Oceanography of the Tarium Niryutait Marine Protected Area: 2015-2025

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by

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ABSTRACT

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The Tarium Niryutait Marine Protected Area (TN MPA) was established to conserve Eastern Beaufort Sea beluga whales and their associated habitats. The Beluga Habitat Program is a long-term program integrating passive acoustic monitoring and complementary oceanographic measurements across the three MPA parcels within TN MPA: Kittigaryuit, Niaqunnaq, and Okeevik. This study presents an overview of eleven years of oceanographic monitoring data collected through the Beluga Habitat Program. We present data collected through instrumented seabed moorings deployed annually from 2015 to 2025, focused on seabed and surface water temperature, salinity, turbidity, and wave conditions. Additionally, we present complementary hydrometric records from the Mackenzie Delta collected by Environment and Climate Change Canada. We found consistent seasonal patterns in water temperature and salinity within the estuary. Across the TN MPA, warmer, fresher, and more turbid conditions were associated with deployment locations near river mouths. Freshwater level and discharge in the Mackenzie Delta peaked from late May to early June. The Niaqunnaq MPA tended to yield more pronounced seasonal and spatial fluctuations in water conditions compared to the other two parcels. Wave height and direction of origin varied across the three parcels, likely influenced by local geography and seasonality in wind speed, dominant direction, and storm frequency. This report will contribute to a growing baseline inventory of ecological indicators within the TN MPA and will provide insight into climate-driven changes in estuarine conditions that may influence beluga habitat use and distribution.

RÉSUMÉ

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La Zone de protection marine Tarium Niryutait (ZPM TN) a été établie afin de conserver les bélugas de l'est de la mer de Beaufort et leurs habitats. Le Programme sur l'habitat du béluga est un programme à long terme qui intègre la surveillance acoustique passive et des mesures océanographiques complémentaires dans les trois secteurs de la ZPM TN : Kittigaryuit, Niaqunnaq et Okeevik. Cette étude présente un aperçu de onze années de données de surveillance océanographique recueillies dans le cadre du Programme sur l'habitat du béluga. Nous présentons les données collectées au moyen de mouillages instrumentés installés annuellement sur le fond marin de 2015 à 2025, portant principalement sur la température de l'eau au fond et en surface, la salinité, la turbidité et les conditions de vague. De plus, nous présentons des relevés hydrométriques complémentaires du delta du Mackenzie recueillis par Environnement et Changement climatique Canada. Nous avons observé des profils saisonniers constants de température et de salinité de l'eau dans l'estuaire. À l'échelle de la ZPM TN, les conditions plus chaudes, moins salines et plus turbides étaient associées aux sites de déploiement situés à proximité des embouchures de rivières. Les niveaux d'eau douce et les débits dans le delta du Mackenzie ont atteint leur maximum de la fin mai au début juin. La ZPM Niaqunnaq présentait généralement des variations saisonnières et spatiales plus marquées des conditions de l'eau que les deux autres secteurs. La hauteur des vagues et leur direction de provenance variaient entre les trois secteurs, probablement sous l'influence de la géographie locale ainsi que des variations saisonnières de la vitesse du vent, de sa direction dominante et de la fréquence des tempêtes. Le présent rapport contribuera à l'enrichissement de l'inventaire de référence des indicateurs écologiques de la ZPM TN et fournira des renseignements sur les changements des conditions estuariennes attribuables au climat, susceptibles d'influencer l'utilisation de l'habitat et la répartition des bélugas.

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EXECUTIVE SUMMARY

The Tarium Niryutait Marine Protected Area (TN MPA) is Canada's first Arctic MPA and plays a critical role in conserving Eastern Beaufort Sea (EBS) beluga whales and their supporting ecosystems. The TN MPA is divided into three MPA parcels: Kittigaryuit (Kugmallit Bay), Niaqunnaq (West Mackenzie Bay), and Okeevik (East Mackenzie Bay), each overlapping with high-use summer habitats for belugas. These three parcels also align with traditional beluga hunting areas used by the Inuvialuit communities of Aklavik, Inuvik, and Tuktoyaktuk. EBS beluga whales migrate annually from the Bering Sea to the Beaufort Sea and Amundsen Gulf, with the Mackenzie River estuary serving as one of the world's largest known beluga aggregation sites. Due to the cultural and ecological significance of the TN MPA, there is a need to understand how beluga and other marine wildlife use these areas as well as how environmental change is affecting this shallow estuarine ecosystem.

The Beluga Habitat Program is a long-term monitoring program that began in 2014 with the goal to evaluate oceanographic and acoustic conditions within the TN MPA. The program has gradually expanded its coverage and has included deployments in all three MPA parcels since 2021. Environmental conditions within the estuary have been shown to influence beluga distribution, with specific "hotspots" being associated with warmer, fresher, and more turbid waters. Understanding how belugas use these habitats and how environmental change affects the estuary is essential for their long-term conservation.

This report summarizes eleven years of oceanographic and freshwater flow data collected from 2015 to 2025, including annual monitoring in Kittigaryuit MPA and Kugmallit Bay as well as more recent deployments in West Mackenzie Bay and East Mackenzie Bay. Instrumented seabed moorings were deployed annually across all three MPA parcels, with locations in part selected based on Indigenous Knowledge and community priorities. Here we focus on reporting water characteristics measured using CTD loggers, wave conditions monitored using Sofar Spotter buoys, and freshwater level and flow recorded at Environment and Climate Change Canada (ECCC) hydrometric monitoring stations in select channels of the Mackenzie Delta.

Seabed water temperatures were highest in Kittigaryuit, followed by Okeevik and Niaqunnaq, with warmer conditions generally further inland or closer to freshwater inputs. Sea surface temperature measurements were closely aligned across the three MPA parcels and were generally higher than seabed temperatures. Salinity patterns varied across parcels, with Niaqunnaq showing the most distinct spatial gradients between offshore versus more inland deployment locations. Turbidity was generally higher in Okeevik, with seasonal declines observed across the TN MPA. Niaqunnaq generally experienced greater wave heights compared to the other two parcels. Patterns in wave direction of origin appear to be influenced by local geography and shift seasonally to some degree. Mean wave

periods were longest in Niaqunnaq, and peak periods were highest in Okeevik. Freshwater level and discharge at select channels of the Mackenzie Delta peaked from late May to early June, beginning slightly earlier at stations further upstream.

This report contributes to a growing baseline inventory of ecological indicators within the TN MPA and support ecological monitoring through data presentation on indicators outlined in the TN MPA Monitoring Plan. Establishing a comprehensive baseline of environmental conditions within the TN MPA provides the foundation for understanding and monitoring how beluga whales respond to oceanographic change.

1. INTRODUCTION

1.1 BACKGROUND

The Tarium Niryutait Marine Protected Areas (TN MPA) was officially designated in August 2010 as Canada's first Arctic Marine Protected Area (Canada Gazette, 2010). The primary goal of the TN MPA is to conserve beluga whales and their supporting ecosystems while preserving the harvesting traditions of Inuvialuit (Fisheries and Oceans Canada and Fisheries Joint Management Committee 2013a). The TN MPA encompasses three distinct Marine Protected Area parcels: Kittigaryuit (Kugmallit Bay), Niaqunnaq (West Mackenzie Bay), and Okeevik (East Mackenzie Bay). These parcels align with traditional beluga hunting zones used by the Inuvialuit communities of Aklavik, Inuvik, and Tuktoyaktuk, and overlap with high-use summer areas for Eastern Beaufort Sea (EBS) beluga whales (*Delphinapterus leucas,* Qilalugaq; Norton and Harwood 1986, Harwood and Smith 2002, Harwood et al. 2014). Due to the cultural and ecological significance of the TN MPA, there is a need to understand how beluga and other marine wildlife use these areas as well as how environmental change is affecting this shallow estuarine ecosystem.

Recent surveys have estimated the population of EBS beluga whales at over 38,000 individuals, making it one of the largest beluga populations in Canada (Marcoux et al. 2025). These whales migrate annually from overwintering habitats in the Bering Sea to summering areas in the Beaufort Sea and Amundsen Gulf, including the TN MPA (Richard et al. 2001, Harwood and Smith 2002, Storrie et al. 2023). Seasonal aggregations in the Mackenzie River estuary (hereafter, Mackenzie Estuary) represent one of the largest known beluga concentrations globally (Harwood and Smith 2002). Belugas typically arrive in the area in mid to late June, closely following the retreat of sea ice from coastal areas within the estuary (Fraker et al. 1979, Harwood et al. 2014, Hornby et al. 2016, Scharffenberg et al. 2025). Individual whales may spend a few days to a week in the estuary, with some individuals moving back and forth between the Mackenzie Estuary and areas around Amundsen Gulf several times throughout the open water season (Richard et al. 2001, Storrie et al. 2022). Fidelity to coastal habitats within the TN MPA is particularly pronounced between early and late July (Harwood et al. 2014).

Environmental conditions are known to influence beluga distribution and habitat use. Coastal and estuarine zones are thought to support several key life functions for beluga, including feeding, calving, moulting, and socializing (Fraker et al. 1979, St. Aubin et al. 1990, Smith et al. 1992, Mayette et al. 2022). Within the Mackenzie Estuary, beluga distribution tends to be highly clumped into "hotspots" that are used annually (Harwood et al. 2014, Scharffenberg et al. 2019, Scharffenberg et al. 2025). Relative abundance of belugas within these hotspots can be highly variable, with West Mackenzie Bay and Shallow Bay (Niaqunnaq MPA) historically used by 3-4 times more belugas than other areas of the

estuary from early to mid-July (Harwood et al. 2014). The warm, turbid, and fresher coastal waters in these areas likely offer a variety of benefits for beluga, including providing a thermal advantage, particularly for calves, and lower salinity conditions to support moulting processes (St. Aubin et al. 1990, Scharffenberg et al. 2019, Noel et al. 2022). Belugas also exhibit behavioural responses to storm events, moving away from desirable hotspots to deeper waters or areas more sheltered from high winds and waves (Scharffenberg et al. 2020). Given beluga habitat use is closely tied to sea ice and estuarine conditions, understanding climate-driven changes in the Arctic is critical.

The environmental conditions known to influence beluga movement and shape the areas they inhabit are undergoing rapid change. Landfast ice break-up has been occurring earlier in recent decades across the TN MPA (Lee et al. 2025), consistent with trends of sea ice loss and longer open-water seasons across the Arctic (Overeem et al. 2011, Overland and Wang 2013, Mallet et al. 2021). These conditions heighten the potential for storm activity, increased wave action, and coastal erosion (Overeem et al. 2011), which contribute to turbidity in nearshore areas (Klein et al. 2019). The Beaufort Sea has exhibited some of the highest erosion rates in the Arctic (Lantuit et al. 2012) and rapid shoreline change has been documented across the TN MPA (Lee et al. 2025). Additionally, shifts in hydrological cycles, such as more frequent storm surges (Vermaire et al. 2013) and earlier spring flows (Woo and Thorne 2003, Yang et al. 2015), influence the volume, timing, and content of freshwater inputs to the Mackenzie Estuary. The plumes generated by these inputs can extend several hundred kilometres offshore and exert significant influence on water temperature, salinity, and chemistry within the estuary (Carmack and Macdonald 2002, Nghiem et al. 2014). These physical changes are already being felt by communities in the region, where Indigenous knowledge holders have observed thinner ice, unpredictable timing of spring break-up, and disrupted travel routes and harvesting activities within the Mackenzie Delta (Ziegler et al. 2024). Recognizing the impact of these widespread and interconnected changes, climate and environmental change have been highlighted as a main ecosystem stressor within the TN MPA (Fisheries and Oceans Canada and Fisheries Joint Management Committee 2013a). Additionally, indicators associated with sea ice, oceanography, and physical habitats have been developed in the TN MPA Monitoring Plan to guide long-term monitoring efforts and ecosystem assessment within the region (Fisheries and Oceans Canada and Fisheries Joint Management Committee 2013b).

The Beluga Habitat Program (hereafter, BHP) is a long-term program focused on monitoring environmental and acoustic conditions, and evaluating climate-driven environmental changes within the TN MPA. Given that beluga are sensitive to their environment and will respond to local cues, climate-driven shifts in estuarine conditions may have implications for beluga habitat use and population dynamics within the TN MPA (Scharffenberg et al. 2019, Noel et al. 2022, Lee et al. 2025). Data collected through the BHP,

including water temperature, salinity, and parameters related to sediment dynamics, contribute towards the 'oceanographic' and 'coastal erosion' indicators identified in the TN MPA Monitoring Plan (Fisheries and Oceans Canada and Fisheries Joint Management Committee 2013b). Alongside environmental measurements and habitat monitoring, this program also collects acoustic data that contribute towards describing the estuarine soundscape and inferring beluga habitat use patterns. Establishing a comprehensive baseline of environmental conditions within the TN MPA provides the foundation for understanding and monitoring how beluga whales respond to coastal and oceanographic change.

1.2 OBJECTIVES

As part of ongoing ecological monitoring efforts in the TN MPA, the BHP has conducted passive acoustic monitoring complemented with oceanographic data collection since 2014. Here we provide an overview of the oceanographic datasets collected from 2015 to 2025 as part of the BHP. We summarize 11 years of seasonal monitoring in Kugmallit Bay (Kittigaryuit MPA), including ten consecutive seasons of oceanographic data collected from deployments at East Whitefish. Additionally, we have collected seven seasons of monitoring data collected in Niaqunnaq MPA (West Mackenzie Bay) and five in Okeevik MPA (East Mackenzie Bay). Between 2021 and 2025, oceanographic data were collected across all three parcels of the TN MPA, providing comprehensive spatial coverage of the region. This is a long-term program that allows us to identify status, trends, and reference levels in ecological indicators that were identified as being important for measuring the success of the MPA. In addition to these oceanographic datasets, we provide a complementary summary of water level and discharge data collected at select Environment and Climate Change Canada (ECCC) hydrometric monitoring stations installed in channels providing freshwater inputs to MPA parcels.

This report will support Canadian Science Advisory Secretariat (CSAS) recommendations (Brewster et al. 2021, Fisheries and Oceans Canada 2024) and monitoring efforts within the TN MPA, as well as complement publicly accessible metadata reports (Scharffenberg et al. 2024, Westphal et al. 2026a, Westphal et al. 2026b) and datasets associated with the program. Oceanographic data collected under the BHP and summarized in part in this report 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.

2. MATERIALS AND METHODS

2.1 STUDY AREA

The Mackenzie River system is the largest and longest river system in Canada, forming the second largest delta in the Arctic (over 13,000 km^2) where it drains into the Beaufort Sea (Emmerton et al. 2007). The Mackenzie River outflows are one of the dominant influences on the chemical and physical characteristics of the delta, providing significant freshwater inputs containing large concentrations of suspended nutrients, minerals, and sediment downstream into the estuary (Carmack and Macdonald 2002). Seabed composition within the estuary is dominated by featureless, flat seabed largely comprised of silty surficial sediments, with occasional scoured or disturbed areas, sandy shoals, deeper channels, and longshore bars (Whalen et al. 2020). Beluga have been noted to preferentially select these scoured or disturbed areas and sandy shoals, particularly during the late season, and potentially avoid the deeper channels and longshore bars (Whalen et al. 2019). The Mackenzie Estuary is ice-covered from early October until mid-late June (Galley et al. 2008, Lee et al. 2025). Following ice break-up, the estuary provides important summering habitat for the EBS beluga population (Norton and Harwood 1986) as well as a variety of other wildlife species.

The TN MPA management zone is located within the Mackenzie Estuary and encompasses 1800 km^2 divided among three spatially distinct MPA parcels (*Tarium Niryutait Marine Protected Areas Regulations*, SOR/2010-190, Figure 1). Moving east to west, these three MPA parcels are: Niaqunnaq (West Mackenzie Bay and Shallow Bay), Okeevik (East Mackenzie Bay), and Kittigaryuit (Kugmallit Bay). The boundaries of these parcels were designed based on beluga harvest management zones and correspond to traditional hunting areas for the communities of Aklavik, Inuvik, and Tuktoyaktuk, respectively (Fisheries and Oceans Canada and the Fisheries Joint Management Committee 2013a).

Kittigaryuit MPA, the easternmost parcel within the TN MPA, covers a 464 km^2 area in Kugmallit Bay. Kugmallit Bay in general is very shallow and within the Kittigaryuit MPA depth is generally less than 2 m (Canadian Hydrographic Service Nautical Chart 'Kugmallit Bay 7663', Whalen et al. 2020). The East Channel of the Mackenzie River discharges freshwater into the southwestern corner of Kugmallit Bay near the East Whitefish subsistence harvest camp (Figure 1). Dominant wind patterns in the Kittigaryuit region are north-easterly, with some protection from northwesterly and northerly winds provided by Richards and Hendrickson Islands, respectively (Lee et al. 2025). Spring ice break-up is generally later at Kittigaryuit compared to Niaqunnaq, but earlier than at Okeevik. While the break-up of landfast ice has been occurring earlier in all three MPA parcels (Loseto et al. 2018, Gully et al. 2025), the greatest rate of change has been observed at Kittigaryuit (Lee et al. 2025). In recent years at Kittigaryuit, ice break-up has been documented around June

20, 12 days earlier than the average date in the 1970s (Lee et al. 2025). Kittigaryuit is located near the community of Tuktoyaktuk, near Hendrickson Island and the East Whitefish subsistence harvest camp. The majority (65.3%) of whales harvested in the Mackenzie Delta between 1980 and 2025 were landed in Kugmallit Bay (Harwood et al. 2020, Campbell et al. 2024a, Campbell et al. 2024b, Murray et al. 2024, FJMC unpublished data).

Niaqunnaq MPA is the largest of the three MPA parcels, covering approximately 1041 km^2 on the western side of the delta in West Mackenzie Bay. Water depth in this area is generally consistent between 1-3 m in depth, with a narrow, deeper channel running down the centre of the bay (Canadian Hydrographic Service Nautical Chart 'Mackenzie Bay 7662'). The West and Napoiak Channels of the Mackenzie River discharge freshwater into the eastern side of Shallow Bay (Figure 1). Niaqunnaq MPA is dominated by strong northwesterly winds and tends to experience taller, wind-driven waves compared to Okeevik and Kittigaryuit (Lee et al. 2025). Ice break-up tends to occur at Niaqunnaq 5-8 days earlier than the other parcels, with an average break-up date of June 16 over the last decade (Lee et al. 2025). Ice break-up at Niaqunnaq has been occurring earlier with each decade and most recently was estimated to be occurring 12 days earlier compared to the 1970s (Lee et al. 2025). Marine traffic is generally low within this MPA, with the exception of small outboard vessel traffic between Aklavik and Shingle Point where traditional subsistence whaling and fishing camps are located (Worden et al. 2020, Scharffenberg et al. 2024). An estimated 13.3% of the whales harvested in the Mackenzie Delta between 1980 and 2015 were landed in Shallow Bay (Harwood et al. 2020), though the numbers have decreased drastically in recent years (Harwood et al. 2020, Worden et al. 2020).

Okeevik MPA is the smallest of the three TN MPA parcels, encompassing a 243 km^2 area of East Mackenzie Bay. Okeevik is generally shallow, with a depth of less than 3 m across the MPA with the exception of a couple of narrow channels (Canadian Hydrographic Service Nautical Chart 'Mackenzie Bay 7662'). Kumak Channel, fed by the Middle Channel of the Mackenzie River, discharges freshwater into East Mackenzie Bay near Kendall Island (Figure 1). Okeevik is surrounded by Pelly, Kendall, and Garry Islands, which provide some protection from northwesterly winds and open ocean wave action. While average wind speeds are comparable across the three MPA parcels, Okeevik can experience much higher maximum wind speeds than the other two parcels (Lee et al. 2025). Annual ice break-up generally occurs later at Okeevik than at Niaqunnaq or Kittigaryuit. Average annual ice break-up date in Okeevik between 2010 and 2021 was June 23, which was 11 days earlier than the average date in the 1970s (Lee et al. 2025). Subsistence harvest camps are located on Kendall, Baby, and Garry Islands (Figure 1), however, marine traffic is generally lower in Okeevik MPA than elsewhere in TN MPA. An estimated 21.4% of the whales harvested in

the Mackenzie Delta between 1980 and 2015 were landed in the Kendall Island area (Harwood et al. 2020).

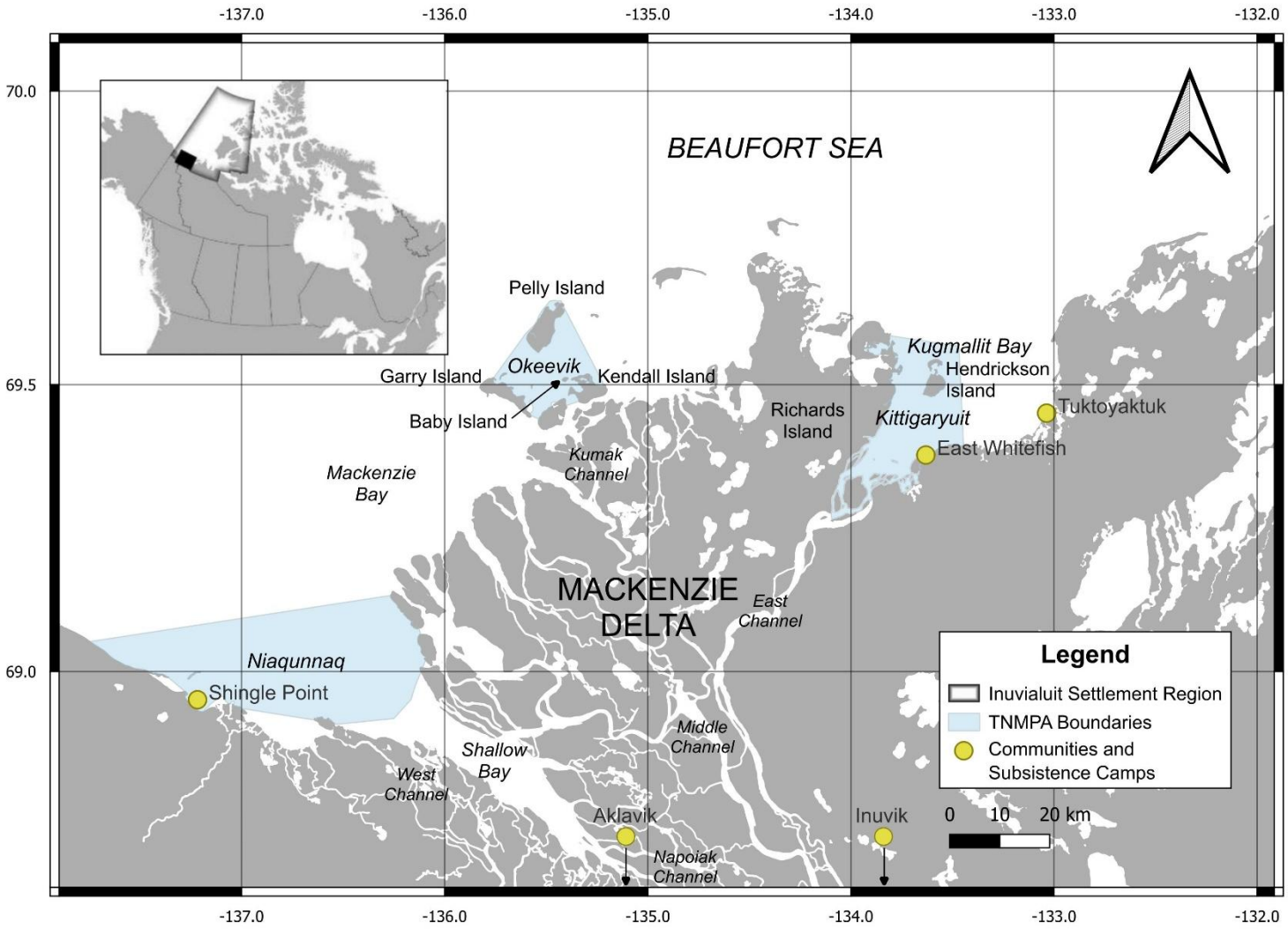


Figure 1. Map of the Mackenzie Delta and estuary showing the location of the three parcels of the TN MPA. The communities of Tuktoyaktuk, Aklavik, and Inuvik as well as subsistence camps at Shingle Point and East Whitefish are indicated with yellow points. Note: Aklavik and Inuvik are located south of map extent, as indicated with black arrows.

2.2 SEABED MOORINGS

Seabed mooring locations were selected based on Indigenous Knowledge of beluga distribution and known hotspots (Harwood et al. 2014, Scharffenberg et al. 2024), in addition to priorities identified by nearby communities (Figures 2 to 4). These moorings were deployed as part of a long-term beluga acoustic monitoring program, incorporating both acoustic recorders and oceanographic instruments attached to aluminum frame moorings (Scharffenberg et al. 2024, Westphal et al. 2026a, Westphal et al. 2026b). Seabed mooring deployments were completed soon after ice break-up in late June to early July and typically retrieved prior to freeze up in mid-late September (Table 1). In some cases, deployment occurred later in the season (e.g., Atkinson Point in mid-July 2022 and 2023), or retrieval was completed earlier (e.g., Niaqunnaq deployments retrieved in mid-August 2019).

Seabed moorings were deployed within Kugmallit Bay and Kittigaryuit MPA from 2014 to 2025 (Figure 2, Table 1). Deployments began in 2014, where one acoustic mooring was deployed close to the stations used in Simard et al. (2014) and a second mooring with oceanographic sensors was deployed in the middle of Kugmallit Bay. Following these initial deployments, locations were selected to assess the persistence of previously identified beluga hotspots (Harwood et al. 2014) and relationships to environmental drivers of beluga habitat use within the bay.

Data collection was gradually expanded across the TN MPA following the successful mooring deployments in Kugmallit Bay and Kittigaryuit MPA. Moorings were first deployed within Niaqunnaq MPA in 2018 (Figure 3, Table 1; Scharffenberg et al. 2024), at the request of the Aklavik Hunters and Trappers Committee (HTC). In 2021, the program was expanded to Okeevik MPA at the request of the Inuvik HTC (Figure 4, Table 1; Scharffenberg et al. 2024). Since 2021, moorings have been deployed annually in all three MPA parcels (Table 1). Mooring design and instrumentation details are described in detail in available metadata reports (Scharffenberg et al. 2024, Westphal et al. 2026a, Westphal et al. 2026b).

Seabed mooring designs were reviewed annually and refined in discussion with field crews and HTCs (refer to detailed descriptions in Scharffenberg et al. 2024, Westphal et al. 2026a, Westphal et al. 2026b). As such, mooring design differed over the 2014-2025 monitoring period, as features were modified for easier, more reliable deployment/retrieval and to minimize risks to wildlife (Figure 5). Mooring designs consisted of weighted aluminum frames equipped with oceanographic instruments, acoustic recorders, and GPS smart buoys. Instrument models varied across parcels and years, but included RBR (RBR Concerto, Duo, and Solo models; RBR Ltd., Kanata, Canada) and Star-ODDI (Star-Oddi Ltd., Gardabaer, Iceland) CTD loggers (see Scharffenberg et al. 2024, Westphal et al. 2026a, Westphal et al. 2026b for detailed instrumentation summaries). Oceanographic

instruments were attached to posts and/or the legs of the frame using electrical tape, hose clamps, and zip ties. Each mooring was fixed with up to 72 lbs of weight and had an up to 15 m groundline attached to 30+ lbs weight, which was then attached to a buoy at the water surface. The buoy was a standard inflatable buoy until 2020, after which they were replaced by satellite-linked Sofar Ocean Wave Spotter buoys (Sofar Ocean, San Francisco, CA, USA).

Table 1. Locations of mooring deployments and variables recorded during the open water seasons of 2015-2025. Note: this table should not be considered exhaustive for data collected as part of the Beluga Habitat Program. For expanded deployment and instrumentation details refer to Scharffenberg et al. 2024 and Westphal et al. 2026a, Westphal et al. 2026b. NR = Not Recorded. Note: greyed out squares refer to measurements recorded by instruments that were not recovered from the field. Location names, coordinates, and associated datasets are reflective of the available datasets on the Government of Canada's Open Government Portal.

MPA Parcel	Location	Year	Latitude	Longitude	Deploy Date	Recovery Date	Depth (m)	Water Temp. Bottom (°C)	SST (°C)	Salinity (PSU)	Turbidity (NTU)	Waves
Kittigaryuit	Channel	2015	69.3940	-133.8675	18-Jun	23-Aug	9.0	X				
		2016	69.3981	-133.8560	13-Jun	22-Aug	9.1	X				
		2017	69.3947	-133.8620	20-Jun	19-Aug	8.0	X				
	East Hendrickson	2017	69.4984	-133.4346	21-Jun	19-Aug	2.2	X		X		
	East Whitefish	2016	69.3804	-133.6344	14-Jun	22-Aug	1.4	X		X		
		2017	69.3804	-133.6344	21-Jun	19-Aug	1.1	X				
		2018	69.3804	-133.6344	20-Jun	31-Aug	1.4	X				
		2019	69.3804	-133.6344	21-Jun	8-Aug	1.4	X				
		2020	69.3820	-133.6323	24-Jun	8-Sep	2.1					X
		2021	69.3824	-133.6324	25-Jun	23-Sep	2.3	X				X
		2022	69.3832	-133.6322	25-Jun	19-Sep	1.3	X	X		X	X
		2023	69.3856	-133.6347	19-Jun	30-Jul			X			X
		2024	69.3966	-133.6270	27-Jun	16-Sep	2.7	X	X	X	X	X
		2025	69.3968	-133.6260	29-Jun	23-Sep	2.9	X	X	X	X[a]	X
	Mid Kugmallit B	2016	69.4591	-133.5650	16-Jun	22-Aug	2.5	X		X		
	Mid Kugmallit	2015	69.4465	-133.6124	16-Jun	21-Aug	2.5	X		X		
		2017	69.4448	-133.6113	20-Jun	19-Aug	1.6	X		X	X	
		2019	69.4434	-133.5902	20-Jun	13-Aug	1.8	X		X		
		2020	69.4434	-133.5902	24-Jun	8-Sep	NR		X			X
		2021	69.4430	-133.5902	25-Jun	23-Sep	1.7	X		X		X
		2022	69.4157	-133.5228	25-Jun	19-Sep	2.4	X		X		X
		2023	69.4254	-133.4870	19-Jun	10-Sep	2.2	X		X		X

[a] In 2025, turbidity measurements were only collected from 29 June to 4 July at the East Whitefish deployment.

Table 1. Continued

MPA Parcel	Location	Year	Latitude	Longitude	Deploy Date	Recovery Date	Depth (m)	Water Temp. Bottom (°C)	SST (°C)	Salinity (PSU)	Turbidity (NTU)	Waves
Kittigaryuit	West Hendrickson	2015	69.5067	-133.6982	16-Jun	21-Aug	2.5	X		X		
		2017	69.5077	-133.6980	21-Jun	19-Aug	1.6	X		X		
		2019	69.5053	-133.7183	20-Jun	13-Aug	1.8	X		X		
		2020	69.5053	-133.7183	24-Jun	8-Sep	1.6		X			X
		2021	69.5047	-133.7192	25-Jun	23-Sep	1.7	X		X		X
		2022	69.5037	-133.7180	25-Jun	19-Sep	1.7	X	X	X		X
		2023	69.5037	-133.7162	19-Jun	10-Sep	1.7	X	X	X		X
		2024	69.5041	-133.7160	28-Jun	16-Sep	1.8	X	X	X		X
		2025	69.5052	-133.7170	29-Jun	24-Sep	1.8	X		X	X	X
Kugmallit Bay	Atkinson Point	2022	69.7750	-132.1063	17-Jul	11-Sep	5.6	X	X	X	X	X
		2023	69.7697	-132.1291	14-Jul	13-Sep	5.4		X			X
Niaqunnaq	Escape Reef	2023	69.0347	-137.1189	28-Jun	24-Sep	NR	X	X	X		X
	Niaqunnaq	2020	69.0649	-136.5642	26-Jun	13-Sep	1.7	X	X	X		X
	Niaqunnaq East	2021	68.9697	-136.4443	27-Jun	16-Sep	1.9	X	X	X	X	X
		2022	68.9700	-136.4424	30-Jun	23-Sep	1.9	X		X	X	X
		2023	68.9780	-136.4311	28-Jun	24-Sep	1.8	X		X	X	X
		2024	68.9366	-136.5970	25-Jun	30-Sep			X			X
		2025	68.9785	-136.4340	6-Jul	24-Sep	1.8	X	X	X		X
	Niaqunnaq Mid	2023	69.0092	-136.7447	28-Jun	24-Sep	2.2	X		X	X	X
	Niaqunnaq North	2021	69.0888	-136.9912	27-Jun	16-Sep	3.0	X	X	X		X
		2022	69.0556	-136.7187	30-Jun	23-Sep	2.2	X	X	X		X
	Niaqunnaq West	2021	68.9960	-136.9714	27-Jun	16-Sep	2.5	X	X	X		X
		2022	69.0002	-136.9437	30-Jun	23-Sep	2.5	X		X		X
		2024	68.9549	-136.9090	25-Jun	30-Sep	3.0	X	X	X		X
		2025	68.9549	-136.9140	6-Jul	24-Sep	3.2	X	X	X		X

Table 1. Continued

MPA Parcel	Location	Year	Latitude	Longitude	Deploy Date	Recovery Date	Depth (m)	Water Temp. Bottom (°C)	SST (°C)	Salinity (PSU)	Turbidity (NTU)	Waves
Niaqunnaq	Shingle Point Ocean	2019	68.9874	-137.4044	17-Jun	12-Aug	1.7	X		X	X	
		2020	68.9874	-137.4044	26-Jun	13-Sep	1.7	X			X	X
		2021	69.0429	-137.3933	27-Jun	16-Sep	5.2	X	X	X	X	X
		2022	69.0368	-137.3794	22-Jul	23-Sep	5.2	X	X	X		X
	Shingle Point Bay	2019	69.0060	-137.4166	16-Jun	12-Aug	5.2	X		X	X	
		2020	69.0060	-137.4166	26-Jun	13-Sep	4.9	X	X	X	X	X
Okeevik	Garry Island	2021	69.5132	-135.6673	28-Jun	16-Sep	1.4	X	X	X	X	X
		2022	69.5134	-135.6605	26-Jun	19-Sep	1.4	X		X		X
		2023	69.5147	-135.6565	22-Jun	20-Sep	1.2	X		X		X
	Kendall Island	2021	69.5147	-135.3733	28-Jun	16-Sep	1.7	X	X	X	X	X
		2022	69.5274	-135.3702	26-Jun	19-Sep	1.3	X	X	X	X	X
	Okeevik	2024	69.5188	-135.4880	22-Jun	23-Sep	1.9	X	X	X	X	X
	Pelly Island	2023	69.6078	-135.1884	22-Jun	20-Sep	2.8	X	X	X	X	X
		2025	69.6032	-135.2310	5-Jul	8-Sep	2.4	X	X	X		X

Definitions:

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. In 2015-2019 this was the bottom depth recorded using a depth sounder at the time of deployment. From 2020-2025, 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 instruments. 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.
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.
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, m), period (s), and direction of origin (degrees). Wave condition measurements were collected at the water surface.

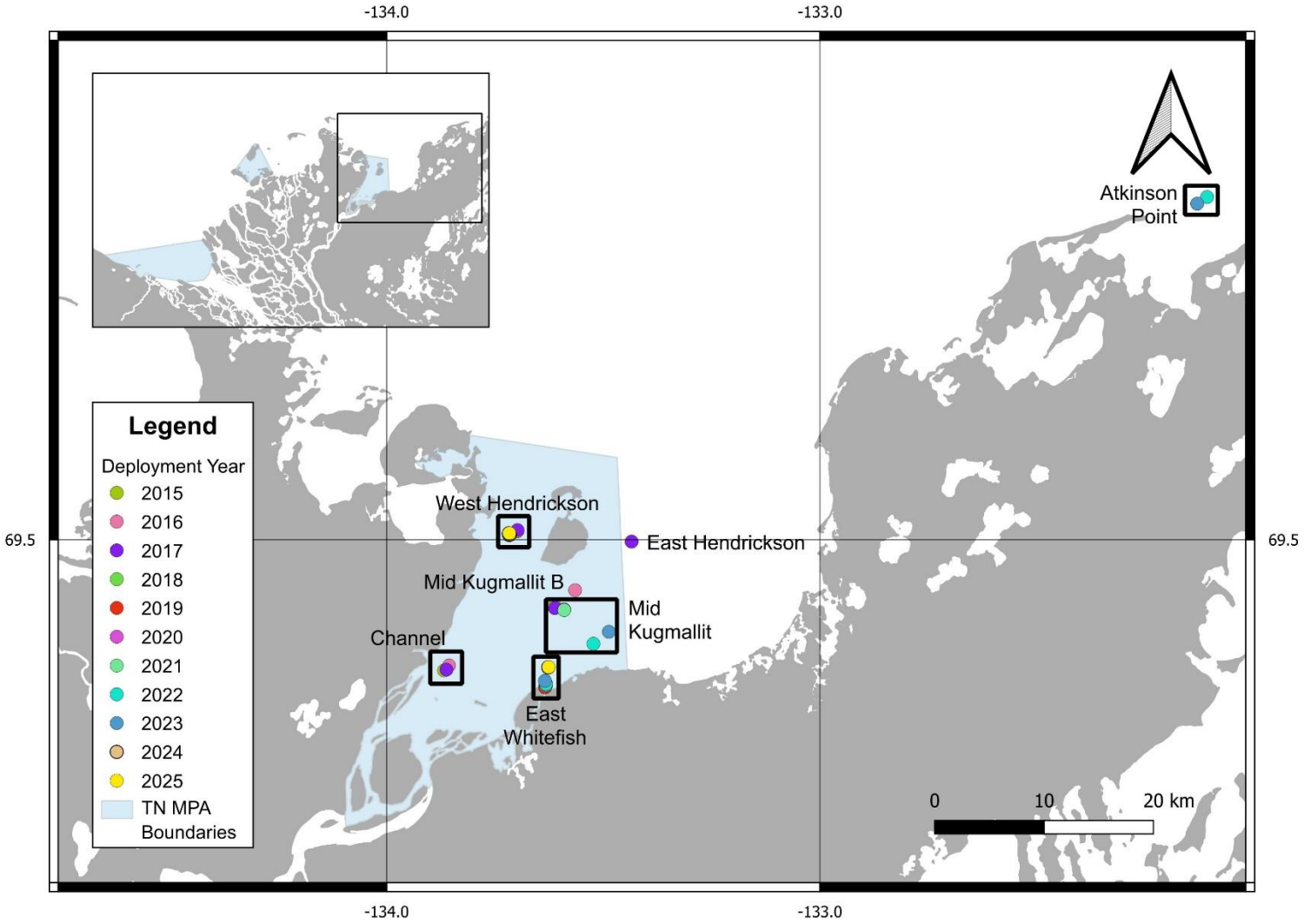


Figure 2. Map of Kittigaryuit MPA showing the location of seabed mooring deployments from 2015–2025. Refer to Table 1 for a detailed description of deployment location, timing, and instrumentation. Location names and coordinates are reflective of the available datasets on the Government of Canada's Open Government Portal.

