Overview of recent shipping activities along the Northern Sea Route

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ABSTRACT
This paper investigated characteristics of shipping activity along the Northern Sea Route between 2013 and 2017. Authors collected ship information including ship type, and position from Northern Sea Route Administration. Based on these ship information, characteristics of current shipping activity was investigated.

The number of sailed ships increases from June to September, and then decreases from September to November for each year. The number of sailed ships was highest in 2016 and lowest in 2015. For ship type, general cargo, oil/chemical tanker and bulk cargo are dominant ship types that sailed the NSR from June to November. For ice class, in June and November, the NSR was sailed mainly by ships with PC7 or higher, which is caused by harder ice condition compared with other summer and fall season. In contrast, many lower ice class ships had sailed the NSR from July to October.

1. INTRODUCTION
Since 1979, satellite mapping has revealed an overall trend of decreasing late-summer sea ice extent in the Arctic, with all the lowest years on record occurring since 2007. Climate model projections indicate that the decreasing trend of Arctic sea ice will continue in the future for both extent and thickness. The decrease in sea ice has fueled speculations of potential new trans-Arctic shipping routes linking the Atlantic and Pacific Oceans¹,²). The Arctic Ocean has three principal shipping routes from Europe to the Pacific Asia: the Northern Sea Route (NSR) along the Siberian Coast, the Northwest Passage (NWP) through the Canadian Arctic Archipelago, and the North Pole Route (NPR) from Europe via Fram Strait across the North Pole to Bering Strait. The NSR, in particular, is in the spotlight, as it has the most favourable ice conditions among the three main transarctic routes.

Numerous studies on Arctic shipping issues seem to have sprung up in the past two decades. Several dozen papers have investigated the future of Arctic shipping, based on the idea of Arctic sea ice shrink and shorter distances as the driver for the expansion of the shipping³). In addition, a number of studies examined feasibility of NSR compared to the conventional shipping routes, especially focusing on the cost competitiveness⁴). However, analysis of the real shipping traffic data is lacking. Many studies have
mentioned those historic shipping events\textsuperscript{5)}, and the fact of increasing NSR shipping activities in the past few years, but few of them looked into details of these ship traffic data to identify interesting results.

The objectives of this study were (a) characterization of the temporal variations of shipping activities along NSR; and (b) characterization of the spatial variations of shipping activities along NSR.

2. DATA SOURCES

Northern Sea Route Administration (NSRA) has reported daily information about movements of vessels nearby and in the water area of the NSR at 9 am of UTC time between 2013 and 2017, which includes vessel name, IMO number, shipowner, flag, ice class, position, speed and Estimated Time of Arrival (ETA) for boundaries or port of the NSR.

3. RESULTS

Annual mean Dead Weight Tonnage (DWT) and ship numbers for ships sailed in NSR from 2013 to 2017 are shown in Figure 1. Ship number for large ship grew gradually to 167 at 2016 and then dropped in 2017, while for small ship, the peak of ship number appeared at 2014 with 194 ships. More small ship sailed in NSR except for 2016. Mean DWT for large ship decreased from 2013 to 2015, and then increased in 2016 and 2017, while small ships’ mean DWT was stable with around 1800 DWT between 2013 and 2017. Large ship was accounted for more than 90\% in total DWT of all ships in the period from 2013 to 2017, while small ship was dominated in ship number. Therefore, we will study on large and small ships’ activity separately in this study. Ships were separated into 10 groups (tanker, bulk carrier, general cargo, heavy lift, dredger, research and survey vessel, icebreaker, fishing vessel, passenger ship, and tug) according to their ship types.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig1.png}
\caption{Annual ship number (filled bars) and mean DWT (solid lines with filled circles) for ships sailed in NSR from 2013 to 2017. Ships with DWT larger than 5000 tons and smaller than 5000 tons are expressed by using red and blue colors, respectively. Mean DWT was defined as the average of the DWT for the large or small ships sailed in NSR for each year.}
\end{figure}
(1) Shipping activity of tanker

Figure 2 shows monthly mean DWT and ship number for large and small tanker ships sailed in NSR from March of 2013 to December of 2017.

