"Mircea cel Batran" Naval Academy Scientific Bulletin, Volume XX – 2017 – Issue 1
The journal is indexed in: PROQUEST / DOAJ / Crossref / EBSCOhost / INDEX COPERNICUS / DRJI / OAJI / JOURNAL INDEX / I2OR / SCIENCE LIBRARY INDEX / Google Scholar / Academic Keys/ ROAD Open Access / Academic Resources / Scientific Indexing Services / SCIPIO / JIFACTOR

THE IMPACT OF THE SEA WATER FREEZING PHENOMENON ON MILITARY OPERATIONS ON THE ROMANIA'S BLACK SEA'S SHORE

Dinu ATODIRESEI[1]
Sergiu SERBAN[2]
Robert-Vlad BADIU[3]
[1]Adv. Instructor, PhD Department of Maritime and River Navigation and Transportation ,,Mircea cel Batran" Naval Academy, Constanta, Romania, dinu.atodiresei@anmb.ro
[2]Instructor, Eng., PhD candidate Department of Naval and Port Engineering and Management, ,,Mircea cel Batran" Naval Academy, Constanta, Romania, sergiu.serban@anmb.ro
[3]Student Department of Maritime Engineering ,,Mircea cel Batran" Naval Academy, Constanta, Romania, rugby_31@yahoo.com

Abstract: *The purpose of this paper is to emphasize the importance of studying the ice regime at the Black Sea, as there are not many studies made on the Black Sea's water freezing phenomena. Based on the few studies made in this domain, which include meteorological data analysis, satellite images of the main parameters which determine the optimal conditions for sea ice formation, periodic measurements and observations of the ice evolution along the past decades, we have analyzed their results and drawn some conclusions regarded to the negative influence of these rare but very important phenomena on the main military activities executed on the Romania's Black Sea's shore by different naval, air and special units forces.*

Keywords: *ice regime, freezing phenomena, military activities, meteorological data analysis*

1. Introduction

The ice occupies 15% of the planetary ocean's surface. Ice formation is possible at high and medium latitudes.

The ice is divided into two categories:

a). ice which is formed by the freezing process of the sea water;

b). ice which is formed by the freezing process of the continental water- icebergs.

Sea water ice is formed when its temperature drops below its freezing point, mostly depending on its salinity. The continental water freezes at 0^oC, but because of the presence of small quantities of salt, it remains in liquid state until it reaches a lower temperature. When the salinity of water reaches the value of 24,7 ‰, the freezing temperature is $-1,3^oC$, while at 32 ‰ (The Arctic Ocean) the freezing temperature is between $-1,7°C^\circ$ and -2^oC. [3] The salinity influences the freezing rate of water because of the fact that it modifies its density. The continental water contracts when freezes, while its density decreases. The sea water salinity usually has a value of 35, but, in some areas, especially where there is a considerable river flow in the waters of the sea, the salinity value decreases very much.[9]

When the process of freezing is being analyzed, the importance of salinity consists not only in its directly effect of lowering the values of freezing temperature, but, also, in its effect on the water density. [6]

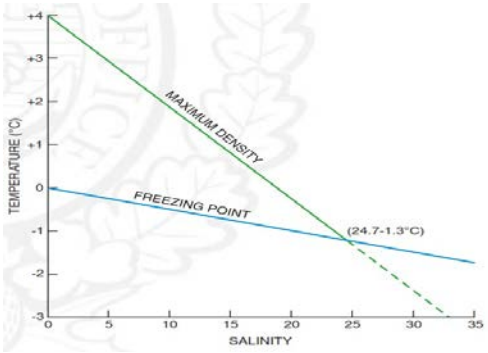

Figure 1- The maximum density and the freezing temperature influenced by temperature and salinity

In the diagram from the Figure 1 [7] it is shown the link between temperature, salinity and maximum density. It can be observed that waters with low salinity reach the maximum density before the freezing temperature and waters with higher salinity values reach the freezing temperature before density reaches its maximum theoretical value. [6]

The sea water ice is formed in several steps: around the crystallization cores are formed small ice elements ("ice needles") and then these needles collide and form small ice floes that float above the water. When snow falls, these ice floes form an ice mass which can even occupy large areas. [3]

DOI: 10.21279/1454-864X-17-I1-003

The snow fall increaseas the freezing process of water. The snow fall phenomenon is followed by a significant temperature drop and a creation of many ice cores. The ice thickness can rise up to 7-10 centimetres during the first 24 hours. Sea ice is a very bad heat conductor. As a result, the thickness growth proccess is significally slowed down after the first 10-15 centimetres of ice have formed. Due to the fact that snow acts like an isolator, as long as the ice keeps beeing covered with snow, its heat conductivity reduces.