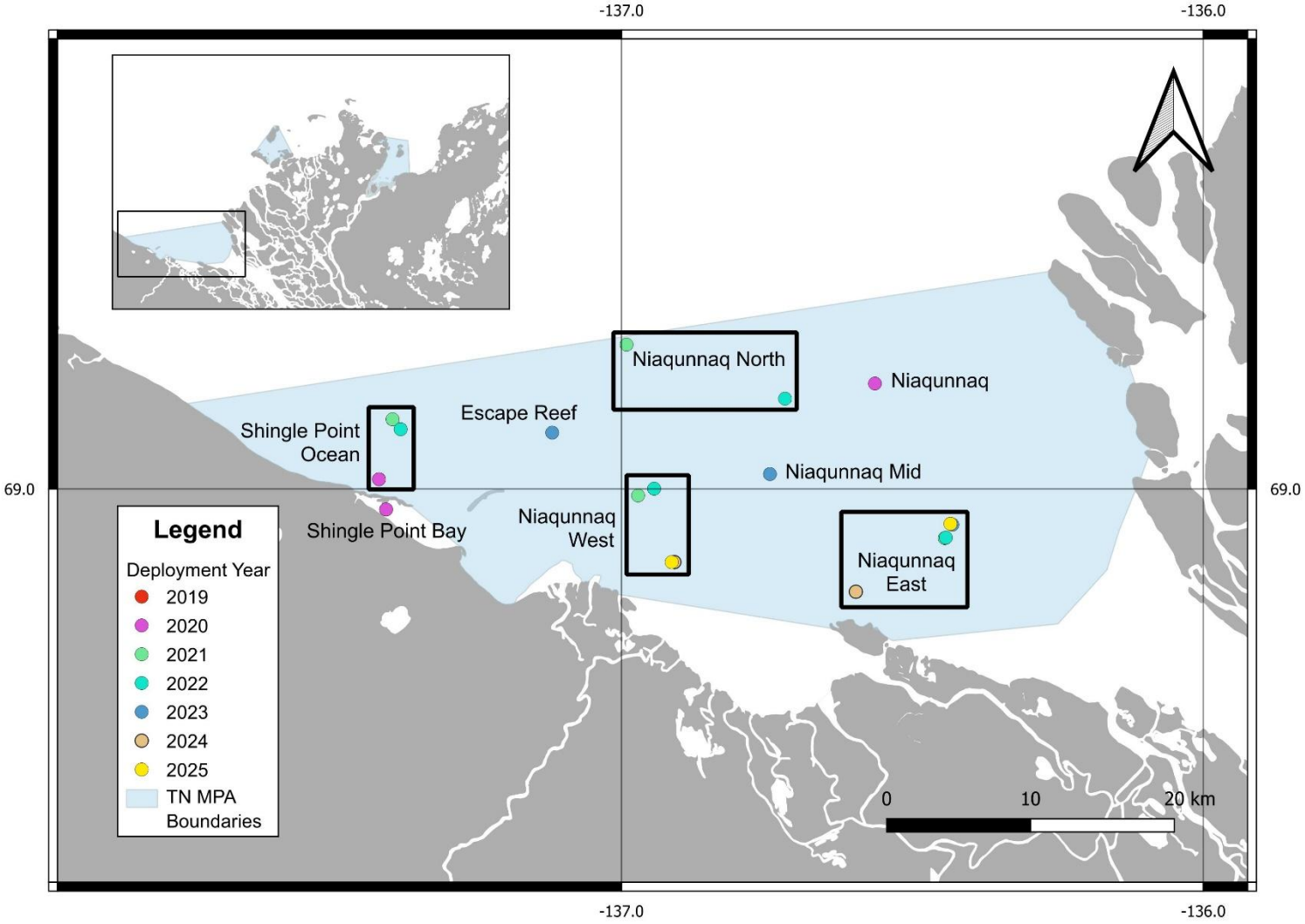


Figure 3. Map of Niaqunnaq MPA showing the location of seabed mooring deployments from 2019–2025. Refer to Table 1 for a detailed description of deployment location, timing, and instrumentation. Location names and coordinates are reflective of the available datasets on the Government of Canada's Open Government Portal.

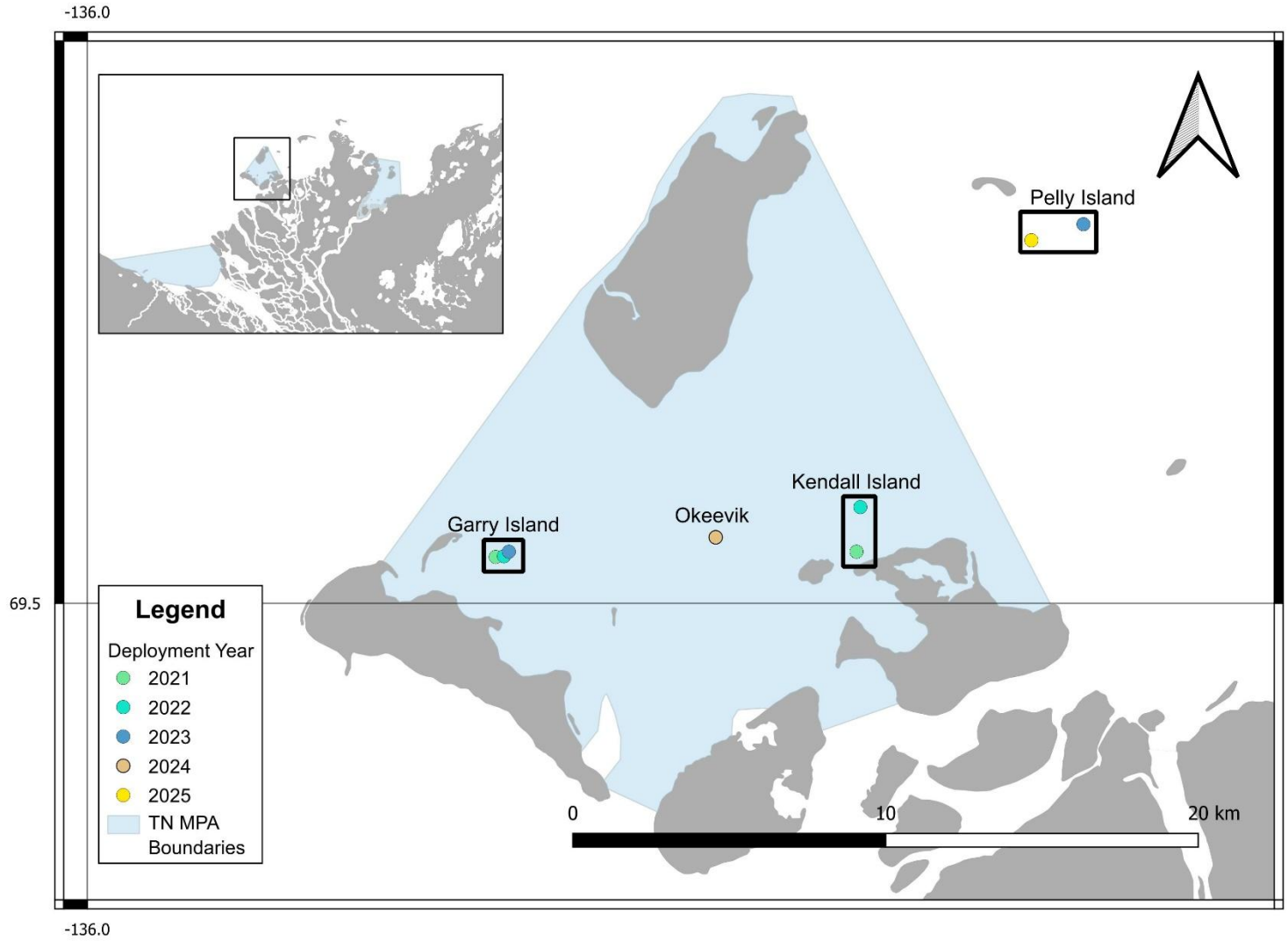


Figure 4. Map of Okeevik MPA showing the location of seabed mooring deployments from 2021–2025. Refer to Table 1 for a detailed description of deployment location, timing, and instrumentation. Location names and coordinates are reflective of the available datasets on the Government of Canada's Open Government Portal.

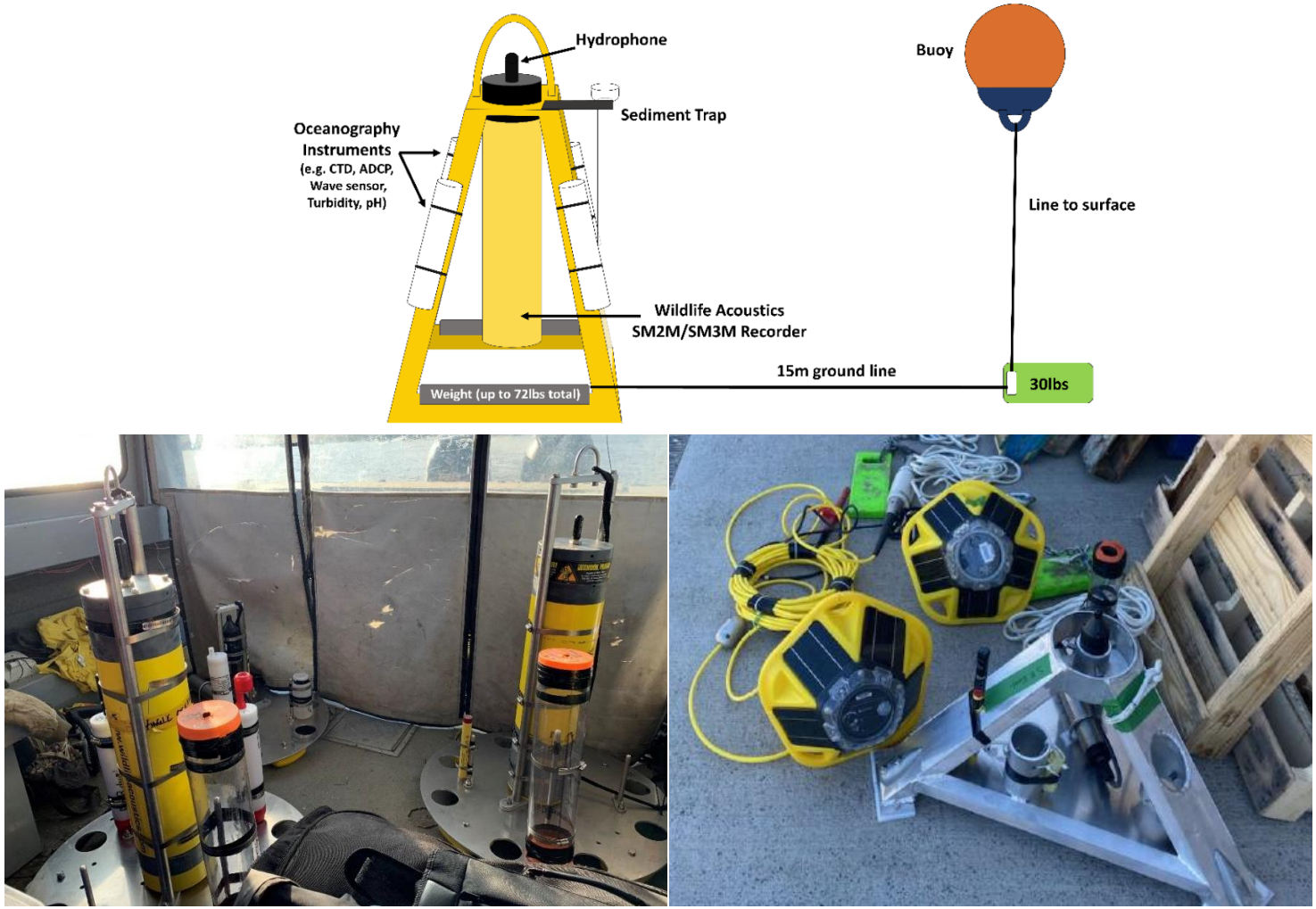


Figure 5. Examples of mooring designs used for seabed mooring deployments from 2015-2025 (adapted from Scharffenberg et al. 2024). Top: mooring design used at all locations from 2015-2019 with the exception of East Whitefish. Bottom left: mooring design used in 2020. Bottom right: mooring design used at most locations from 2021-2025. These moorings were deployed as part of the Beluga Habitat Program. Please refer to Scharffenberg et al. 2024, Westphal et al. 2026a, and Westphal et al. 2026b for additional details on mooring design and deployment.

2.3 HYDROMETRIC MONITORING STATIONS

The Water Survey of Canada (within ECCC) operates a network of hydrometric monitoring stations at locations across Canada. Within the Mackenzie Delta, gauging stations are positioned along the main trunks and distributaries of the Mackenzie River, including near outflows providing freshwater inputs into the Mackenzie Estuary and TN MPA. These stations provide streamflow and/or water level (stage) data through the ECCC hydrometric database (HYDAT). ECCC hydrometric stations collect measurements seasonally or year-round. Water level is measured at regular intervals at the monitoring station and reported through HYDAT in metres (m). Streamflow is derived using water levels and a fitted stage-discharge curve, and reported through HYDAT in cubic metres per second (m^3/s).

We selected five ECCC hydrometric stations for the purposes of this study: one installed in each of the East, Napoiak, and Kumak Channels near outflows into each respective MPA parcel, and one installed upstream in each of the larger trunks of the East and Middle Channels (Figure 6). These were selected to provide an overview of seasonal freshwater flows both up- and downstream of outflows into MPA parcels from 2015-2025.

The three stations positioned downstream close to outflows into each MPA parcel (10LC013, 10MC023, and 10LC019) collected water level only (Table 2). The two stations positioned upstream (10LC002 and 10MC008) collected both water level and discharge measurements (Table 2). We focused our summary on measurements collected from early spring through to the end of September to coincide with the time of year where we would expect peak flows and freshwater inputs to be most relevant for our oceanographic measurements.

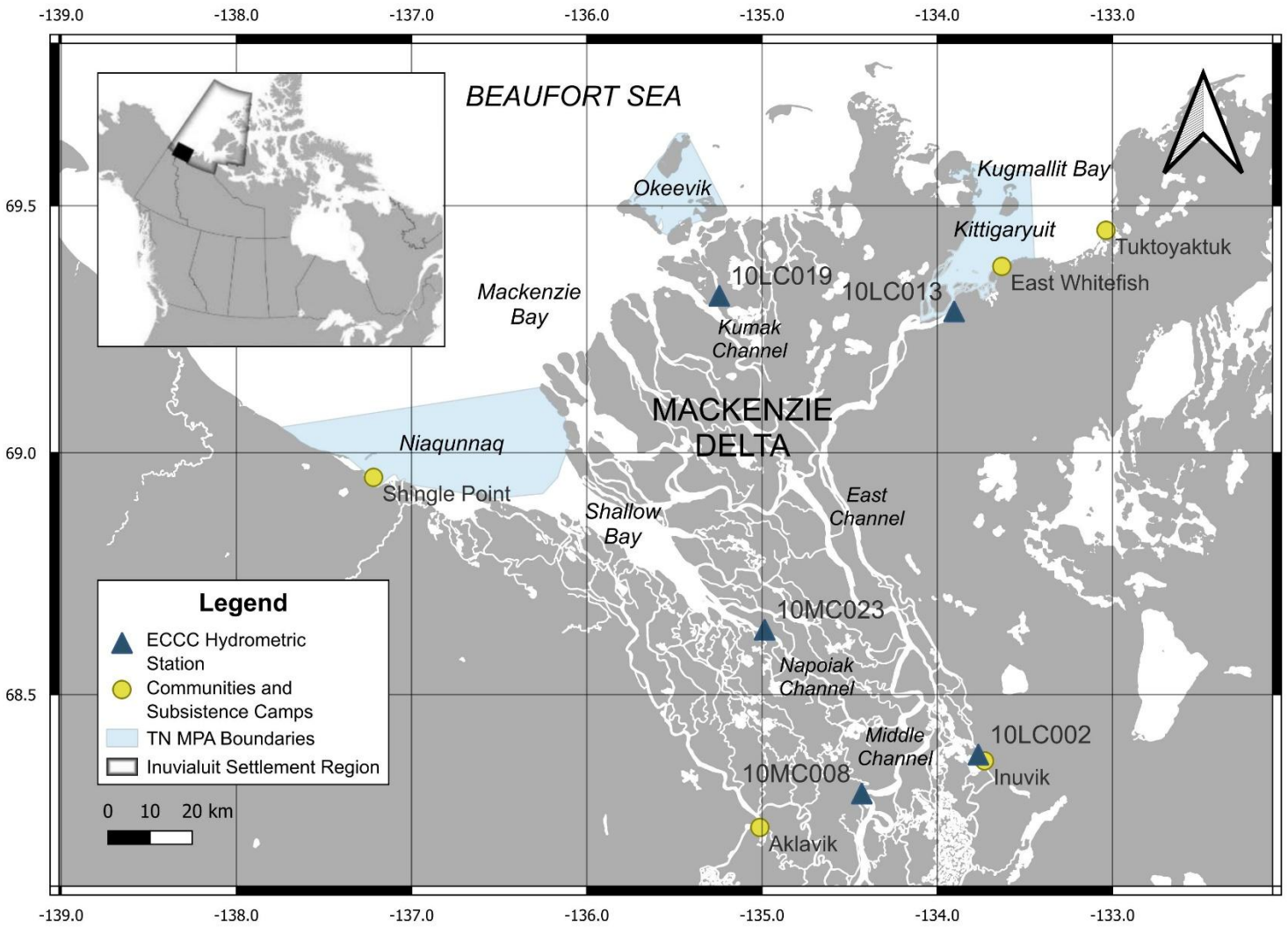


Figure 6. Map of the Mackenzie Delta showing the location of Environment and Climate Change Canada (ECCC) hydrometric monitoring stations. Relevant river channels are labeled and the communities of Tuktoyaktuk, Aklavik, and Inuvik as well as subsistence camps at Shingle Point and East Whitefish are indicated with yellow points.

Table 2. Locations of Environment and Climate Change Canada (ECCC) monitoring stations and the variables recorded between 2015-2025.

Channel	ECCC Station	Latitude	Longitude	Water Level (m)	Discharge (m^3/s)
East	10LC002	68.3742	-133.7647	X	X
	10LC013	69.2878	-133.9028	X	
Middle	10MC008	68.2922	-134.4297	X	X
	10MC023	68.6356	-134.9844	X	
	10LC019	69.3194	-135.2433	X	

2.4 WATER CHARACTERISTICS

Ocean temperature, salinity, and turbidity measurements were collected using conductivity, temperature, and depth (CTD) recorders. RBR (Concerto, Duo, and Solo models; RBR Ltd., Kanata, Canada) and Star-ODDI (Star-Oddi Ltd., Gardabaer, Iceland) CTD loggers were mounted on weighted seabed moorings. Beginning in 2020, Sofar Ocean Wave Spotter Buoys (Ocean Technologies, San Francisco, USA) equipped with CTD loggers were also attached to deployed moorings using ground and buoy lines (Figure 5).

Ocean temperature (hereafter, water temperature) was recorded as temperature of the water just above the seafloor (refer to Table 1 for depth of individual moorings). Sea surface temperature (SST) was recorded within approximately 10 cm of the water surface using Sofar Ocean Wave Spotter buoys (hereafter, Sofar Spotter buoys). Both water temperature and SST were recorded in degrees Celsius (°C). Salinity was measured as practical salinity (PSU), which was derived from measurable properties: electrical conductivity, temperature, and pressure. Turbidity was recorded as Nephelometric Turbidity Units (NTU), measured using sensors that detect light scattered by solid particles suspended in water.

The configuration of oceanographic instruments varied by mooring and year (Table 1). For each instrument, sampling rate was chosen to balance sampling frequency and the power and space requirements that would allow the instrument to record the entire study period (Table 1; refer to Scharffenberg et al. 2024, Westphal et al. 2026a, and Westphal et al. 2026b for full instrumentation and setting details).

2.5 WAVE CONDITIONS

Wave condition measurements, including amplitude, period, and direction of origin, were collected using Sofar Spotter buoys from 2020-2025 (Table 1). As mentioned above, these buoys were attached to the weighted seabed moorings and first deployed in 2020. These smart buoys transmitted position and collected wave condition information at the water surface at hourly intervals.

Sofar Spotter buoys are compact, solar-powered units that use a sampling rate of 2.5 Hz and GPS-based measurements to determine the three-dimensional displacement of the wave buoy. This is used to calculate bulk wave parameters including significant wave height as well as peak and mean wave period (Shimura et al. 2022). Significant wave height is measured as the mean of the highest one-third of the waves (recorded in metres, m) during a defined period. Mean period is the average time from crest to trough of waves in seconds (s). Peak period is also recorded by displacement of the buoy, however, it is the average time in seconds from crest to trough of the most energetic waves specifically. Wave regimes dominated by wind-driven waves tend to have smaller peak periods, while wave regimes with larger peak periods tend to be dominated by ocean swell.

2.6 ANALYSES

2.6.1 Water characteristics

We explored underlying trends in water temperature, SST, salinity, and turbidity across multiple temporal (hourly to interannual) and spatial (deployment location and MPA) scales. Minor variations or anomalies in deployment duration and timing led to some uneven data coverage among years. Given the expected seasonality in these parameters, missing portions of a seasonal dataset may introduce bias in summary statistics. To account for this, all interannual analyses were weighted according to annual sample size.

Data summaries were generated for average hourly water temperature, SST, salinity, and turbidity using the "tidyverse" toolbox (Wickham et al. 2019) in RStudio (R Core Team 2024). We calculated both weighted interannual averages (± standard deviation) and annual averages (± standard deviation) for each deployment. Interannual averages, summary statistics, and key dates of interest were compiled for all four variables, with detailed annual summaries provided in Appendices A–D.

We examined the prevalence and timing of elevated values based on predefined thresholds: ≥15°C for water temperature and SST, and ≥5 PSU for salinity. The temperature threshold reflects values in the upper quartile (75th percentile) of these datasets, while the salinity threshold follows the definition used by Lee et al. (2025) for classifying "saline" versus "fresh" conditions. For each variable, we calculated the weighted interannual average and standard deviation of the proportion of measurements exceeding their respective threshold. We also reported the earliest and latest calendar dates when threshold exceedances were observed. Salinity was further examined using the classification approach outlined by Lee et al. (2025), where conditions were designated as "saline" when salinity measurements were ≥5 PSU and "fresh" when <5 PSU. A saline event was defined as a period during which a site remained "saline" for at least 24 consecutive hours. For each deployment location, we quantified the total number of saline events, mean duration (± standard deviation), and key dates of interest.

Broader seasonal trends were assessed at both interannual and annual scales. To compare interannual seasonal patterns for each MPA parcel, we calculated average hourly values over the season across deployment locations and years. We then derived the median and interquartile range of these hourly averages and visualized them using LOESS smoothing to highlight seasonal trends ("base" package, R Core Team 2024; "ggplot2" package, Wickham 2016). For annual fluctuations within each MPA parcel, we calculated hourly averages across deployment locations for each deployment year. A six-hour rolling average was then calculated and the resulting time series were plotted by year and MPA ("zoo" package, Zeileis and Grothendieck 2005).

We examined seasonality in water temperature, SST, salinity, and turbidity across and within MPA parcels. Seasonal changes were first evaluated at two-week intervals from June to September by pooling data across years for each deployment location and calculating average values for successive intervals. These averages were imported into Ocean Data View (Schlitzer 2023), where spatial coverage was visualized using a weighted-average gridding function for each variable and year.

2.6.2 Wave Conditions

We examined underlying spatial and temporal trends in wave height, direction of origin, peak period, and mean period. Minor variations or anomalies in deployment duration and timing led to some uneven data coverage among years. Given the expected seasonality in wave conditions, missing portions of a seasonal dataset may introduce bias in summary statistics. To account for this, all interannual analyses were weighted according to annual sample size.

Wave condition data was first filtered to remove erroneous measurements related to buoy submergence events or other measurement errors using the "tidyverse" toolbox (Wickham et al. 2019) in RStudio (R Core Team 2024). We opted to filter wave data in a similar manner to Lee et al. (2025), where filtering was completed based on the time series spike test method suggested in Bushnell et al. (2015). Each variable dataset was filtered twice, removing any values that exceeded four times the standard deviation of the dataset. This resulted in <5% of data points being removed from most datasets, with the exception being peak period where <10% of data points were removed.

Data summaries were generated for average hourly wave height, direction of origin, peak period, and mean period using the "tidyverse" toolbox (Wickham et al. 2019) in RStudio (R Core Team 2024). We calculated both weighted interannual averages (± standard deviation) and annual averages (± standard deviation) for each deployment location where data was collected. Interannual averages and summary statistics are reported for all four variables, with detailed annual summaries provided in Appendices E and F.

Broader seasonal changes in peak period were assessed at an annual scale. For each MPA parcel, we calculated hourly averages across deployment locations for each year. A 24-hour rolling average was then applied to smooth short-term variability ("zoo" package, Zeileis and Grothendieck 2005), and the resulting time-series were plotted by year and MPA to visualize seasonal trends ("ggplot2" package, Wickham 2016).

We assessed spatial changes in wave height and direction of origin. We focused on variation in wave height and direction of origin between July and August, months of peak beluga activity in the estuary. For each MPA parcel, we filtered the wave condition datasets to exclude measurements collected outside of July and August. We created bins based on direction of origin, where each bin spanned 10-degree increments. Wave height measurements were then binned based on their direction of origin and we calculated the average wave height within each directional bin. These values were visualized using polar plots ("ggplot2" package, Wickham 2016), where bar orientation represented wave direction, bar length indicated frequency, and colour denoted average wave height.

2.6.3 Freshwater Levels and Discharge

We summarized freshwater levels and discharge measurements collected from 2015-2025 to complement the timeframe of oceanographic datasets collected through BHP. ECCC provides both preliminary (e.g., recent or real-time) and historical datasets through HYDAT. Within the Mackenzie Delta, water level and the stage-discharge relationship can be influenced by ice conditions, storm surges, backflow, and other delta effects. Historical datasets (i.e., measurements collected before 2018) have been reviewed by ECCC staff for data quality and integrity, with ECCC removing measurements as needed or posting relevant remarks regarding any influence from delta effects. Preliminary datasets (i.e., measurements collected between 2018-2025) have not yet been reviewed by Water Survey of Canada hydrometric offices within ECCC, therefore, short-term spikes or surges should be interpreted with caution.

We explored underlying trends in freshwater levels and discharge across multiple temporal (daily to interannual) and spatial scales. There was some uneven data coverage over the season and/or between years that was not uniform across ECCC stations. This could be due to delta effects, ice conditions, instrument maintenance, ECCC review, or a variety of other considerations. Given the importance of the spring freshet and seasonality in a snowmelt-dominated river system, missing portions of early spring conditions within a dataset may introduce bias into summary statistics. To help account for this, we created a criterion to determine whether a given year had sufficient coverage of the peak flow period for inclusion in further analyses. We first calculated a potential peak flow period between 2000 and 2025 for each station. We selected this extended timeframe to ensure we would capture several years of complete or near-complete coverage of the peak flow period. We

generated a three-day rolling average of water level between May and September ("zoo" package, Zeileis and Grothendieck 2005) and then calculated the average date when water level was at its maximum. We defined a two-week potential peak period around this date (i.e., average date ± seven days) that was used to determine whether an annual dataset had sufficient coverage of the spring freshet to include in further analyses. If a given year did not have a minimum of 50% coverage of that site-specific range, it was excluded.

Data summaries were generated for average hourly water level and discharge between May and September from 2015-2025 using the "tidyverse" toolbox (Wickham et al. 2019) in RStudio (R Core Team 2024). We calculated both weighted interannual averages (± standard deviation) and annual averages (± standard deviation) for each monitoring station, in addition to median and maximum values. We examined the timing of elevated spring flows in several ways. Centre of Timing (CT) was defined as the "centre of mass" of the seasonal flow, the date where half the seasonal flow has occurred and half is still to come. In systems dominated by spring snowmelt, we would expect CT to occur earlier in the season. We also considered peak timing, defined as the day of the year with the maximum observed value of a three-day rolling average of water level or discharge. Finally, we considered the timing of the high-flow period. We defined the start or onset of this high-flow period as the date when water level or discharge ≥ the 90th percentile of seasonal values and the end date where level or discharge first fell below this threshold. Interannual averages, summary statistics, and key dates of interest were compiled for both variables, with detailed annual summaries provided in Appendices G and H.

Broader seasonal trends were assessed at both interannual and annual scales. To compare interannual seasonal patterns, we calculated average daily values over the season across years for each monitoring station. We then derived the median and interquartile range of these daily averages and visualized them to highlight overarching seasonal trends ("base" package, R Core Team 2024; "ggplot2" package, Wickham 2016). For annual fluctuations at each monitoring station, we plotted a three-day rolling average with blocks defining high-flow periods where water level or discharge ≥ the 90th percentile of seasonal values. Finally, we summarized "high" versus "low" flow years. We defined years where the average water level or discharge was greater than or equal to the interannual average to be "high" and those below to be "low".

3. RESULTS

3.1 WATER CHARACTERISTICS

3.1.1 Seabed water temperature

Water temperatures at the seabed were highest within Kittigaryuit MPA, followed by Okeevik and Niaqunnaq (Table 3, Figure 7). The Atkinson Point deployment location east of Kittigaryuit MPA reported lower average temperatures than almost all other deployment locations within the TN MPA (2022 average: 5.6°C ± 3.3°C). All three parcels followed a similar seasonal pattern, where water temperature gradually increased in the early summer to a peak around mid-July before a gradually decline to freeze-up (Figures 7 to 10). There is some interannual and seasonal variability, more pronounced at the Niaqunnaq and Okeevik sites compared to Kittigaryuit (Figures 7 to 11). Deployment locations closer to channel/ river mouths tended to have warmer seabed water temperatures compared to those farther away (Table 3, Figure 11).

Instrumented moorings have been deployed in Kittigaryuit since 2015 (Scharffenberg et al. 2024). The deployment locations most consistently sampled between 2015-2025 were East Whitefish and West Hendrickson (Tables 1 and 3). The highest average water temperatures were at the Channel deployment location, where the interannual average (± SD) was 15.8°C ± 0.5°C and 65.4% ± 13.9% of hourly temperature measurements were ≥15°C (Table 3). Average water temperature was lowest at the East Hendrickson deployment location, where the 2017 average was 11.4°C ± 3.3°C with 13.4% of hourly temperatures ≥15°C. Of the locations with multi-year datasets, West Hendrickson reported the lowest average temperatures with an interannual average was 12.7°C ± 0.7°C with 26.8% ± 6.6% of hourly temperatures ≥15°C (Table 3). The lowest minimum temperature documented within Kittigaryuit MPA was recorded at West Hendrickson on 17 June 2015 at 0.8°C and the highest maximum was recorded at East Whitefish on 14 July 2016 at 22.3°C (Table 3). Maximum documented temperatures were recorded between the second and third weeks of July at most locations (Figure 11), except for East Hendrickson where it was recorded on 11 August 2017. The earliest date where an hourly temperature ≥15°C was recorded was consistent across deployment locations on 21 June and 23 June. The latest date where an hourly temperature ≥15°C was recorded was more variable, but generally between the second week of August and first week of September (Table 3, Figure 8). All deployment locations reported at least a portion of water temperature measurements at the seabed as ≥15°C (Table 3).

Average water temperatures at the seabed were generally lower at Niaqunnaq MPA compared to the rest of TN MPA (Table 3, Figure 7). The deployment locations most consistently sampled between 2019-2025 were Niaqunnaq East and Niaqunnaq West. The

highest average water temperature was documented at the Niaqunnaq Mid deployment location, where the 2023 average (± SD) was 14.1°C ± 4.2°C with 47.9% of hourly temperatures ≥15°C (Table 3). Of the locations with multi-year datasets, Niaqunnaq East reported the highest temperatures with an interannual average (± SD) of 13.4°C ± 1.2°C with 33.6% ± 13.7% of hourly temperatures ≥15°C. Average water temperature was lowest at the Shingle Point Ocean deployment location, where the interannual average (± SD) was 5.5°C ± 0.8°C with no recorded hourly temperatures ≥15°C. The lowest minimum temperature documented within Niaqunnaq MPA was recorded at Shingle Point Ocean on 26 June 2020 at -0.7°C and the highest maximum was recorded at Niaqunnaq East on 8 July 2022 at 22.2°C (Table 3). Maximum temperatures were recorded in the first and second weeks of July at most sites (Figure 11), with the exceptions of Shingle Point Bay and Shingle Point Ocean when it was recorded on 25 July 2019 and 9 August 2020, respectively. The earliest date where an hourly temperature ≥15°C was recorded was between the last week of June and first week of July across sites (Table 3). The latest date when an hourly temperature ≥15°C was recorded was variable among locations, but generally documented between the first and third week of August (Table 3). Escape Reef and Shingle Point Ocean generally had cooler water temperatures compared to other deployment locations, where the former only reported 0.6% of hourly temperatures ≥15°C and the latter reported none (Table 3).

Okeevik MPA is the most recent addition to our monitoring program, with data collection beginning in 2021 (Tables 1 and 3). The most extensive water temperature datasets to date was recorded at Garry Island. The highest average water temperature was documented at the Kendall Island deployment location, where the interannual average (± SD) was 13.8°C ± 0.3°C with 37.9% ± 0.6% of hourly temperatures ≥15°C (Table 3). Average water temperature was lowest at the Pelly Island deployment location, where the interannual average (± SD) of 9.0°C ± 0.7°C with 0.4% ± 0.5% of recorded hourly temperatures ≥15°C. The lowest minimum temperature documented within Okeevik MPA was recorded at the Okeevik deployment location on 7 July 2024 at 0.8°C and the highest maximum was recorded at Garry Island on 4 July 2022 at 21.4°C (Table 3). Maximum temperatures were recorded in the first and second week of July at most sites (Figure 11), except for the Okeevik location where it was recorded on 8 August 2024. The earliest date where an hourly temperature ≥15°C was recorded was during the last week of June at most sites (Table 3). The latest date where an hourly temperature ≥15°C was recorded was variable across deployment locations, documented between the first week of August and first week of September (Table 3). Pelly Island generally recorded cooler water temperatures, with no measurements ≥15 °C in 2023 and only 1.0 % of hourly temperatures ≥15 °C in 2025.

Table 3. Summary of seabed water temperatures as recorded just above the seafloor across TN MPA from 2015-2025. Shown are weighted average (± standard deviation), minimum, and maximum values recorded at each location; date where highest temperature was recorded; and the earliest date, latest date, and the weighted average proportion (± standard deviation) of recorded temperatures 15°C or higher. Refer to Table 1 for a summary of annual deployment locations and Appendix A for annual summary statistics for each deployment location.

			Seabed water temperature (°C)				Temperature ≥15°C		
MPA Parcel	**Location**	**Year Range**	**Weighted Interannual Avg (± SD)**	**Min**	**Max**	**Date with Maximum**	**Weighted Interannual Avg (± SD) Proportion (%)**	**Earliest Date**	**Latest Date**
Kittigaryuit	Channel	2015-2017	15.78 ± 0.51	11.09	21.36	2016-Jul-15	65.4 ± 13.9	2016-Jun-21	2016-Aug-20
	East Hendrickson	2017	11.44	1.54	17.68	2017-Aug-11	13.4	2017-Jun-23	2017-Aug-14
	East Whitefish	2016-2019, 2021-2022, 2024-2025	14.04 ± 0.76	5.39	22.27	2016-Jul-14	38.3 ± 13.9	2017-Jun-21	2022-Sep-04
	Mid Kugmallit	2015, 2017, 2019, 2021-2023	14.47 ± 0.60	3.91	21.16	2023-Jul-23	45.8 ± 9.7	2015-Jun-21, 2017-Jun-21	2022-Sep-04
	Mid Kugmallit B	2016	14.48	7.48	21.40	2016-Jul-14	38.5	2016-Jun-23	2016-Aug-10
	West Hendrickson	2015, 2017, 2019, 2021-2025	12.66 ± 0.74	0.76	21.46	2023-Jul-22	26.8 ± 6.6	2015-Jun-21	2024-Aug-19
Kugmallit Bay	Atkinson Point	2022	5.58	0.19	12.54	2022-Aug-09	0.0	-	-
Niaqunnaq	Escape Reef	2023	9.04	0.53	17.56	2023-Jul-02	0.6	2023-Jul-02	2023-Jul-03
	Shingle Point Bay	2019-2020	9.91 ± 0.91	0.87	16.53	2019-Jul-25	3.4 ± 3.9	2019-Jun-24	2020-Aug-07
	Shingle Point Ocean	2019-2021	5.45 ± 0.81	-0.68	13.33	2020-Aug-09	0.0 ± 0.0	-	-
	Niaqunnaq	2020	12.72	6.84	16.68	2020-Jul-13	10.2	2020-Jun-30	2020-Aug-24
	Niaqunnaq East	2021-2023, 2025	13.43 ± 1.22	4.53	22.17	2022-Jul-08	33.6 ± 13.7	2021-Jun-27	2023-Aug-18
	Niaqunnaq Mid	2023	14.09	6.52	21.04	2023-Jul-07	47.9	2023-Jun-28	2023-Aug-13
	Niaqunnaq North	2021-2022	11.58 ± 1.00	2.48	21.58	2022-Jul-06	16.4 ± 7.3	2021-Jun-27	2022-Aug-06
	Niaqunnaq West	2021-2022, 2024-2025	10.97 ± 0.98	1.61	21.28	2022-Jul-08	18.3 ± 7.4	2021-Jun-27, 2024-Jun-27	2024-Aug-13

Table 3. Continued.

