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ACCESS

Arctic Climate Change, Economy and Society

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D2.12 – Navigation efficiency on the NSR and in difficult shipping zones as effected by Climate Change

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PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	X

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Introduction

Recent changes of the Arctic sea ice cover can influence on the Arctic shipping along the Northern Sea Route (NSR) in the following ways:

- Changing the length of non-icebreaker navigation period;
- Increase of the traditional terms of non-icebreaker navigation.

In this study we considered both options. The length of non-icebreaker navigation period directly affects total expenses on icebreaker escorting. In general, the longer stay of the ice-free conditions along the NSR - the lower is the transportation costs. However, even in case of ice-free conditions over the most part of the NSR, local ice massifs could be an unavoidable obstacle calling for icebreaker escorting(for example, ice conditions in summer 2007 in Vilkitsky Strait). Expected increase of traditional terms of non-icebreaker navigation in the Arctic is first of all linked with later onset of autumn freezing and earlier spring break up. Estimations of this increase were carried out on the basis of available climate model data.

2. Length of non-icebreaker navigation period

Characterizing conditions of navigation along the NSR the most important is estimation of possibility the non-icebreaker navigation of different ice class vessels. To define terms and conditions of non-icebreaker navigation the special criteria were determined in the AARI (Table 1). These criteria allow to calculate terms of beginning and finishing the non-icebreaker navigation.

Obviously, Arctic shipping without icebreaker assistance significantly decreases expenses. However, in some ice conditions efficiency and safety of navigation without icebreaker assistance is inevitably decreasing [Buzuev, 2002].

Possible terms of non-icebreaker navigation of the vessels ice class Arc 5 were calculated for the NSR and particularly for its Western and Eastern parts (Fig. 1-3).

Table 1 – Criteria to determine beginning and finishing the non-icebreaker navigation (AARI's experience data)

Ice class	Fast ice		Drifting ice					
	Beginning (spring)	Finishing (autimn)	Beginning	Finishing				
			Stable decreasing ice concentration to…	Amount of remained ice (if total ice concentration is 9-10 points)				
				9	7-8	4-6	1-3	0
Arc7 (type SA-15)	100 cm (if melting stage is 3 points)	50 cm	9 tenths	Date of stable ice formation	Date when ice thickness grows to H=5-10 cm	Date when young ice grows to H=15-20 cm	Date when young ice grows to H=25-30 cm	Date when ice thickness grows to H=50 cm
Arc5-Arc4	NP	15-20 cm	4-6 tenths	NP	NP	Date of stable ice formation	Date when young ice grows to H=5-10 cm	Date when young ice grows to H=15-20 cm

Remark: NP – non-icebreaker navigation is not possible;

The most significant peculiarities of non-icebreaker navigation ice conditions variability are following:

- the mostly favorable ice conditions for navigation maintained since beginning of regular sea ice reconnaissance in 1937 to 1956. Although duration of favorable period changed in a broad range, possibilities for non-icebreaker navigation appeared every year (Fig. 1);
- during 1957-1969 significant part of the NSR was covered by close ice and non-icebreaker navigation was impossible;
- during 1970-1983 sea ice conditions remained almost the same, but sometimes were possibilities for non-icebreaker navigation;
- during 1989-2000 the strongest fluctuations of ice conditions were observed along the navigational routes. Moreover, repeatability of unfavorable conditions for non-icebreaker navigation increased in this period. However length of routes covered by close ice in August-September was relatively short (60-100 nm);
- during the first decade of XXI century period of non-icebreaker navigation increased, especially on the Eastern part of the NSR (Fig. 2 and 3).