Sea ice is firstly formed in shelter waters, near the coastline, in bays and straits where are no currents and in regions where the water salinity has a very low value. [3]

If the wind blows from the continent, the ice can break off the coast; if the wind blows from the open sea, the coastal ice and the ice floes from the open sea collide and form an icy structure called "ice wall". [3]

The thickness of ice is maintained depending on the duration of low temperature periods. In 24 hours the ice thickness can rise up to 2 cm.

2. The sea ice study of the Romania's Black Sea shores

Ice usually appears in the NW part of the Black Sea, near the coastline, the average days with ice being 40 days/year in Odessa bay, and even 100 days/year during years with severe winters; in the area of Kerci strait 40 to 80 days/year, depending on the actions of cold winds (1 to 5 days/year in soft winters)[1]

The most severe weather conditions are in Kirkinit bay where water freezes every year. Also, the Danube River, Nistru and Nipru rivers form ice structures in the areas where they flow into the sea, even in soft winters. The sea ice is present mostly from December to March. [2]

In the last 120 years the frequency of different types of winters in the Black Sea region is the following: 15% severe winters, 35% moderate winters and 50% soft winters [1]. The ice thickness is 0,3 m in the N of Black Sea (0,2 in the area of Kerci Strait); the maximum thickness is 0,6 to 0,7m during the severe winters, and the maximum ice extent (in February) has been recorded from Novorosiysk and northern shores to the western and southern shores (to Eregeli). [2]

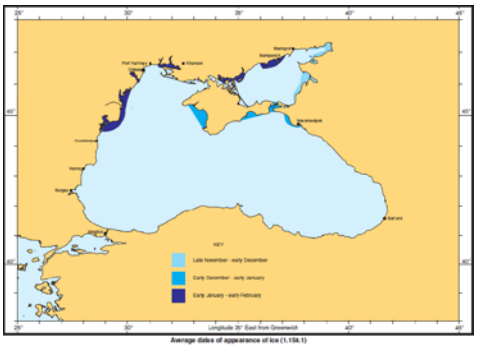

Figure 2- The average period of sea ice phenomenon at the Black Sea shores [2]

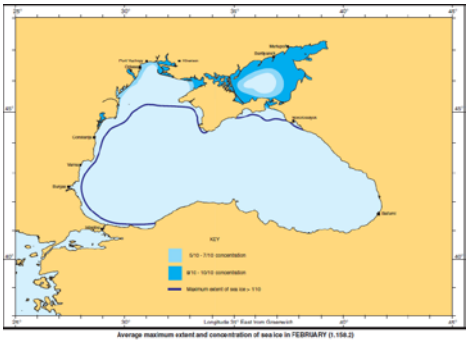

Figure 3- The average extent of sea ice in February (Black Sea shores) [2]

Regarding the air and water temperatures, the frequency of sea water freezing events at the Black Sea is not very high. Even though, these phenomena may occur sometimes, having impressive manifestations in some winters with important consequences on navigation and military operations.