			Seabed water temperature (°C)				Recorded Temperature ≥15°C		
MPA Parcel	Location	Year Range	Weighted Interannual Avg (± SD)	Min	Max	Date with Maximum	Weighted Interannual Avg (± SD) Proportion (%)	Earliest Date	Latest Date
Okeevik	Okeevik	2024	11.77	0.77	19.96	2024-Aug-08	25.5	2024-Jun-25	2024-Aug-17
	Pelly Island	2023, 2025	9.02 ± 0.66	1.48	16.44	2025-Jul-07	0.4 ± 0.5	2025-Jul-06	2025-Aug-04
	Garry Island	2021-2023	12.79 ± 0.55	1.45	21.42	2022-Jul-04	28.3 ± 10.3	2023-Jun-25	2023-Aug-11
	Kendall Island	2021-2022	13.81 ± 0.27	2.90	19.21	2022-Jul-08	37.9 ± 0.6	2022-Jun-26	2022-Sep-03

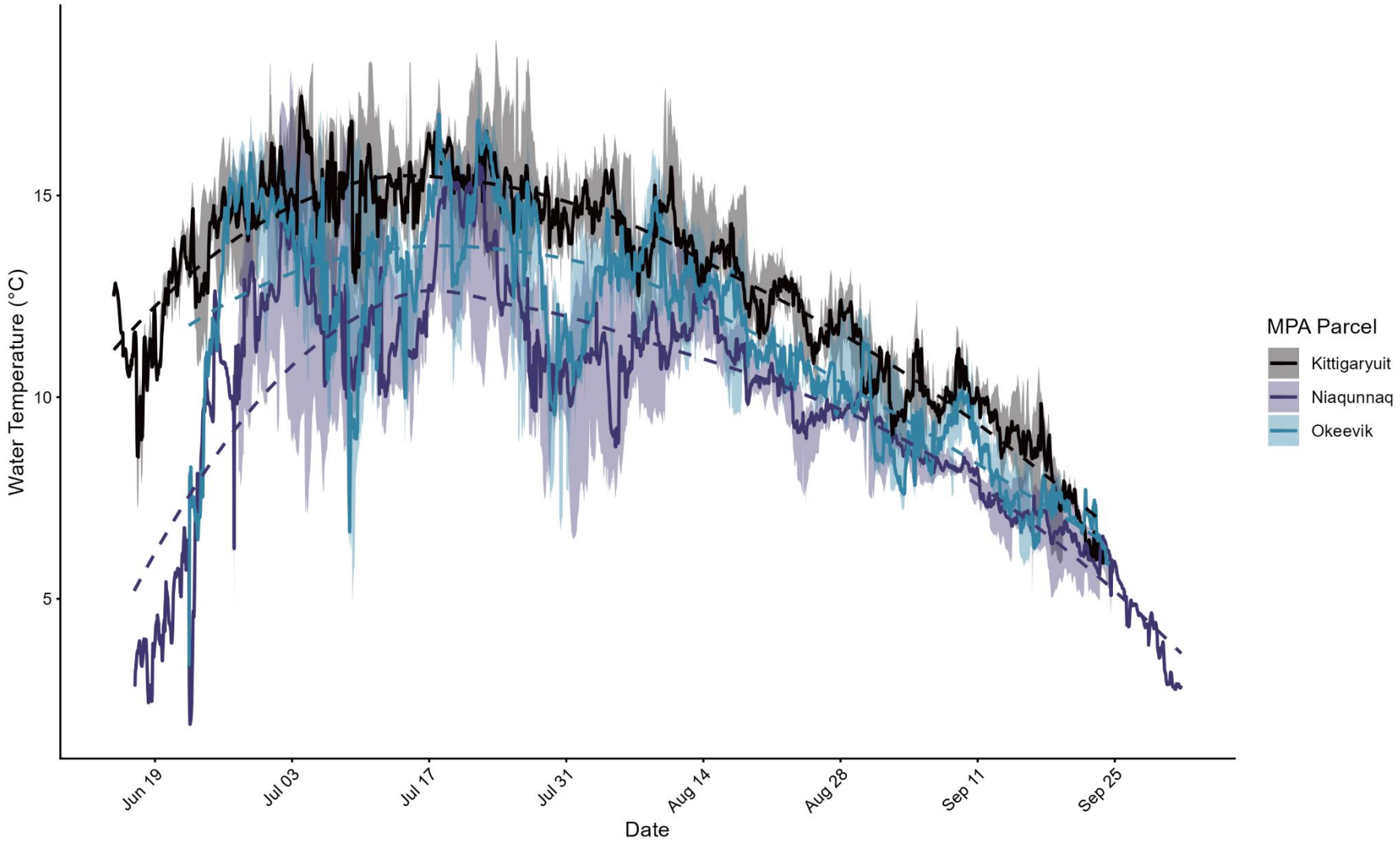


Figure 7. Seabed water temperature (°C) across sites and years within the TN MPA. Measurements span 2015-2025 in Kittigaryuit, 2019-2025 in Niaqunnaq, and 2021-2025 in Okeevik. Solid lines represent the median value of hourly averages calculated across sites and years within each MPA parcel. Shaded areas indicate the interquartile range around each median value. Dashed lines represent smoothed LOESS lines to highlight overarching trends for each MPA parcel. Refer to Table 1 for a summary of deployments used to produce this graphic.

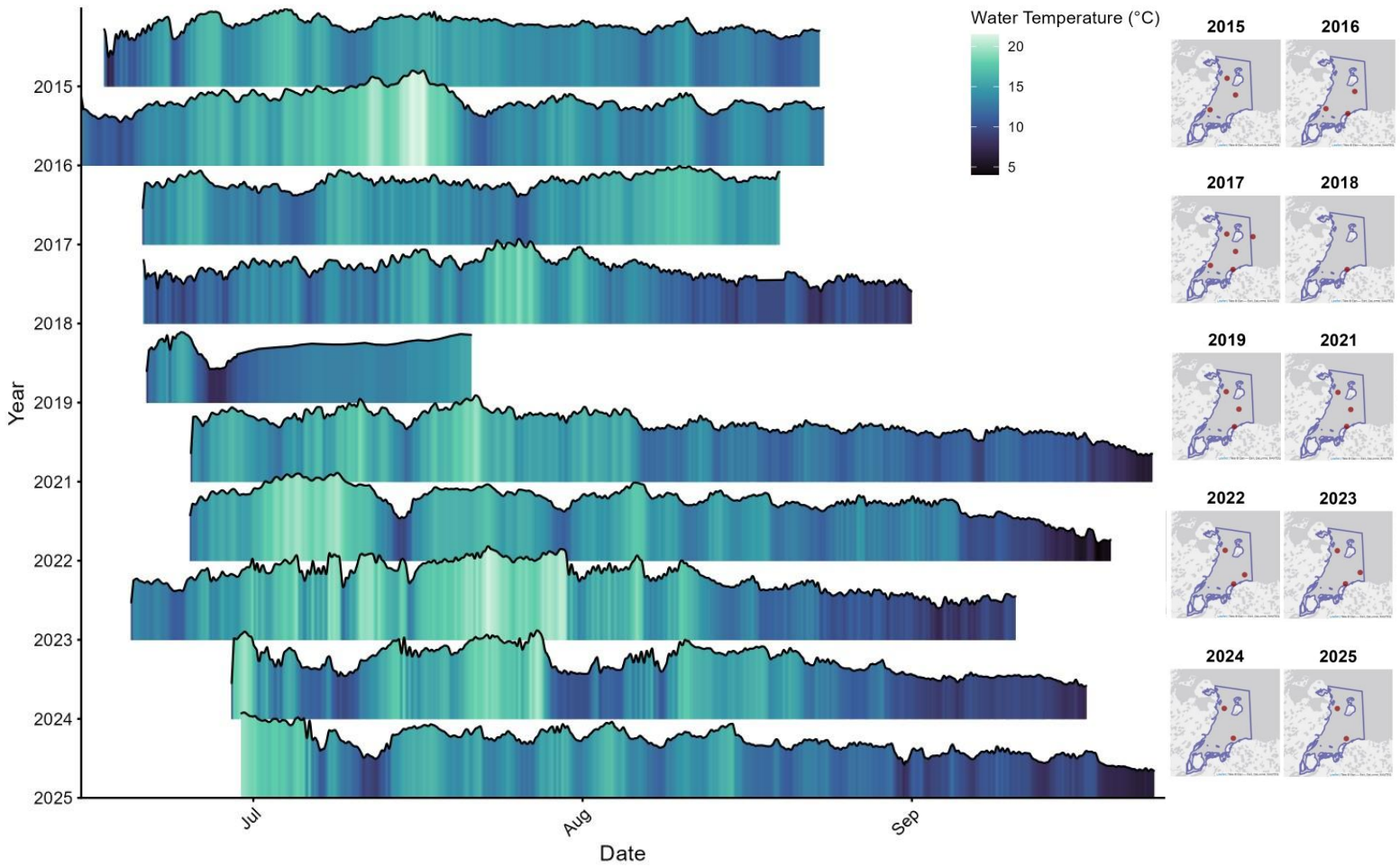


Figure 8. Left: seabed water temperature (°C) across years and deployment locations at Kittigaryuit MPA from 2015-2025. Note: seabed temperature data was not collected in 2020. Measurements were collected hourly at all locations, except for East Whitefish in 2019 where temperature was recorded once daily at noon. For each deployment year, the average hourly water temperature was calculated across deployment location(s) and is displayed here as a 6-hour rolling average. Right: annual maps of deployment locations within Kittigaryuit MPA that contributed data to the summary on the left. Refer to Table 1 for a summary of deployments used to produce this graphic.

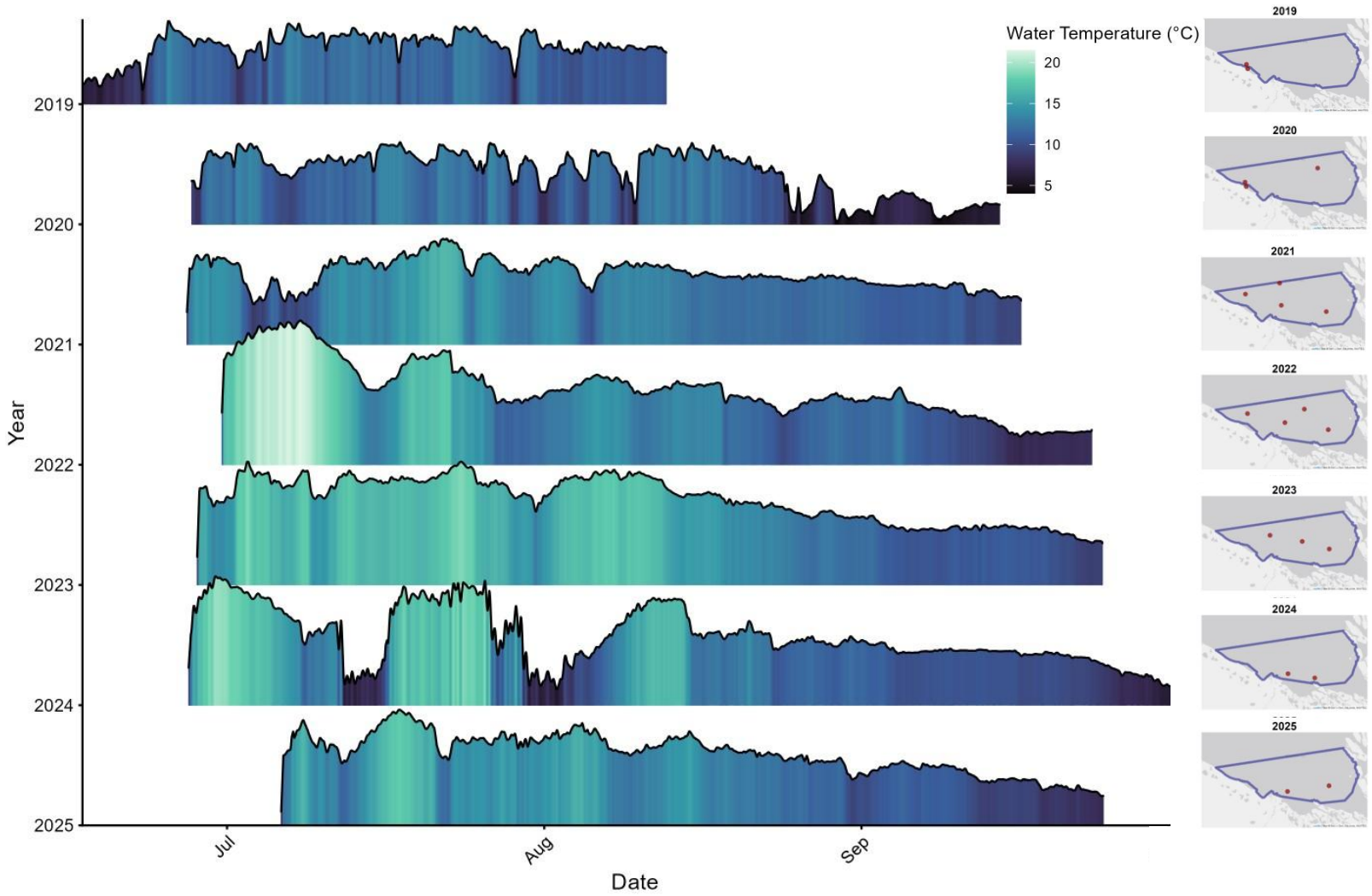


Figure 9. Left: seabed water temperature (°C) across years and deployment locations at Niaqunnaq MPA from 2019-2025. Measurements were collected hourly at all locations. For each deployment year, the average hourly water temperature was calculated across deployment location(s) and is displayed here as a 6-hour rolling average. Right: annual maps of deployment locations within Niaqunnaq MPA that contributed data to the summary on the left. Refer to Table 1 for a summary of deployments used to produce this graphic.

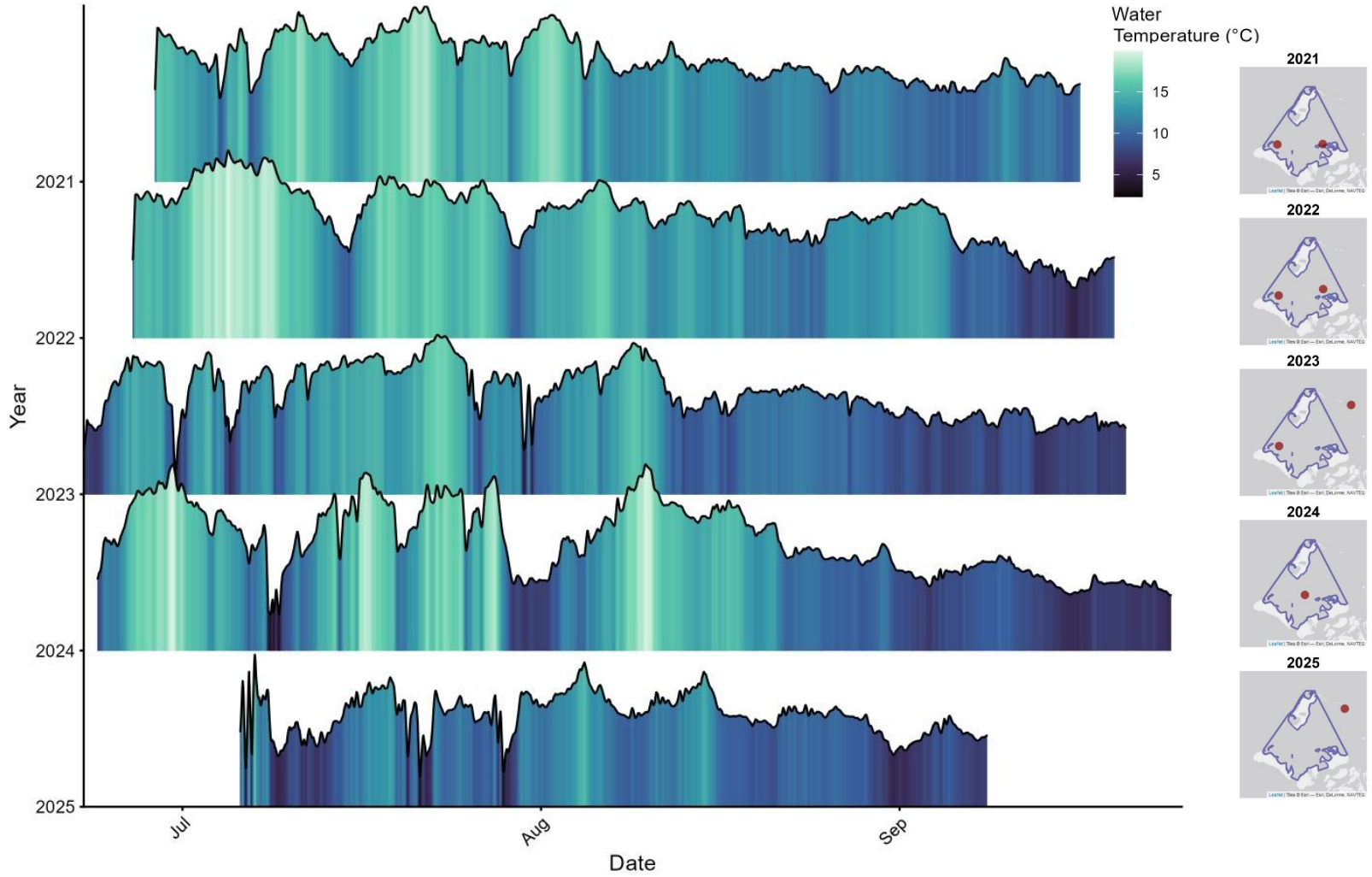


Figure 10. Left: seabed water temperature (°C) across years and deployment locations at Okeevik MPA from 2021-2025. Measurements were collected hourly at all locations. For each deployment year, the average hourly water temperature was calculated across deployment location(s) and is displayed here as a 6-hour rolling average. Right: annual maps of deployment locations within Okeevik MPA that contributed data to the summary on the left. Refer to Table 1 for a summary of deployments used to produce this graphic.

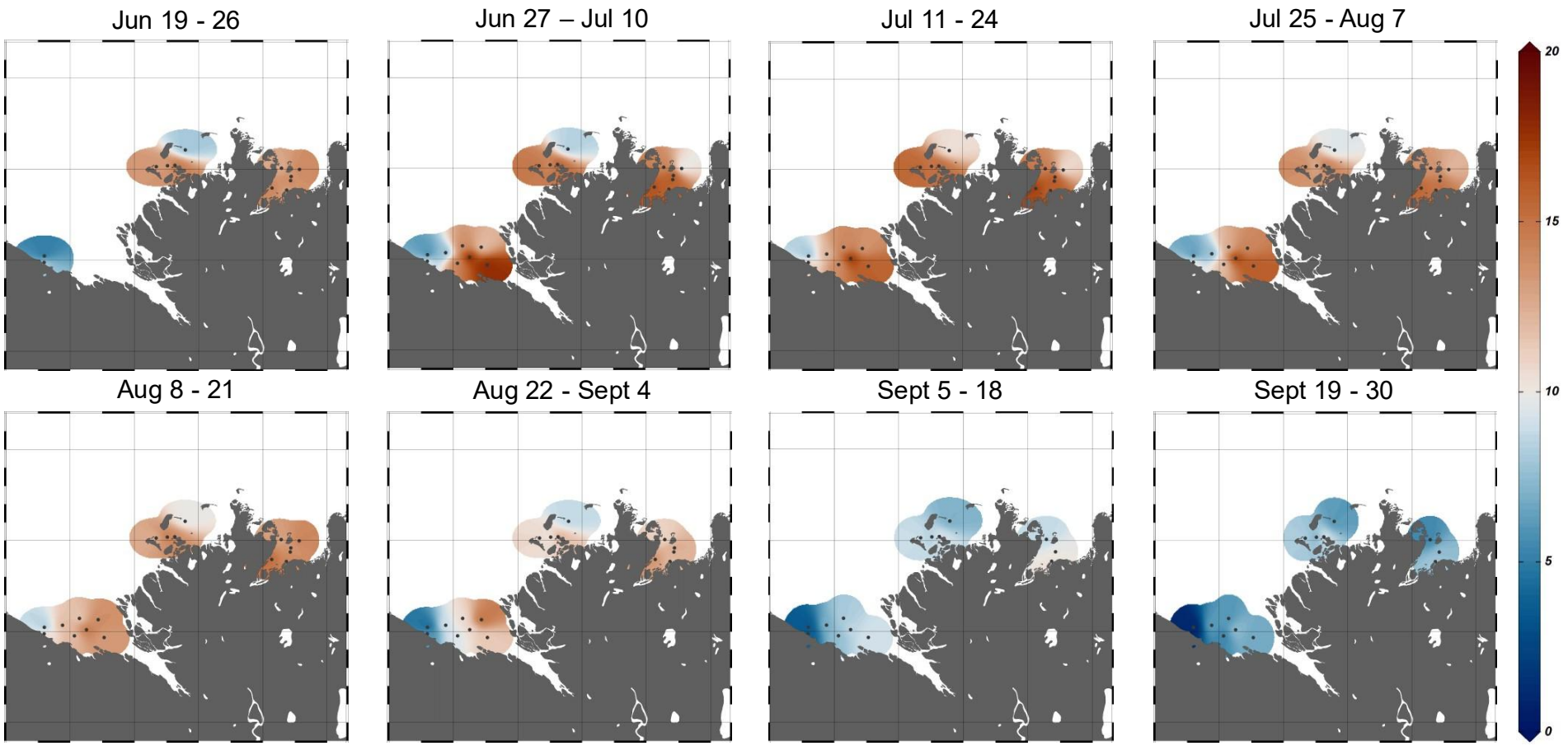


Figure 11. Two-week average seabed water temperature (°C) measured across the TN MPA. Measurements span 2015-2025 in Kittigaryuit, 2019-2025 in Niaqunnaq, and 2021-2025 in Okeevik. Measurements were collected hourly at locations indicated with black points. For each two-week period, the average hourly water temperature was calculated at each deployment location and coverage was modelled with weighted-average gridding in Ocean Data View. Note: temperature measurements were typically recorded hourly, except for East Whitefish in 2019 when temperature was recorded once daily at noon. The final two-week period is shortened to reflect the latest retrieval date within the dataset. Refer to Table 1 for a summary of deployments used to produce this graphic.

3.1.2 Sea surface water temperature

SST was recorded within approximately 10 cm of the water surface using Sofar Spotter buoys which were first deployed in 2020. Similar to seabed water temperature, SST was highest within Kittigaryuit MPA, followed by Okeevik and lastly Niaqunnaq (Table 4, Figures 12 and 13). The Atkinson Point deployment location east of Kittigaryuit MPA reported lower average SST compared to almost any other deployment location within the TN MPA (interannual average ± SD: 9.8°C ± 0.5°C). All three parcels followed a similar seasonal pattern, where SST gradually increased in the early summer to a peak around mid-July before declining towards freeze-up (Figures 12 and 13). In general, average and median SST tended to be higher than seabed water temperature across MPA parcels (Tables 3 and 4, Figures 12 and 14). This difference was most pronounced at Niaqunnaq MPA (Figure 14). Deployment locations closer to channel/river mouths tended to have warmer water temperatures compared to those farther away (Table 4, Figure 13).

The deployment locations within Kittigaryuit that were most consistently sampled for SST between 2020-2025 were West Hendrickson followed by East Whitefish (Table 4). The highest average SST was documented at East Whitefish, where the interannual average (± SD) was 15.0°C ± 1.5°C and 50.8% ± 16.4% of hourly SST measurements were ≥15°C (Table 4). Average SST was lowest at the West Hendrickson deployment location, where the interannual average (± SD) was 13.1C ± 0.8°C with 29.1% ± 13.3% of hourly temperatures ≥15°C. Both the lowest minimum and highest maximum temperatures documented within Kittigaryuit were recorded at West Hendrickson at 0.1°C on 4 July 2020 and at 26.3°C on 4 July 2022 (Table 4). Maximum documented temperatures were recorded between late June and late July across the MPA (Table 4, Figure 13). The earliest date when hourly temperature was ≥15°C was recorded also ranged from late June to late July across the MPA (Table 4). The latest date when an hourly temperature ≥15°C was recorded was more consistent from mid to late August (Table 4). All deployment locations reported at least a portion of water temperatures measurements ≥15°C (Table 4, Figure 12).

We recorded lower average SST at Niaqunnaq MPA compared to the rest of TN MPA (Table 4, Figure 12). The deployment locations most consistently sampled between 2020-2025 were at Niaqunnaq East and Niaqunnaq West. The highest average SST was documented at the Niaqunnaq East deployment location, where the interannual average (± SD) was 13.3°C ± 1.4°C with 34.1% ± 15.2% of hourly temperatures ≥15°C (Table 4). Average SST was lowest at the Shingle Point Ocean deployment location, where the 2020 average (± SD) was 9.5°C ± 3.8°C with no recorded hourly temperatures ≥15°C. The lowest minimum temperature documented within Niaqunnaq MPA was recorded at Shingle Point Ocean on 7 September 2020 at -0.2°C and the highest maximum was recorded at Niaqunnaq North on 10 August 2022 at 29.5°C (Table 4). Maximum temperatures at each deployment location were recorded from late July to mid-August across deployment locations (Table 4, Figures

12 and 13). The earliest date where an hourly temperature ≥15°C was consistently recorded in the last week of June across sites (Table 4). The latest date where an hourly temperature ≥15°C was recorded was variable across deployment locations, but generally documented between the second and last week of August (Table 4).

Okeevik MPA is the most recent addition to our monitoring program (Tables 1 and 4). The highest average SST was documented at the Kendall Island location, where the interannual average (± SD) was 14.1°C ± 0.4°C with 40.4% ± 1.1% of hourly temperatures ≥15°C (Table 4). Average SST was lowest at the Pelly Island location, where the interannual average (± SD) was 11.4°C ± 0.5°C with 16.8% ± 9.7% of hourly temperatures ≥15°C. The lowest minimum and highest maximum SST were both documented at the Okeevik location in 2024 with 0.8°C on 7 July and 22.0°C on 14 July (Table 4). Maximum SST were recorded between early July and early August across sites (Table 4, Figures 12 and 13). The earliest date where an hourly temperature ≥15°C was recorded was the last week of June across locations (Table 4). The latest date where an hourly temperature ≥15°C was recorded was between early August to early September (Table 4).

Table 4. Summary of sea surface water temperatures (SST) across the TN MPA from 2020-2025. Shown are weighted average (± standard deviation), minimum, and maximum hourly values recorded at each location; date where highest temperature was recorded; and the earliest date, latest date, and the weighted average proportion (± standard deviation) of recorded temperatures ≥15°C. Refer to Table 1 for a summary of annual deployment locations and Appendix B for annual summary statistics for each deployment location.

			SST (°C)				SST ≥15°C		
MPA Parcel	**Location**	**Year Range**	**Weighted Interannual Avg (± SD)**	**Min**	**Max**	**Date with Maximum**	**Weighted Interannual Avg (± SD) Proportion (%)**	**Earliest Date**	**Latest Date**
Kittigaryuit	Channel	-	-	-	-	-	-	-	-
	East Hendrickson	-	-	-	-	-	-	-	-
	East Whitefish	2022-2024	15.00 ± 1.47	5.62	22.56	2024-Aug-07	50.8 ± 16.4	2023-Jun-25	2022-Sep-4
	Mid Kugmallit	2020	13.43	3.22	17.40	2020-Jul-31	24.3	2020-Jul-13	2020-Aug-25
	Mid Kugmallit B	-	-	-	-	-	-	-	-
	West Hendrickson	2020, 2022-2024	13.10 ± 0.84	0.08	26.34	2022-Jul-04	29.1 ± 13.3	2023-Jun-25	2022-Sep-3
Kugmallit Bay	Atkinson Point	2022-2023	9.79 ± 0.48	2.04	19.98	2023-Jul-21	5.5 ± 5.3	2023-Jul-15	2023-Aug-08
Niaqunnaq	Escape Reef	2023	12.47	4.96	20.80	2023-Jul-27	32.3	2023-Jun-28	2023-Aug-11
	Shingle Point Bay	2020	-	-	-	-	-	-	-
	Shingle Point Ocean	2020	9.46	-0.21	14.56	2020-Jul-26	0.0	-	-
	Niaqunnaq	2020	12.57	4.90	18.31	2020-Aug-18	14.0	2020-Jun-30	2020-Aug-25
	Niaqunnaq East	2021, 2024-2025	13.34 ± 1.42	4.46	22.20	2024-Jul-25	34.1 ± 15.2	2024-Jun-26	2024-Aug-20
	Niaqunnaq Mid	2023	-	-	-	-	-	-	-
	Niaqunnaq North	2021-2022	12.46 ± 0.13	4.44	29.52	2022-Aug-10	23.7 ± 1.2	2021-Jun-27	2022-Aug-10
	Niaqunnaq West	2021, 2024-2025	11.69 ± 1.23	2.82	23.56	2024-Jul-24	24.8 ± 12.4	2024-Jun-26	2024-Aug-13
Okeevik	Okeevik	2024	12.51	0.78	22.02	2024-Jul-14	32.2	2024-Jun-25	2024-Aug-20
	Pelly Island	2023, 2025	11.35 ± 0.52	1.86	21.84	2023-Aug-06	16.8 ± 9.7	2023-Jun-30	2025-Aug-15
	Garry Island	2021	12.62	7.45	19.84	2021-Jul-10	22.3	2021-Jun-28	2021-Aug-05
	Kendall Island	2021-2022	14.06 ± 0.37	3.66	20.42	2022-Jul-04	40.4 ± 1.1	2022-Jun-26	2022-Sep-03

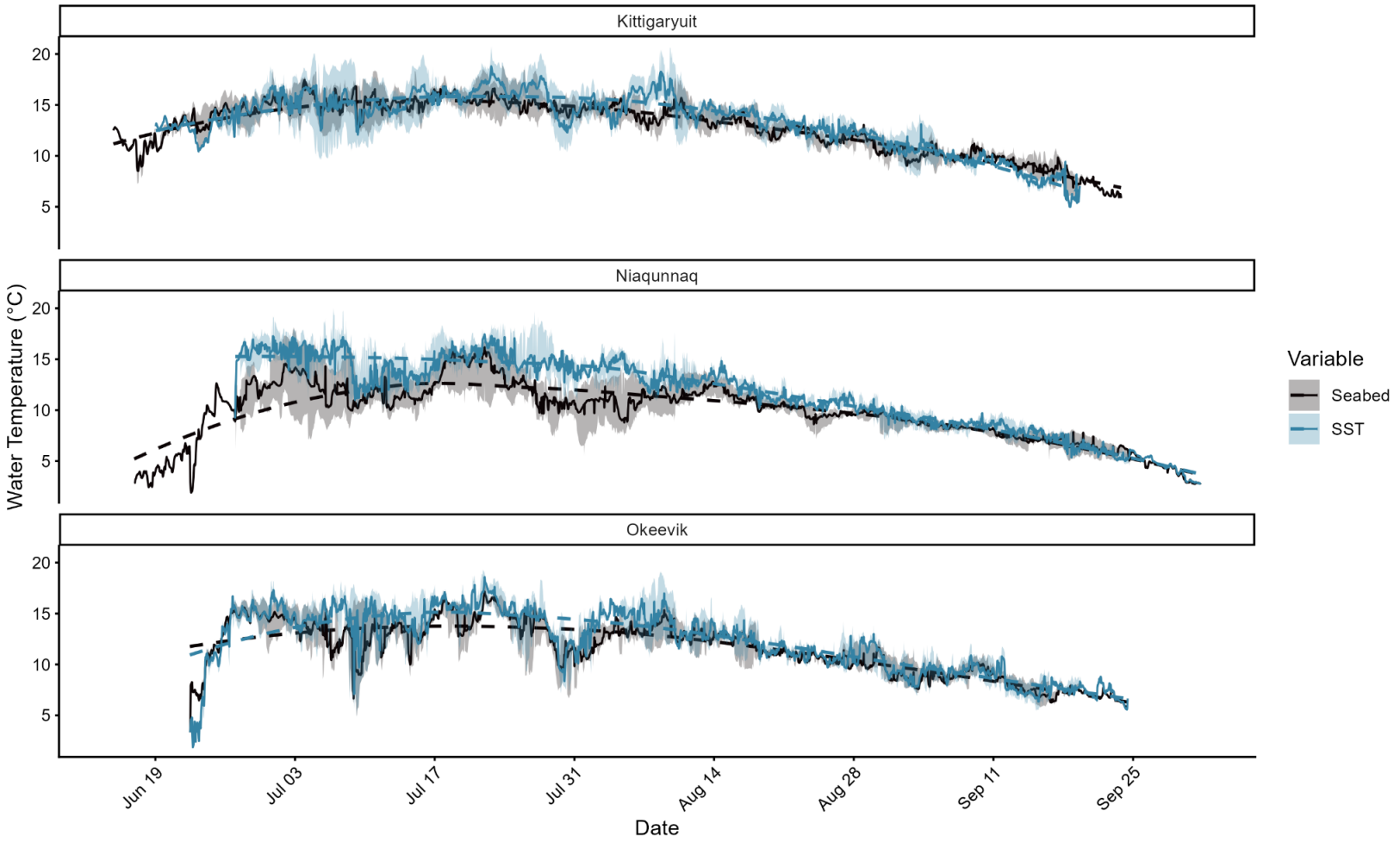


Figure 12. Seabed and sea surface (SST) water temperature (°C) summarized across sites and years within the TN MPA. Seabed temperature measurements span 2015-2025 in Kittigaryuit, 2019-2025 in Niaqunnaq, and 2021-2025 in Okeevik. SST measurements span 2020-2025 in Kittigaryuit and Niaqunnaq, and 2021-2025 in Okeevik. Solid lines represent the median value of hourly averages calculated across sites followed by years within each MPA. Shaded areas represent the interquartile range around each median value. Dashed lines represent

smoothed LOESS lines to highlight trend for each variable within that MPA parcel. Refer to Table 1 for a summary of deployments used to produce this graphic.

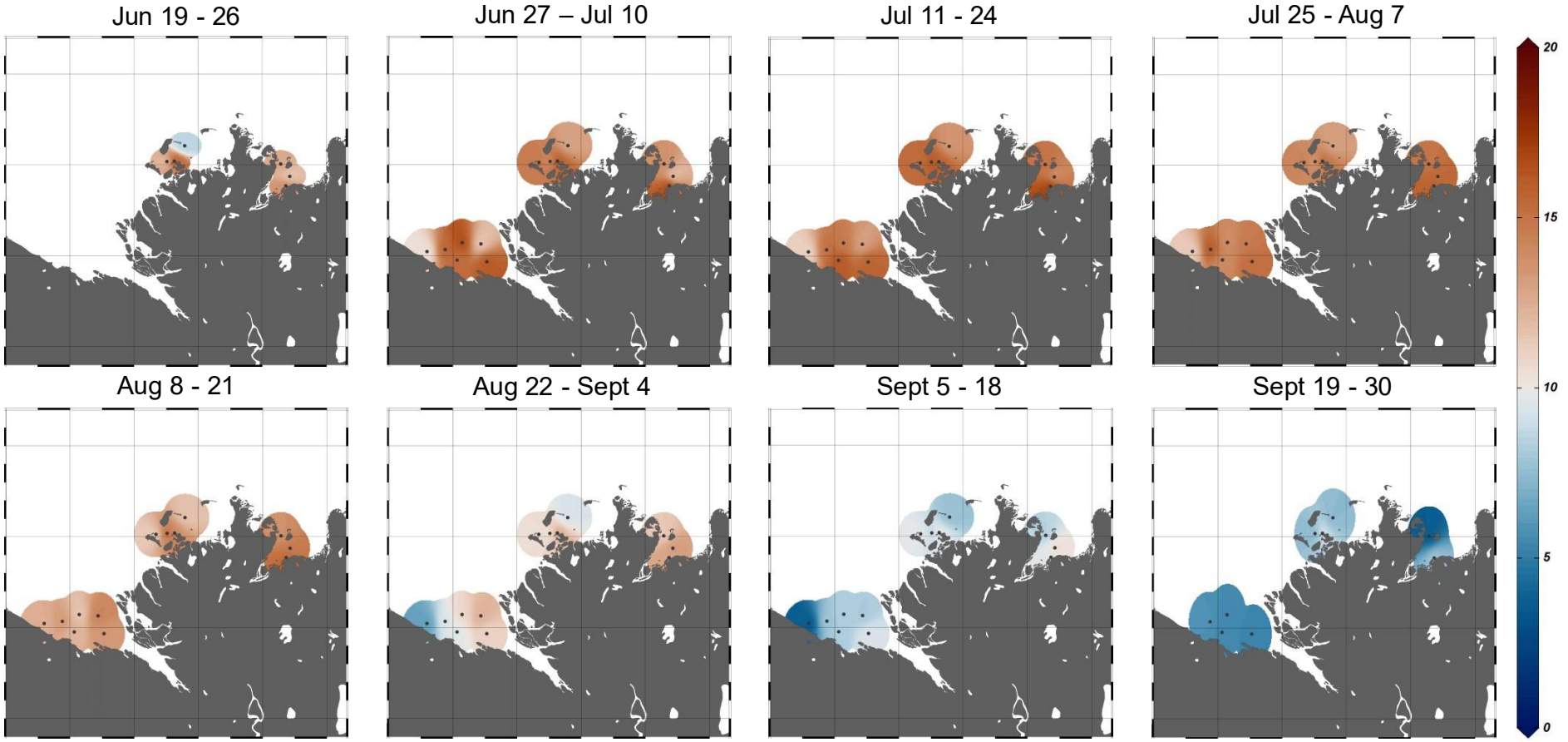


Figure 13. Two-week average sea surface water temperature (°C, SST) measured across the TN MPA. Measurements were collected hourly at locations indicated with black points from 2020-2025 in Kittigaryuit and Niaqunnaq, and from 2021-2025 in Okeevik. For each two-week period, the average hourly SST was calculated at each deployment location and coverage was modelled with weighted-average gridding in Ocean Data View. The initial and final two-week periods are shortened to reflect the earliest and latest deployment dates within the dataset while maintaining consistency with Figure 11. Refer to Table 1 for a summary of deployments used to produce this graphic.

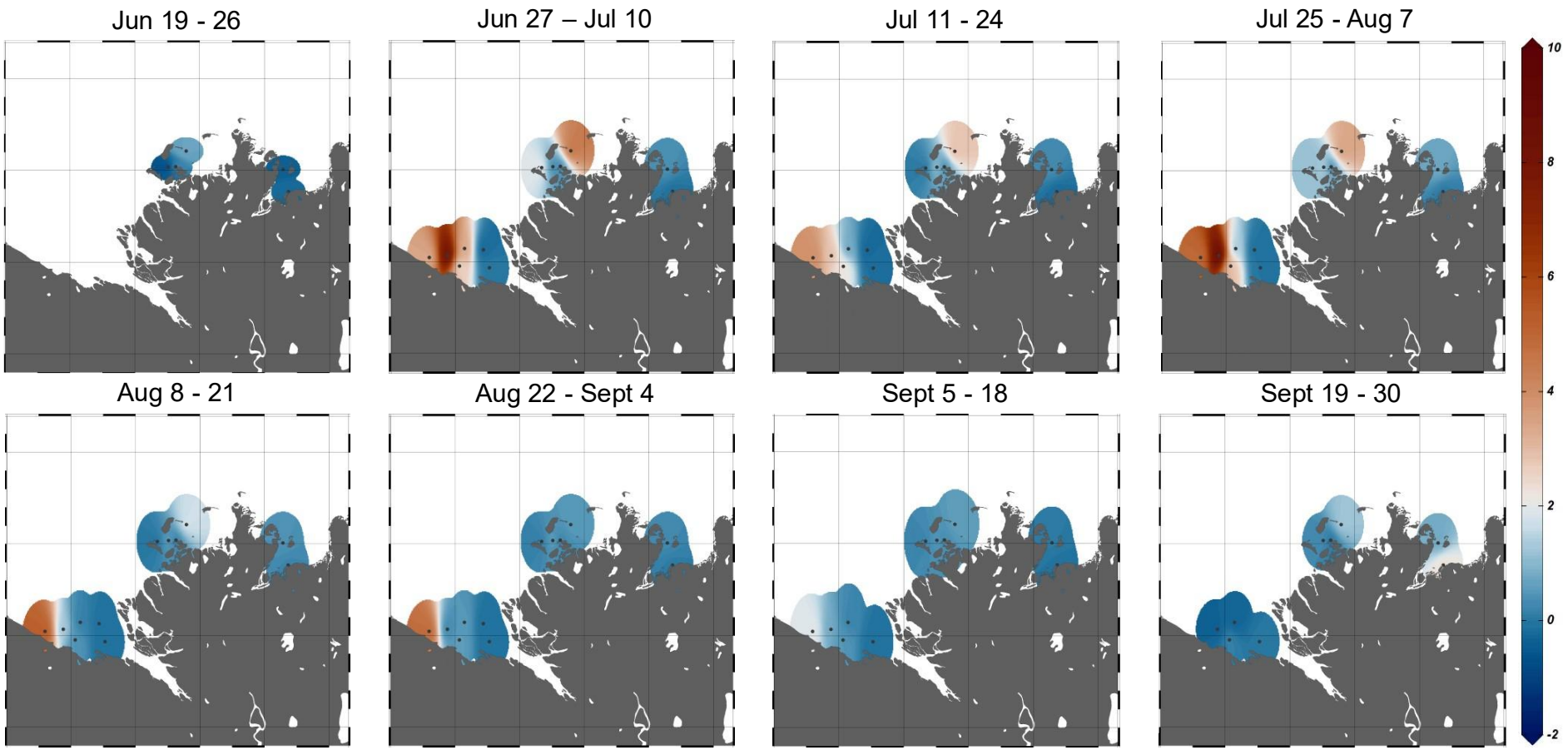


Figure 14. Two-week average temperature stratification measured across the TN MPA. Measurements were collected hourly at locations indicated with black points from 2020-2025 in Kittigaryuit and Niaqunnaq, and from 2021-2025 in Okeevik. Displayed is the temperature difference between sea surface water temperature (°C, SST) and seabed water temperature (°C). For each two-week period, the average temperature stratification was calculated at each deployment location and coverage was modelled with weighted-average gridding in Ocean Data View. The initial and final two-week periods are shortened to reflect the earliest and latest deployment dates within the dataset while maintaining consistency with Figures 11 and 13. Refer to Table 1 for a summary of deployments used to produce this graphic.

