Beluga Habitat Program: Seabed Mooring Deployments in the Tarium Niryutait Marine Protected Area, 2024

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by

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TABLE OF CONTENTS

LIST OF TABLES iv
LIST OF FIGURES v
ABSTRACT vi
RÉSUMÉ vii
ACKNOWLEDGEMENTS 1
1. INTRODUCTION 1
  1.1 BACKGROUND 1
  1.2 OBJECTIVES 2
2. MATERIALS AND METHODS 3
  2.1 STUDY AREA 3
  2.2 MOORING DEPLOYMENT 3
  2.3 MOORING DESIGN 4
  2.4 ACOUSTIC RECORDINGS 4
  2.5 OCEANOGRAPHIC DATA 4
REFERENCES 5
INSTRUMENT METADATA 7
DEPLOYMENT CONFIGURATIONS 13

LIST OF TABLES

Table 1: Locations of mooring deployments and variables recorded during the summer of 2024. Note: greyed out squares refer to measurements recorded by instruments that were not recovered from the field. 7

Table 2: Settings and location of all hydrophones deployed in the TN MPA during the 2024 field season. NP = Not Provided by manufacturer. NA = Not Applicable, hydrophone was not recovered at the end of the field season..... 9

Table 3: Settings and location of all oceanographic instruments (except hydrophones) deployed in the TN MPA during the 2024 field season. For hydrophone settings and locations see Table 2. NR = Not Recorded. NA = Not Applicable, instrument was not recovered at the end of the field season.....11

LIST OF FIGURES

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 2024. 13

Figure 2: Map of Okeevik MPA moorings deployed in 2024. The dotted line represents the movement trajectory of the Pelly Island mooring as it was pushed by sea ice from its original deployment location (labelled “Pelly Island” and “June 22, 2024”) to its final shoreline location (western-most point labelled “June 24, 2024”). The Pelly Island mooring was equipped with a Sofar Spotter buoy, which recorded and transmitted its location at regular intervals, permitting us to track the trajectory of its movement with confidence. Movement points are labeled with the transmission date of each specified location. 14

Figure 3: Map of Niaqunnaq MPA moorings deployed in 2024. The dotted line represents the movement trajectory of the Niaqunnaq East buoy after it broke free of its mooring until it was retrieved. The Niaqunnaq East buoy was a Sofar Spotter buoy, which recorded and transmitted its location at regular intervals, permitting us to track the trajectory of its movement between breaking free and retrieval with confidence. Movement points are labeled with the transmission date of each specified location. 15

Figure 4: Map of Kugmallit Bay and Kittigaryuit MPA moorings deployed in 2024. The dotted line represents a summarized movement trajectory of the Fairway buoy after it broke free of its mooring (labelled “Fairway Buoy” and “July 7, 2024”) until it was retrieved (labelled “July 13, 2024”). The Fairway buoy was a Sofar Spotter buoy, which records and transmits its location at regular intervals, permitting us to track the trajectory of its movement between breaking free and retrieval with confidence. Movement points are labeled with the transmission date of each specified location. 16

Figure 5: Mooring frame design (above) and Sofar Spotter buoys (below) used at all deployment locations in 2024. Configuration and settings for acoustic recorders and hydrophones are outlined in Table 2 and oceanographic instruments in Table 3. 17

ABSTRACT

Westphal, A.M., Scharffenberg, K., Whalen, D., Rankin, C., 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, 2024. Can. Data. Rep. Fish. Aquat. Sci. 1494: vii + 17 p.

The Tarium Niryutait Marine Protected Area (TN MPA) was designated as Canada's first Arctic Marine Protected Area in 2010 with the goal of protecting 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 conducted passive acoustic monitoring complemented with oceanographic data collection since 2014. Since its inception, the program has gradually expanded to incorporate mooring deployments in all three MPA parcels of TN MPA. 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 2024 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 2024, moorings were deployed in all three parcels of TN MPA: two in Niaqunnaq MPA, two in Okeevik MPA, and three in Kittigaryuit MPA. To date, this program has conducted 11 seasons of monitoring in Kugmallit Bay (Kittigaryuit MPA), seven in Niaqunnaq MPA, and four in Okeevik MPA.

RÉSUMÉ

Westphal, A.M., Scharffenberg, K., Whalen, D., Rankin, C., 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, 2024. Can. Data. Rep. Fish. Aquat. Sci. 1494: vii + 17 p.

La Zone de protection marine Tarium Niryutait (ZPM TN) a été désignée en 2010 comme la première zone de protection marine de l'Arctique canadien afin 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. Depuis sa création, le programme s'est progressivement élargi pour inclure le déploiement de mouillages dans les trois secteurs de la ZPM TN. 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 sur 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 2024. 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 2024, des mouillages ont été déployés dans les trois secteurs de la ZPM TN : deux dans la ZPM Niaqunnaq, deux dans la ZPM Okeevik et trois dans la ZPM Kittigaryuit. À ce jour, ce programme a réalisé onze saisons de surveillance dans la baie Kugmallit (ZPM Kittigaryuit), sept dans la ZPM Niaqunnaq et quatre dans la ZPM Okeevik.