During the severe winters, the ice extent line approaches the 50m depth line and crosses along the west coastline, from Cape Tarhankut to strait Bosfor. [2]

The average period of freezing phenomenon is usually 20 days on the north shores and 10 days on the south shores. There have also been recorded periods of severe winters in which the sea has been frozen on very large areas, up to 10-15 miles in the open sea. There are also periods in which such events lasted more than 45 days in Constanta (1928-1929, 1941-1942, 1953-1954). There is also a cyclicity of such severe winters, which occur every 3-4 years for soft freezing events and 11-12 years for severe freezing events. [4]

The annual number of days with snow falls and freezing phenomena at the Romania's Black Sea shore is 33,1 days in Constanta, 21,6 days in Mangalia, 21,8 days in Sulina and 25,5 days on the entire Romanian shore. [5]

DOI: 10.21279/1454-864X-17-I1-003

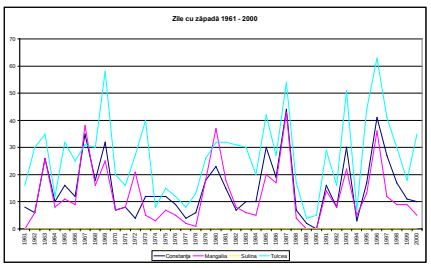

Figure 4- The average number of days with snow fall and days with snow [4]

The freezing of sea water phenomenon takes place in the west basin of Black Sea very close to the shore, in the shelter waters, where the salinity level of the sea is very low (15-17‰), when the temperatures are very low during the winter. [4]
The shore ice usually appears in the second half of December where the rivers flow into the sea and in the second half of Febraury on the west coast of Black Sea. The freezing phenomena disappear at the end of February – beginning of March. [4]
In climatology, freezing days are considered those days in which the minimum temperature of air is lower or equal to 0^{o}C. [4]
The Romanian shores and basins have the least days with freezing phenomena in the entire country. In addition, the Romanian shores also have the least days with an air temperature less or equal to 0^{o}C. [4]

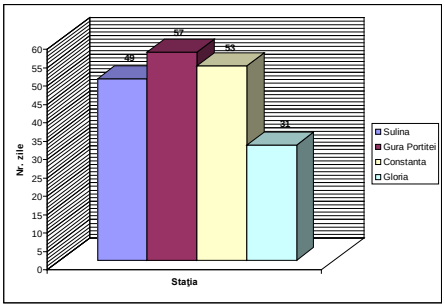

Figure 5- The average number of freezing days (1998-2007) [4]

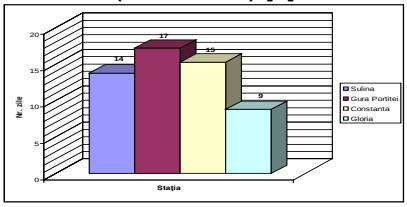

Figure 6- The average number of winter days (1998-2007) [4]

The ideal conditions for sea water freezing phenomenon:

- The permanent maintain of negative temperatures with daily average lower than -5^{o}C for at least 10 days or lower than -10^{o}C for at least 3 days;
- The weak winds;
- Calm sea waters (weak waves);
- Ice floes brought by the Danube; [4]

In the past 8 decades, the strongest freezing phenomena took place in 1929, 1954, 1963 etc. For example, on February 1954, the ice crust extended for 2-4 km in the open sea. [4]
The 1984 – 1985 winter was rough in many zones of the Earth and was characterized by severe thermal conditions on the Romanian coast – daily mean air temperature from -10°C to -15°C and a minimum of -16.7°C. As a consequence, there were three periods of freezing totalizing 47 days, a value close to the longest freezing periods mentioned at the Romanian Black Sea coast for the last 56 years, the maximum of 58 days having been recorded in 1929 (Borcea, 1931; Smocov, 1985). The ice lasted for the whole month of March, unlike the previous cases, which appeared mainly during January and February. The sea currents and the wind produced the disintegration of the primary ice field and contributed later to the secondary ice field formation and the ice was, probably, partly originating inland drifted by the Danube. The permanent wind regime (western and northern winds) recorded at Constanta and the negative values of the air temperature anomaly (~ -2ºC) in the Western Black Sea favored the persistence of the sea ice.[8]
One of the most recent freezing events on the Romania's Black Sea shores was on 23 to 29 January 2006. The minimum temperatures noticed during its period were recorded on January 23 (-19,9^{o}C at Sulina, -19,6^{o}C at Gura Portitei and 17,5^{o}C at Constanta). [4]
Analyzing the graphics in Figure 7 and Figure 8, we can notice that even if the average temperature of the air started to drop below 0^{o}C on January 7 and below -5^{o}C on January 20-22, the freezing of the sea water didn't take place until the average air temperature dropped below -10^{o}C on January 23. From January 23, the water temperature began to drop under 0^{o}C.

