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Shipping Trends in Nunavut from 1990-2015

Jackie Dawson
Olivia Mussells
Luke Copland
Natalie Carter

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Department of Geography, Environment and Geomatics

uOttawa

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DATA MANAGEMENT

Metadata for this study has been permanently housed in the Polar Data Catalogue and can be found here: **https://www.polardata.ca/** Polar Data Catalogue is a database of metadata and data that describes, indexes, and provides access to diverse data sets generated by Arctic and Antarctic researchers. The metadata records follow ISO 19115 and Federal Geographic Data Committee (GGDC) standard formats to facilitate exchange with other data centres.

EXECUTIVE SUMMARY

This study involved in-depth examination of the past and present shipping activities across Nunavut, Canada from 1990 to 2015. The analysis was performed using Canadian Coast Guard NORDREG data and a geospatial database constructed by the research team. Marine traffic increased dramatically over the 26-year period examined in the study. The total distance travelled by all vessels doubled between 1990 (345,567 km) and 2015 (793,684 km), with a notably steep increase in distance between 2005 (430,0073 km) and 2008 (702,561 km) and the distance travelled by some vessel types increased more substantially than others (e.g., pleasure crafts, fishing vessels, and general cargo). The spatial concentration of ship traffic has been relatively consistent over time, however some changes in intensity and distribution are evident within certain vessel types and particularly in the Northwest Passage and throughout the Kitikmeot region. There has been a clear shift in geographic concentration of tourism vessels that favours the Northwest Passage over southern areas utilized in the past. Some vessel types, such as fishing vessels and bulk carriers, are more spatially limited than others such as passenger ships and icebreakers which are seen throughout Nunavut.

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INTRODUCTION

Marine transportation is an essential industry to Canada. International marine trade was valued nationally at 205 billion in 2015 (CCA 2017) and it has been estimated that 90% of all goods that are manufactured and purchased globally are now shipped at some point by sea (George, 2013). As a predominantly island based territory, Nunavut, Canada is highly dependent upon marine transportation, where ships support community re-supply (food, fuel, and goods), construction (community-based and mines), local economic activities (tourism, mining, fishing), and cultural livelihoods (traditional activities and subsistence harvesting). Over the past decade shipping in Nunavut has increased substantially in association with the exploration and extraction of natural resources, the increase in cargo trade and transport, the proliferation of the fishing and tourism industries, and the intensification of community re-supply needs (Pizzolato et al. 2014).

The increase in ship traffic to Nunavut is linked directly to socio-economic factors such as globalization, commodity prices, demographics, and societal trends (CCA 2017, George 2013, Dawson et al. 2017) but the ability for ships to travel more frequently has been facilitated by climate change. Recent trends in sea ice show substantial reductions in the central Arctic and Canadian Arctic Archipelago (CAA), including the Northwest Passage (NWP) (Howell et al., 2006; Guy, 2006; Tivy et al., 2011), with expectations that the NWP will be increasingly ice-free in the next few decades (Sou & Flato, 2009). There has been a shift from a predominantly thick perennial arctic sea ice regime to a younger, thinner, more seasonal sea ice regime (Parkinson, 2014; Comiso, 2012; Maslanik et al., 2011) that makes the region more accessible for ship traffic and that lengthens the length of the open water season. For example, between 2002 and 2009, multi-year ice (MYI) coverage in the Canadian sector of the Arctic Ocean declined by 83% (Maslanik et al., 2011), and from 1979 to 2013 the pan-Arctic melt season length increased by an average of 5 days per decade-1 (Stroeve al., 2014). This thinning of sea ice has led to the lengthening of Arctic shipping seasons into the spring and fall, and has been directly and statistically correlated with some of the increases observed in vessel traffic in certain regions of the Canadian Arctic (Pizzolato et al. 2014, 2016).

The objective of this study was to comprehensively examine historic changes to shipping traffic in Nunavut, Canada from 1990-2015, both temporally and spatially. Analysis evaluation of shipping trends by 1) overall activity, 2) vessel type, 3) Nunavut region, and 4) near-by communities. It is necessary to understand the changing trends in shipping activity in Nunavut so that evidence-based decisions can be made that balance the environmental, economic, and cultural imperatives of the region. This shipping trends analysis can be used to: 1) aid federal decision makers to deploy and invest in appropriate search and rescue, navigational aids, and other marine infrastructure and to develop policies that facilitate a safe and sustainable shipping environment; 2) help the territorial government invest in appropriate protected areas planning and to facilitate local economic development opportunities; and 3) enable local government, communities and Inuit leaders to manage and preserve island-based Inuit owned lands, enhance safety and security for local marine transportation and harvesting activities, and ensure that Inuit and northern voices are infused into federal and national decisions that impact the Nunavut marine environment.

STUDY METHODS

Currently, there is limited understanding of the specific and statistically significant longer-term changes in shipping trends in the north. The most precise global source of data on spatial ship traffic comes from satellite-based systems such as Automatic Information System (AIS) data, which is recorded in real time at a second/millisecond time scale. However, for Canadian Arctic regions there are currently two major challenges in using AIS data for longitudinal trends analysis including; 1) data is only captured from ships with AIS transponders that are turned on, and 2) data are only available since 2010. Similar challenges exit with other satellite based systems such as Long Range Identification and Tracking (LRIT), which like AIS data, is useful for real-time ship tracking of larger vessels that tend to carry transponders but lacks utility for longitudinal research applications such as geographic trends analysis of multiple vessel types. Because of the identified limitations of AIS and LRIT data, in this study we use a recently developed geospatial shipping activities database that was established specifically for the Canadian Arctic region.

The database used in this study was constructed using Canadian Coast Guard (CCG) non-spatial NORDREG ship archive data (1990-2015) that was extensively quality controlled for accuracy and consistency. The NORDREG dataset contains daily reports of vessel locations at 16:00 UTC for mandatory reporting vessels since 2010 (i.e., vessels that are 300 gross tonnes or more, engaged in towing or pushing another vessel if the combined gross tonnage is 500 gross tonnage or more, or if a vessel is carrying a pollutant or dangerous good, or towing a vessel carrying a pollutant or dangerous good (CCG 2013) as well as vessel positions that voluntarily reported their location within the NORDREG zone, mostly on the daily or sub-daily timescale. The NORDREG data also includes of an archive with vessel name, call sign, International Maritime Organization (IMO) number, entry and exit dates of the NORDREG zone, vessel length, width, and other non-spatial characteristics. Using this information supplementary ship specification data were added to ship archive (see Pizzolato et al. 2014) including ship draft, length, and width in addition to the marine mobile service identity number (MMSI) when available. The quality controlled dataset was then geo-located and joined using least-cost path (LCP) approach that considered three variables, 1) distance to land, 2) bathymetric data (ETOPO2v2), and 3) sea ice data (CISDA). All of the analysis was undertaken using ESRI ArcGIS 10.2, Python, and the ArcPy Python scripting module. See Pizzolato et al. 2016 and Dawson et al. 2017 for full methodological details. The accuracy of the database evaluated by cross-referencing outputs with AIS data for known voyage paths and calculating error estimates. Error estimates are very reasonable and range of 8.77 ±0.91 km (excluding Hudson Bay).

It is also likely that the database underestimates the number of km traveled by pleasure craft and other smaller vessels because these vessels are not required via Canadian regulations to report to NORDREG (see Johnston et al. (2017). Additional details on database construction can be found in Pizzolato et al. (2016) and Dawson et al. (2017).

STUDY AREA

The study area included the marine regions of the Canadian territory of Nunavut extending out to the Economic Exclusion Zone (EEZ), defined as 200 nautical miles (370km) from the coast (Figure 1). Nunavut is the newest (1999), largest, and northernmost territory in Canada. In 2016, the total population of Nunavut was 35,944 people who are living in one of 25 different communities that range in size from under 500 people (Chesterfield Inlet, Gris Fiord, Kimmirut, Whale Cove) to over 7,000 (Iqaluit). All but one of the communities in Nunavut are coastal, and all are serviced by air and sea (Government of Nunavut, 2017). Nunavut is also home to a large portion of the fabled Northwest Passage, a sea route connecting the Pacific and Atlantic oceans. The Northwest Passage offers shipping companies significant distance savings between for example New York and Hong Kong than the currently utilized global trade routes through the Suez or Panama canals (Smith and Stephenson 2013; Pizzolato et al. 2014).

Figure 1: Study Area (Nunavut Marine Area)

MARINE VESSEL TYPES IN NUNAVUT

Many types of marine vessels operate in Nunavut, Canada, each with distinct characteristics and cargo (Table 1). Communities across the territory rely heavily upon ships as a means of transporting goods to service the region. Supplying communities via ships is crucial, especially should the population grow or the needs of communities' change (Hodgson et al., 2013; Prowse et al., 2009). Additionally, with some of the largest untapped natural resource reserves in the world located within the Arctic, the potential for increased marine activity due to oil and gas exploration and extraction is a possibility (Prowse et al., 2009; Pizzolato et al., 2014). The prospective increase in northern resource-extraction projects (e.g., Baffinland Mary River Iron Ore Mine) and subsequent increases in the export of raw goods and materials out of the North will not only increase regular bulk shipments, but will also likely require increased marine transportation during the construction phase of these projects (Hodgson et al., 2013). Small-scale commercial fishing operations within the Canadian Arctic are expanding further north as ice-free conditions persist for longer periods (Hodgson et al., 2013). Marine tourism (both pleasure craft and passenger ships) has expanded rapidly over the past two decades in the Canadian Arctic, and is likely to increase further as the demand for "exploration" tourism increases (Dawson et al., 2007; 2014; 2017; Pizzolato et al., 2014; Hodgson et al., 2013; Lasserre & Têtu, 2015).

Table 1

Description of Vessel Types Found in Nunavut and their Associated Uses

CLASSIFICATION	DESCRIPTION	EXAMPLES OF SHIP TYPES
GOVERNMENT VESSELS AND ICEBREAKERS	• Designed to move and navigate in ice-covered waters • Must have a strengthened hull, an ice-clearing shape, and the power to push through ice	• Coastguard • Icebreakers (private, research, government) • Research vessels
CONTAINER SHIPS	• Cargo ships that carry their load in truck-size containers	• Cargo transport
GENERAL CARGO	• Carries various types and forms of cargo	• Community re-supply • Roll on/roll off cargo
BULK CARRIERS	• Bulk carriage of ore (can carry either oil or loose or dry cargo, but not simultaneously)	• Timber • Oil, ore • Automobile carriers
TANKER SHIPS	• Bulk carriage of liquids or compressed gas	• Oil, natural gas, and chemical tankers
PASSENGER SHIPS	• Ships that carry passengers for remuneration	• Cruise ships • Ocean liners • Ferries
PLEASURE CRAFT	• Recreational vessels that do not carry passengers for remuneration	• Motor yachts • Sail boats • Row boats
TUG / BARGE	• Tug: Designed for towing or pushing, and general work duties • Barge: non-propelled vessel for carriage of bulk or mixed cargo	• Re-supply vessels • Bulk cargo transport
FISHING VESSELS	• Fishing boats are used in commercial fishing activity • Generally small vessels, between 30 and 100 meters	• Small fishing boats • Trawlers • Whaling boats • Fish-processing boats
OIL AND GAS EXPLORATION VESSELS	• Designed specifically for the exploration and extraction of natural gas and oil	• Seismic, oceanic, and hydrographic survey vessels • Oil drilling/storage vessels • Offshore re-supply • Portable oil platform vessels • Other oil and gas support vessels

Source: Pizzolato et al. 2014; Dawson et al. 2017

TEMPORAL TRENDS (1990-2015)

The total annual kilometres traveled by all vessel types in the Nunavut marine area has more than doubled over the past 25 years, increasing from 345,567 km in 1990 to 793,684 km in 2015 (Figure 2). The highest number of km traveled in any single year within the record occurred in 2014 when ships covered a record 841,742 km of Nunavut's waters. Since 1990 average traffic volume has increased consistently but with some variability year to year (Figure 2). To better understand the temporal changes in ship traffic, the study period (1990-2015) has been divided into four distinct periods: i) baseline (1990-200) representing a relatively stable period with limited growth; ii) phase 1 (2001-2005), a period of slight decline; iii) phase 2 (2006-2010), a period of rapid growth; and iv) phase 3 (2011-2015), a period of continued growth and development.

During the baseline period of 1990 to 2000 vessel traffic increased slightly but in general remained relatively steady, hovering between 345,567 and 494,252 km per year with an average of 414,033 km traveled per year. The average annual km traveled during phase 1 (2000-2005) increased only slightly from the baseline period to a total of 443,111 km per year, ranging between 411,775 km (2004) and 475,079 km (2001) per year. During phase 2 (2006-2010) the number of kilometres traveled by vessels in Nunavut's waters rapidly increased to an average of 643,404 km per year and ranging from 507,157 (2006) to 754,276 km (2010). During the most recent period (phase 3, 2011-2015) traffic increased even more to an average of 760,818 km per year, which represents an 84% increase from the baseline period. With the exception of 2012 when km traveled decreased to similar levels seen in the early period of phase 2, total km traveled over the past five years of the record have consistently been the highest over the past quarter century. The record period does exhibit natural variability between years, but overall trends indicate a clear increase in shipping activity in Nunavut waters.

Figure 2: Total Annual Kilometres Traveled by All Vessel Types in the Nunavut Marine Area

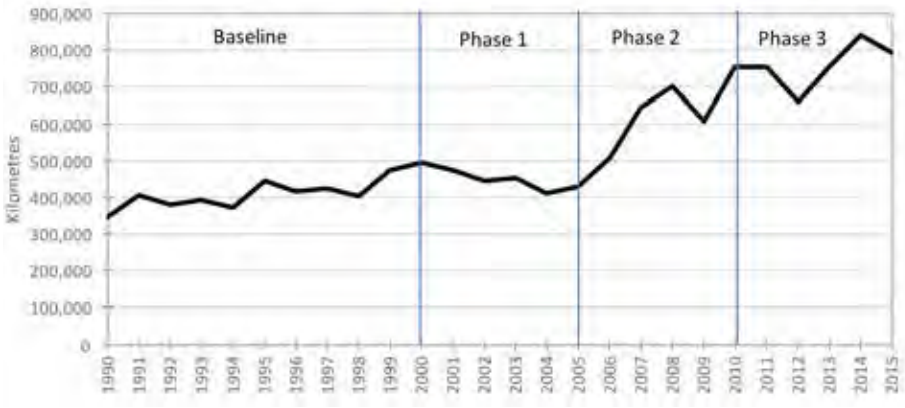


Figure 3 breaks down the total number of km traveled by vessel type from 1990 to 2015. General cargo (re-supply) and government icebreakers (including research vessels) consistently travel the greatest number of kilometres each year. From 1990 to 2006 general cargo vessels averaged just over 100,000 km annually with limited variability. However, beginning in 2007 (notably a record low sea ice year) general cargo activity began to increase. By 2010 the distance traveled increased to 166,259 km and then to 194,844 km during the record highest year of 2014. Icebreaking and research activity has stayed relatively constant throughout the record, although some varaiblity is observable and a minor increase in average km traveled is noted in phases 2 and 3. Tanker ships, fishing vessels, and pleasure craft (i.e. private yachts) notably increased during phases 2 and 3, while passenger vessel activity has decreased slightly in recent years.

Figure 3: Total Annual Kilometres Traveled in the Nunavut Marine Area, by Vessel Type, from 1990 to 2015.

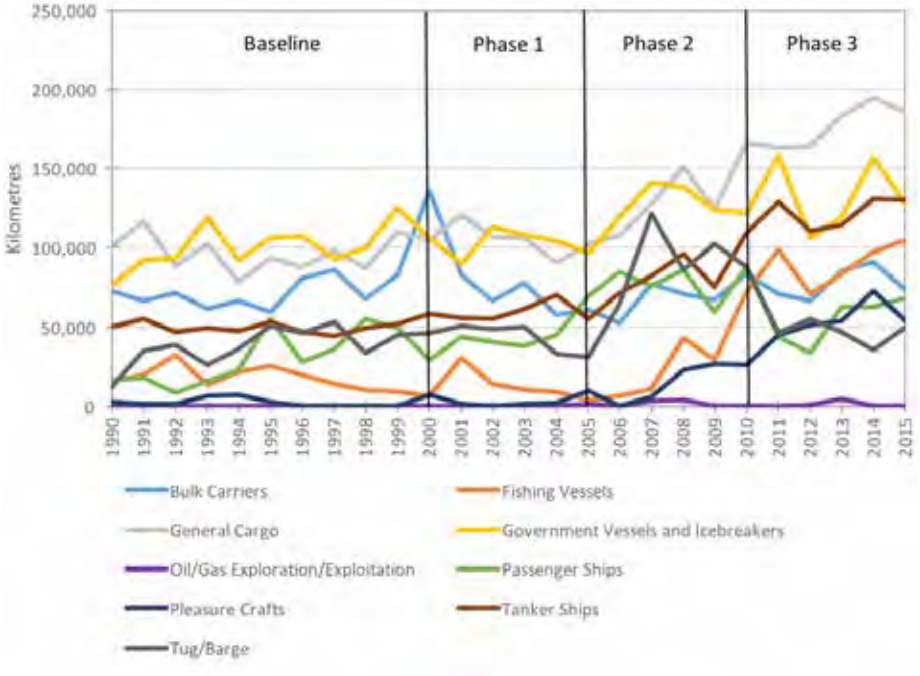
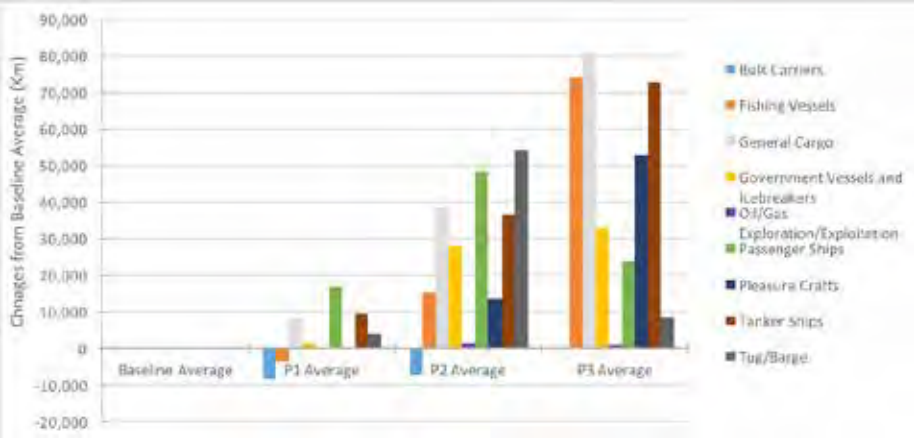


Figure 4 provides a visual representation of the change in average annual kilometres traveled by vessel type using the baseline period (1990-2000) as a benchmark and comparing trends observed in phases 1, 2, and 3. Bulk carrier activity decreased in phases 1 and 2 and equalized again in phase 3. Fishing vessels decreased in phase 1, increased slightly in phase 2 and then increased dramatically in phase 3, likely because of recent investments made to support the local fisheries industry (CBC, 2013). General cargo, tanker ships, and tug and barge activity has steadily increased in all phases compared to the baseline. Passenger ships increased moderately in phase 1, more dramatically in phase 2, but have since declined slightly to just above phase 1 levels. The fastest growing sector of vessel activity in terms of km travelled is pleasure craft, which stayed constant in phase 1, increased slightly in phase 2, and then increased dramatically in phase 3.

Figure 4: Change in Annual Average Kilometres Traveled from Baseline Period to Phase 1, Phase 2 and Phase 3 by Vessel Type

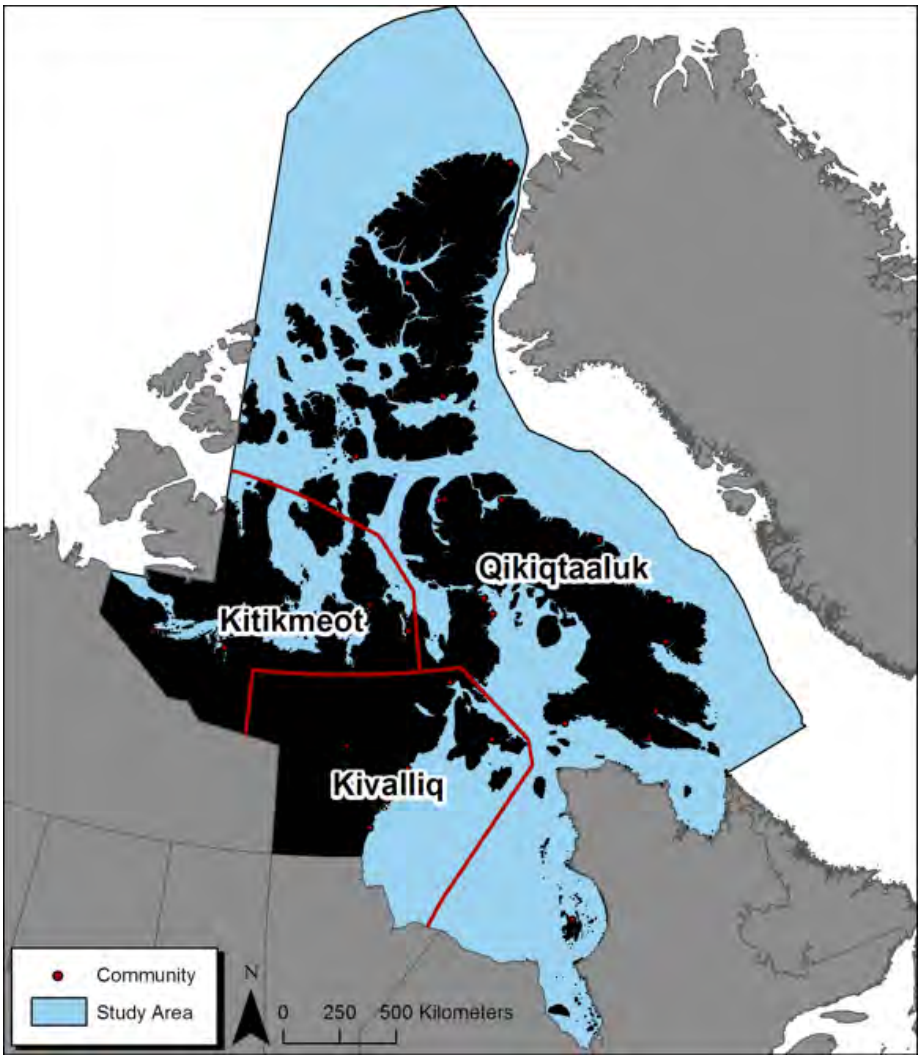


DISTRIBUTION BY VESSEL TYPE ACROSS NUNAVUT REGIONS

The territory of Nunavut is divided into three distinct regions: the Kitikmeot, which is the most western area of the territory, the Qikiqtaaluk, which is the largest and most eastern region encompassing Baffin Bay and the northern island chains, and the Kivalliq, which is located in the central south region of the territory (Figure 5). Vessel traffic distribution is examined within these three distinct geographic regions to determine the relative proportion of vessel types that have been in operation and how this distribution has changed over time. The distribution of vessel types is based on 'total distance traveled' by each vessel type in the three temporal phases described above compared to the baseline period. The decision to examine total distance traveled by vessel type was chosen

because alternative measures such as total vessel count (i.e. number of vessels present in the region) or total vessel voyages (i.e. an estimation of the total number of individual voyages made by each vessel present in the region) would not fully capture the true distributional changes in total vessel activity in Nunavut marine waters over time.

Figure 5: Map of Nunavut Regions

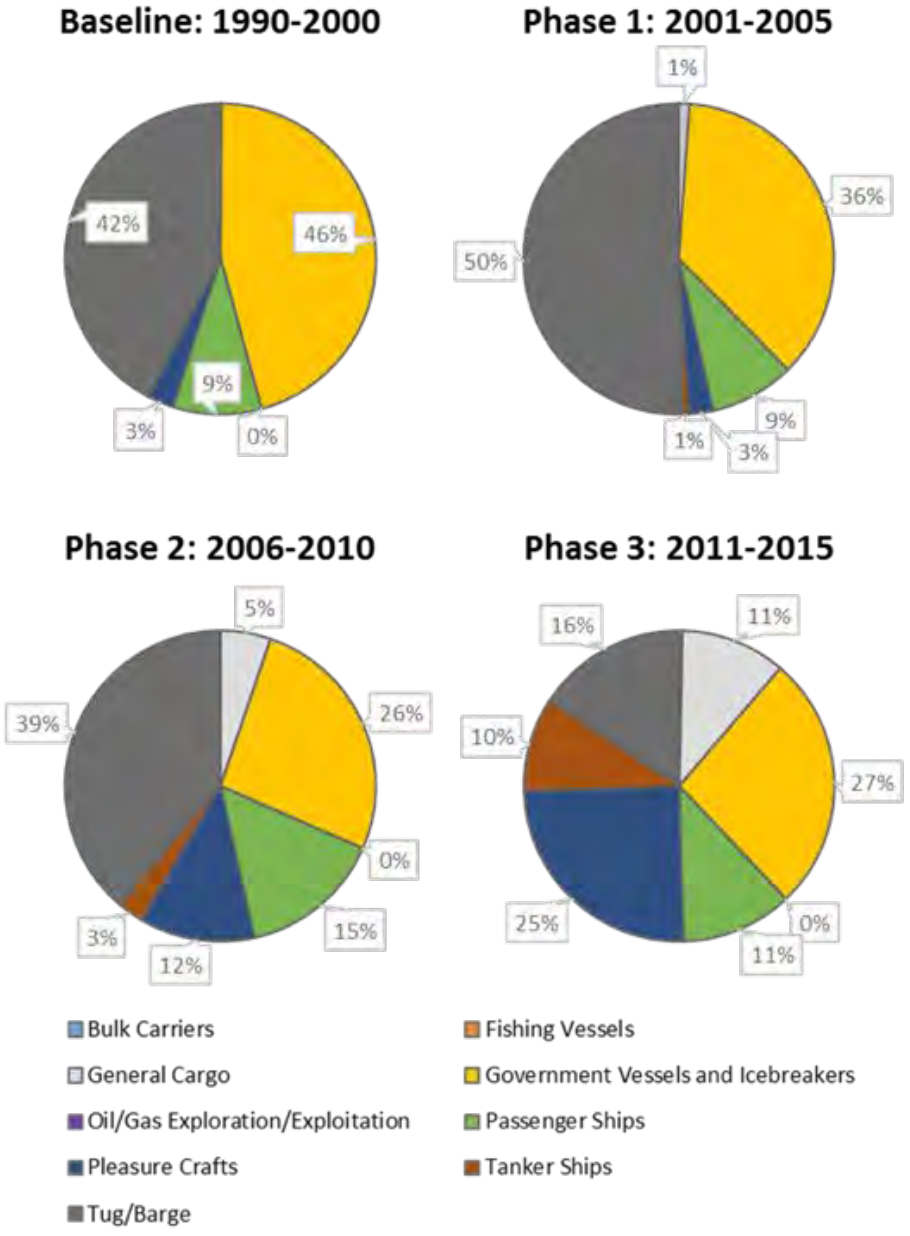


KITIKMEOT REGION

The distribution of vessel activity by km traveled in the Kitikmeot region between 1990 and 2000 was dominated by government vessels and icebreakers (46%) and tug and barge traffic (42%) that was likely supporting general cargo and other activities. Other vessel activity at the time was made up by passenger ships (9%) and pleasure craft (3%). Over the study period the proportion of government vessels and ice breakers and tug and barge traffic decreased significantly to include just 27% and 16% respectively in the 2011-2015 time period. This is not because there

is less icebreaking and tug traffic, in fact there has been an increase over time, but rather the decreased distribution is due to the increase in vessel variety now operating in the region. For example, pleasure craft now make up 25% of total traffic distribution by km traveled, second only to government icebreakers. If just the total number of ships present in the region is considered, then pleasure craft now make up 44% of total vessels compared to 10% in the baseline period (not shown in figure). Tanker ships have also increased over time and most recently made up 10% of total km traveled by all vessels in the Kitikmeot region (Figure 6).

