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COMPARATIVE ANALYSIS OF TWO MARITIME ROUTES IN PART OF NORTH AMERICA IN THE CONTEXT OF GLOBAL WARMING, MELTING ICE CAPS AND OPENING OF NEW PASSAGES FOR NAVIGATION

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Abstract. The subject of this paper is to analyze comparative two maritime routes planned different for a ship that carry cargo from the United Kingdom to the Norton Sound, (63o 48'N / 161o21'W). The route are analyzed separately as a result of the evolution of the thermal regime, the ice in the last ten years in the area of North America and the impact of ice caps, from the perspective of total distance and opportunity of navigation. Take into consideration all three possible routes on this date, only the north-west route was included in this comparative analysis. The results presents a difference of 6070 Nm between the classic route (using Panama Channel) and the route through north-west passage, in safety condition.

Keywords: *hydro meteorological parameters, maritime routes, voyage optimization, ECDIS, ice navigation*

1. Introduction

On 16 August 2017, the LNG tanker Christophe de Margerie owned by Russian shipping line Sovcomflot completed the journey between Norway and South Korea along Russia's northern coast. It was the first time a ship of this sort had traversed these waters without icebreakers, and it did so in record time: 19 days, 30% faster than the traditional route through the Suez Canal [1].

While the Northern Sea Route above Russia (also known as the Northeast Passage) has been open to shipping traffic since mid-August, recent satellite data show that the most direct course in the Northwest Passage now appears to be navigable as well [2].

"The Northwest Passage (NWP), connecting the Atlantic and Pacific Oceans, is a sea route through the Arctic Ocean, along the northern coast of North America via the waterways among the Canadian Arctic Archipelago. There are five to seven different seaways through the Archipelago, including the McClure

Strait, the Prince of Wales Strait, and Baffin Bay via the Davis Strait. Except for the route through Baffin Bay and the Davis Strait, the other routes are not suitable for larger ships." [3]. In August 2007, the NWP became accessible to ships without an escorting icebreaker, with the early advent of global warming. At least three ships successfully completed their journey in 2007. In September 2007, the European Space Agency announced that ice shrinkage had opened up the passage for the first time since 12 records began in 1978.

2. Methods used to analyzed

To analyze the evolution of ice for NWP was used different data and images from NASA Nimbus-7 satellites using passive microwave sensors, and for highlighting the decrease of ice volume monthly/ annually was used information from PIOMAS [6].

To evaluate the total distance for both routes, was used Electronic Chart Display and Information System (ECDIS) software [8]- Transas 3000, available onboard and used to planning the voyages in safety condition. Compared the results resulted the advantages of arctic routes using the north-west passage.

ECDIS software is used to share geographic electronic information system used for maritime navigation in accordance with International Maritime Organization (IMO) regulations. We could consider ECDIS software such as an alternative to paper nautical charts. The software displays all the information from Electronic Navigational Charts and provides continuous position and navigational safety information. Also, the software could integrates the position of ships, heading and speed through water. This software could interface with radar, Navtex or AIS (Automatically Identification Systems) and also could generate alarms when the ship is in proximity to navigational hazards.

3 . Results

3.1. Analyses of the evolution of the ice regime for the NWP

During the study regarding the variation of ice regime in part of North America, we analyze the NWP due to its position along the north part of North America (Figure 1).

Figura 1- Northwest Passage

On the route of NWP we recognize Multy-Year Ice (ice formed for more than two years), very winding straits and numerous formations type pingo (small ice-covered islands, found in the Arctic area), which make the navigation very difficult.

