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Black Sea littoral military operations - environment impact

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Abstract. The firstobjective of this article is to highlight the main features of the Black Sea environmentfrom the perspective of the military littoral operations.Variousoceanographic data, especially wind and wave data coming from observations or numericalmodelswere analyzed in order to find out the aspects which impact on the military littoral operations as a whole, as also the equipment, sensors, personnel or tactics. The present paper also gives some tactical guidance regarding planning and executing such operations and draw a comparison between the littoral battle space and open-sea warfare.

Keywords: Black Sea, Romanian nearshore, military operations, environmental impact

1. Introduction

About 80 percent of world states bordering the sea and the same percent of world capitals are located within thelittoral area. All seaborne trade has the origin and terminates within the littoral area.

In 2013, like volume, 80 percent of the global trade was carried by ships [1].

The above considerations along with the actual security challenges occurring not only within the Black Sea basin area, but also at global level make as the Navy and other military services to consider the littoral area as having at least the same relevance with open sea battlespace.

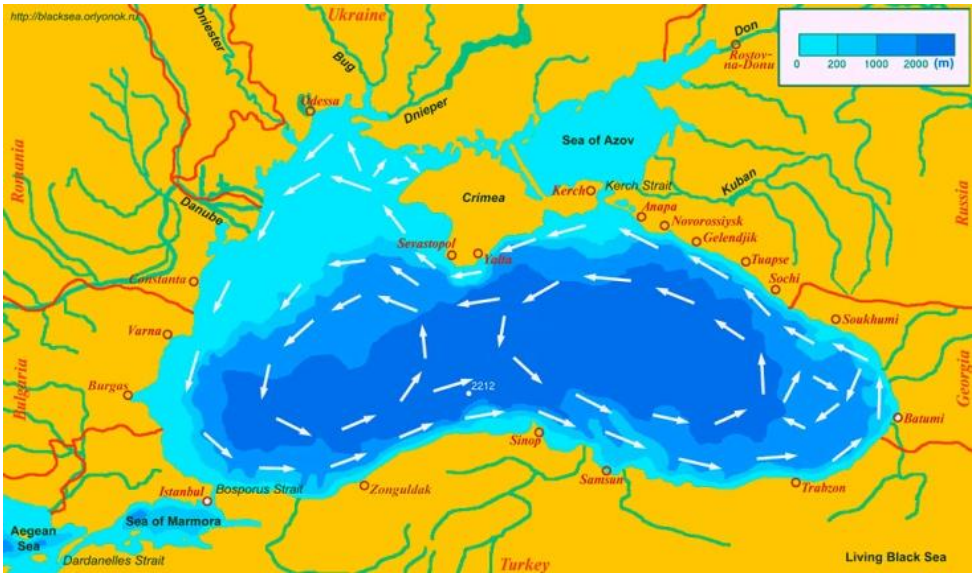


Figure 1. Black Sea map [22]

Particularly, the Black Sea has a complicate security climate,being neighbored by three countries, members of NATO – Turkey, Romania,and Bulgaria, the remaining three being former USSR members – Russia, Ukraine,and Georgia.

Russia hasmost relevant military capabilities in the area trying to play a leading role in the area, being also a NATO antagonist and Turkey is controlling the straits of Bosporus and Dardanelles [2].

The Black Sea basin lies between the southeastern part of Europe and is linked with the Marmara Sea by Bosporus Strait and further with the Mediterranean Sea by Dardanelles Strait. Within the north-eastern side of the Black Sea, Kerch Strait connects it with Azov Sea.

The sea basin is split by a ridge which lies S of Crimean Peninsula in NW sub-basin characterized by 100 miles shelves with shallow depths and a narrower shelf within SE sub-basin rarely exceeding 10 miles. The maximum value of the Black Sea depth is 2.200 m reached S of Crimean Peninsula [3].

The salinity of the Black Sea is only 18‰ at surface and 22.3‰ in deeper layers. These valuesare reduced due to the continental river water influx (The Danube, Dnieper, Dniester,andBuh),and reduced volume exchanged with the Mediterranean Sea. It is known that there are two currents: a surface one conveying about 600 km^3/year, waters with low salinity from the Black Sea to the Mediterranean Sea and a reverse one conveying about 300 km^3/year, Mediterranean waters with high salinity values[4].

