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RESEARCH

Implications of changing shipping patterns near communities across Arctic Canada

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Abstract

The increase in shipping in the Canadian Arctic has significant impacts on Inuit coastal communities and their traditional way of life. Examples include the risk of chemical spills, underwater noise and ships' hulls acting as vectors for non-indigenous species, all of which impact ecosystems and wildlife which Inuit rely on for health, food security and cultural sustainability. However, the number and types of ships travelling near communities and the associated risks remain poorly quantified, limiting effective management strategies. We use ship tracklines generated from Automatic Identification System (AIS) ship positions between 2013 and 2022 to calculate voyages within 20 km of 43 communities distributed throughout Northern Canada (north of 60° N and Hudson Bay). Over 10 years, voyages increased significantly by a factor of 1.7 (from 116 in 2013 to 317 in 2022), with the largest increases due to dry bulk, cargo and government/research vessels. This varies between communities, with 15 (35%) having shown little change or a small decrease in shipping, and 28 (65%) showing an increase. Six communities accounted for the majority of the overall increase. We examine these sites in detail, identifying drivers behind the voyage increases such as the proximity to mines, growing resupply needs, tourism expansion and increased navigability along transit routes close by due to the reduction in sea ice. Our results on the rate and drivers of change in ship traffic provide essential insights for local and regional governance of shipping impacts.

Keywords Arctic · Shipping · Communities · Impacts

Introduction

Shipping has been increasing throughout the Canadian Arctic for decades, with the greatest increases along major maritime trade routes, including Hudson Strait (Arctic Bridge), along western Baffin Bay from Davis Strait to the north of Baffin Island, and the southern route of the Northwest Passage (Pizzolato et al. 2014, 2016; Dawson et al. 2018, 2022; Supp. Figure 1). Between 1990 and 2015, the total annual distance travelled by ships increased by more than 250% (Dawson et al. 2018). Growth has been driven by socioeconomic changes, including natural resource development (Tai et al. 2019; van Luijk et al. 2019), increased tourism (Lassere and Tetu, 2015; Weber et al. 2021) and trans-Arctic trade aspirations (Zhao and Zhang, 2024; Melia et al. 2016), all enabled by declining sea ice (Dawson et al. 2017; Mudryk et al. 2021; Copland et al. 2021). Sea ice extent in the Canadian Arctic has decreased by 5–20% per decade over the past fifty years (Mudryk et al. 2021). Although regional-scale trends in Arctic shipping have been previously assessed in prior studies, fine-scale patterns of vessel traffic near coastal communities remain almost entirely undocumented. This gap is particularly striking in the Canadian Arctic, where no peer-reviewed analysis has quantified community-proximal shipping at a national scale. Although vessel traffic in the Canadian Arctic is a growing and legitimate concern for communities, overall traffic volumes remain substantially

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lower than in other circumpolar regions such as Greenland, Svalbard and Northern Europe (PAME 2024; Müller et al. 2023; Sander and Mikkelsen 2025). This contrast underscores the importance of understanding how even relatively modest increases in local traffic could have cumulative and outsized impacts on Inuit communities whose marine environments are highly sensitive and culturally significant.

Traditional coastal communities are widely distributed throughout the Canadian Arctic, in the Inuit homeland known as Inuit Nunangat, and would be affected if the number of ships travelling near them changes. Increased shipping poses risks to the environment that is central to Inuit culture and livelihood, including harvesting marine and terrestrial species for consumption, sharing and subsistence, for travel, physical and mental health, and to support the Inuit knowledge system (Inuit Tapiriit Kanatami (ITK) 2017, 2018; Parks Canada 2019; see also arcticcorridors.ca/reports). Marine areas also hold deep cultural significance and are accessed year-round (ICC 2014; See also arcticcorridors.ca/reports). At the same time, residents in Canadian Arctic communities depend on non-community-based ships for essential resupply of goods, food and fuel, and, in some cases, tourism as a source of income (e.g. sale of traditional arts and crafts, landing fees and tourist guide income). Perceptions of shipping among Inuit vary based on whether the vessel brings clear benefits to the community (e.g. resupply vessels) or have less direct benefits (e.g. bulk carriers).

Inuit are highly aware that shipping is increasing, through seeing it first hand at their doorstep, and have articulated concerns about shipping's impact on marine and coastal environments, wildlife and access to traditional "country food" (marine mammals, fish and plants) (Zhu et al. 2023; ICC 2008; ITK 2018; Dawson et al. 2020b; van Luijk et al. 2022; see arcticcorridors.ca/reports). Environmental risks from shipping can include: oil, fuel and other chemical spills (van Luijk et al. 2019; Nunavut Impact Review Board, 2020); underwater noise pollution impacting marine mammals, fishes and invertebrates (Halliday et al. 2017; 2022); and ballast water and hull fouling introducing non-indigenous, potentially invasive, species (Goldsmit et al. 2018; Boyse et al. 2025). The increasing shipping season length means that icebreakers in particular travel more frequently in the early and late season, disrupting sea ice development/roughness, which has major impacts on wildlife and hunters (Dawson et al. 2020a). Despite these community-identified concerns, there remains no systematic quantification of shipping exposure at the community scale, limiting the ability of communities and decision-makers to evaluate local risks, plan adaptations and shape emerging policy.

Inuit concerns about increased shipping were identified through the Arctic Corridors Northern Voices (ACNV) research project (Dawson et al. 2020a; also see https://www.arcticcorridors.ca/), where Inuit from 14 communities mapped culturally significant areas most vulnerable to shipping. This work produced adaptation strategies and policy advice (Dawson et al. 2017; 2020b). These findings underscored the need for empirical, spatially explicit data on vessel traffic near communities that until now have not existed. As vessel traffic continues to expand across the Arctic, establishing community-scale baselines is increasingly urgent. The relative sparsity of shipping in the Canadian Arctic today presents a critical opportunity to document current patterns and develop strong governance approaches before traffic intensifies in the coming decades.

Here, we use a dataset of ship tracks derived from Automatic Identification System (AIS) data to quantify voyages within 20 km of 43 Canadian Arctic communities over the past decade, the first large-scale assessment of community-proximal shipping anywhere in the Canadian Arctic. By identifying which vessel types most commonly travel near each community and how these patterns are changing, we provide an evidence base for future research on community-level impacts and highlight locations at greatest risk. By generating novel, community-scale traffic patterns, our study fills a critical knowledge gap and directly supports Inuit self-determination in shipping governance, enabling more informed participation in regional, national and international policy processes.