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1. INTRODUCTION

1.1 BACKGROUND

Eastern Beaufort Sea (EBS) beluga whale (*Delphinapterus leucas,* Qilalugaq) population spends the winter in the Bering Sea and in the spring migrate to summering areas in the Beaufort Sea and Amundsen Gulf (Fraker et al. 1979, Storrie et al. 2022). In the late spring thousands of EBS beluga whales will travel to the Mackenzie River estuary (hereafter, Mackenzie Estuary), where they will wait for the land-fast ice to break-up and allow access to warmer, coastal areas within the estuary (Norton and Harwood 1986, Harwood et al. 2014). EBS beluga whales congregate within the Mackenzie Estuary, tending towards the warm, turbid, fresher waters along the coast (Harwood et al. 2014, Scharffenberg et al. 2019, Noel et al. 2022). The warmer, fresher water in these coastal areas may provide a variety of benefits to belugas, including aiding the moulting process (St. Aubin et al. 1990, Smith et al. 1992) or providing thermal benefits for calves or young beluga (Sergeant 1973). Shallow waters and bottom substrate type may support moulting and specific site use within parts of the estuary (Whalen et al. 2019).

The Tarium Niryutait Marine Protected Area (TN MPA) was designated as a Marine Protected Area in 2010 with the goal of protecting beluga whales and their habitat within the Mackenzie Estuary (*Tarium Niryutait Marine Protected Areas Regulations*, SOR/2010-190). The TN MPA consists of three MPA parcels: Niaqunnaq (West Mackenzie Bay), Okeevik (East Mackenzie Bay), and Kittigaryuit (Kugmallit Bay). In addition to providing important summer habitat for beluga whales, this region also supports a diverse array of other marine mammals, fishes, waterfowl, and seabirds (Cobb et al. 2008). Given the area's ecological significance, there is a need to understand how accelerated environmental change is affecting physical oceanography, sediment dynamics, and the shallow ecosystem within the TN MPA, particularly in areas frequented by beluga whales and coastal fishes.

The Beluga Habitat Program is a long-term monitoring program focused on monitoring environmental and acoustic conditions and assessing climate-driven environmental changes within the TN MPA. The program uses coastal observatories (i.e., instrumented seabed moorings) to examine how beluga whales are responding to coastal and oceanographic change, while providing Inuvialuit community members and the general public with observations of environmental conditions. These observatories collect acoustic data complemented with

oceanographic measurements, 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. 2025). The datasets are used to analyze indicators identified in the TN MPA Monitoring Plan (Fisheries and Oceans Canada and Fisheries Joint Management Committee 2013a), including beluga distribution, timing of beluga arrival to the estuary, anthropogenic noise, and baseline physical/environmental conditions.

Since the Beluga Habitat Program began pairing acoustic data collection with oceanographic measurements in 2014, we have gradually expanded data collection to include all three parcels of TN MPA (Scharffenberg et al. 2024). This broader geographic coverage has allowed us to begin examining long-term trends both within and across regions in the estuary. With the completion of the Beluga Habitat Program's 2024 field season, we now have 11 years of continuous monitoring in Kugmallit Bay, including nine consecutive years of data collected from deployments at East Whitefish. Additionally, we have collected seven years of monitoring data in Niaqunnaq MPA and four years in Okeevik MPA. This long-term monitoring program which will allow us to identify status, trends, and reference levels in ecological indicators which were identified as being important for measuring the success of the MPA at achieving its conservation objective (Fisheries and Oceans Canada and Fisheries Joint Management Committee 2013a). The dataset also provides a critical foundation for monitoring environmental change and assessing impacts on beluga habitat use, both within parcels of the TN MPA and across the estuary.

1.2 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. The purpose of this addendum is to build on an earlier publication of Beluga Habitat Program metadata encompassing all mooring deployments associated with the program from 2014 to 2022 (Scharffenberg et al. 2024) and in 2023 (Westphal et al. 2026). Here we provide an overview of the Beluga Habitat Program and provide metadata for all mooring deployments (i.e., methods, deployment times, instrument settings, etc.) from 2024. 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 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 (Fisheries and Oceans Canada, DFO) and pending approval of co-management bodies.