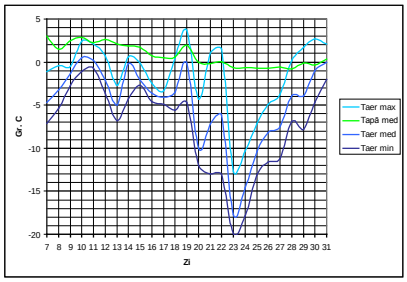

Figure 7- The air and water temperatures evolution at Sulina on January 2006 [4]

DOI: 10.21279/1454-864X-17-I1-003

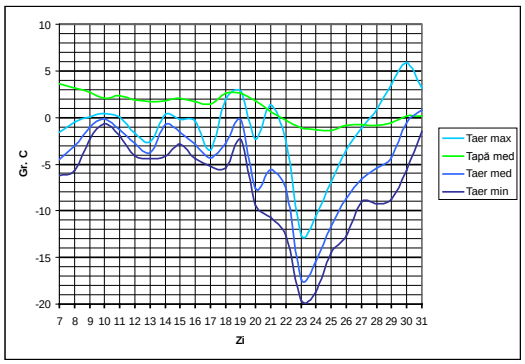

Figure 8- The air and water temperatures evolution at Gura Portiței on January 2006 [4]

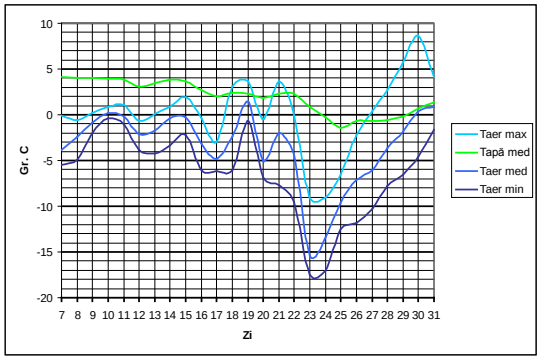

Figure 9- The air and water temperatures evolution at Constanța on January 2006 [4]

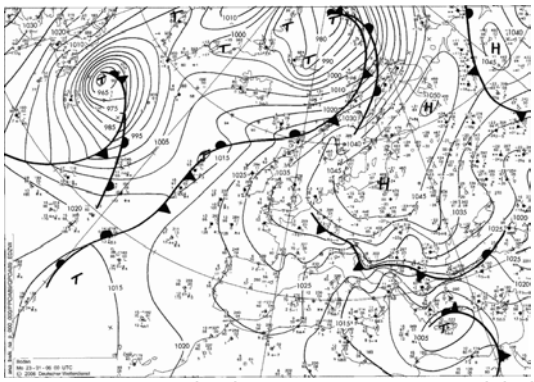

Figure 10- Atmospheric pressure on ground (mb), Europe, 23.01.2006/00 UTC (after www.wetter3.de) [4]

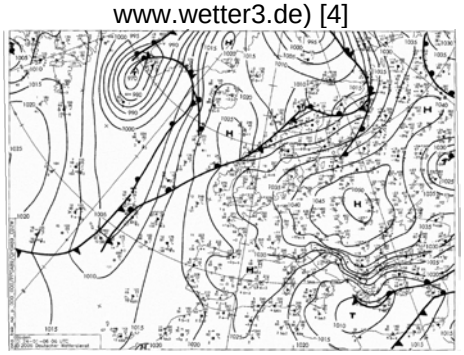

Figure 11- Atmospheric pressure on ground (mb), Europe, 24.01.2006/00 UTC (after www.wetter3.de) [4]

As we can see in the previous figures (Figure 10 and Figure 11), the sea water freezing phenomenon took place after the northern, central and south-east areas of Europe were covered by a high pressure atmospheric system of Scandinavian anticyclone, which has in its core a value of over 1050 mb. This anticyclone generated an extremely cold polar air.