Study area, data and methods

Our study uses ship tracklines that were modelled from AIS ship position data (2013–2022) by Nicoll et al. (2025). A summary of the methods used by Nicoll et al. (2025) to clean and filter the raw position data, then convert them to tracklines using linear interpolation between consecutive positions, is provided in Supplementary Information. AIS data has limitations, such as signal manipulation and detection gaps, but robust data cleaning techniques were employed to reduce errors to a minimum, resulting in a trackline dataset with high vessel coverage and temporal resolution and accurate filtering (Nicoll et al. 2025; Supplementary Information). We attributed the ship types (acquired from online marine intelligence databased sources) to the tracklines, enabling quantification of vessel voyages by ship type. The AIS dataset available to us covered the region north of 60°, plus Hudson Bay. This region includes 43 currently inhabited coastal communities, which vary in population size from 104 in Sachs Harbour, to 7429 in the largest community, Iqaluit (in the 2021 Canadian Population Census) (Supp. Figure 1, Supp. Table 1).

Geographic analyses were conducted in ArcGIS Pro 3.1.0 and statistical analyses in Microsoft Excel, with our method illustrated in the flowchart (Fig. 1). To assess ships travelling close to communities, tracklines were clipped to 20-km radius circular buffer polygons around each community.

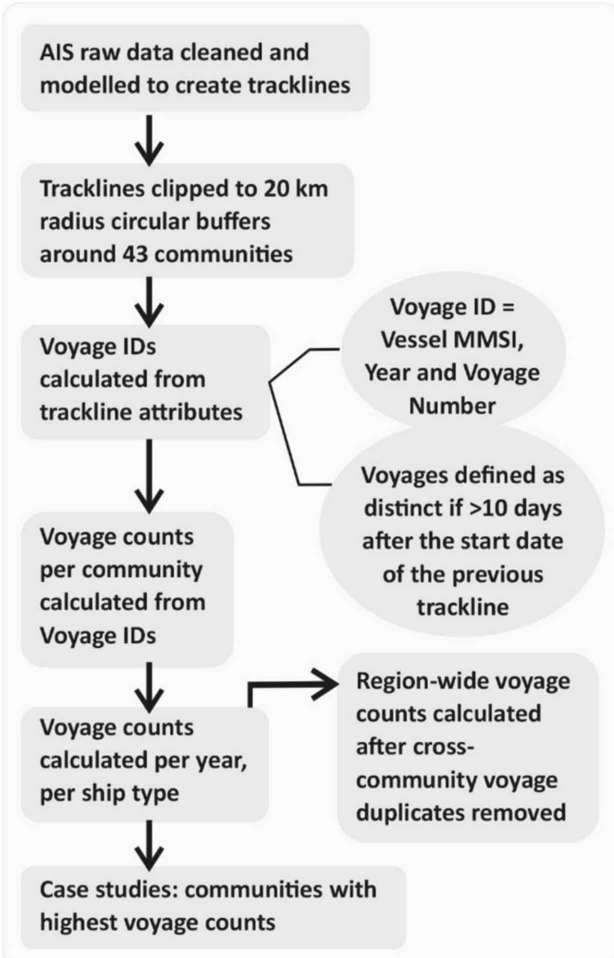

Fig. 1 Shipping data analysis methodology

This distance was chosen based on information such as local travel routes mapped during the ACNV project (Dawson et al. 2020a) and validated by Inuit team members from Arviat and Mittimatalik (Pond Inlet). The objective was to capture vessels that both enter the port/harbour of each community and those that transit close to communities, as well as areas of frequent harvesting, fishing and cultural activities (Dawson et al. 2020a; van Luijk et al. 2022). The navigable area within the 20-km buffers varies between communities due to the coastline shape; however, the consistent distance from each community enabled statistical comparisons for the regions of travel from the communities, whilst omitting vessels that transit further offshore.

Voyage "IDs" were attributed to each trackline, based on the vessel Maritime Mobile Service Identity (MMSI), year and the voyage number for that year. Individual tracklines have varying frequencies of start and end dates, as they were interpolated from the AIS positions recorded on intervals ranging from a few minutes to several days (Nicoll et al. 2025). We define voyages as distinct when the trackline start date occurs more than 10 days after the start date of the vessel's previous trackline. "Voyage count" at each community was then defined as the number of distinct voyages within 20 km of the community. This means that vessels may have stayed close to communities for a few days, but these were counted as only one voyage. For regionwide community voyage counts, Voyage ID duplicates were removed, resulting in unique voyage calculations. The method we used to calculate voyage counts enabled a consistent quantification of changes in shipping per year, at both a local and regional scale. It must be noted that the number of vessels present near a community at any one time may have been greater than the calculated voyage counts due to omissions in the AIS data (see dataset limitations in Supplementary Information).

There are 11 vessel types ascribed to vessels in the trackline dataset (Supp. Table 2). Tugs/Port Vessels were excluded, as they operate daily around most communities and therefore do not have independent voyages as defined in our study. Local boats (i.e. small boats used for travel and hunting) are also not included in the dataset, meaning results reflect mostly non-community-based ships.

Given the 10-year timeframe, annual trends were tested with a non-parametric Mann–Kendall test. Changes over time were significant when p-value < 0.05. To compare communities, we also calculated mean differences in annual voyage counts between two 5-year periods. All results were validated and interpreted in collaboration with Inuit team members from Arviat and Mittimatalik.