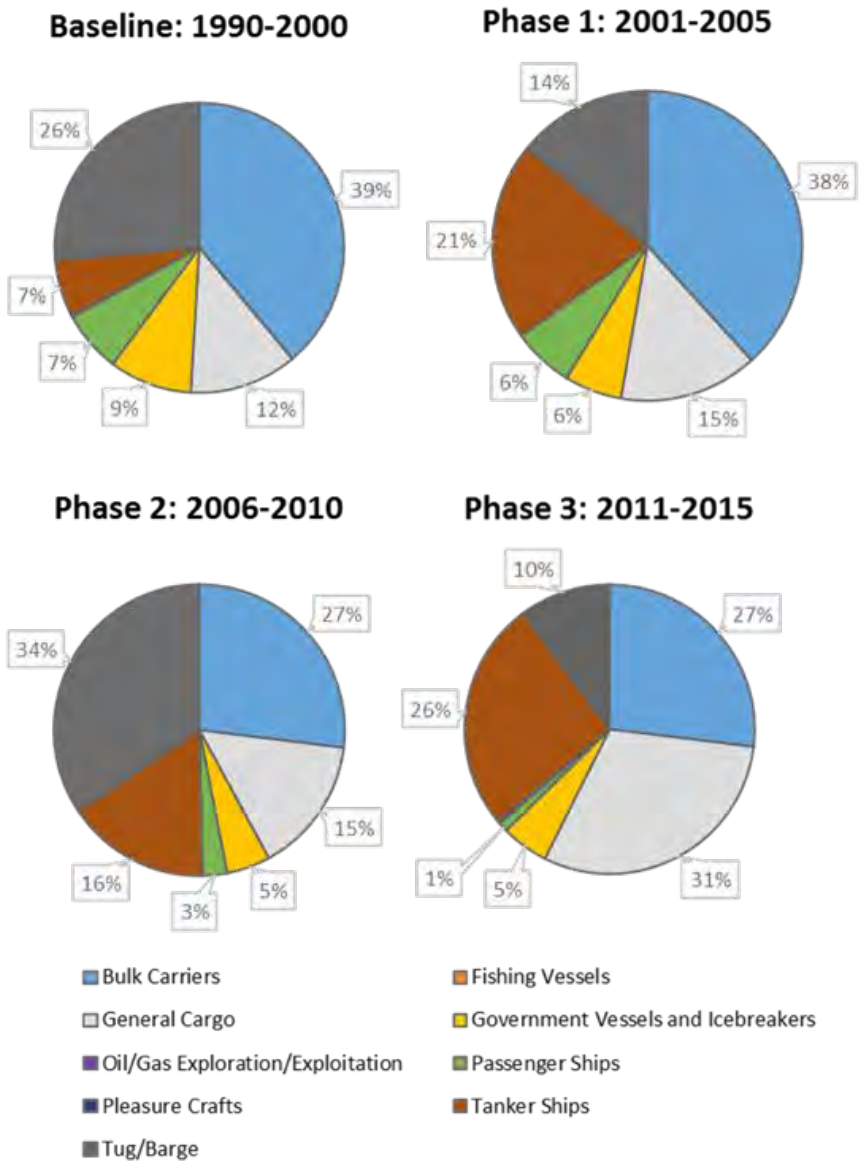
Figure 6: Relative proportions of ship traffic in the Kitikmeot Region based on annual distance travelled, 1990-2015



KIVALLIQ REGION

The Kivalliq region has experience much less variability in vessel distribution by km traveled over time than was evident in the Kitikmeot region. From 1990-2000 the region consisted mostly of bulk carrier (39%) and tug and barge (26%) activity. General cargo (12%) government icebreakers (9%), passenger ships (7%), and tanker ships (7%) made up the remaining distribution. Over time vessel distribution has changed but only limitedly. In recent years (2011-2015), there has been a reduction in bulk carrier (27%), tug and barge (10%), government icebreaking activity (5%), and passenger ships (5%) as well as an increase in general cargo (31%) and tanker ships (26%).

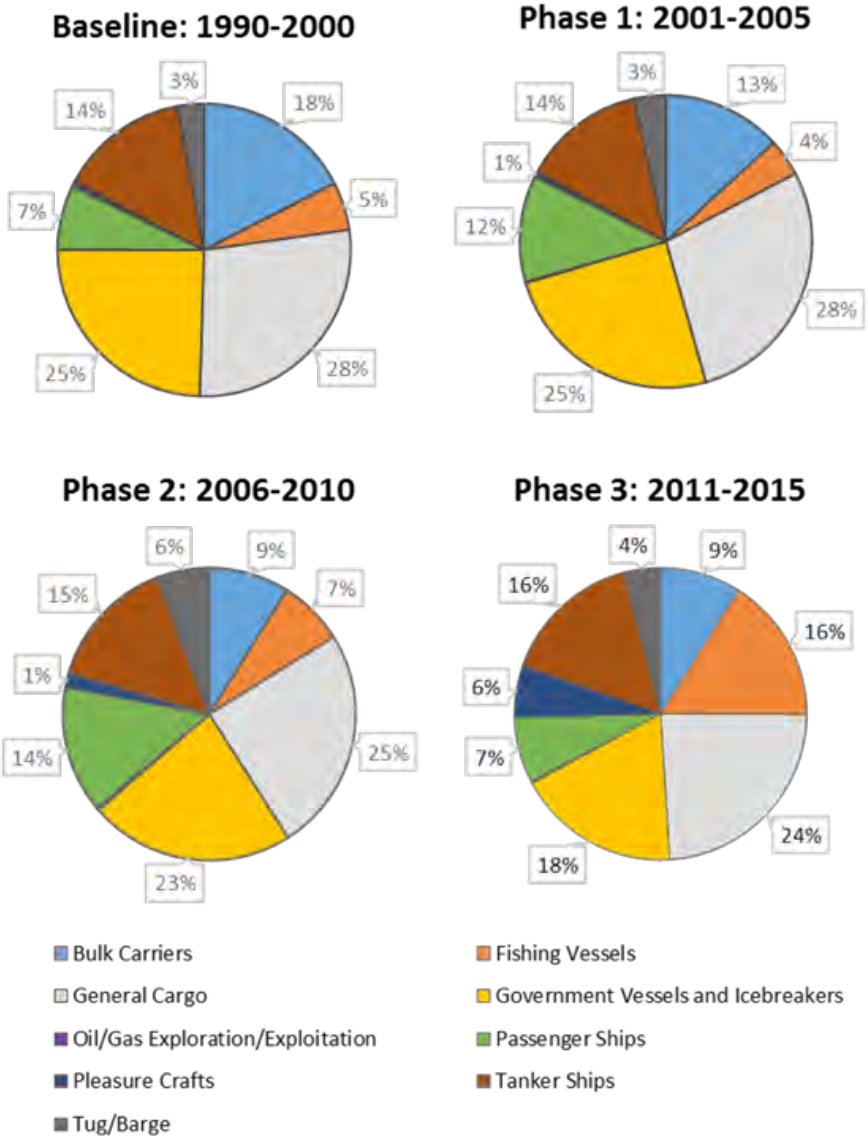
Figure 7: Relative ship traffic by type for the Kivalliq Region, 1990-2015



QIKIQTAALUK REGION

Similar to the Kivalliq region the distribution of vessel types by km traveled is more stable in the Qikiqtaaluk region compared to the highly variable Kitikmeot region. Between 1990-2000 the distribution of vessel traffic by km in the Qikiqtaaluk region included 28% general cargo, 25% government icebreakers, 18% bulk carriers, 14% tanker ships, 7% passenger ships, 5% fishing, and 3% tug and barge. In more recent years (2011-2015) the distribution of tanker ships, fishing vessels, and pleasure craft have increased to 16%, 16% and 6% respectively, while the distribution of general cargo, government ice breaking, and bulk carriers reduced to 24%, 18% and 9% respectively.

Figure 8: Relative ship traffic by vessel type in the Qikiqtaaluk Region, 1990-2015



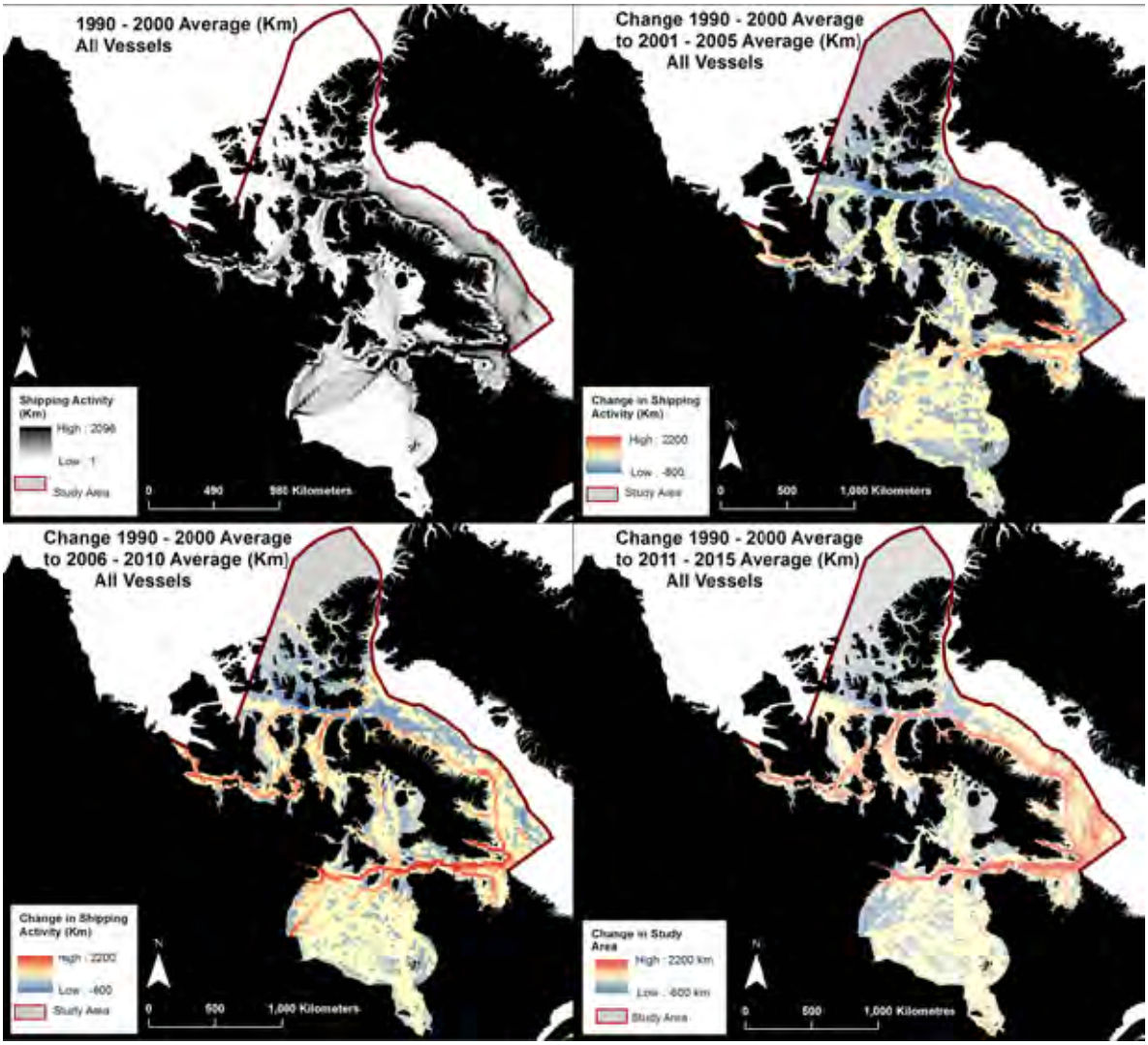
SPATIAL TRENDS

Figure 11 provides a panel display the spatial distribution of kilometres traveled by all vessel types during the baseline period, and the change in activity from the baseline period to phases 1, 2, and 3. In the 1990 to 2000 baseline period, vessel traffic was concentrated throughout Hudson Strait, with clear travel routes from the Strait to the east coast of mainland Nunavut and to the Port of Churchill. High traffic intensity is also observable along the eastern coast of Baffin Island, through Lancaster Sound and into the Queen Maud Gulf, and moderate intensity is visible through Lancaster Sound to Resolute as well as through Foxe Basin. In phase 1 (2000-2005), total vessel traffic decreased off the coast of Baffin Island and to Resolute, likely related to a decrease in tankers and bulk carriers because of the closures of the Polaris (Cornwallis Island, near Resolute) and Nanisivik (Baffin Island, near Arctic Bay) mines in 2002. There was also a slight increase in traffic through Hudson Strait.

Compared to the baseline period, phase 2 (2006-2010) shows an even more dramatic intensification of traffic through Hudson Strait, with clear travel routes to communities in Ungava Bay and along the east coast of mainland Nunavut. There was also a clear increase in traffic through the southern route of the Northwest Passage and around the west coast of Prince of Wales Island that had not occurred earlier in the period of record, and a rebound of coastal traffic along the eastern coast of Baffin Island. Further declines in traffic were observed in and around Baffin Bay and also around Resolute and Nansivik.

Relative to the baseline period, vessel traffic in phase 3 (2011-2015), displays significant intensification through Hudson Strait towards Baker Lake, potentially due to increasing traffic associated with the opening of the Meadowbank Gold mine, north of Baker Lake, in 2010. There was also an increase in traffic along the eastern coast of Baffin Island, greater than that seen in phase 2. Finally, there continues to be a clear increase in traffic through the southern route of the Northwest Passage and throughout the Kitikmeot Region.

Figure 9: Annual Average Kilometres Traveled by All Vessel Types (Baseline: 1990—2000) (top left). Change in Annual Average Kilometres Traveled between Baseline and Phase 1 (2001-2005) (top right); Change in Annual Average Kilometres Traveled between Baseline and Phase 2(2006-2010) (bottom left); Change in Annual Average Kilometres Traveled between Baseline and Phase 3 (2011-2015) (bottom right).



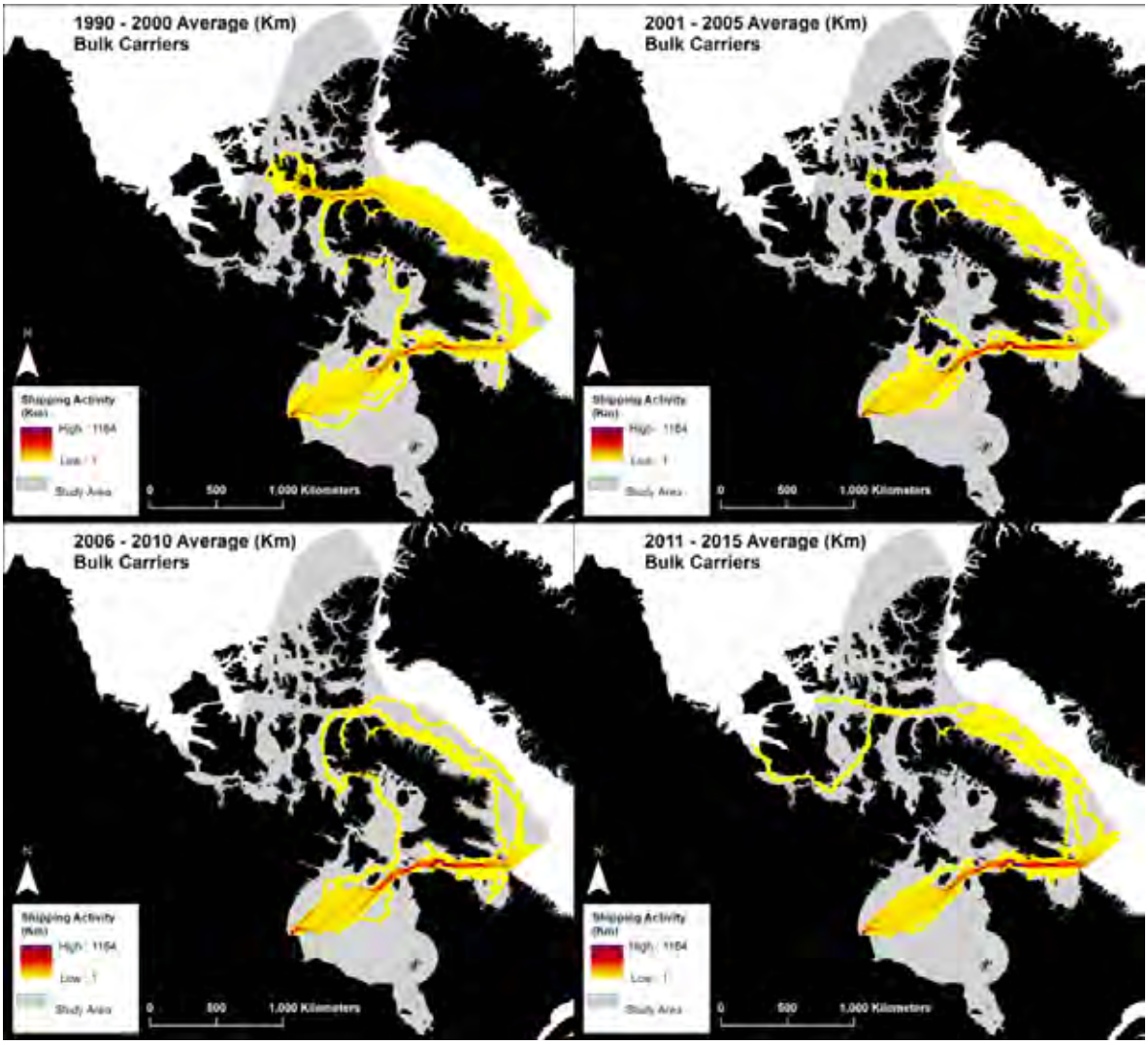
SPATIAL TRENDS BY VESSEL TYPE

The following sections provide figures that display the spatial patterns (km traveled) by vessel type for each of the baseline period (1990-2000), phase 1 (2001-2005), phase 2 (2006-2010), and phase 3 (2011-2015).

BULK CARRIERS

Bulk carriers include those vessels carrying materials such as dry or loose cargo, timber and ore. During the baseline period, there was extensive bulk carrier traffic off the east coast of Baffin Island and through Lancaster Sound. This was likely due to the presence of the Polaris and Nanisivik mines, which were active from 1981 to 2002 and 1976 to 2002 respectively. The mines were serviced by bulk carriers bringing fuel and leaving with holds full of ore. By phase 1, there was still some bulk carrier traffic through Lancaster Sound but it had begun to concentrate through Hudson Strait and to the Port of Churchill. The Raglan mine, in northwestern Quebec, began operations in 1998 and was serviced year-round by ice-strengthened bulk carriers. By phase 2, there was less bulk carrier traffic along the east coast of Baffin Island and an even greater concentration of vessel traffic through Hudson Bay to the Port of Churchill. In phase 3, notably, there were bulk carriers traveling through the Northwest Passage for the first time. The Nordic Orion (operated by Nordic bulk carriers) was the first bulk carrier to do so, making the transit in September 2013. It was followed by the Nunavik (operated by Fednav) in 2014. Additionally, in phase 3, there was a return of bulk carrier traffic to northeastern Baffin Island, where the Mary River mine opened in 2014.

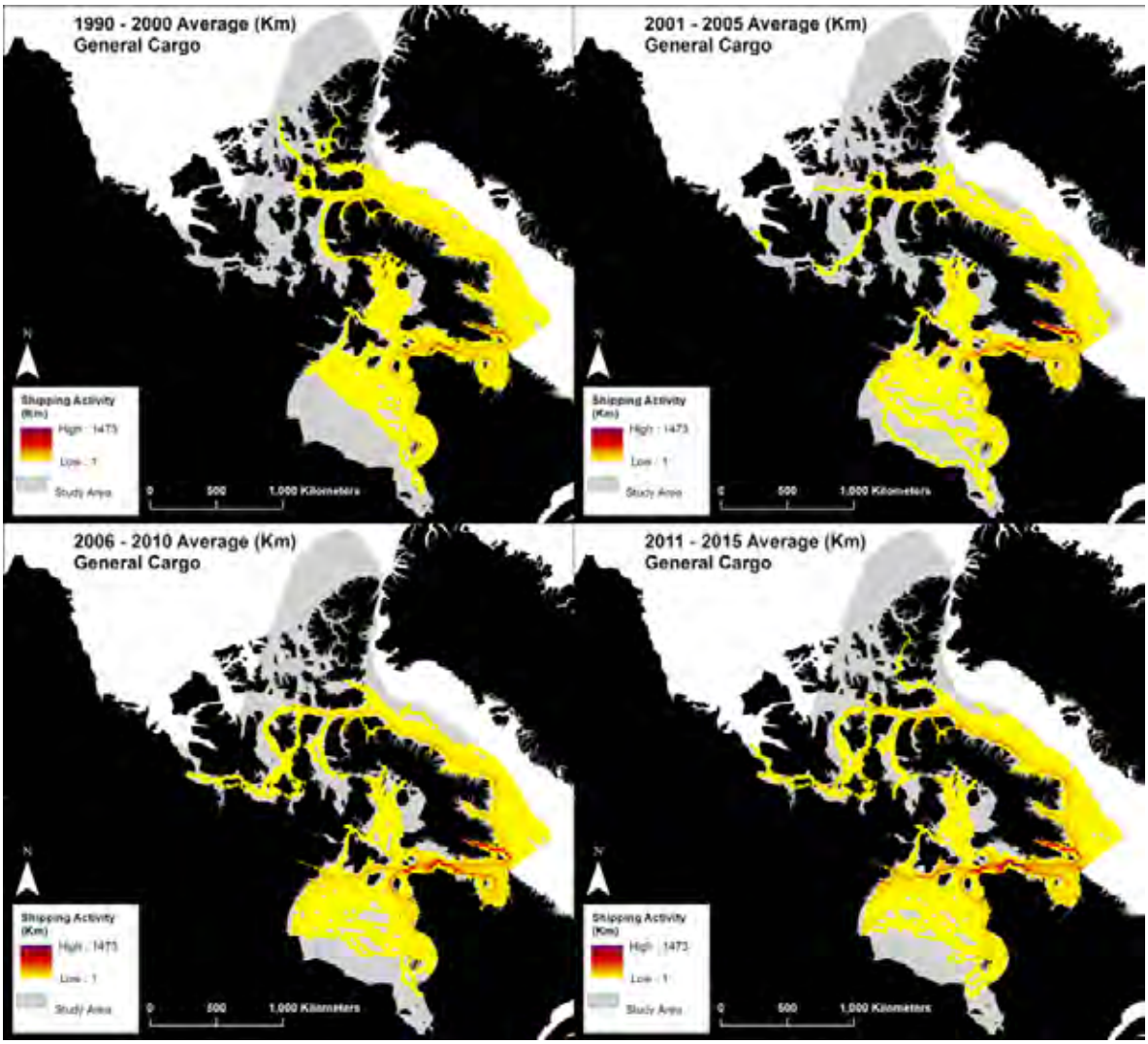
Figure 10: Annual Average Kilometres Traveled by Bulk Carriers, Baseline Period (top left), Phase 1 (top right), Phase 2 (bottom left), Phase 3 (bottom right).



GENERAL CARGO

General cargo includes vessels used for community re-supply, and as such, they have been consistently present in the Nunavut marine region throughout the study period. Between phases 1 and 3 general cargo traffic increased in the Kitikmeot region and around Prince of Wales Island and continued to intensify through Hudson Strait and along the east coast of mainland Nunavut. There are clear increases in traffic trends to Nunavut communities and in particular to larger communities such as Iqaluit, Baker Lake, Rankin Inlet, and Arviat

Figure 11: Annual Average Kilometres Traveled by General Cargo, Baseline Period (top left), Phase 1 (top right), Phase 2 (bottom left), Phase 3 (bottom right).