2. MATERIALS AND METHODS

2.1 STUDY AREA

The Mackenzie Estuary is located in the Inuvialuit Settlement Region, western Canadian Arctic, where the Mackenzie River meets the Beaufort Sea (Figure 1). The influx of fresh, sediment-rich water from the Mackenzie River mixing with cool salt water within the estuary creates a dynamic environment where water temperature, salinity, and turbidity can fluctuate spatially and temporally across the estuary (Lee et al. 2025). The TN MPA management zone encompasses 1800 km^2 across the estuary (*Tarium Niryutait Marine Protected Areas Regulations*, SOR/2010-190), parceled into three MPAs with the conservation objective of protecting beluga whales and their habitat (Fisheries and Oceans Canada and Fisheries Joint Management Committee 2013b). 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 boundaries of these parcels were designed based on beluga harvest management zones and traditional hunting areas for the Aklavik, Inuvik, and Tuktoyaktuk communities (Fisheries Joint Management Committee 2024). A detailed description of the study area and rationale can be found in a previously published metadata report associated with the Beluga Habitat Program (Scharffenberg et al. 2024).

2.2 MOORING DEPLOYMENT

In 2024, we continued to build on a long-term, baseline description of the soundscape and oceanographic conditions across all three parcels of the TN MPA. Please refer to Scharffenberg et al. (2024) for a description of 2014-2022 and Westphal et al. (2026) for 2023 program activities.

In 2024, the Beluga Habitat Program continued to use instrumented moorings equipped with acoustic and environmental sensors in all three parcels of the TN MPA (Figure 1). Two moorings were redeployed in the Kittigaryuit MPA, one offshore from East Whitefish subsistence camp and a second west of Hendrickson Island. Two moorings were deployed in Niaqunnaq MPA, both repositioned close to the southern shoreline. In the Okeevik MPA, one mooring was deployed, positioned roughly centred between Pelly, Garry, and Kendall Islands. In addition to moorings deployed within the TN MPA, we deployed two moorings in Kugmallit Bay outside of the Kittigaryuit MPA and a third mooring outside of Okeevik MPA east of Pelly Island. In 2024, we added a mooring near the Fairway Buoy at the request of Tuktoyaktuk Hunters and Trappers Committee (HTC). This mooring location was selected as part of a study assessing anthropogenic sounds associated with local vessel traffic (e.g., navigation sonars) and beluga vocalizations.

Mooring deployments are timed to occur as early as safely possible following landfast ice break-up to capture the arrival of beluga into the estuary. The Okeevik MPA moorings were the earliest deployments completed in the 2024 field season (Figure 2, Table 1). While landfast ice had broken up at the time of deployment, sea ice was still present within the area. Shortly after deployment prevailing winds pushed free-floating sea ice towards the deployment area. This sea ice pushed the Pelly Island mooring west towards the southern shore of Pelly Island, where the mooring remained for almost the entirety of the deployment period (Figure 2). The mooring included a Sofar Spotter buoy (Sofar Ocean, San Francisco, CA, USA), which recorded and

transmitted its location at regular intervals, allowing us to track the trajectory of its movement with confidence. Both the mooring frame and buoy were recovered in the fall.

Unfortunately, two buoys broke free of their moorings over the course of the 2024 deployment season. First, the eastern buoy in Niaqunnaq broke free during a storm event towards the end of the deployment season (Figure 3). Based on frequent submersion events throughout the summer, we suspect there was too little slack in the buoy line which added strain on the mooring line and connections. The second mooring was deployed near Fairway Buoy in Kugmallit Bay and floated free from the mooring shortly after deployment (Figure 4). The Fairway buoy was later retrieved on Hendrickson Island. In this instance, the exact cause of the buoy breaking free is unknown and we will review our deployment methods with field leads prior to the 2025 season. Both moorings included a Sofar Spotter buoy allowing us to track the trajectory of its movement between breaking free and retrieval with confidence. In both cases the buoys were recovered, but the mooring frames and attached instruments were not.

2.3 MOORING DESIGN

Moorings were redesigned in collaboration discussions with the Inuvik, Aklavik, and Tuktoyaktuk HTCs following the unfortunate entanglement of a beluga in 2023 (Westphal et al. 2026). Design modifications for 2024 mooring deployments included the addition of tubing to prevent surface lines from looping, and a geofencing feature on the Sofar Spotter buoys to notify the team of any movement which could be indicative of whale entanglement (Figure 5). There were no entanglements in the 2024 field season. We will continue to make further modifications to mooring designs based on feedback from deployment/recovery teams and discussions with Inuvik, Aklavik, and Tuktoyaktuk HTCs.

