...::KENT AKADEMİSİ | URBAN ACADEMY

Volume: 15 Issue: 2 - 2022 | Cilt: 15 Sayı 2 - 2022

ARTICLE INFO | MAKALE KÜNYESİ
Research Article | Araştırma Makalesi
Submission Date | Gönderilme Tarihi: 09.04.2022
Admission Date | Kabul Tarihi: 30.05.2022

CITATION INFO | ATIF KÜNYESİ
Usluer, H.B., Alkan, G.B., Turan, O. (2022). Prediction of the Effects of the Current Regime on Ship's Maneuvering at the Strait of İstanbul, *Kent Akademisi Dergisi*, *15*(2):611-629
https://doi.org/10.35674/kent.1098026

Prediction of the Effects of the Current Regime on Ship's Maneuvering at the Strait of İstanbul

Akıntı Rejiminin İstanbul Boğazındaki Gemi Manevralarına Etkisinin Tahminlenmesi

Hasan Bora Usluer [1], Güler Bilen Alkan [2], Osman Turan [3]

ÖZ

Türk Boğazları Sistemi veya Deniz Alanı; İstanbul, Çanakkale Boğazları ve Marmara Denizi'nden oluşur. Türk Boğazları aynı zamanda dünyanın en işlek doğal su yolları arasındadır. Ulusal ve uluslararası deniz ticareti, Asya ve Avrupa kıtalarını birbirine bağlayarak deniz trafiğini artırmaktadır. Bu çalışma, Türk Boğazlarının deniz tarafından dolmuş eski bir nehir vadisi olduğunu, akıntılar gibi farklı ve zorlu deniz şartlarının gemilere seyir esnasında nasıl etkilediğini göstermektedir. Tarih boyunca, Türk Boğazlarında 1979'da Independenta ve son olarak da 2018'de Vitaspirit gibi ünlü birçok tehlikeli çarpışma ve deniz kazaları meydana gelmiştir. Tüm çatışmaların teknik ve doğal etkilerine derinlemesine bakılması gerekmektedir. Ayrıca çalışma da insan refleksi ile teknik ve doğal etkilerin nasıl kontrol altına alınabileceğini araştırmaktadır. Doğal etkilerin teknik olarak tahmin edilebileceğini ve denizcilerin düzenli eğitim ve farkındalıkla tüm etkileri kontrol altına alabileceklerini göstermektedir. Sonuç olarak, mevsimsel ve sürekli olarak deniz bilimleri ölçülebilir ve denizcilere gerçek zamanlı hizmet verebilirse, doğal etkiler kontrol edebilir, denizler korunurken kıyı kesimlerinde şehir/kent yaşamını da olumlu etkileyecektir.

Anahtar Kelimeler: Türk Boğazları Deniz Alanı, Deniz Bilimleri, Deniz Ulaştırma ve İşletmesi, Deniz Yönetimi Stratejisi, Çatışma.

ABSTRACT

The Turkish Straits System or Sea Area consists of the Strait of İstanbul, the Strait of Canakkale, and the Sea of Marmara. The Turkish Straits are also among the busiest natural waterways in the world. Local and international maritime trade increases maritime traffic by connecting Asia and Europe continents. This study shows that the Turkish Straits are a former river valley drowned by the sea at the end of the tertiary period and affects different and demanding marine sciences situations like water currents to the ships and seafarers during navigation. Throughout history, many hazardous collisions and marine accidents happened at the Turkish Straits famously like an Independenta in 1979 and lately Vitaspirit in 2018. Suppose we need to look deeply at many reasons for all collisions, and technical and natural effects. This study tries to find the answer to natural effects that could control by human reflex and eligible technical types of equipment at the Turkish Straits? The end of the study shows that natural effects could predict with technical equipment, and seafarers could control all effects with regular education and awareness. The result is that if all straits could measure and survey deeply and continuously seasonal and could service real on time ships, seafarers could control their ships to natural effects. Thus, while the seas will be protected, it will also positively affect city/urban life in the coastal areas.

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Keywords: Turkish Strait Sea Area, Marine Science, Maritime Transportation and Management, Strategy of Maritime Management, Collision.

INTRODUCTION:

The Straits of İstanbul and Canakkale, which are acronyms of the Turkish Strait Sea Area (TSSA) and constitute the Turkish Straits Sea area, are shown in Fig. 1 as the best natural waterway shown in the world. Besides two significant straits, an inner sea, The SoM, completes TSSA. The Straits are also linking the Black Sea-BS to the Aegean Sea-AS. Nowadays, the Turkish Straits have become more critical due to energy transportation off the BS. Also, this area is a very strategic waterway. The Straits are similar to a river in the valley, so they have a really good natural geographic structure. Due to this geographic form, having different values on the surface and bottom level cause different current speed on the straits.

Figure 1. Turkish Strait Sea Area Overview (Usluer, 2016; The Turkish Republic, Ministry of Transportation and Infrastructure, 2022)