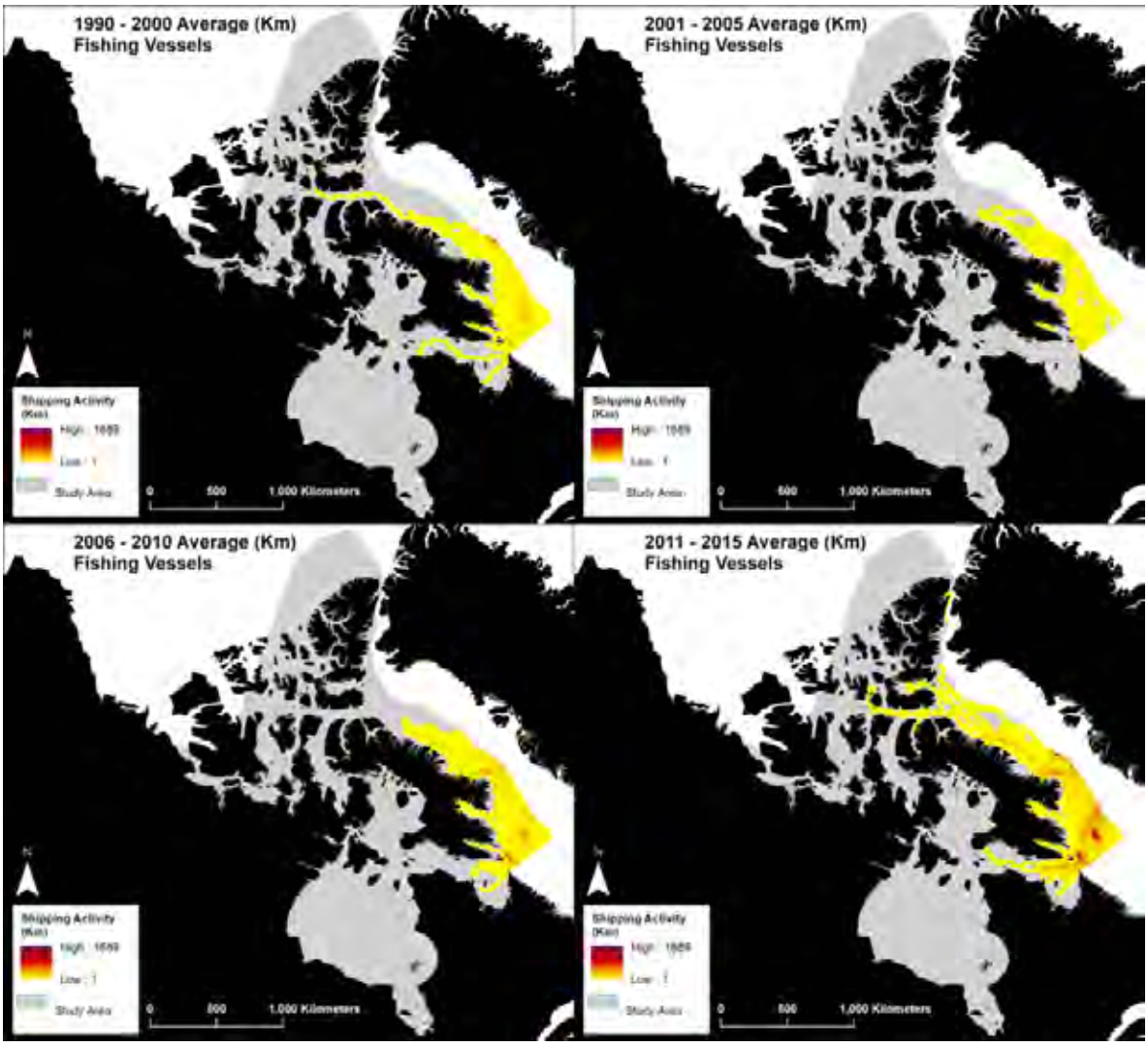


FISHING VESSELS

Fishing activity in Nunavut is highly concentrated off the east coast of Baffin Island. Between the baseline period and phase 1, fishing activity actually decreased in terms of spatial distribution and was concentrated around the southern and eastern extents of Baffin Island, whereas it previously extended into northern Baffin Island and the Hudson Strait. In phase 2 fishing activity intensified off the eastern coast of Baffin Island and extended slightly further south. The spatial extent and intensification of fishing activity was most dramatic in phase 3 where activity is now taking place further north, expanding into Lancaster Sound and as far west as Resolute and Little Cornwallis Island. Fishing vessel traffic is

also notably more intense in areas east of Hudson Strait and southern Baffin Island in recent years (see Brubacher Development Strategies Inc. 2004 for information on the early development of Nunavut fisheries).

Figure 12: Annual Average Kilometres Traveled by Fishing Vessels, Baseline Period (top left), Phase 1 (top right), Phase 2 (bottom left), Phase 3 (bottom right).

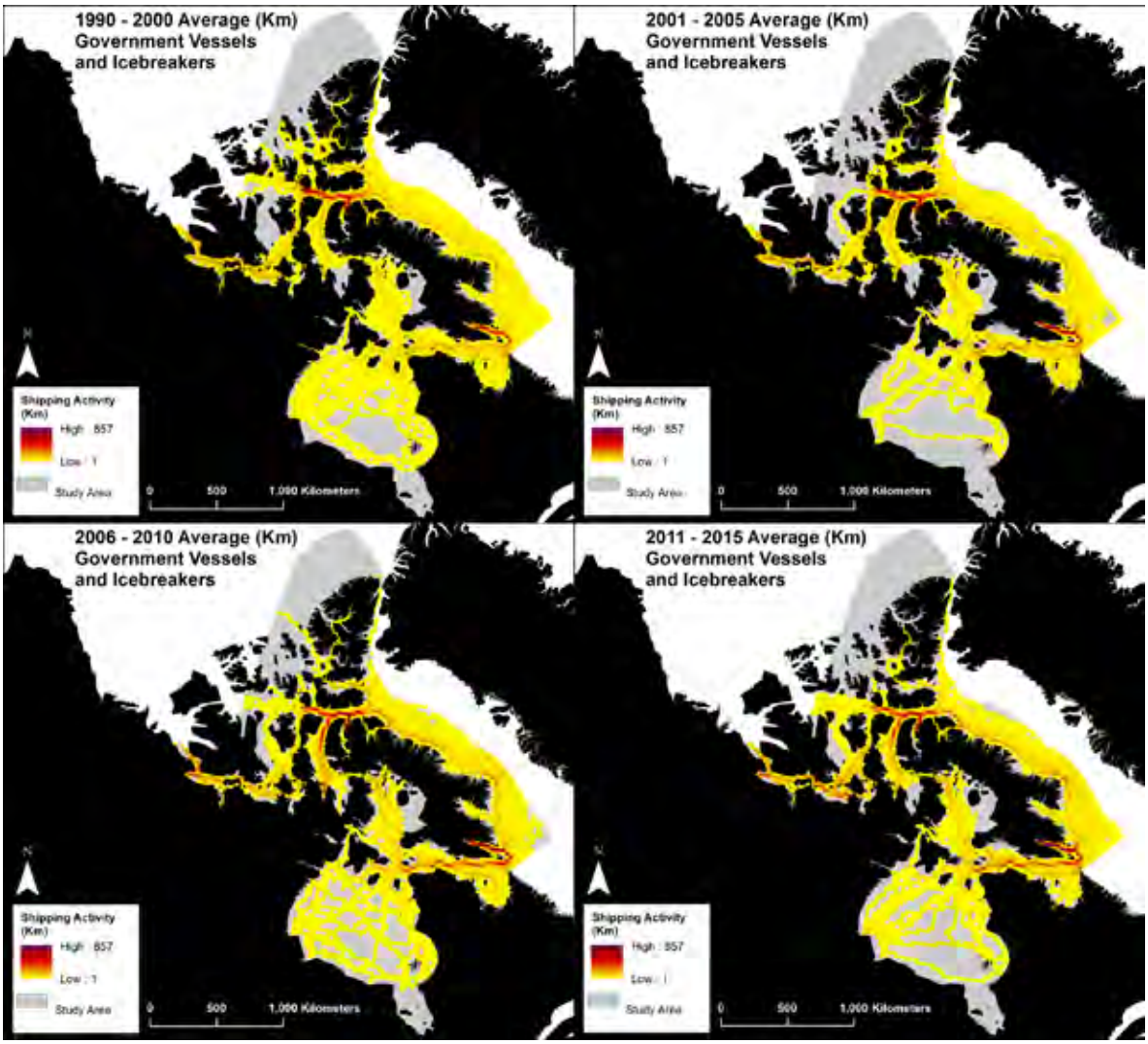


GOVERNMENT VESSELS AND ICEBREAKERS

Government vessels and icebreakers include all Canadian Coast Guard vessels, private icebreaking vessels, as well as any public or private research vessels operating in the territory. Throughout the study period, government vessels and icebreakers were found in all of the study area, except the very far north. During the baseline period, there was a concentration of vessel traffic through Lancaster Sound and the Parry Channel, as well as from Iqaluit through the Hudson Strait. These traffic

patterns also occurred in phase 1, with a slight intensification in traffic along the eastern coast of Baffin Island and a coincident decrease in traffic in Hudson Bay. In phase 2, there was heavier traffic through the Northwest Passage, south from the Parry Channel and into Queen Maud Gulf as well as throughout the Hudson Strait. This was also the period where the CCG vessel the Amundson was re-activated and underwent a conversion to become a research-intensive vessel. The Amundson has consistently been involved in marine research activities since 2003 and continues to be active today. There are little changes observed between phases 2 and 3, with the exception of the addition of a few vessels travelling north of Ellesmere Island and a slight increase through the western half of the Parry Channel.

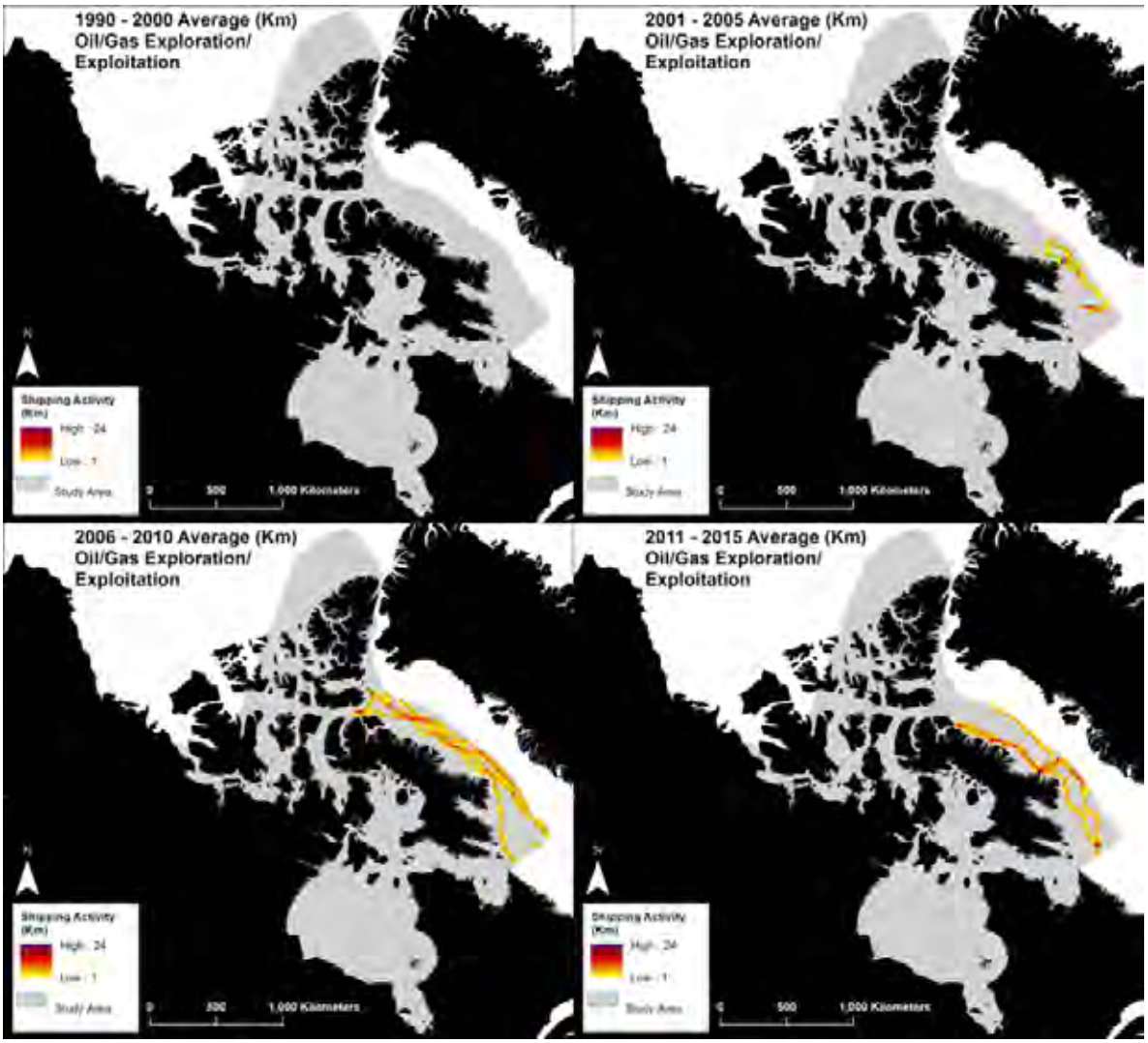
Figure 13: Annual Average Kilometres Traveled by Government Vessels and Icebreakers, Baseline Period (top left), Phase 1 (top right), Phase 2 (bottom left), Phase 3 (bottom right).



OIL/GAS EXPLORATION VESSELS

There was oil and gas exploration activity throughout what is now the Northwest Territories in the early 1990s but there was none during the baseline period in what is now Nunavut. There was limited activity by oil and gas exploration vessels off the east coast of Baffin Island during phase 1 and then a slight increase during phases 2 and 3. However, overall ship traffic by oil and gas exploration vessels is minimal compared to other vessel types in Nunavut. Notably other vessel types such as tankers and bulk carriers were involved in natural resource activities in the territory throughout the study period and thus this finding that there was limited oil/gas exploration vessel activity does not conclude that the industry was not active.

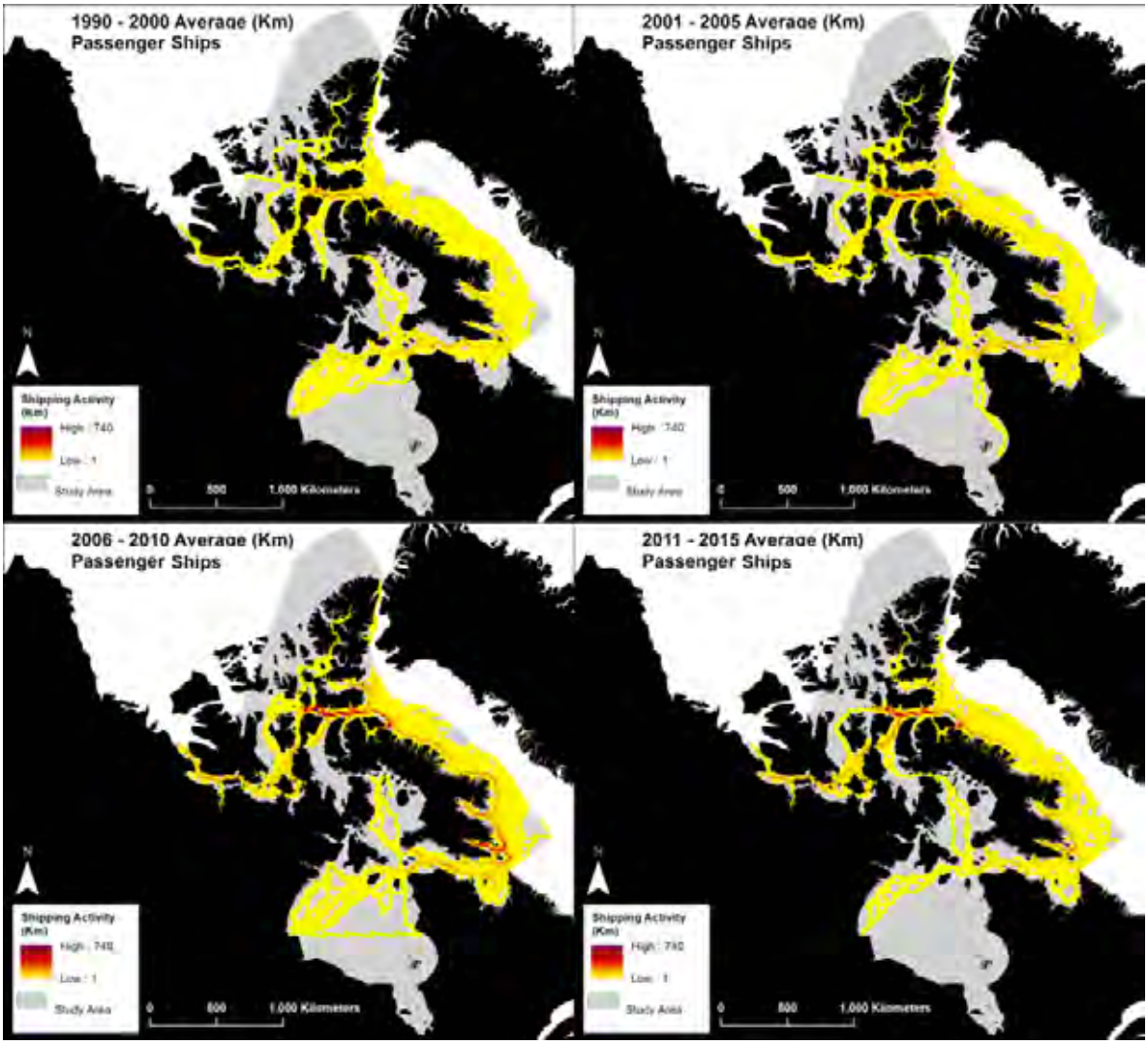
Figure 14: Annual Average Kilometres Traveled by Oil/Gas Exploration/Exploitation Vessels, Baseline Period (top left), Phase 1 (top right), Phase 2 (bottom left), Phase 3 (bottom right).



PASSENGER SHIPS

Passenger ships are classified as vessels carrying passengers for remuneration. In Nunavut, these vessels tend to be expedition style ships carrying around 200 tourists and a similar number of crew. However, the territory has more recently begun to also attract larger cruise vessels that can carry more than 1000 guests (e.g., Crystal Serenity, summer 2016 and 2017). During the baseline period, passenger ships were already operating throughout the entire Nunavut marine region. By phase 2, the passenger vessels began operating predominantly around Lancaster Sound, Parry Channel grew, and the eastern coast of Baffin Island compared to phase 1 where they tended to operate further south in Hudson Bay and Hudson Strait. By phase 3, there was minimal passenger ship traffic in Hudson Bay and a clear favour for routes through the Northwest Passage.

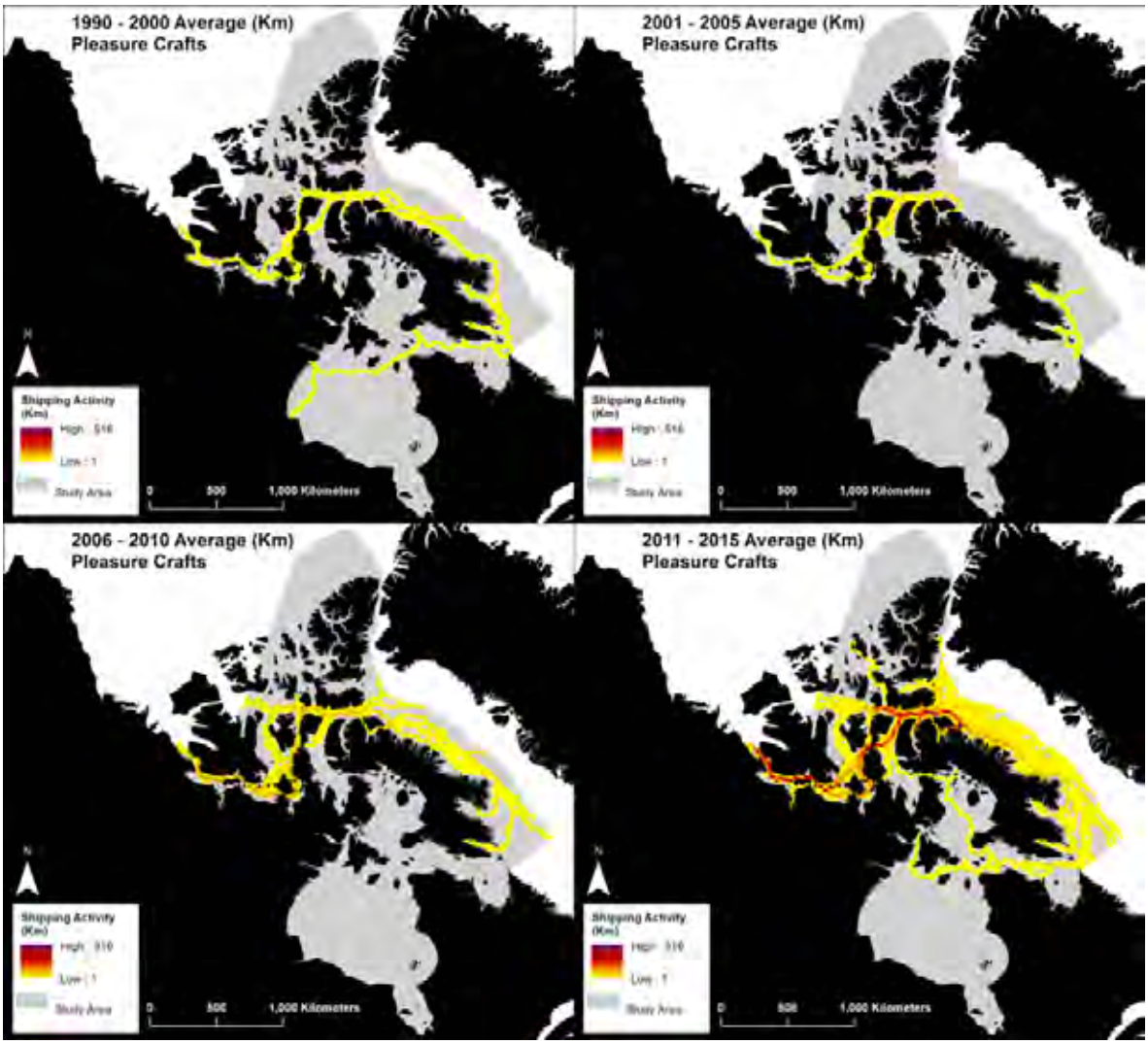
Figure 15: Annual Average Kilometres Traveled by Passenger Ships, Baseline Period (top left), Phase 1 (top right), Phase 2 (bottom left), Phase 3 (bottom right).



PLEASURE CRAFT

Pleasure craft are non-commercial vessels often characterized as yachts that typically carry between 1 (sail boats) and 50 people (luxury yachts). During the baseline period, the annual average number of km traveled by pleasure craft was 2,590. The annual km traveled by pleasure craft rose to 2836 km in phase 1, then increased five-fold by phase 2 to 13,580 km, and reached a record 52,799 km per year in phase 3. The spatial distribution of pleasure craft in the baseline period included routes through the southern northwest passage, along the eastern coast of Baffin Island and through Hudson Strait and the northern end of Hudson Bay. In phase 1 the spatial extent of pleasure craft decreased before increasing again in phase 2 and then increasing again in phase 3. In phase 3 there is a clear intensification of pleasure craft activity throughout the Northwest Passage (both the northern and southern routes but with higher intensities in the south). Pleasure craft also ventured further north than ever before and forged new routes on the western side of Baffin Island.

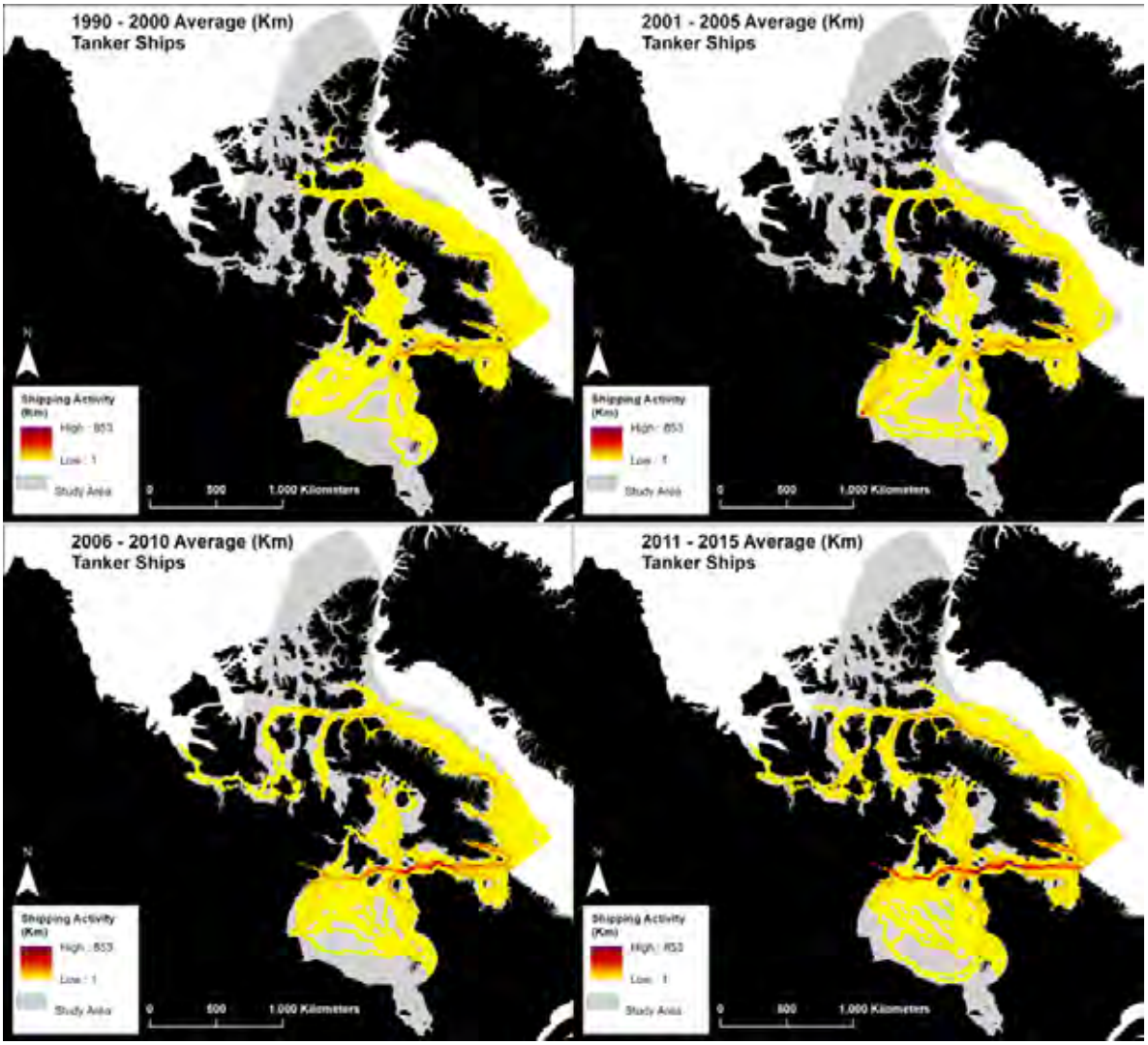
Figure 16: Annual Average Kilometres Traveled by Pleasure Crafts, Baseline Period (top left), Phase 1 (top right), Phase 2 (bottom left), Phase 3 (bottom right).