The minimum expansion of sea ice in the Arctic area of North America in September 2017 reached a new record of lows (the other records were in 2002, 2006, 2007 and 2012). The melting that took place in 2007 was at a minimum of 39%, making possible for the first time in human history the complete opening of the NWP. This dramatic melting of 2007 produced the concern scientists. From 2008 to 2011, sea ice reached a new all-time low. During 2012, the record was exceeded in the final part of August, with three months left from the melting season. This minimum continued to decrease, reaching on September 16, 2012 a melted area of 770,000 square meters. The ice stretches shown in Figure 2 were observed by the NASA Nimbus-7 satellite using passive microwave sensors and via the SSMIS (Microwave Imager / Sounder) of the Defense Meteorological Satellite Program (DMSP) [5]. Multi-year ice is presented in light white colors, and medium-thickness ice is presented in dark blue to light blue colors.

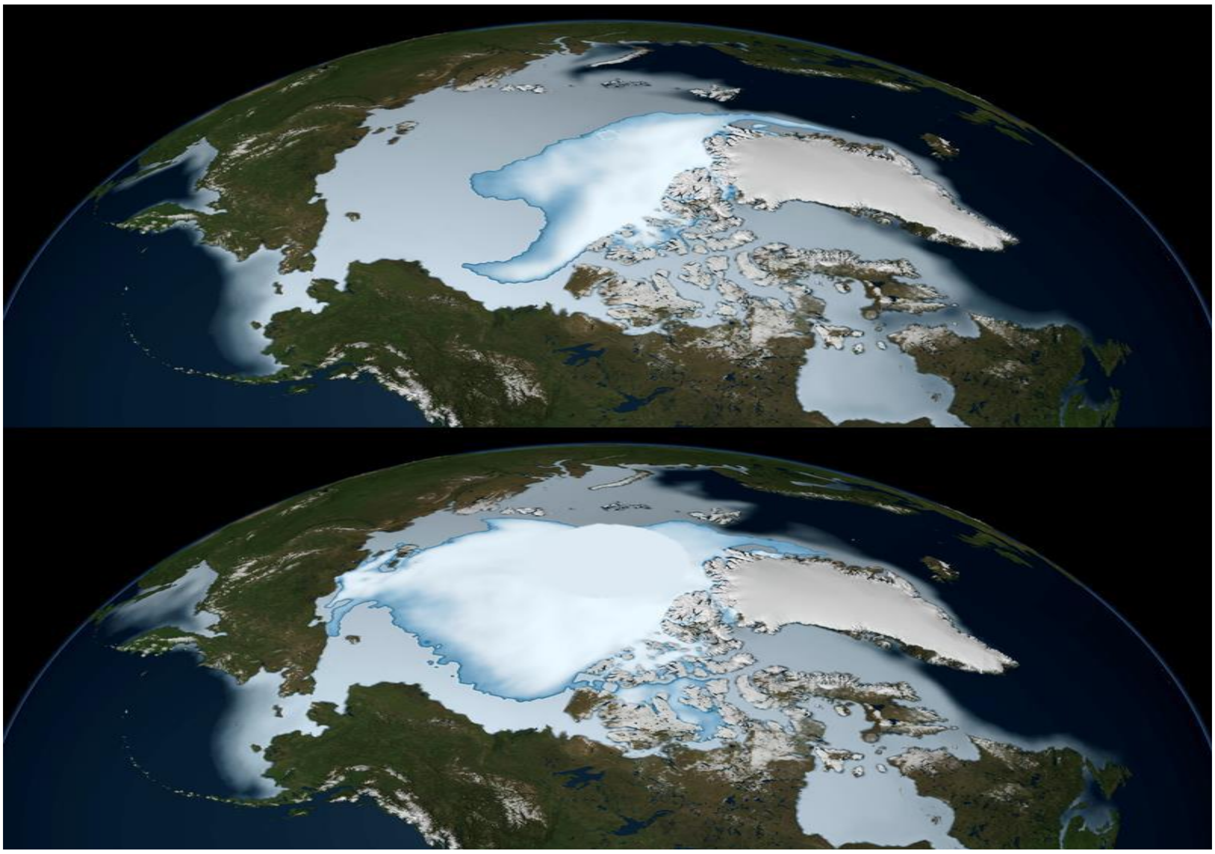

Figure 2. Sea ice cover in 1980 (bottom picture) and 2012 (top picture). Images observed by NASA Nimbus-7 satellite