Chiggiato et al. (2012) explained that the straits' depth varies from steep hydrographical data (mostly bathymetric) near the northern edge with three deep depressions inside in the form of a valley with a slight slope starting from the southern borderline. The Turkish Straits Sea area, the Strait of İstanbul's current scheme, generally presents a stratified two-layer system. However, some areas are stratified into three layers. The current system of TSSA is divided into two parts, upper and lower layers. In contrast, the surface or upper layer flows towards the SoM, and the lower current moves towards the BS. The speeds of layers throughout the depth display remarkable changes over time with different seasons. Due to the TSSA cartographic form, there appear to be differences in the direction and intensity of the current. From the beginning of the 1980s, technically talented scientists made efficient studies that approached very close the issues of the Turkish Straits. Lots of examples like Çeçen et al. (1981) and Bayazıt and Sümer (1982) accomplished new perspectives, containing formulations. It has not been studied extensively yet because of the insufficient sampling of the Mediterranean water coming into the BS, the strait of İstanbul (Bosphorus) opening to the BS topographically. Tolmazin (1985), Latif et al. (1991), and Yuce et al. (1996) both have accurate descriptions of the operation of İstanbul. Also, first fluxes through results studies presented by Ünlüata et al. (1990). Marine sciences (hydrography and oceanographic data details) related to the SOM have been studied by many researchers, such as Beşiktepe et al. (1994). After all, the flow and the underlying physics have been highlighted by Ünlüata et al. (1990); Gregg et al. (1999); Özsoy et al. (2001); Gregg and Özsoy (2002). Some short reviews on the Turkish Straits and its role in coupling two more (some places three) extensive layers have been provided by Beşiktepe et al. (1993, 1994, and 2000) also Schroeder et al. (2012). From Demyshev and Dovgaya (2007), The dynamics of the Turkish Straits attracted not only considerable attention but also literature on the numerical modeling of the general sea circulation of the SoM Also, it is nearly absent and significantly idealised. Chiggiato et al. (2012) mentioned that the Turkish Straits System TSS 2008" and "TSS 2009 projects and also international scientific programs were carried out under the coordination of the NATO Undersea Research Centre (NURC) and the Naval Research Laboratory (NRL) from August 2008 to March 2009. The project name was Project "Exchange Processes in Ocean Straits. The Strait's sea was extensively sampled with several instruments' deployments, Conductivity/Temperature/ Depth (CTD) rosette, Acoustic Doppler Current Profilers (ADCPs), surface Lagrangian type drifters, current meter moorings hydrographic, oceanographic and meteorological observations. Some other details, such as the straits' influence on the BS and the Mediterranean Sea-MS, can be presented by Özsoy and Ünlüata (1997, 1998) and also Jordà et al. (2016). Some other pieces of information based on entire studies of the İstanbul Strait issues can be presented by Ünlüata et al. (1990), Latif et al. (1991), Özsoy et al. (1995, 1996, 1998, 2001), Gregg et al. (1999), Gregg and Özsoy (1999, 2002), and the other valuable works by Jarosz et al. (2011, 2011 a,b, 2012, 2013). From İstanbul Strait's measurements are the central geographical and geometrical constrictions in the flow path where strictly hydraulic controls are provided (Latif et al. 1990, Dorrell et al. 2016) and provided and verified by model results (Sözer 2013; Sözer and Özsoy 2016). Farmer and Armi (1986) predicted that to be responsible for establishing a maximal exchange regime. Also, some sub-maximal hydraulic control studies from (Latif et al. 1990; Ünlüata et al. 1990) where a single contraction at the subjects the flow in Canakkale Strait’s Nara Pass. Akten (2004) studied İstanbul Strait. With this study, currents and darkness are the two dominant factors causing marine casualties in the İstanbul Strait. Sözer and Özsoy (2002) also studied the İstanbul Strait about the exchange flow based on the S-Coordinates Rutgers University Model, a 3D ocean model. The Strait was studied concerning open boundary conditions and mixing parameters under idealised geometrical, hydrographical, and oceanographical conditions.

1. Overview of the Turkish Strait Sea Area

Turkey has a considerable Turkish Straits Sea Area. Furthermore, they are a great waterway that linked the continents (Asia and Europe). TSSA consists of the Strait of İstanbul-SOI, the Sea of Marmara-SOM, and the Strait of the Canakkale-SOC. By the SoM, one of the TSSA components, the Aegean Sea from the south and the BS from the north are united. The Turkish Straits have been influential in geography, strategy, and geopolitics throughout history. The critical reason for TSSA's sea being the only trade and transportation route between the Mediterranean-MS and the BS is its strategic situation. In the Turkish Straits, since 1936, all maritime countries in the world have known and accepted the validity of the Montreux Convention (Usluer et.al. 2016). The term Turkish Straits, first used in the 1923 Lausanne Straits Convention, was still used in the 1936 Montreux Convention. The Montreux Convention guarantees the freedom of sea transportation from the BS to the AS and the MS to prevent the passage of all civilian ships in peacetime and naval vessels that have no shore to the BS in wartime. As a result of this usage, although the SoM is also used in transit and innocent passage through the Turkish Straits, İstanbul has not changed the legal, political, and strategic existence and meaning of TSSA (Pazarcı, 2015).

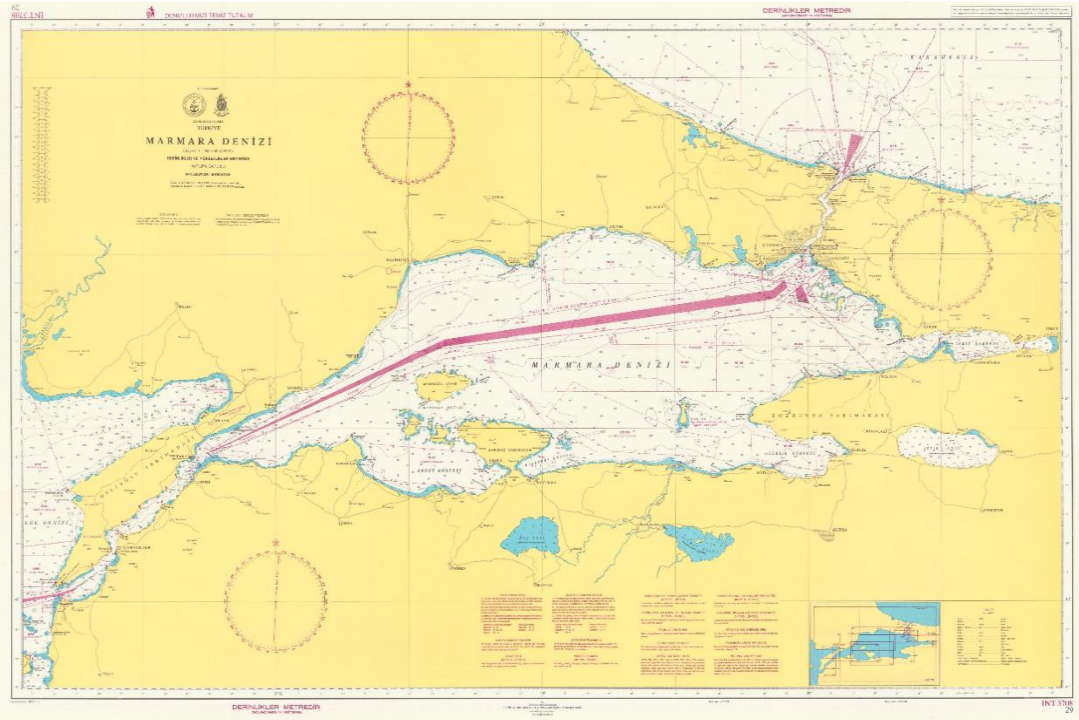

Figure 2. Turkish Strait Sea Area Overview TR 29 Paper Chart (Scanned original TN-ONHO Paper Chart).