Results

Changes in overall ship voyages near communities

The total number of ship tracklines between 2013 and 2022 varied across the region north of 60° N and Hudson Bay, with highest densities occurring in the Hudson Strait and west Baffin Bay (Fig. 2a). As a result, the geographical distribution of ship voyage counts within 20 km of communities varied from 2 at Qamani'tuaq (Baker Lake) to 988 at Mittimatalik (Fig. 2b; Supp. Figure 1; Supp. Table 3). Total annual voyage counts close to all 43 communities increased from 116 voyages in 2013 to 317 voyages in 2022, with a statistically significant linear trend (Mann–Kendall p-value 0.002) (Fig. 3). This is an increase of 201 voyages, and a factor increase of 1.73. At this constant linear trend, the forecast is 451 voyages by 2030. Of course, this forecast will be affected by factors such as caps on shipping activity around mines (e.g. Baffinland Mary River Mine has a 20-year lifespan; therefore, activities are due to cease in 2035), and limits to the number of ice breakers and cruise ships that exist. The increase in ship traffic observed at the community scale is also seen throughout the region as a

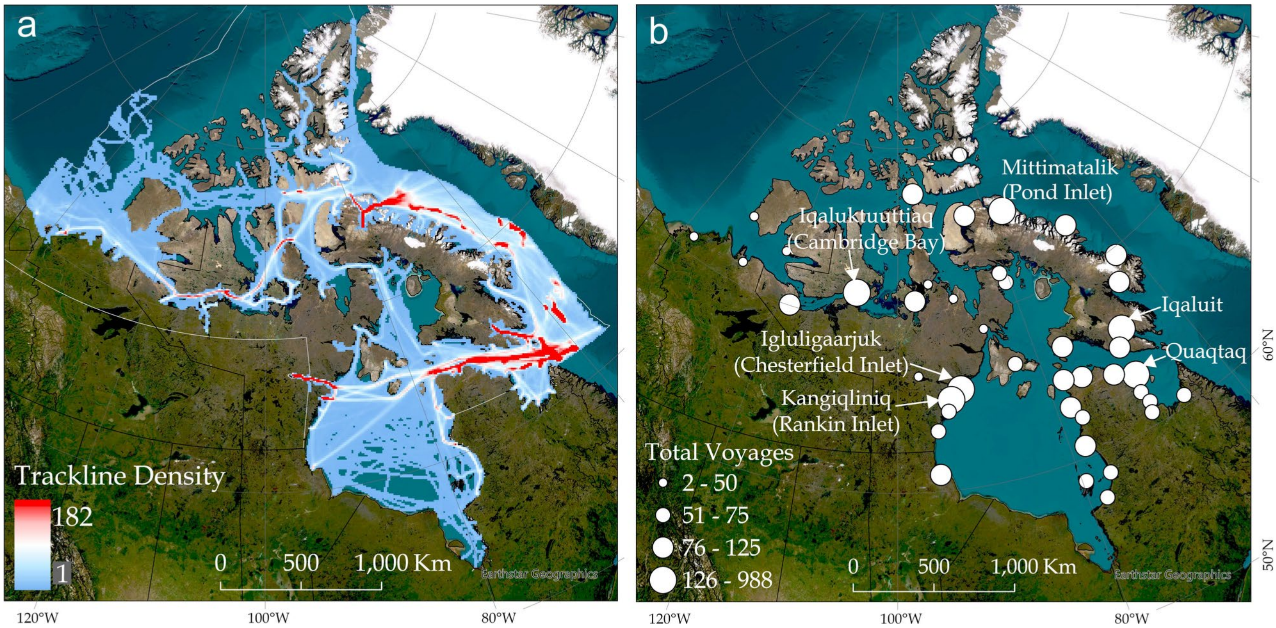

Fig. 2 **a** Trackline density for all ship tracks between 2013 and 2022 (tracklines per 10 km^2 grid cell). **b** Total voyage counts (2013–2022) within 20 km of each community are shown by graduated symbol size for each community. The six communities with the highest voyage counts are labelled

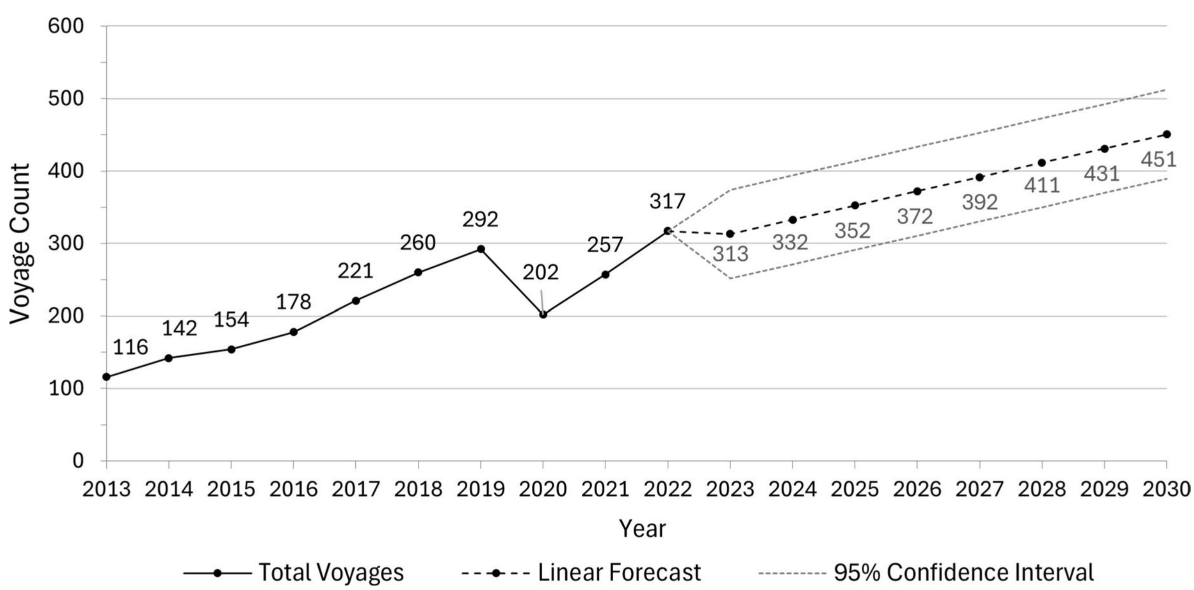

Fig. 3 Total voyage counts per year within 20 km of all 43 communities between 2013 and 2022, with a linear forecast between 2023 and 2030

whole (Supp. Figure 2). The sizeable reduction in voyage counts in the year 2020 was due to the COVID-19 Pandemic, when there was a global reduction in shipping activity (March et al. 2021), with 2021 being the recovery year, followed by the return to normal shipping activity in 2022.