TANKER SHIPS

Tanker ships are bulk carriers of liquids and compressed gases. During the baseline period, tanker ships predominantly traveled in the eastern half of the study region; extended east towards Resolute, through Baffin Bay and then intensifying in the Hudson Strait. In phase 1, tanker traffic increased in Hudson Bay, along the eastern coast of mainland Nunavut, and also through Hudson Strait. In phase 2, there was an increase in the spatial distribution of tanker traffic throughout the Northwest Passage and into the Kitikmeot region. At the same time tanker traffic further intensified through Hudson Strait and into Chesterfield Inlet. The trends from phase 2 continued into phase 3, which displays additional intensification of tanker traffic through the Northwest Passage and in Hudson Bay

Figure 17: Annual Average Kilometres Traveled by Tanker Ships, Baseline Period (top left), Phase 1 (top right), Phase 2 (bottom left), Phase 3 (bottom right).

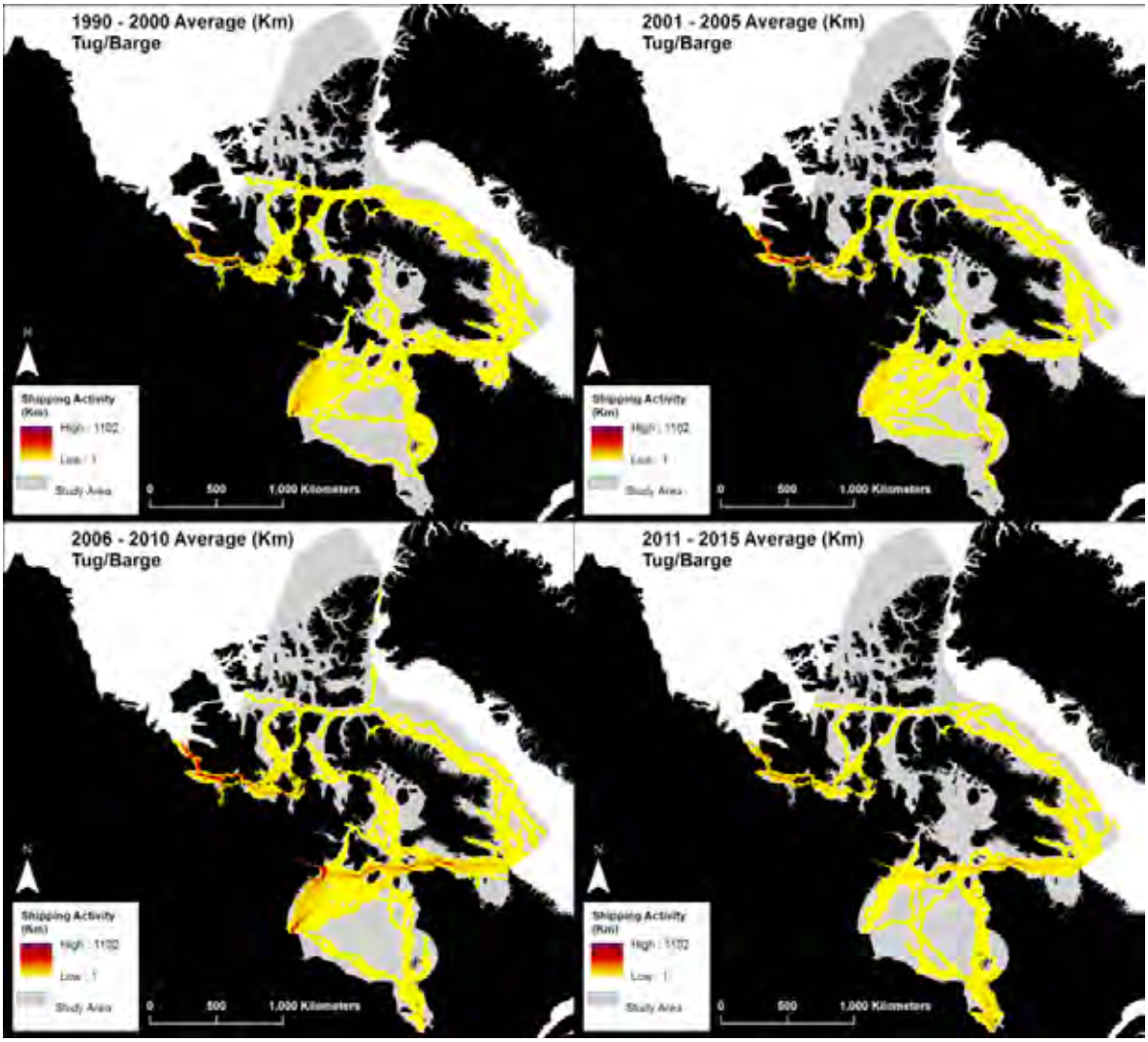


TUG/BARGE

Tug and barge vessels tend to support community re-supply and economic development activities in the region and therefore these vessel types are frequently found around communities. During the baseline period, traffic peaked in the southern Kitikmeot and out of the port of Churchill and along the eastern coast of mainland Nunavut. In phase 1, tug/barge traffic remained extensive throughout the study region, with an increased concentration in the southern Kitikmeot. In phase 2, there was an intensification of tug/barge traffic in eastern Hudson Bay, from the Port of Churchill to the communities along the eastern mainland of Nunavut and through Hudson Strait. Traffic was also concentrated in and around Cambridge Bay and Dolphin and Union Strait. In phase 3,

there was a decline in the spatial distribution of traffic and vessel patterns again become more similar to those observed in phase 1.

Figure 18: Annual Average Kilometres Traveled by Tugs/ Barges, Baseline Period (top left), Phase 1 (top right), Phase 2 (bottom left), Phase 3 (bottom right).



VESSEL TRAFFIC NEAR NUNAVUT COMMUNITIES

Local residents of the 25 Nunavut communities have expressed increased concern about the potential impacts of observed increases in shipping activity throughout the territory. Until now the distribution of shipping traffic by community has been challenging to obtain. Using a 50-km radius around communities, table 3 shows the change in annual average shipping traffic (all vessels) observed between the baseline period (1990 – 2000) and phase 3 (2011-2015). The community of Pond Inlet experienced close to a tripling of vessel traffic activity, representing the greatest increase in annual traffic of any Nunavut community (baseline 2,067 km/yr., compared to 6,188 km/yr. in phase 3). This increase around Pond Inlet is mainly attributable to increases in tourism vessels, bulk carrier and tanker traffic related to the Mary River mine. Chesterfield Inlet and Baker Lake had the second and fourth highest increases in vessel traffic that was also related to increases in tanker ships and general cargo ships servicing Medowbank Gold Mine. Cambridge Bay had the third highest increase in vessel traffic that can be explained by the increasing number of vessels transiting the Northwest Passage, including pleasure craft, passenger ships, general cargo, and tanker ships. Resolute and Arctic Bay both experienced declines in ship traffic that is likely related to the closures of the Polaris and Nanisivik Mines near each of these communities, respectively.

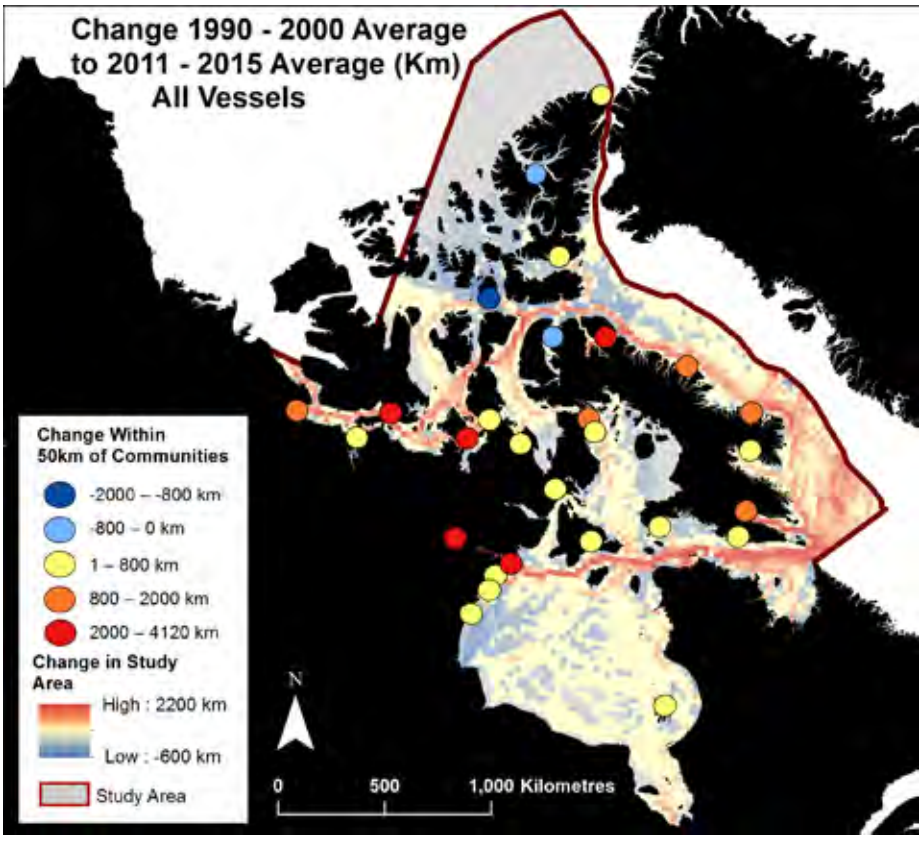
Table 2: Average Annual Kilometres Traveled within 50 km of Communities in 1990-2000 and 2011-2015 for all vessel types.

COMMUNITY	AVERAGE ANNUAL KM 1990-2000	AVERAGE ANNUAL KM 2011-2015	CHANGE
POND INLET	2067	6188	4120
CHESTERFIELD INLET	762	4758	3996
CAMBRIDGE BAY	2365	5220	2855
BAKER LAKE	0	2193	2193
GJOA HAVEN	852	2924	2073
QIKIQTARJUAQ	1632	3480	1848
IQALUIT	2714	4395	1682
CLYDE RIVER	2059	3543	1484
IGLOOLIK	890	1861	971
KUGLUKTUK	479	1389	910
RANKIN INLET	1138	1768	630
HALL BEACH	1279	1867	588
TALOYOAK	211	744	533
SANIKILUAQ	491	1016	525
PANGNIRTUNG	1022	1508	486
CORAL HARBOUR	522	923	401
GRISE FIORD	820	1176	356
WHALE COVE	1059	1337	278
KUGAARUK	260	535	275
ARVIAT	801	1053	252
CAPE DORSET	1478	1677	199

COMMUNITY	AVERAGE ANNUAL KM 1990-2000	AVERAGE ANNUAL KM 2011-2015	CHANGE
REPULSE BAY	366	516	150
KIMMIRUT	1028	1169	141
ALERT	0	55	55
UMINGMAKTOK	573	626	53
EUREKA	453	231	-223
ARCTIC BAY	3552	3112	-440
RESOLUTE	6361	4542	-1819

Figure 21 displays the overall spatial change in vessel traffic from the baseline period to phase 3 (2011-2015) (depicted in the background as vessel tracks) as well as the proportional changes in vessel traffic experienced within 50 km of each Nunavut community (depicted in the foreground as coloured dots). The red dots represent communities that have experienced the greatest increase in shipping traffic compared to the blue dots, which represent communities experiencing a decrease. Orange and yellow dots represent moderate to low increases respectively. Communities experiencing the most significant increases in shipping traffic are those located along major shipping routes and near operational mining sites. Resolute Bay has experienced the greatest decrease in shipping activity related to the reduction in local mining activity and also because consistently chose to traverse the Northwest Passage via the southern route instead of the northern route due to unpredictable but often thick multi-year ice that builds up near the community.

Figure 19: Change in Vessel Traffic (Km) within 50km of Communities, from 1990-2000 Average to 2011-2015 Average and Changes in Overall Vessel Traffic during the same period.



CONCLUSION

This study has outlined the temporal and spatial trends in ship traffic in Nunavut, Canada from 1990-2015. Overall, there has been an increase in the average number of kilometers that ships have traveled in the territory as well as an increase in the number, and type vessels. Vessel types that consistently make up the greatest proportion of traffic in Nunavut include general cargo (re-supply vessels) and government icebreakers (including private ice breakers and research ships). The fastest growing vessel sector is pleasure craft (private yachts), followed closely by fishing vessels. Other vessel types that are exhibiting increases include tanker ships and tug and barge activity that is related to community re-supply, and increased general cargo vessels. Passenger ships and tanker ships have declined slightly in recent years but not significantly.

The spatial distribution of vessels by some vessel type has also changed over the past 25 years. Not surprisingly the location of general cargo, tanker ships, and bulk carriers has been largely linked to the location of communities and natural resource projects and thus traffic patterns are relatively spatially consistent. Fishing activities remain concentrated on the eastern side of Baffin Island but have expanded both to the north and the south. Tourism vessels have displayed the most dramatic shifts in spatial distribution; in recent years passenger vessel and pleasure craft traffic has been highly concentrated through the Northwest Passage, whereas in the past it was less concentrated and often took place in more southerly regions around Hudson Bay.

Further increases in shipping activity are expected in Nunavut as sea ice regimes continue to change leading to increased accessibility and shipping season lengths (Pizzolato et al. 2014; 2016; Smith and Stephenson 2013). Other factors will also influence shipping trends in the territory including commodity prices, insurance, probable risk, demand, fuel prices, and others (Dawson et al 2017; others). It is plausible to speculate that the region will continue to experience an increase in shipping activity into the next century. Regional demographics and a focus on a fisheries economy suggest that general cargo, tug and barge, and fishing traffic will not decrease. Larger cruise vessels (e.g., Crystal Serenity) and smaller private yachts are beginning to see the region as attractive (CBC, 2014; Johnston et al. 2017) and it is likely that the trends for adventurers and yachters to visit Nunavut via the Northwest Passage will continue. Mining and natural resource exploration has slowed down in recent years but may increase again in the future as the international demand for energy continues to grow and as more and more non-Arctic nations are becoming interested in Arctic resources.

Nunavut is well positioned to benefit from shipping activities in the territory but development is not without risks. It is vital that pro-active governance measures such as the low impact shipping corridors (see **www.arcticcorridors.ca** and Pew Charitable Trusts 2016), pro-active vessel management, local monitoring programs, and collaborative co-management and shared leadership initiatives on Arctic shipping and oceans management continue.

REFERENCES CITED

Brubacher Development Strategies Inc. (2004). An overview of Nunavut Fisheries: background paper. Retrieved from, **http://www.nunavuteconomicforum.ca/public/files/library/FISHERIE/An%20Overview%20of%20Nunavut%20Fisheries%20(March%202004).pdf**

Canadian Coast Guard (CCG). (2013). *Vessel traffic reporting Arctic Canada traffic zone (NORDREG)*. Retrieved from: **http://www.ccg-gcc.gc.ca/eng/MCTS/Vtr_Arctic_Canada**

CBC (2013, 19 September). Pangnirtung's small craft harbour opens. Retrieved from: **http://www.cbc.ca/news/canada/north/pangnirtung-s-small-craft-harbour-opens-1.1859764**

CBC (2014, 15 August). Crystal Serenity becomes 1st luxury ship to tackle the Northwest Passage. Retrieved from: **http://www.cbc.ca/news/canada/north/crystal-serenity-to-become-1st-luxury-ship-to-tackle-northwest-passage-1.2737374**

CCA (Canadian Council of Academies) (2017). The value of commercial marine shipping to Canada. Ottawa (ON): The Expert Panel on the Social and Economic Value of Marine Shipping to Canada, Council of Canadian Academies.

Comiso, J. C. (2012). Large decadal decline of Arctic multiyear ice cover. *J Climate*, 25(4), 1176–1193. doi: 10.1175/JCLI-D-11-00113.1

Dawson, J., Copland, L., Johnston, M.E., Pizzolato, L., Howell, S., Pelot, R., Etienne, L., Matthews, L., and Parsons, J. (2017). Adaptation Strategies and Policy Options for Arctic Shipping in Canada. Report prepared for Transport Canada. Ottawa

Dawson J., Johnston M. E., & Stewart E. J. (2014). Governance of Arctic expedition cruise ships in a time of rapid environmental and economic change. *Ocean & Coastal Management, 89,* 88–99. doi:10.1016/j.ocecoaman.2013.12.005

Dawson J., Maher P., & Slocombe S. D. (2007). Climate change, marine tourism and sustainability in the Canadian Arctic: Contributions from systems and complexity approaches. *Tourism in Marine Environments, 4*(2/3), 69–83.

Eguíluz, V. M., J. Fernández-Gracia, X. Irigoien, and C. M. Duarte (2016), A quantitative assessment of Arctic shipping in 2010–2014, Sci. Rep., 6, 30682, doi:**10.1038/srep30682**.

George, R. (2013). 90% of Everything: Inside shipping, the invisible industry that puts clothes on your back, gas in your car, food on your plate. New York: Metropolitan Books

Government of Nunavut (2017). Government of Nunavut. Found at, **http://www.gov.nu.ca/**

Guy, E. (2006). Evaluating the viability of commercial shipping in the Northwest Passage. *Journal of Ocean Technology, 1*(1), 9–18.

Hodgson, J. R. F., Russell, W. D., & Megganety, M. (2013). *Exploring plausible futures for marine transportation in the Canadian Arctic: A scenarios' based approach*. Ottawa: Transport Canada.

International Maritime Organization (IMO). (1974). *International convention for the safety of life at sea* (SOLAS). Retrieved from: **http://www.imo.org/About/Conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-(solas),-1974.aspx**

Johnston, M., Dawson, J., De Souza, E., & Stewart, E.J. (2017). Managing the fastest growing marine shipping sector in Arctic Canada: Pleasure craft vessels, *Polar Record*. 53(1), 67-78.

Laliberté, F., Howell, S. E. L., & Kushner, P. J. (2016). Regional variability of a projected sea ice-free Arctic during the summer months. *Geophysical Research Letters*, 43(1), 256–263. doi: 10.1002/2015GL066855

Lasserre, F., & Têtu, P. L. (2015). The cruise tourism industry in the Canadian Arctic: Analysis of activities and perceptions of cruise ship operators. *Polar Record, 51*(1), 24–38. doi:10.1017/S0032247413000508

Maslanik, J., Stroeve, J., Fowler, C., & Emery, W. (2011). Distribution and trends in Arctic sea ice age through spring 2011. *Geophysical Research Letters, 38*(13), L13502. doi:10.1029/2011GL047735

Parkinson, C. L. (2014). Spatially mapped reductions in the length of the Arctic sea ice season. *Geophysical Research Letters, 41*(12), 4316–4322. doi:10.1002/2014GL060434

Pew Charitable Trusts. (2016). The Integrated Arctic Corridors Framework: Planning for Responsible Shipping in Canada's Arctic Waters. Washington, DC: Oceans North Canada. Retrieved from: **http://www.pewtrusts.org/en/research-and-analysis/reports/2016/04/the-integrated-arctic-corridors-framework**

Pizzolato, L., Howell, S. E. L., Derksen, C., Dawson, J., & Copland, L. (2014). Changing sea ice conditions and marine transportation activity in Canadian Arctic waters between 1990 and 2012. *Climatic Change, 123*(2), 161–173. doi: 10.1007/s10584-013-1038-3

Pizzolato, L., S. E. L. Howell, J. Dawson, F. Laliberté, and L. Copland (2016), The influence of declining sea ice on shipping activity in the Canadian Arctic, Geophys. Res. Lett., 43, 12,146–12,154, doi:10.1002/2016GL071489.

Prowse, T. D., Furgal, C., Chouinard, R., Melling, H., Mildurn, D., & Smith, S. (2009). Implications of climate change for economic development in Northern Canada: Energy, resource, and transportation sectors. *AMBIO, 38*(5), 272–281.

Smith, L. C., & Stephenson, S. R. (2013). New trans-Arctic shipping routes navigable by midcentury. *Proceedings of the National Academy of Sciences, 110*(13), E1191–E1195. doi: 10.1073/pnas.1214212110

Sou, T., & Flato, G. (2009). Sea ice in the Canadian Arctic Archipelago: Modeling the past (1950–2004) and the Future (2041–60). *Journal of Climate, 22*(8), 2181–2198. doi: 10.1175/2008JCLI2335.1

Stroeve, J. C., Markus, T., Boisvert, L., Miller, J., & Barrett, A. (2014). Changes in Arctic melt season and implications for sea ice loss. *Geophysical Research Letters, 41*(4), 1216–1225. doi:10.1002/2013GL058951

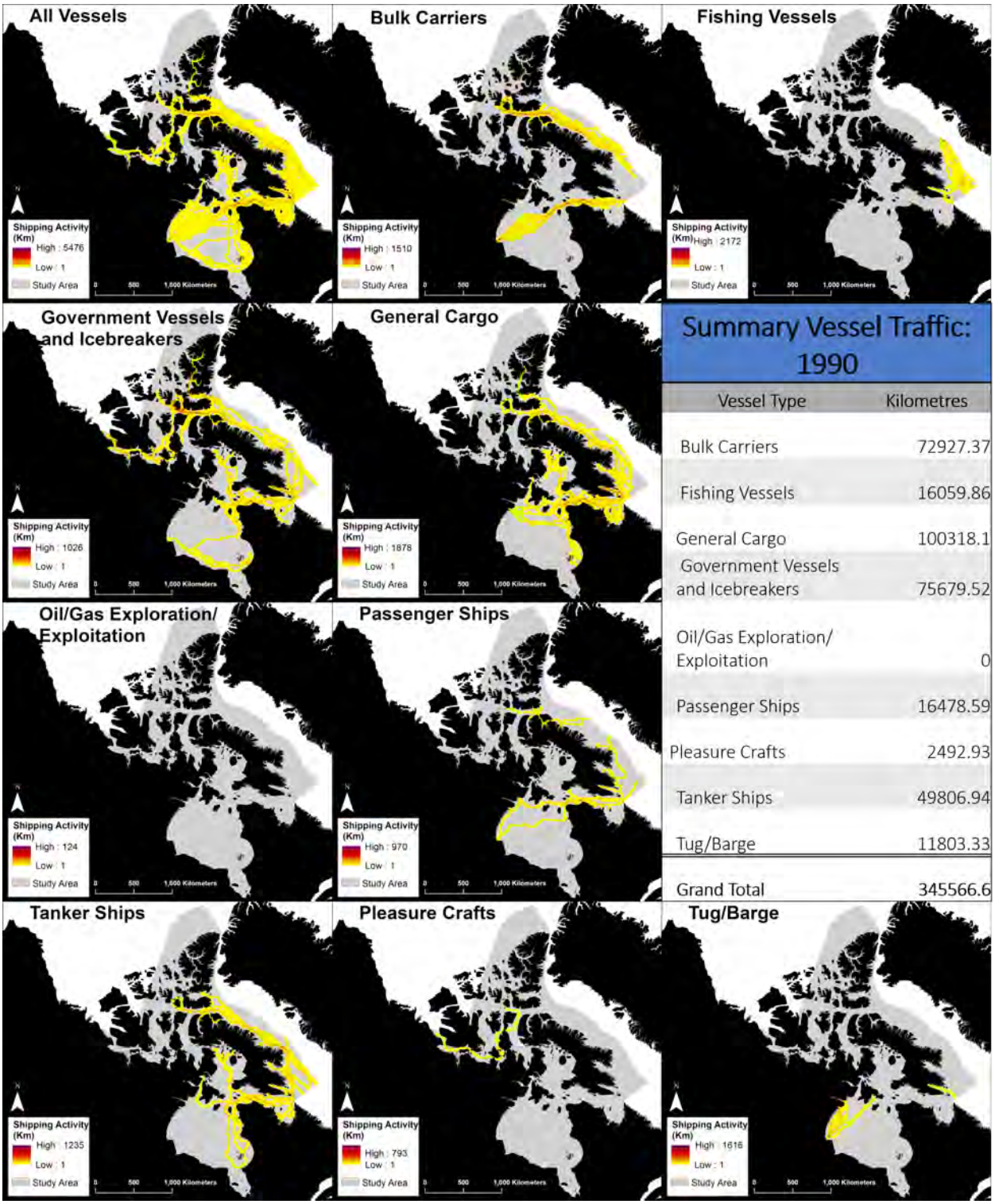
Tivy, A., Howell, S. E. L., Alt, B., McCourt, S., Chagnon, R., Crocker, G., et al. (2011). Trends and variability in summer sea ice cover in the Canadian Arctic based on the Canadian Ice Service Digital Archive. *Journal of Geophysical Research: Oceans, 116*(C3). doi:10.1029/2011JC007248

APPENDIX A: ANNUAL KILOMETERS TRAVELED BY VESSEL TYPE (1990-2015)

YEAR	BULK CARRIERS	FISHING VESSELS	GENERAL CARGO	GOVERNMENT VESSELS AND ICEBREAKERS	OIL/GAS EXPLORATION/ EXPLOITATION	PASSENGER SHIPS	PLEASURE CRAFTS	TANKER SHIPS	TUG/BARGE	GRAND TOTAL
1990	72927	16060	100318	75680	0	16479	2493	49807	11803	345567
1991	66346	19763	117306	92547	0	17914	1655	55214	34847	405590
1992	71241	32098	88590	93680	0	8584	1203	46611	38526	380533
1993	61320	13548	102260	118619	0	16092	6271	49203	26135	393449
1994	66561	21436	78610	92256	0	22644	6928	47384	36021	371841
1995	59195	25158	93379	106348	0	54980	2498	52986	50877	445421
1996	80801	19823	87773	107513	0	27870	0	46674	46386	416839
1997	85839	13776	98291	92955	0	35966	0	44234	53382	424444
1998	67759	10210	87040	99725	0	54846	0	49616	33835	403032
1999	82653	8914	110230	125148	0	49414	205	51797	45039	473400
2000	136274	6345	105116	106195	0	29096	7242	58026	45956	494252
BASELINE AVERAGE	77356	17012	97174	100970	0	30353	2590	50141	38437	414033
2001	82838	30571	120542	89958	0	43634	1168	55989	50378	475079
2002	66429	14173	107070	112946	0	40725	0	54959	48455	444756
2003	77809	10307	106184	108293	326	38032	1582	61550	49808	453891
2004	57816	8839	90416	104476	0	44941	2035	70555	32678	411755
2005	60627	4120	102189	96834	1510	69621	9394	54928	30850	430073