The rate of decline of the entire arctic ice cover has accelerated. In the years 1979-1996, the average decline per decade was 2.2%. In 2008, this decline reached values of 10.7%. The thickness of the ice layer and the mass of the ice volume are much more difficult to determine than the expansion of ice deposits. Accurate measurements can only be made at a limited number of points. However, studies support the idea of a very large decline in ice expansion as well as the thickness of their layers. The volume of ice present in the arctic area of North America shows a greater decline than the expansion of ice. Since 1979, the volume of Arctic ice has decreased by 80%.

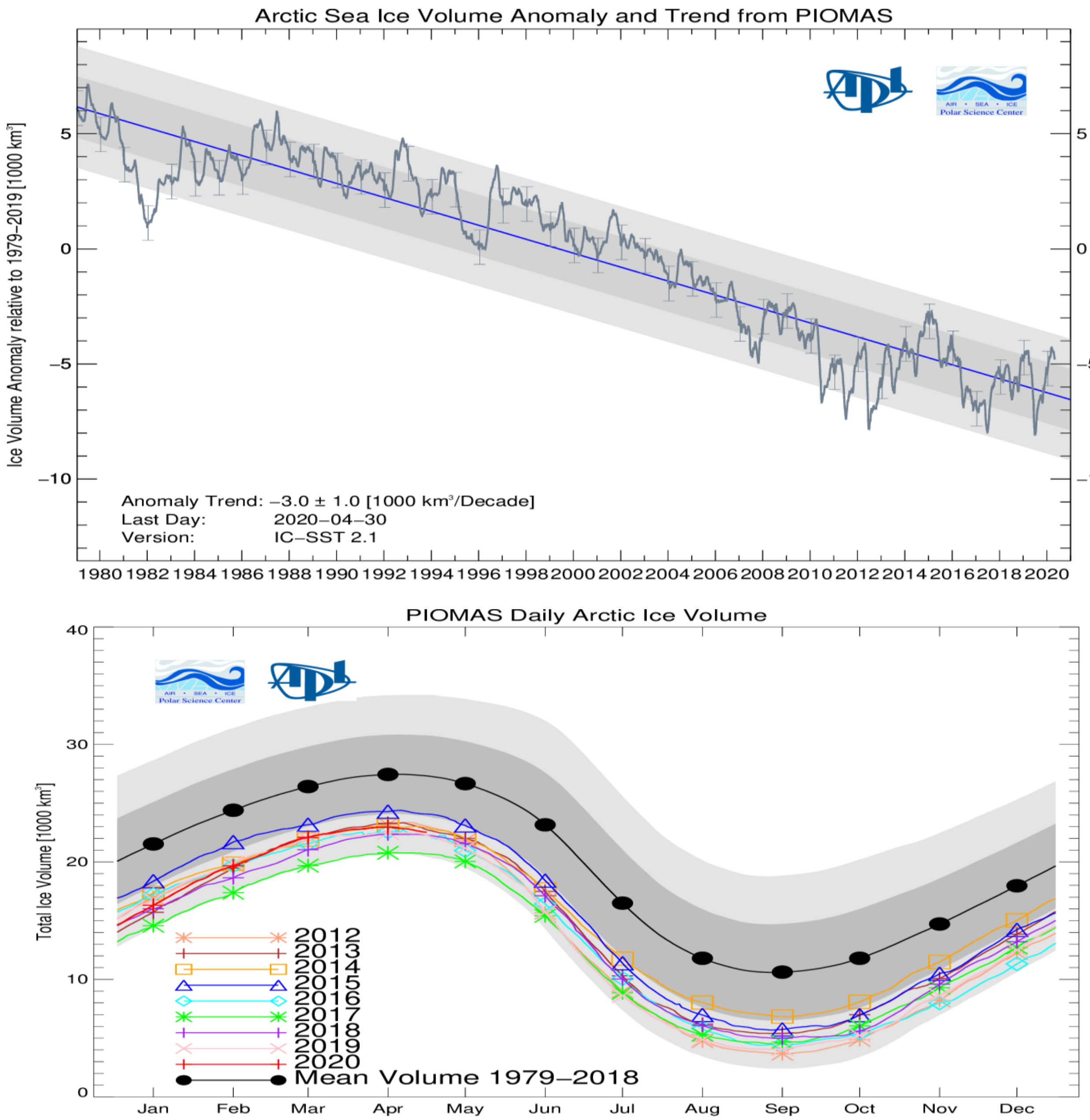

Figure 3- Seasonal variation and long-term reduction of the volume of ice deposits at sea. a) annual; b) monthly. Adaptation after PIOMAS (Pan-Arctic Ice Ocean Modeling and Assimilation System) [6].

Average Arctic sea ice volume in April 2020 was 22,800 km3. This value is 2100 km3 above the record minimum value of 20,700 km3 set in 2017, making it the sixth lowest on record. Monthly ice volume was 37% below the maximum in 1979 and 24% below the mean value for 1979-2019. April 2020 ice volume falls almost one standard deviations above the trend line (Fig.3). [6].

The opening of this route is also difficult due to territorial sovereignty issues: the Government of Canada claims that the NWP is part of Canada's inland waters, while the U.S.A. and some European countries argue that the passage is an international strait and that its transit must be made without the imposing taxes.

The water depth in the eastern part of this passage is 15 m, which makes this route not a viable option to ensure the maritime connection between Europe and Asia.