2.4 ACOUSTIC RECORDINGS

Moorings deployed in 2024 were equipped with a Sound Trap acoustic recorder (Ocean Instruments, NZ) with the exception of one site where a Loggerhead acoustic recorder (Loggerhead Instruments, FL, USA) was used (Table 1). Three models of Sound Trap acoustic recorders (Ocean Instruments, NZ) were used in 2024: ST300 STD models, which were both attached to mooring frames that were lost at sea; ST300 HF models were programmed with a 192 kHz sample rate and 25% duty cycle (15 min on, 45 min off); and ST400 models were programmed with a 96 or 192 kHz sample rate and 8.3% duty cycle (5 min on; 55 min off, Table 2). A Loggerhead acoustic recorder (Loggerhead Instruments, FL, USA) was deployed at one site in 2024. 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 and Solo models; RBR Ltd., Kanata, Canada) or Star-ODDI (Star-Oddi Ltd., Gardabaer, Iceland) CTD instrument. Instrument configuration prioritized comprehensive coverage for collecting temperature, depth, conductivity, and wave condition measurements and targeted collection of 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 2024. Note: 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	69.3966	-133.6270	2.7	27-Jun	16-Sep	X	X	X	X	X	X	X
West Hendrickson	69.5041	-133.7160	1.8	28-Jun	16-Sep	X	X	X	X		X	X
Fairway Buoy[a]	69.5150	-133.1000		2-Jul	11-Jul		X				X	
Okeevik	69.5188	-135.4880	1.9	22-Jun	23-Sep	X	X	X	X	X	X	X
Pelly Island[b]	69.5582	-135.5290	1.0	22-Jun	23-Sep	X	X	X	X		X	X
Niaqunnaq West	68.9549	-136.9090	3.0	26-Jun	30-Sep	X	X	X	X		X	X
Niaqunnaq East[c]	68.9366	-136.5970		26-Jun	30-Sep		X				X	

[a] Buoy floated free from mooring shortly after deployment and was recovered on Hendrickson Island. The mooring frame was not recovered.
[b] Prevailing winds pushed free-floating sea ice towards the Pelly Island mooring shortly after deployment. This mooring was then pushed west towards the southern shore of Pelly Island, where it remained for almost the entirety of the deployment period. The mooring frame was recovered at the end of the season.
[c] Buoy broke free from mooring during a storm towards the end of the deployment season and was recovered. The mooring frame was not recovered.

Definitions:

Bottom Depth: In 2024, bottom depth was not recorded at deployment time. The datum 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 5 or 15 minutes every hour.

Table 2: Settings and location of all hydrophones deployed in the TN MPA during the 2024 field season. NP = Not Provided by manufacturer. NA = Not Applicable, hydrophone was not recovered at the end of the field season.

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	5230	ST300 (HF)	27-Jun	9-Aug	15/45	192	“High”	NP	176.6	0
West Hendrickson	-	Loggerhead	28-Jun	16-Sep	15/45	96	12.4	-169.9	NP	0
Fairway Buoy[a]	5262	ST300 (STD)	2-Jul	-	NA	NA	“High”	NP	176.5	0
Okeevik	6839	ST400 (STD)	22-Jun	23-Sep	5/55	96	“High”	NP	176.4	0
Pelly Island[b]	6840	ST400 (STD)	22-Jun	23-Sep	5/55	192	“High”	NP	175.7	0
Niaqunnaq East[c]	5269	ST300 (STD)	26-Jun	-	NA	NA	“High”	NP	176.1	0
Niaqunnaq West	6067	ST300 (HF)	26-Jun	25-Jul	15/45	192	“High”	NP	175.2	0

[a]Buoy floated free from mooring shortly after deployment, buoy was recovered on Hendrickson Island. The mooring frame was not recovered.
[b]Prevailing winds pushed free-floating sea ice towards the Pelly Island mooring shortly after deployment. The Pelly Island mooring was pushed west towards the southern shore of Pelly Island, where the mooring remained for almost the entirety of the deployment period. Mooring frame was recovered at the end of the season.
[c]Buoy broke free from mooring during a storm towards the end of the deployment season and was recovered. The mooring frame was 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 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.
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 2024 field season. For hydrophone settings and locations see Table 2. NR = Not Recorded. NA = Not Applicable, instrument was not recovered at the end of the field season.

Location	Record Start Date	Record End Date	Variables	Serial Number	Model	Settings
East Whitefish	27-Jun	16-Sep	Conductivity, Temperature, Depth	206639	RBR Concerto	2Hz rate, 10 samples, 10min period
East Whitefish	27-Jun	16-Sep	Turbidity	206574	RBR Solo	5min period
East Whitefish	27-Jun	16-Sep	Waves, SST	0528	Sofar Spotter Buoy	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted every 30min
West Hendrickson	28-Jun	16-Sep	Conductivity, Temperature, Depth	214427	RBR Concerto	2Hz rate, 60 samples, 10min period
West Hendrickson	28-Jun	16-Sep	Waves, SST	1006	Sofar Spotter Buoy	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted every 30min
Fairway Buoy[a]	2-Jul	-	Conductivity, Temperature	10945	Star-ODDI	NA
Fairway Buoy[a]	2-Jul	-	Turbidity	235352	RBR Solo	NA
Fairway Buoy[a]	2-Jul	11-Jul	Waves, SST	0532	Sofar Spotter Buoy	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted every 30min
Okeevik	22-Jun	23-Sep	Conductivity, Temperature, Depth	205124	RBR Concerto	2Hz rate, 20 samples, 10min period
Okeevik	22-Jun	23-Sep	Turbidity	235323	RBR Solo	5min period
Okeevik	22-Jun	23-Sep	Waves, SST	30414	Sofar Spotter Buoy	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted every 30min
Pelly Island[b]	22-Jun	23-Sep	Conductivity, Temperature, Depth	214426	RBR Concerto	2Hz rate, 60 samples, 10min period
Pelly Island[b]	22-Jun	23-Sep	Waves, SST	30421	Sofar Spotter Buoy	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted every 30min