There must be underlined the fact that during this freezing period, the optimal conditions for ice formation (soft wind blows, soft sea waves) did not contribute in its development. So, the average wind speed was up to 14m/s at Sulina and 9-10m/s at Gura Portitei and Constanta.

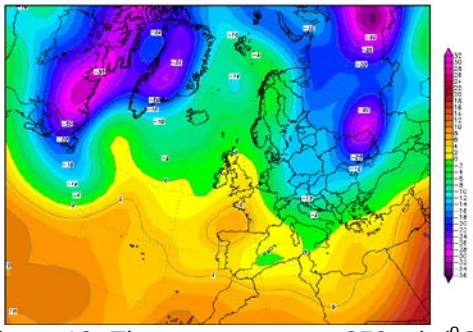

Figure 12- The temperature at 850 mb (^{o}C), Europe, 23.01.2006/00 UTC(www.wetterzentrale.de) [4]

In the winter of 2012, after a period with very low temperatures in January-February, combined with an exceptional storm, on the shore appeared specified ice structures- ice foot, grouped in layers.

The field campaign took place in south of Grind Chituc, until Grănicieri point. The observations and GPS measurements revealed an ice layer with a thickness of over 1m. At the time of observations, the ice layer was in decline, but we could still notice pretty wide widths. In the northern area of the pier at Vadu, the thickness of ice layer exceeded 2m due to the effect of ice floes pushed by the waves from NE. [5]

The ice structures protected the beach from the destructive actions of the waves which appeared during the second storm, which took place at the beginning of February. [5]

DOI: 10.21279/1454-864X-17-I1-003

3. The impact of the sea water freezing phenomenon on military operations on the Romania's Black Sea's shore

Military activities \ Utilized forces			Surface vessels (frigate, corvette, minesweeper, mine planter etc.)	Submarines	Planes	Helicopters	Specialized vessels(hovercrafts, military divers, hydrographic vessel)	TOTAL
a). Control and identification activities of the naval, air and underwater potential enemies		In open sea	0	0	0	0	0	0
		Near the shore	4	2	0	0	3	9
b).Minesweeping activities	By contact	In open sea	1	0	0	0	1	2
		Near the shore	4	0	0	3	4	11
	By destruction	In open sea	0	0	0	0	0	0
		Near the shore	4	0	0	1	4	9
c).Mine planting activities		In open sea	0	0	0	0	0	0
		Near the shore	4	0	1	1	4	10
d). Experimental activities (weapons and tactics)		In open sea	1	0	0	0	0	1
		Near the shore	2	0	0	2	4	8
e). Infantry assault from the sea			4	3	2	2	4	15
f). Monitoring the naval traffic, patrol and intervention		In open sea	1	0	0	0	1	2
		Near the shore	4	3	0	2	3	12
g). Hydrographic measurements and studies		In open sea	1	0	0	0	0	1
		Near the shore	4	1	0	2	4	11
TOTAL			34	9	3	13	32	

Figure 13- The impact level of ice formation event on the military activities and forces

Legend:

1. Insignificant impact
2. Weak impact
3. Medium impact
4. Strong impact
5. Very strong impact

In Figure 13 we have presented the major military activities on the Romania's Black Sea's shore, categorized in two major sections (activities executed in open sea and activities executed near the shore), along with their impact points. The most common activities are represented by:
a). Control and identification activities of the naval, air and underwater potential enemies;
b).Minesweeping activities (by contact/by destruction);
c). Mine planting activities;
d). Experimental activities (weapons and tactics);
e). Infantry assault from the sea;
f).Monitoring the naval traffic, patrol and intervention;
g). Hydrographic measurements and studies;
Moreover, we have also mentioned the main forces (naval, air and specialized) which execute these activities and may be influenced, more or less, by the sea water freezing phenomena.

