackenzie Delta region, showing mooring deployment locations in 2020.

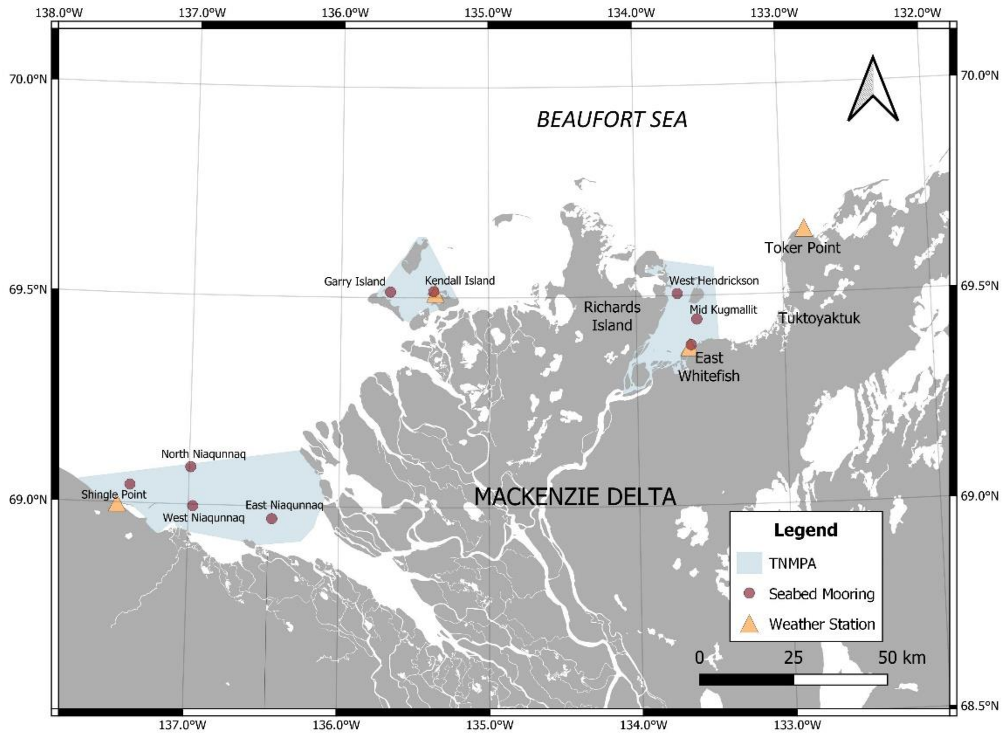

Figure 8: Map of the Mackenzie Delta region, showing mooring deployment locations in 2021.

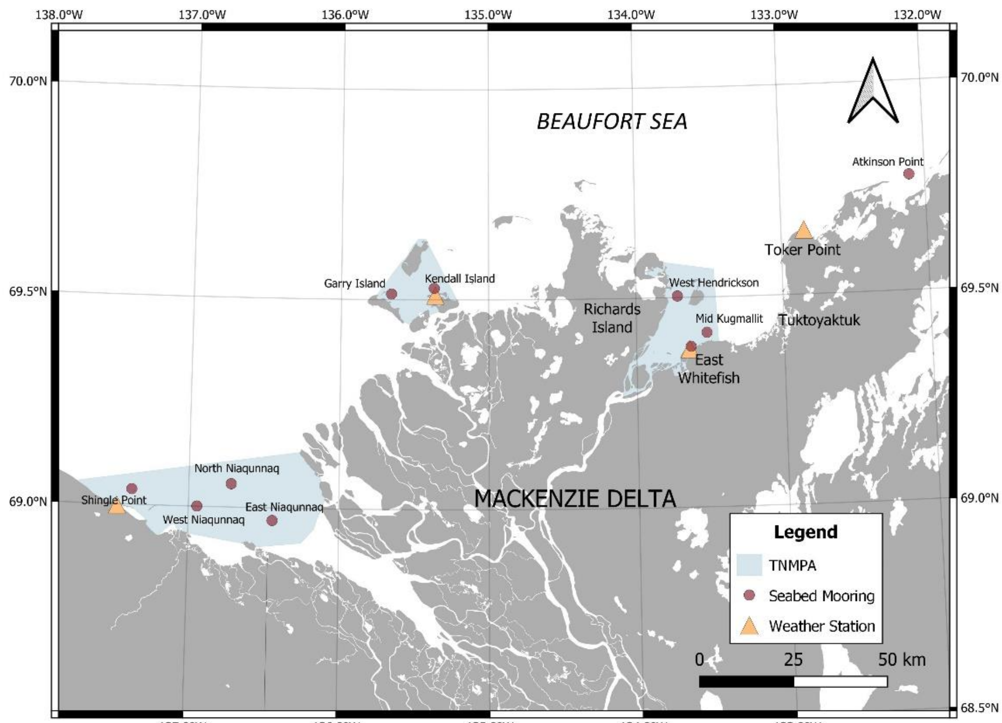

Figure 9: Map of the Mackenzie Delta region, showing mooring deployment locations in 2022.