Niaqunnaq East[c]	26-Jun	30-Sep	Conductivity, Temperature	10948	Star-ODDI	NA
Niaqunnaq East[c]	26-Jun	30-Sep	Waves, SST	31041	Sofar Spotter Buoy	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted every 30min
Niaqunnaq West	26-Jun	30-Sep	Conductivity, Temperature, Depth	235351	RBR Concerto	2Hz rate, 10 samples, 5min period
Niaqunnaq West	26-Jun	30-Sep	Waves, SST	31145C	Sofar Spotter Buoy	Waves: 2.5Hz continuous; SST 10s period; data averaged and transmitted every 30min

[a] Buoy floated free from mooring shortly after deployment, buoy was recovered on Hendrickson Island. The mooring frame was not recovered.
[b] Prevailing winds pushed free-floating sea ice towards the Pelly Island mooring shortly after deployment. The Pelly Island mooring was pushed west towards the southern shore of Pelly Island, where the mooring remained for almost the entirety of the deployment period. Mooring frame was recovered at the end of the season.
[c] Buoy broke free from mooring during a storm towards the end of the deployment season and was recovered. The mooring frame was 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.
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.
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

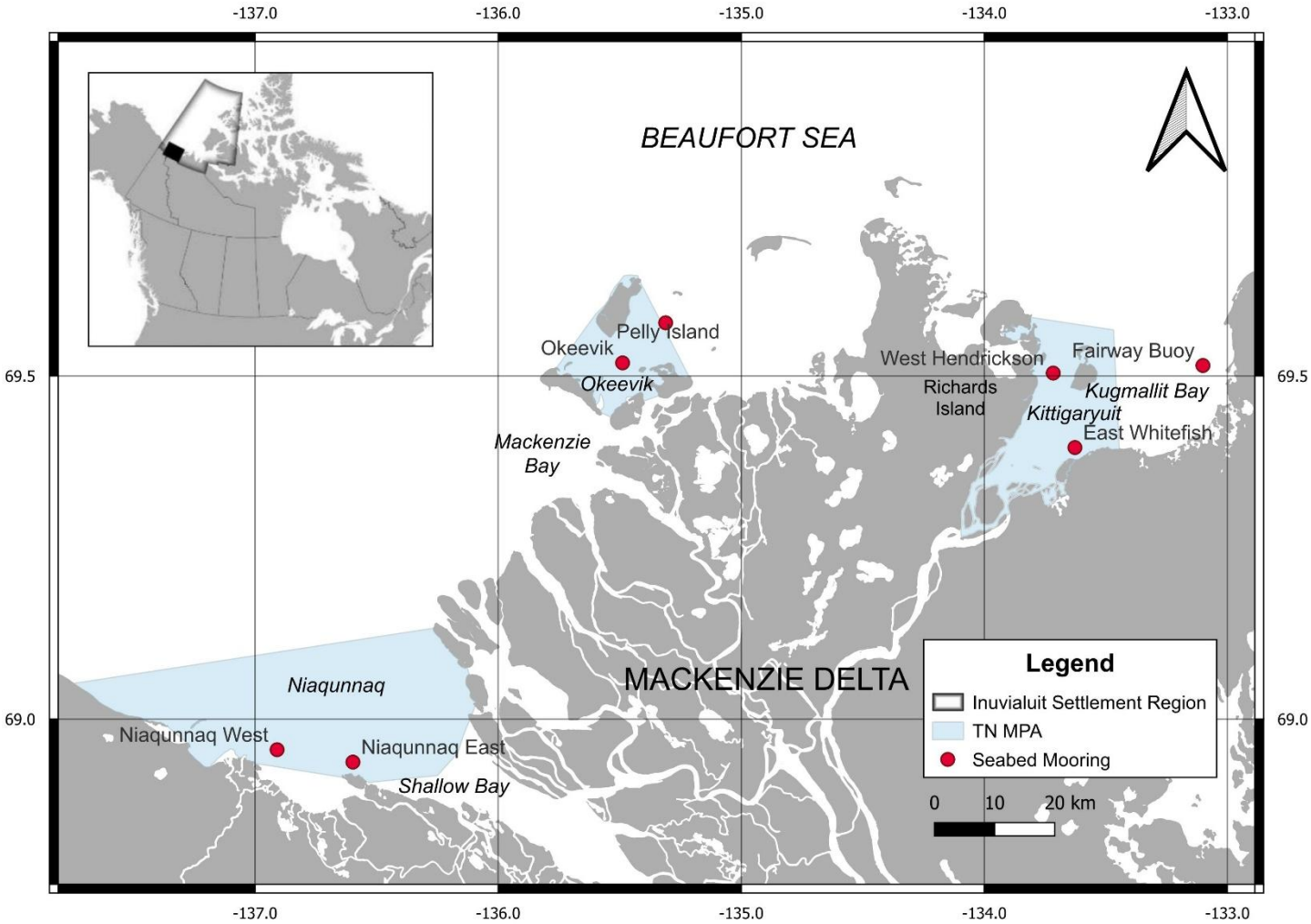


Figure 1: Map of the Mackenzie Delta and estuary showing the location of the three parcels of the TN MPA and each mooring deployed in 2024.

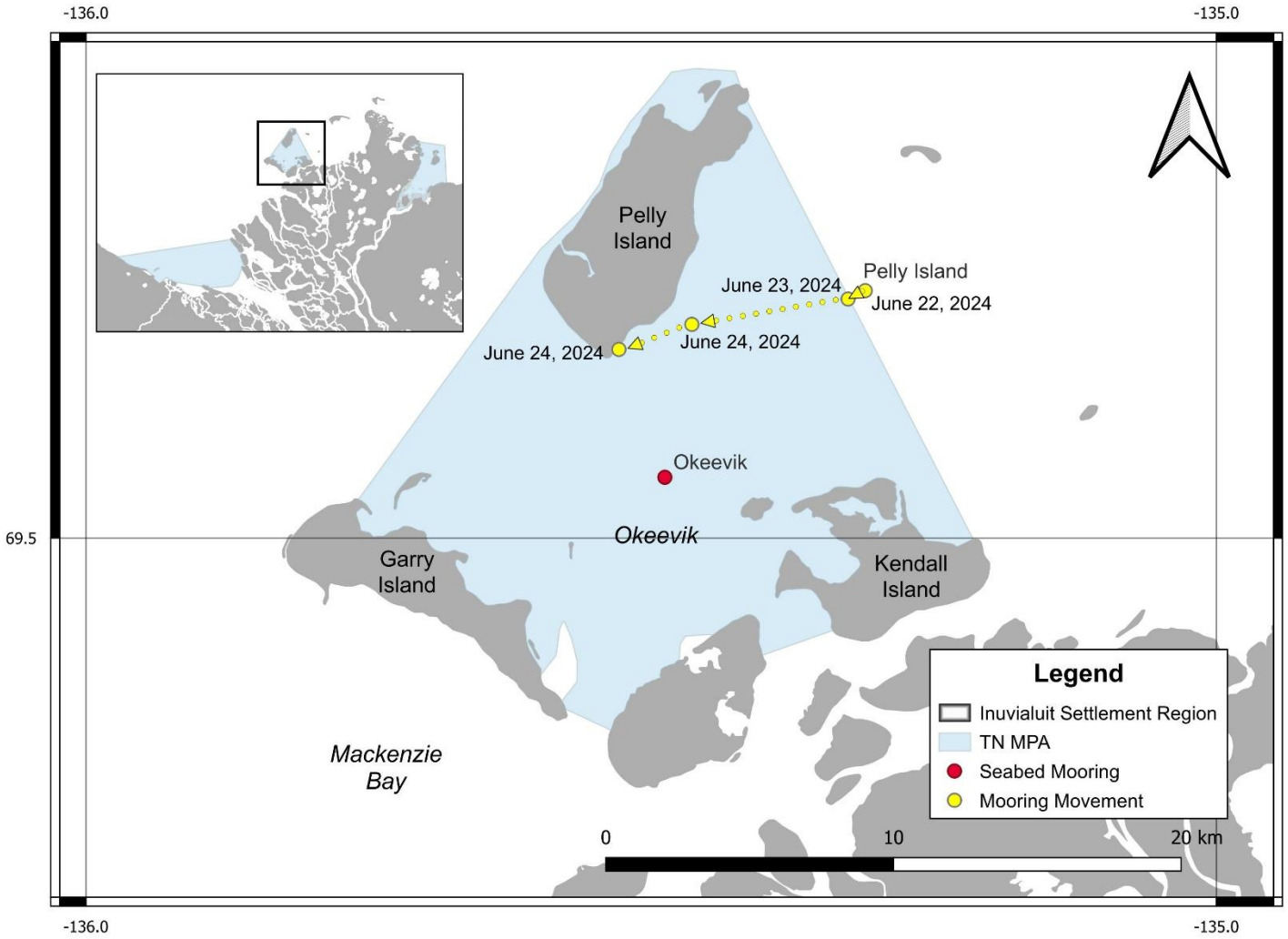


Figure 2: Map of Okeevik MPA moorings deployed in 2024. The dotted line represents the movement trajectory of the Pelly Island mooring as it was pushed by sea ice from its original deployment location (labelled “Pelly Island” and “June 22, 2024”) to its final shoreline location (western-most point labelled “June 24, 2024”). The Pelly Island mooring was equipped with a Sofar Spotter buoy, which recorded and transmitted its location at regular intervals, permitting us to track the trajectory of its movement with confidence. Movement points are labeled with the transmission date of each specified location.