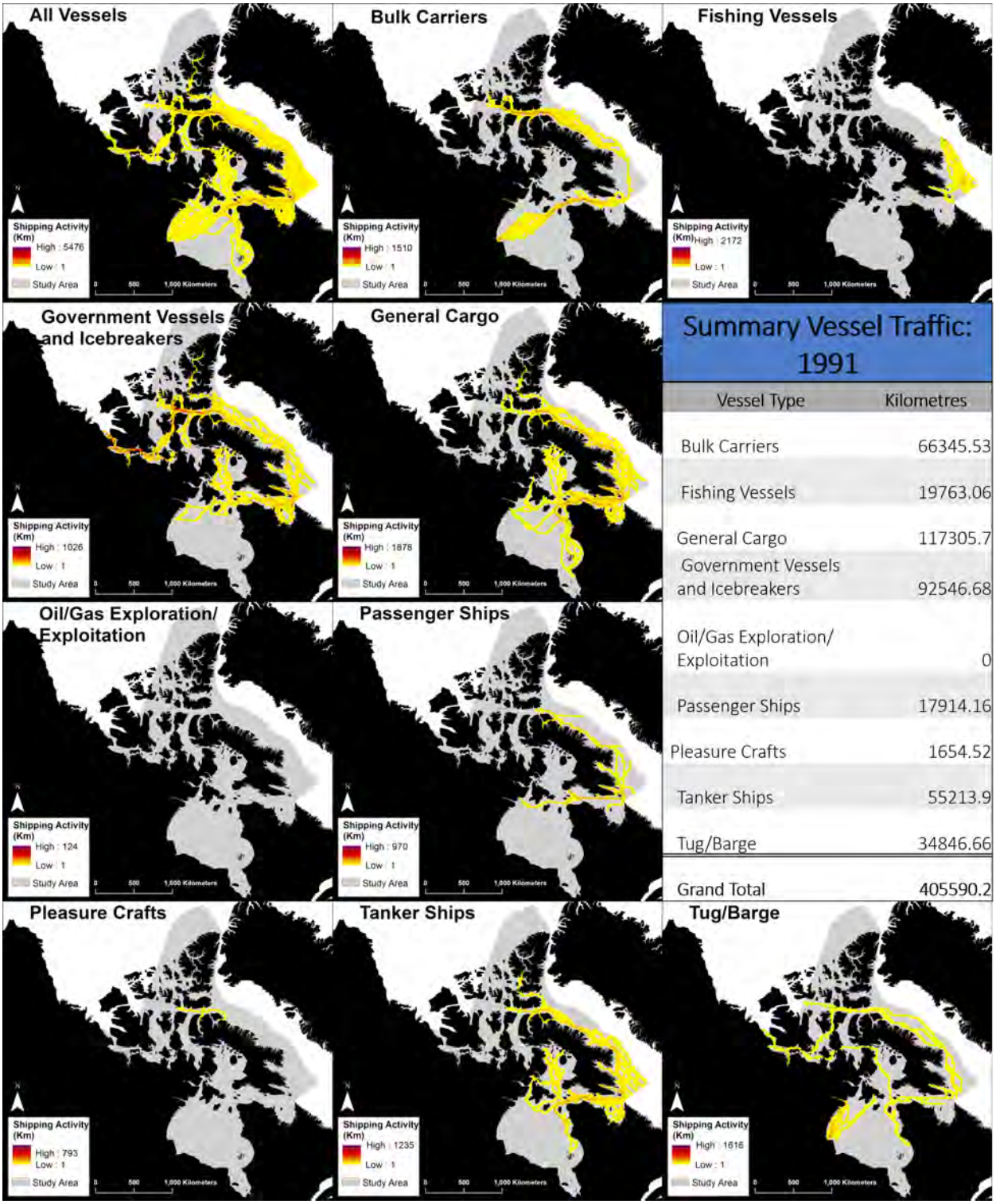
YEAR	BULK CARRIERS	FISHING VESSELS	GENERAL CARGO	GOVERNMENT VESSELS AND ICEBREAKERS	OIL/GAS EXPLORATION/ EXPLOITATION	PASSENGER SHIPS	PLEASURE CRAFTS	TANKER SHIPS	TUG/BARGE	GRAND TOTAL
P1 AVERAGE	69104	13602	105280	102501	367	47391	2836	59596	42434	443111
CHANGE FROM BASELINE	-8252	-3410	8106	1532	367	17037	245	9455	3997	29077
2006	52366	6323	108335	119342	80	84519	0	71432	64760	507157
2007	77135	10649	128068	141003	3202	75981	5757	82481	121496	645773
2008	70891	43158	151244	138281	3886	85973	22871	96253	86286	702561
2009	66853	29049	124319	123879	0	59225	26475	75160	102295	607256
2010	83340	72057	166259	121981	0	87704	25749	109275	87911	754276
P2 AVERAGE	70117	32247	135645	128897	1434	78680	16171	86920	92550	643404
CHANGE FROM BASELINE	-7239	15235	38471	27927	1434	48327	13580	36779	54113	229371
2011	70837	98603	163027	158206	228	43728	44754	128938	45943	754265
2012	66280	70838	164063	106556	599	33503	51510	110983	55304	659637
2013	85603	83801	183378	119852	4371	62673	54048	114323	46711	754760
2014	90805	97436	194844	157087	0	62557	72569	130734	35711	841742
2015	73348	104881	185691	127723	0	68127	54068	130004	49842	793684
P3 AVERAGE	77375	91112	178201	133885	1040	54118	55390	122996	46702	760818
CHANGE FROM BASELINE	19	74100	81027	32915	1040	23764	52799	72855	8265	346784

APPENDIX B: VESSEL TYPE TRENDS BY YEAR (1990-2015)



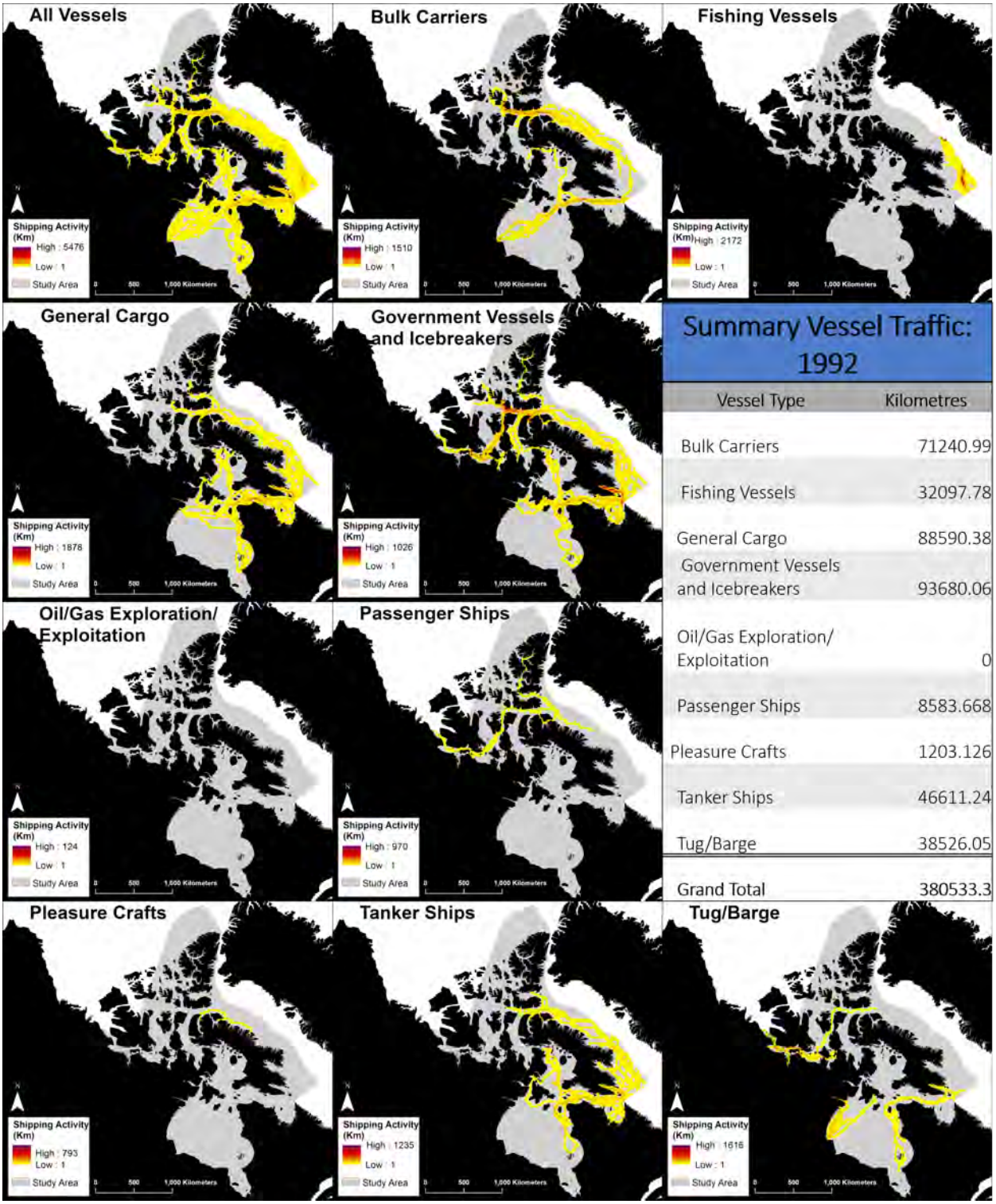
Summary Vessel Traffic: 1990

Vessel Type	Kilometres
Bulk Carriers	72927.37
Fishing Vessels	16059.86
General Cargo	100318.1
Government Vessels and Icebreakers	75679.52
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	16478.59
Pleasure Crafts	2492.93
Tanker Ships	49806.94
Tug/Barge	11803.33
Grand Total	345566.6



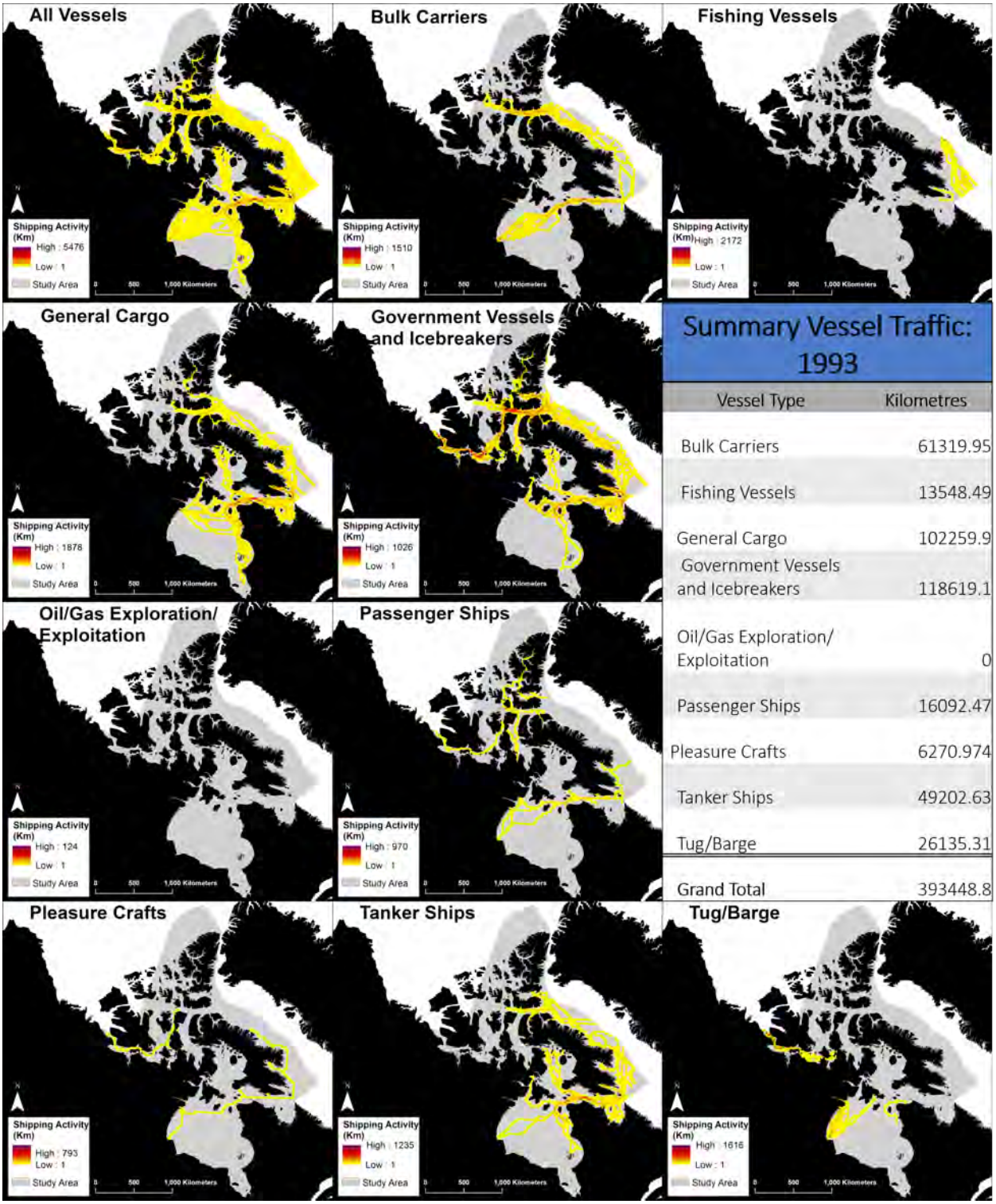
Summary Vessel Traffic: 1991

Vessel Type	Kilometres
Bulk Carriers	66345.53
Fishing Vessels	19763.06
General Cargo	117305.7
Government Vessels and Icebreakers	92546.68
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	17914.16
Pleasure Crafts	1654.52
Tanker Ships	55213.9
Tug/Barge	34846.66
Grand Total	405590.2



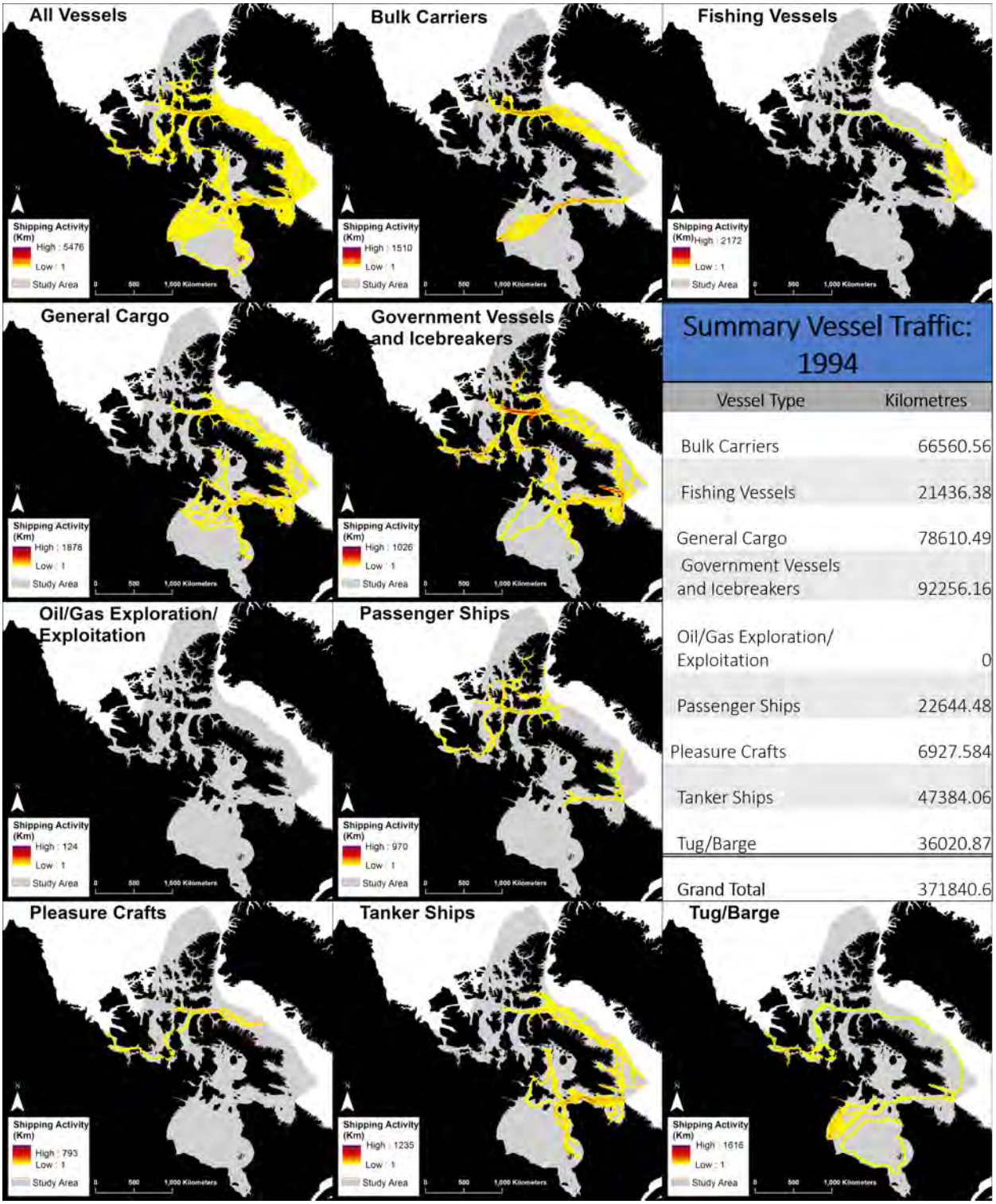
Summary Vessel Traffic: 1992

Vessel Type	Kilometres
Bulk Carriers	71240.99
Fishing Vessels	32097.78
General Cargo	88590.38
Government Vessels and Icebreakers	93680.06
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	8583.668
Pleasure Crafts	1203.126
Tanker Ships	46611.24
Tug/Barge	38526.05
Grand Total	380533.3



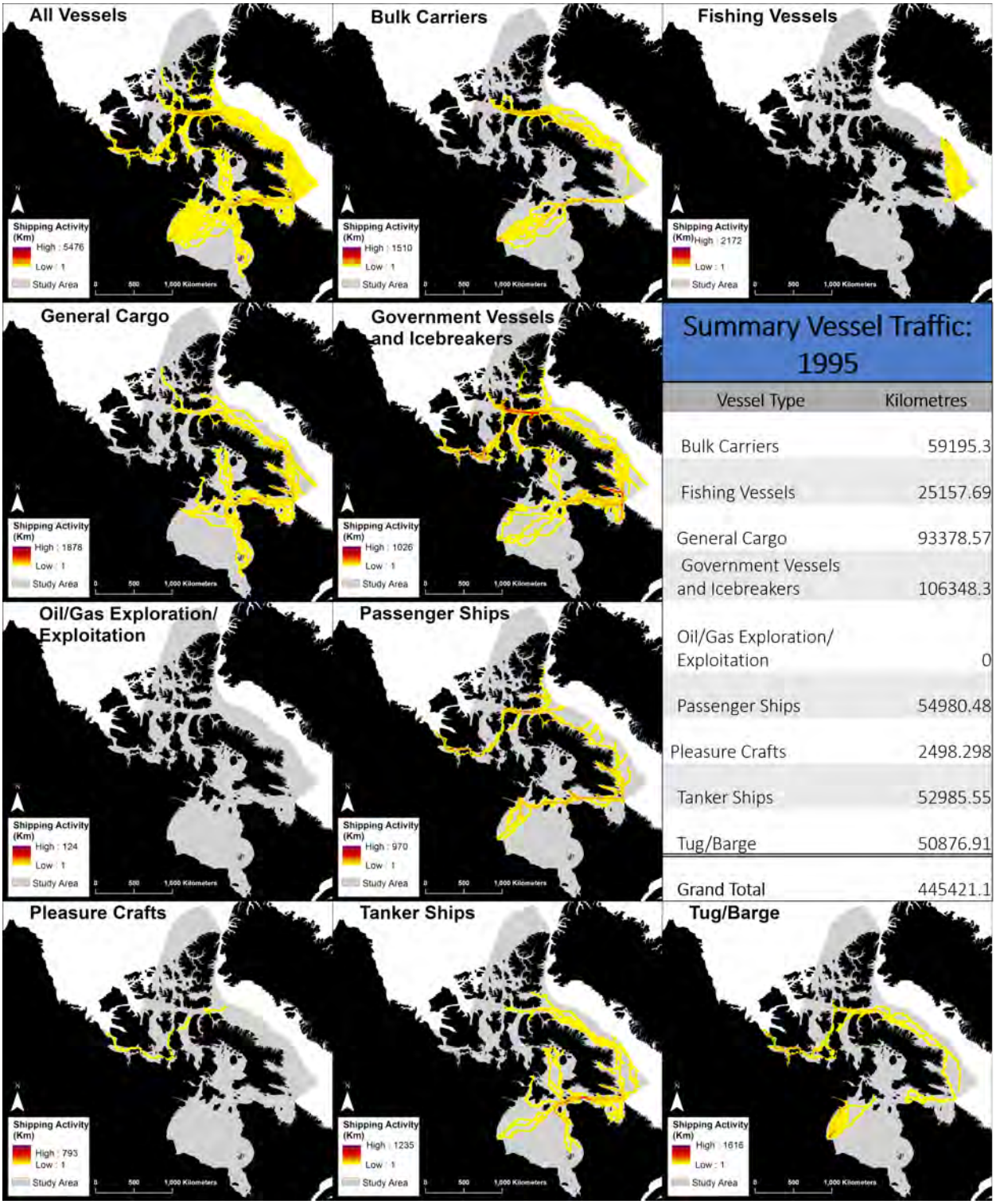
Summary Vessel Traffic: 1993

Vessel Type	Kilometres
Bulk Carriers	61319.95
Fishing Vessels	13548.49
General Cargo	102259.9
Government Vessels and Icebreakers	118619.1
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	16092.47
Pleasure Crafts	6270.974
Tanker Ships	49202.63
Tug/Barge	26135.31
Grand Total	393448.8



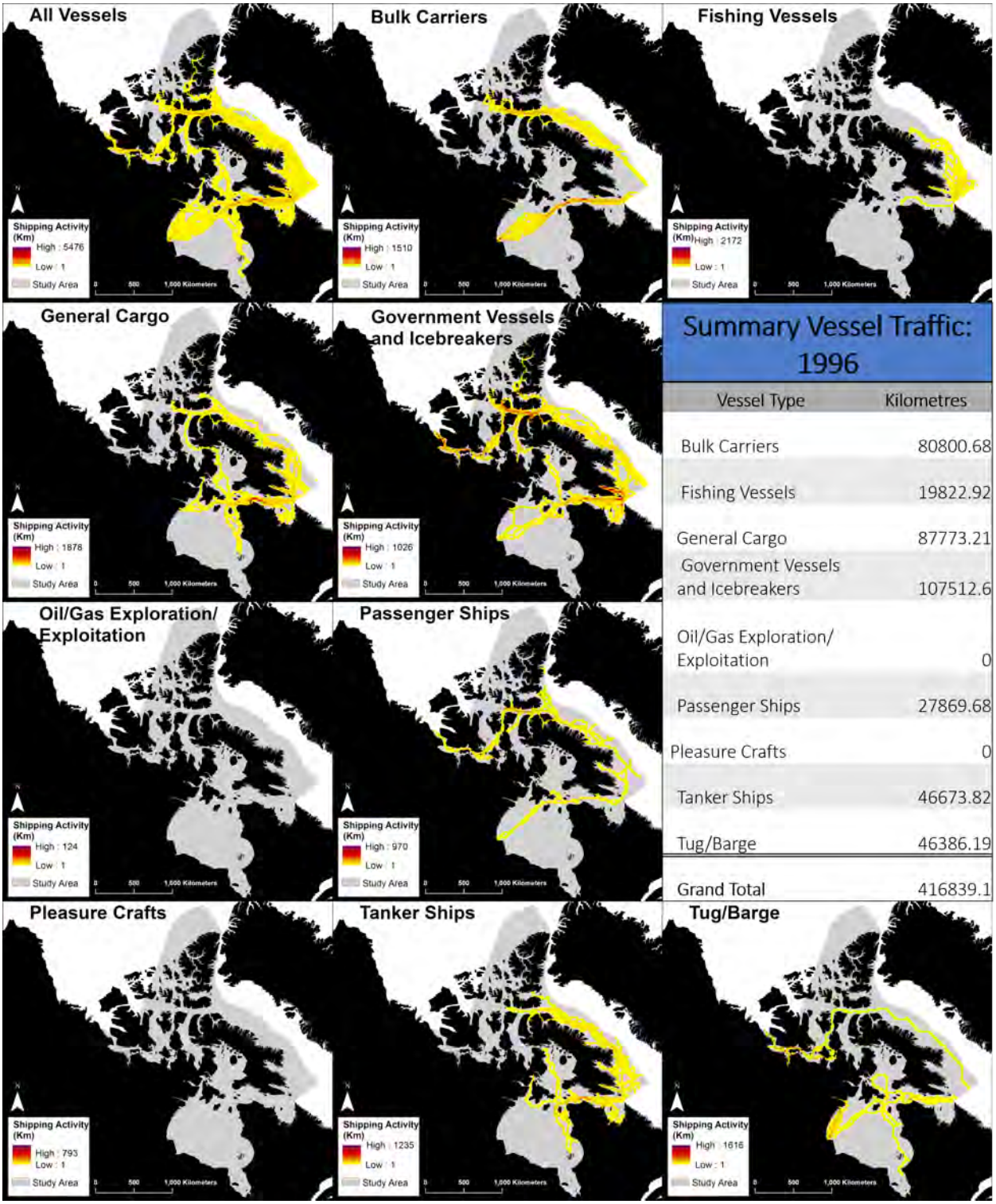
Summary Vessel Traffic: 1994

Vessel Type	Kilometres
Bulk Carriers	66560.56
Fishing Vessels	21436.38
General Cargo	78610.49
Government Vessels and Icebreakers	92256.16
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	22644.48
Pleasure Crafts	6927.584
Tanker Ships	47384.06
Tug/Barge	36020.87
Grand Total	371840.6