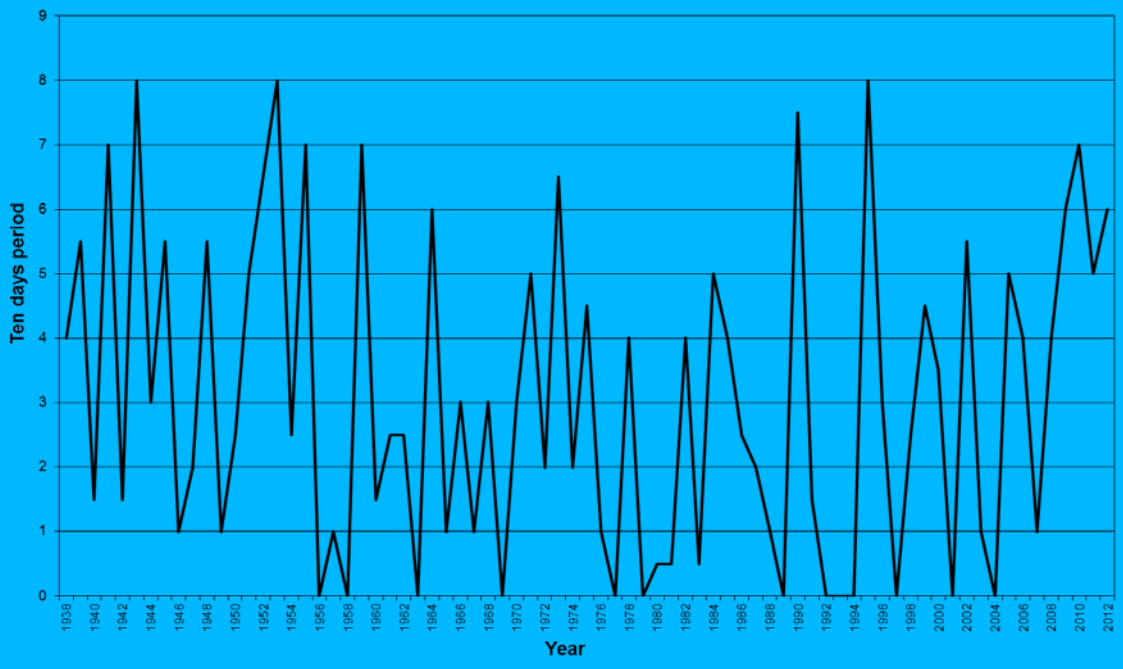

Figure 1 – Ten days periods of non-icebreaker navigation along the NSR for the vessels of ice class Arc 5

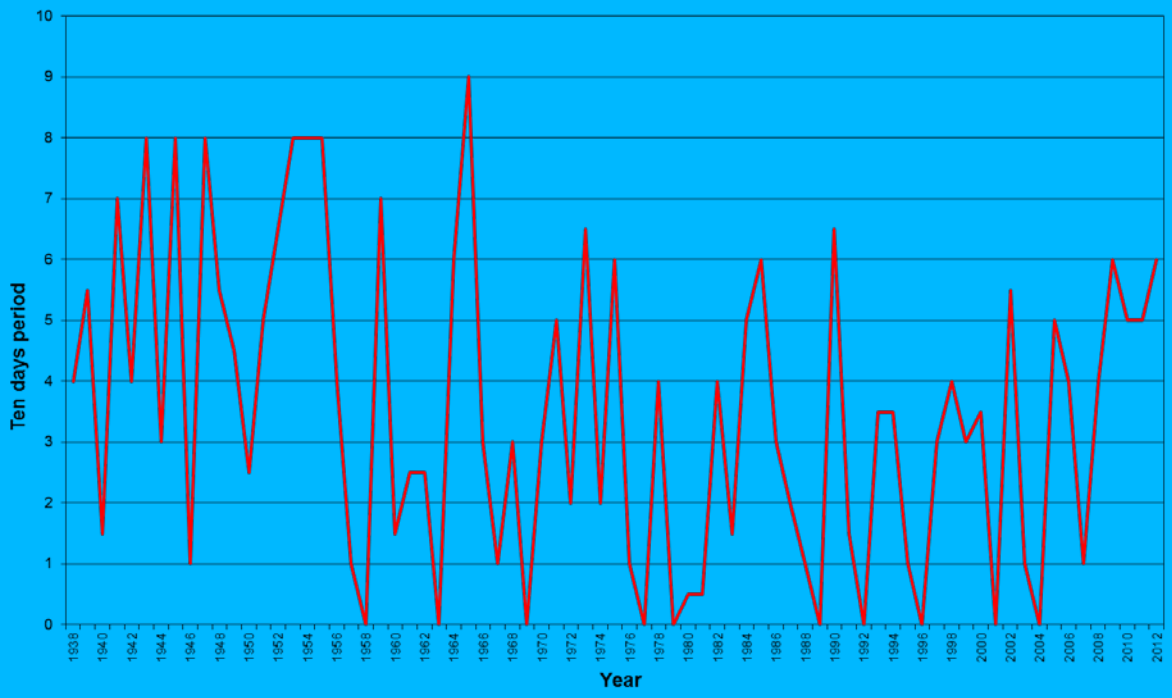

Figure 2 – Ten days periods of non-icebreaker navigation along the Western part of the NSR for the vessels of ice class Arc 5