Obligatory annual archive documents for Turkey and reports called 'Report Annual Sur le Mouvement des Navires a Travers Les Detroits Turcs' have been submitted to the United Nations Secretary-General since 1945, following the Montreux Convention, to be given to the High Contracting Parties. In the Third United Nations Geographical Names Standardization conference held in Athens in 1977, with 152 participants from 59 countries, the expression Turkish Straits was used, and without 11 governmental agreements and global observers were present. The conference's main subject that was authorized to follow the term Turkish Straits, is to standardize the names of the geographical formation. In this way, nations will be able to be named nationally in their geographies (UN, 1979). Turkish Straits, which is used as the title of the document in question, is a national determination and the validation of international credibility and recognition and proof of its international credibility. In addition, the status of the Straits in recent years has become the most important sea route for world energy transportation, oil, and transportation of products. The Straits have also led to conflicts with countries that have a coast to the BS or no coastline/shoreline but have political, economic, and strategic interests due to the gains of the geography they have been in throughout the recorded history. It divides the land area of the Turkish state into two, the Asian and European sides in the continental sense. And also it is a legal theme in terms of its territorial integrity and independence. The following words of Titulescu, who represented Romania at the 1936 Montreux Conference, made it possible for a foreigner to express the importance of the straits globally; "The TSSA is the heart of Turkish Republic but also the lungs of North countries of Blacksea."

1.1. The Strait of İstanbul

The Turkish Straits have importance as an oil transportation route from the Caspian Sea via the Mediterranean to the ocean area. That is why the area has great importance for energy transportation (Usluer, 2021). Turkey, geographically, is a country where four seasons are experienced, and their effects are seen. The Turkish Straits are in a natural valley structure. It slopes from the BS to the SoM. Due to the chemical properties of the water coming from the BS, the upper layer forms the water column where the current is felt the most. One of the most critical issues that will affect safe navigation is the effect of the current on the ship. At the same time, the presence of fog due to the meteorological impacts will affect the safety of navigation again. Although there are difficulties during the passage, considering the morphology of the Straits and the flow dynamics of the water, which is in a natural valley structure, the İstanbul voyage statistics of official records show that 41,112 ships in 2019, 38,404 ships in 2020, and 38,551 ships in 2021.

1.2. The Strait of Çanakkale

The 37 nautical miles part of the 164 nautical miles length forms the Canakkale Strait. Gökaşan et al. (2008) showed an article that the Strait of Çanakkale has an envelopment shape subdivided into three morphological regions. Moreover, they pointed to marine science effects on the strait, and statistics from the Ministry of Transport and Infrastructure show that 43.759 ships in 2019, 42.036 ships in 2020, and 43.342 ships used the Strait of Canakkale in 2021.

2. The Reason for the Study

As it is well known, there are different surface and subsurface currents that have been observed at different depths in the Turkish Straits Sea Area. Many types of research made by official institutions before. But one of the last and most important research was carried out by the Turkish Navy, Office of Navigation, Hydrography, and Oceanography-TN-ONHO. Research conducted between 2005 and 2007 was officially published by Oceanographic Atlas Books in 2009. This Atlas Book has been examined in different seasons and depths, and it shows the different effects of currents at different depths. Many collisions had been occurred at the İstanbul Strait due to many reasons. An important one of them is the current sea regime also. The current regime can also affect ship movement. The main questions are '' If possible, can we predict current before navigation? And ''If yes, Can we use all these parameters about predictions for navigation safety?''. The straits connect the continents of Asia and Europe and link the Black and the Aegean Seas. Thus, it makes an outstanding contribution to national and international maritime transport. Maritime traffic density of the Turkish Straits, which has increased over the years, has attracted attention towards the end of the 20th century. While only 4,500 ships passed through the Strait of İstanbul (Bosphorus) in 1936, it reached 24,000 in 1985, 46,954 in 1995, and 48,079 in 2000 (Taşlıgil, 2004).

Table 1. Number and capacity of Vessels passing through the Strait of Istanbul between 2006 and 2021.

Years	Number of Vessels	Total Gross Tonnage	LOA longer than 200 mt.
2006	54.880	475.796.880	3.653
2007	56.606	484.867.696	3.653
2008	54.396	515.639.614	3.911
2009	51.422	514.656.446	3.871
2010	50.871	505.615.881	3.623
2011	49.798	523.543.509	3.800
2012	48.329	550.526.579	3.866
2013	46.532	551.771.780	3.801
2014	45.529	582.468.334	4.295
2015	43.544	565.216.784	3.930
2016	42.553	565.282.287	3.873

2017	42.978	599.324.748	4.005
2018	41.103	613.088.166	4.106
2019	41.112	638.892.062	4.400
2020	38.404	619.758.776	4.952
2021	38.551	631.920.375	5306

2.1. Selected Sample Area Information of the Strait of İstanbul

The area between Bebek and Kandilli position and the area coordinates between 41-04.45 N & 29-02.85 E and 41-04.75 N & 29-03.35 E, were examined according to the Oceanographic Atlas, and its survey data from winter 2005 to summer 2007 (Usluer, 2016).