3.1.3 Salinity

Kittigaryuit and Okeevik MPAs showed similar seasonal and interannual trends in salinity measurements; however, Niaqunnaq MPA generally had higher salinity overall and distinct seasonal trends from the other two parcels (Tables 5 and 6, Figures 15 and 16). Kittigaryuit and Okeevik deployment locations reported fresher conditions at the start of the deployment period which gradually increased throughout the season (Figure 15). In contrast, Niaqunnaq deployment locations reported more saline conditions at the start of the deployment period which initially decline before peaking again in mid-August and finally declining towards the end of the season (Figure 15). There is some interannual variability within the parcels, more pronounced at the Niaqunnaq sites compared to Kittigaryuit and Okeevik (Figures 17 to 19). The Atkinson Point deployment location east of Kittigaryuit MPA was more saline (2022 average ± SD: 14.8 ± 9.2 PSU, range: 0.7 – 29.1) for a greater portion of the season (77.5%) compared to other Kugmallit Bay deployments (Tables 5 and 6). Deployment locations closer to river mouths tended to have fresher conditions compared to those farther away, most distinctly within Niaqunnaq MPA (Tables 5 and 6, Figures 16 to 19).

The deployment locations most consistently sampled between 2015-2025 were West Hendrickson and Mid Kugmallit, which have eight and six seasons of salinity data, respectively. Salinity varied spatially and temporally within Kittigaryuit MPA between 2015 and 2025 (Tables 5 and 6, Figures 15 to 17). The 2017 East Hendrickson deployment yielded the highest salinity measurements (2017 average ± SD: 13.6 ± 9.8 PSU, range: 0.1-29.9) and was deemed saline (≥5 PSU) for 69.7% of the deployment season (Table 5). Of the locations with multi-year datasets, West Hendrickson reported higher salinity (interannual average ± SD: 5.2 ± 2.3 PSU, range: 0.0 - 29.0) and was deemed saline for 36.8% ± 13.6% of the deployment season on average (Table 4). Conditions at the remaining deployment locations were largely fresh, with East Whitefish yielding the lowest average salinity (interannual average ± SD: 0.7 ± 0.5 PSU, range: 0.1 – 24.2). Saline events (≥5 PSU for minimum of 24 consecutive hours) occurred at all sites and ranged from 24 to 443 hours (i.e., 1.0 – 18.5 days) in length (Table 6). Overall, Kittigaryuit locations reported fresher conditions at the start of the deployment period, which gradually increased in salinity throughout the season in most years (Figures 15 to 17). This trend was more pronounced in some years, whereas in others conditions remained largely fresh for the majority of the season (Figure 17).

Deployments within Niaqunnaq MPA were more consistently saline compared to those within Kittigaryuit and Okeevik (Tables 5 and 6). Salinity varied spatially and temporally within Niaqunnaq MPA between 2019 and 2025 (Tables 5 and 6, Figures 15, 16, and 18). The Shingle Point Ocean deployment yielded the highest salinity measurements (interannual average ± SD: 20.8 ± 3.2 PSU, range: 0.5 – 31.2) and was deemed saline (≥5

PSU) for 96.4% ± 5.4% of the deployment season (Table 5). Of the sites with multi-year datasets, the Niaqunnaq East site yielded the lowest salinity measurements (interannual average ± SD: 0.4 ± 0.4 PSU, range: 0.0 – 23.6; Table 5). Saline events (≥5 PSU for a minimum of 24 consecutive hours) occurred at most sites and ranged from 24 to 2007 hours (i.e., 1.0 – 83.6 days) in length, with Escape Reef having saline conditions 99.8% of the 2023 season (Table 6). The Niaqunnaq location (2020) was the only site that did not report any measurements ≥5 PSU for the duration of the deployment season. Overall, Niaqunnaq deployment locations reported more saline conditions at the start of the deployment period, which declined before peaking again in mid-August and finally declined towards the end of the season (Figures 15, 16, and 18). In general, deployment locations located more interior towards Shallow Bay (e.g., Niaqunnaq East) tended to be fresher whereas those farther out towards the Beaufort Sea (e.g., Escape Reef) tended to be more saline (Figure 18). Interannual variation was more pronounced within Niaqunnaq compared to other MPA parcels, potentially driven in part by more interior vs. coastal sampling locations in a given year (Table 5, Figure 18).

Salinity varied spatially and temporally within Okeevik MPA between 2021 and 2025 (Tables 5 and 6, Figures 15, 16, and 19). Of the sites with multi-year datasets, the Pelly Island deployment yielded the highest salinity measurements (interannual average ± SD: 4.3 ± 1.9 PSU, range: 0.2– 22.5) and was deemed saline (≥5 PSU) for 23.2% ± 27.5% of the deployment season (Table 5). The Kendall Island deployment yielded the lowest salinity measurements (interannual average ± SD: 0.5 ± 0.4 PSU, range: 0.1 – 26.7) and was deemed saline (≥5 PSU) for 2.4% ± 2.3% of the deployment season (Table 5). Saline events (≥5 PSU for minimum of 24 consecutive hours) occurred at all sites and ranged from 24 to 370 hours (i.e., 1.0 – 15.4 days) in length (Table 6). In general, deployment locations located closer to the Kumak Channel outflow (e.g., Kendall Island) reported fresher conditions compared to sites further west or north (e.g., Garry Island and Pelly Island; Figure 19). Similar to Kittigaryuit, Okeevik deployment locations reported fresher conditions at the start of the deployment period, which gradually increased in salinity throughout the season in most years (Figures 15 and 16).

Table 5. Summary of salinity (PSU) measurements recorded just above the seafloor across the TN MPA from 2015-2025. Shown are weighted interannual average (± standard deviation), minimum, and maximum hourly values recorded at each location; and the weighted interannual average proportion of measurements ≥5 PSU. Refer to Table 1 for a summary of annual deployment locations and Appendix C for annual summary statistics for each deployment location.

			Salinity (PSU)				Salinity ≥5 PSU
MPA Parcel	**Location**	**Year Range**	**Weighted Interannual Avg (± SD)**	**Min**	**Max**	**Date with Maximum**	**Weighted Interannual Avg (± SD) Proportion (%)**
Kittigaryuit	Channel	-	-	-	-	-	-
	East Hendrickson	2017	13.61	0.09	29.93	2017-Jul-19	69.7
	East Whitefish	2016, 2024-2025	0.68 ± 0.49	0.12	24.15	2025-Jul-07	4.1 ± 4.3
	Mid Kugmallit	2015, 2017, 2019, 2021-2023	1.81 ± 1.75	0.00	25.79	2022-Sep-18	9.7 ± 11.2
	Mid Kugmallit B	2016	1.28	0.11	16.54	2016-Aug-12	7.2
	West Hendrickson	2015, 2017, 2019, 2021-2025	5.17 ± 2.25	0.00	29.01	2017-Jul-20	36.8 ± 13.6
Kugmallit Bay	Atkinson Point	2022	14.84	0.66	29.06	2022-Sep-11	77.5
Niaqunnaq	Escape Reef	2023	20.31	3.28	29.49	2023-Jul-29	99.8
	Shingle Point Bay	2019	9.99	0.00	26.51	2019-Aug-04	71.8
	Shingle Point Ocean[a]	2019-2022	20.76 ± 3.20	0.54	31.21	2020-Sep-06	96.4 ± 5.4
	Niaqunnaq	2020	0.13	0.12	0.15	2020-Aug-22	0.0
	Niaqunnaq East	2021-2023, 2025	0.37 ± 0.40	0.00	23.60	2025-Sep-18	1.6 ± 2.9
	Niaqunnaq Mid	2023	2.46	0.00	15.41	2023-Jul-09	26.8
	Niaqunnaq North	2021-2022	6.78 ± 5.64	0.08	27.46	2021-Jul-07	40.2 ± 39.3
	Niaqunnaq West	2021-2022, 2024-2025	9.32 ± 3.55	0.00	28.77	2025-Jul-06	57.0 ± 14.3

[a] In 2022, salinity was recorded at the bottom and top of the mooring at this deployment. The measurements included in this analysis were collected at the bottom of the deployment, which would be comparable to collection methods across other deployment years and locations.

Table 5. Continued.

MPA Parcel	Location	Year Range	Salinity (PSU)				Salinity ≥5 PSU
			Weighted Interannual Avg (± SD)	Min	Max	Date with Maximum	Weighted Interannual Avg (± SD) Proportion (%)
Okeevik	Okeevik	2024	6.70	0.15	23.77	2024-Sep-14	44.8
	Pelly Island	2023, 2025	4.33 ± 1.87	0.15	22.48	2025-Jul-21	23.3 ± 27.5
	Garry Island	2021-2023	3.70 ± 2.00	0.00	31.92	2023-Jul-31	23.2 ± 16.6
	Kendall Island	2021-2022	0.54 ± 0.36	0.08	26.74	2022-Sep-16	2.4 ± 2.3

Table 6. Summary of saline events (minimum of 24 consecutive hours ≥5 PSU) from measurements recorded just above the seafloor across the TN MPA from 2015-2025. Shown are the earliest date, latest date, total number, average duration (± standard deviation), maximum duration, and minimum duration of events. Refer to Table 1 for a summary of annual deployment locations and Appendix C for annual summary statistics for each deployment location.

			Saline Events (≥5 PSU for ≥ 24 Hours)					
MPA Parcel	**Location**	**Year Range**	**Earliest Date**	**Latest Date**	**Total Events**	**Avg (± SD) Duration (hours)**	**Min Duration (hours)**	**Max Duration (hours)**
Kittigaryuit	Channel	-	-	-	-	-	-	-
	East Hendrickson	2017	2017-Jun-30	2017-Aug-15	5	183.6 ± 164.1	25	443
	East Whitefish	2016, 2024-2025	2024-Aug-06	2024-Aug-30	3	29.3 ± 2.9	26	31
	Mid Kugmallit	2015, 2017, 2019, 2021-2023	2023-Jul-06	2021-Sep-17	12	52.3 ± 29.9	26	109
	Mid Kugmallit B	2016	2016-Aug-10	2016-Aug-10	1	-	90	90
	West Hendrickson	2015, 2017, 2019, 2021-2025	2019-Jun-25	2021-Sep-21	56	67.9 ± 38.5	24	208
Kugmallit Bay	Atkinson Point	2022	2022-Jul-18	2022-Aug-14	6	167.0 ± 251.2	31	674
Niaqunnaq	Escape Reef	2023	2023-Jun-28	2023-Jul-02	2	-	113	2007
	Shingle Point Bay	2019	2019-Jun-22	2019-Jul-19	6	158.7 ± 213.9	36	588
	Shingle Point Ocean[a]	2019-2022	2019-Jun-16	2022-Sep-16	11	583.0 ± 694.2	25	1957
	Niaqunnaq	2020	-	-	0	-	-	-
	Niaqunnaq East	2021-2023, 2025	2025-Aug-26	2025-Sep-18	3	33.3 ± 8.3	24	40
	Niaqunnaq Mid	2023	2023-Jul-08	2023-Sep-06	7	69.1 ± 42.0	26	149
	Niaqunnaq North	2021-2022	2021-Jul-02	2021-Sep-10	7	209.3 ± 139.7	36	416
	Niaqunnaq West	2021-2022, 2024-2025	2021-Jul-02	2024-Sep-29	27	161.3 ± 185.3	25	791

[a] In 2022, salinity was recorded at the bottom and top of the mooring at this deployment. The measurements included in this analysis were collected at the bottom of the deployment, which would be comparable to collection methods across other deployment years and locations.

Table 6. Continued.

			Saline Events (≥5 PSU for ≥ 24 Hours)					
MPA Parcel	**Location**	**Year Range**	**Earliest Date**	**Latest Date**	**Total Events**	**Avg (± SD) Duration (hours)**	**Min Duration (hours)**	**Max Duration (hours)**
Okeevik	Okeevik	2024	2024-Jul-18	2024-Sep-13	6	146.8 ± 131.5	39	370
	Pelly Island	2023, 2025	2025-Jul-11	2025-Aug-30	10	66.3 ± 59.0	25	214
	Garry Island	2021-2023	2021-Jul-03	2021-Sep-15	19	45.3 ± 23.8	24	106
	Kendall Island	2021-2022	2022-Sep-11	2022-Sep-15	2	-	27	33

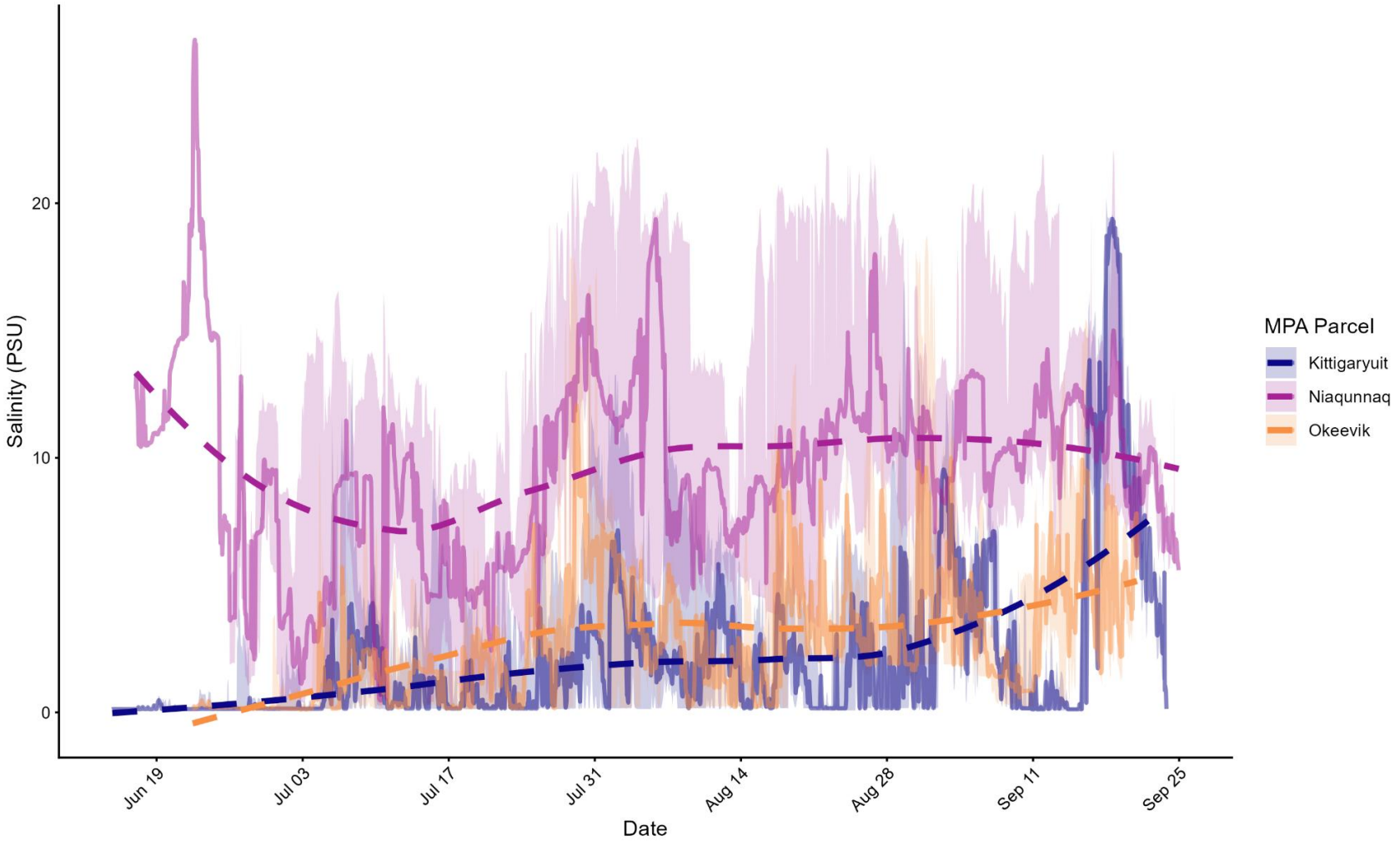


Figure 15. Seasonal salinity (PSU) trends across sites and years within the TN MPA. Measurements span 2015-2025 in Kittigaryuit, 2019-2025 in Niaqunnaq, and 2021-2025 in Okeevik. Solid lines represent the median value of hourly averages calculated across sites and years within each MPA. Shaded areas represent the interquartile range around each median value. Dashed lines represent smoothed LOESS lines to highlight overarching trends for each MPA parcel. Refer to Table 1 for a summary of deployments used to produce this graphic. Note: dataset has been trimmed to focus on the main deployment period shared across years.

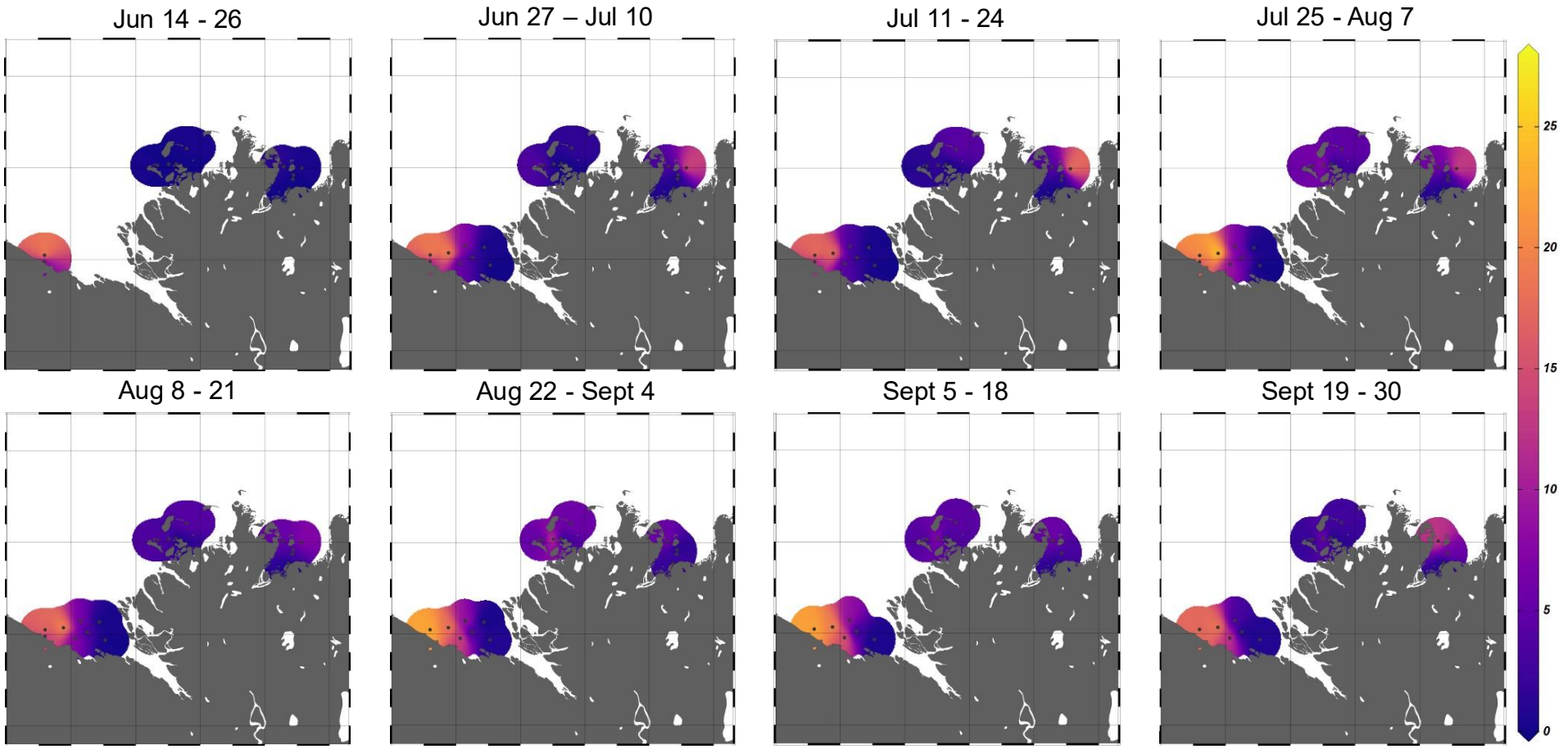


Figure 16. Two-week average salinity (PSU) measured across the TN MPA from 2015-2025. Measurements were collected hourly at locations indicated with black points. For each two-week period, average salinity was calculated for each deployment location and coverage was modelled with weighted-average gridding in Ocean Data View. The initial and final two-week periods are shortened to reflect the earliest and latest deployment dates within the dataset. Refer to Table 1 for a summary of deployments used to produce this graphic.

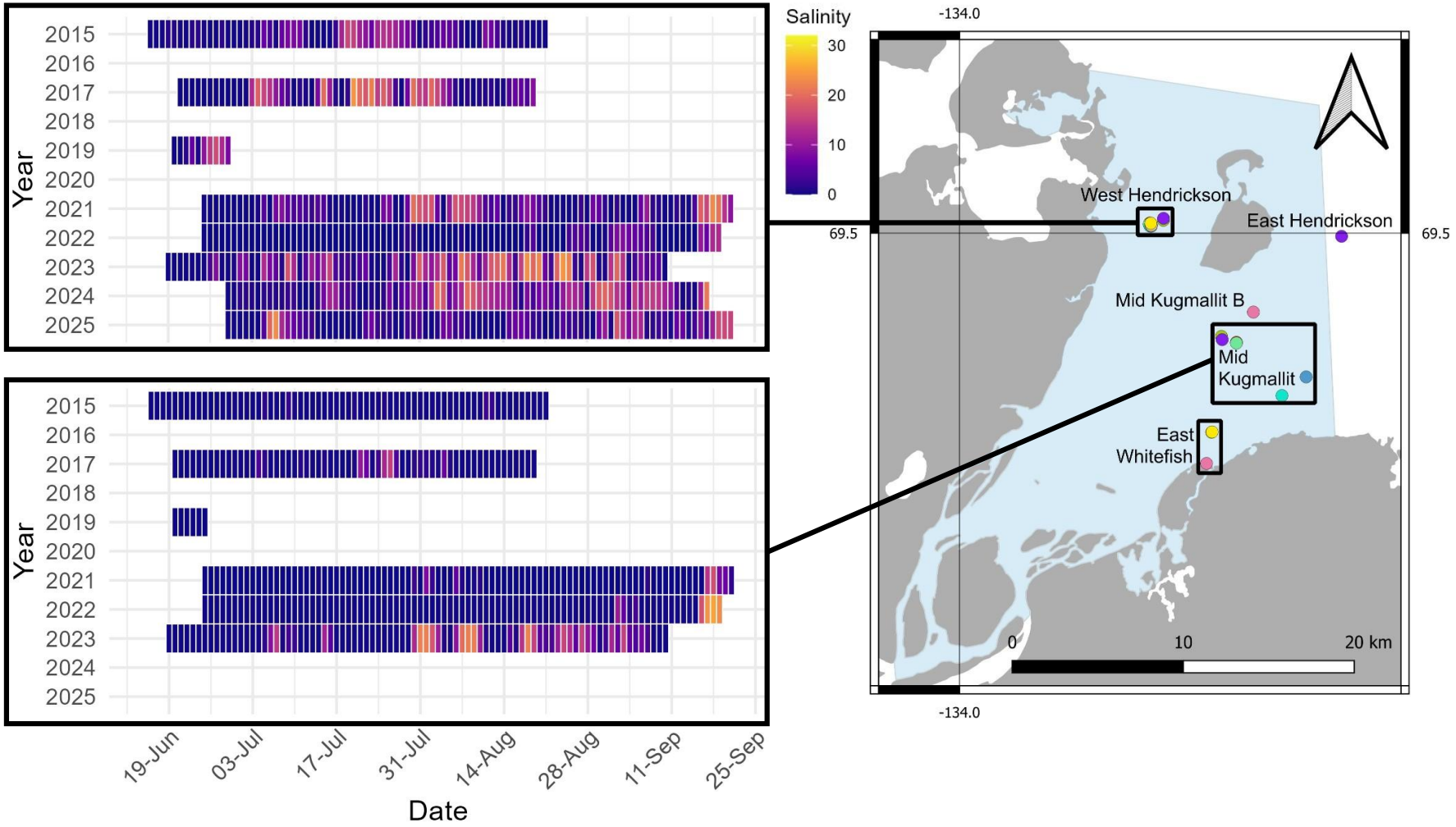


Figure 17. Multi-year comparison of average daily salinity (PSU) measurements collected across Kittigaryuit MPA from 2015-2025. Left: Salinity tile plots for: West Hendrickson (upper left) and Mid Kugmallit (lower left) deployment locations. Right: Map of annual deployment locations at Kittigaryuit MPA where salinity data were collected, included for spatial reference against salinity tile plots at right. Refer to Table 1 for a summary of deployments used to produce this graphic.

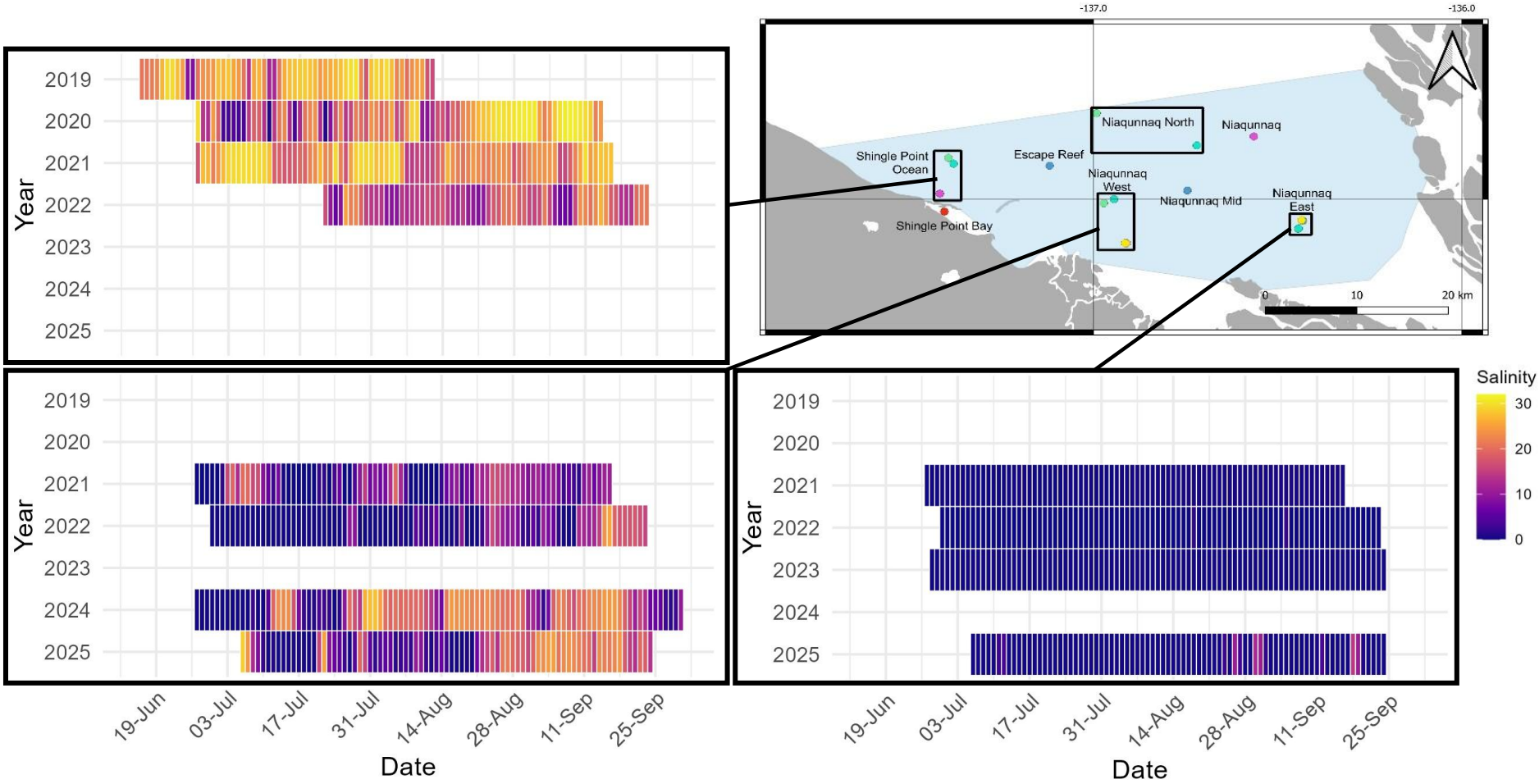


Figure 18. Multi-year comparison of average daily salinity (PSU) measurements collected across Niaqunnaq MPA from 2019-2025. Salinity tile plots for: Shingle Point Ocean (upper left), Niaqunnaq West (lower left), and Niaqunnaq East (lower right) deployment locations. Upper right: Map of annual deployment locations at Niaqunnaq MPA where salinity data was collected, included for spatial reference against salinity tile plots at left and below. Refer to Table 1 for a summary of deployments used to produce this graphic.

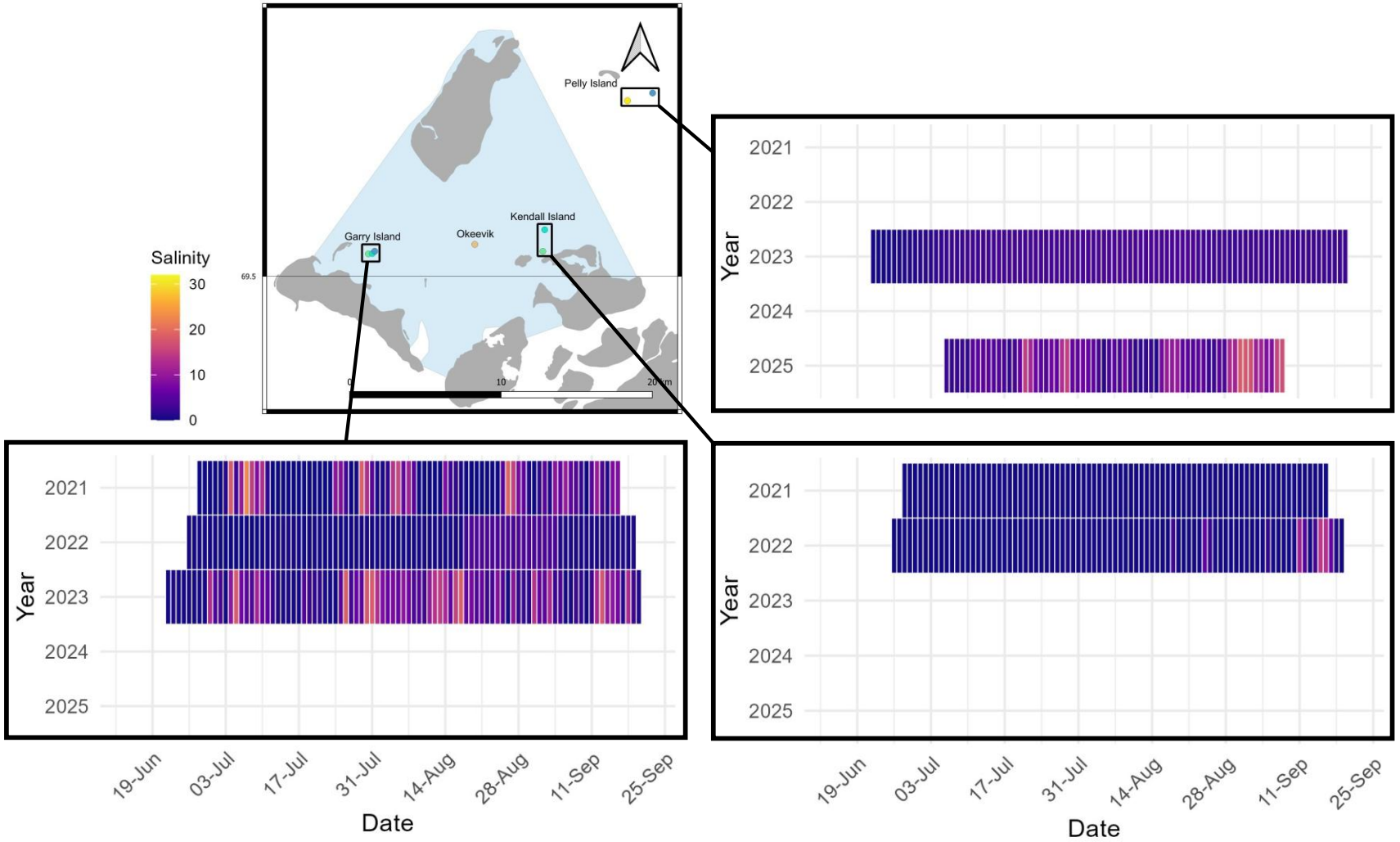


Figure 19. Multi-year comparison of average daily salinity (PSU) measurements collected across Okeevik MPA from 2021-2025. Upper left: Map of annual deployment locations at Okeevik MPA where salinity data was collected, included for spatial reference against salinity tile plots at right. Right and below are salinity tile plots for: Pelly Island (upper right), Kendall Island (lower right), and Garry Island (lower left) deployment locations. Refer to Table 1 for a summary of deployments used to produce this graphic.

3.1.4 Turbidity

Okeevik MPA generally reported more turbid conditions throughout the season compared to Kittigaryuit and Niaqunnaq (Table 7, Figure 20). Turbidity measurements at Niaqunnaq MPA were fairly consistent over the season, with some increase in early to mid-July and to a lesser degree in early to mid-September. Turbidity between and within deployment locations was variable, though most locations experienced their most turbid conditions between the second and fourth weeks of July with a couple exceptions later in August (Table 7).

Within Kittigaryuit MPA we collected turbidity data across four non-consecutive deployment seasons at three locations (Table 7). Turbidity was highly variable among locations, however the Mid Kugmallit site yielded the highest turbidity measurements (2017 average ± SD: 390.8 ± 396.9 NTU, range: 0.0 – 1866.6; Table 7). East Whitefish yielded the lowest turbidity measurements with an interannual average (± SD) of 74.4 ± 4.9 NTU (range: 0.0 – 687.4 NTU; Table 7). The highest turbidity measurements were detected between the second and fourth weeks in July. Atkinson Point east of Kittigaryuit MPA yielded lower turbidity measurements than Mid Kugmallit, but higher than East Whitefish (Table 7).

Deployments within Niaqunnaq MPA reported less turbid conditions compared to Okeevik (Table 7, Figure 20). Turbidity within Niaqunnaq was generally highest in early to mid-July, but otherwise remained relatively consistent over the season (Figure 20). The Shingle Point Ocean deployment location yielded the highest turbidity measurements (interannual average ± SD: 171.4 ± 64.3 NTU, range: 0.5 – 1511.7; Table 7). The Shingle Point Bay deployment location yielded the lowest turbidity measurements (interannual average ± SD: 27.8 ± 7.3 NTU, range: 0.0 – 562.7; Table 7). Most locations yielded their highest turbidity measurements between the first and final weeks of July, with the exception of Niaqunnaq Mid which produced its highest measurement 23 August 2023 (Table 7).

Deployments within Okeevik MPA generally reported more turbid conditions compared to the rest of the TN MPA (Table 7, Figure 20). The Garry Island deployment yielded the highest turbidity measurements (2021 average ± SD: 411.1 ± 252.1 NTU, range: 51.5 – 1429.7; Table 7). The Kendall Island deployment location was the only location with a multi-year dataset and yielded an interannual average (± SD) of 169.0 ± 101.7 NTU (range: 0.5 – 1078.0 NTU; Table 7). In general, deployment locations located farther west (e.g., Garry Island) tended to be more turbid whereas those farther east (e.g., Pelly Island) tended to be less turbid. All locations yielded their highest turbidity measurements between the first and final weeks of July (Table 7).

Table 7. Summary of seabed turbidity (NTU) as recorded just above the seafloor across the TN MPA from 2015-2025. Shown are weighted interannual average (± standard deviation), minimum, and maximum hourly values recorded at each location; and the date where highest turbidity measurement was recorded. Refer to Table 1 for a summary of annual deployment locations and Appendix D for annual summary statistics for each deployment location.

			Turbidity (NTU)			
MPA Parcel	**Location**	**Year Range**	**Weighted Interannual Avg (± SD)**	**Min**	**Max**	**Date with Maximum**
Kittigaryuit	Channel	-	-	-	-	-
	East Hendrickson	-	-	-	-	-
	East Whitefish	2022, 2024-2025[a]	74.37 ± 4.93	0.05	687.39	2024-Jul-27
	Mid Kugmallit	2017	390.77	0.00	1866.61	2017-Jul-19
	Mid Kugmallit B	-	-	-	-	-
	West Hendrickson	2025	216.55	5.61	1116.77	2025-Jul-11
Kugmallit Bay	Atkinson Point	2022	339.10	10.73	858.10	2022-Aug-19
Niaqunnaq	Escape Reef	-	-	-	-	-
	Shingle Point Bay	2019-2020	27.78 ± 7.28	0.00	562.65	2020-Jul-04
	Shingle Point Ocean	2019-2021	171.40 ± 64.28	0.45	1511.74	2020-Jul-10
	Niaqunnaq	-	-	-	-	-
	Niaqunnaq East	2021-2023	128.35 ± 64.02	0.34	962.10	2022-Jul-29
	Niaqunnaq Mid	2023	132.19	10.33	867.10	2023-Aug-23
	Niaqunnaq North	-	-	-	-	-
	Niaqunnaq West	-	-	-	-	-
Okeevik	Okeevik	2024	228.27	9.52	1237.12	2024-Jul-07
	Pelly Island	2023	186.36	0.00	1137.45	2023-Jul-14
	Garry Island	2021	411.05	51.53	1429.67	2021-Jul-11
	Kendall Island	2021-2022	169.01 ± 101.66	0.46	1077.97	2022-Jul-28

[a] In 2025, turbidity measurements were only collected from June 29 to July 4 at the East Whitefish deployment.