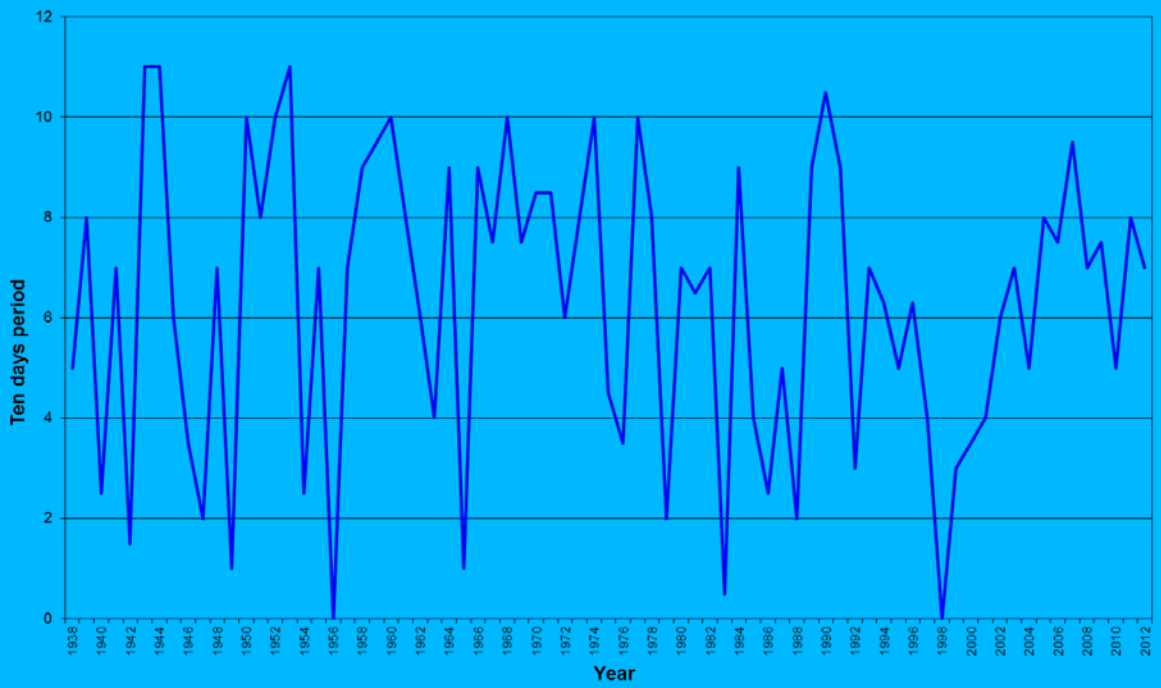

Figure 3 – Ten days periods of non-icebreaker navigation along the Eastern part of the NSR for the vessels of ice class Arc 5

3. Terms of non-icebreaker navigation

Even taking into account recent climate changes, sea ice conditions along the NSR preventing non-icebreaker navigation are forming in the summer period. Increasing the terms of non-icebreaker navigation is caused by following processes: earlier beginning of ice melting and later beginning of ice formation, because of total increase of the air and water temperature.

Specialists from the A.M. Obukhov Institute of Atmospheric Physics used results of numerical experiments with global climate models to estimate changes of the navigational period duration [Mokhov and Khon, 2011]. Based on these data, duration of the navigational period along the NSR to the end of XXI century will be 134 days (standart deviation 38 days, Table 2). Total ice concentration of 15%, 30% and 50% was used as a criteria to determine terms of navigation. Unfortunately this work does not tell us for which ice class of the vessels and with or without icebreaker these terms were calculated.

Obviously that prevailing of the young ice along the NSR during the autumn months, caused by later terms of ice formation and absence of the old ice can significantly increase duration of the transit navigation.