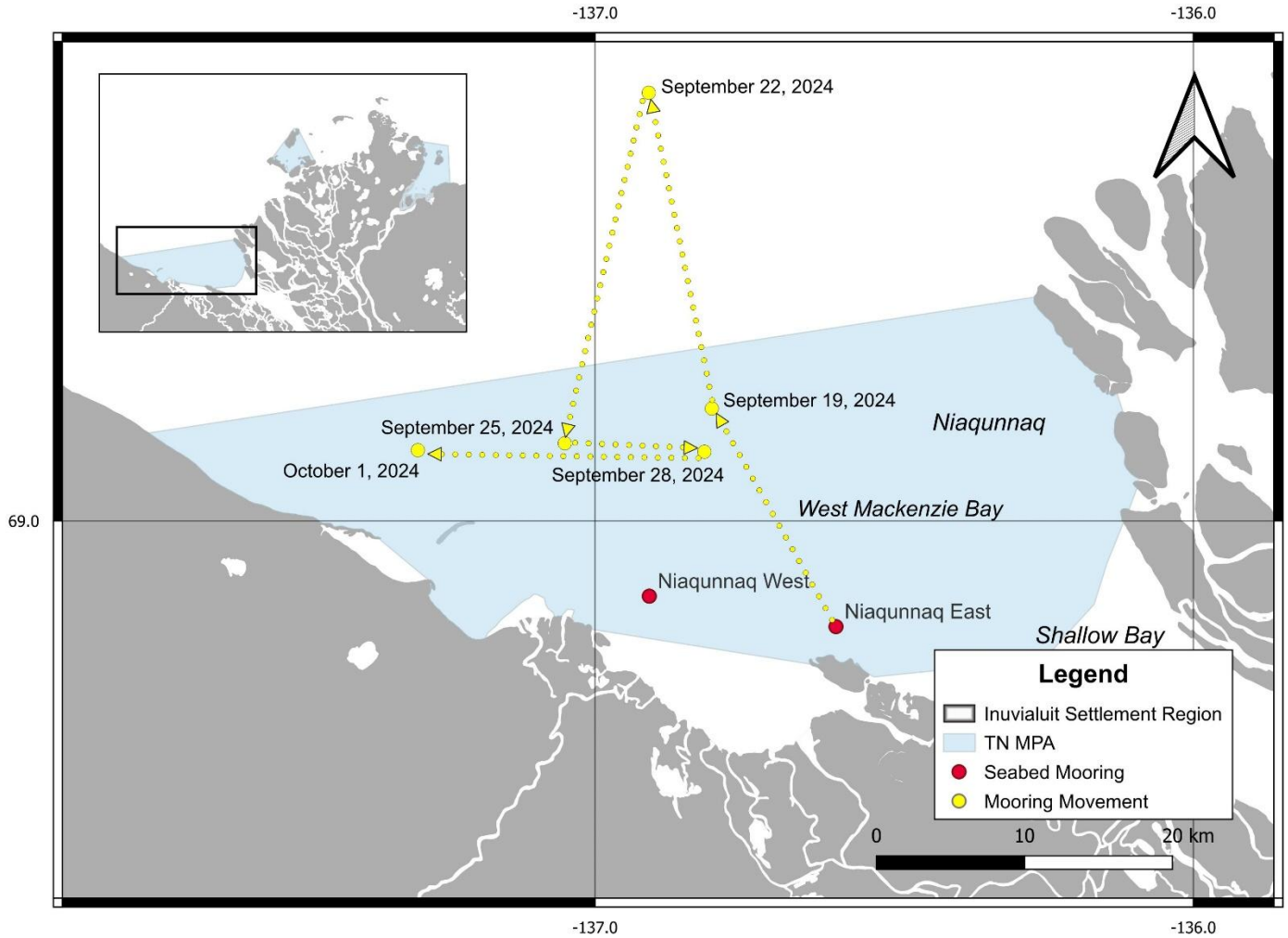


Figure 3: Map of Niaqunnaq MPA moorings deployed in 2024. The dotted line represents the movement trajectory of the Niaqunnaq East buoy after it broke free of its mooring until it was retrieved. The Niaqunnaq East buoy was a Sofar Spotter buoy, which recorded and transmitted its location at regular intervals, permitting us to track the trajectory of its movement between breaking free and retrieval with confidence. Movement points are labeled with the transmission date of each specified location.