This article will further analyze the impact of environmental factors (oceanography, wind, wave, currents and human activities) on military operations conducted within the Romanian littoral area.

2. Tactical considerations

The term littoral refers to a coastal region or ashore.

From the military point of view, the littoral is comprising two operating segments: *seaward*one consisting ofthe area from open sea to the shore that has to be controlled to support ashore operations and *landward* one, the inland area that can be defended/supported from the sea [1].

A tactical approach regarding sea waters is metaphorical speaking “water colors” which state three water colors depending on the proximity of the land. Thus,*blue* is considered the farthest from the land – open sea waters, *green* refers to littoral waters while*brown* are rivers, bays, and estuaries (or deltas).

Nowadays, with the emergence of High-Value ships or Units (HVU) the blue color is assigned to the most capable units (ocean-going ships) while*green* to that area where is not suitable to send an HVU and the force should be dispersed due to the necessity to be stealth enough or special features are required. *Brown*is linked tocraftoperations, but cannot be limited to riverine, estuarine or bays operations, sometimes seaward littoral segment can be referred as brown, this is the sense of having in figure 1 a fourth category of waters - green/brown. According tothe water color concept, littoral operations are conducted within green and brown waters [5].

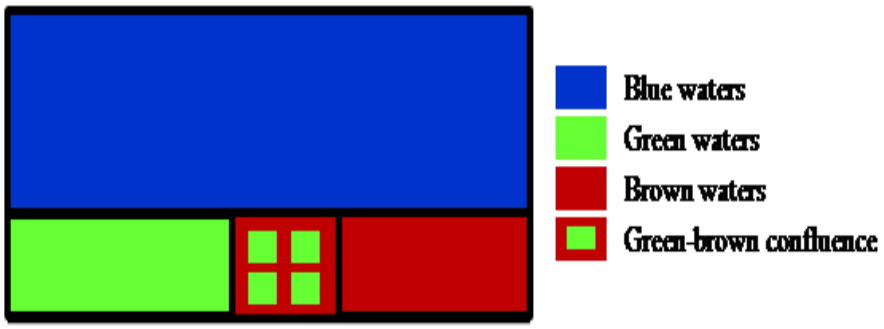


Figure 2. Water color concept depiction

The littoral operational features differ from the open sea by some specific features like:

- limited operations areas;
- adjacency of enemy area of operation;
- complex operational picture;
- unequal and complicated environmental condition[6].

The complicated tactical picture with commercial ships navigating to and from main ports (Constanța, Mangalia and Midia), pleasure crafts operating within littoral resort station area (mainly Mamaia and Mangalia), fishing vessels operating within predominant fish stocks (i.e. Danube river mouths) will determine the fleet conducting littoral warfare to enforce inhibiting but necessary rules of

engagement. The confinement will likely delay an adequate tactical response and give the adversary the opportunity to conceal behind non-military traffic and even launch isolated attacks [6].

BecausetheBlack Sea communicates with other seas by two straits; itis referred to as being semi-enclosed sea or narrow sea.

With the longest distance from one shore to another of about 648 Nautical miles (Nm), within the Black Sea basin is difficult to employ large surface ships, submarines,andaircraft in a decisive littoral operation or as the main effort. Moreover, littoral battle space is most suitable for landing operations (amphibious warfare - AMW) as decisive operations along with gaining sea and air superiority. To maintain sea and air superiority is necessary to conduct some support tasks like antiair warfare(AAW), antisurface warfare (ASUW), antisubmarine warfare (ASW), mine warfare (MIW)and sustainable operations (LOG) [6],[7].

These operations will be analyzed in the context of the Romanian shoreof theBlack Sea environment.

3. Black Sea environment impact

3.1 Bathymetry

As depicted in Figure 3, Romanian littoral is characterized by very shallow and shallow waters, for example,in the coastal environment of Tuzla, the water depths are less than 100 m for more than 75 nm while near Sulina the same depths can be reached at about 126 nm.

Romanian shore is mostly flat, suitable for landing operations, especially within the Corbu beach area and the waters, facilitate defense against AMW while obstacles postured on the beach will canalize or impede vehicular traffic.