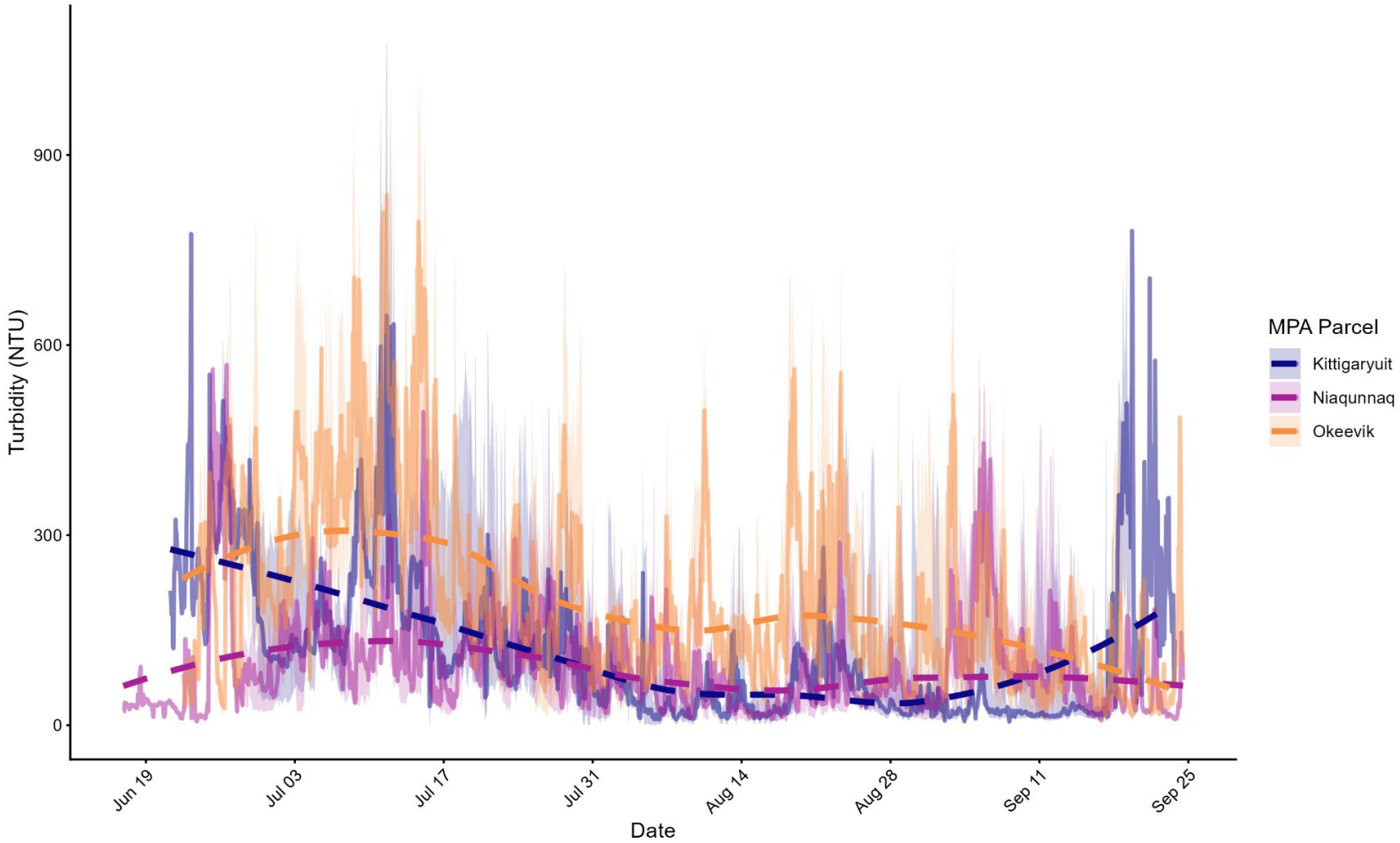


Figure 20. Seasonal trends in seabed turbidity (NTUs) across sites and years within the TN MPA from 2015-2025. Measurements span 2015-2025 in Kittigaryuit, 2019-2025 in Niaqunnaq, and 2021-2025 in Okeevik. Solid lines represent the median value of hourly averages calculated across sites followed by years within each MPA. Shaded areas represent the interquartile range around each median value. Dashed lines represent smoothed LOESS lines to highlight overarching trends for each MPA parcel. Refer to Table 1 for a summary of deployments used to produce this graphic.

3.2 WAVE CONDITIONS

3.2.1 Wave height and direction of origin

Wave heights were generally higher within Niaqunnaq MPA compared to Okeevik and Kittigaryuit (Table 8). All three parcels displayed periodic spikes in wave heights over the season, presumably during storm or high wind events within the vicinity, with Niaqunnaq experiencing the highest average and greatest range of wave heights (Table 8, Figures 21 to 26). All three parcels show distinct patterns in direction of origin for waves, presumably influenced in part by local land masses and predominant wind direction (Figures 22, 24, and 26). These patterns persist between July and August, with Okeevik MPA exhibiting the most visible shift in direction of origin between July and August (Figure 26). Atkinson Point just east of Kittigaryuit MPA reported the highest average wave height compared to the rest of TN MPA (interannual average ± SD: 0.44 ± 0.01 m) though not the highest maximum wave height (1.86 m on 11 August 2022, compared to 3.76 m on 3 September 2024 at Niaqunnaq East). The timing of maximum documented wave heights varied within MPA parcels, ranging from the first week of July through to the first week of September (Table 8).

Kittigaryuit MPA generally experienced lower wave heights compared to the rest of TN MPA (Table 8, Figures 21 and 22). The highest average wave height within Kittigaryuit MPA was recorded at Mid Kugmallit, where the interannual average (± SD) was 0.24 ± 0.01 m with a range of 0.02 – 0.85 m (Table 8). Average wave height was lowest at the West Hendrickson deployment location, where the interannual average (± SD) was 0.22 ± 0.01 m (range: 0.01 – 0.69 m). The lowest minimum wave height documented within Kittigaryuit MPA was recorded at West Hendrickson at 0.01 m on 11 July 2020 and the highest maximum was at East Whitefish at 1.13 m on 27 July 2024 (Table 8). The dominant direction of origin of waves within Kittigaryuit MPA was northeast, roughly between the eastern side of Hendrickson Island the opening of Kugmallit Bay into the Beaufort Sea (Table 8, Figure 22). Waves originating from the northwest direction were higher on average compared to other directions (Figure 22).

We recorded higher average wave heights at Niaqunnaq MPA compared to the rest of TN MPA (Table 8, Figures 23 and 24). The highest average wave height was documented at the Shingle Point Ocean deployment location (interannual average ± SD: 0.43 ± 0.03 m, range: 0.03 – 1.77 m; Table 8). Average wave height was lowest at Shingle Point Bay (2020 average was 0.09 ± 0.05 m), a location that is sheltered from prevailing winds by the Shingle Point spit. Of the deployment locations with multi-year datasets, Niaqunnaq East and West had the same interannual average (± SD) wave heights at 0.33 ± 0.20 m and 0.33 ± 0.03 m respectively (Table 8). The lowest minimum wave height documented within Niaqunnaq MPA was recorded at Shingle Point Bay at 0.01 m on 24 August 2020 and the highest maximum was recorded at Niaqunnaq East on 3 September 2024 at 3.76 m (Table 8). The

dominant direction of origin of waves within Niaqunnaq MPA was northwest, the direction where Shallow Bay opens up into the Beaufort Sea (Figure 24). Waves originating from the south were higher on average compared to other directions; however, relatively few waves were documented from this direction (Figure 24).

Average wave height varied temporally and spatially across Okeevik MPA (Table 8, Figures 25 and 26). The highest average (± SD) wave height was documented at the Pelly Island deployment location, where the interannual average was 0.31 ± 0.03 m (range of 0.04 – 1.15 m; Table 8). Among the deployment locations with multi-year datasets, Garry Island had average (± SD) wave heights of 0.23 ± 0.01 m (range of 0.04 – 0.63 m). Average wave height was lowest at the Kendall Island location, where the interannual average (± SD) was 0.19 ± 0.01 m. The lowest minimum wave height documented within Okeevik MPA was recorded at the Okeevik and Kendall Island sites at 0.03 m on 9 July 2024 and 20 August 2021, respectively. The highest maximum was 1.15 m at Pelly Island on 29 August 2025 (Table 8). There were two dominant directions of origin for waves within Okeevik MPA, northwest between Pelly and Garry Islands, and east-north-east between Pelly and Kendall Islands (Figure 26). East-north-east direction was less dominant in August compared to July. In August, waves originating from the south were higher on average compared to other directions; however, this pattern was less apparent in July (Figure 26).

Table 8. Summary of wave height and direction of origin across the TN MPA from 2020-2025. Tabulated are weighted interannual average (± standard deviation), minimum, maximum, and the date with the maximum value for wave height; and the interannual average (± standard deviation) for the wave direction of origin. Refer to Table 1 for a summary of annual deployment locations and to Appendix E for annual summary statistics for each deployment location.

			Wave Height (m)				Wave Direction of Origin (degrees)
MPA Parcel	**Location**	**Year Range**	**Weighted Interannual Avg (± SD)**	**Min**	**Max**	**Date with Maximum**	**Weighted Interannual Avg (± SD)**
Kittigaryuit	Channel	-	-	-	-	-	-
	East Hendrickson	-	-	-	-	-	-
	East Whitefish	2020-2025	0.23 ± 0.02	0.02	1.13	2024-Jul-27	131.39 ± 19.97
	Mid Kugmallit	2020-2023	0.24 ± 0.01	0.02	0.85	2022-Aug-18	126.86 ± 13.87
	Mid Kugmallit B	-	-	-	-	-	-
	West Hendrickson	2020-2025	0.22 ± 0.01	0.01	0.69	2024-Jul-27	115.35 ± 17.43
Kugmallit Bay	Atkinson Point	2022-2023	0.44 ± 0.01	0.05	1.86	2022-Aug-11	124.43 ± 13.45
Niaqunnaq	Escape Reef	2023	0.38	0.07	1.25	2023-Sep-02	219.69
	Shingle Point Bay	2020	0.10	0.01	0.33	2020-Jul-03	164.05
	Shingle Point Ocean	2020-2022	0.43 ± 0.03	0.03	1.77	2022-Sep-04	218.13 ± 13.60
	Niaqunnaq	2020	0.22	0.03	0.58	2020-Jul-04	218.42
	Niaqunnaq East	2021-2025	0.33 ± 0.20	0.02	3.76	2024-Sep-03	220.72 ± 14.25
	Niaqunnaq Mid	2023	0.25	0.04	0.73	2023-Jul-09	210.63
	Niaqunnaq North	2021-2022	0.32 ± 0.07	0.04	1.13	2021-Sep-06	226.44 ± 6.54
	Niaqunnaq West	2021-2025	0.33 ± 0.03	0.03	1.78	2025-Aug-24	231.88 ± 5.11
Okeevik	Okeevik	2024	0.27	0.03	1.11	2024-Aug-20	201.26
	Pelly Island	2023, 2025	0.31 ± 0.03	0.04	1.15	2025-Aug-29	136.24 ± 3.27
	Garry Island	2021-2023	0.23 ± 0.01	0.04	0.63	2022-Jul-14	186.10 ± 9.26
	Kendall Island	2021-2022	0.19 ± 0.01	0.03	0.68	2022-Aug-18	166.01 ± 6.82

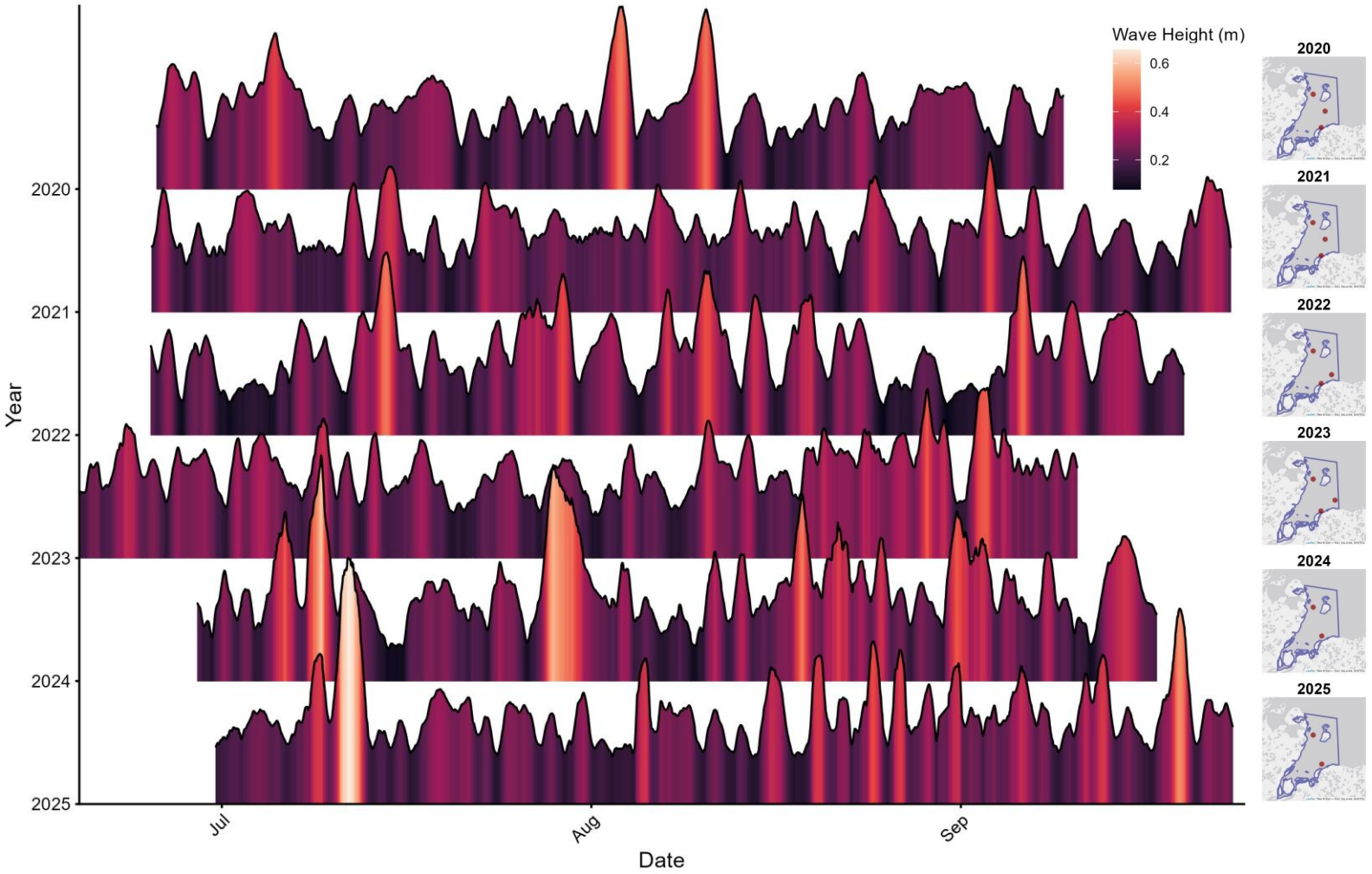


Figure 21. Left: seasonal and annual variation in wave height (m) across deployment locations at Kittigaryuit MPA from 2020-2025. For each deployment year, average hourly wave height was calculated across deployment location(s) and is displayed as a 24-hour rolling average. Right: annual maps of deployment locations within Kittigaryuit MPA that contributed data to the summary on the left. Refer to Table 1 for a summary of deployments used to produce this graphic.

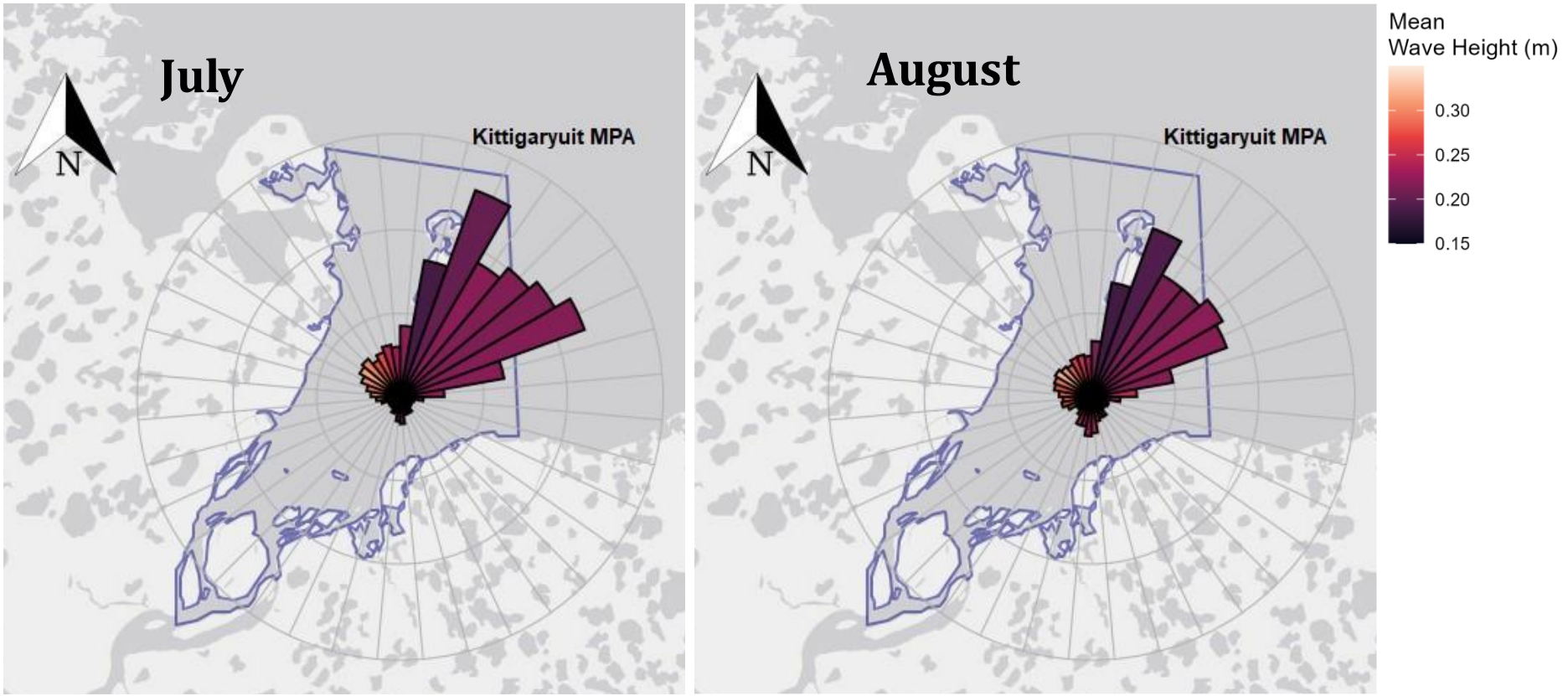


Figure 22. Polar plots summarizing direction of wave origin and wave height (m) at Kittigaryuit MPA during July (left) and August (right) from 2020-2025. Direction of bars on polar plot indicates direction of wave origin, relative length of bar is the frequency of that direction of origin, and colouration is the average mean height (m) of waves from the indicated direction of origin. Wave height was averaged across sites and years. Refer to Table 1 for a summary of deployment locations.

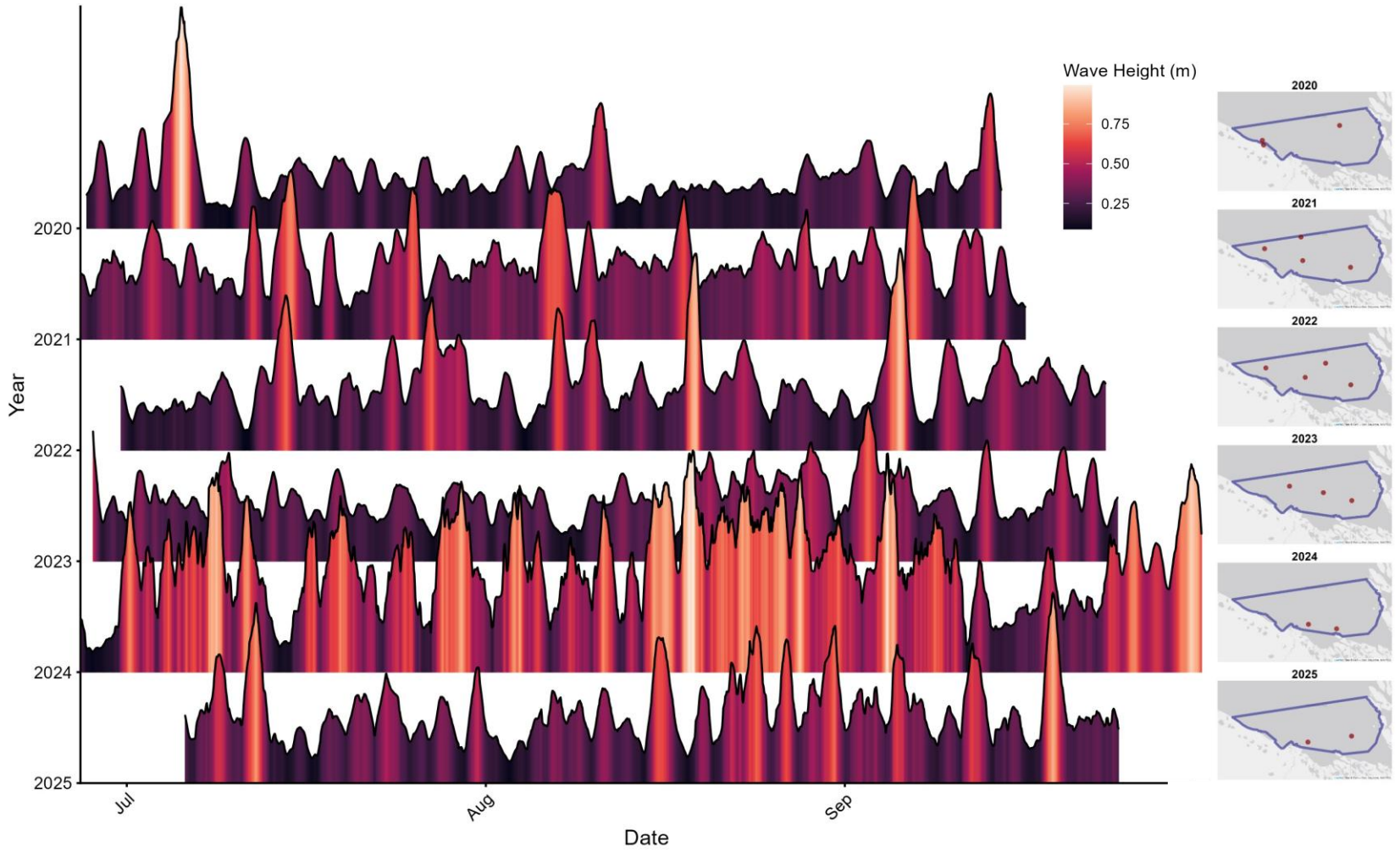


Figure 23. Left: seasonal and annual variation in wave height (m) across deployment locations at Niaqunnaq MPA from 2020-2025. For each deployment year, average hourly wave height was calculated across deployment location(s) and is displayed as a 24-hour rolling average. Right: annual maps of deployment locations within Niaqunnaq MPA that contributed data to the summary on the left. Refer to Table 1 for a summary of deployments used to produce this graphic.

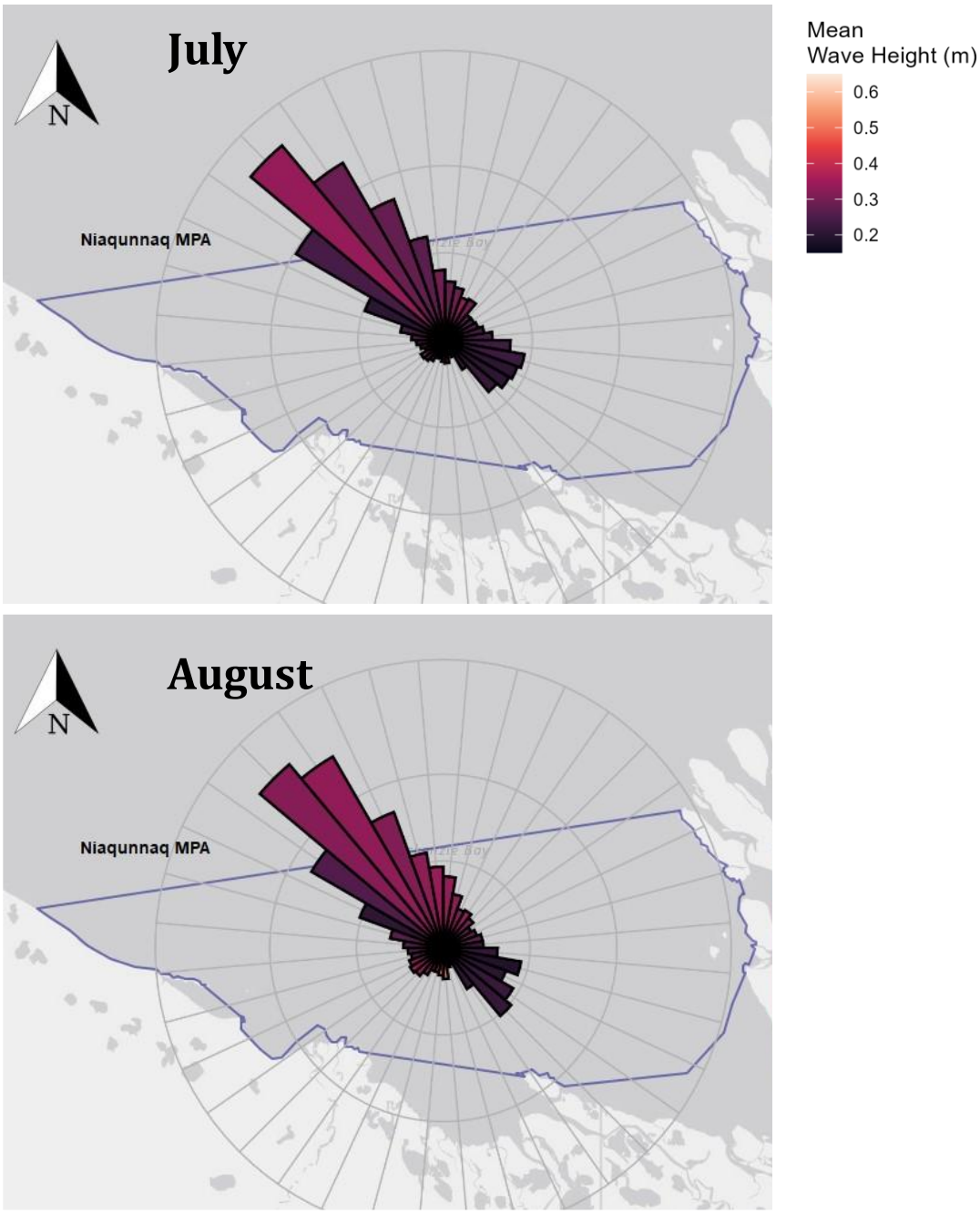


Figure 24. Polar plots summarizing direction of wave origin and wave height (m) at Niaqunnaq MPA during July (above) and August (below) from 2020-2025. Direction of bars on polar plot indicates direction of wave origin, relative length of bar is the frequency of that direction of origin, and colouration is the average mean height (m) of waves from the indicated direction of origin. Wave height was averaged across sites and years. Refer to Table 1 for a summary of deployment locations.

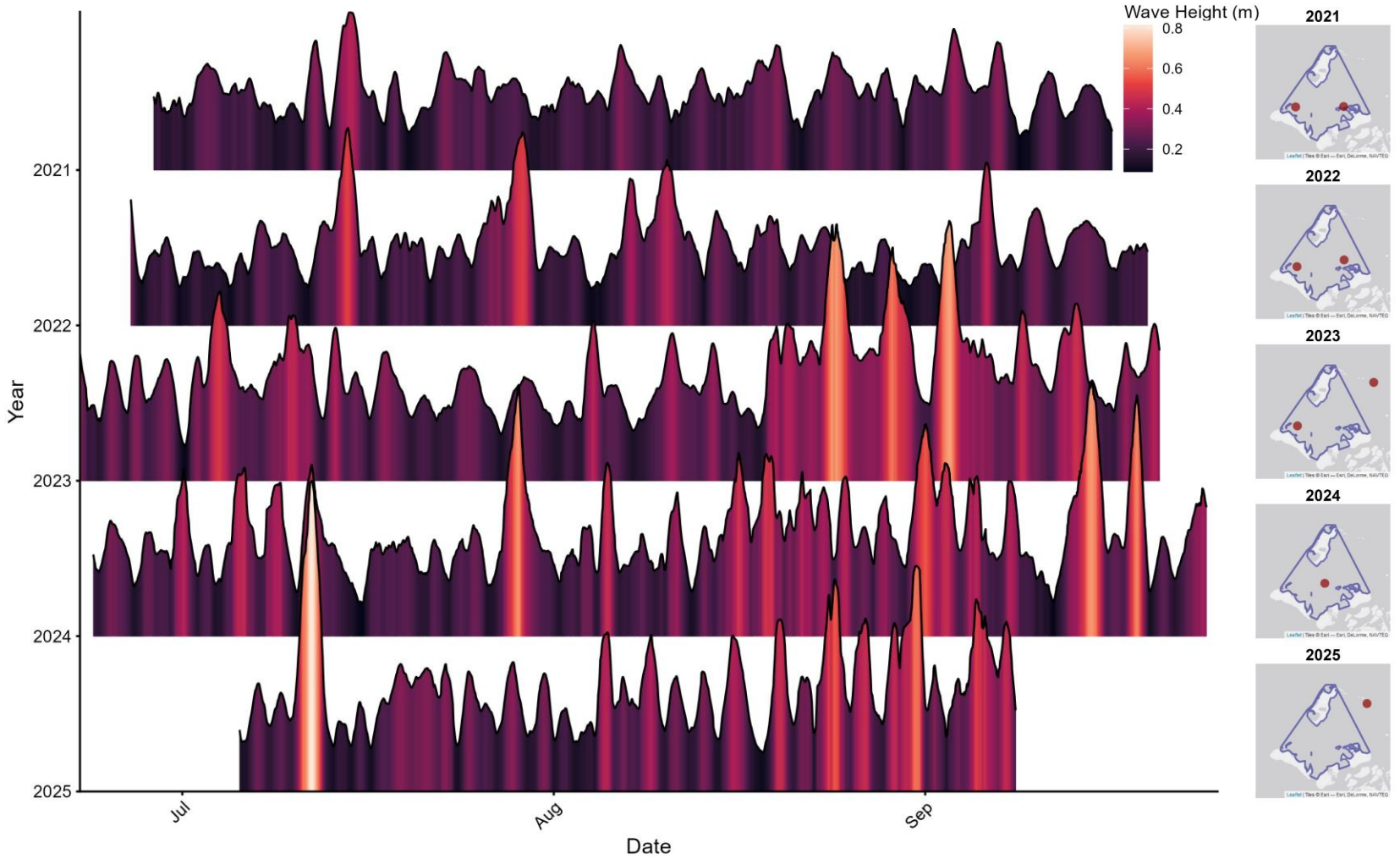


Figure 25. Left: seasonal and annual variation in wave height (m) across deployment locations at Okeevik MPA from 2021-2025. For each deployment year, average hourly wave height was calculated across deployment location(s) and is displayed as a 24-hour rolling average. Right: annual maps of deployment locations within Okeevik MPA that contributed data to the summary on the left. Refer to Table 1 for a summary of deployments used to produce this graphic.

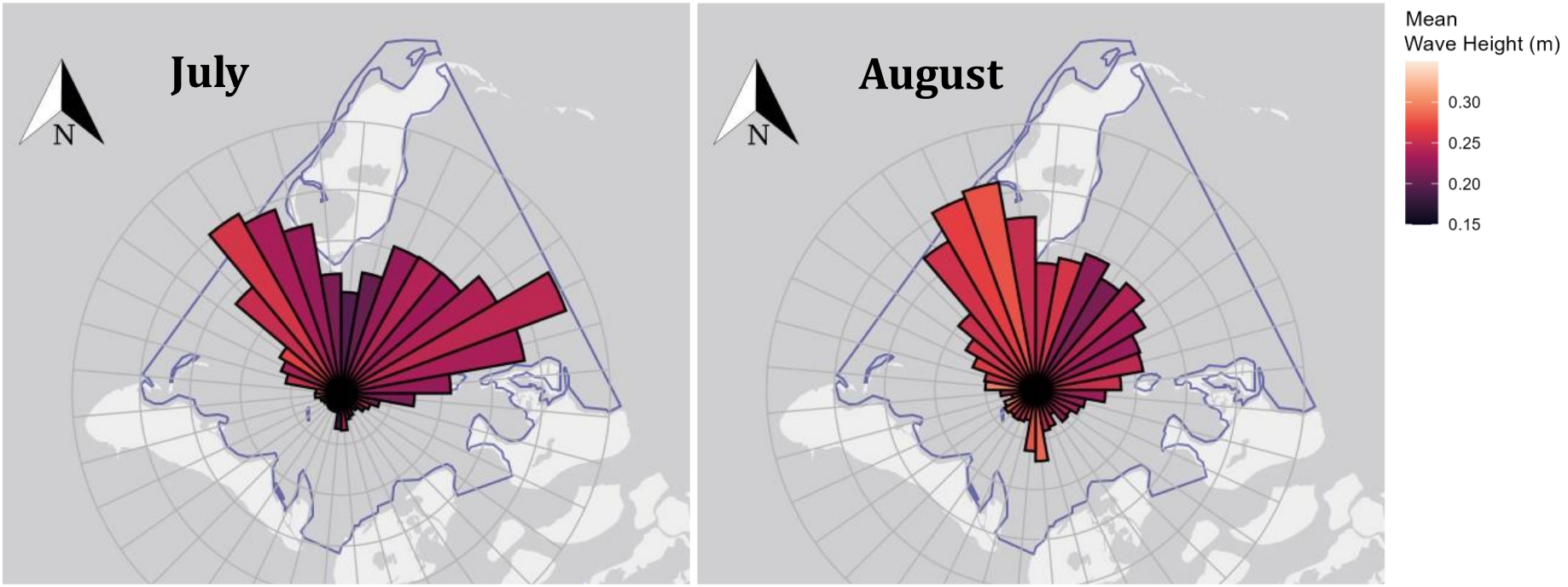


Figure 26. Polar plots summarizing direction of wave origin and wave height (m) at Okeevik MPA during July (left) and August (right) from 2021-2025. Direction of bars on polar plot indicates direction of wave origin, relative length of bar is the frequency of that direction of origin, and colouration is the average mean height (m) of waves from the indicated direction of origin. Wave height was averaged across sites and years. Refer to Table 1 for a summary of deployment locations.

3.2.2 Wave period

Wave regimes dominated by wind-driven waves tend to have smaller peak periods, while large peak periods tend to indicate wave regimes dominated by ocean swell. Mean and peak wave periods were generally shorter within Kittigaryuit MPA compared to Okeevik and Niaqunnaq (Table 9, Figures 27 to 29). Mean wave period was longest in Niaqunnaq MPA compared to the other parcels, whereas peak wave period was longest in Okeevik MPA. Atkinson Point just east of Kittigaryuit MPA reported longer average mean period (interannual average ± SD: 3.7 ± 0.1 s, range: 1.9 – 10.5 s) but comparable peak period (interannual average ± SD: 7.9 ± 1.1 s, range: 1.4 – 29.9 s) to deployment locations within Kittigaryuit MPA (Table 9).

Kittigaryuit MPA generally experienced shorter average mean and peak wave periods compared to the rest of TN MPA (Table 9, Figures 27 to 29). The longest average mean and peak periods were documented at the East Whitefish deployment location, where the interannual averages (± SD) were 2.7 ± 0.1 s and 9.0 ± 0.7 s respectively (Table 9). The shortest average mean and peak periods were documented at the Mid Kugmallit deployment location, where the interannual average (± SD) was 2.3 ± 0.1 s and 6.0 ± 0.8 s, respectively (Table 9). The longest maximum mean period was documented at East Whitefish at 8.2 s on 29 August 2024. The longest maximum peak period was documented at 34.1 s on 23 September 2025 at both East Whitefish and on multiple dates at West Hendrickson (Table 9). The shortest minimum mean and peak periods were documented at Mid Kugmallit at 1.6 s on 30 June 2022 and 1.3 s on 28 July 2020, respectively (Table 9).

Niaqunnaq MPA generally experienced longer average mean wave periods compared to the rest of TN MPA (Table 9, Figures 27 to 29). The longest average mean and peak periods were documented at Shingle Point Bay, where the 2020 averages (± SD) were 3.9 ± 1.9 s and 17.5 ± 8.1 s, respectively (Table 9). Of the locations with multi-year datasets, the longest average mean and peak periods were documented at the Niaqunnaq East deployment location, where the interannual averages (± SD) were 3.3 ± 2.1 s and 9.6 ± 5.3 s respectively. The shortest average mean period was documented at the Niaqunnaq deployment location, where the 2020 average (± SD) was 2.3 ± 0.3 s (Table 9). Of the locations with multi-year datasets, the shortest average mean period was documented at Niaqunnaq North with an interannual average (± SD) of 2.6 ± 0.3 s. The shortest average peak period was documented at the Escape Reef deployment location, where the 2023 average (± SD) was 4.5 ± 2.8 s (Table 9). Of the locations with multi-year datasets, the shortest average peak period was documented at Niaqunnaq North with an interannual average (± SD) of 2.6 ± 0.3 s. The longest maximum mean period was documented at Niaqunnaq East at 19.4 s on 6 August 2024 and the peak period was at Shingle Point Bay, Niaqunnaq East, and Niaqunnaq West at 34.1 s, each on multiple dates(Table 9). The shortest minimum mean period was

documented at Niaqunnaq Mid at 1.6 s on 16 August 2023 and the peak period was at Shingle Point Bay at 1.3 s on 23 July 2020 (Table 9).

Okeevik MPA generally experienced longer average peak wave periods compared to the rest of TN MPA (Table 9, Figures 27 to 29). The longest average mean period was documented at the Pelly Island deployment location, where the interannual average (± SD) was 2.8 ± 0.1 s (Table 9). The shortest average mean period was documented at Kendall Island location with an interannual average (± SD) of 2.2 ± 0.0 s. The longest average peak period was documented at the Garry Island deployment location, where the interannual average (± SD) was 9.5 ± 2.1 s (Table 9). The shortest average peak period was documented at the Pelly Island deployment location, where the interannual average (± SD) was 7.6 ± 1.8 s (Table 9). The longest maximum mean period was documented at the Okeevik deployment location at 9.3 s on 4 July 2024. The longest maximum peak period was documented at the Okeevik, Garry Island, and Kendall Island deployment locations at 34.1 s on 10 September 2024, 14 July 2023, and 8 July 2021, respectively (Table 9). The shortest minimum mean period was documented at Pelly Island at 1.5 s on 27 June 2023 and the peak period was at Kendall Island at 1.3 s on 4 August 2022 (Table 9).

Table 9. Summary of mean period and peak period of waves in the TN MPA from 2020-2025. Shown are weighted interannual average (± standard deviation), minimum, maximum values for both mean and peak period. Refer to Table 1 for a summary of annual deployment locations and Appendix F for annual summary statistics for each deployment location.