Communities that have had the largest total voyage counts have also experienced some of the highest increases in voyage counts over this period (Fig. 4; Supp. Table 3). Mittimatalik has shown a much greater increase than any other community, from 41 voyages in 2013 to 143 in 2022

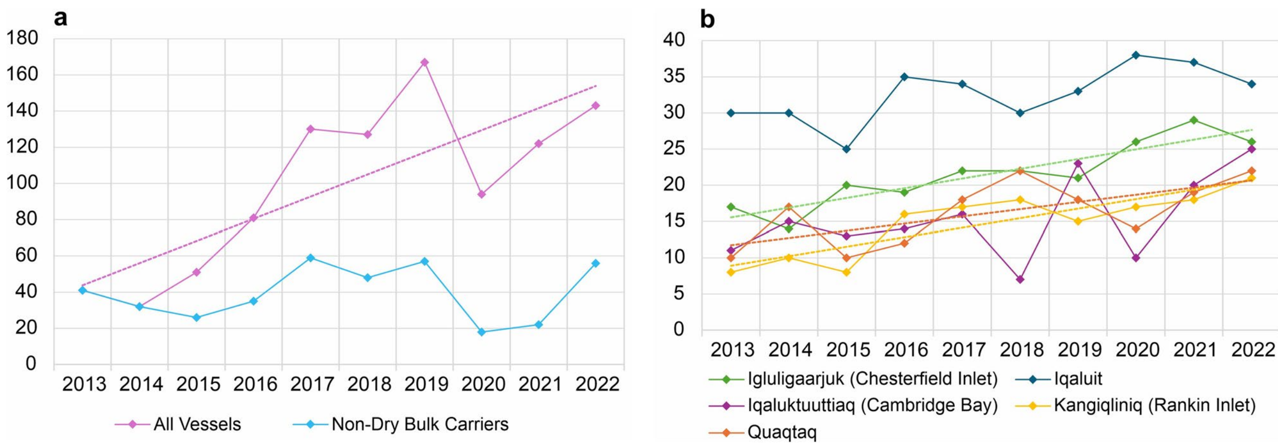

Fig. 4 Voyage counts per year for communities with the highest total voyage counts between 2013 and 2022. Linear trendlines are dashed lines, shown for communities where the increase is statistically significant (p-value < 0.05). **a** Annual voyage counts for Mittimatalik for all vessels and with dry bulk carriers removed. **b** The annual voyage counts for the next five most frequently visited communities: Igluligaarjuk (Chesterfield Inlet), Quaqtaq, Kangiqliniq (Rankin Inlet), Iqaluit and Iqaluktuuttiaq (Cambridge Bay)

(Fig. 4a). This large increase is primarily due to the opening of the Baffinland Mary River Iron Ore Mine in 2015, which has resulted in a vast number of Bulk Carriers transiting through Eclipse Sound and passing by Mittimatalik on the way to/from the port at the head of Milne Inlet. This community will be examined in more detail in the "Case studies: Communities with highest voyage counts" section. If Bulk Carrier tracklines are removed from the voyage counts close to Mittimatalik there is a substantially smaller increase in total voyages by other vessels, from 41 to 56, without statistical significance over the 10-year period (Fig. 4a). The number of Bulk Carriers travelling close to this community is so great that, without these, the sum total of voyages around all 43 communities is substantially reduced. Whereas the overall voyage count around all communities has increased by a factor of 1.73, without Bulk Carriers this is reduced to a factor increase of 1.24, from 103 voyages in 2013 to 231 in 2022 (Supp. Figure 3). The increase is lower but still statistically significant (Mann–Kendall p-value 0.02).

After Mittimatalik, the next five most visited communities over the 10-year period have all experienced annual increases in voyage counts, with Igluligaarjuk (Chesterfield Inlet), Quaqtaq and Kangiqliniq (Rankin Inlet) each showing a statistically significant linear trend (p-values 0.004, 0.02 and 0.005 respectively) (Fig. 4b). Iqaluit and Iqaluktuuttiaq (Cambridge Bay) have also shown an overall increase in voyages, but without a statistically significant trend. We look at these communities as case studies for determining the primary drivers of voyage increases ("Case studies: Communities with highest voyage counts").

There has not been an increase in voyages at all communities, but rather there is considerable variation in voyage change between communities. Of the 43 communities, 28 (65%) have shown an increase in mean voyage numbers from the early (2013–2017) to recent (2018–2022) time periods (Fig. 5; Supp. Table 3). This ranges in scale, from a mean increase of 0.2 voyages per year (Ikpiarjuk (Arctic Bay), Pangnirtung and Kangirsuk), which are not significant, to 63.6 voyages per year (Mittimatalik), which shows a significant increase in ship traffic. In total, 11 (25.6%) communities have shown an overall decrease in voyage count, with the largest decrease (3.4 voyages per year) occurring at Qausuittuq (Resolute). Four communities had no difference in mean voyage counts between the two time periods (Fig. 5; Supp. Table 3). The geographic distribution of changes in shipping at communities follows no distinct pattern but can be linked to the regionwide changes in trackline densities (Supp. Figure 4). For example, increases have occurred at locations on primary shipping routes, including northwest Baffin Bay, Hudson Strait and through Chesterfield Inlet. There is no direct link between the local shape of the coastline (which determines the navigable area surrounding the communities) and voyage counts (Supp. Table 3).

Changes in ship voyages near communities by ship types

Knowing the drivers of the increase in voyages at communities where this has occurred could lead to a better understanding of how shipping may change for other communities in the future. The types of ships that visit communities is a key characteristic that could explain any temporal patterns, at both a regional and local scale, and help with risk mitigation.

There are 10 different types of ships in our dataset (Supp. Table 4). For all 43 communities combined, between the