DOI: 10.21279/1454-864X-17-I1-003

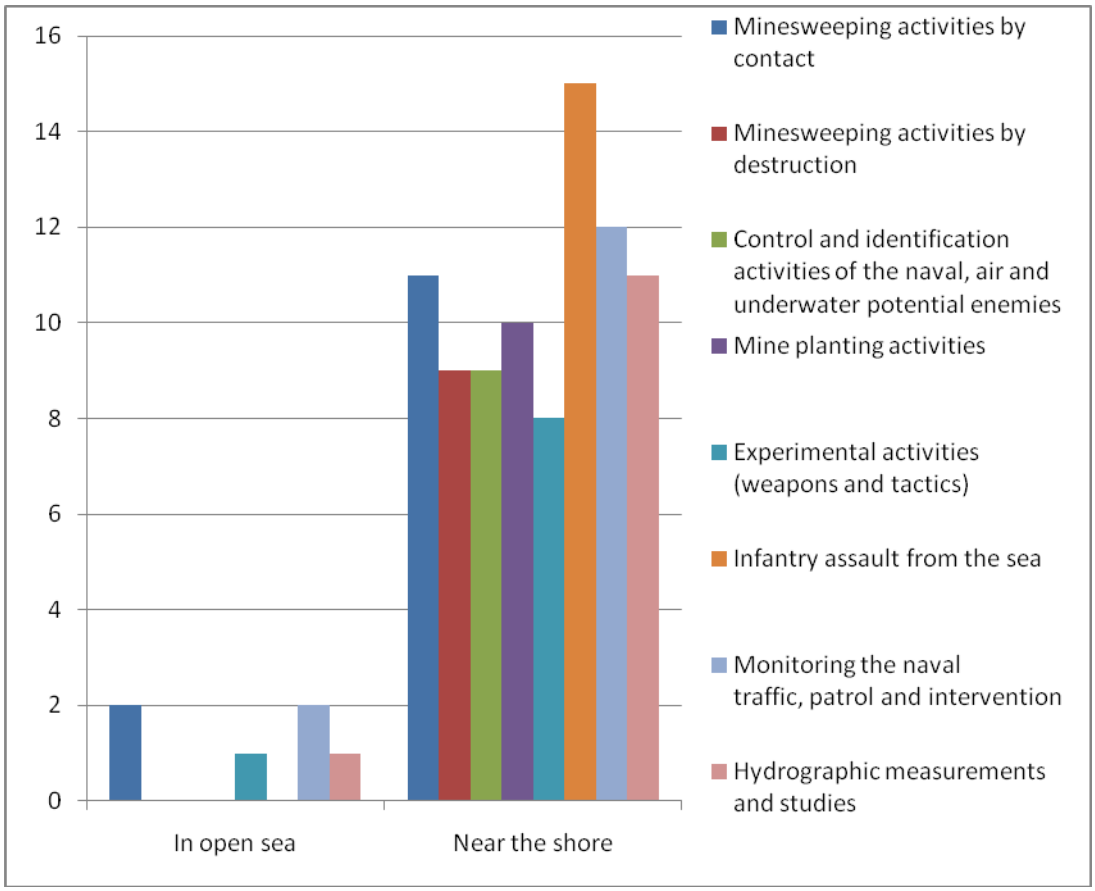

Figure 14- The most common military activities on the Romania's Black Sea's shore and their cumulated points in being affected by ice formation

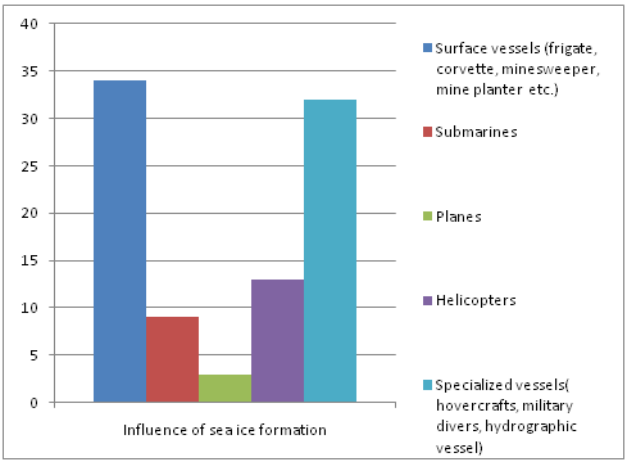

Figure 15- The military forces and their cumulated points in being affected by ice formation

In Figure 14 we can observe that the most affected military activity is the infantry assault from the sea. The forces involved are mainly naval, sea water freezing phenomenon having a major impact on the ships, as they cannot operate safely in icy shelter waters. Also, the equipment and personnel involved in the activity may be at risk, as the ice layer may break anytime.