			Mean Period (seconds)			Peak Period (seconds)		
MPA Parcel	**Location**	**Year Range**	**Weighted Interannual Avg (± SD)**	**Min**	**Max**	**Weighted Interannual Avg (± SD)**	**Min**	**Max**
Kittigaryuit	Channel	-	-	-	-	-	-	-
	East Hendrickson	-	-	-	-	-	-	-
	East Whitefish	2020-2025	2.65 ± 0.07	1.68	8.24	9.00 ± 0.66	1.29	34.12
	Mid Kugmallit	2020-2023	2.28 ± 0.10	1.63	5.59	6.03 ± 0.77	1.27	29.86
	Mid Kugmallit B	-	-	-	-	-	-	-
	West Hendrickson	2020-2025	2.35 ± 0.10	1.65	5.75	7.54 ± 1.50	1.30	34.12
Kugmallit Bay	Atkinson Point	2022-2023	3.66 ± 0.10	1.85	10.45	7.94 ± 1.08	1.38	29.86
Niaqunnaq	Escape Reef	2023	2.88	1.74	5.97	4.53	1.47	17.06
	Shingle Point Bay	2020	3.89	1.60	11.25	17.46	1.29	34.12
	Shingle Point Ocean	2020-2022	3.09 ± 0.08	1.56	7.13	5.75 ± 0.81	1.33	29.86
	Niaqunnaq	2020	2.25	1.80	3.71	6.95	1.51	29.86
	Niaqunnaq East	2021-2025	3.28 ± 2.13	1.57	19.41	9.59 ± 5.25	1.32	34.14
	Niaqunnaq Mid	2023	2.27	1.55	4.09	5.25	1.46	29.86
	Niaqunnaq North	2021-2022	2.55 ± 0.26	1.61	5.62	5.29 ± 0.33	1.43	29.86
	Niaqunnaq West	2021-2025	2.92 ± 0.48	1.58	13.92	8.23 ± 2.29	1.44	34.14
Okeevik	Okeevik	2024	2.76	1.78	9.33	8.98	1.39	34.14
	Pelly Island	2023, 2025	2.83 ± 0.08	1.52	8.32	7.59 ± 1.82	1.37	29.87
	Garry Island	2021-2023	2.53 ± 0.08	1.62	5.65	9.51 ± 2.10	1.28	34.12
	Kendall Island	2021-2022	2.19 ± 0.04	1.58	5.13	7.63 ± 0.24	1.26	34.12

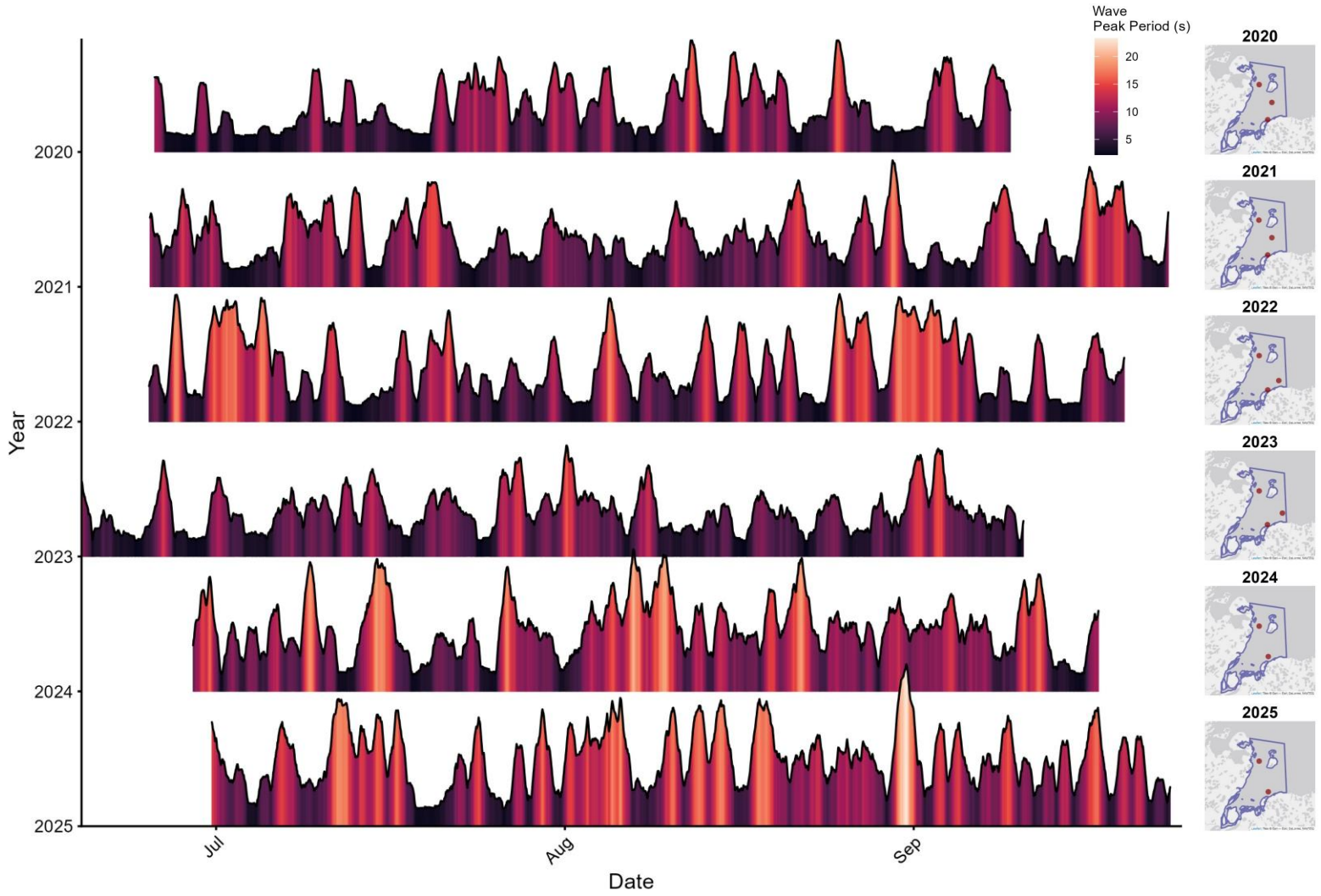


Figure 27. Left: seasonal and annual variation in wave peak period (s) across deployment locations at Kittigaryuit MPA from 2020-2025. For each deployment year, average hourly wave peak period was calculated across deployment location(s) and is displayed as a 24-hour rolling average. Right: annual maps of deployment locations within Kittigaryuit MPA that contributed data to the summary on the left. Refer to Table 1 for a summary of deployments used to produce this graphic.

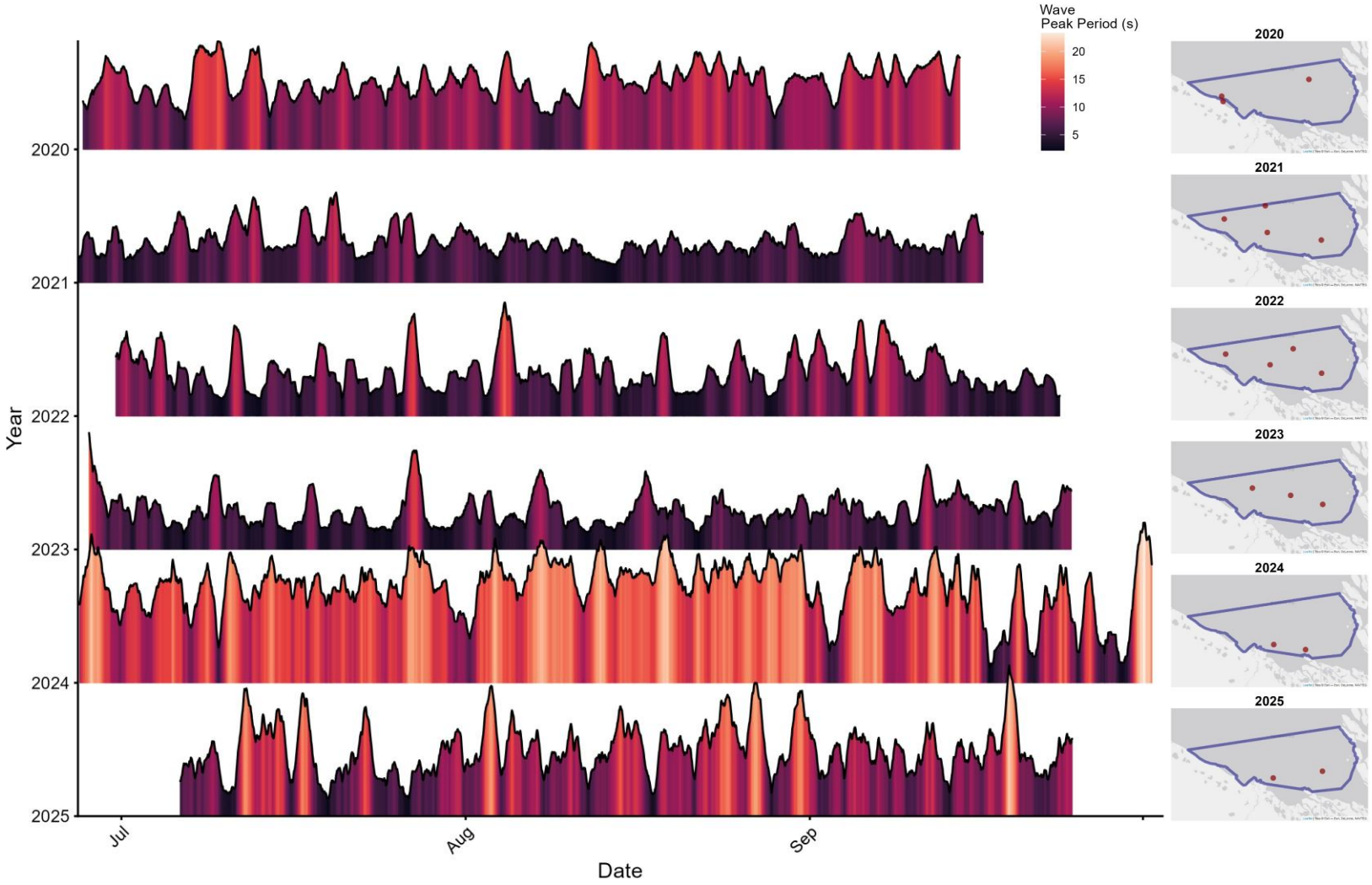


Figure 28. Left: seasonal and annual variation in wave peak period (s) across deployment locations at Niaqunnaq MPA from 2020-2025. For each deployment year, average hourly wave peak period was calculated across deployment location(s) and is displayed as a 24-hour rolling average. Right: annual maps of deployment locations within Niaqunnaq MPA that contributed data to the summary on the left. Refer to Table 1 for a summary of deployments used to produce this graphic.

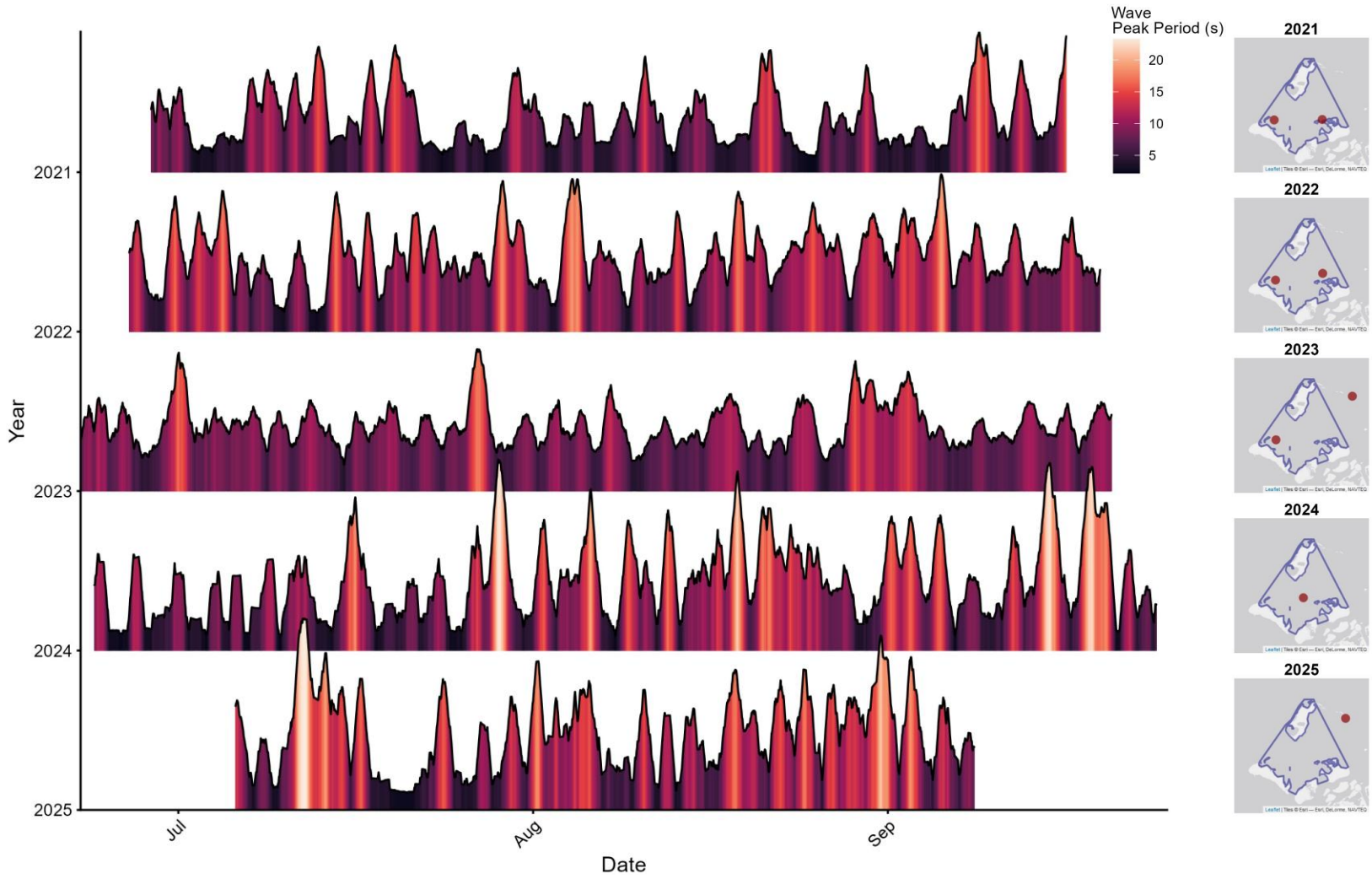


Figure 29. Left: seasonal and annual variation in wave peak period (s) across deployment locations at Okeevik MPA from 2021-2025. For each deployment year, average hourly wave peak period was calculated across deployment location(s) and is displayed as a 24-hour rolling average. Right: annual maps of deployment locations within Okeevik MPA that contributed data to the summary on the left. Refer to Table 1 for a summary of deployments used to produce this graphic.

3.3 FRESHWATER

3.3.1 Water level

We examined the timing of elevated spring water levels in several ways: 1) the high-flow period, the start of which was defined as when water level ≥ the 90th percentile of seasonal values and the end date where the level first fell below this threshold; 2) centre of timing (CT), the date representing the midpoint of seasonal elevated water levels; and 3) date of highest water level, the day of the year with the highest observed value of a three-day rolling average. Additionally, we counted the number of high-water days over the course of a season, where a high-water day was defined as any day between May and September where water level was ≥ the 90th percentile of seasonal values. In some instances, a few days to a couple of weeks in May and/or June were missing observations, potentially affecting the determination of the end date of the high-flow period and CT timing.

Water levels at ECCC monitoring stations upstream (10LC002 and 10MC008) generally reported peak flows earlier in the season compared to downstream stations (Table 10, Figure 30). Peak timing among channels was fairly similar, with the start of the peak flow beginning in the third week of May, maximum flows in the fourth, and peak flow ending in the last days of May or first week of June (Table 10). Locations further upstream generally experienced more high-water days, and those days tended to be more concentrated during the early spring, compared to downstream (Table 10, Figures 31-32). The number of high-water days and CT both tended to be more variable at downstream locations, particularly at 10LC013 and10LC019 (Table 10, Figures 31-32). The high-flow period and date of highest flow tended to occur later in the spring in recent years compared to earlier in the study period (Table 10, Figures 33-34).

ECCC monitoring stations upstream (10LC002 and 10MC008) experienced higher average, median, and maximum water levels compared to downstream stations (Table 10 and Figure 30). Over the study period, most stations reported higher than average water levels from 2020-2022 and lower than average water levels on either side of this period (Figure 35). 10LC013, located within the East Channel and close to Kugmallit Bay, reported relatively consistent water levels year-to-year compared to 10LC002, located near Inuvik (Figures 31, 33, and 35). 10MC008, located within the Middle Channel and west of Inuvik, reported similar annual variation to 10LC002, located farther east in the East Channel (Figures 31, 32, and 35). Downstream in Middle Channel, 10MC023 (located close to Shallow Bay) showed a more muted version of 10MC008 while 10LC019 (located in Kumak Channel south of Okeevik MPA) often showed dramatic annual variation (Figures 32, 34, and 35).

Table 10. Summary of peak timing and water level (m) at Environment and Climate Change Canada (ECCC) monitoring stations located on the East and Middle Channels of the Mackenzie River. Peak timing is summarized with the start and end dates of the peak period, date of three-day maximum water level, and centre of timing, all shown as days (d) ± standard deviation. Water level is summarized as number of high-water days, weighted interannual average (± standard deviation), interannual median (± standard deviation), and maximum values for water level. Refer to Table 2 for a summary of ECCC monitoring station locations and Appendix G for annual summary statistics for each location.

			Peak Timing				Water Level (m)			
Channel	**ECCC Station**	**Year Range**	**Start Date of Peak Period (± SD)**	**Date of 3-Day Max (± SD)**	**End Date of Peak Period (± SD)**	**Centre of Timing (± SD)**	**Number of High-water Days (d ± SD)**	**Weighted Interannual Avg (± SD)**	**Weighted Interannual Median (± SD)**	**Max**
East	10LC002	2015-2024	18-May ± 3.9 d	25-May ± 3.8 d	3-Jun ± 3.9 d	14-Jul ± 0.8 d	15.9 ± 0.3	12.5 ± 0.5	12.3 ± 0.5	15.4
	10LC013	2015-2017, 2019, 2021-2023, 2025	19-May ± 5.2 d	29-May ± 4.6 d	31-May ± 7.0 d	16-Jul ± 8.7 d	14.1 ± 2.5	10.0 ± 0.1	9.9 ± 0.1	11.3
Middle	10MC008	2016, 2021-2025	17-May ± 4.9 d	26-May ± 5.6 d	31-May ± 24.8 d	15-Jul ± 1.8 d	15.2 ± 1.0	12.2 ± 0.6	11.9 ± 0.5	15.4
	10MC023	2015-2025	21-May ± 3.6 d	28-May ± 4.2 d	4-Jun ± 5.9 d	14-Jul ± 1.0 d	15.5 ± 1.8	11.5 ± 0.2	11.3 ± 0.3	13.3
	10LC019	2016, 2019, 2021-2022, 2024-2025	22-May ± 5.7 d	29-May ± 4.9 d	6-Jun ± 20.3 d	7-Jul ± 18.1 d	11.5 ± 3.4	10.2 ± 0.2	10.1 ± 0.2	11.1

Definitions:

Start Date of Peak: First date in the season where water level was ≥ the 90th percentile of seasonal values.
End Date of Peak: First date after the Date of Onset where water level was < the 90th percentile of seasonal values.
Centre of Timing: "Centre of mass", the date representing the midpoint of seasonal elevated water levels.
High-water Days: Days where water level was ≥ the 90th percentile of seasonal values.

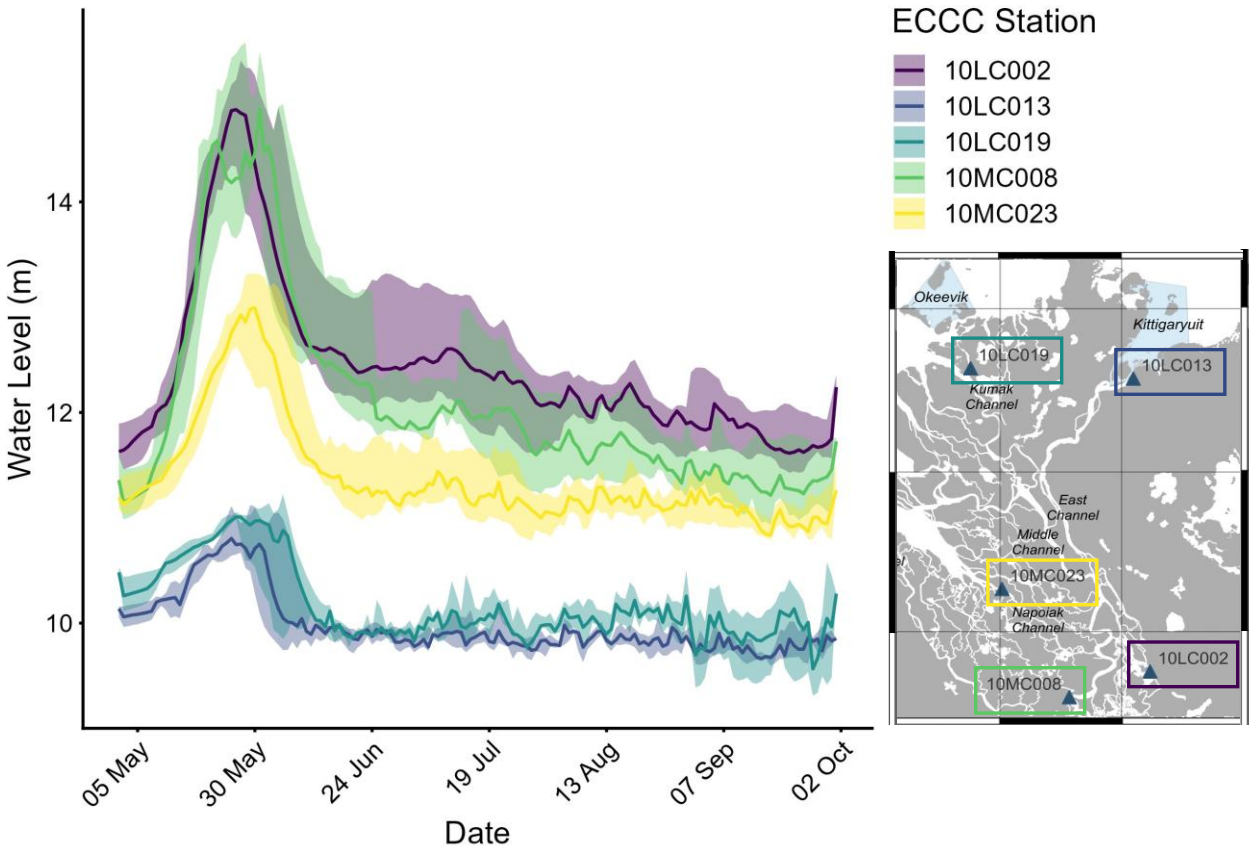


Figure 30. Water level (m) recorded at Environment and Climate Change Canada (ECCC) stations across the Mackenzie Delta between 2015 and 2025. Two stations are located in the East Channel: 10LC002 upstream near Inuvik and 10LC013 downstream near Kugmallit Bay. Three stations are located in the Middle Channel: 10MC008 upstream between Aklavik and Inuvik, 10MC023 downstream near Shallow Bay, and 10LC019 downstream near Okeevik MPA. Solid lines represent the median value of daily averages calculated across years recorded at each ECCC station. Shaded areas represent the interquartile range around each median value. Refer to Table 2 for a summary of ECCC stations used to produce this graphic.

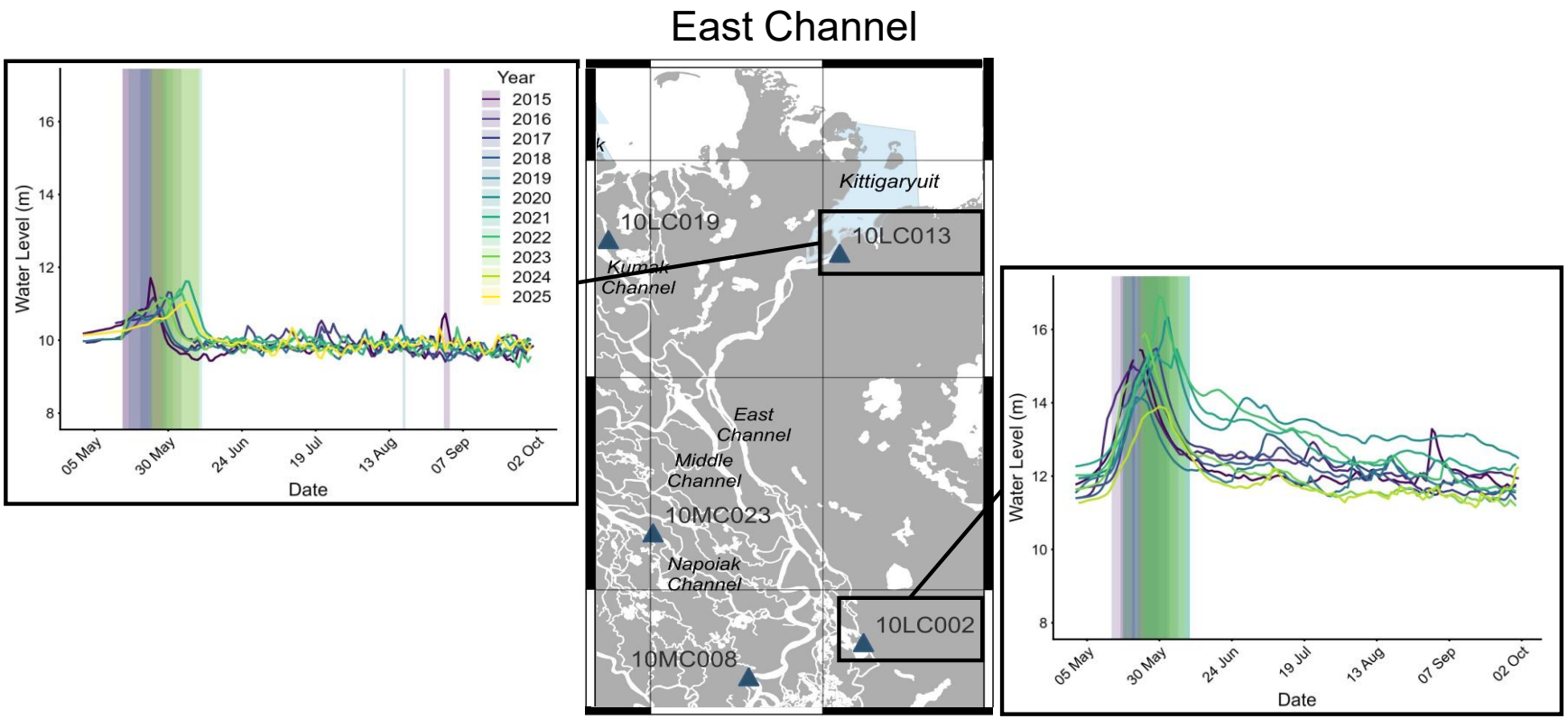


Figure 31. Water level (m) recorded at Environment and Climate Change Canada (ECCC) stations 10LC013 (upper left) and 10LC002 (lower right) on the East Channel of the Mackenzie River. Solid lines represent daily average water level recorded at each ECCC station between 2015 and 2025. Shaded areas summarize high-water periods where water level was ≥ the 90th percentile of seasonal values. Refer to Table 2 for a summary of ECCC stations used to produce this graphic and Appendix G for annual summary statistics for each location.

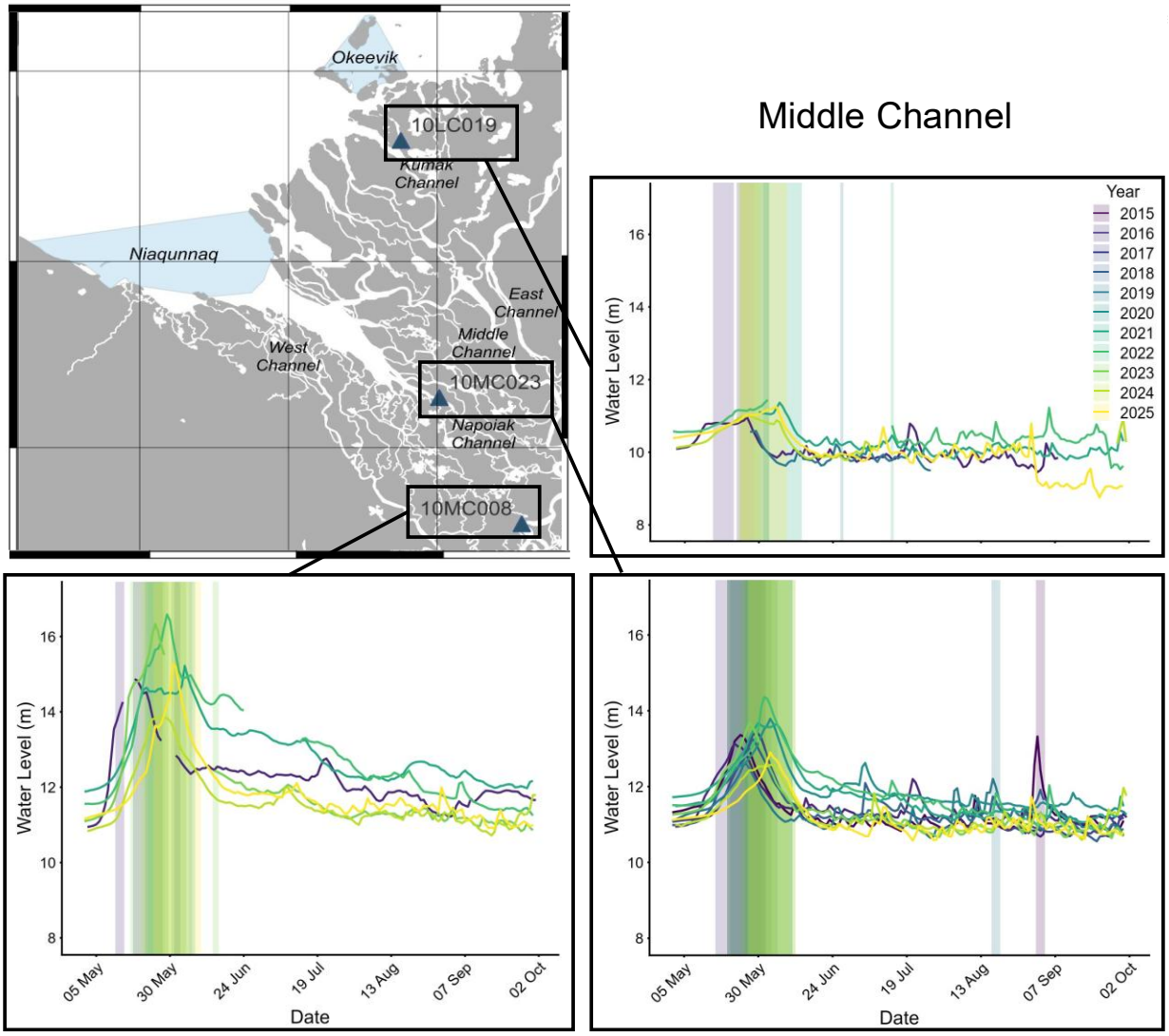


Figure 32. Water level (m) recorded at Environment and Climate Change Canada (ECCC) stations 10LC019 (upper right), 10MC023 (lower right), and 10MC008 (lower left) on the Middle Channel of the Mackenzie River. Solid lines represent daily average water level recorded at each ECCC station between 2015 and 2025. Shaded areas summarize high-water periods where water level was ≥ the 90th percentile of seasonal values. Refer to Table 2 for a summary of ECCC stations used to produce this graphic and Appendix G for annual summary statistics for each location.

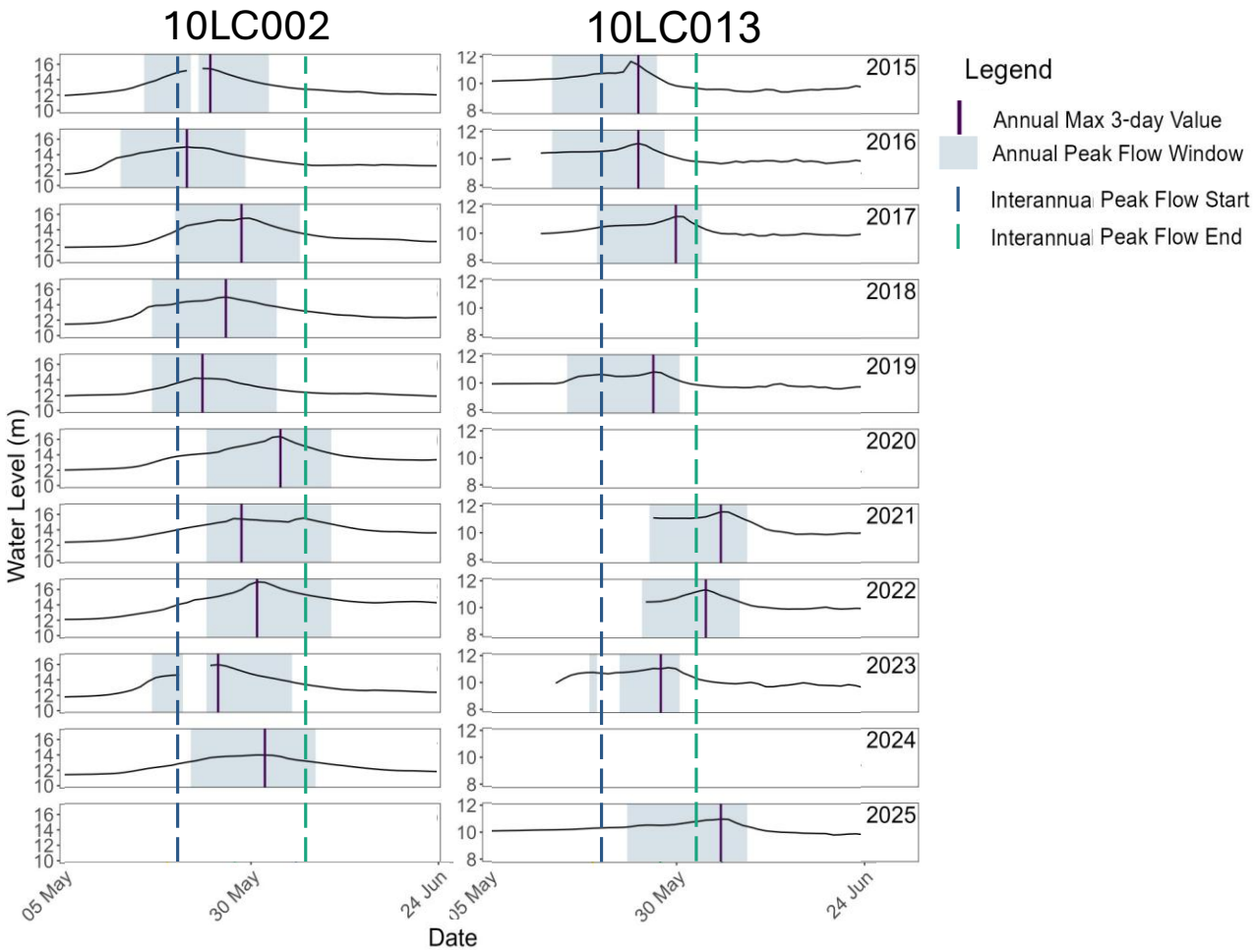


Figure 33. Water level (m) in May and June from 2015-2025 recorded at Environment and Climate Change Canada (ECCC) stations 10LC002 (left) and 10LC013 (right) on the East Channel of the Mackenzie River. Solid black lines are daily average water level, shaded areas summarize high-water periods (water level ≥ the 90th percentile of seasonal values), and solid purple lines delineate date of the maximum three-day rolling average. Vertical dashed lines represent the start and end of the high-water period averaged across all years. Note: some years were excluded from analyses due to lack of or insufficient data collection.

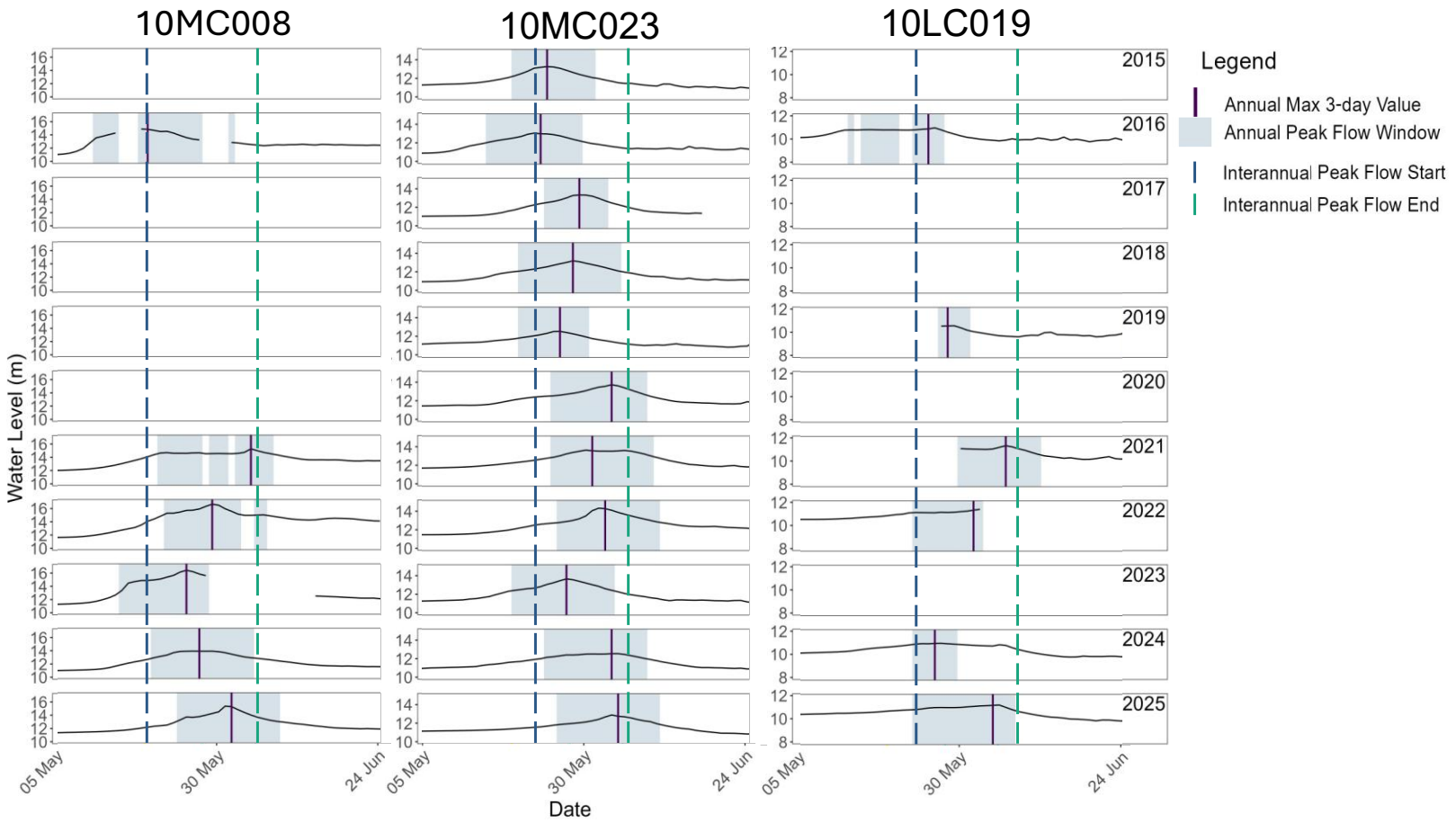


Figure 34. Water level (m) recorded in May and June from 2015-2025 at Environment and Climate Change Canada (ECCC) stations 10MC008 (left), 10MC023 (middle), and 10LC019 (right) on the Middle Channel of the Mackenzie River. Solid black lines are daily average water level, shaded areas summarize high-water periods (water level ≥ the 90th percentile of seasonal values), and solid purple lines delineate date of the maximum three-day rolling average. Vertical dashed lines represent the start and end of the high-water period averaged across all years. Note: some years were excluded from analyses due to lack of or insufficient data collection.