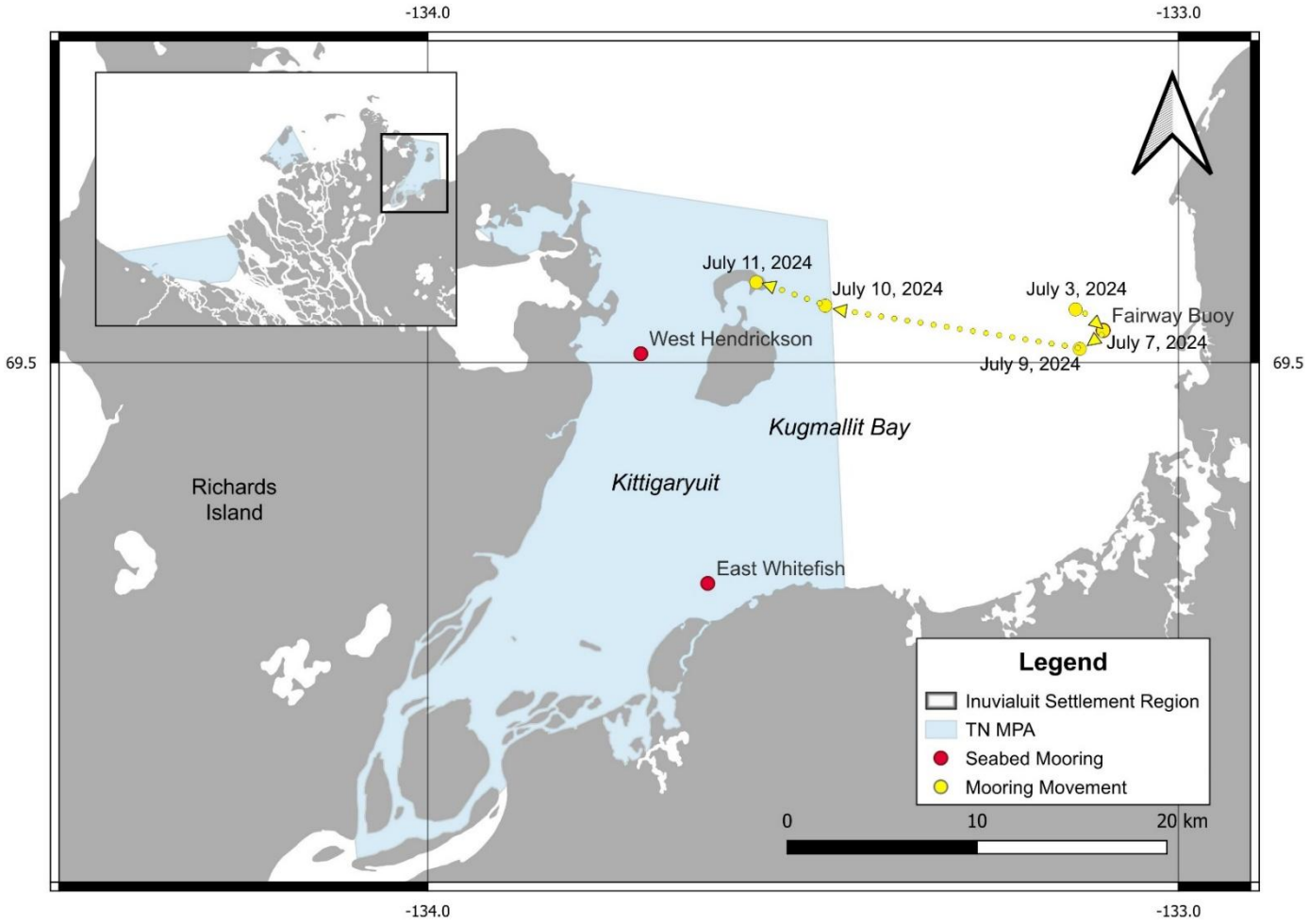


Figure 4: Map of Kugmallit Bay and Kittigaryuit MPA moorings deployed in 2024. The dotted line represents a summarized movement trajectory of the Fairway buoy after it broke free of its mooring (labelled “Fairway Buoy” and “July 7, 2024”) until it was retrieved (labelled “July 13, 2024”). The Fairway buoy was a Sofar Spotter buoy, which records and transmits its location at regular intervals, permitting us to track the trajectory of its movement between breaking free and retrieval with confidence. Movement points are labeled with the transmission date of each specified location.



Figure 5: Mooring frame design (above) and Sofar Spotter buoys (below) used at all deployment locations in 2024. Configuration and settings for acoustic recorders and hydrophones are outlined in Table 2 and oceanographic instruments in Table 3.