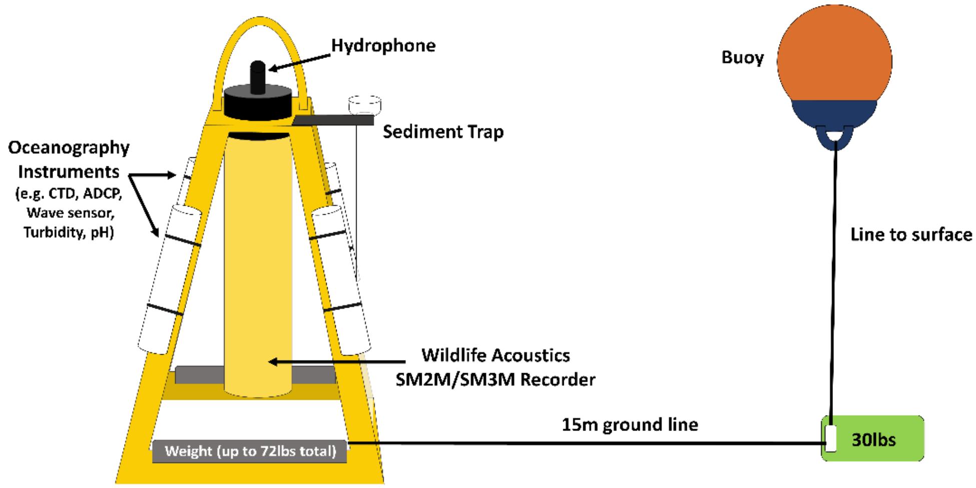

Figure 10: Mooring design for all locations except East Whitefish 2015-2019. Acoustic recorder and hydrophone settings are outlined in Table 2. The configuration of oceanographic instruments varied by location and year as outlined in Table 3.

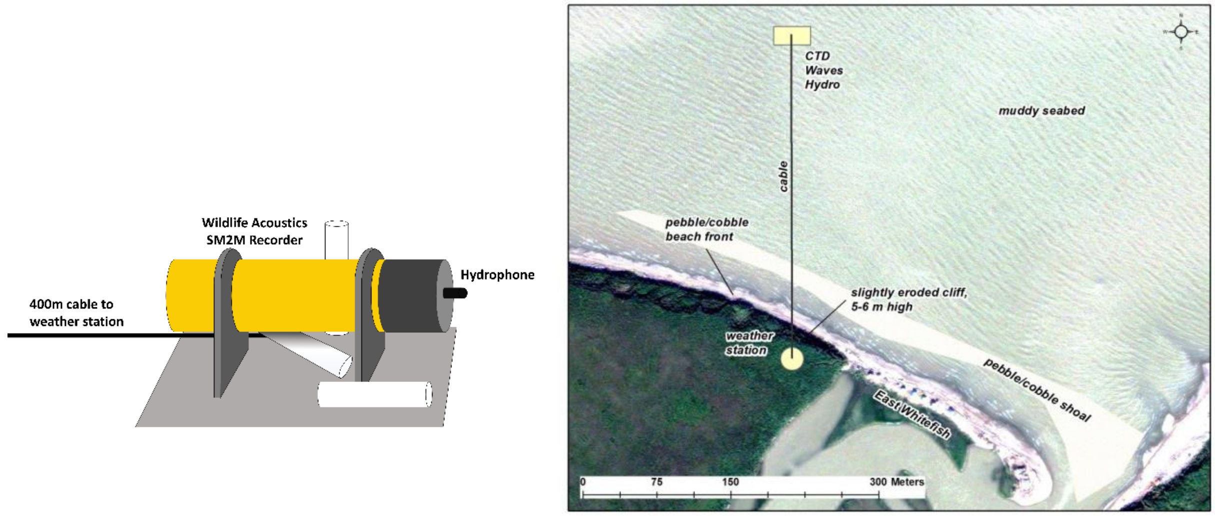

Figure 11: Mooring design at East Whitefish 2016-2019. Oceanographic instruments (CTD, TDR, and/or wave logger) were cabled to the weather station and recordings were transmitted to a publicly accessible webpage in near real-time.

Figure 12: Mooring design in 2020. Two moorings with SM2M acoustic recorders are in front, a smaller mooring with a Sound Trap acoustic recorder is shown in the back.

Figure 13: Mooring frames used in 2021 and 2022. Frames equipped with Sound Trap hydrophones are in the foreground, while those equipped with SM2M hydrophones are in the background. Also shown are the 'smart' buoy system.