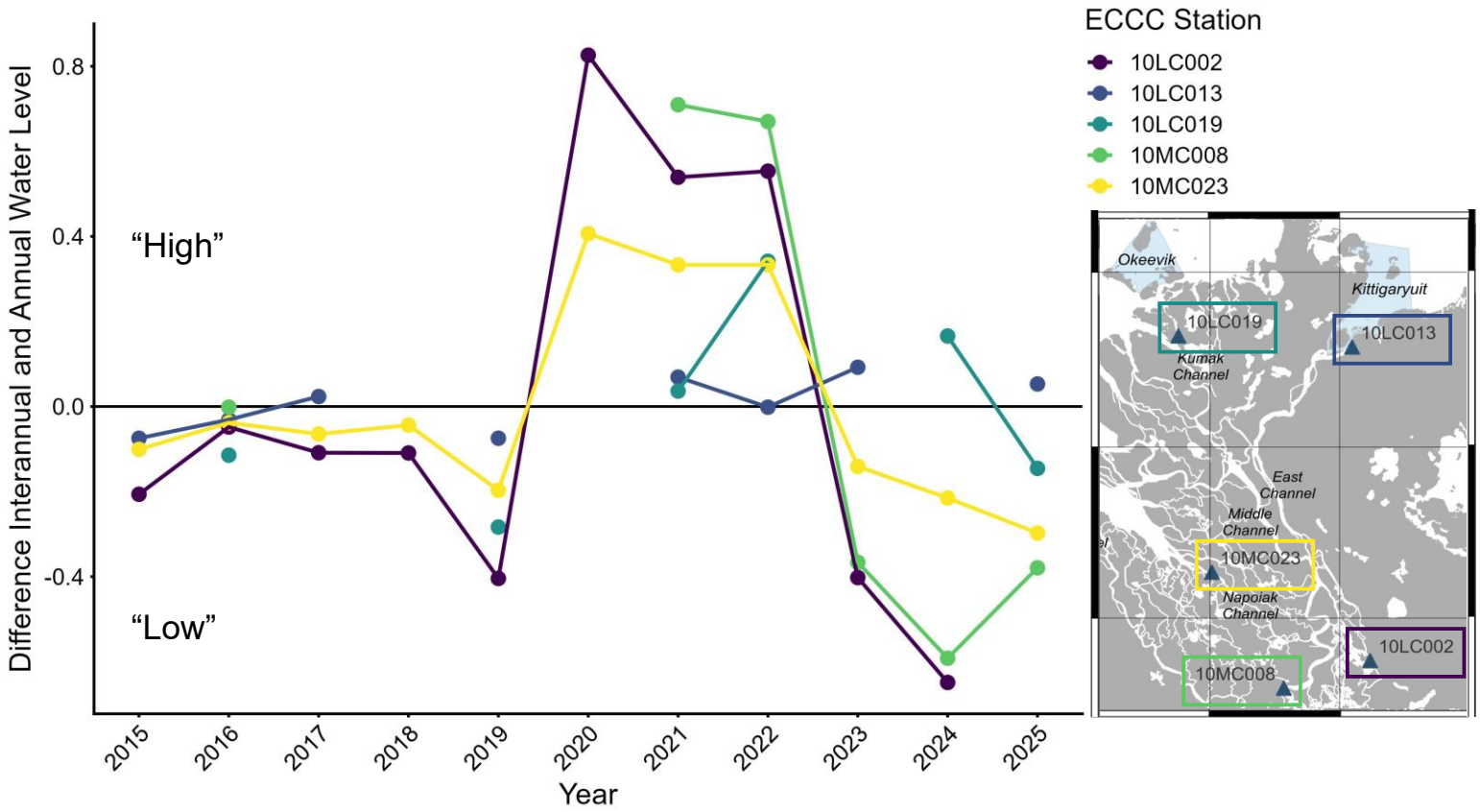


Figure 35. Visualization of "high" and "low" water years recorded at Environment and Climate Change Canada (ECCC) stations on the East and Middle Channels of the Mackenzie River between 2015 and 2025. Two stations are located in the East Channel: 10LC002 upstream near Inuvik and 10LC013 downstream near Kugmallit Bay. Three stations are located in the Middle Channel: 10MC008 upstream between Aklavik and Inuvik, 10MC023 downstream near Shallow Bay, and 10LC019 downstream near Okeevik MPA. Points represent the difference between the interannual and annual average water level at a given site, where a year was deemed "high" if the annual average was greater than interannual and "low" if it was lesser at the specified station. Lines connect points with successive years of measurements. Refer to Table 2 for a summary of ECCC stations used to produce this summary and Appendix G for annual summary statistics for each location.

3.3.2 Discharge

Similar to water level, we examined the timing of elevated spring discharge in several ways: 1) the high-flow period, the start of which was defined as when discharge ≥ the 90th percentile of seasonal values and the end date where the discharge first fell below this threshold; 2) CT, the date where half the seasonal discharge has occurred and half is still to come; and 3) date of highest discharge, the day of the year with the highest observed value of a three-day rolling average. Additionally, we counted the number of high-discharge days over the course of a season, where a high-discharge day was defined as any day between May and September when discharge was ≥ the 90th percentile of seasonal values. In some instances, a few days to a couple of weeks in May and/or June were missing observations, potentially affecting the determination of the end date of the high-flow period and CT timing.

ECCC monitoring station 10LC002 had data coverage for almost the entirety of the study period, however, station 10MC008 only had sufficient coverage for the first and last couple of years of that period (Table 11). Peak timing of discharge rates was comparable at ECCC monitoring stations 10LC002 (East Channel) and 10MC008 (Middle Channel), with the start of peak flow beginning in the third week of May, maximum flows in the fourth week, and peak flow ending in the first week of June (Table 11, Figures 36 and 37). Both stations reported a similar number of high-water days each year, almost entirely concentrated between mid-May and early June (Table 11, Figure 36). CT tended to occur earlier at 10MC008 compared to 10LC002 (Table 11), however, this could be an artefact of the difference in data coverage.

ECCC station 10MC008 reported average, median, and maximum discharge values that were roughly 25-40 times greater than station at 10LC002 (Table 11). Over the study period, 10LC002 reported higher than average discharge rate 2020-2022 and lower than average discharge on either side of this period (Figure 37). This pattern closely mirrors water level for 10LC002 (Figure 35). 10MC008 reported higher than average discharge in 2015-2016 and lower in 2024-2025 (Figure 37); however, this should be interpreted with caution. These higher-than-average discharge rates at 10MC008 may be an artefact of data coverage, given the stage-discharge relationship and that water levels at all stations were reported as lower than average in 2015-2016 (Figure 35).

Table 11. Summary of peak timing and discharge rate (m^3/s) at Environment and Climate Change Canada (ECCC) monitoring stations located on the East and Middle Channels of the Mackenzie River. Peak timing is summarized with the start and end dates of the peak period, date of three-day maximum water level, and centre of timing, all shown ± standard deviation. Discharge is summarized as number of high-discharge water days (d), weighted interannual average (± standard deviation), interannual median (± standard deviation), and maximum values for water level. Refer to Table 2 for a summary of ECCC monitoring station locations and Appendix H for annual summary statistics for each location.

			Peak Timing				Discharge (m^3/s)			
Channel	**ECCC Station**	**Year Range**	**Start Date of Peak (± SD)**	**Date of 3-Day Maximum (± SD)**	**End Date of Peak (± SD)**	**Centre of Timing (± SD)**	**Number of High-discharge Days (± SD)**	**Weighted Interannual Avg (± SD)**	**Weighted Interannual Median (± SD)**	**Max**
East	10LC002	2015-2024	19-May ± 2.9 d	26-May ± 3.5 d	4-Jun ± 2.9 d	3-Jul ± 6.1 d	15.0 ± 1.4 d	272.6 ± 102.5	218.2 ± 89.4	903.4
Middle	10MC008	2015-2016, 2024-2025	18-May ± 3.9 d	23-May ± 5.2 d	3-Jun ± 4.3 d	11-Jul ± 4.1 d	14.8 ± 1.7 d	11034.7 ± 1897.4	10438.8 ± 2279.1	23575.0

Definitions:

Start Date of Peak: First date in the season where water level was ≥ the 90th percentile of seasonal values.
End Date of Peak: First date after the Date of Onset where water level was < the 90th percentile of seasonal values.
Centre of Timing: "Centre of mass" of seasonal flow, the date where half the seasonal flow has occurred and half is still to come.
High-discharge Days: Days where water level was ≥ the 90th percentile of seasonal values.

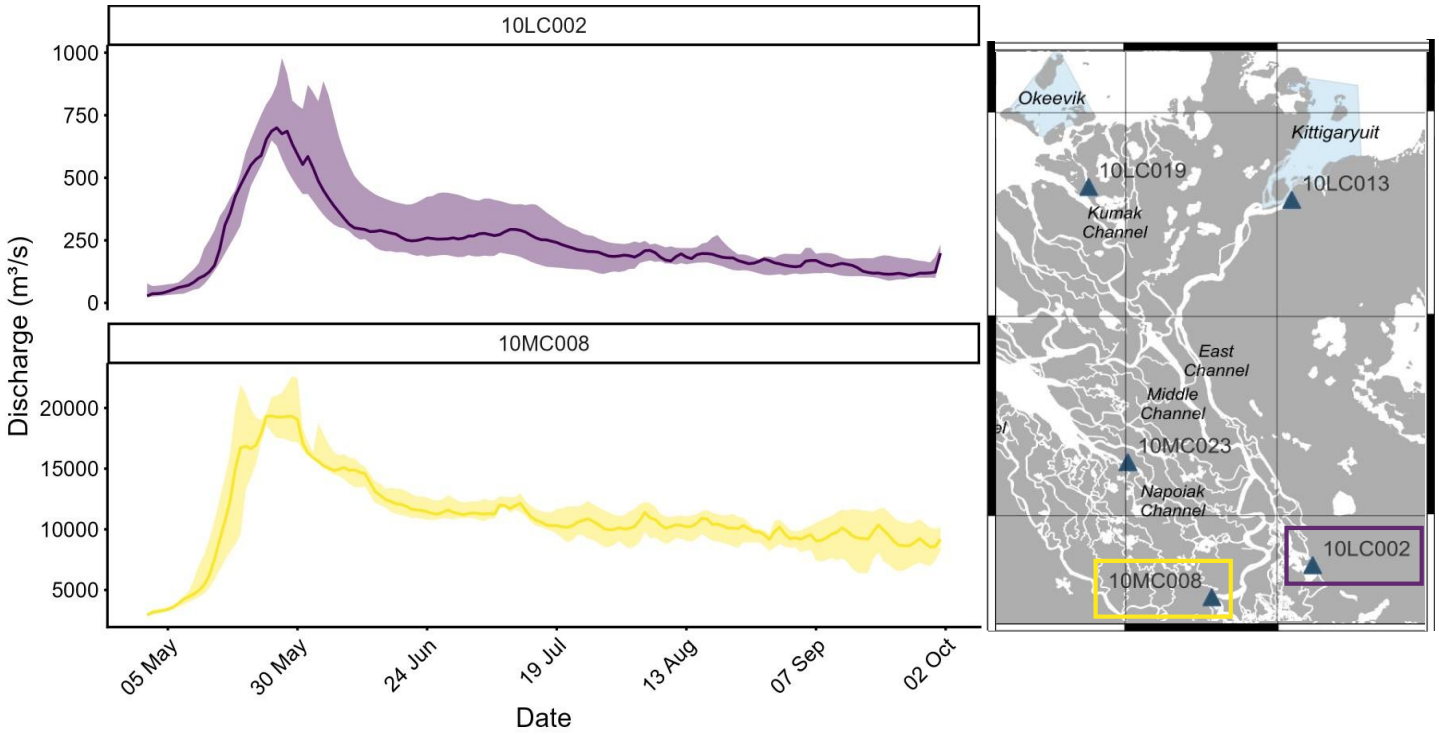


Figure 36. Freshwater discharge (m^3/s) recorded at Environment and Climate Change Canada (ECCC) stations located on the East (upper left, 10LC002) and Middle (lower left, 10MC008) Channels of the Mackenzie River between 2015 and 2025. Solid lines represent the median value of daily averages calculated across years recorded at each ECCC station. Shaded areas represent the interquartile range around each median value. Refer to Table 2 for a summary of ECCC stations used to produce this summary.

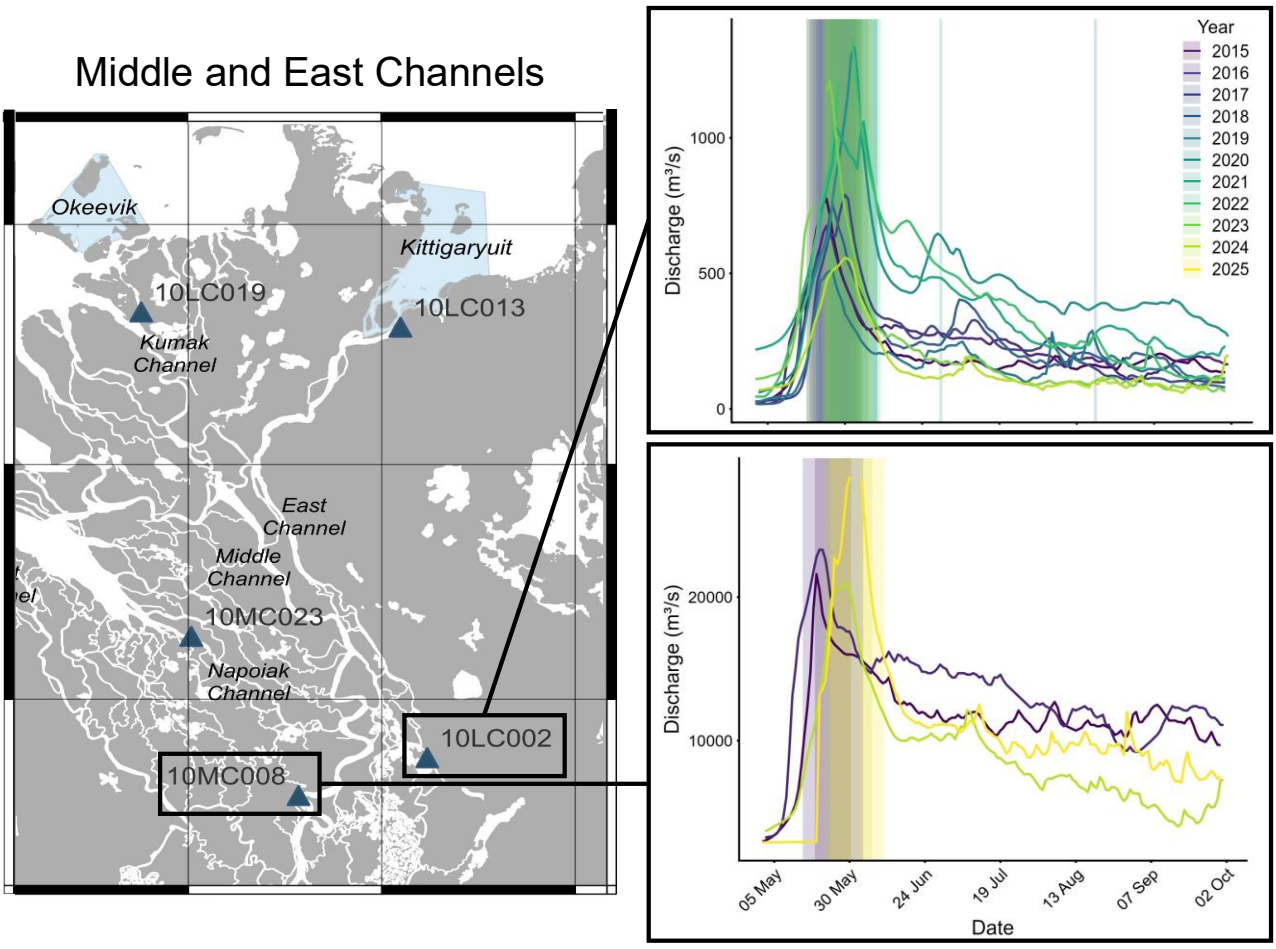


Figure 37. Freshwater discharge (m^3/s) recorded at Environment and Climate Change Canada (ECCC) stations located on the East (upper right, 10LC002) and Middle (lower right, 10MC008) Channels of the Mackenzie River. Solid lines represent daily average water level recorded at each ECCC station between 2015 and 2025. Shaded areas summarize high-water periods where discharge was ≥ the 90th percentile of seasonal values. Refer to Table 2 for a summary of ECCC stations used to produce this summary and Appendix H for annual summary statistics for each location.

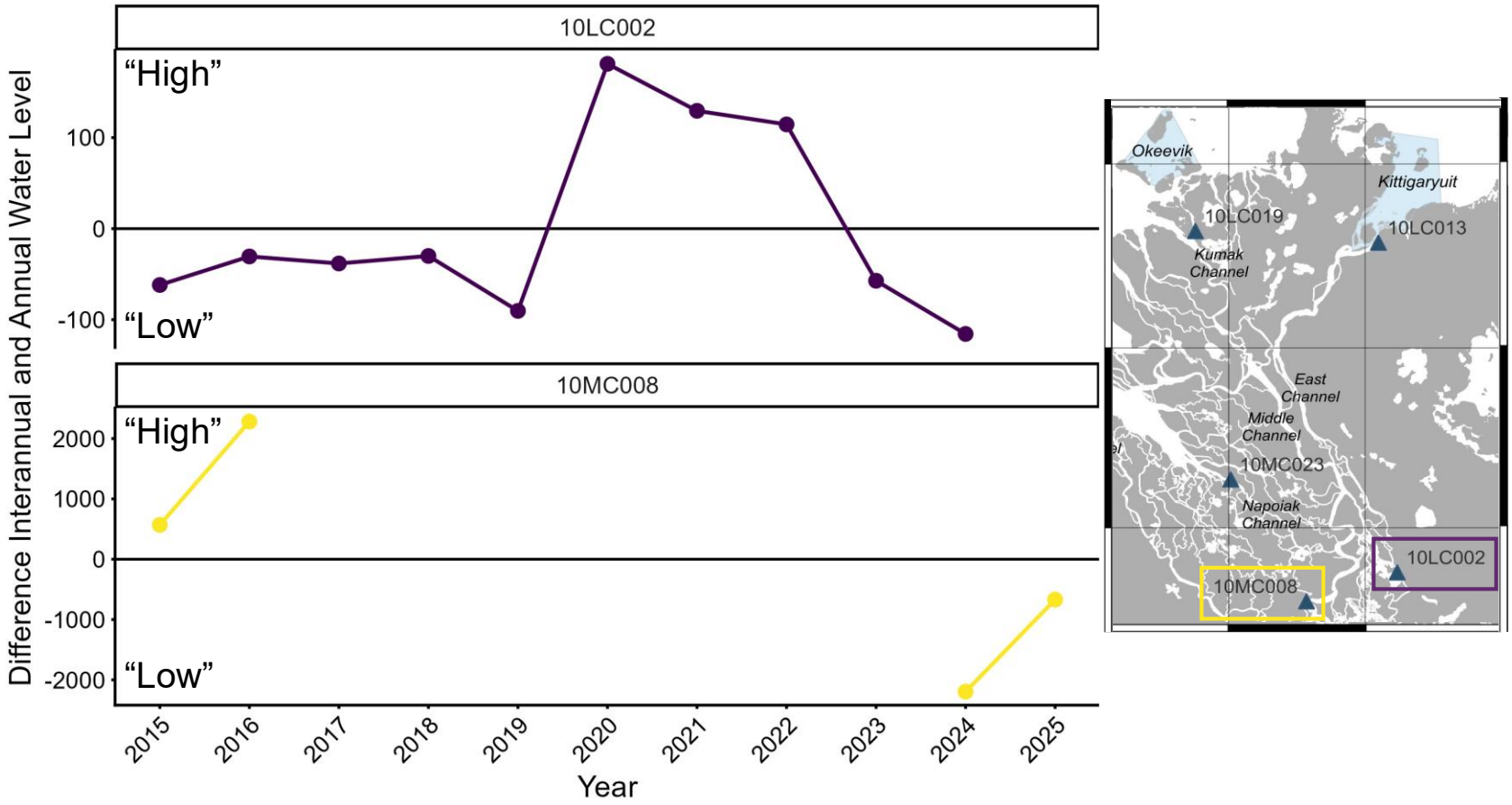


Figure 38. Visualization of "high" and "low" water years recorded at Environment and Climate Change Canada (ECCC) stations on the East (10LC002, above) and Middle (10MC008, below) Channels of the Mackenzie River between 2015 and 2025. Points represent the difference between the interannual and annual average water level at a given site, where a year was deemed "high" if the annual average was greater than interannual and "low" if it was lesser at the specified station. Lines connect points with successive years of measurements. Refer to Table 2 for a summary of ECCC stations used to produce this summary and Appendix H for annual summary statistics for each location.

4. DISCUSSION

The Arctic is experiencing the impacts of climate change faster than any other region, warming at a rate nearly four times greater than the global average (Rantanen et al. 2022). The Mackenzie Estuary is no exception; climate and environmental change have been identified as the main ecosystem stressor within the TN MPA (Fisheries and Oceans Canada and Fisheries Joint Management Committee 2013a). Indigenous Knowledge holders have observed thinner ice and unpredictable timing of spring breakup within the Mackenzie Delta in recent decades (Ziegler et al. 2024). Disrupted travel routes and harvesting activities within the Mackenzie Delta have also been noted (Worden et al. 2020, Ziegler et al. 2024), with hunters in the Delta reporting belugas arriving in the estuary earlier in the spring and leaving later in the summer in recent years (Harwood et al. 2020). Given the cultural and ecological significance of the Mackenzie Estuary and TN MPA, understanding how environmental change is altering this shallow estuarine ecosystem and impacting the wildlife that depend on it is essential to assessing the effectiveness of management measures.

This report presents an overview of water temperature, salinity, turbidity, and wave conditions collected across the TN MPA between 2015-2025 through the BHP. Interpreting the oceanographic data presented here requires acknowledging several limitations inherent to a long-term program that has evolved substantially over its first decade. The BHP has been modified over the course of this 11 year study period. Specifically, spatial coverage has expanded to include all three MPA parcels, deployment strategies have been refined to address challenges and improve data collection, and instrumentation has been adapted to address key priorities and sub-projects (Scharffenberg et al. 2024, Westphal et al. 2026a, Westphal et al. 2026b). Program refinement, combined with the naturally dynamic interface between the Mackenzie River and the coastal Beaufort Sea, has introduced spatial and seasonal heterogeneity into the dataset. These factors limit the confidence with which interannual variability can be interpreted, therefore, we did not attempt long term trend analyses in this report. However, while fine scale annual comparisons should be approached cautiously, the broader spatial and temporal patterns described here are robust, particularly monthly summaries, comparisons among parcels, and contrasts between river-influenced vs. more marine sites. In recent years, the program has moved toward more consistent deployment locations across the TN MPA and improved standardization of instrumentation. This increasing consistency will enhance the ability to detect future in-situ trends and will strengthen the dataset's utility for assessing climate-driven change. The oceanographic measurements compiled here also offer opportunities to support and validate remotely sensed products, such as satellite-derived sea surface temperature or turbidity, which could extend the temporal scope of trend analyses beyond the mooring record.

Publishing this overview is intended to make BHP datasets more accessible and useful to a broader research community. Raw measurements are available through the Government of Canada Open Data Portal and we anticipate that clearer documentation of the program's structure, methods, and data products will facilitate integration into other studies. BHP moorings already support a wide range of research; hydrophones deployed alongside oceanographic sensors have provided insight into environmental drivers of beluga habitat use (e.g., Scharffenberg et al. 2019, Scharffenberg et al. 2025) and these same platforms have been used for targeted studies (e.g., sediment trap deployments to quantify carbon fluxes, van Crimpen et al. 2025). Additionally, these datasets are relevant for interpreting findings from ongoing fish ecology programs (Brewster et al. 2016, Brewster et al. 2018), coastal erosion studies (Lee et al. 2025), and emerging contaminant monitoring efforts. As water sampling for contaminants, nutrients, and other biogeochemical indicators expands in the region, there is strong potential for cross-program collaboration and shared interpretation of environmental change.

Recent recommendations from reviews of the TN MPA Monitoring Plan (Fisheries and Oceans Canada 2013b) support current objectives of the BHP and highlight opportunities to strengthen and expand the program (Brewster et al. 2021, Fisheries and Oceans Canada 2024). Coastal erosion, which is accelerating across the Arctic and is particularly pronounced in the Mackenzie Delta region (Lee et al. 2025), is a process influenced by the physical conditions currently measured through the BHP. Parameters such as turbidity, wave energy, temperature, and wind conditions can help clarify the mechanisms driving shoreline change and sediment transport (Lee et al. 2025, Klein et al. 2019). Additionally, freshwater discharge from the Mackenzie River remains a dominant driver of estuarine conditions, influencing ice breakup, sediment transport, and distribution of belugas and their prey (Carmack and Macdonald 2002, Klein et al. 2019, Nghiem et al. 2014, Noel et al. 2022). Incorporation of ECCC's hydrometric monitoring network water level and discharge data is therefore essential, both as contextual information and as a potential explanatory variable for observed changes within the MPA. The current TN MPA Monitoring Plan outlines key indicators for long-term ecosystem tracking, including water temperature, salinity, sediment dynamics, and beluga habitat use (Fisheries and Oceans Canada and Fisheries Joint Management Committee 2013b). Strengthening linkages between BHP oceanographic measurements and ongoing coastal erosion research would improve understanding of how climate-driven physical processes interact within the TN MPA. More recent reviews of indicators for the MPA have emphasized the importance of core oceanographic variables (e.g., temperature, salinity, turbidity) including wave and wind conditions as direct drivers of beluga habitat use and ecosystem function (Brewster et al. 2021, Fisheries and Oceans Canada 2024). Expanding the TN MPA Monitoring Plan to formally include these parameters, along with additional water quality metrics such as contaminants, nutrients, carbon, nitrogen, and phosphorus, would provide a more comprehensive picture of ecosystem health.

This overview of oceanography in TN MPA underscores the importance of long-term, comprehensive monitoring within the region. The oceanographic dataset, combined with recommendations outlined above represent an important piece of an integrated, ecosystem-based monitoring framework for the TN MPA. Continued investment in consistent, multi-disciplinary monitoring, paired with open data sharing and collaboration across programs, will enhance our ability to detect environmental change, understand its implications for beluga whales and other species, and support informed stewardship of this culturally and ecologically significant region.

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Appendix A. Seabed water temperature within the TN MPA

Summary of seabed water temperatures recorded just above the seafloor, summarized by deployment year. Shown are average (± standard deviation), minimum, and maximum values recorded at each location; date where highest temperature was recorded; and the earliest date, latest date, and the average proportion of recorded temperatures that were 15°C or higher. Refer to Table 1 for a summary of annual deployment and retrieval dates for each location.

			Temperature (°C)				Temperature ≥15°C		
MPA Parcel	**Location**	**Year**	**Average (± SD)**	**Max**	**Min**	**Date with Maximum**	**Proportion of Measurements (%)**	**Earliest Date**	**Latest Date**
Kittigaryuit	Channel	2015	15.25 ± 1.26	18.53	12.35	5-Jul	56.6	23-Jun	12-Aug
		2016	15.66 ± 2.09	21.36	11.30	15-Jul	55.7	21-Jun	20-Aug
		2017	16.51 ± 1.14	18.90	11.09	8-Jul	86.3	22-Jun	19-Aug
	East Hendrickson	2017	11.44 ± 3.30	17.68	1.54	11-Aug	13.4	23-Jun	14-Aug
	East Whitefish	2016	14.49 ± 2.68	22.27	8.37	14-Jul	39.3	23-Jun	14-Aug
		2017	15.54 ± 1.61	19.55	11.81	7-Jul	62.7	21-Jun	19-Aug
		2018	12.66 ± 2.55	19.47	5.39	25-Jul	15.3	4-Jul	1-Aug
		2019	13.50 ± 1.89	16.09	9.19	24-Jun	22.6	23-Jun	20-Jul
		2020	-	-	-	-	-	-	-
		2021	13.81 ± 2.68	19.87	6.19	21-Jul	36.5	25-Jun	12-Aug
		2022	14.17 ± 2.97	20.16	5.44	5-Jul	40.6	25-Jun	4-Sep
		2023	-	-	-	-	-	-	-
		2024	14.38 ± 3.15	20.58	7.56	25-Jul	45.7	27-Jun	20-Aug
		2025	13.57 ± 2.79	19.72	5.85	30-Jun	32.2	29-Jun	15-Aug
	Mid Kugmallit	2015	14.26 ± 1.85	18.30	9.26	2-Jul	35.8	21-Jun	11-Aug
		2017	15.47 ± 1.72	18.51	9.64	7-Jul	64.7	21-Jun	19-Aug
		2019	14.03 ± 1.46	16.60	11.20	24-Jun	33.9	22-Jun	24-Jun
		2020	-	-	-	-	-	-	-
		2021	13.78 ± 2.60	19.31	6.15	21-Jul	37.0	25-Jun	12-Aug
		2022	14.16 ± 3.14	19.71	3.91	4-Jul	45.8	26-Jun	4-Sep
		2023	15.01 ± 3.61	21.16	6.91	23-Jul	50.2	25-Jun	13-Aug
	Mid Kugmallit B	2016	14.48 ± 2.70	21.40	7.48	14-Jul	38.5	23-Jun	10-Aug

Appendix A. Continued.

			Temperature (°C)				Temperature ≥15°C		
MPA Parcel	**Location**	**Year**	**Average (± SD)**	**Max**	**Min**	**Date with Maximum**	**Proportion of Measurements (%)**	**Earliest Date**	**Latest Date**
Kittigaryuit	West Hendrickson	2015	12.49 ± 2.77	17.96	0.76	3-Jul	20.4	21-Jun	10-Aug
		2017	13.65 ± 2.46	18.22	7.35	9-Aug	33.0	22-Jun	18-Aug
		2019	11.59 ± 2.92	16.42	7.51	24-Jun	18.9	22-Jun	25-Jun
		2020	-	-	-	-	-	-	-
		2021	12.33 ± 3.09	19.82	4.15	21-Jul	23.3	26-Jun	12-Aug
		2022	12.97 ± 3.77	20.52	1.82	8-Jul	31.7	26-Jun	18-Aug
		2023	13.81 ± 3.55	21.46	6.89	22-Jul	37.8	25-Jun	11-Aug
		2024	12.04 ± 3.42	20.42	5.19	29-Jun	23.0	28-Jun	19-Aug
		2025	11.73 ± 3.42	19.60	4.54	29-Jun	19.9	29-Jun	15-Aug
Kugmallit Bay	Atkinson Point	2022	5.58 ± 3.30	12.54	0.19	9-Aug	0.0	-	-
		2023	-	-	-	-	-	-	-
Niaqunnaq	Escape Reef	2023	9.04 ± 3.28	17.56	0.53	2-Jul	0.6	2-Jul	3-Jul
	Niaqunnaq	2020	12.72 ± 2.07	16.68	6.84	13-Jul	10.2	30-Jun	24-Aug
	Niaqunnaq East	2021	13.92 ± 2.57	20.34	9.18	21-Jul	38.7	27-Jun	6-Aug
		2022	13.29 ± 3.54	22.17	6.54	8-Jul	27.5	30-Jun	13-Aug
		2023	14.86 ± 4.58	22.07	6.23	30-Jul	51.8	28-Jun	18-Aug
		2024	-	-	-	-	-	-	-
		2025	11.52 ± 3.36	20.39	4.00	6-Jul	15.0	6-Jul	15-Aug
	Niaqunnaq Mid	2023	14.09 ± 4.16	21.04	6.52	7-Jul	47.9	28-Jun	13-Aug
	Niaqunnaq North	2021	10.56 ± 3.07	18.42	2.48	21-Jul	9.0	27-Jun	23-Jul
		2022	12.56 ± 3.69	21.58	5.65	6-Jul	23.6	30-Jun	6-Aug
	Niaqunnaq West	2021	11.80 ± 3.14	18.80	3.58	22-Jul	21.1	27-Jun	3-Aug
		2022	12.12 ± 4.21	21.28	2.50	8-Jul	25.3	30-Jun	6-Aug
		2024	10.18 ± 4.19	19.16	2.16	28-Jun	20.3	27-Jun	13-Aug
		2025	9.82 ± 3.08	16.14	1.61	17-Jul	5.1	16-Jul	20-Jul
	Shingle Point Bay	2019	10.98 ± 3.00	16.53	1.77	25-Jul	8.0	24-Jun	27-Jul
		2020	9.14 ± 3.72	15.06	0.87	7-Aug	0.2	7-Aug	7-Aug

Appendix A. Continued.

			Temperature (°C)				Temperature ≥15°C		
MPA Parcel	**Location**	**Year**	**Average (± SD)**	**Max**	**Min**	**Date with Maximum**	**Proportion of Measurements (%)**	**Earliest Date**	**Latest Date**
Niaqunnaq	Shingle Point Ocean	2019	6.45 ± 2.71	12.61	0.64	25-Jun	0.0	-	-
		2020	5.22 ± 3.81	13.33	-0.68	9-Aug	0.0	-	-
		2021	5.97 ± 3.05	10.71	0.66	10-Aug	0.0	-	-
		2022	4.18 ± 2.99	12.89	-0.38	23-Jul	0.0	-	-
Okeevik	Garry Island	2021	12.06 ± 3.03	19.67	2.11	21-Jul	18.2	28-Jun	4-Aug
		2022	12.83 ± 3.10	21.42	5.99	4-Jul	23.6	26-Jun	7-Aug
		2023	13.41 ± 3.88	20.99	1.45	22-Jul	41.9	25-Jun	11-Aug
	Kendall Island	2021	14.09 ± 2.05	18.80	9.43	10-Jul	37.3	28-Jun	12-Aug
		2022	13.55 ± 3.38	19.21	2.90	8-Jul	38.5	26-Jun	3-Sep
	Okeevik	2024	11.77 ± 3.73	19.96	0.77	8-Aug	25.5	25-Jun	17-Aug
	Pelly Island	2023	8.47 ± 2.30	14.27	1.48	3-Jul	0.0	-	-
		2025	9.80 ± 2.24	16.44	2.17	7-Jul	1.0	6-Jul	4-Aug

Appendix B. Sea surface water temperature within the TN MPA

Summary of sea surface water temperatures (SST), summarized by deployment year. Shown are average (± standard deviation), minimum, and maximum values recorded at each location; date where highest temperature was recorded; and the earliest date, latest date, and the average proportion of recorded temperatures that were ≥15°C. Refer to Table 1 for a summary of annual deployment and retrieval dates for each location.

			SST (°C)				SST ≥15°C		
MPA Parcel	**Location**	**Year**	**Average (± SD)**	**Max**	**Min**	**Date with Max Temp**	**Proportion of Measurements (%)**	**Earliest Date**	**Latest Date**
Kittigaryuit	Channel	2015	-	-	-	-	-	-	-
		2016	-	-	-	-	-	-	-
		2017	-	-	-	-	-	-	-
	East Hendrickson	2017	-	-	-	-	-	-	-
	East Whitefish	2016	-	-	-	-	-	-	-
		2017	-	-	-	-	-	-	-
		2018	-	-	-	-	-	-	-
		2019	-	-	-	-	-	-	-
		2020	-	-	-	-	-	-	-
		2021	-	-	-	-	-	-	-
		2022	14.13 ± 2.90	19.98	5.62	4-Jul	39.4	26-Jun	4-Sep
		2023	17.93 ± 2.54	21.24	11.16	21-Jul	82.8	25-Jun	30-Jul
		2024	14.43 ± 3.24	22.56	7.72	7-Aug	47.7	27-Jun	20-Aug
		2025	-	-	-	-	-	-	-
	Mid Kugmallit	2015	-	-	-	-	-	-	-
		2017	-	-	-	-	-	-	-
		2019	-	-	-	-	-	-	-
		2020	13.43 ± 1.94	17.40	3.22	31-Jul	24.7	13-Jul	25-Aug
		2021	-	-	-	-	-	-	-
		2022	-	-	-	-	-	-	-
		2023	-	-	-	-	-	-	-
	Mid Kugmallit B	2016	-	-	-	-	-	-	-

Appendix B. Continued.

			SST (°C)				SST ≥15°C		
MPA Parcel	**Location**	**Year**	**Average (± SD)**	**Max**	**Min**	**Date with Max Temp**	**Proportion of Measurements (%)**	**Earliest Date**	**Latest Date**
Kittigaryuit	West Hendrickson	2015	-	-	-	-	-	-	-
		2017	-	-	-	-	-	-	-
		2019	-	-	-	-	-	-	-
		2020	12.35 ± 2.76	16.94	0.08	27-Jul	10.3	24-Jul	24-Aug
		2021	-	-	-	-	-	-	-
		2022	12.97 ± 3.71	26.34	1.90	4-Jul	29.1	26-Jun	3-Sep
		2023	14.45 ± 3.91	21.10	6.66	22-Jul	47.4	25-Jun	17-Aug
		2024	12.49 ± 3.68	21.28	4.52	14-Jul	29.0	28-Jun	19-Aug
		2025	-	-	-	-	-	-	-
Kugmallit Bay	Atkinson Point	2022	9.29 ± 2.44	14.10	2.04	4-Aug	0.0	-	-
		2023	10.24 ± 3.31	19.98	3.42	21-Jul	10.7	15-Jul	8-Aug
Niaqunnaq	Escape Reef	2023	12.47 ± 4.02	20.80	4.96	27-Jul	32.5	28-Jun	11-Aug
	Niaqunnaq	2020	12.57 ± 2.60	18.31	4.90	18-Aug	14.1	30-Jun	25-Aug
	Niaqunnaq East	2021	13.76 ± 2.60	20.64	8.94	21-Jul	37.5	27-Jun	6-Aug
		2022	-	-	-	-	-	-	-
		2023	-	-	-	-	-	-	-
		2024	15.03 ± 3.30	22.20	8.00	25-Jul	53.2	26-Jun	19-Aug
		2025	11.54 ± 3.40	20.42	4.46	6-Jul	15.8	6-Jul	15-Aug
	Niaqunnaq Mid	2023	-	-	-	-	-	-	-
	Niaqunnaq North	2021	12.58 ± 2.73	19.82	7.88	21-Jul	25.3	27-Jun	5-Aug
		2022	12.32 ± 3.90	29.52	4.44	10-Aug	22.5	30-Jun	10-Aug
	Niaqunnaq West	2021	12.86 ± 2.89	19.34	7.36	21-Jul	32.6	27-Jun	5-Aug
		2022	-	-	-	-	-	-	-
		2024	11.89 ± 4.30	23.56	2.80	24-Jul	31.4	26-Jun	13-Aug
		2025	9.62 ± 2.93	19.92	4.04	6-Jul	2.7	6-Jul	14-Aug

Appendix B. Continued.