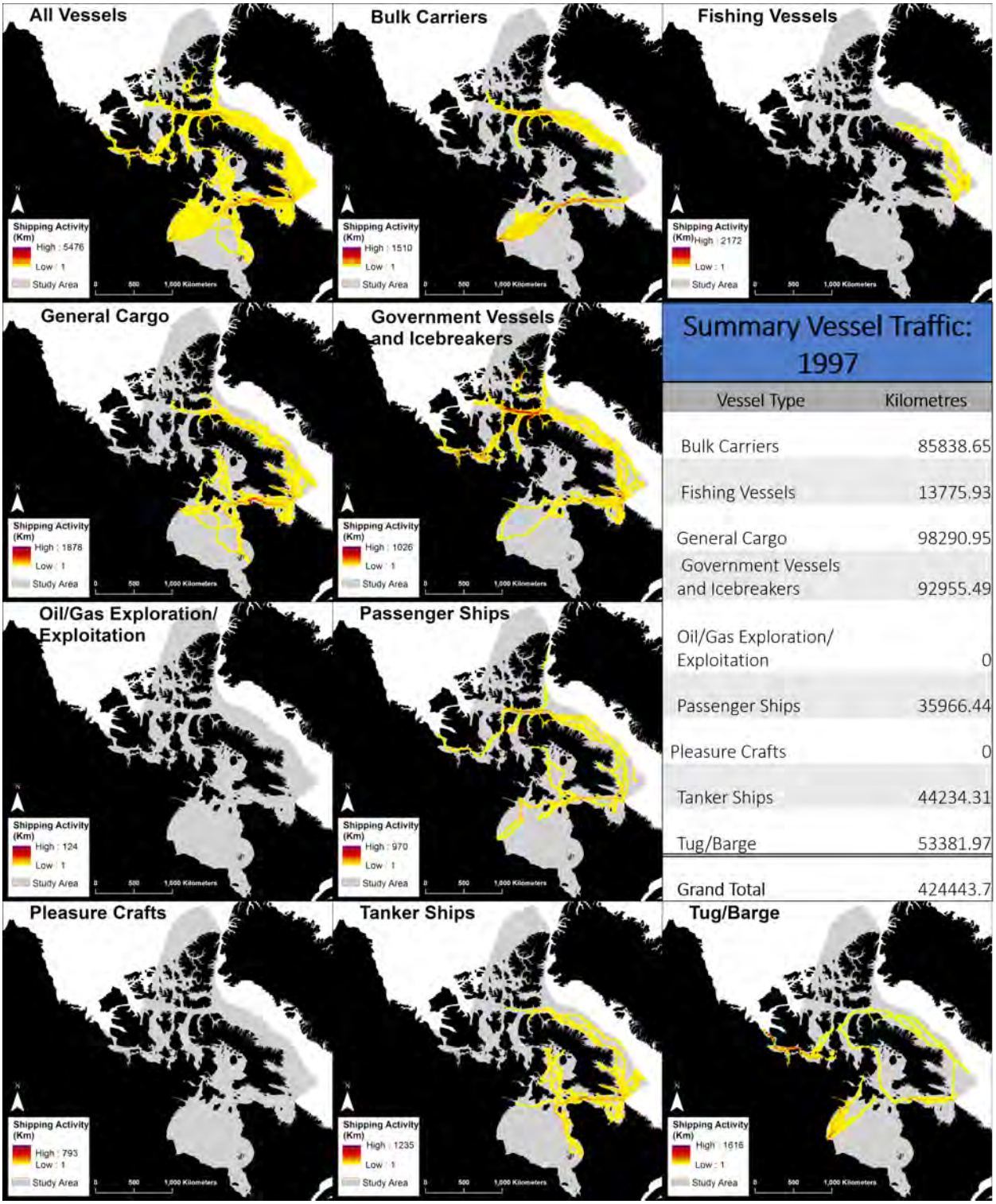
Summary Vessel Traffic: 1995

Vessel Type	Kilometres
Bulk Carriers	59195.3
Fishing Vessels	25157.69
General Cargo	93378.57
Government Vessels and Icebreakers	106348.3
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	54980.48
Pleasure Crafts	2498.298
Tanker Ships	52985.55
Tug/Barge	50876.91
Grand Total	445421.1



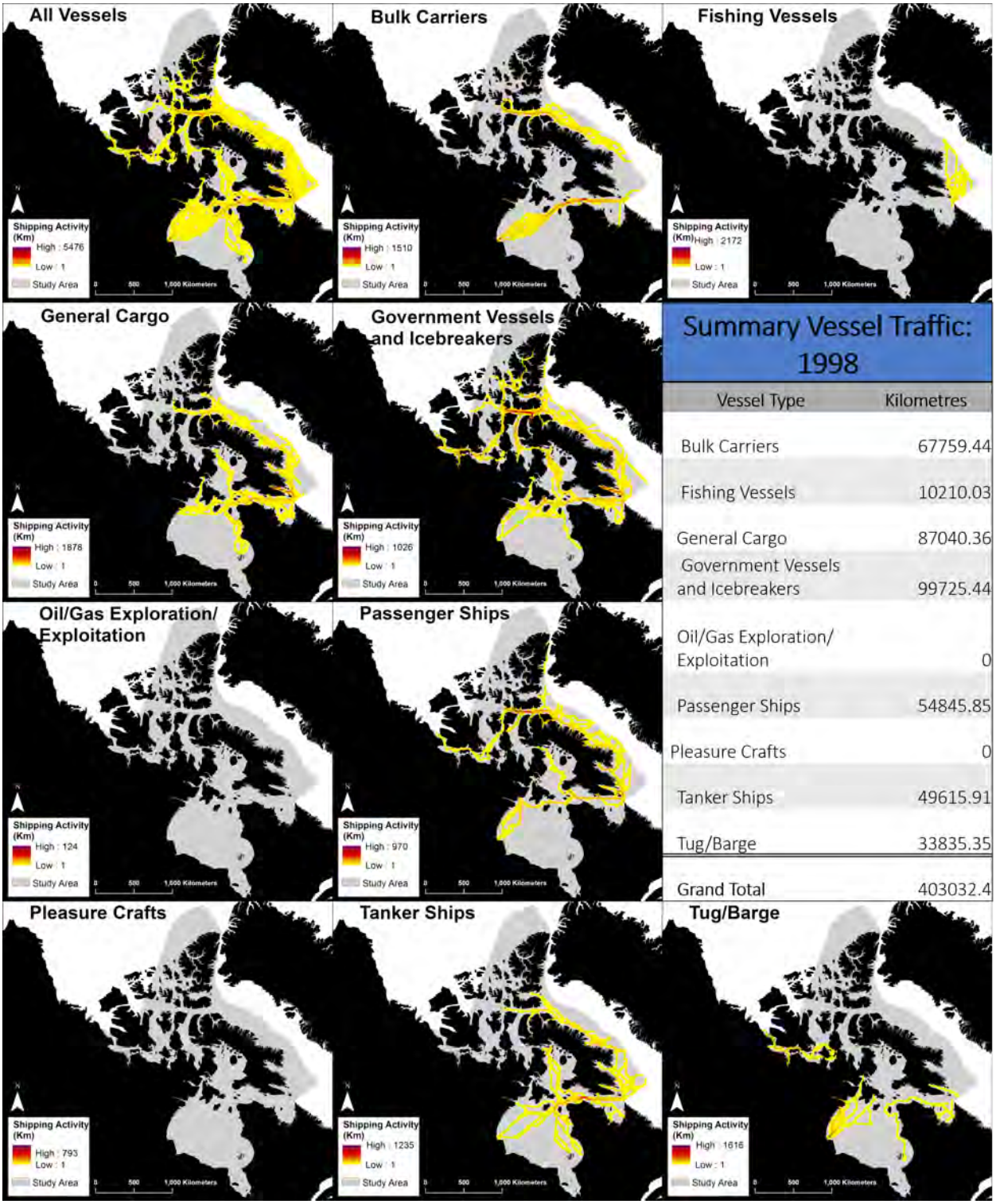
Summary Vessel Traffic: 1996

Vessel Type	Kilometres
Bulk Carriers	80800.68
Fishing Vessels	19822.92
General Cargo	87773.21
Government Vessels and Icebreakers	107512.6
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	27869.68
Pleasure Crafts	0
Tanker Ships	46673.82
Tug/Barge	46386.19
Grand Total	416839.1



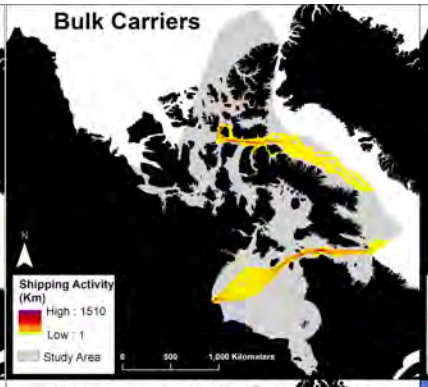
Summary Vessel Traffic: 1997

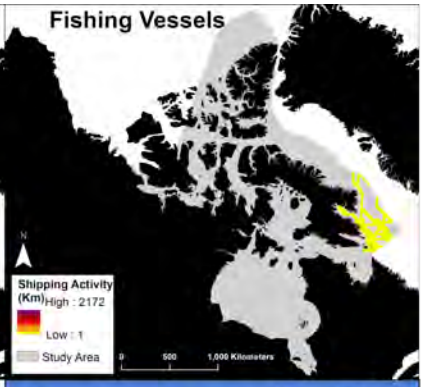
Vessel Type	Kilometres
Bulk Carriers	85838.65
Fishing Vessels	13775.93
General Cargo	98290.95
Government Vessels and Icebreakers	92955.49
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	35966.44
Pleasure Crafts	0
Tanker Ships	44234.31
Tug/Barge	53381.97
Grand Total	424443.7

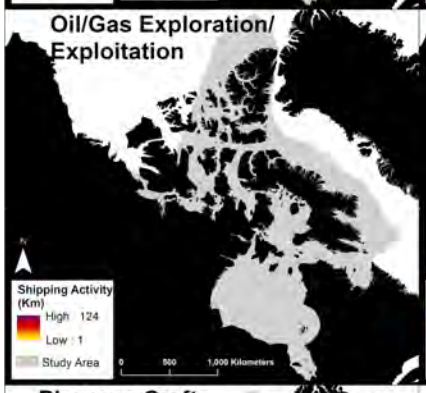


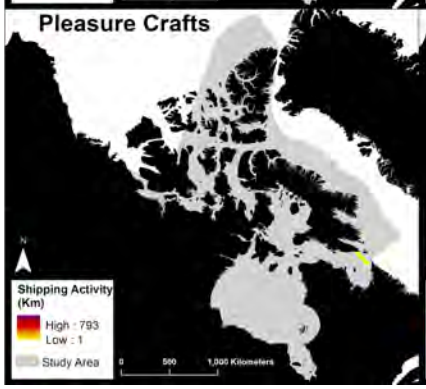
Summary Vessel Traffic: 1998

Vessel Type	Kilometres
Bulk Carriers	67759.44
Fishing Vessels	10210.03
General Cargo	87040.36
Government Vessels and Icebreakers	99725.44
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	54845.85
Pleasure Crafts	0
Tanker Ships	49615.91
Tug/Barge	33835.35
Grand Total	403032.4



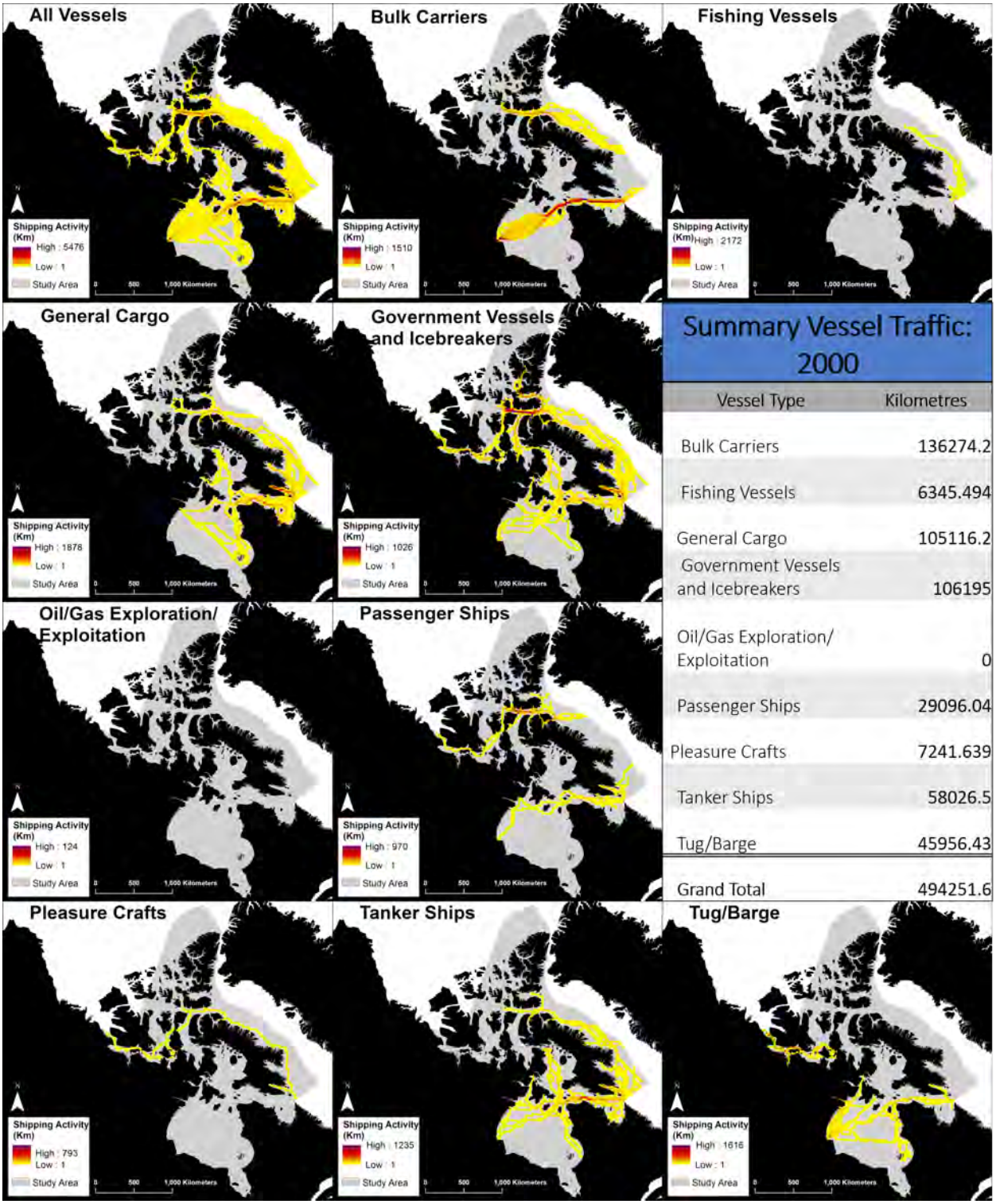






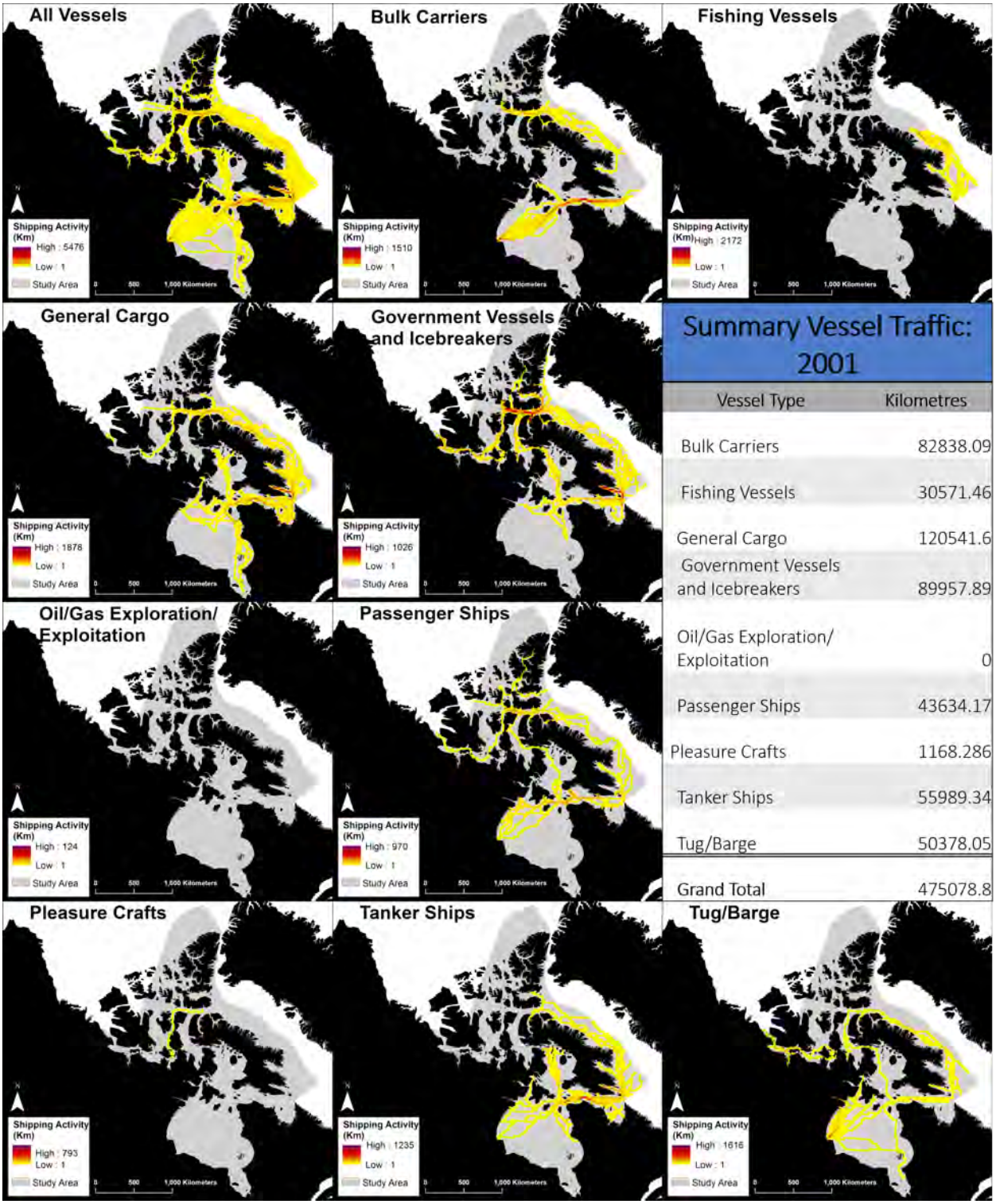
Summary Vessel Traffic: 1999

Vessel Type	Kilometres
Bulk Carriers	82652.55
Fishing Vessels	8914.34
General Cargo	110230.4
Government Vessels and Icebreakers	125147.8
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	49413.87
Pleasure Crafts	205.126
Tanker Ships	51797.07
Tug/Barge	45039
Grand Total	473400.1



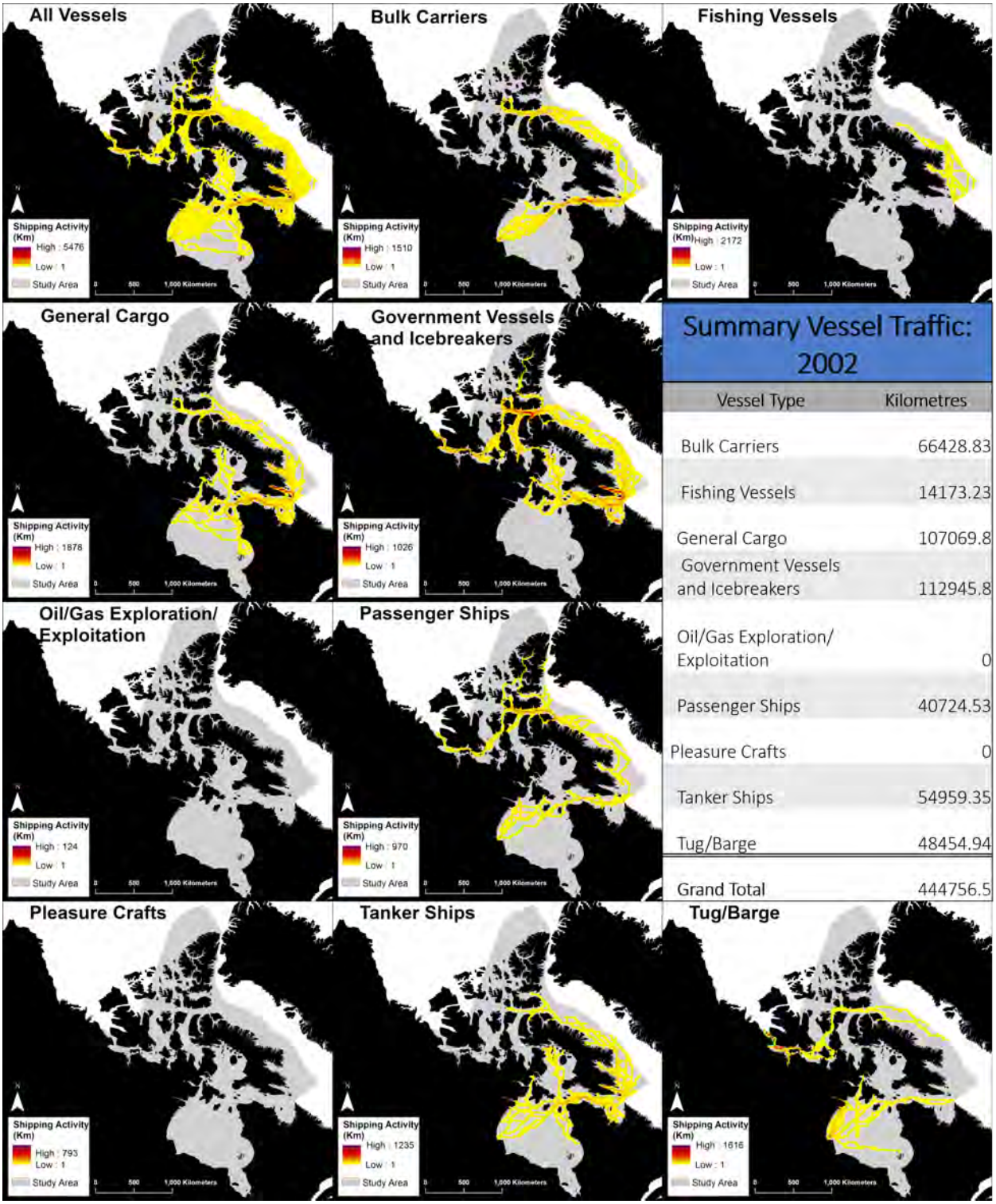
Summary Vessel Traffic: 2000

Vessel Type	Kilometres
Bulk Carriers	136274.2
Fishing Vessels	6345.494
General Cargo	105116.2
Government Vessels and Icebreakers	106195
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	29096.04
Pleasure Crafts	7241.639
Tanker Ships	58026.5
Tug/Barge	45956.43
Grand Total	494251.6



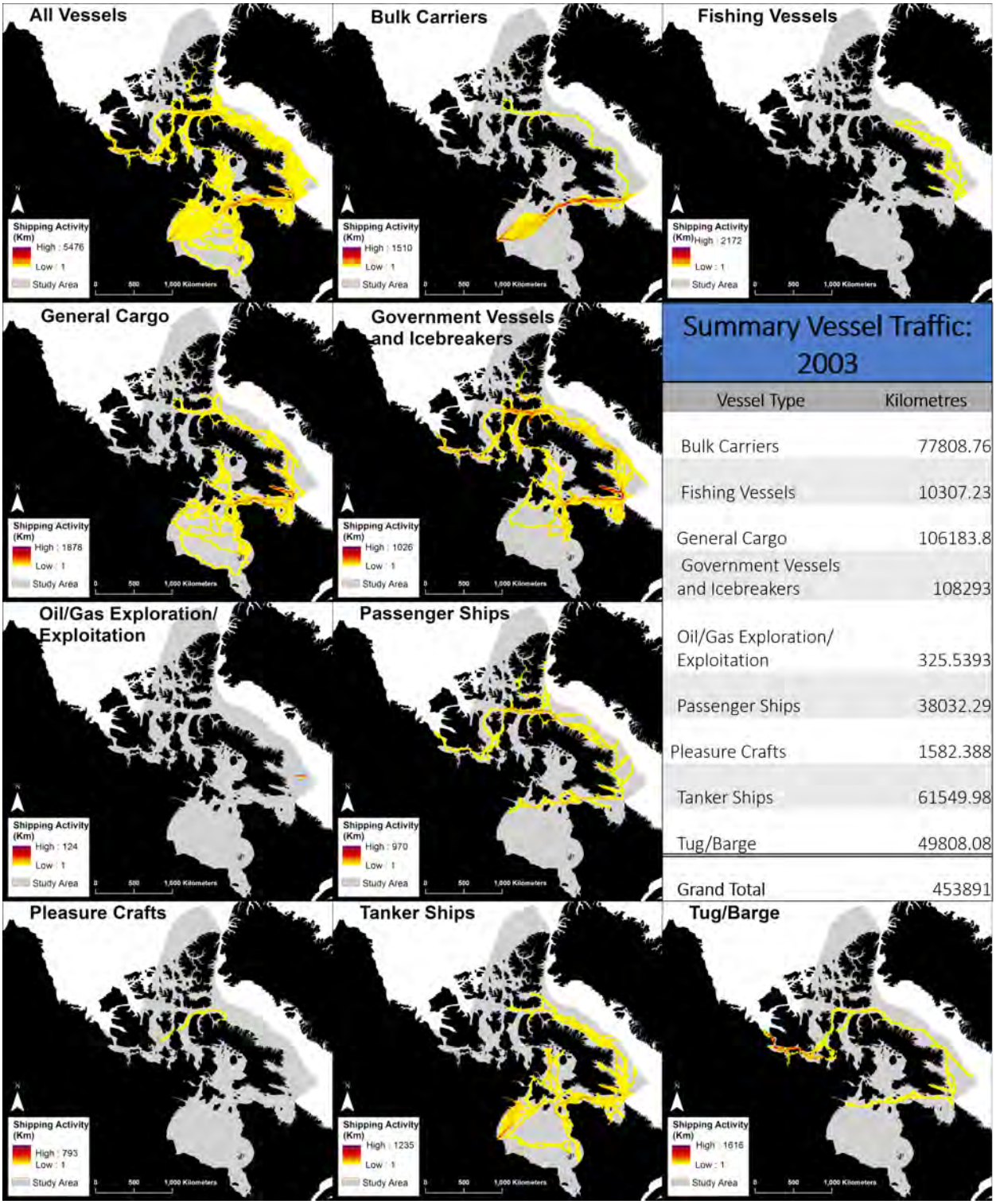
Summary Vessel Traffic: 2001

Vessel Type	Kilometres
Bulk Carriers	82838.09
Fishing Vessels	30571.46
General Cargo	120541.6
Government Vessels and Icebreakers	89957.89
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	43634.17
Pleasure Crafts	1168.286
Tanker Ships	55989.34
Tug/Barge	50378.05
Grand Total	475078.8