Table 2 – Duration of the navigational season along the NSR, days

Satellite data (1979-2007) (days/standard deviation)	Chosen models (1979-2007) (days/standard deviation)	Chosen models (2080-2099) (days/standard deviation)
49 (+/-18)	51 (+/-20)	134 (+/-38)

Note: Chosen models: CCSM3, ECHO-G, GFDL 2.0, HadGEMI, IPSL-CM4.

Long-term forecasts of the navigational period (30-50 years) are practically true only if global climate warming will continue and intensify.

There are some areas along the NSR, where ice conditions for navigation are the most difficult ones. Location of these areas depends on position of the fast ice and ice massifs. Regions, where unfavorable conditions for navigation are forming occasionally are shown on Figure 4. These areas are located in the following regions:

- south-western part of the Kara Sea (Novozemelskiy ice massif);
- fast ice area in the north-eastern part of the Kara Sea, including Vilkitskiy Strait;

- western part of the Laptev Sea (Taimyr ice massif);
- Sannikov Strait;
- eastern part of the East-Siberian Sea (Aionskiy ice massif);

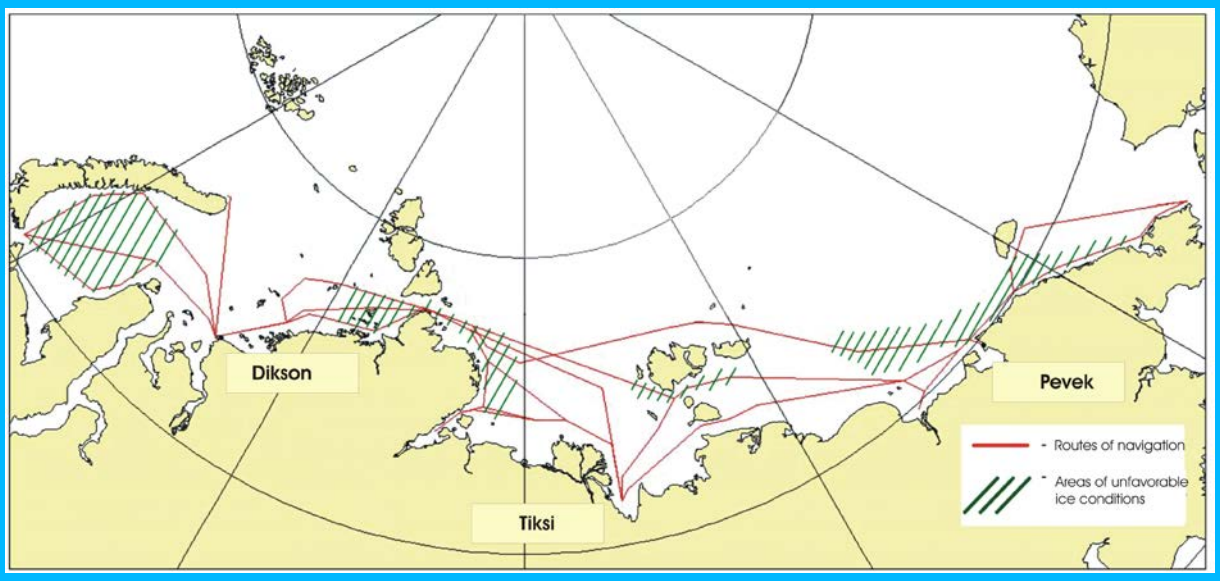

Figure 4 – Location of the areas with unfavorable conditions of navigation and navigational routes along the NSR

Sea ice distributes irregular along the NSR. Unfavorable conditions of navigation can be observed only along some parts (sometimes only one part) of the NSR. However these blocking parts cause necessity to use icebreaker assistance.

As an example such situation was observed during August-September (months of the most favorable conditions of navigation) in 1998, 2003, 2004 and 2007 (Fig. 5-7).

In the second decade of September 1998 sea ice conditions did not allow for vessels of the ice class Arc 5 to navigate without icebreaker assistance in the Long Strait and to the west of this strait.

In the third decade of August 2003 close ice blocked Vilkitskiy Strait from the western side (Fig. 6) and in the first decade of September 2004 close ice of the Taimirskiy massif did not allow non-icebreaker navigation in the western part of the Laptev Sea (Fig. 7). Formation of these areas predetermined necessity of icebreaker assistance for transit navigation along the NSR, although almost the whole lengths of the NSR had favorable ice conditions.