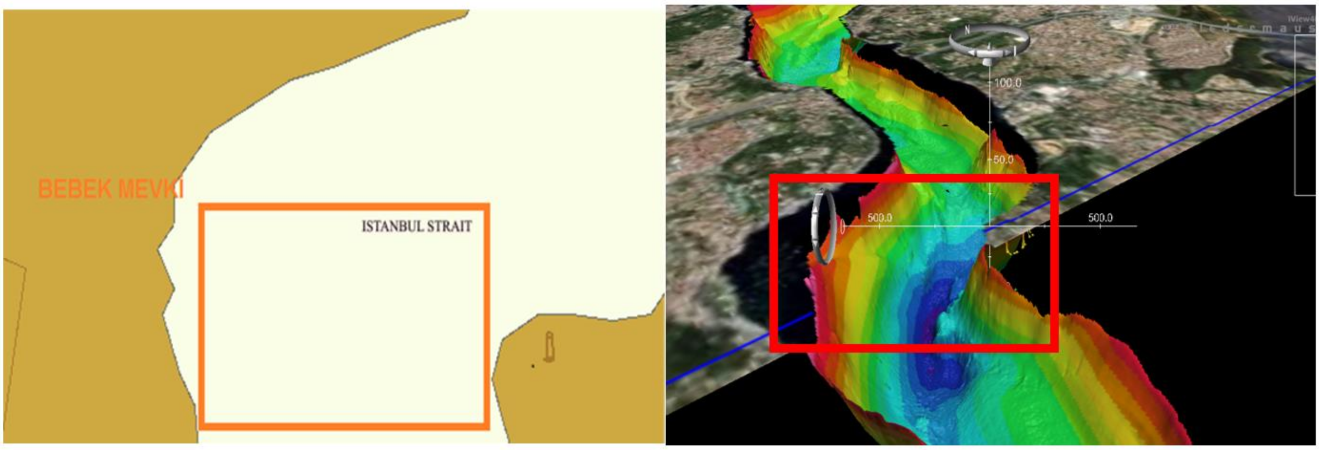

Figure 3. Selected Area 2D/3D screens between Bebek and Kandilli (Usluer, 2016).

Table 2. Important collision at the Strait of Istanbul

Year	Vessel Name	Collision Point	Effects of accidents
1960	World Harmony vs. Peter Zoranic	Kanlıca	Collision, fire 18.000 tons spilled
1964	Norborn vs. Peter Zoranic's Wreck	Kanlıca	Crush, fire tons of spilled
1966	Lutks vs. Kda ransky Oktiabr	Kız Kulesi	Collision, fire 1850 tons spilled
1970	Ancona crushed coastline	Rumelihisarı	Collision, fire 53.000 tons spilled
1979	Independentia vs. Evriali	Haydarpaşa	Collision, fire 94.600 tons spilled
1980	Nordic Faith vs. Stavanda		Collision, fire
1988	Bluestar vs. Gaziantep	Ahırkapı	Collision, 1.000 tons spilled
1990	Jambur vs. Da Tung Shan	Sarıyer	Collision, 2.600 tons spilled

1991	Madonna Lilly vs. Rabunion 18	Kanlıca	Collision, 20.000 animals drowned
1994	Nassia	Blacksea entrance	Collision, 30.000 tons spilled, fired
2002	Gottia	Bebek	Collision, 30.000 tons spilled

Table 3. Selected studies about Marine Accidents and oil spills in the Strait of İstanbul

Year	Studies
2003	Oil Transport in the Turkish Straits System: A Simulation of Contamination in the Istanbul Strait. (Örs)
2006	Finding risky areas for oil spillage after tanker accidents at Istanbul strait. (Başar et al.)
2007	Ship-Originated Pollution in the Istanbul Strait (Bosphorus) and Marmara Sea. (Doğan et al.)
2007	The Case Studies for Oil Spill Simulation in Istanbul Strait. (Can et.al.)
2008	Studies of marine chemical pollution at Turkish Straits and Sea of Marmara. (İncaz et.al.)
2009	Environmental effects of maritime traffic on the İstanbul Strait. (Birpınar et al.)
2015	The analysis of life safety and economic loss in marine accidents occurring in the Turkish Straits. (Uğurlu et al.)
2015	Marine accident analysis for collision and grounding in oil tanker using FTA method. (Uğurlu et al.)
2018	Potential impacts of oil spill damage around the planned oil rigs at the Black Sea. (Başar et.al.)
2018	Application of MARPOL Related with oil spill in Turkey. (Akyüz et al.)
2021	Modeling of possible tanker accident oil spills in the Istanbul Strait in order to demonstrate the dispersion and toxic effects of oil pollution. (Yıldız et.al.)

METHODS AND MATERIALS:

This study measured the Turkish Straits System or Sea Area’s data by the Turkish Navy, Office of Navigation, Hydrography, and Oceanography. The following Table 4 also includes summer season values. The tables below provide characteristic information for the same region and the same season (Atlas,2009).