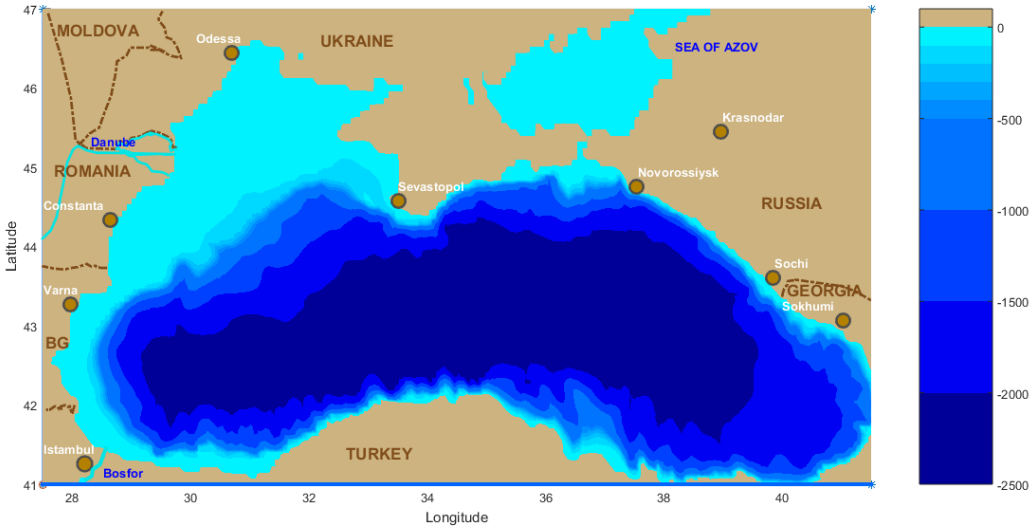


Figure 3. Black Sea bathymetric map

Choke points and navigation hazard, near shore, hinder fleet posture, the speed of advance and increase the possibility of localization and targeting by an adversary, the egress dispersion and evasive posture being degraded.

Romanian littoral has many inlets (Danube river delta, Razelm – Sinoe area, etc.) which can be used by small ships or even submarines to get concealment and to launch opportunity attacks.

The submarine operation in shallow littoral waters can be hindered or even facilitated depending onthe constitution of the seabed and water depth, in areas with a flat bottom and sandy sediments a submarine can shutdown noise source and lie on the seabed being difficult to locate with both optical and acoustic sensors. From the water depth perspective the submarine needs some water clearance above mast or under the keel, sometimes being necessary to immerse further to avoid aerial detection but shallow water will restrict this ability [6].

Wreckages are used as concealment by submarines or surface ships if apparent body part of the wreck is available. Submarines are difficultly classified as independent bodies being seen as part of wrecks or even independent wrecks [1].

Romanian littoral wrecks are depicted in figure 4.

Performance of ASW sensors, both acoustic and electro-optical limited by bottom scattering or suspended particles of sand or mud, this weak point being exploited by submarines operating in shallow waters. Torpedoes with sonar head encounter the same limitations.