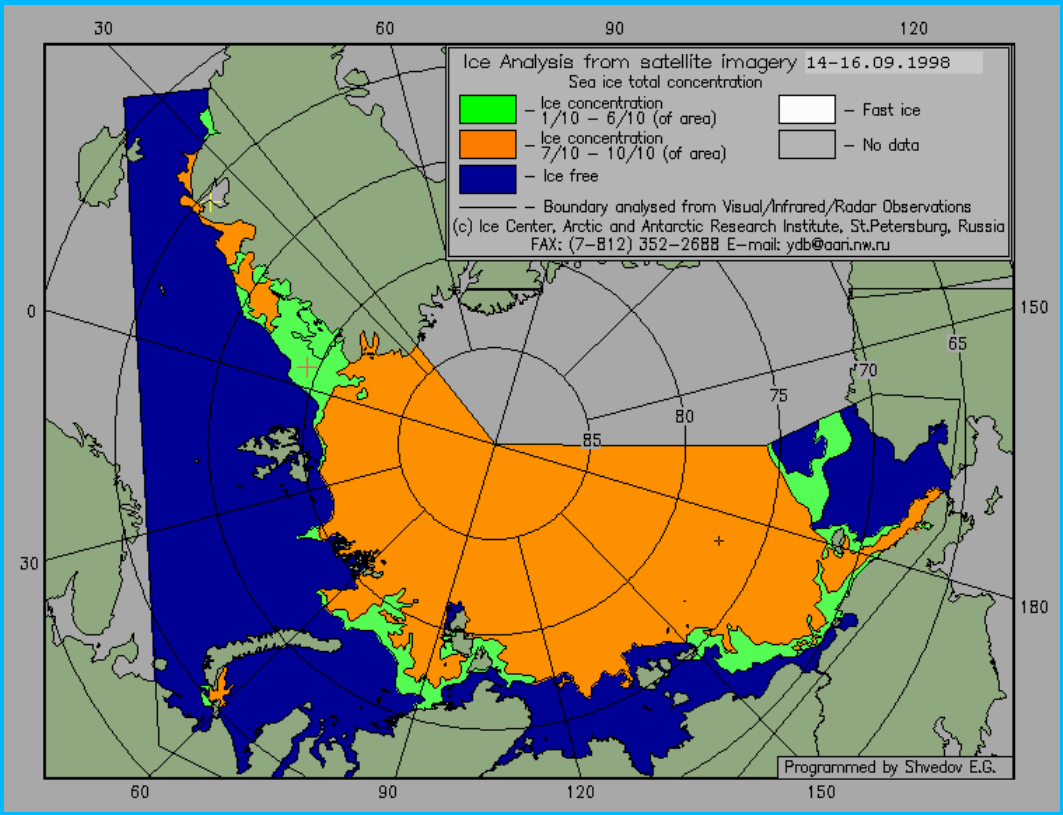

Figure 5 – Distribution of sea ice cover along the NSR in the second decade of September 1998