Table 4. 2005 (Left side) and 2006 (Right Side) Summer Seasons Data

BEBEK - KANDILLI SURFACE CURRENT TABLE 0-10 METERS			
LAT	LONG	DIRECTION	CURRENT
41-04,75	29-02,85	23.34	2.4 KNOTS
41-04,75	29-02,9	68.20	2.4 KNOTS
41-04,75	29-02,95	34.19	2.4 KNOTS
41-04,75	29-03,0	228.26	2.4 KNOTS
41-04,75	29-03,05	250.04	2.4 KNOTS
41-04,75	29-03,1	252.00	2.4 KNOTS
41-04,75	29-03,15	245.51	2.8 KNOTS
41-04,75	29-03,2	250	2.8 KNOTS
41-04,75	29-3,25	242	2.8 KNOTS
41-04,75	29-03,3	223.06	2.8 KNOTS
41-04,75	29-3,35	248.11	2.8 KNOTS
41-04,7	29-02,85	297.18	2.4 KNOTS
41-04,7	29-02,9	282.20	2.4 KNOTS
41-04,7	29-02,95	210.21	2.4 KNOTS
41-04,7	29-03,0	205.53	2.4 KNOTS
41-04,7	29-03,05	235.39	2.4 KNOTS
41-04,7	29-03,1	55.45	2.4 KNOTS
41-04,7	29-03,15	45.51	2.4 KNOTS
41-04,7	29-03,2	243.51	2.6 KNOTS
41-04,7	29-3,25	244.52	2.6 KNOTS
41-04,7	29-03,3	240.33	2.8 KNOTS
41-04,7	29-3,35	246.17	2.8 KNOTS
41-04,65	29-02,85	33.01	2.4 KNOTS
41-04,65	29-02,9	35.01	2.4 KNOTS
41-04,65	29-02,95	35.13	2.4 KNOTS
41-04,65	29-03,0	246.02	2.8 KNOTS
41-04,65	29-03,05	244.47	2.8 KNOTS
41-04,65	29-03,1	240	2.8 KNOTS
41-04,65	29-03,15	240.04	2.8 KNOTS
41-04,65	29-03,2	249.57	2.8 KNOTS
41-04,65	29-3,25	253.44	2.8 KNOTS
41-04,65	29-03,3	240.46	2.8 KNOTS
41-04,65	29-3,35	251.44	2.8 KNOTS
41-04,6	29-02,85	17.25	2.4 KNOTS
41-04,6	29-02,9	355.21	2.4 KNOTS
41-04,6	29-02,95	24.02	2.4 KNOTS
41-04,6	29-03,0	244.44	2.8 KNOTS
41-04,6	29-03,05	232.40	2.8 KNOTS
41-04,6	29-03,1	250.52	2.8 KNOTS
41-04,6	29-03,15	252.36	3.0 KNOTS
41-04,6	29-03,2	248.41	3.0 KNOTS
41-04,6	29-3,25	255.11	3.0 KNOTS
41-04,6	29-03,3	244.24	3.0 KNOTS
41-04,6	29-3,35	252.21	3.0 KNOTS
41-04,55	29-02,85	317.59	2.8 KNOTS
41-04,55	29-02,9	281.52	2.8 KNOTS
41-04,55	29-02,95	329.15	2.8 KNOTS
41-04,55	29-03,0	251.02	2.8 KNOTS
41-04,55	29-03,05	240.47	2.8 KNOTS
41-04,55	29-03,1	247.04	2.8 KNOTS
41-04,55	29-03,15	245.18	2.8 KNOTS
41-04,55	29-03,2	232.32	2.8 KNOTS
41-04,55	29-3,25	248.16	2.8 KNOTS
41-04,55	29-03,3	248.55	2.8 KNOTS
41-04,55	29-3,35	250.35	2.8 KNOTS
41-04,5	29-02,85	276.02	2.8 KNOTS
41-04,5	29-02,9	232.29	2.8 KNOTS
41-04,5	29-02,95	235.50	2.8 KNOTS
41-04,5	29-03,0	227.52	2.8 KNOTS
41-04,5	29-03,05	227.13	2.8 KNOTS
41-04,5	29-03,1	231.07	2.8 KNOTS
41-04,5	29-03,15	237.49	2.8 KNOTS
41-04,5	29-03,2	245.30	2.8 KNOTS
41-04,5	29-3,25	239.34	2.8 KNOTS
41-04,5	29-03,3	240.01	2.8 KNOTS
41-04,5	29-3,35	240.50	2.8 KNOTS
41-04,45	29-02,85	11.21	2.8 KNOTS
41-04,45	29-02,9	335.34	2.8 KNOTS
41-04,45	29-02,95	338.13	2.8 KNOTS
41-04,45	29-03,0	216.24	2.8 KNOTS
41-04,45	29-03,05	225.32	2.8 KNOTS
41-04,45	29-03,1	228.25	2.8 KNOTS
41-04,45	29-03,15	217.52	2.8 KNOTS
41-04,45	29-03,2	222.54	2.8 KNOTS
41-04,45	29-3,25	198.58	2.8 KNOTS
41-04,45	29-03,3	220.39	2.8 KNOTS
41-04,45	29-3,35	209.08	2.8 KNOTS

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41-04,65	29-03,3	240.46	2.8 KNOTS
41-04,65	29-3,35	251.44	2.8 KNOTS
41-04,6	29-02,85	17.25	2.0 KNOTS
41-04,6	29-02,9	355.21	2.0 KNOTS
41-04,6	29-02,95	24.02	2.4 KNOTS
41-04,6	29-03,0	244.44	2.4 KNOTS
41-04,6	29-03,05	232.40	2.4 KNOTS
41-04,6	29-03,1	250.52	2.8 KNOTS
41-04,6	29-03,15	252.36	2.8 KNOTS
41-04,6	29-03,2	248.41	2.8 KNOTS
41-04,6	29-3,25	255.11	2.8 KNOTS
41-04,6	29-03,3	244.24	2.8 KNOTS
41-04,6	29-3,35	252.21	2.8 KNOTS
41-04,55	29-02,85	317.59	2.0 KNOTS
41-04,55	29-02,9	281.52	2.0 KNOTS
41-04,55	29-02,95	329.15	2.4 KNOTS
41-04,55	29-03,0	251.02	2.4 KNOTS
41-04,55	29-03,05	240.47	2.4 KNOTS
41-04,55	29-03,1	247.04	2.8 KNOTS
41-04,55	29-03,15	245.18	2.8 KNOTS
41-04,55	29-03,2	232.32	2.8 KNOTS
41-04,55	29-3,25	248.16	2.8 KNOTS
41-04,55	29-03,3	248.55	2.8 KNOTS
41-04,55	29-3,35	250.35	2.8 KNOTS
41-04,5	29-02,85	276.02	2.0 KNOTS
41-04,5	29-02,9	232.29	2.0 KNOTS
41-04,5	29-02,95	235.50	2.4 KNOTS
41-04,5	29-03,0	227.52	2.4 KNOTS
41-04,5	29-03,05	227.13	2.4 KNOTS
41-04,5	29-03,1	231.07	2.8 KNOTS
41-04,5	29-03,15	237.49	2.8 KNOTS
41-04,5	29-03,2	245.30	2.8 KNOTS
41-04,5	29-3,25	239.34	2.8 KNOTS
41-04,5	29-03,3	240.01	2.8 KNOTS
41-04,5	29-3,35	240.50	2.8 KNOTS
41-04,45	29-02,85	11.21	2.0 KNOTS
41-04,45	29-02,9	335.34	2.0 KNOTS
41-04,45	29-02,95	338.13	2.4 KNOTS
41-04,45	29-03,0	216.24	2.4 KNOTS
41-04,45	29-03,05	225.32	2.4 KNOTS
41-04,45	29-03,1	228.25	2.8 KNOTS
41-04,45	29-03,15	217.52	2.8 KNOTS
41-04,45	29-03,2	222.54	2.8 KNOTS
41-04,45	29-3,25	198.58	2.8 KNOTS
41-04,45	29-03,3	220.39	2.8 KNOTS
41-04,45	29-3,35	209.08	2.8 KNOTS