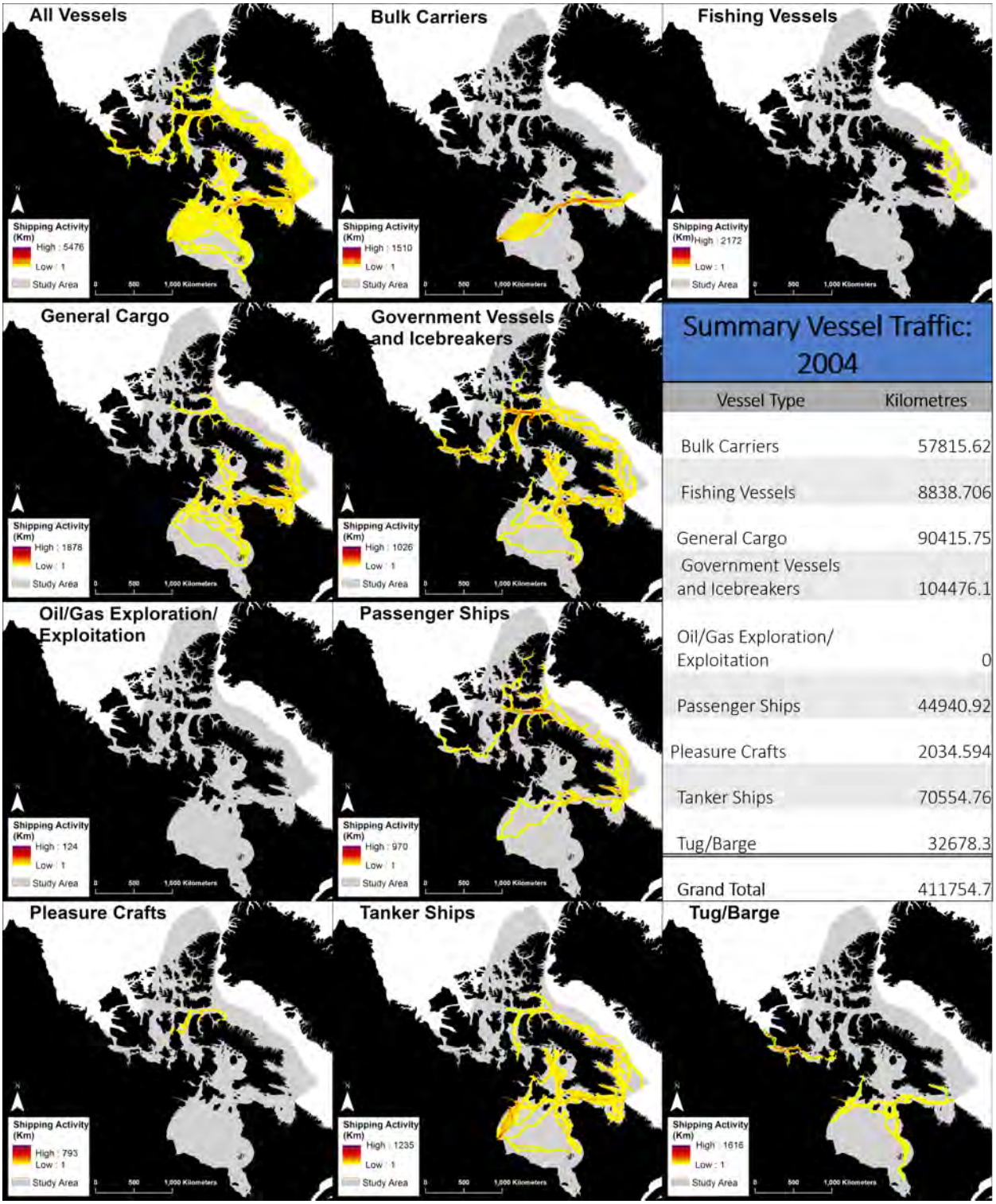
Summary Vessel Traffic: 2002

Vessel Type	Kilometres
Bulk Carriers	66428.83
Fishing Vessels	14173.23
General Cargo	107069.8
Government Vessels and Icebreakers	112945.8
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	40724.53
Pleasure Crafts	0
Tanker Ships	54959.35
Tug/Barge	48454.94
Grand Total	444756.5



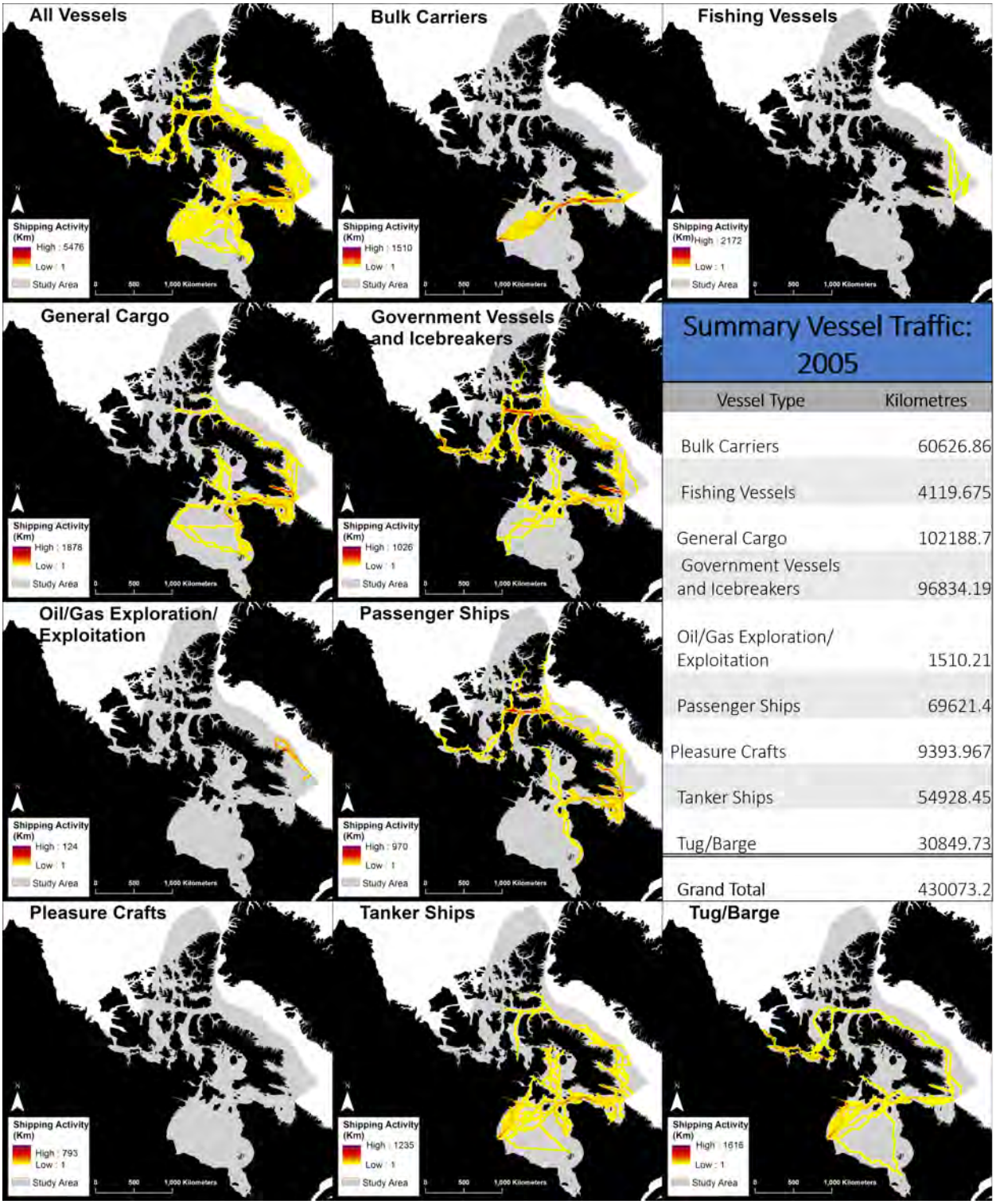
Summary Vessel Traffic: 2003

Vessel Type	Kilometres
Bulk Carriers	77808.76
Fishing Vessels	10307.23
General Cargo	106183.8
Government Vessels and Icebreakers	108293
Oil/Gas Exploration/ Exploitation	325.5393
Passenger Ships	38032.29
Pleasure Crafts	1582.388
Tanker Ships	61549.98
Tug/Barge	49808.08
Grand Total	453891



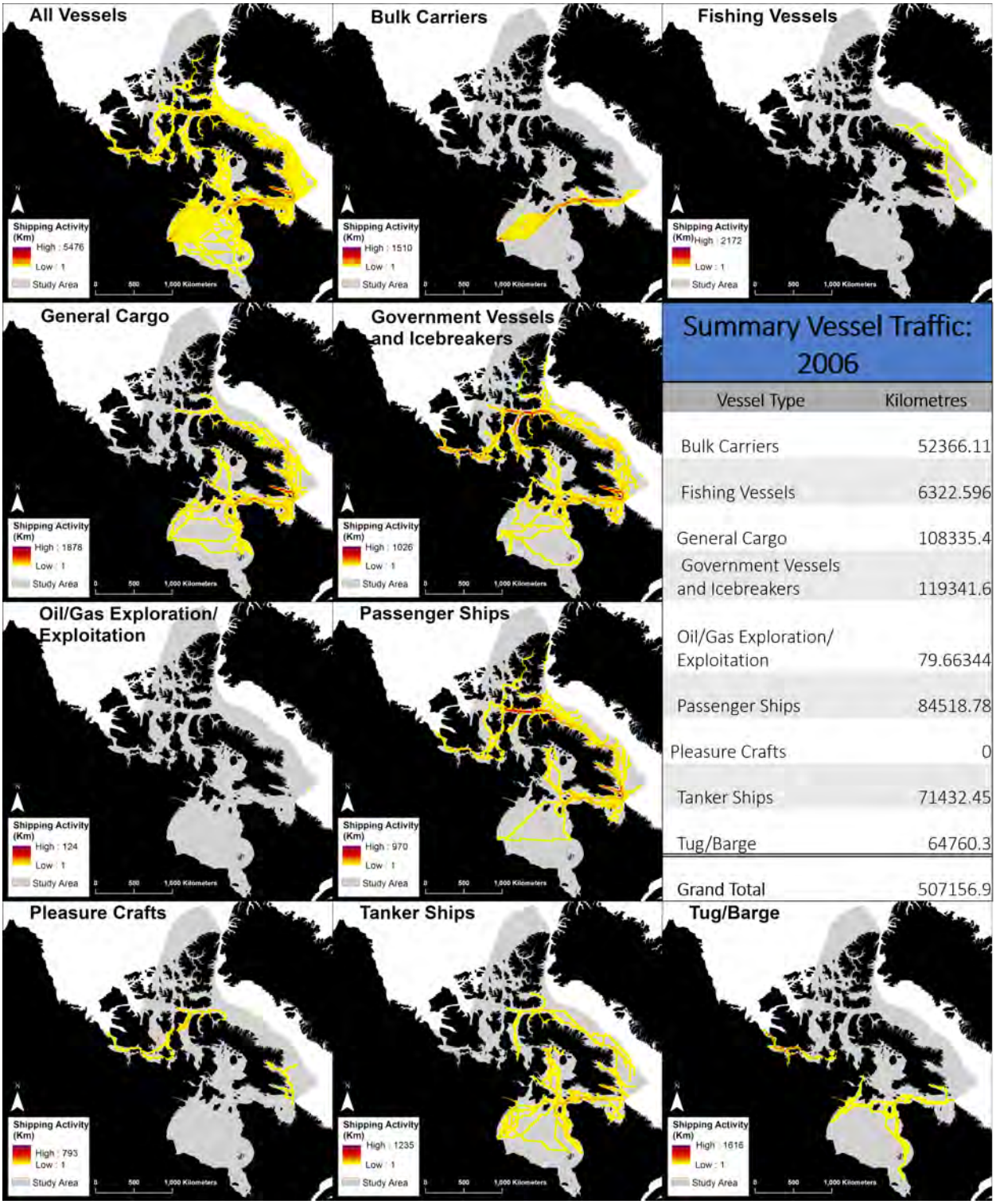
Summary Vessel Traffic: 2004

Vessel Type	Kilometres
Bulk Carriers	57815.62
Fishing Vessels	8838.706
General Cargo	90415.75
Government Vessels and Icebreakers	104476.1
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	44940.92
Pleasure Crafts	2034.594
Tanker Ships	70554.76
Tug/Barge	32678.3
Grand Total	411754.7



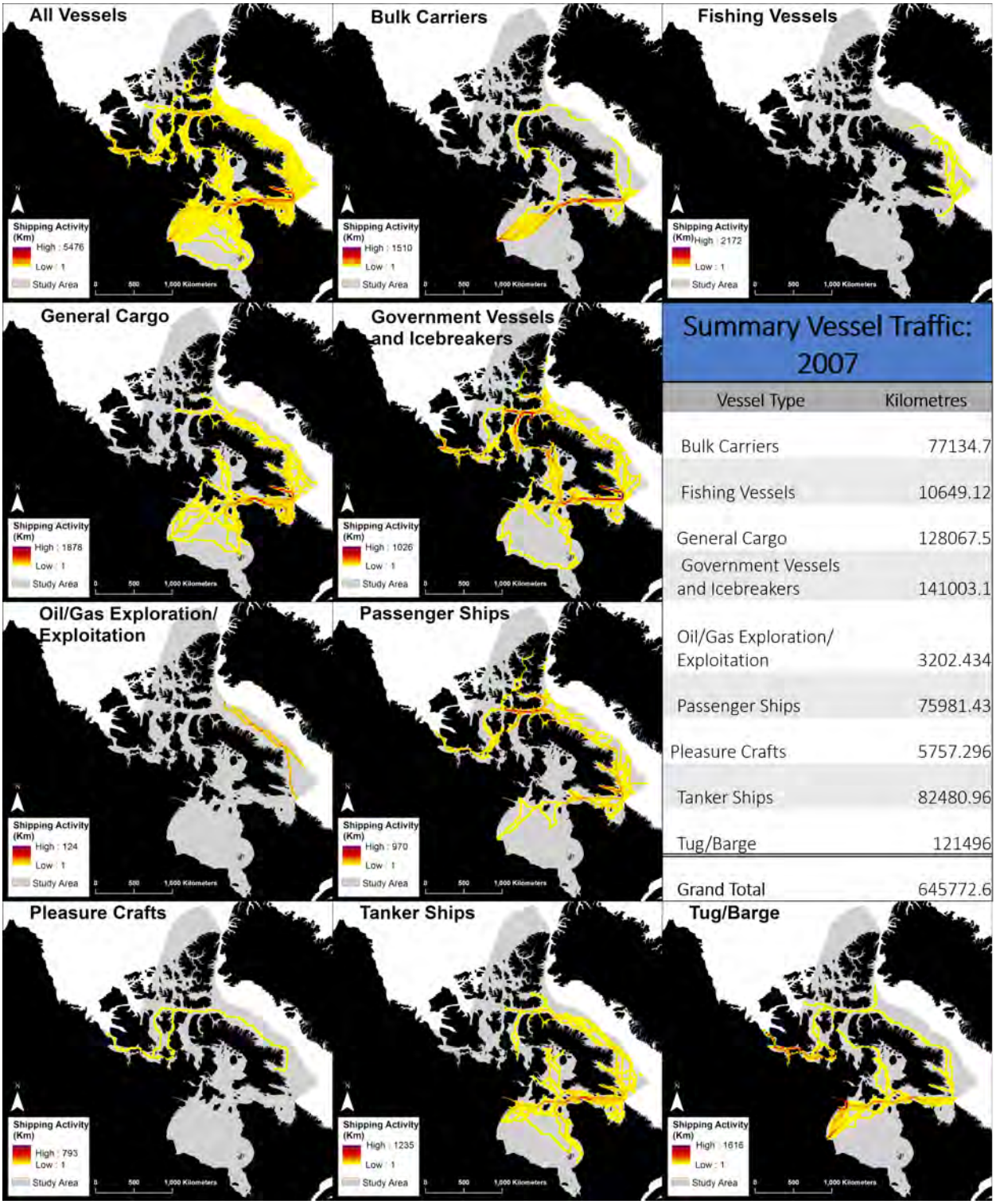
Summary Vessel Traffic: 2005

Vessel Type	Kilometres
Bulk Carriers	60626.86
Fishing Vessels	4119.675
General Cargo	102188.7
Government Vessels and Icebreakers	96834.19
Oil/Gas Exploration/ Exploitation	1510.21
Passenger Ships	69621.4
Pleasure Crafts	9393.967
Tanker Ships	54928.45
Tug/Barge	30849.73
Grand Total	430073.2



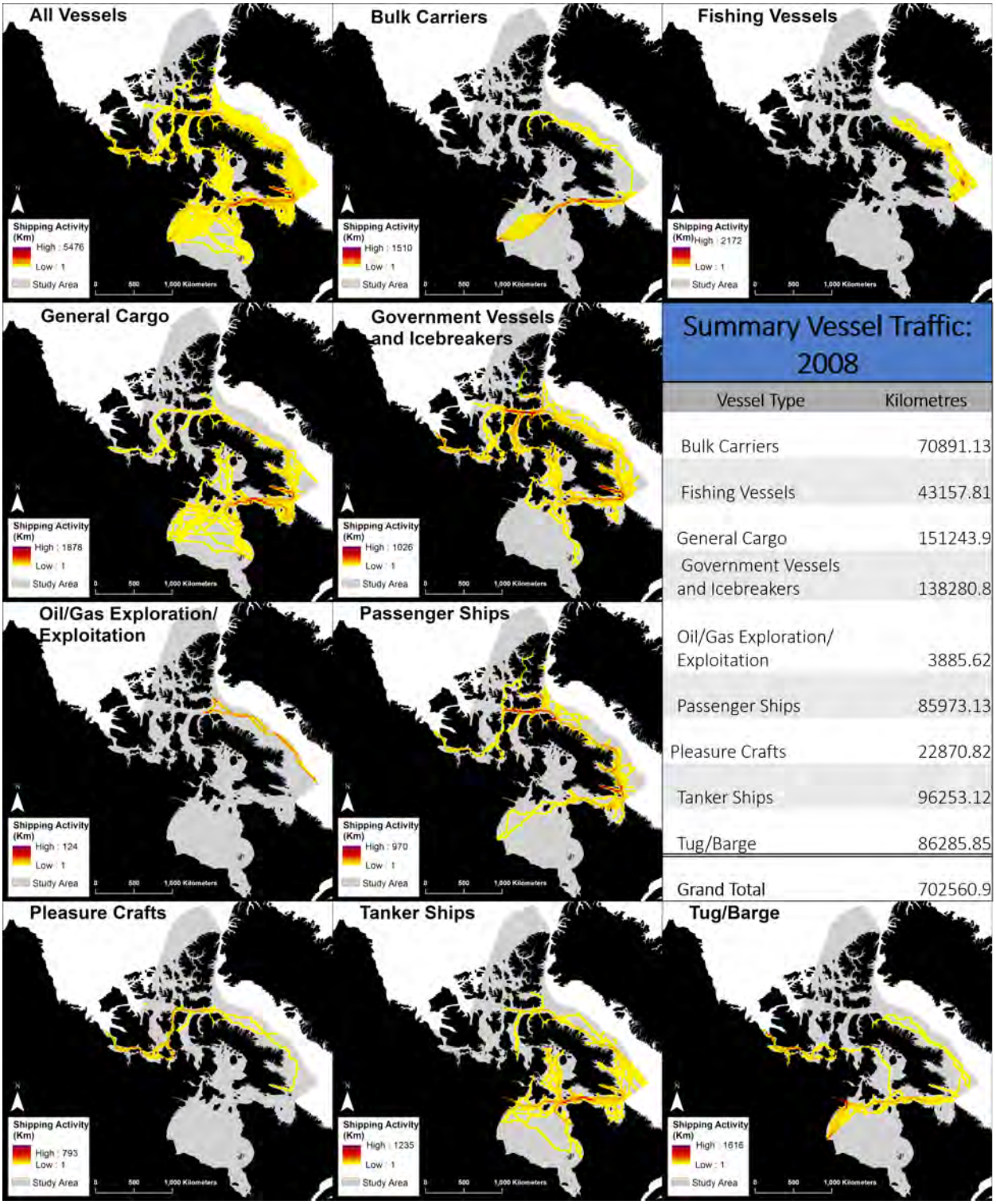
Summary Vessel Traffic: 2006

Vessel Type	Kilometres
Bulk Carriers	52366.11
Fishing Vessels	6322.596
General Cargo	108335.4
Government Vessels and Icebreakers	119341.6
Oil/Gas Exploration/ Exploitation	79.66344
Passenger Ships	84518.78
Pleasure Crafts	0
Tanker Ships	71432.45
Tug/Barge	64760.3
Grand Total	507156.9



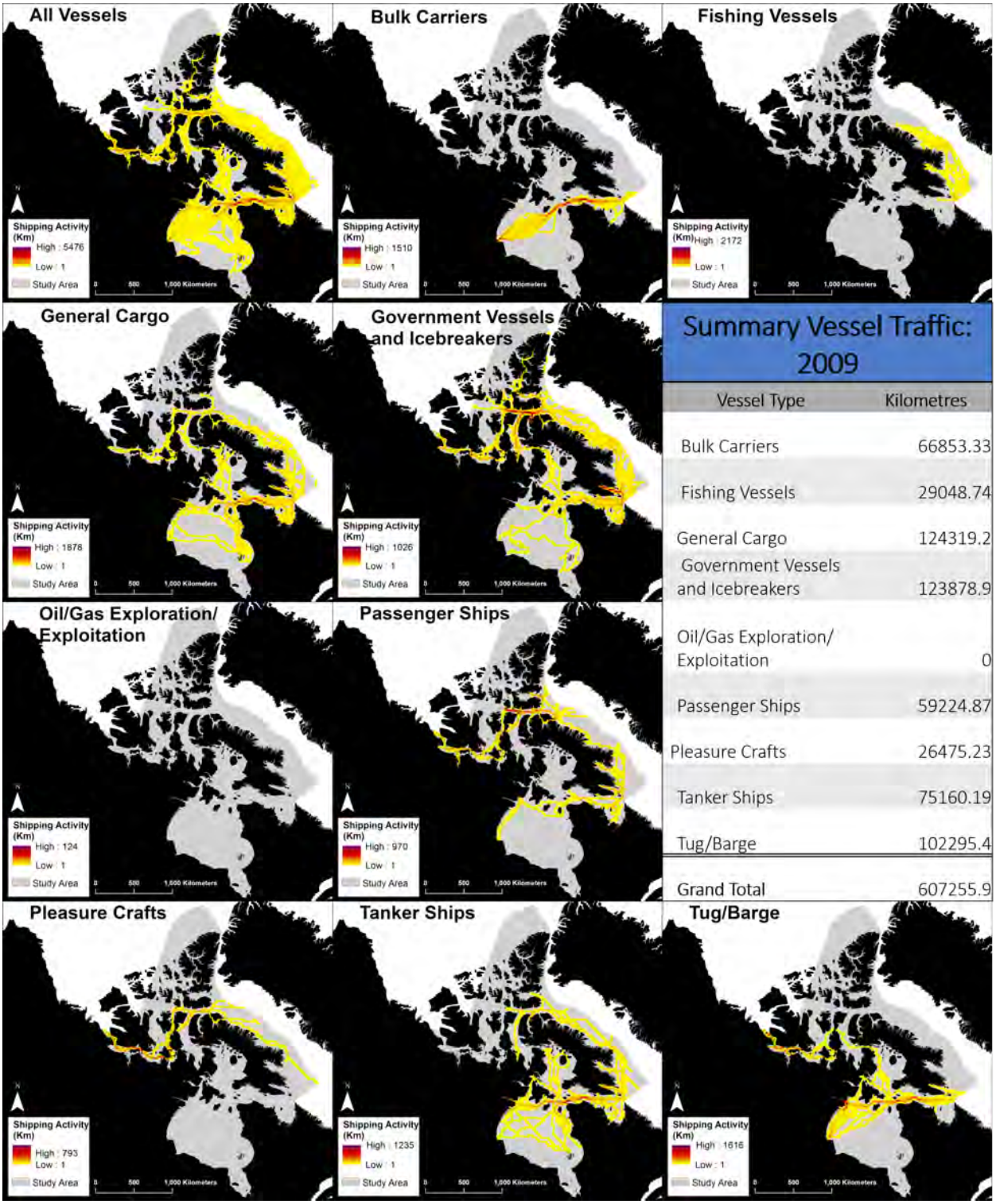
Summary Vessel Traffic: 2007

Vessel Type	Kilometres
Bulk Carriers	77134.7
Fishing Vessels	10649.12
General Cargo	128067.5
Government Vessels and Icebreakers	141003.1
Oil/Gas Exploration/ Exploitation	3202.434
Passenger Ships	75981.43
Pleasure Crafts	5757.296
Tanker Ships	82480.96
Tug/Barge	121496
Grand Total	645772.6