For large tanker ships, both ship number and mean DWT were relatively high in warm season (July, August, September and October) compared to cold season (November, December, January, February, March, April, May and June) for all 5 years. In warm season, ship number and mean DWT decreased gradually from 2013 to 2015 and then increased rapidly in 2016 and 2017. whereas, in cold season, ship number and mean DWT grew obviously from 2013 to 2017. Main activity area for large tanker was south-western part of the Kara Sea and western part of the Laptev Sea as shown in Figure 3. The increased shipping activity was mainly occurred in south-western part of the Kara Sea, as indicated by high ship record number in 2016 and 2017. Small tanker ships mainly appeared in warm season in south-western part of the Kara Sea, eastern part of the Laptev Sea and the East-Siberian Sea for all 5 years (Figure 2 and 4).

**Fig. 2** Monthly ship number (filled bars) and mean DWT (solid lines with filled circles) for tanker ships sailed in NSR from March of 2013 to December of 2017. Large and small ships are expressed by using red and blue colors, respectively. Tanker ships include crude oil tanker, oil/chemical tanker and inland tanker ships.
(2) Shipping activity of bulk carrier

As shown in figure 5, most bulk carrier sailed in NSR was large ship. Large bulk carrier exhibited similar variation trends in monthly ship number and mean DWT, showing relatively higher values in warm season than those in cold season (Figure 3). For year to year variation, ship number grew rapidly from 2013 to 2014 and then fell down gradually from 2014 to 2017. Shipping activity for large bulk carrier was mainly conducted in south-western part of the Kara Sea as shown in Figure 6.

Only one small bulk carrier with around 1000 DWT appeared at south-western part of the Kara Sea, eastern part of the Laptev Sea from July to September in 2016 (Figure 5 and 7).
(3) Shipping activity of general cargo

Large general cargo ships showed a clear seasonal variation with relatively high ship number in warm season compared with cold season for all 5 years, while mean DWT exhibited clear seasonal variation with low
value in warm season in 2013 and 2014, and became stable in 2016 and 2017 (Figure 8). Regarding year to year variation, in both warm and cold season, ship number went up gradually from 2013 to 2016 and then decreased in 2017. Shipping activity for large general cargo was mainly occurred in south-western part of the Kara Sea as shown in Figure 9.

Small general cargo ships mainly appeared in warm season in south-western part of the Kara Sea, eastern part of the Laptev Sea and North-eastern part of the East-Siberian Sea (Figure 8 and 10).

**Fig. 8** Same as figure 2, but for general cargo ships

**Fig. 9** Same as figure 3, but for large general cargo ships
(4) Shipping activity of heavy lift

As shown in Figure 11 and 12, shipping activity of heavy lift mainly occurred in south-western part of the Kara Sea in warm season and increased gradually from 2014 to 2016, and then went down in 2017.

Fig. 10 Same as figure 3, but for small general cargo ships

Fig. 11 Same as figure 2, but for heavy lift ships

Fig. 12 Same as figure 3, but for large heavy lift ships
(5) Shipping activity of dredger

Dredging operation in NSR area was mostly conducted in south-western part of the Kara Sea in warm season (Figure 13, 14 and 15). As shown in figure 13, dredging activity increased slightly from 2013 to 2015 after that went down in 2016 and 2017.
(6) Shipping activity of research and survey ship

Similar with dredger, research and survey activity largely occurred in south-western part of the Kara Sea in warm season (Figure 16, 17 and 18). Regarding ship number, research and survey activity went up gradually from 2013 to 2016 and then decreased in 2017 (Figure 16).

**Fig. 15** Same as figure 3, but for small dredger ships

**Fig. 16** Same as figure 2, but for research and survey ships
Shipping activity of icebreaker was relatively high in warm season compared to cold season in 2013 and 2014 (Figure 19). On the contrary, icebreaker’s shipping activity was predominated in cold season than in warm season between 2015 and 2017. For year to year variation, monthly ship number increased in cold season and decreased in warm season from 2013 to 2017. Icebreakers were mainly conducted activity in south-western part of the Kara Sea in cold season, and then move to the Laptev Sea, the East-Siberian Sea, and Chukchi Sea in warm season as shown in Figure 20.