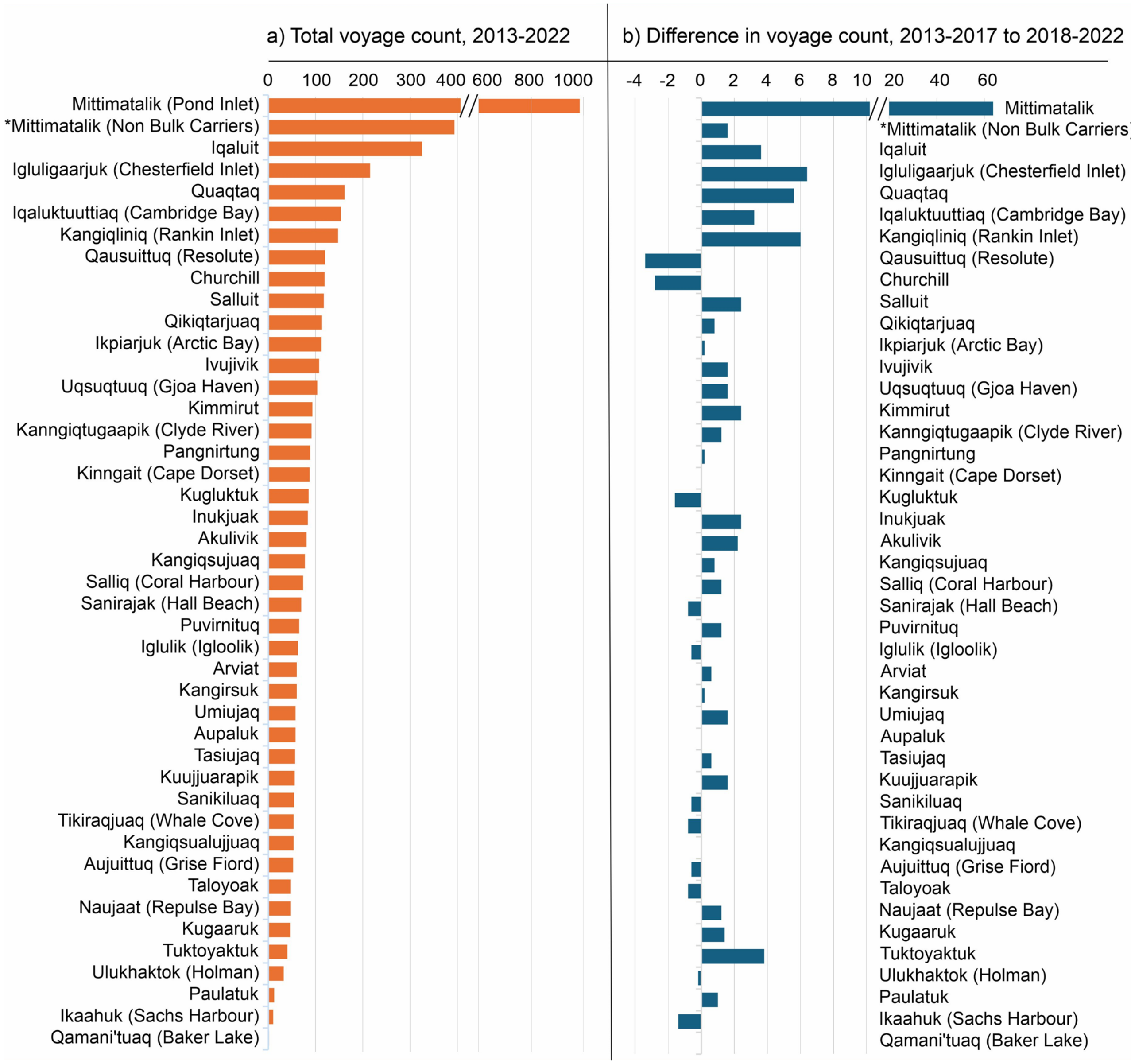

Fig. 5 Total voyage counts (2013–2022) and difference in voyage counts from mean 2013–2017 to mean 2018–2022 for each community. *Mittimatalik voyage counts not including dry bulk carriers are shown beneath the same community total voyage counts

years 2013 and 2022, there has been an increase in the number of voyages of 8 of the ship types: cargo, dry bulk, fishing, government/research, passenger, pleasure and tanker vessels (Fig. 6; Supp. Table 4). Ferry and "Roll-on Roll-off" (Ro-Ro) vessels showed a reduction in voyages, and container vessel voyages were minimal (6 in total).

Of the ship types that have had an overall increase in voyages, cargo, dry bulk, government/research and fishing vessels have increased with statistical significance (Mann–Kendall p-value < 0.05). The total voyage counts of both cargo vessels (p-value 0.025) and dry bulk carriers (p-value 0.002) reached a peak in 2019, followed by small reductions in the years since then. Government/research vessel voyage counts (p-value 0.02) have had considerable variability over the 10-year period, reaching a peak in 2018, also followed by a drop in 2020, and then an increase once the COVID-19 pandemic travel restrictions were lifted (Supp. Table 4). Fishing vessel voyage increase (p-value 0.039) was greatest in the two most recent years, although the numbers were lower in total than for the other ship types.

There has not been a statistically significant increase in voyages in the other ship type categories, but even so, increases have occurred here too. The drop in Passenger and Pleasure type vessel voyages in years 2020–2021 was

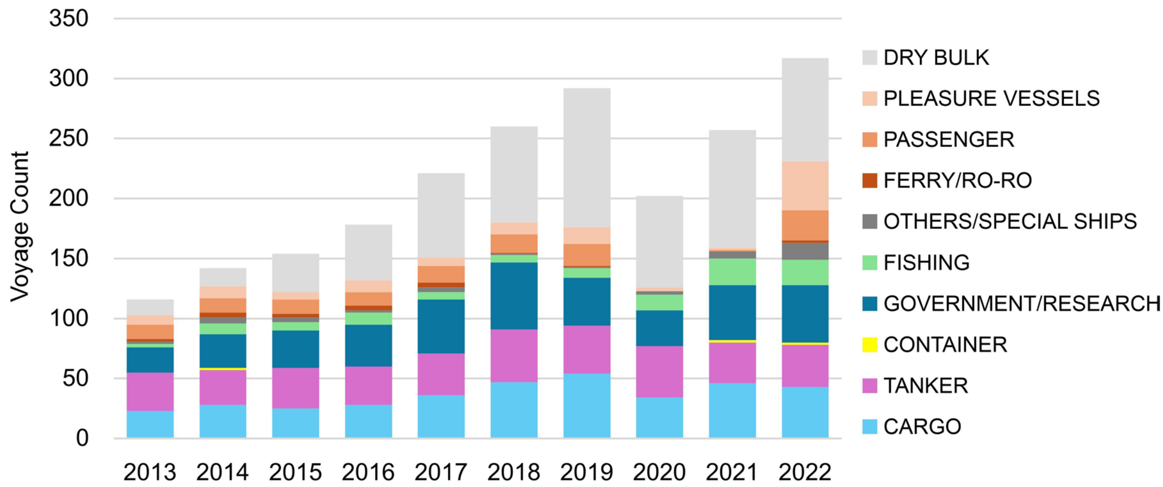

Fig. 6 Total voyage counts close to all 43 communities, by ship type

due to the travel restrictions in place during the pandemic, followed by a sharp rise in 2022 when access had returned to normal, reaching a number higher than any in the 9 years previous.