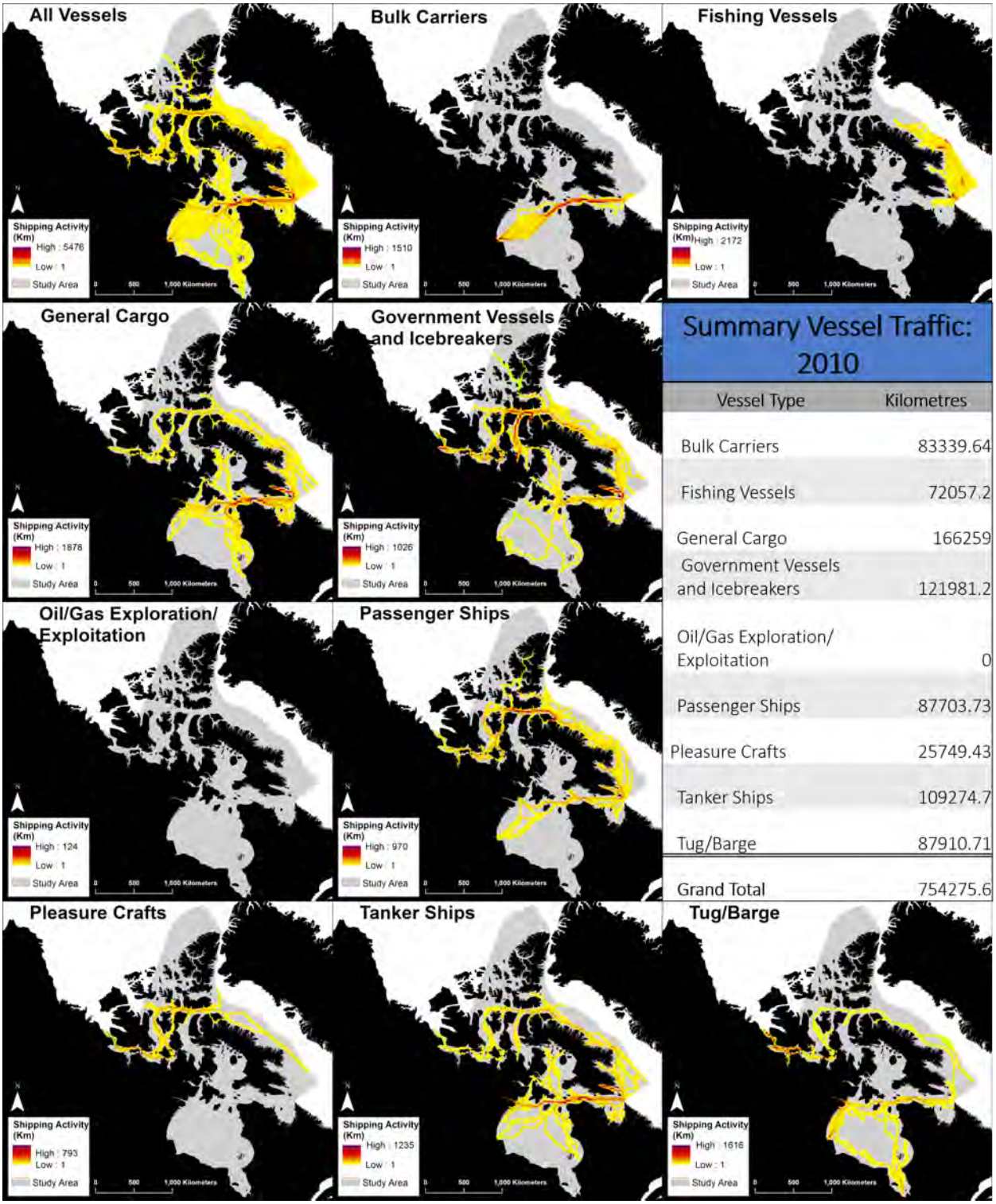
Summary Vessel Traffic: 2008

Vessel Type	Kilometres
Bulk Carriers	70891.13
Fishing Vessels	43157.81
General Cargo	151243.9
Government Vessels and Icebreakers	138280.8
Oil/Gas Exploration/ Exploitation	3885.62
Passenger Ships	85973.13
Pleasure Crafts	22870.82
Tanker Ships	96253.12
Tug/Barge	86285.85
Grand Total	702560.9



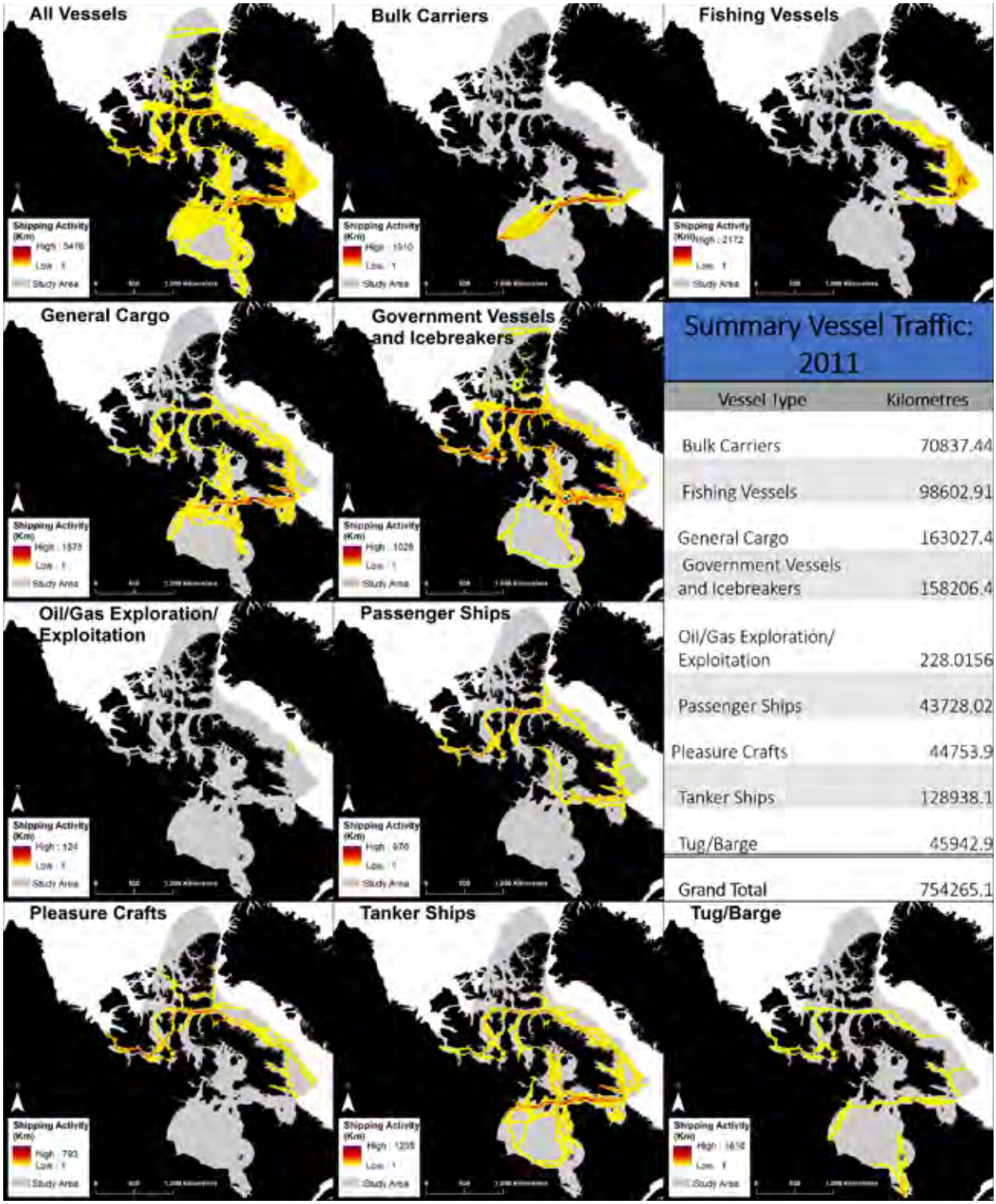
Summary Vessel Traffic: 2009

Vessel Type	Kilometres
Bulk Carriers	66853.33
Fishing Vessels	29048.74
General Cargo	124319.2
Government Vessels and Icebreakers	123878.9
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	59224.87
Pleasure Crafts	26475.23
Tanker Ships	75160.19
Tug/Barge	102295.4
Grand Total	607255.9



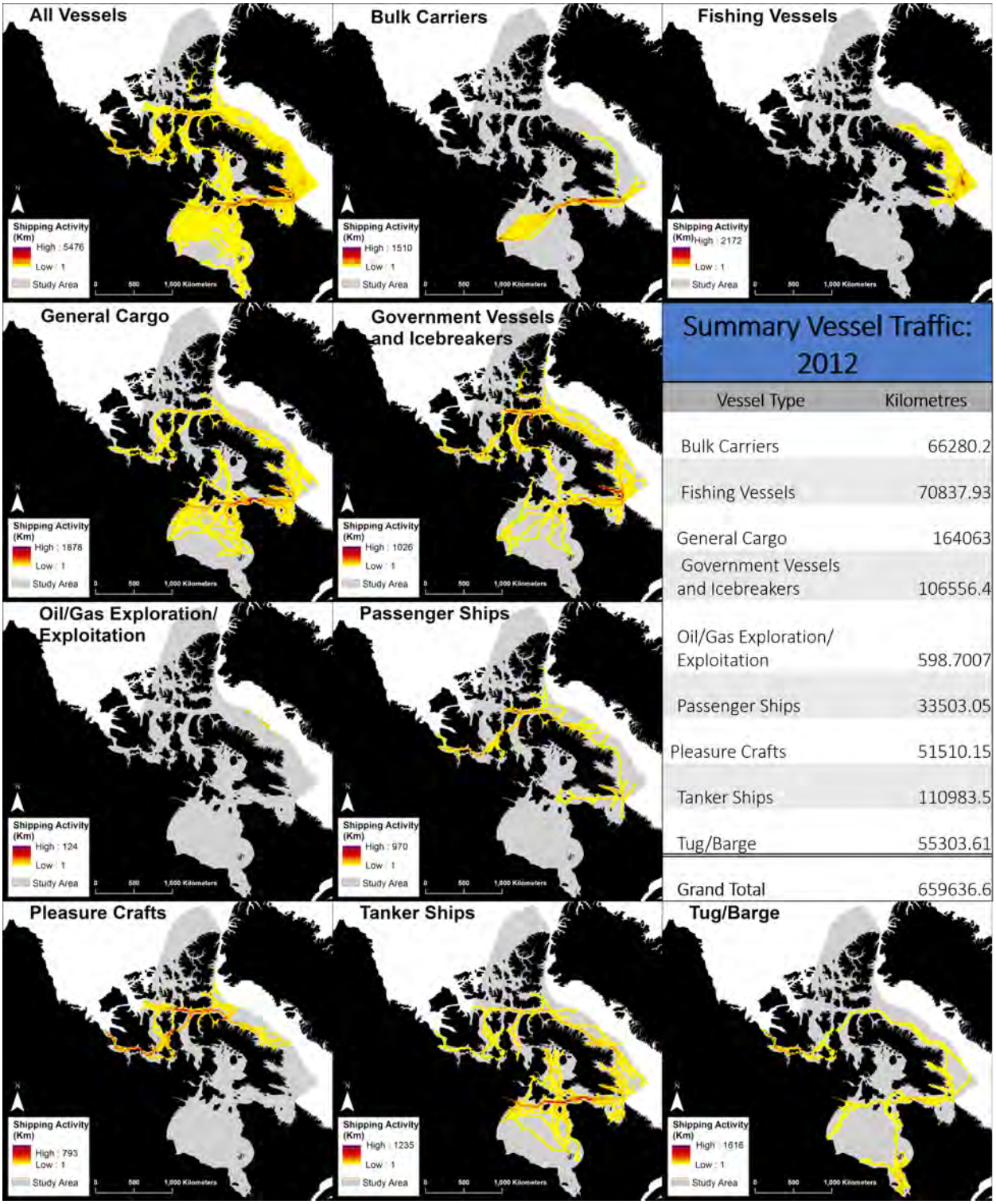
Summary Vessel Traffic: 2010

Vessel Type	Kilometres
Bulk Carriers	83339.64
Fishing Vessels	72057.2
General Cargo	166259
Government Vessels and Icebreakers	121981.2
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	87703.73
Pleasure Crafts	25749.43
Tanker Ships	109274.7
Tug/Barge	87910.71
Grand Total	754275.6



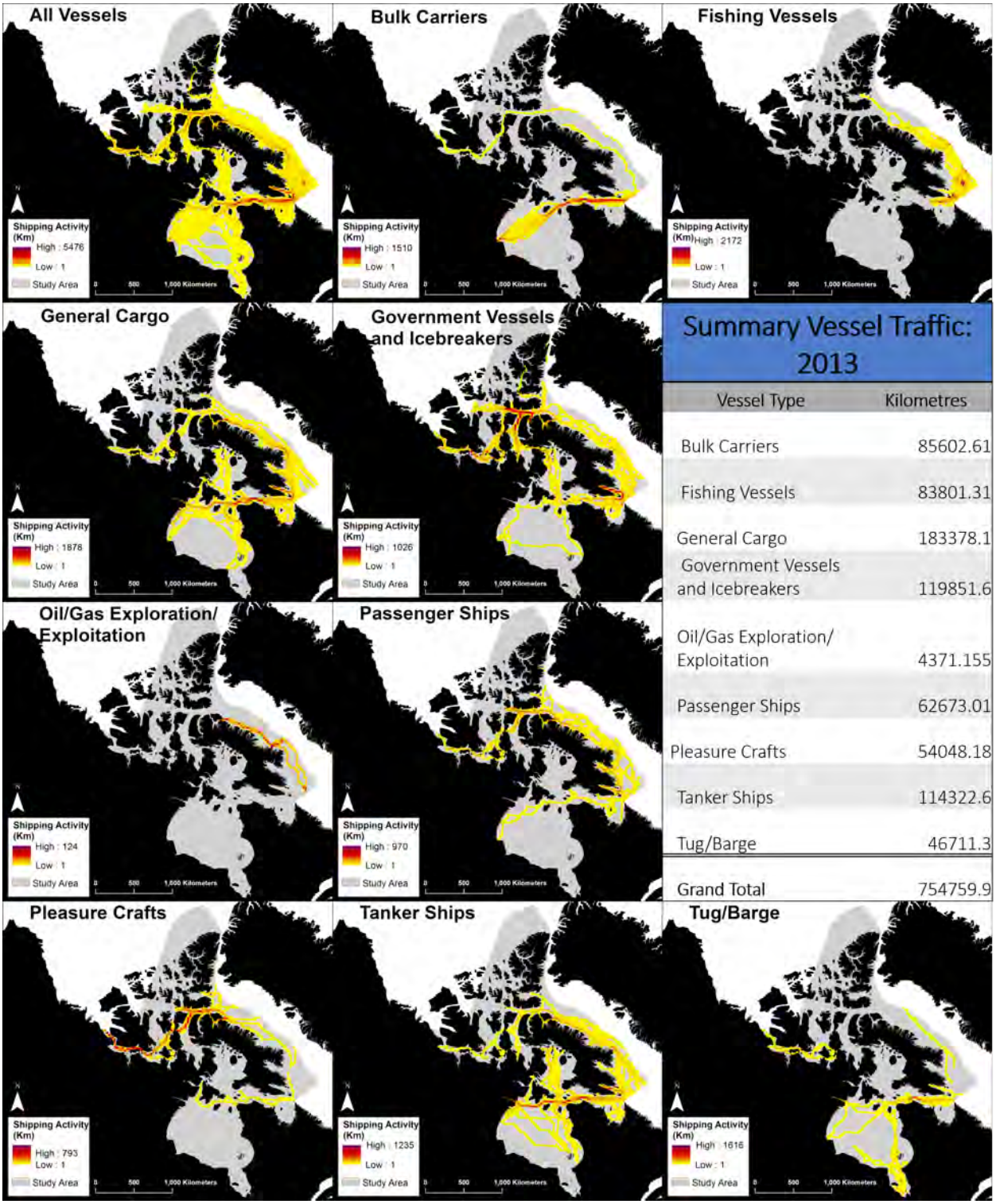
Summary Vessel Traffic: 2011

Vessel Type	Kilometres
Bulk Carriers	70837.44
Fishing Vessels	98602.91
General Cargo	163027.4
Government Vessels and Icebreakers	158206.4
Oil/Gas Exploration/ Exploitation	228.0156
Passenger Ships	43728.02
Pleasure Crafts	44753.9
Tanker Ships	128938.1
Tug/Barge	45942.9
Grand Total	754265.1



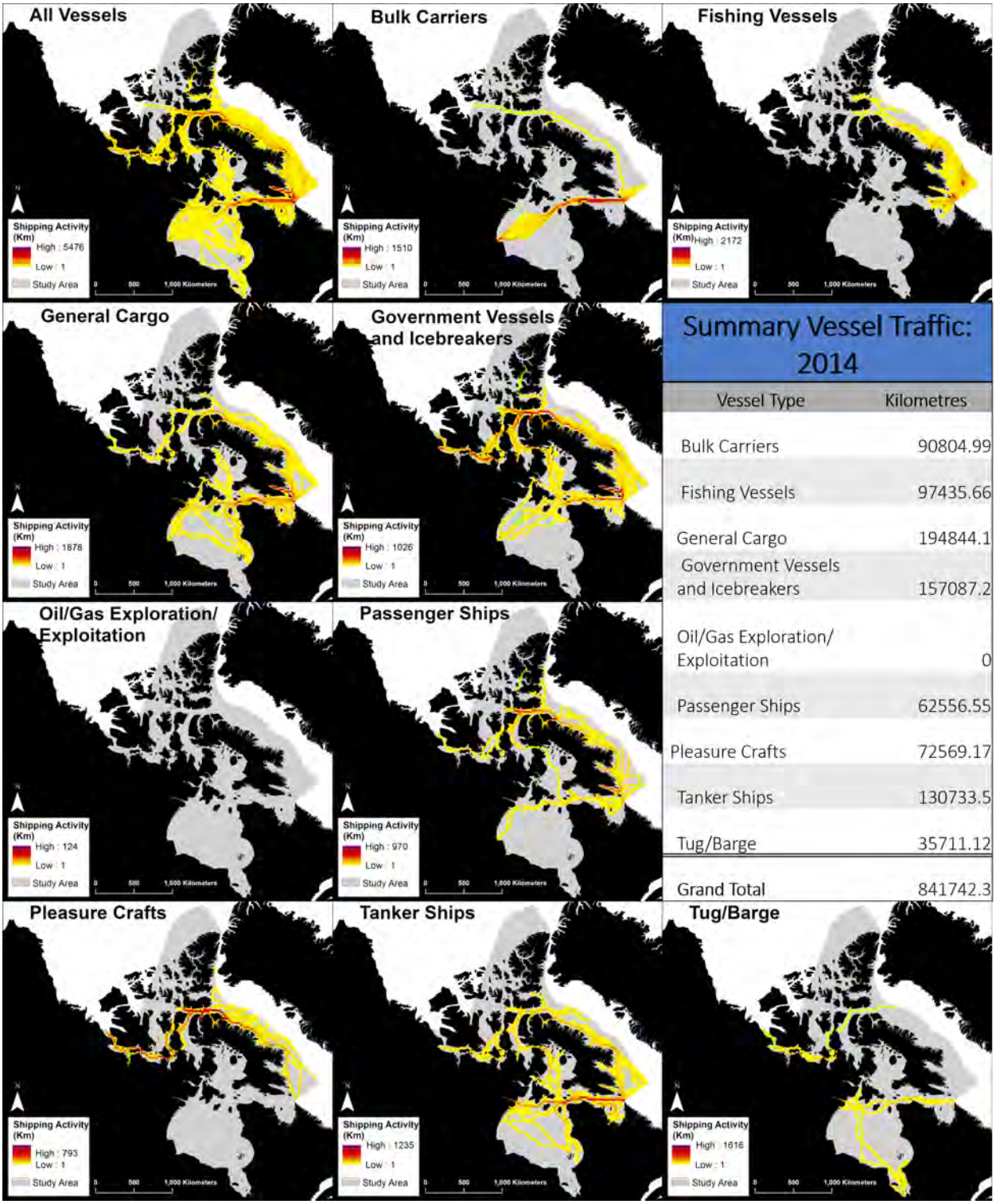
Summary Vessel Traffic: 2012

Vessel Type	Kilometres
Bulk Carriers	66280.2
Fishing Vessels	70837.93
General Cargo	164063
Government Vessels and Icebreakers	106556.4
Oil/Gas Exploration/ Exploitation	598.7007
Passenger Ships	33503.05
Pleasure Crafts	51510.15
Tanker Ships	110983.5
Tug/Barge	55303.61
Grand Total	659636.6



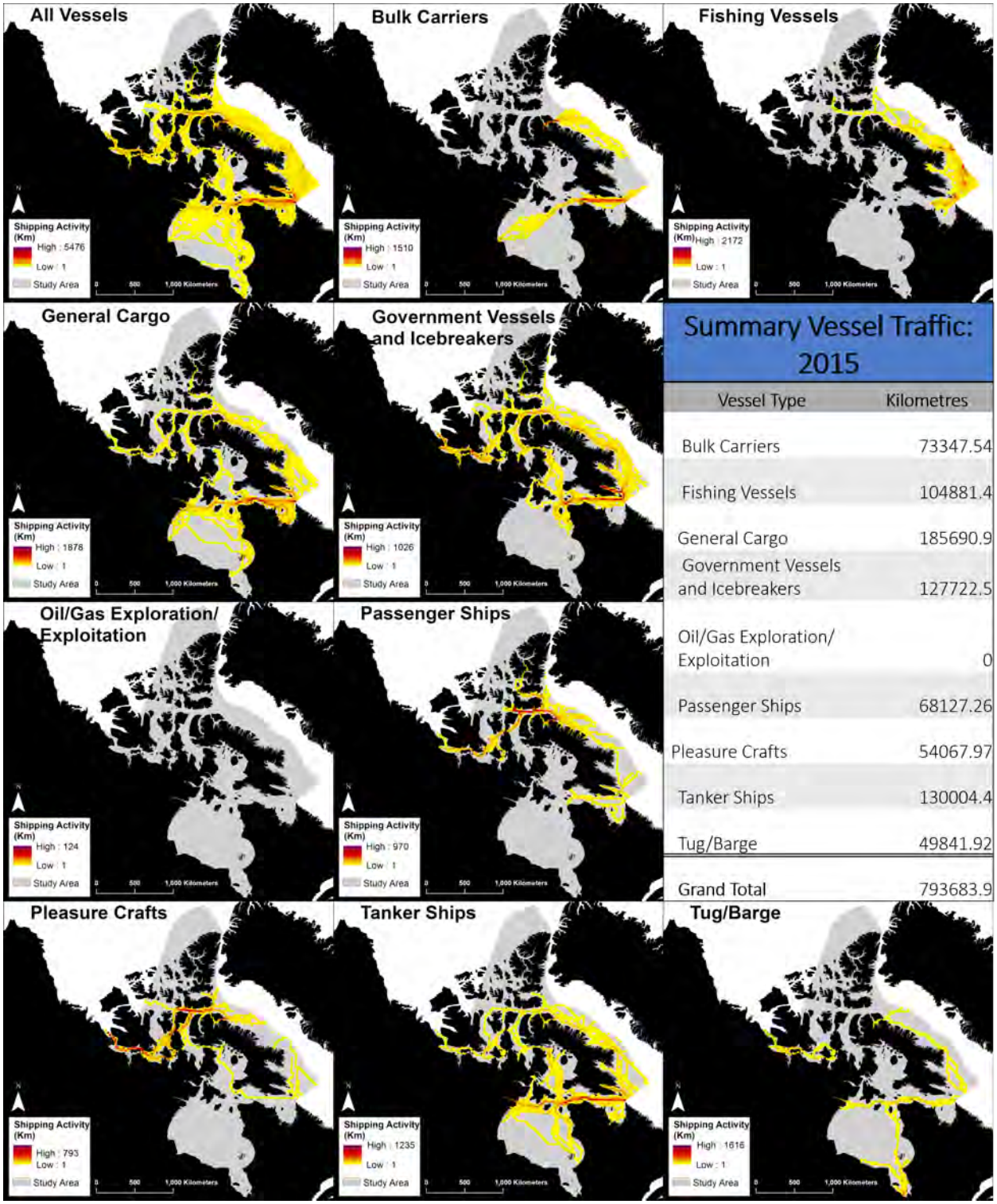
Summary Vessel Traffic: 2013

Vessel Type	Kilometres
Bulk Carriers	85602.61
Fishing Vessels	83801.31
General Cargo	183378.1
Government Vessels and Icebreakers	119851.6
Oil/Gas Exploration/ Exploitation	4371.155
Passenger Ships	62673.01
Pleasure Crafts	54048.18
Tanker Ships	114322.6
Tug/Barge	46711.3
Grand Total	754759.9



Summary Vessel Traffic: 2014

Vessel Type	Kilometres
Bulk Carriers	90804.99
Fishing Vessels	97435.66
General Cargo	194844.1
Government Vessels and Icebreakers	157087.2
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	62556.55
Pleasure Crafts	72569.17
Tanker Ships	130733.5
Tug/Barge	35711.12
Grand Total	841742.3



Summary Vessel Traffic: 2015

Vessel Type	Kilometres
Bulk Carriers	73347.54
Fishing Vessels	104881.4
General Cargo	185690.9
Government Vessels and Icebreakers	127722.5
Oil/Gas Exploration/ Exploitation	0
Passenger Ships	68127.26
Pleasure Crafts	54067.97
Tanker Ships	130004.4
Tug/Barge	49841.92
Grand Total	793683.9