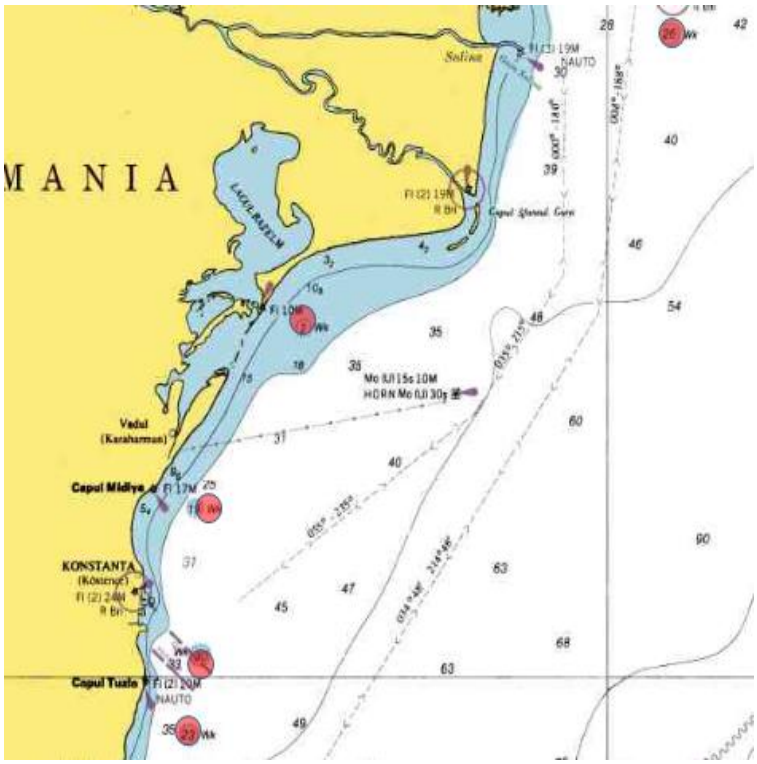


Figure 4. Wrecks along Romanian littoral

A major issue in an acoustic location within shallow waters is a high rate of false alarms from irregularities of the seabed or magnetic anomalies (one magnetic anomaly is reported S of Capul Tuzla). False alarms result in extra time, fuel, equipment and weapons consumption.

Shallow waters are suitable for MIW, all types of mines can be used due to mud and shells seabed littoral area which allows mines to sink or to be concealed from sensors detection and hunting.

Beloware presented some oceanographic factors impacting MIW and mine countermeasures (MCM).

Table 1. MIW and MCM - oceanographic factors impact [8]

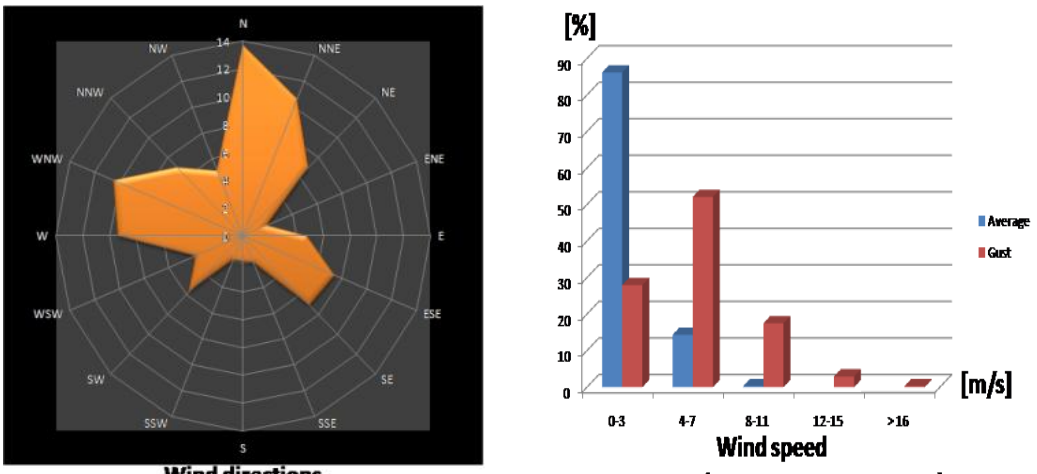
Area / Element	Riverine/Delta	Very shallow waters	Shallow waters
Bathymetry	**E**	**E**	**E**
Sediment grain size	**E**	**E**	**E**
Seafloor clutter density	**U**	**E**	**E**
Bottom roughness	**U**	**E**	**E**
Mine burial	**E**	**E**	**E**