Increases in total voyage counts are not indicative of consistent increases across the region, but rather it is due to a small number of communities that have experienced a significant increase that strongly contributes to the total number (Fig. 5). By examining communities that have had an overall increase in voyage numbers, it can help us to determine the reasons why, and as a result, whether other communities might have similar increases in the future.

Case studies: Communities with highest voyage counts

We focus on the six communities that have experienced the highest number of voyages over the 10-year period (Supp. Figure 5), all of which have had an increase in the number of voyages, as explained in the "Changes in overall ship voyages near communities" section (Fig. 4). As previously described, Mittimatalik has dry bulk carriers as its primary vessel type. Of the remaining five communities, three have cargo vessels as their primary vessel type (Supp. Table 5), namely Iqaluit, Quaqtaq and Kangiqliniq; Igluligaarjuk has tanker vessels as its primary ship type; and Iqaluktuuttiaq has government/research vessels. Total voyage counts and changes for each community and ship type are quantified in Supp. Table 6. Each of the communities has had a unique temporal distribution of voyages by different ship types (Fig. 7), which we explain here in more detail.

Mittimatalik (Pond Inlet)

Mittimatalik had a population size of 1555 in the 2021 census, which was a 3.8% reduction since 2016 (1617) (Supp. Table 1). It has seen a dramatic increase in visitations from dry bulk carriers over the past decade (Fig. 7a-1). A sharp increase occurred at the time that Baffinland Iron Ore Mine at Mary River began operations in 2015, and the ships transiting to and from the mine port at Milne Inlet pass close to Mittimatalik. The dry bulk carriers do not stop at the community, but rather transit through Eclipse Sound, mostly at a distance of 5 km or more from the community. However, impacts at this distance and beyond will still have substantial effects on the community, especially given how community members travel for hunting and cultural activities (Carter et al. 2018). The current situation around Mittimatalik is a prime example of the extent to which shipping can increase when large mines are opened nearby. Conversely, the opposite trend occurs when mines close, leading to a stark decline in voyage counts. An example of this can be seen for the community of Qausuittuq (Resolute), where ship voyages have continued to decline following the closing of the Polaris lead and zinc mine on Little Cornwallis Island in 2004 (Fig. 5).

If dry bulk carriers are removed from the voyage counts at Mittimatalik, there has been no significant positive trend in any of the other ship categories (Fig. 7a-2; Supp. Figure 6). It has one of the highest number of voyages of all communities in all ship type categories (Supp. Table 6), but there has been a high inter-annual variability in both the total number of voyages and voyage count by ship type. The reduction in voyages in 2020–2021 is due to the COVID-19 pandemic,

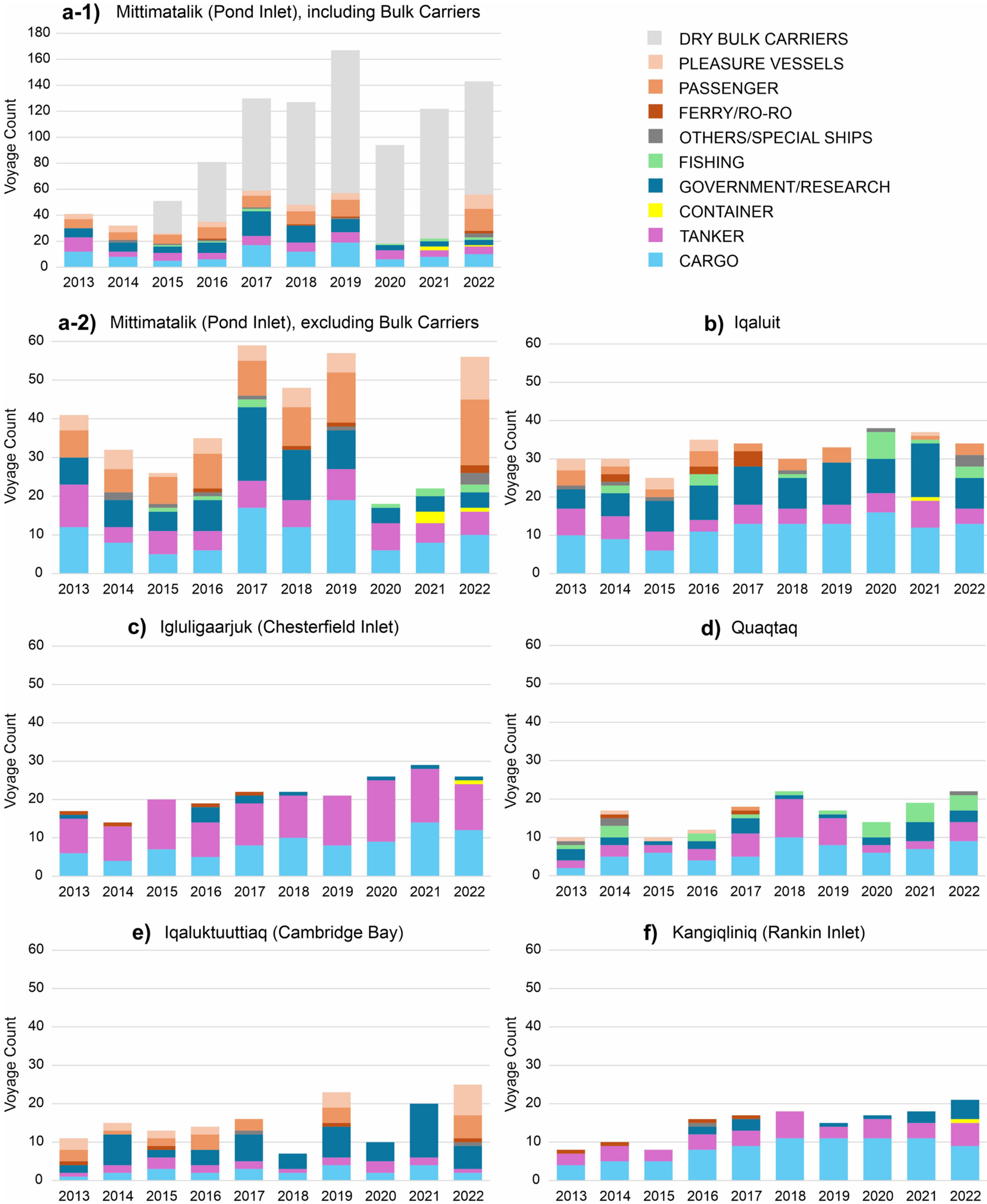

Fig. 7 Annual voyage numbers by ship type, within 20 km of the 6 most visited communities: Mittimatalik with Dry Bulk Carriers included (**a**−1) and without (**a**−2); **b** Iqaluit; **c** Igluligaarjuk (Chesterfield Inlet); **d** Quaqtaq; **e** Iqaluktuuttiaq (Cambridge Bay); and **f** Kangiqliniq (Rankin Inlet)

which is more noticeable here than at other communities. This is due to it being a popular destination for tourists, as it is located in Lancaster Sound which is one of the openings to the popular Northwest Passage. Further, it is the Canadian Border Services Agency (CBSA) seasonal location for the eastern Arctic where all cruise ship passport checks must be carried out, in effect requiring all cruise ships to make a stop in this community.