In 2016, a Chinese company showed its intention to execute regular voyages with ships on this route, following a successful passage of a cargo ship, Nordic Orion, with a tonnage of 73500 tdw, in September 2013 [4] .Being loaded at full capacity, the ship had a draft too large to cross the Panama Canal.

3.2 Comparative analysis between the NWP and the classic maritime route

Figure 4 shows the route planned using ECDIS software, for a ship that has to carry cargo from the UK (50°05’N / 006°08’W) to Norton Sound Bay, located in western Canada (63°48’N / 161°21’W).

Figure 4- NWP planning using ECDIS software

From the data presented in Figure 5 we notice that the distance that a ship has to travel to reach its destination, passing through the NWP, in total safety, is 5056.72 Nm.

New | Load Route | Unload Route | Focus on Route | WP Editor | Save | M.Britanie-golful Norton Sound

WP	Name	Lat	Lon	RL/GC	Distance	Course	Total Distance
0		50° 05.000' N	006° 08.000' W	XXXX	XXXX	XXXX	XXXX
1		59° 58.591' N	055° 06.585' W	RL	1782.41 nm	289.5°	1782.41 nm
2		74° 09.916' N	065° 36.913' W	RL	887.13 nm	344.4°	2669.54 nm
3		74° 18.916' N	095° 44.564' W	RL	493.46 nm	271.0°	3163.00 nm
4		73° 59.861' N	114° 15.133' W	RL	305.28 nm	266.4°	3468.27 nm
5		75° 37.601' N	126° 41.622' W	RL	219.52 nm	296.8°	3687.80 nm
6		70° 32.767' N	170° 03.395' W	RL	814.66 nm	247.9°	4502.45 nm
7		65° 58.363' N	168° 46.298' W	RL	276.92 nm	174.1°	4779.37 nm
8		64° 18.601' N	167° 52.326' W	RL	102.66 nm	167.2°	4882.03 nm
9		63° 48.000' N	161° 21.000' W	RL	174.69 nm	100.1°	5056.72 nm
>>>>	XXXX			XXXX	XXXX	XXXX	XXXX

Figure 5- The waypoints resulted using ECDIS software for NWP

Figure 6 shows the planned route for a ship to carry cargo from the same area, Great Britain (50o05'N / 006o08'W), to western Canada, in the Gulf of Norton Sound (63o48'N / 161o21'W), the navigation route being traced through southern North America, the ship transiting the Panama Canal.