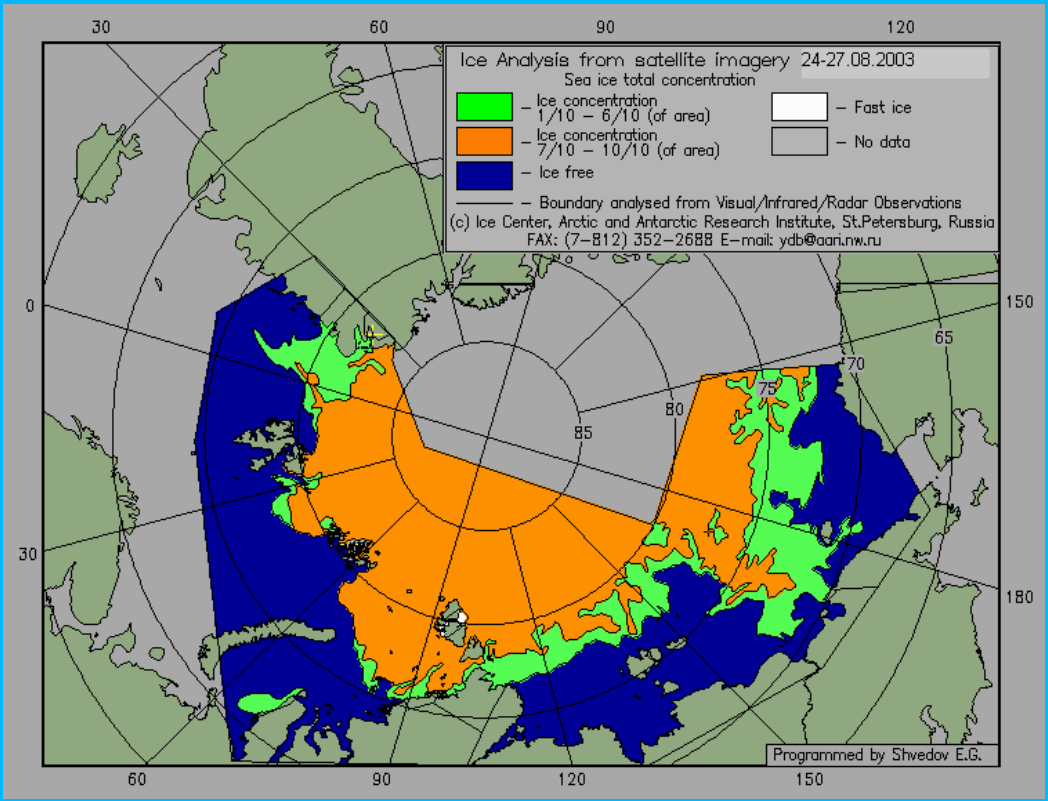

Figure 6 – Distribution of sea ice cover along the NSR in the third decade of August 2003

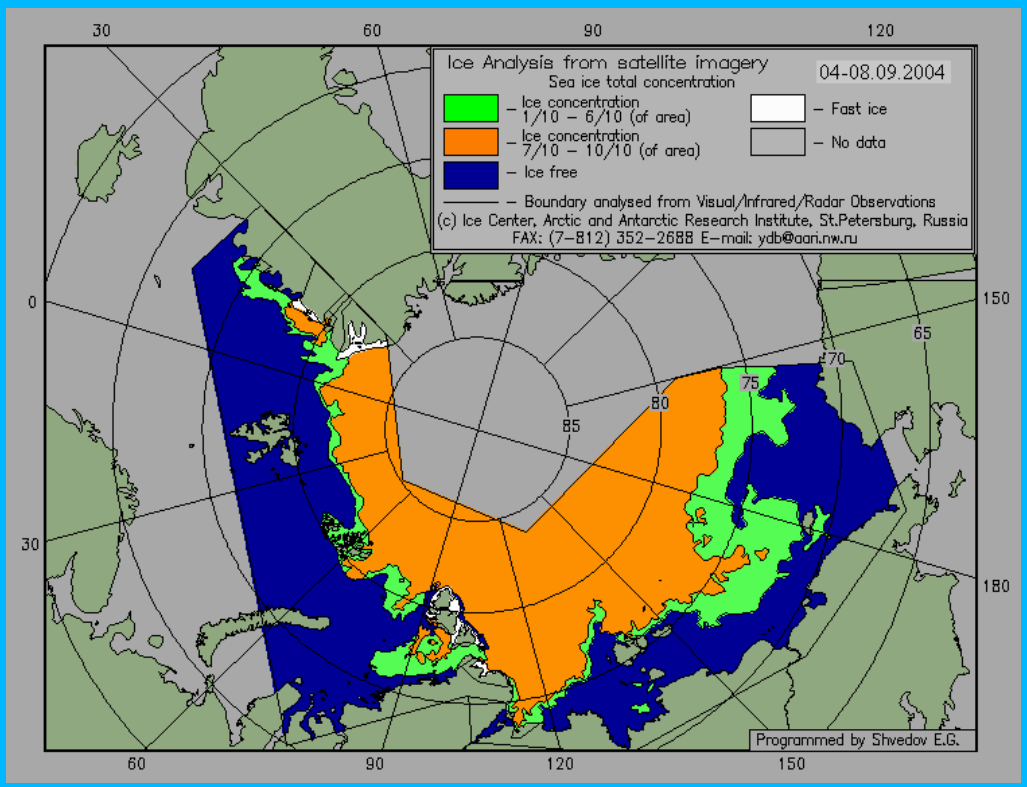

Figure 7 – Distribution of sea ice cover along the NSR in the first decade of September 2004