The lack of increase in cargo vessels at Mittimatalik may be due to the small decline in population size and therefore no increase in demand for general supplies. Future ship numbers may be affected by the management plan for the new National Marine Conservation Area (NMCA), the Tallurutiup Imanga (Lancaster Sound), although this is still in the process of being finalized and it remains unclear what ships might still be permitted to continue transiting through the NMCA (e.g. fishing, tourism, dry bulk). Community members have expressed concern that if there is an expansion of the Baffinland mine, it would result in even more ships transiting to and from its location.

Iqaluit

Iqaluit is the largest community and capital of Nunavut, with a population size of 7429 in 2021. As is the case with Mittimatalik, there has been a small reduction in population size since the 2016 survey, in this case by 311 (4%) (Supp. Table 1). It has had the second largest number of voyages in total between 2013 and 2022 (326) and there has been an increase, although this was not a statistically significant trend (Fig. 4b; Supp. Table 3). This increase has not been driven by natural resources, but rather because it is an access hub for communities further north. For this reason, it is a busy harbour and airport, and increasing resupply demands may explain the increase in number of ship types including cargo vessels (116 voyages) and government/research vessels (88 voyages) (Supp. Table 6). There has been a smaller increase in fishing vessel voyages, but a decrease in pleasure craft voyages (Fig. 7b). The overall increase in shipping has occurred despite the ongoing presence of sea ice in Frobisher Bay each year, which causes risk to ships, especially those that are non-ice strengthened (Dawson et al. 2022). The likelihood of ship grounding or accidents may increase if the number of voyages continues to increase at this location (Nicoll et al. 2024).

Igluligaarjuk (Chesterfield Inlet)

Igluligaarjuk is a much smaller community than Mittimatalik and Iqaluit, with a population size of 397 in 2021. It too saw a population decrease, from 437 in 2016 (9.2%). It has had the third highest number of voyages overall (216) (Supp. Table 3), and it has had a statistically significant increase in total voyages (Fig. 4b), which was largely due to an increase in cargo and tanker vessels (Fig. 7c; Supp. Table 6). The community is served by air (Chesterfield Inlet Airport), and by sea. It is popular with tourists, although there has been no increase in tourist ships over the past 10 years (Fig. 7c). Like Mittimatalik, Igluligaarjuk has been impacted by mining in the vicinity, whereby voyage numbers have increased due to the presence of active gold mines nearby. The number of tanker voyages at Igluligaarjuk (117 in total between 2013 and 2022) is significantly greater than at any other community. Meadowbank Gold Mine is located 300 km west of Hudson Bay near Baker Lake, and the Meliadine Gold Mine is located between Igluligaarjuk and Kangiqliniq (Fig. 2b). Both mining projects are operated by Agnico Eagle Mines (AEM), and Meadowbank Gold Mine opened in 2010, and Meliadine Gold Mine was approved for development in February 2017 and achieved commercial production in May 2019 (https://www.aemnunavut.ca). Transport of fuel and dry goods to and from the mines are on barges, and "sealift operations" are undertaken to transfer bulk supplies and heavy equipment. Both mines depend on sealift from locations close to Igluligaarjuk, which explains the increase in cargo vessels and tanker voyages within 20 km of the community over the past decade. It should be noted that the mine shipping close to Igluligaarjuk is on a much smaller scale than the shipping to/from the mine close to Mittimatalik (Fig. 7).

Quaqtaq

Quaqtaq is a small community, although it has grown in recent years from a population of 403 (2016) to 453 (2021) (12.4%). It is located in Nunavik, on the Arctic Bridge shipping route. Quaqtaq has had fewer voyages than the three communities described above, but there has been a statistically significant, albeit small, increase overall (Fig. 4b). This increase has been due to a number of different reasons. Cargo vessels and tankers are the dominant ship types here (62 and 42 voyages respectively), which have both shown small positive trends (Fig. 7d; Supp. Table 6). More cargo vessels have visited this community in recent years as it is a growing community and a hub for ocean resupply vessels. There have been more tanker vessels passing by to and from Deception Bay, which is the port for ships transporting ore from Raglan Nickel Mine. In addition, there has been an increase in fishing close by in Hudson Strait. Quaqtaq has a small airport and access roads to other communities making it a hub for goods arriving by cargo ship and subsequent on-land community resupplies. Geography is also a factor in this location, whereby Hudson Strait is narrow and ships, including those transiting the popular Arctic Bridge shipping route, are naturally funnelled closer to the community.

Iqaluktuuttiaq (Cambridge Bay)

Iqaluktuuttiaq is located on the southern coast of Victoria Island, and its population has remained approximately the same between 2016 (1766) and 2021 (1760) (Supp. Table 1). There has been an increase from 11 voyages in 2013 to 25 in 2022 (Fig. 7e). The predominant ship type has been government/research vessels overall (60 from a total of 154 voyages). This has been the primary ship type each year, with the exception of 2022 when passenger and pleasure vessels had a substantial increase in number following the drop in number during the COVID-19 pandemic years, 2020–2021. Tourist vessels have made up a larger proportion of the voyages than at any other community except Mittimatalik, as this community is also along the Northwest Passage route for cruise tourism. Cargo vessels and tankers have also regularly passed within 20 km of this community transiting the Northwest Passage route. Here, a reduction in sea ice in this region has influenced the number of ship voyages (Copland et al. 2021). In recent years, it has become more easily accessible, both from the west and the east, and there has been a larger number of visits by government/research vessels as well as tourist vessels on this popular route. Community supplies are brought by sealift from cargo vessels such as Desgagnés vessels, and Coastguard vessels bring resupplies. The Canadian High Arctic Research Station is located at Iqaluktuuttiaq, which explains the larger number of government/research vessels at this community.