E - essential; U - useful

3.2 Wind impact

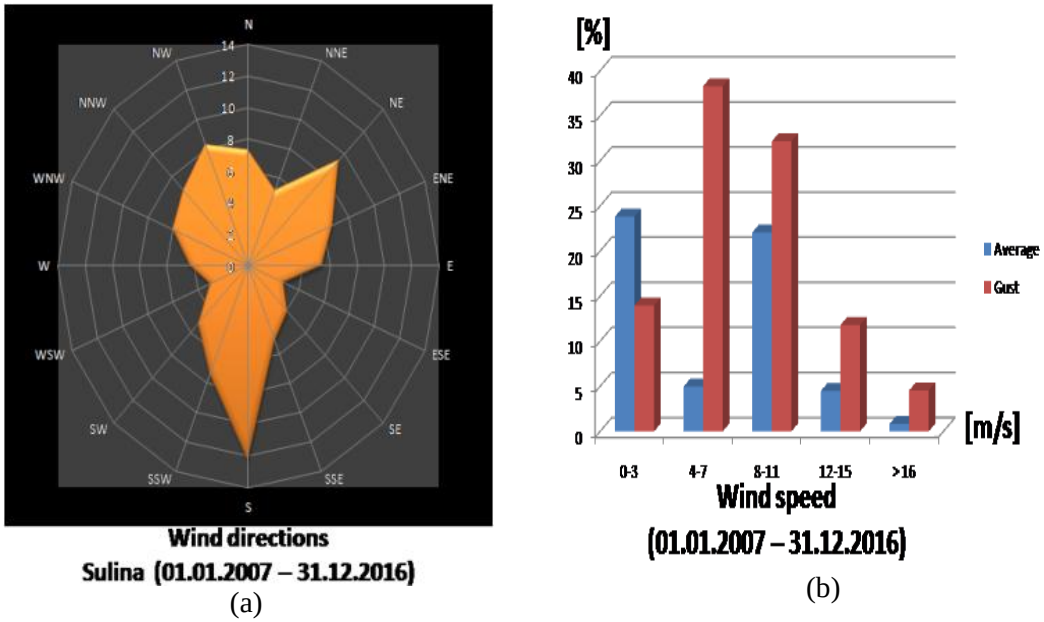
Due to its geographic position, Black Sea climate is under the influence of continental air masses, polar air coming from the north and northeast and tropical air masses coming from the southwest (Mediterranean Sea basin area). North Atlantic Oscillation (NAO) and El Niño-Southern Oscillation (ENSO) influence short-term climatic patterns within the Black Sea basin, reducing the strength of polar masses in winter [9].

Wind speeds exceeding 13,8 m/s (7 on the Beaufort scale) are considered unsafe for marine navigation, waves with a height exceeding 4 m being generated [10].



(a) (b)

Figure 5. Wind measurements at Constanța meteorological station [19]
(a) directions (b) speed



(a) (b)

Figure 6. Wind measurements at Sulina meteorological station [19]
(a) directions (b) speed

Further, the article will analyze the values measured during the ten year period (2007-2016) at two meteorological stations: Constanța and Sulina, in an eight measurements per day basis (52.120 values at each station) on sixteen directions.

Analyzing the values from graphs above we observe that at Constanța prevailing wind directions are from the northern sector, while at Sulina dominants are south sector winds.

Wind with values of speed above 13,8 m/s speed was registered at both stations, but few values for Constanța while at Sulinanot onlygustbut also average values were measured above this threshold.

Some limitations are to be considered regarding Constanța meteorological station because the station area is surrounded by a high building which prevents wind measurement devices to get proper values.

The wind affects marine navigation in many ways, from hindering ships maneuver to producing wind waves and a rough state of the sea, shutting off military operations and severely impacting on merchant voyages.

Bellow has presented the impact of the wind on some military littoral operations and some critical values which have to be considered during planning and execution phase of a littoral operation.

Table 2. Impact of wind on littoral operations [11]

OPERATION	VALUE[m/s]	IMPACT
AMW	>3,6 >18	- personnel landing and smokeoperations; - waves limits;
Intelligence	>31	- equipment damage;
Ground maneuver	>3,6 >10 >39 >64	-damage antennas and transmissions lines; - visibility restriction due to sand blowing; - aerial resupply; - antenna failure; - equipment failure;
Aviation	>16	- mission planning; - aircraft safety;
Commnuication and information systems	>3,6 >13 >35 >40	- radar noise; - antenna safety; - communication antenna; - radio antenna;

At Sulina station were registered 1.200 values of gust wind speed above 18 m/s and 131 values of average wind speed. These valuesprove that in the Romanian littoral areas the wind has characteristics that seriously impact on military littoral operations.

3.3 Wave impact

According to [12] the data collected from in situ measurements at the Gloria drilling platform, located in the NW part of the Black Sea ($43^0$31’ N $29^0$31’ E), indicate a wave regime with average height values between 1,3 m and 1,6 m, though, 8,6 m height waves can occur in extreme weather conditions, especially during the winter time. On 04th January 1995, within the northern pier area of Constanța harbor, two merchant ships, Paris and You Xiu, sunk and the crews, 54 seamen died (no crew members survived) due to extreme sea condition with 11 meters wave height and sea state nine on the Beaufort scale.

As a trend can be observed from Figure 7 that waves height is decreasing as the wave is reaching the shore due to the proximity of the seabed, but with a negative impact on the capacity of acoustic and optical sensors to provide accurate data for ASUW, MIW,and MCM.