All data had been presented by Oceanographic Atlas in 2009 and measured the Turkish Strait Sea Area differently nine times in four seasons. Conductivity, Temperature, Depth- CTD, and Acoustic Doppler Current Profiler-ADCP were used for sampling. For sea currents measured by 300kHz RDI Broadband ADCP. The data were processed differently, but the best solutions came from MATLAB and sub-applications. This study includes linear regression from regression analysis and Least square fits. All surveyed data are obtained from several experiments. Three different depth areas, which had been selected from 0-10 meters, 10-20 meters, and 20-30 meters, were examined separately during 2005's summer season. There was a matrix that had been customized 7x11 status was examined. In this area, each matrix was applied separately to depths of 0-10 meters, depths of 10-20 meters, and depths of 20-30 meters. In this study, trying to work with prediction analytics from data mining. It was also emphasized that the data surveyed had been repeated three times in the same season, taking into consideration the availability of more used and reliable results and the acquisition of archival features. (Usluer,2016)

Furthermore, they contain a significant amount of random noise caused by measurement errors from the survey circumstances. The main intention of curve fitting is to find a smooth curve that fits all the data possible on points called on the average level. The resulting curve should have a simple form like a low-order polynomial. Furthermore, curve values do not reproduce the noise. Formula with math is like ;f (a) = f (a;b0, b1, . . . , bm). The formula is great and simple. Moreover, it has the function that is to be fitted to the *n* + 1 surveyed data points (xi,yi), i = 0, 1, . . . , n. The notation implies that we have a function of symbol a that contains m+ 1 variable parameters b0, b1, . . . , bm, where m < *n.* The form of f (a) is determined beforehand, usually from the theory associated with the experiment from which the data are obtained. The method means of adjusting the fit are all parameters, which include. Fitting a straight line is the primary helpful way for a solution. Furthermore, the best way to find fitting a straight line is known as regression analysis. Regression analysis is a statistical tool for the investigation of relationships between variables, and also, Regression analysis is the method of analysis used to measure the relationship between two or more data. Now, try to know how the relative relationship between the two variables is calculated; moreover, if possible, we can develop a regression equation to forecast or predict the expected and desired variable. Basically formula is f (x) = a +bx or y = bx+a. The symbol y is the value that, trying to forecast, the "b" is the slope of the regression, the "x" is the value of our independent value, and the "a" represents the y-intercept. A linear regression analysis depends on two values with a dependent and an independent variable. It is called Simple Linear Regression. The established regression model is tried to be calculated using the observed values taken as an example of the problem of interest. The values expected from that model, for this reason, will be estimated values. The sum of the squares of the differences between the actual Y values and the estimated Y values using the Least Squares method is minimized to obtain the closest results to the actual coefficients, which are developed for the calculation of the estimated coefficients and variables. Mathematically goal is to obtain the smallest value of ε (error term) in the equation $Y = \alpha + \beta X + \varepsilon$. f (x) = a +bx or y = bx+a formula is also shows fitting straight line.

The formula can show minimized like below,

$$\mathbf{S(a, b) = \sum_{i=0}^{n} [yi - f(xi)]^2 \text{ and; } = \sum_{i=0}^{n} [yi - a - bxi]^2.}$$

The method means of adjusting the fit are all parameters, which include. Fitting a straight line is the primary helpful way for a solution. Furthermore, the best way to find fitting a straight line is known as regression analysis. Linear regression analysis is the most commonly used method of statistical science and, therefore, scientific articles. It is used to estimate what kind of a random or more variable we have in our studies concerning the dependent variable. This measurement means, in a sense, the magnitude of the relationship between the variable and the behavior. As mentioned earlier, this analysis can be done using a single variable or multiple variables. The other variables are kept constant in the studies using more than one variable (Ceteris Paribus Method). The coefficients are used when expressing the variables associated with the independent variables with a value. In the analysis, these coefficients are shown as linear regression coefficients, and the linear regression coefficient shows us the magnitude of loyalty. The linear regression analysis examples exist in the following to see how to use this brief information in research.

The model used in the study is Linear Regression and Least Squares Method. Linear regression analysis is to create a model that predicts the variable to be determined based on the variable or variables that can be detected more easily or earlier than the variable to be determined.

1. *Regression analysis* is an analysis method used to measure the relationship between two or more variables. If the analysis is done using a single variable, it is called univariate regression; if more than one variable is used, it is called multivariate regression analysis. With the regression analysis, information can be obtained about the existence of the relationship between the variables and, if there is, the strength of this relationship (Ferraro & Giordani 2013).
2. Linear regression analysis with one dependent and one independent variable is called Simple Linear Regression. The established regression model is tried to be calculated by using the observation values taken as an example related to the problem of interest. (D'Urso & Massari,2013). Therefore, the models we set up will be estimated values. Linear Regression, in other words, Least Squares Method, is a process to determine the best fit and best fit line for data points. A simple calculation and linear mathematical equations are used for its proof. The simple problem is used to find the straight line y=a+bx that best fits the data pairs (Xn, Yn), n{1,….., N}.
3. The Least Squares method was developed to calculate the estimated coefficients and variables and obtain the closest results to the actual coefficients; the sum of the squares of the difference between the absolute Y values and the estimated Y values is minimized. Mathematically, our goal is to ensure that the ε (error term) in the equation Y=α+βX+ε gets the smallest value (Chachi,2019).