Even in 2007 (year of the second historical minimum of the Arctic sea ice area) close ice of the Taimirskiy ice massif blocked the NSR in summer period and did not allow transit without icebreaker assistance (Fig. 8)

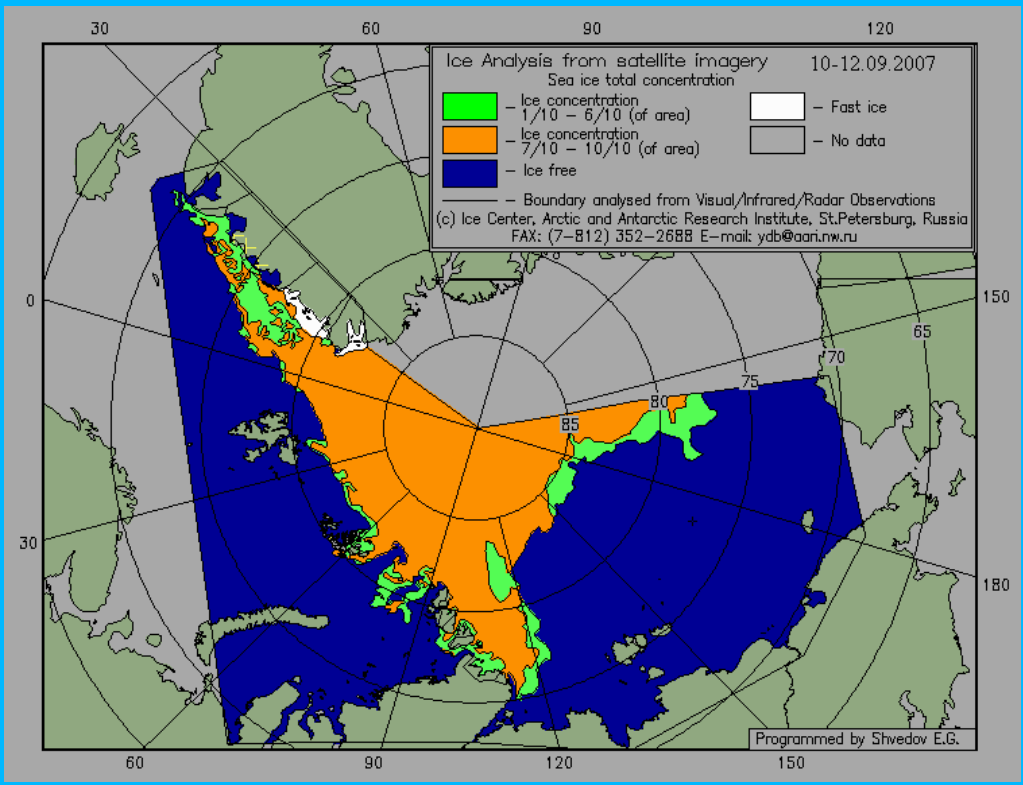

Figure 8 – Distribution of sea ice cover along the NSR in the second decade of September 2007

Conclusions

Intensified usage of the NSR for the transit navigation during the last years confirms profitability of the regular cargo transportation from the Europe to the Asia and back. Increase of the cargo transportation, application of flexible rate policy and improving of the sea ice conditions in summer along the NSR contributed to intensification of the transit navigation along the NSR.

Increasing the terms of non-icebreaker navigation and terms of transit navigation with icebreaker assistance up to half a year is possible in case of continuation of the global climate warming in the nearest future.

Recent climate variability, increasing of the cargo transport along the NSR, using the high-latitudinal routes of the NSR requires maintaining existent icebreakers and building new icebreakers, which are necessary for safe and reliable navigation.

References:

Buzuev A.Ya., 2002. Analysis of the multi-year data about the terms of non-icebreaker navigation to characterize climate changes in conditions of navigation along the NSR in summer. // Conf. proc. "Hydrometeorological support of the business activity in the Arctic and frozen Seas". St.Petersburg, 27-29 March 2002 r. P. 256-267.

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