(7) Shipping activity of icebreaker

Shipping activity of icebreaker was relatively high in warm season compared to cold season in 2013 and 2014 (Figure 19). On the contrary, icebreaker’s shipping activity was predominated in cold season than in warm season between 2015 and 2017. For year to year variation, monthly ship number increased in cold season and decreased in warm season from 2013 to 2017. Icebreakers were mainly conducted activity in south-western part of the Kara Sea in cold season, and then move to the Laptev Sea, the East-Siberian Sea, and Chukchi Sea in warm season as shown in Figure 20.
Shipping activity of fishing

Fishing activity in NSR area was mostly conducted in south-western part of the Kara Sea in warm season (Figure 21, 22 and 23). As shown in figure 13, fishing activity increased from 2013 to 2014, after that went down slightly in 2015, 2016 and 2017.
(9) Shipping activity of passenger ship

Number of passenger ship was relatively high in 2013 and 2014 compared to 2015, 2016 and 2017 (Figure 24). Passenger ship appeared in Chukchi Sea in each year, and also sailed in the Kara Sea in 2013, in
south-western part of the Kara Sea and North-eastern part of the East-Siberian Sea in 2014 as shown in Figure 25.

**Fig. 24** Same as figure 2, but for passenger ships

**Fig. 25** Same as figure 3, but for small passenger ships

**(10) Shipping activity of tug**

Figure 26 showed number of tug was highest in 2014, and then became low in 2015, 2016 and 2017. Tug activity largely occurred in south-western part of the Kara Sea in warm season (Figure 27).
4. CONCLUSIONS

In this study, temporal and spatial variations of shipping activities for 10 ship types (tanker, bulk carrier, general cargo, heavy lift, dredger, research and survey vessel, icebreaker, fishing vessel, passenger ship, and tug) in NSR water areas were investigated. All ship types’ shipping activity showed a clear seasonal variation with more sailed ships in warm season compared to cold season.

Tanker’s shipping activity increased gradually from 2013 to 2017. Main shipping area of tanker was in south-western part of the Kara Sea.

Bulk carrier’s shipping activity increased rapidly from 2013 to 2014, and then fell down from 2014 to 2017. Shipping activity was mainly conducted in south-western part of the Kara Sea.

General cargo’s shipping activity went up gradually from 2013 to 2016 and then decreased in 2017. Main shipping activity was occurred in south-western part of the Kara Sea.

Heavy lift’s shipping activity was mainly in south-western part of the Kara Sea, and increased gradually from 2014 to 2016, and then went down in 2017.
Dredging operation was mostly conducted in south-western part of the Kara Sea, and increased slightly from 2013 to 2015, after that decreased in 2016 and 2017.

Research and survey activity was largely occurred in south-western part of the Kara Sea, and went up gradually from 2013 to 2016, and then decreased in 2017.

Icebreaker activity increased in cold season and deceased in warm season from 2013 to 2017. Icebreakers were mainly conducted activity in south-western part of the Kara Sea in cold season, and then move to the Laptev Sea, the East-Siberian Sea and Chukchi Sea in warm season.

Fishing activity in NSR area was mostly conducted in south-western part of the Kara Sea, and increased from 2013 to 2014, after that went down slightly in 2015, 2016 and 2017.

Passenger ship activity was mainly appeared in Chukchi Sea, and relatively high in 2013 and 2014 compared to 2015, 2016 and 2017.

Tug’s activity was conducted in south-western part of the Kara Sea, increased from 2013 to 2014 and decreased from 2014 to 2017.

ACKNOWLEDGMENT:
This research is supported by Japan Arctic Research Network Center(J-ARC Net) and Global Institution for Collaborative Research and Education(GI-CoRE).

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