Figure 6 - Southern Route (crossing the Panama Canal) using ECDIS software

From the data presented in Figure 7, we notice that the distance that a ship has to travel to reach its destination, passing through the south of North America and transiting the Panama Canal, in safe conditions, is 11126.58 Nm.

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WP	Name	Lat	Lon	RL/GC	Distance	Course	Total Distance
5		09° 18.537' N	079° 55.275' W	RL	4.86 nm	179.5°	4480.65 nm
6		09° 14.599' N	079° 55.754' W	RL	3.95 nm	186.9°	4484.60 nm
7		09° 10.296' N	079° 52.283' W	RL	5.49 nm	141.3°	4490.09 nm
8		09° 10.217' N	079° 49.171' W	RL	3.08 nm	091.5°	4493.17 nm
9		09° 06.910' N	079° 48.454' W	RL	3.37 nm	167.8°	4496.54 nm
10		09° 06.752' N	079° 46.699' W	RL	1.74 nm	095.2°	4498.28 nm
11		09° 06.516' N	079° 41.992' W	RL	4.66 nm	092.9°	4502.94 nm
12		09° 02.183' N	079° 38.960' W	RL	5.25 nm	145.2°	4508.20 nm
13		08° 59.820' N	079° 36.089' W	RL	3.69 nm	129.6°	4511.88 nm
14		08° 57.693' N	079° 34.334' W	RL	2.74 nm	140.6°	4514.62 nm
15		08° 54.542' N	079° 33.058' W	RL	3.38 nm	158.1°	4518.00 nm
16		06° 43.615' N	079° 04.921' W	RL	133.27 nm	167.9°	4651.27 nm
17		07° 05.756' N	089° 13.789' W	RL	605.96 nm	272.1°	5257.23 nm
18		54° 18.906' N	175° 48.040' W	RL	5105.97 nm	303.6°	10363.20 nm
19		63° 53.037' N	165° 10.663' W	RL	661.56 nm	029.5°	11024.76 nm
20		63° 48.000' N	161° 21.000' W	RL	101.83 nm	092.8°	11126.58 nm
>>>>	XXXX			XXXX	XXXX	XXXX	XXXX

Figure 5- The waypoints resulted using ECDIS software for Southern Route

4. Discussion

We observe by comparison the distance on the route that through on the south of North America is double that which involves the transit of the Northwest Passage, indicating a difference of 6070 miles between the classic route (Panama Canal) and the NWP. This significant reduction in the distance that ships have to travel necessarily means a major impact both from an economic point of view, by reducing fuel and arrival time, but also from a climatic point of view, decrease the level of emissions that ships emit into the atmosphere [7].

The only thing that companies and ships need to consider is the safety of the crew and the ship when transiting the Northwest Passage. It is very winding and may show significant ice deposits in some regions. Thus, companies may need to use icebreakers to assist them during the passage of the passage and to make their route accessible. This includes additional costs.

However, transport vessels built specifically to operate in the Arctic will also have no problems and will be able to transit without problems the maritime regions where ice deposits are located.

5. Conclusions

In conclusion, maritime traffic in the Northeastern Pacific Ocean and the Northwestern Atlantic Ocean varies significantly during the year, depending on the hydrometeorological conditions that may vary from year to year. The most unfavorable time of year for the safe execution of voyages in this area is between February and March when the ice extends most from the coast to the sea.

Also, ice caps that detach from the coast of Alaska reach the waters of the Bering Sea, and can collide with ships, increasing the risk of water holes in their bodies. However, due to climate change, new shipping routes through North America will soon be open. These routes significantly reduce the distance that ships have to travel from Europe or eastern North America to the west coast of North America or to the west coast of Canada. Thus, these northern routes have a significant advantage from an economic and climatic point of view, reducing transport costs, but also the level of pollutants emitted into the atmosphere by transport ships.

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