Kangiqliniq (Rankin Inlet)

Kangiqliniq is the second largest community in Nunavut and is the business and transportation hub of the Kivalliq region, with a population size of 2975 (2021). It has seen a population increase of 133 (4.7%) since 2016. Here, there has been a consistently small increase in vessel voyages since 2013 (Fig. 7f). The largest number of voyages was by cargo vessels (84 voyages, from a total of 147), almost the same as at Igluligaarjuk (83 voyages) (Supp. Table 6). By contrast, the number of tanker vessel voyages (43) was less than half of those at Igluligaarjuk (117). One reason for the voyage increase is due to the presence of Meliadine Gold Mine, located between Igluligaarjuk and Kangiqliniq (see above). However, as the largest number of voyages was by cargo vessels, rather than tanker vessels, it is also likely due to the increasing population size of the large community, similar to Iqaluit.

Discussion and conclusion

We quantified ship voyages close to 43 Inuit communities in Northern Canada over the past decade, providing a baseline for self-governance when managing future shipping changes. Overall, voyages increased close to communities, mirroring offshore trends throughout the Canadian Arctic (Supp. Figure 2). However, shipping density and trends varied between the communities, reflecting local drivers. The community with the largest voyage count throughout the 10-year period is Mittimatalik, and the opening of the mine close by in 2015 is responsible for most of the significant increase in vessel traffic in the region. This highlights the influence of large-scale natural resource development projects on isolated regions and communities. Mining projects elsewhere in the Arctic have shown ways that they have been organised to the benefit of local communities (Bidgood and Hall 2024). For example, Red Dog mine in Alaska is co-owned by Teck Alaska and the NANA Indigenous corporation, and Voisey's Bay nickel mine near Nain has an Environmental Management Agreement with the Innu of Labrador. At Mittimatalik, an Inuit Impact and Benefit Agreement was established that specifies the parameters for Baffinland's winter shipping operations, including that ship tracks be consistent across trips, Inuit participation in monitoring, and that the relationship of Inuit to sea and ice be respected (Baffinland 2016). The risks from large numbers of vessels can be considerable, however, and our results show that there has been no reduction in the annual voyage counts within 20 km of the community.

Our case studies of the communities with the next highest voyage counts show how growing resupply needs and increasing tourism (excluding 2020–2021) contributed substantially to traffic increases. Geographic "hubs" also emerged, including mining sites, urban centres and research centres, with changes in hub activity, such as those now occurring at Quaqtaq, significantly affecting voyage counts. Shifts in these drivers may lead to an increase in voyages in the future at communities that have, as yet, shown little change. Future growth is expected in places like Churchill, on the west coast of Hudson Bay, where there are discussions underway about reopening the port, which would lead to a significant increase in ship traffic. The level of traffic close to communities is also affected by their proximity to popular shipping routes (e.g. Quaqtaq on Hudson Strait; Mittimatalik on the Northwest Passage). There has been a greater commercial drive to use shipping routes in Pan-Arctic waters for the transportation of goods, and access to natural resources (Eguíluz et al. 2016; Nicoll et al. 2025). This is likely to continue (Melia et al. 2016; Zhao et al. 2024); therefore, coastal communities are actively looking for ways to adapt and respond. The preferred approach is research that combines Inuit Qaujimajatuqangit and scientific monitoring techniques, which provides a foundation for how many communities wish to engage with shipping issues and is the basis for how this project was conducted. Whilst the Arctic ship traffic is increasing, the Canadian Arctic waters currently have lower vessel traffic than other regions of the Arctic

(Sander and Mikkelsen 2025), so now is the time to prevent detrimental impacts through strong and evidence-based governance and regulation before the problems get worse.

The degree of impact of shipping on communities is also dependent on the shipping season length determined by the amount of sea ice in the vicinity. For example, regionwide the shipping season lengths vary from approximately 10 to 30 weeks (Cook et al. 2024), making annual voyage totals more temporally concentrated where communities are accessible for only a short period of the year. The impacts on the community therefore may be greater during the short window than they might be on a community with the same number of ship voyages over a longer period.

Increasing ship traffic presents multiple risks. Larger vessels contribute to underwater noise that disrupts wildlife and alters migratory, foraging, mating/breeding and social behaviour (e.g. Moore et al. 2012; Halliday et al. 2020); tankers carrying oil are a higher risk for oil spills (van Luijk et al. 2019); increasing air and marine pollution has significant impacts on the environment (e.g. Corbett et al. 2010; Huntington et al. 2020); and transport of non-indigenous and/or invasive species on ships travelling from outside of the Arctic presents risks to the local ecology (e.g. Goldsmit et al. 2019). Passenger vessels bring additional concerns, including increased human traffic and disturbance in sensitive areas, strain on local infrastructure, limited search and rescue capacity in the Arctic, and environmental impacts of vessel anchoring (Dawson et al. 2016; 2018; Stewart et al. 2011). However, tourist vessels, along with re-supply vessels, also bring benefits to communities. Cargo and tanker vessels in particular play a critical role in community sustainability, providing annual or semi-annual deliveries that are necessary for food security, energy, construction and infrastructure. Therefore, it is important to understand ship types and their specific impacts at the community level, and it is critical to put policies in place to reduce future risk, whilst not impacting the benefits. One example of a policy that would make a difference is moderate slowdowns of fixed pitch propeller vessels, which is shown to be beneficial and reduces the noise impacts on marine mammals (Findlay et al. 2023). Our results can support Inuit communities in conducting more informed, vessel-specific cost–benefit assessments, guiding local preferences for routing, timing, ship type regulation and mitigation measures.

Our findings provide baseline data on increased ship traffic in Northern Canada and the associated risks to communities. They reinforce calls for increased involvement of Inuit in the development of Arctic shipping policy at all stages of the decision-making process (Dawson et al. 2020a, b; ICC 2008; ITK 2017, 2018; Porta et al. 2017; Chircop 2023). The renewed focus on the Arctic by the Government of Canada in the development of the Arctic Northern Policy Framework and the creation of the new Arctic Region provides new opportunities for the development of equitable shipping policy that works for and is supported by Inuit and Inuit Nunangat. Further research is required to explore how shipping and coastal management policies are operating in practice and to ensure Inuit inclusion in decision-making is realized on the ground.

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Data availability Data is provided within supplementary information files.

Declarations

Conflict of interest The authors declare no competing interests.

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