The second group of activities which are very affected by ice formation are the experimental activities, which imply many near shore operating vessels, followed by the minesweeping and mine planting activities.

DOI: 10.21279/1454-864X-17-I1-003

In Figure 14 we can observe that the most affected military activity is the infantry assault from the sea. The forces involved are mainly naval, sea water freezing phenomenon having a major impact on the ships, as they cannot operate safely in icy shelter waters. Also, the equipment and personnel involved in the activity may be at risk, as the ice layer may break anytime.
The second group of activities which are very affected by ice formation are the experimental activities, which imply many near shore operating vessels, followed by the minesweeping and mine planting activities.

In figure 15 we notice that the most affected forces by the ice formation phenomenon are the surface vessels, which include a wide variety of ships that operate near the coastline, including minesweeper, mine planter etc. The vessels which are mostly affected are the ones which execute their activities near the shore and cannot avoid a direct contact with the ice. On the second place are the specialized vessels, which also need to approach very close to the shore in order to execute their missions.

Conclusions

Taking all into consideration, the study of sea water freezing phenomenon is very important on the Romania's Black Sea's coast, even though is a rare event.
First of all, this rare event is affecting a large number of our ships, hindering their ability to successfully finish their assigned missions. Even though the area affected is very small, the military activities must not be affected at all.
Secondly, an ice regime study can help us make a very good plan of defense, in case of a potential threat from aggressive countries. Knowing the vessels that are mostly affected by this phenomenon, we can develop a strategy in order to use their war capacity at maximum, even if the conditions are not favorable for completing war missions. What is more, we can also use the ice floes and layers in our advantage, developing a strategy in which we can limit the threatening military activities of other aggressive military forces.

Bibliography

[1]- Shuisky, Y. D. 1993. The general characteristics of the Black Sea coasts.In:Kos'yan, R. (ed..)Coastlines of the Black Sea. Americal Society of Civil Engineers, New York, 25 – 49
[2]- Black Sea's pilot card - 2000
[3]- Atodiresei D., Meteorologie şi oceanografie -2011 Note de curs, Editura ANMB,Constanţa,
[4] Romeo Boşneagu, Valentin Ciuchea, Camelia Vasilache, Lucian Dumitrache, 2012 *Analiza evoluţiei fenomenelor meteo extreme (ceaţă, îngheţ, vânt) şi influenţa lor asupra transporturilor maritime la litoralul românesc al Mării Negre.* DHM -,,Buletinul ştiinţific nr.1,
[5] L. Alexandrov, L. Boicenco, V. Coatu, D. Diaconeasa,C. Dumitrache,O. Dumitrescu, M.Golumbeanu, L. Lazăr, V. Malciu,R. Mateescu, V. Maximov, D. Micu, E. Mihailov, M. Nenciu, S. Nicolaev, V. Niță, A. Oros, A. Spînu, E. Stoica, C. Tabarcea, F. Timofte, D. Țigănuș, T. Zaharia – *Report on the state of the marine and coastal environment in 2012*, NIMRD Issue no. 43, Pages 5 – 138
[6] - Pescaru, Cornelia ; Pescaru, Al., Meteorologie marină , Editura Nautica, Constanta, 2005.
[7]- Butterworth-Heinemann., An introduction to dynamic meteorology., Elsevier Oxford, 2004
[8]- Smocov, F., Smocov, V. (1985). The formation and evolution of sea ice at the Romanian coast of the Black Sea during the 1985 winter, Recherches Marine. (18): 53 – 57.
[9] Nicolae, F.M., Beizadea, H., Popa, C., Nistor, F., *Quantitative Indicators for Black Sea's Environmental Impact Assesment, Land Forces Academz, The 16th International Conference „Knowledge Based Organization 2010"*, Conference Proceedings Vol.2, pg. 232-238 – indexed ISI Proceedings of Web of Knowledge, ISSN 1843-6722, Sibiu, Romania, 2010.

DOI: 10.21279/1454-864X-17-I1-003