	1	2	3	4	5	6	7	8	9	10	11
1	1.8000	2	1.8000	2	2	1.8000	2	2	2	2	2
2	1.8000	2	2.4000	2.2000	1.8000	1.8000	1.6000	2	1.6000	1.6000	1.6000
3	2	2	2	1.8000	2	2	2	1.8000	1.8000	2.1000	2
4	1.6000	1.6000	1.8000	1.8000	2	2.1000	1.8000	1.8000	1.8000	1.6000	2
5	1.8000	2	1.6000	2.1000	2	2.2000	1.8000	2	1.6000	1.8000	2
6	2.2000	2.4000	2.2000	2.4000	2.4000	2	2.2000	1.8000	2	2	1.6000
7	2	1.8000	1.8000	2.4000	2.4000	2.4000	2	2	2.2000	2.2000	2
8											
9											
10											
11											
12											

Figure 4. Least Square method data processing screen 1

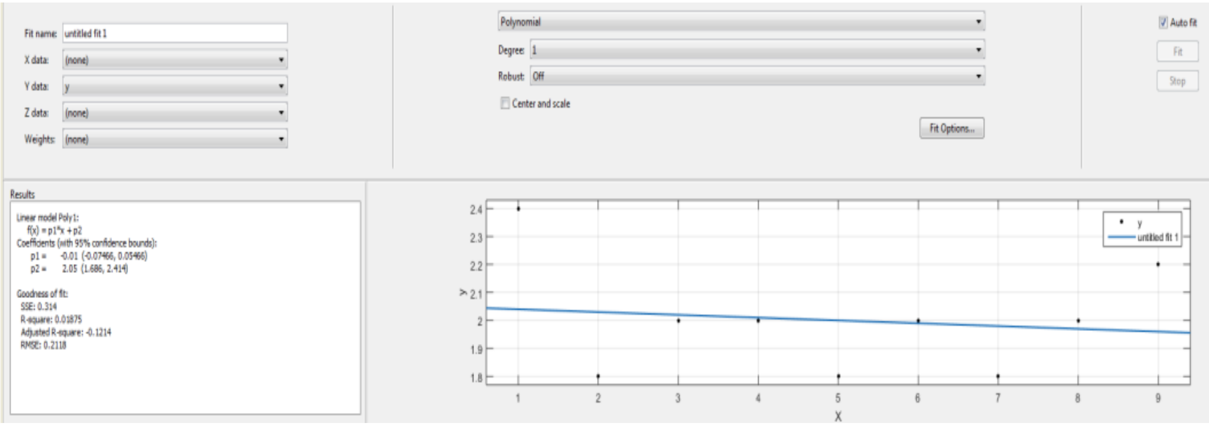

Figure 5. Least Square method data processing screen 2

```
Linear model Poly1:
    f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
      p1 =      -0.01  (-0.07466, 0.05466)
      p2 =       2.05  (1.686, 2.414)

Goodness of fit:
  SSE: 0.314
  R-square: 0.01875
  Adjusted R-square: -0.1214
  RMSE: 0.2118
```

Figure 6. MATLAB Prediction Analyse processing screen

CASE OF STUDY:

The Strait of Istanbul's common current direction and speed values are very different. The following scenarios have been applied to forecasting for the study, and the shapes found. Moreover, fluid performance suitable direction items to the vessels and sea dynamics movements were determined for the present region.

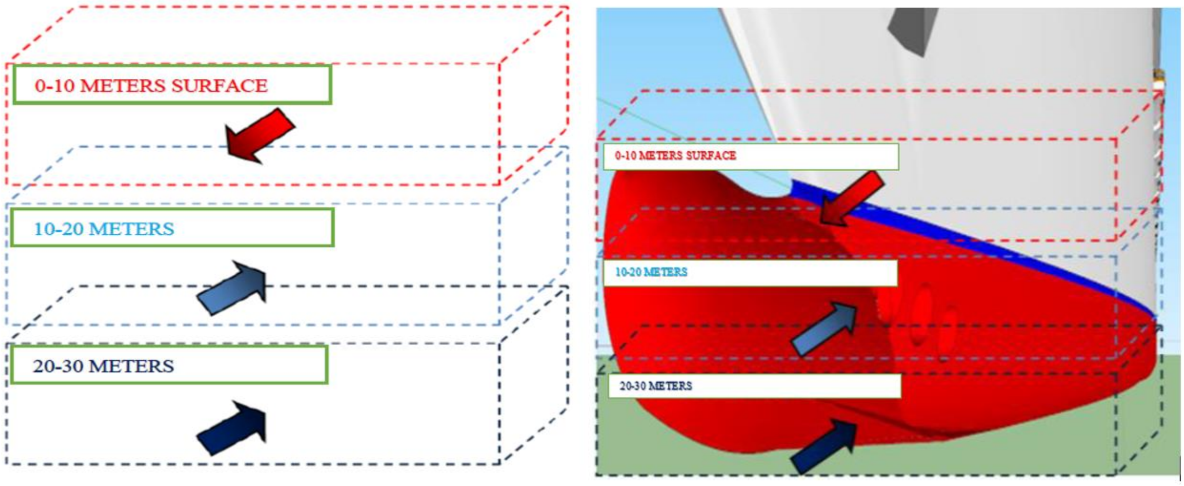

Figure 7. The direction of the water column at Istanbul Strait and effects on the vessel (Usluer, 2016).

According to the scenario;

1. The Vessel is 100 LOA which has a 7 meters draught and 7 Knots velocity,

2. The Vessel is 100 LOA which has a 12 meters draught and 7 Knots velocity,

3. The Vessel is 100 in LOA and has a 21 meters draught and 7 Knots velocity in the selected area.

A Vessel is moving from the Blacksea to the Sea of Marmara at a speed of 7 knots at a starting course of 201,06 ° starting from 41.0775 & 29.0533 was considered for a vessel moving from the Sea of Marmara to the Blacksea at a speed of 7 knots on the course of 21,06 °.

RESULTS:

Results and graphics are shown bellows. Graphics were calculated from the MATLAB program. All parameters and circumstances were examined separately at each depth level. Moreover, it shows the effects of the water, which include current direction and speed, high essential factors in the Vessel's movement while navigating on the Turkish Straits.

1. A vessel is 100 in LOA, with a 7 meters draught and 7 NM speed, navigating from The Blacksea to the SoM with a route of 201,06 ° at Fig 8.