Sensors are also seriously affected by surface sea state; the waves negatively influence sound propagation within shallow waters affecting proper sonar detection of submarines and mines in MIW and ASUW.

Table 3. Significant wave height values based on COPERNICUS data (31.12.2015) withintheRomanian littoral area [20]

LATITUDE - NORTH	LONGITUDE-EAST											AVG.
	29°59'58"	29°48'52"	29°39'58"	29°28'52"	29°19'58"	29°08'52"	28°59'58"	28°48'52"	28°39'58"	28°28'52"	28°19'58"	
43°21'36"	2,9	2,9	3	3,1	3,2	3,2	3,1	3	2,7	1,5	1	2,7
43°31'36"	2,8	2,8	2,9	3,1	3,1	3,1	3	2,8	2,5	n/a	n/a	2,9
43°41'36"	2,7	2,8	2,8	2,9	3	2,9	2,8	2,6	2,2	n/a	n/a	2,7
43°51'36"	2,6	2,7	2,8	2,8	2,8	2,7	2,6	2,3	1,9	n/a	n/a	2,6
44°01'36"	2,5	2,6	2,7	2,6	2,6	2,4	2,4	2,1	1,7	n/a	n/a	2,4
44°11'36"	2,4	2,5	2,5	2,5	2,4	2,3	2,2	1,9	1,5	n/a	n/a	2,2
44°21'36"	2,4	2,4	2,4	2,3	2,2	2,1	1,9	1,6	n/a	n/a	n/a	2,2
44°31'36"	2,3	2,3	2,2	2,1	2	1,8	1,6	n/a	n/a	n/a	n/a	2,0
44°41'36"	2,2	2,1	2	1,7	1,4	1,1	n/a	n/a	n/a	n/a	n/a	1,8
44°51'36"	2	1,9	1,6	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1,8
45°01'36"	1,8	1,6	1,1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1,5
45°11'36"	1,6	1,4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1,5
45°21'36"	1,3	1,1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1,2
45°31'36"	1,1	0,8	0,5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0,8

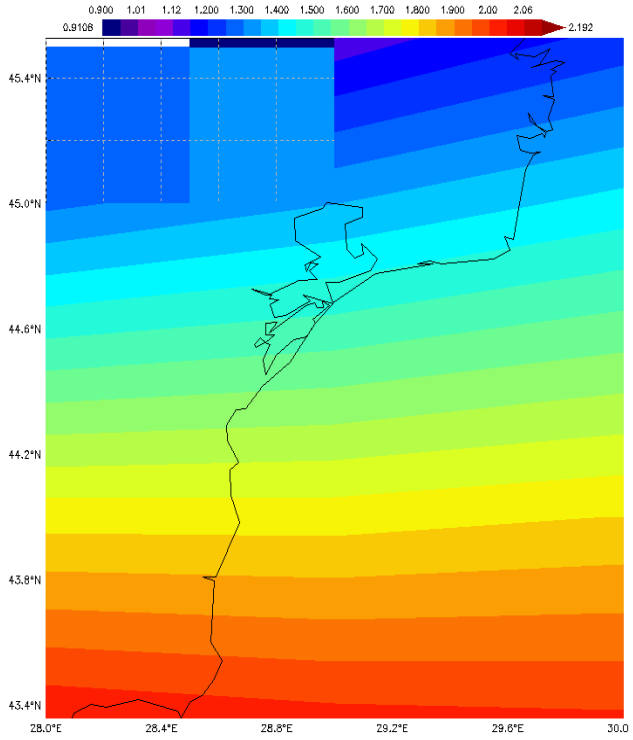


Figure 7. Significant waves height values within Romanian littoral area (31.12.2015) based on AVISO data set [21]

Moreover, irregular distribution of shapes and sizes of waves affect radar returns signal with effect on radar ability to detect, acquire and track targets or to provide an accurate operational picture of the battle space.

Sea surface roughness has a negative impact on all types of operations from sensor efficiency, crew sickness up to stability of ships or sensors, ammunition, either appending the ship or moored/floating within littoral battlespace [1].