			SST (°C)				SST ≥15°C		
MPA Parcel	**Location**	**Year**	**Average (± SD)**	**Max**	**Min**	**Date with Max Temp**	**Proportion of Measurements (%)**	**Earliest Date**	**Latest Date**
Niaqunnaq	Shingle Point Bay	2019	-	-	-	-	-	-	-
		2020	-	-	-	-	-	-	-
	Shingle Point Ocean	2019	-	-	-	-	-	-	-
		2020	9.46 ± 3.78	14.56	-0.21	26-Jul	0.0	-	-
		2021	-	-	-	-	-	-	-
		2022	-	-	-	-	-	-	-
Okeevik	Garry Island	2021	12.62 ± 2.71	19.84	7.45	10-Jul	22.3	28-Jun	5-Aug
		2022	-	-	-	-	-	-	-
		2023	-	-	-	-	-	-	-
	Kendall Island	2021	14.44 ± 2.35	19.58	8.58	10-Jul	41.5	28-Jun	12-Aug
		2022	13.70 ± 3.27	20.42	3.66	4-Jul	39.7	26-Jun	3-Sep
	Okeevik	2024	12.51 ± 3.98	22.02	0.78	14-Jul	32.4	25-Jun	20-Aug
	Pelly Island	2023	11.79 ± 3.76	21.84	1.86	6-Aug	25.3	30-Jun	10-Aug
		2025	10.73 ± 2.43	17.94	4.90	6-Jul	5.4	5-Jul	14-Aug

Appendix C. Salinity and saline events within the TN MPA

Summary of salinity (PSU) measurements and saline events (≥5 PSU minimum 24 hours) recorded just above the seafloor across the TN MPA. Shown are average (± standard deviation), minimum, and maximum values recorded at each location; the proportion of measurements ≥5 PSU; and the start date and duration (hours) of any saline events associated with the indicated deployment location and year. Refer to Table 1 for a summary of annual deployment and retrieval dates for each location.

			Salinity (PSU)			Saline Events (≥5 PSU minimum 24 hours)		
MPA Parcel	Location	Year	Average (± SD)	Max	Min	Proportion of Measurements (%)	Event Start	Duration (hours)
Kittigaryuit	Channel	2015	-	-	-	-	-	-
		2016	-	-	-	-	-	-
		2017	-	-	-	-	-	-
	East Hendrickson	2017	13.61 ± 9.79	29.93	0.09	69.7	30-Jun	238
							13-Jul	117
							18-Jul	443
							11-Aug	25
							15-Aug	95
	East Whitefish	2016	0.15 ± 0.01	0.17	0.12	0.0	-	-
		2017	-	-	-	-	-	-
		2018	-	-	-	-	-	-
		2019	-	-	-	-	-	-
		2020	-	-	-	-	-	-
		2021	-	-	-	-	-	-
		2022	-	-	-	-	-	-
		2023	-	-	-	-	-	-
		2024	1.33 ± 3.38	17.60	0.14	9.9	6-Aug	31
							28-Aug	26
							30-Aug	31
		2025	0.49 ± 2.41	24.15	0.14	1.9	-	-
	Mid Kugmallit	2015	0.29 ± 0.83	8.64	0.12	1.3	-	-
		2017	1.34 ± 3.67	19.69	0.13	8.0	25-Jul	41

Appendix C. Continued.

			Salinity (PSU)			Saline Events (≥5 PSU minimum 24 hours)		
MPA Parcel	Location	Year	Average (± SD)	Max	Min	Proportion of Measurements (%)	Event Start	Duration (hours)
Kittigaryuit	Mid Kugmallit	2019	0.03 ± 0.00	0.03	0.03	0.0	-	-
		2020	-	-	-	-	-	-
		2021	0.78 ± 3.14	19.41	0.00	5.3	17-Sep	52
		2022	1.32 ± 4.85	25.79	0.11	5.9	16-Sep	86
		2023	5.10 ± 7.38	23.17	0.13	32.2	6-Jul	33
							15-Jul	26
							30-Jul	109
							6-Aug	103
							17-Aug	46
							19-Aug	31
							23-Aug	29
							27-Aug	42
							31-Aug	29
	Mid Kugmallit B	2016	1.28 ± 3.35	16.54	0.11	7.2	10-Aug	90
	West Hendrickson	2015	3.71 ± 4.66	16.95	0.11	32.9	5-Jul	30
							8-Jul	94
							18-Jul	98
							24-Jul	148
							11-Aug	42
		2017	6.82 ± 8.28	29.01	0.13	41.5	3-Jul	93
							15-Jul	36
							20-Jul	97
							24-Jul	62
							29-Jul	49
							1-Aug	108
		2019	7.52 ± 6.51	19.72	0.09	57.3	25-Jun	104
		2020	-	-	-	-	-	-

Appendix C. Continued.

			Salinity (PSU)			Saline Events (≥5 PSU minimum 24 hours)		
MPA Parcel	Location	Year	Average (± SD)	Max	Min	Proportion of Measurements (%)	Event Start	Duration (hours)
Kittigaryuit	West Hendrickson	2021	4.98 ± 6.78	25.02	0.12	34.4	7-Jul	34
							29-Jul	106
							5-Aug	130
							17-Aug	43
							6-Sep	30
							17-Sep	107
							21-Sep	40
		2022	1.28 ± 3.07	16.73	0.00	11.8	1-Sep	87
							6-Sep	30
							16-Sep	27
							17-Sep	42
		2023	8.07 ± 8.25	26.15	0.12	51.0	26-Jun	28
							5-Jul	29
							9-Jul	45
							12-Jul	44
							15-Jul	46
							26-Jul	34
							30-Jul	57
							3-Aug	44
							6-Aug	59
							11-Aug	114
							17-Aug	58
							19-Aug	34
							23-Aug	71
							27-Aug	49
							1-Sep	60

Appendix C. Continued.

			Salinity (PSU)			Saline Events (≥5 PSU minimum 24 hours)		
MPA Parcel	Location	Year	Average (± SD)	Max	Min	Proportion of Measurements (%)	Event Start	Duration (hours)
Kittigaryuit	West Hendrickson	2024	7.36 ± 6.66	22.26	0.14	54.1	14-Jul	64
							28-Jul	68
							1-Aug	68
							6-Aug	208
							19-Aug	53
							23-Aug	81
							28-Aug	145
							4-Sep	34
							5-Sep	142
							15-Sep	24
		2025	4.15 ± 5.64	25.96	0.15	32.1	6-Jul	104
							22-Jul	33
							4-Aug	46
							15-Aug	64
							1-Sep	61
							4-Sep	50
							12-Sep	42
							18-Sep	106
Kugmallit Bay	Atkinson Point	2022	14.84 ± 9.21	29.06	0.66	77.5	18-Jul	54
							22-Jul	47
							25-Jul	58
							28-Jul	31
							1-Aug	138
							14-Aug	674
		2023	-	-	-	-	-	-
Niaqunnaq	Escape Reef	2023	20.31 ± 4.67	29.49	3.28	99.8	28-Jun	113
							2-Jul	2007

Appendix C. Continued.

			Salinity (PSU)			Saline Events (≥5 PSU minimum 24 hours)		
MPA Parcel	Location	Year	Average (± SD)	Max	Min	Proportion of Measurements (%)	Event Start	Duration (hours)
Niaqunnaq	Niaqunnaq	2020	0.13 ± 0.00	0.15	0.12	0.0	-	-
	Niaqunnaq East	2021	0.23 ± 0.11	0.45	0.01	0.0	-	-
		2022	0.05 ± 0.39	4.86	0.00	0.0	-	-
		2023	0.16 ± 0.01	0.22	0.03	0.0	-	-
		2024	-	-	-	-	-	-
		2025	1.07 ± 3.39	23.60	0.14	6.8	26-Aug	24
							30-Aug	40
							18-Sep	36
	Niaqunnaq Mid	2023	2.46 ± 3.83	15.41	0.00	26.8	8-Jul	73
							25-Jul	46
							27-Jul	149
							9-Aug	79
							23-Aug	26
							28-Aug	30
							6-Sep	81
	Niaqunnaq North	2021	12.54 ± 7.49	27.46	0.13	80.4	2-Jul	273
							23-Jul	36
							25-Jul	332
							12-Aug	204
							21-Aug	416
							7-Sep	69
							10-Sep	135
		2022	1.26 ± 1.61	12.90	0.08	1.8	-	-

Appendix C. Continued.

			Salinity (PSU)			Saline Events (≥5 PSU minimum 24 hours)		
MPA Parcel	Location	Year	Average (± SD)	Max	Min	Proportion of Measurements (%)	Event Start	Duration (hours)
Niaqunnaq	Niaqunnaq West	2021	7.14 ± 6.35	23.96	0.00	60.0	2-Jul	67
							5-Jul	125
							12-Jul	25
							24-Jul	25
							29-Jul	217
							15-Aug	72
							21-Aug	402
							11-Sep	131
		2022	4.68 ± 6.75	26.81	0.13	32.9	27-Jul	45
							23-Aug	159
							2-Sep	66
							10-Sep	46
							12-Sep	58
							14-Sep	213
		2024	13.58 ± 9.40	27.86	0.15	70.2	11-Jul	135
							25-Jul	60
							28-Jul	366
							13-Aug	460
							3-Sep	490
							29-Sep	44
		2025	11.36 ± 9.40	28.77	0.15	63.4	6-Jul	91
							21-Jul	98
							28-Jul	67
							3-Aug	33
							8-Aug	44
							14-Aug	30
							21-Aug	791

Appendix C. Continued.

			Salinity (PSU)			Saline Events (≥5 PSU minimum 24 hours)		
MPA Parcel	Location	Year	Average (± SD)	Max	Min	Proportion of Measurements (%)	Event Start	Duration (hours)
Niaqunnaq	Shingle Point Bay	2019	9.99 ± 6.77	26.51	0.00	71.8	22-Jun	52
							24-Jun	66
							1-Jul	148
							10-Jul	62
							17-Jul	36
							19-Jul	588
		2020	-	-	-	-	-	-
	Shingle Point Ocean	2019	23.91 ± 5.57	30.38	6.58	100.0	16-Jun	1369
		2020	20.05 ± 9.12	31.21	0.54	87.8	28-Jun	56
							6-Jul	89
							11-Jul	79
							15-Jul	118
							22-Jul	430
							10-Aug	146
							16-Aug	674
		2021	23.30 ± 4.86	30.58	9.30	100.0	27-Jun	1957
		2022	15.49 ± 5.32	27.32	2.49	99.4	22-Jul	25
							24-Jul	1470
Okeevik	Garry Island	2021	4.31 ± 6.71	25.05	0.00	29.8	3-Jul	25
							6-Jul	68
							29-Jul	53
							4-Aug	33
							6-Aug	44
							25-Aug	59
							28-Aug	29
							11-Sep	24
							15-Sep	36

Appendix C. Continued.

			Salinity (PSU)			Saline Events (≥5 PSU minimum 24 hours)		
MPA Parcel	Location	Year	Average (± SD)	Max	Min	Proportion of Measurements (%)	Event Start	Duration (hours)
Okeevik	Garry Island	2022	0.99 ± 1.44	7.78	0.01	0.3	-	-
		2023	5.71 ± 6.77	31.92	0.14	38.9	4-Jul	29
							8-Jul	43
							29-Jul	99
							3-Aug	34
							13-Aug	48
							16-Aug	50
							23-Aug	24
							31-Aug	26
							2-Sep	31
							12-Sep	106
	Kendall Island	2021	0.17 ± 0.02	0.19	0.08	0.0	-	-
		2022	0.90 ± 3.17	26.74	0.12	4.7	11-Sep	27
							15-Sep	33
	Okeevik	2024	6.70 ± 7.18	23.77	0.15	44.8	18-Jul	47
							24-Jul	42
							27-Jul	196
							18-Aug	370
							9-Sep	39
							13-Sep	187

Appendix C. Continued.

			Salinity (PSU)			Saline Events (≥5 PSU minimum 24 hours)		
MPA Parcel	Location	Year	Average (± SD)	Max	Min	Proportion of Measurements (%)	Event Start	Duration (hours)
Okeevik	Pelly Island	2023	2.75 ± 0.91	3.91	0.15	0.0	-	-
		2025	6.54 ± 5.03	22.48	0.16	55.8	11-Jul	27
							12-Jul	46
							21-Jul	40
							23-Jul	36
							26-Jul	25
							28-Jul	57
							31-Jul	76
							16-Aug	116
							29-Aug	26
							30-Aug	214

Appendix D. Turbidity within the TN MPA

Summary of turbidity (NTUs) as recorded just above the seafloor. Shown are average (± standard deviation), minimum, and maximum values recorded at each location. Refer to Table 1 for a summary of annual deployment and retrieval dates for each location.

MPA Parcel	Location	Year	Average (± SD)	Max	Min
Kittigaryuit	Channel	2015	-	-	-
		2016	-	-	-
		2017	-	-	-
	East Hendrickson	2017	-	-	-
	East Whitefish	2016	-	-	-
		2017	-	-	-
		2018	-	-	-
		2019	-	-	-
		2020	-	-	-
		2021	-	-	-
		2022	75.1 ± 102.84	459.36	0.04
		2023	-	-	-
		2024	75.26 ± 87.21	687.39	11.35
		2025	44.37 ± 10.97	60.16	28.52
	Mid Kugmallit	2015	-	-	-
		2017	390.77 ± 396.90	1866.61	0.00
		2019	-	-	-
		2020	-	-	-
		2021	-	-	-
		2022	-	-	-
		2023	-	-	-
	Mid Kugmallit B	2016	-	-	-
	West Hendrickson	2015	-	-	-
		2017	-	-	-
		2019	-	-	-
		2020	-	-	-
		2021	-	-	-
		2022	-	-	-
		2023	-	-	-
		2024	-	-	-
		2025	216.55 ± 206.55	1116.67	5.61
Kugmallit Bay	Atkinson Point	2022	339.1 ± 147.96	858.10	10.73
		2023	-	-	-
Niaqunnaq	Escape Reef	2023	-	-	-
	Niaqunnaq	2020	-	-	-

Appendix D. Continued.

MPA Parcel	Location	Year	Average (± SD)	Max	Min
Niaqunnaq	Niaqunnaq East	2021	168.58 ± 120.51	713.56	18.60
		2022	180.98 ± 193.56	962.10	6.62
		2023	40.93 ± 54.97	514.88	0.34
		2024	-	-	-
		2025	-	-	-
	Niaqunnaq Mid	2023	132.18 ± 128.04	867.10	10.33
	Niaqunnaq North	2021	-	-	-
		2022	-	-	-
	Niaqunnaq West	2021	-	-	-
		2022	-	-	-
		2024	-	-	-
		2025	-	-	-
	Shingle Point Bay	2019	19.27 ± 19.18	78.61	0.13
		2020	34.01 ± 76.39	562.65	0.00
	Shingle Point Ocean	2019	149.17 ± 211.72	1080.50	3.27
		2020	253.69 ± 412.83	1511.74	0.45
		2021	107.24 ± 161.45	1203.09	4.46
		2022	-	-	-
Okeevik	Garry Island	2021	411.05 ± 252.12	1429.67	51.53
		2022	-	-	-
		2023	-	-	-
	Kendall Island	2021	64.32 ± 139.96	836.86	0.46
		2022	267.69 ± 224.71	1077.97	23.65
	Okeevik	2024	228.27 ± 239.49	1237.12	9.52
	Pelly Island	2023	186.36 ± 268.96	1137.45	0.00
		2025	-	-	-

Appendix E. Wave height and direction of origin within the TN MPA

Summary of wave height (m) and the direction of wave origin (degrees). Shown are average (± standard deviation), median, minimum, maximum, and the date with the maximum value for wave height; and the average (± standard deviation), median, minimum, and maximum values for the wave direction of origin. Refer to Table 1 for a summary of annual deployment and retrieval dates for each location.

			Wave Height (m)					Direction of Origin (degrees)			
MPA Parcel	**Location**	**Year**	**Average (± SD)**	**Median**	**Max**	**Min**	**Date of Max**	**Average (± SD)**	**Median**	**Max**	**Min**
Kittigaryuit	Channel	2015	-	-	-	-	-	-	-	-	-
		2016	-	-	-	-	-	-	-	-	-
		2017	-	-	-	-	-	-	-	-	-
	East Hendrickson	2017	-	-	-	-	-	-	-	-	-
	East Whitefish	2016	-	-	-	-	-	-	-	-	-
		2017	-	-	-	-	-	-	-	-	-
		2018	-	-	-	-	-	-	-	-	-
		2019	-	-	-	-	-	-	-	-	-
		2020	0.22 ± 0.10	0.22	0.60	0.03	1-Aug	99.26 ± 103.80	58.30	359.81	0.14
		2021	0.21 ± 0.11	0.19	0.55	0.02	6-Sep	138.42 ± 121.74	67.33	359.89	0.04
		2022	0.21 ± 0.11	0.20	0.67	0.02	18-Aug	129.27 ± 117.09	67.22	359.99	0.08
		2023	0.23 ± 0.10	0.22	0.62	0.03	9-Jul	109.57 ± 103.47	61.31	358.91	1.18
		2024	0.27 ± 0.17	0.23	1.13	0.03	27-Jul	162.79 ± 113.52	144.83	358.40	1.52
		2025	0.25 ± 0.16	0.22	1.12	0.04	11-Jul	135.74 ± 108.45	72.61	358.44	0.52
	Mid Kugmallit	2015	-	-	-	-	-	-	-	-	-
		2017	-	-	-	-	-	-	-	-	-
		2019	-	-	-	-	-	-	-	-	-
		2020	0.23 ± 0.09	0.23	0.64	0.02	2-Aug	109.4 ± 102.27	58.66	359.95	0.08
		2021	0.24 ± 0.09	0.24	0.59	0.03	25-Jun	147.59 ± 109.12	96.87	359.32	0.33
		2022	0.25 ± 0.13	0.24	0.85	0.03	18-Aug	125.97 ± 113.38	69.74	359.58	0.77
		2023	0.26 ± 0.10	0.25	0.72	0.04	2-Sep	121.25 ± 111	67.69	359.32	1.55
	Mid Kugmallit B	2016	-	-	-	-	-	-	-	-	-

Appendix E. Continued.

			Wave Height (m)					Direction of Origin (degrees)			
MPA Parcel	**Location**	**Year**	**Average (± SD)**	**Median**	**Max**	**Min**	**Date of Max**	**Average (± SD)**	**Median**	**Max**	**Min**
Kittigaryuit	West Hendrickson	2015	-	-	-	-	-	-	-	-	-
		2017	-	-	-	-	-	-	-	-	-
		2019	-	-	-	-	-	-	-	-	-
		2020	0.22 ± 0.09	0.22	0.56	0.01	2-Aug	85.25 ± 102.48	33.71	359.99	0.31
		2021	0.22 ± 0.09	0.22	0.52	0.02	5-Aug	111.98 ± 109.47	52.84	360.00	0.04
		2022	0.21 ± 0.09	0.20	0.60	0.03	8-Aug	118.18 ± 116.42	62.53	359.91	0.02
		2023	0.22 ± 0.09	0.21	0.59	0.04	3-Aug	105.32 ± 104.34	47.56	359.40	0.69
		2024	0.23 ± 0.10	0.23	0.69	0.03	27-Jul	143.41 ± 115.13	137.64	359.26	2.23
		2025	0.22 ± 0.09	0.21	0.68	0.04	8-Aug	126.28 ± 108.27	112.92	358.79	1.00
Kugmallit Bay	Atkinson Point	2022	0.43 ± 0.35	0.31	1.86	0.05	11-Aug	138.47 ± 145.49	46.06	360.00	0.08
		2023	0.45 ± 0.27	0.38	1.54	0.09	2-Sep	111.55 ± 134.09	30.39	359.54	0.47
Niaqunnaq	Escape Reef	2023	0.38 ± 0.21	0.34	1.25	0.07	2-Sep	219.69 ± 121.75	294.28	359.35	0.36
	Niaqunnaq	2020	0.22 ± 0.08	0.22	0.58	0.03	4-Jul	218.42 ± 118.53	288.66	359.89	0.18
	Niaqunnaq East	2021	0.25 ± 0.10	0.26	0.64	0.03	6-Sep	219.06 ± 97.91	252.04	359.90	0.27
		2022	0.23 ± 0.11	0.23	0.82	0.02	26-Jul	229.06 ± 97.30	282.11	359.23	0.07
		2023	0.22 ± 0.10	0.23	0.65	0.03	19-Sep	215.97 ± 95.66	248.55	355.01	1.76
		2024	0.77 ± 0.71	0.56	3.76	0.03	3-Sep	194.92 ± 110.08	189.00	359.31	0.18
		2025	0.25 ± 0.14	0.24	1.05	0.04	4-Aug	239.89 ± 88.36	285.14	358.51	3.36
	Niaqunnaq Mid	2023	0.25 ± 0.11	0.25	0.73	0.04	9-Jul	210.63 ± 106.60	232.77	358.10	0.91
	Niaqunnaq North	2021	0.39 ± 0.20	0.35	1.13	0.05	6-Sep	219.76 ± 122.12	281.75	359.79	0.03
		2022	0.25 ± 0.12	0.25	0.81	0.04	26-Jul	232.84 ± 106.70	287.76	359.85	0.32
	Niaqunnaq West	2021	0.31 ± 0.15	0.29	0.92	0.04	1-Aug	223.41 ± 110.11	278.71	359.45	0.39
		2022	0.30 ± 0.16	0.28	1.00	0.04	5-Sep	231.54 ± 108.76	297.06	359.98	0.08
		2024	0.32 ± 0.21	0.27	1.25	0.03	2-Aug	236.70 ± 104.01	298.12	358.28	2.20
		2025	0.39 ± 0.31	0.29	1.78	0.05	24-Aug	235.11 ± 102.07	297.52	358.28	0.78
	Shingle Point Bay	2019	-	-	-	-	-	-	-	-	-
		2020	0.09 ± 0.05	0.08	0.33	0.01	3-Jul	164.05 ± 100.44	119.55	359.47	0.68

Appendix E. Continued.

			Wave Height (m)					Direction of Origin (degrees)			
MPA Parcel	**Location**	**Year**	**Average (± SD)**	**Median**	**Max**	**Min**	**Date of Max**	**Average (± SD)**	**Median**	**Max**	**Min**
Niaqunnaq	Shingle Point Ocean	2019	-	-	-	-	-	-	-	-	-
		2020	0.39 ± 0.26	0.32	1.49	0.05	4-Jul	202.81 ± 151.00	315.08	359.97	0.02
		2021	0.46 ± 0.30	0.37	1.70	0.03	12-Aug	218.35 ± 137.32	298.80	359.89	0.09
		2022	0.44 ± 0.31	0.38	1.77	0.06	4-Sep	237.18 ± 134.86	317.73	359.81	0.15
Okeevik	Garry Island	2021	0.23 ± 0.09	0.23	0.61	0.04	14-Jul	190.21 ± 134.83	158.57	359.98	0.03
		2022	0.22 ± 0.10	0.21	0.63	0.04	14-Jul	195.21 ± 136.14	170.72	359.92	0.11
		2023	0.23 ± 0.09	0.23	0.62	0.04	2-Sep	173.88 ± 128.23	115.94	359.61	1.00
	Kendall Island	2021	0.19 ± 0.07	0.19	0.47	0.03	11-Jul	158.99 ± 126.06	80.01	359.93	0.11
		2022	0.20 ± 0.10	0.20	0.68	0.03	18-Aug	172.64 ± 121.98	110.17	359.83	0.03
	Okeevik	2024	0.27 ± 0.17	0.25	1.11	0.03	20-Aug	201.16 ± 118.04	206.08	358.81	1.00
	Pelly Island	2023	0.34 ± 0.18	0.30	1.09	0.04	23-Aug	139.00 ± 129.68	73.63	359.40	0.47
		2025	0.27 ± 0.18	0.25	1.15	0.05	29-Aug	132.37 ± 101.22	114.87	358.84	0.83

Appendix F. Mean and peak wave period within the TN MPA

Summary of mean period (s) and peak period (s) of waves in the TN MPA. Shown are average (± standard deviation), median, minimum, maximum values for both mean and peak period. Refer to Table 1 for a summary of annual deployment and retrieval dates for each location.

			Mean Period (s)				Peak Period (s)			
MPA Parcel	**Location**	**Year**	**Average (± SD)**	**Median**	**Max**	**Min**	**Average (± SD)**	**Median**	**Max**	**Min**
Kittigaryuit	Channel	2015	-	-	-	-	-	-	-	-
		2016	-	-	-	-	-	-	-	-
		2017	-	-	-	-	-	-	-	-
	East Hendrickson	2017	-	-	-	-	-	-	-	-
	East Whitefish	2016	-	-	-	-	-	-	-	-
		2017	-	-	-	-	-	-	-	-
		2018	-	-	-	-	-	-	-	-
		2019	-	-	-	-	-	-	-	-
		2020	2.60 ± 0.67	2.38	5.68	1.93	7.88 ± 8.24	2.80	29.86	1.59
		2021	2.69 ± 0.89	2.35	6.45	1.76	9.39 ± 9.06	2.76	29.86	1.43
		2022	2.74 ± 0.93	2.36	6.69	1.86	9.17 ± 8.77	2.76	29.86	1.29
		2023	2.48 ± 0.54	2.33	5.06	1.73	7.91 ± 8.25	2.65	29.86	1.60
		2024	2.66 ± 1.03	2.31	8.24	1.68	9.51 ± 8.96	2.72	29.86	1.38
		2025	2.63 ± 0.95	2.32	7.81	1.75	9.44 ± 8.84	2.68	34.12	1.30
	Mid Kugmallit	2015	-	-	-	-	-	-	-	-
		2017	-	-	-	-	-	-	-	-
		2019	-	-	-	-	-	-	-	-
		2020	2.19 ± 0.36	2.11	4.47	1.69	5.87 ± 7.13	2.27	29.86	1.27
		2021	2.19 ± 0.28	2.13	4.00	1.80	5.99 ± 7.16	2.27	29.86	1.47
		2022	2.44 ± 0.61	2.26	5.59	1.63	7.18 ± 7.97	2.55	29.86	1.50
		2023	2.28 ± 0.30	2.21	3.92	1.68	5.02 ± 6.00	2.38	27.30	1.33
	Mid Kugmallit B	2016	-	-	-	-	-	-	-	-
	West Hendrickson	2015	-	-	-	-	-	-	-	-
		2017	-	-	-	-	-	-	-	-
		2019	-	-	-	-	-	-	-	-

Appendix F. Continued.

MPA Parcel	Location	Year	Mean Period (s)				Peak Period (s)			
			Average (± SD)	Median	Max	Min	Average (± SD)	Median	Max	Min
Kittigaryuit	West Hendrickson	2020	2.21 ± 0.29	2.15	3.54	1.65	5.46 ± 6.71	2.30	29.86	1.30
		2021	2.24 ± 0.35	2.14	4.08	1.69	6.23 ± 7.39	2.22	29.86	1.34
		2022	2.34 ± 0.52	2.19	5.03	1.77	7.72 ± 8.09	2.34	29.86	1.38
		2023	2.37 ± 0.46	2.23	4.67	1.73	7.01 ± 7.44	2.36	34.12	1.40
		2024	2.48 ± 0.63	2.26	5.48	1.73	8.80 ± 8.53	2.76	34.12	1.43
		2025	2.46 ± 0.58	2.27	5.75	1.81	9.94 ± 8.84	3.46	34.12	1.50
Kugmallit Bay	Atkinson Point	2022	3.77 ± 1.68	3.16	10.45	1.85	9.06 ± 7.73	5.25	29.86	1.38
		2023	3.57 ± 1.07	3.28	8.15	2.10	6.91 ± 5.49	4.69	25.60	1.66
Niaqunnaq	Escape Reef	2023	2.88 ± 0.73	2.67	5.97	1.74	4.53 ± 2.83	3.61	17.06	1.47
	Niaqunnaq	2020	2.25 ± 0.28	2.17	3.71	1.80	6.95 ± 7.72	2.32	29.86	1.51
	Niaqunnaq East	2021	2.31 ± 0.35	2.22	4.34	1.70	6.89 ± 7.76	2.45	29.86	1.44
		2022	2.32 ± 0.50	2.19	5.46	1.69	7.29 ± 7.90	2.49	29.86	1.52
		2023	2.19 ± 0.34	2.11	4.03	1.57	6.84 ± 7.74	2.32	29.86	1.32
		2024	7.99 ± 4.20	8.26	19.41	1.87	21.40 ± 6.51	23.04	34.14	1.46
		2025	2.47 ± 0.85	2.21	7.20	1.82	8.14 ± 8.40	2.53	29.87	1.40
	Niaqunnaq Mid	2023	2.27 ± 0.33	2.20	4.09	1.55	5.25 ± 6.18	2.40	29.86	1.46
	Niaqunnaq North	2021	2.81 ± 0.61	2.65	5.62	1.71	4.95 ± 4.30	3.30	23.04	1.53
		2022	2.29 ± 0.38	2.20	4.39	1.61	5.61 ± 6.52	2.40	29.86	1.43
	Niaqunnaq West	2021	2.49 ± 0.46	2.36	4.94	1.76	5.38 ± 5.78	2.61	27.30	1.49
		2022	2.51 ± 0.53	2.34	5.10	1.58	6.48 ± 6.82	2.68	29.86	1.44
		2024	3.00 ± 1.15	2.61	8.73	1.92	9.93 ± 8.82	4.74	34.14	1.51
		2025	3.71 ± 2.49	2.60	13.92	1.82	10.97 ± 9.30	5.12	29.87	1.51
	Shingle Point Bay	2019	-	-	-	-	-	-	-	-
		2020	3.88 ± 1.92	3.34	11.25	1.60	17.46 ± 8.11	20.48	34.12	1.29
	Shingle Point Ocean	2019	-	-	-	-	-	-	-	-
		2020	2.98 ± 0.72	2.83	6.04	1.67	4.65 ± 3.06	3.92	18.77	1.33
		2021	3.15 ± 0.90	2.98	7.13	1.56	6.37 ± 5.99	4.08	29.86	1.52
		2022	3.14 ± 0.89	2.93	7.00	1.78	6.29 ± 5.66	4.08	27.30	1.59

Appendix F. Continued.

MPA Parcel	Location	Year	Mean Period (s)				Peak Period (s)			
			Average (± SD)	Median	Max	Min	Average (± SD)	Median	Max	Min
Okeevik	Garry Island	2021	2.43 ± 0.56	2.23	4.81	1.69	6.43 ± 6.65	2.99	29.86	1.28
		2022	2.54 ± 0.64	2.30	5.55	1.81	11.24 ± 8.43	11.15	29.86	1.29
		2023	2.62 ± 0.69	2.36	5.65	1.62	10.61 ± 7.99	9.49	34.12	1.44
	Kendall Island	2021	2.15 ± 0.33	2.05	3.86	1.73	7.39 ± 8.35	2.17	34.12	1.42
		2022	2.23 ± 0.56	2.05	5.13	1.58	7.86 ± 8.35	2.17	29.86	1.26
	Okeevik	2024	2.76 ± 1.33	2.22	9.33	1.78	8.97 ± 8.79	2.36	34.14	1.39
	Pelly Island	2023	2.89 ± 0.88	2.61	6.79	1.52	6.05 ± 5.20	4.45	25.60	1.37
		2025	2.74 ± 1.07	2.34	8.32	1.83	9.73 ± 9.00	3.30	29.87	1.49

Appendix G. Freshwater level at select ECCC hydrometric monitoring stations

Summary of peak timing and water level (m) at Environment and Climate Change Canada (ECCC) monitoring stations located on the East and Middle Channels of the Mackenzie River from 2015-2025. Peak timing is summarized with the start and end dates of the peak period, date of three-day maximum water level, and centre of timing. Water level is summarized as number of high-water days, average (± standard deviation), median, and maximum values. Refer to Table 2 for a summary of ECCC monitoring station locations.

			Peak Timing				Water Level (m)			
Channel	ECCC Station	Year	Start Date of Peak	Date of 3-Day Max	End Date of Peak	Centre of Timing	High-water Days	Average (± SD)	Median	Max
East	10LC002	2015	16-May	24-May	1-Jun	15-Jul	16	12.32 ± 0.81	12.00	15.45
		2016	12-May	20-May	28-May	14-Jul	16	12.48 ± 0.81	12.36	15.00
		2017	20-May	28-May	5-Jun	14-Jul	16	12.42 ± 0.94	12.33	15.48
		2018	17-May	26-May	2-Jun	15-Jul	16	12.42 ± 0.82	12.26	14.97
		2019	17-May	23-May	2-Jun	15-Jul	16	12.12 ± 0.56	12.00	14.16
		2020	23-May	1-Jun	8-Jun	15-Jul	16	13.35 ± 0.81	13.13	16.33
		2021	24-May	28-May	9-Jun	14-Jul	16	13.07 ± 0.91	12.65	15.46
		2022	24-May	30-May	9-Jun	13-Jul	16	13.08 ± 1.24	12.78	16.92
		2023	17-May	25-May	4-Jun	15-Jul	15	12.13 ± 1.01	11.70	15.89
		2024	21-May	30-May	6-Jun	15-Jul	16	11.88 ± 0.67	11.64	13.90
	10LC013	2015	14-May	25-May	28-May	15-Jul	16	9.91 ± 0.39	9.80	11.71
		2016	13-May	24-May	28-May	16-Jul	16	9.95 ± 0.31	9.86	11.17
		2017	20-May	30-May	3-Jun	20-Jul	14	10.00 ± 0.37	9.96	11.32
		2019	16-May	27-May	31-May	15-Jul	16	9.91 ± 0.29	9.81	10.89
		2021	27-May	5-Jun	9-Jun	28-Jul	13	10.05 ± 0.45	9.93	11.62
		2022	26-May	3-Jun	8-Jun	28-Jul	13	9.98 ± 0.36	9.94	11.40
		2023	19-May	28-May	30-May	30-Jun	9	10.07 ± 0.43	9.88	11.17
		2025	24-May	5-Jun	9-Jun	15-Jul	16	10.03 ± 0.32	9.94	11.05
Middle	10MC008	2016	10-May	18-May	1-Jun	17-Jul	15	12.20 ± 0.76	12.00	14.87
		2021	21-May	4-Jun	28-May	14-Jul	16	12.91 ± 0.85	12.59	15.22
		2022	22-May	29-May	3-Jun	15-Jul	14	12.87 ± 1.38	12.34	16.58
		2023	15-May	25-May	14-Jun	18-Jul	14	11.84 ± 1.22	11.34	16.33
		2024	19-May	26-May	4-Jun	14-Jul	16	11.61 ± 0.75	11.34	13.85
		2025	24-May	1-Jun	9-Jun	14-Jul	16	11.82 ± 0.84	11.55	15.27

Appendix G. Continued.

			Peak Timing				Water Level (m)			
Channel	**ECCC Station**	**Year**	**Start Date of Peak**	**Date of 3-Day Max**	**End Date of Peak**	**Centre of Timing**	**High-water Days**	**Average (± SD)**	**Median**	**Max**
Middle	10MC023	2015	19-May	24-May	1-Jun	15-Jul	16	11.35 ± 0.59	11.12	13.36
		2016	14-May	22-May	29-May	15-Jul	16	11.42 ± 0.51	11.26	13.13
		2017	24-May	29-May	3-Jun	13-Jul	10	11.39 ± 0.72	11.12	13.41
		2018	20-May	28-May	5-Jun	15-Jul	16	11.41 ± 0.54	11.27	13.25
		2019	20-May	26-May	31-May	15-Jul	16	11.26 ± 0.39	11.16	12.59
		2020	24-May	2-Jun	8-Jun	15-Jul	16	11.86 ± 0.52	11.68	13.79
		2021	25-May	31-May	10-Jun	14-Jul	16	11.79 ± 0.69	11.64	13.68
		2022	26-May	2-Jun	11-Jun	14-Jul	16	11.79 ± 0.78	11.64	14.37
		2023	19-May	27-May	4-Jun	14-Jul	16	11.31 ± 0.67	11.11	13.69
		2024	23-May	2-Jun	8-Jun	15-Jul	16	11.24 ± 0.48	11.04	12.58
		2025	26-May	4-Jun	11-Jun	15-Jul	16	11.16 ± 0.49	11.00	12.90
	10LC019	2016	12-May	24-May	13-May	4-Jul	13	10.05 ± 0.36	9.92	10.97
		2019	27-May	28-May	1-Jun	26-Jun	7	9.88 ± 0.23	9.82	10.59
		2021	30-May	6-Jun	12-Jun	30-Jul	13	10.20 ± 0.34	10.12	11.37
		2022	23-May	1-Jun	14-Jul	23-Jul	12	10.51 ± 0.36	10.47	11.44
		2024	22-May	25-May	29-May	10-Jun	8	10.33 ± 0.40	10.24	11.01
		2025	23-May	4-Jun	8-Jun	14-Jul	16	10.02 ± 0.60	9.99	11.24

Appendix H. Freshwater discharge at select ECCC hydrometric monitoring stations

Summary of peak timing and discharge rate (m^3/s) at Environment and Climate Change Canada (ECCC) monitoring stations located on the East and Middle Channels of the Mackenzie River from 2015-2025. Peak timing is summarized with the start and end dates of the peak period, date of three-day maximum water level, and centre of timing. Discharge is summarized as number of high-discharge water days, average (± standard deviation), median, and maximum values. Refer to Table 2 for a summary of ECCC monitoring station locations.

			Peak Timing				Water Level (m)			
Channel	**ECCC Station**	**Year**	**Start Date of Peak**	**Date of 3-Day Max**	**End Date of Peak**	**Centre of Timing**	**High-discharge Days**	**Average (± SD)**	**Median**	**Max**
East	10LC002	2015	18-May	24-May	3-Jun	6-Jul	16	210.67 ± 140.34	171.00	776.00
		2016	16-May	23-May	1-Jun	5-Jul	16	241.98 ± 127.82	211.00	675.00
		2017	21-May	30-May	6-Jun	3-Jul	16	234.29 ± 165.38	217.00	790.00
		2018	19-May	26-May	4-Jun	5-Jul	16	242.52 ± 152.38	203.22	752.41
		2019	20-May	25-May	3-Jun	11-Jul	16	182.22 ± 95.04	162.28	508.72
		2020	24-May	1-Jun	8-Jun	11-Jul	16	453.55 ± 222.47	395.50	1333.99
		2021	24-May	28-May	9-Jun	1-Jul	16	401.95 ± 226.37	299.00	1060.00
		2022	23-May	2-Jun	10-Jun	30-Jun	15	387.02 ± 282.21	297.00	1370.00
		2023	17-May	25-May	4-Jun	21-Jun	15	215.29 ± 226.88	118.26	1210.00
		2024	21-May	29-May	6-Jun	29-Jun	16	156.87 ± 123.02	108.00	558.00
Middle	10MC008	2015	18-May	19-May	3-Jun	15-Jul	16	11606.86 ± 3154.43	11500.00	21600.00
		2016	13-May	19-May	30-May	12-Jul	17	13320.39 ± 3684.26	12900.00	23300.00
		2024	20-May	27-May	5-Jun	5-Jul	16	8842.81 ± 4081.64	7630.00	21000.00
		2025	23-May	29-May	10-Jun	13-Jul	15	10368.61 ± 5045.05	9725.00	28400.00