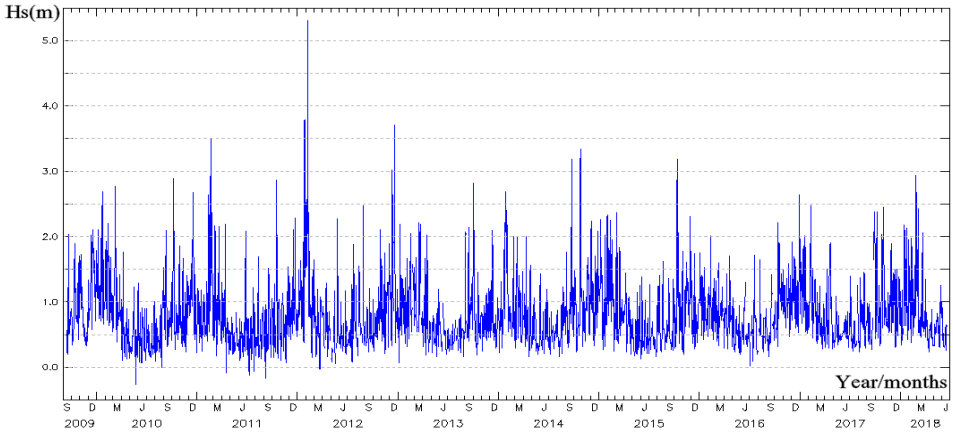


Figure 8. Mean values of significant waves height within Romanian littoral area (14.06.2009 – 20.06.2018) based an AVISO data set [21]

Value of wave height of 1,6 m constitutes a decision point for commanders and weather go criterion for littoral operation [11].

Some indicators are strong points for certain platforms and weaknesses for others, for example, an immersed submarine can take advantage of concealment provided by a rough surface with surface ships conducting ASUW having stability issues and sensors inaccuracy.

Beloware presented some critical values of sea state and wave characteristic and their impact on littoral operations.

Table 4. Wave impact on littoral operations[8], [11]

MIW and MCM wave impact			
Element	**Riverine/delta**	**Very shallow water**	**Shallow water**
Waves	LOW	MEDIUM	HIGH
AMW			
Element	**Critical value**	**Impact**	
State of the sea	> 0,9 m waves	Mission planning	
Intelligence			
Surface visibility at wavelengths of 1,06, 3 – 5 m and 8 – 12 m	< 1600 m	- adversary ability to conceal actions; - detection and identification of targets;	
Ground maneuver operations			
Sea conditions	> 0,9 m waves	Landing operations	
Airborne operations			
Surface visibility at wavelengths of 1,06, 3 – 5 m and 8 – 12 m	≤ 400 m ≤ 1600 m ≤ 4800 m	- mission planning – infrared sensors; - navigation and target acquisition – rotary wing; - day mission planning – minimum takeoff or landing – minimum fixed wings; - night mission planning – minimum takeoff or landing – minimum fixed wings;	
Waterborne surface assault – sea state			
Platform	**Favorable**	**Marginal**	**Unfavorable**
Combat rubber reconnaissance craft (CRRC)	1	2	> 2
Landing craft, mechanized (LCM)	2	3	> 3
Landing craft, utility (LCU)	2	3	> 3
Landing craft, air cushion (LCAC)	3	4	> 4

Concluding remarks

Due to overlapping of physical mediums, decisive littoral operations have to be conducted by jointly/combined, even multinational task force. This multiservice/multinational approach will result in compensating deficiencies of one service by strong capabilities of one another.

All components of such operation (sea, air, land) have to be placed under one naval commander, though, due to the environmental complexity and density of equipment and forces, these operations will require a highly decentralized chain of command, the German concept ”mission command” is the most suitable to achieve the goals of such operations.

Secure, fast, continuous communications for participants are key elements in achieving success along with getting timely and accurate data from sensors and environment data.

Littoral warfare, particularly in narrow sea, differs in many instances from open-sea warfare being directly influenced by geomorphologic, hydrographic and oceanographic characteristics oftheenvironment.

From above analyses it results that the Black Sea environment is very complex and challenging with beaches suitable for landing, wrecks, noticeable human activities, seabed constitution which affects the performance of sensors and meteorological phenomena which can affect or even deny the execution of a littoral military operation.

Designing appropriate task force to conduct littoral operations is, perhaps, the most challenging prerequisite for achieving success, adequate littoral capabilities must be employed without disregarding open-sea assets support.

Acknowledgment

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