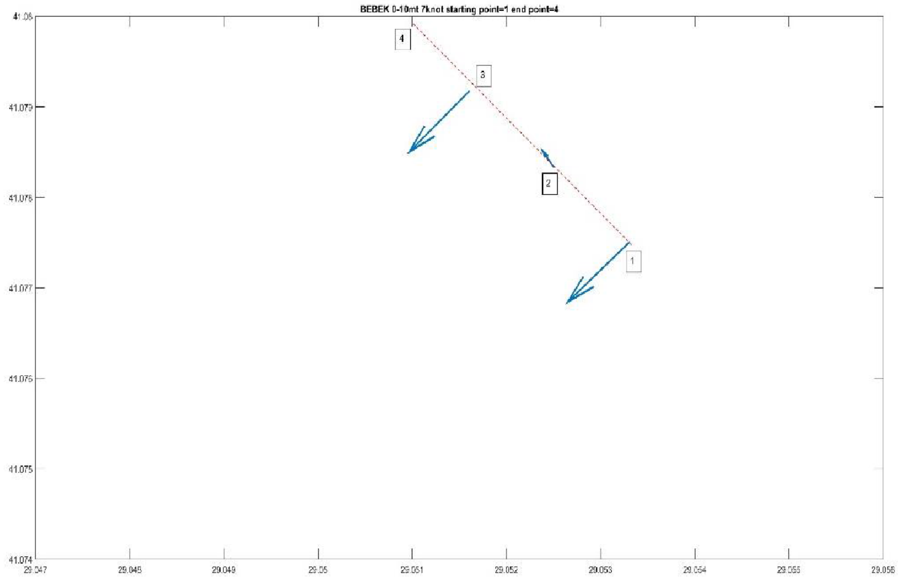

Figure 8. 0-10 meters current effect to the ship which is moving from Blacksea to the Sea of Marmara.

2. A Vessel is 100 in LOA, which has a 7 meters draught and 7 NM speed, navigating from the SoM to Blacksea with a route of 21,06 ° at Fig 9.

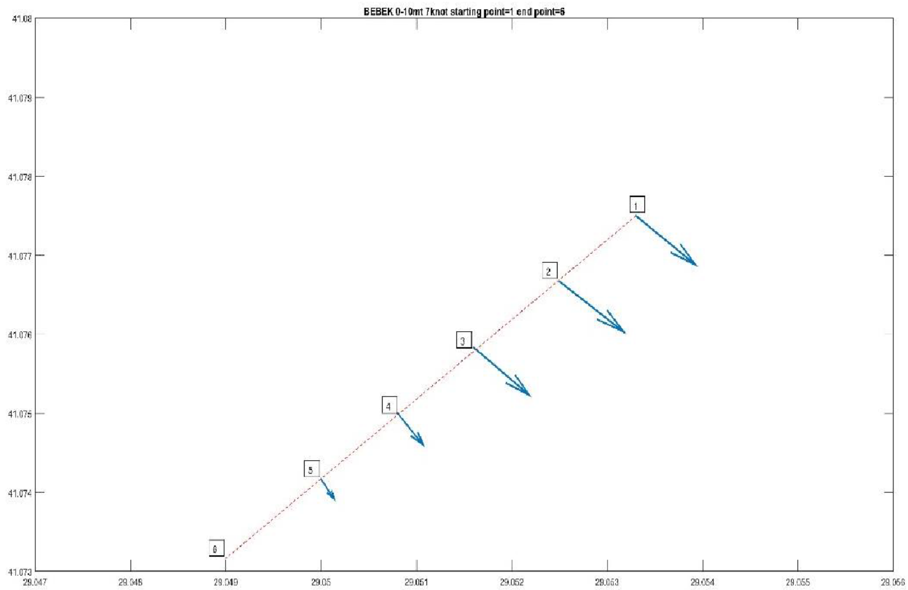

Figure 9. 0-10 meters current effect to the ship which is moving from the Sea of Marmara to the Blacksea.

3. A Vessel is 100 in LOA, with a 12 meters draught and 7 NM speed. Also, two different sea-level currents affect the vessel and navigation from Blacksea to the SoM with a route of 201,06 ° in Fig 10.

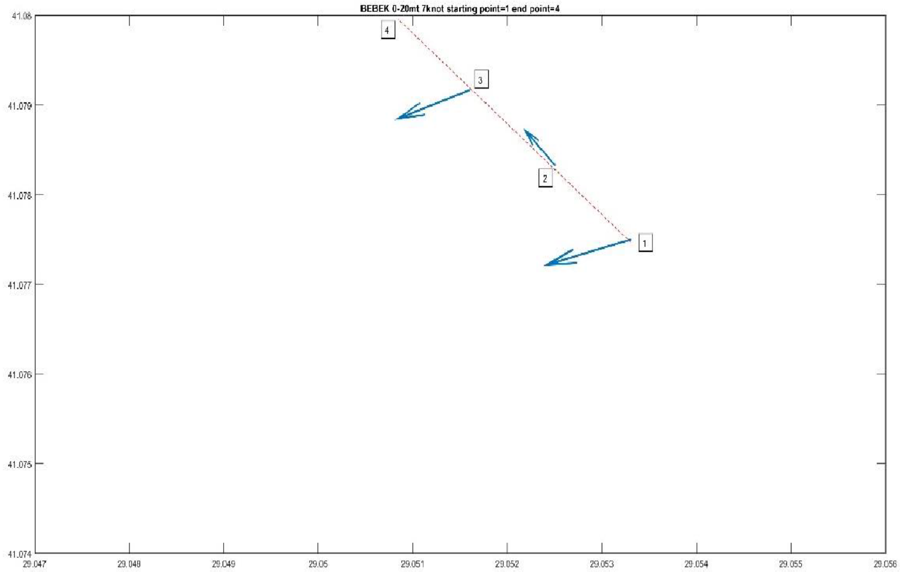

Figure 10.0-20 meters current effect to the ship which is moving from Blacksea to the Sea of Marmara.

4. A Vessel is 100 in LOA and has a 12 meters draught and 7 NM speed. Also, two different sea-level currents affect the Vessel and navigation from the SoM to Blacksea with a route of 21,06 ° in Fig 11.

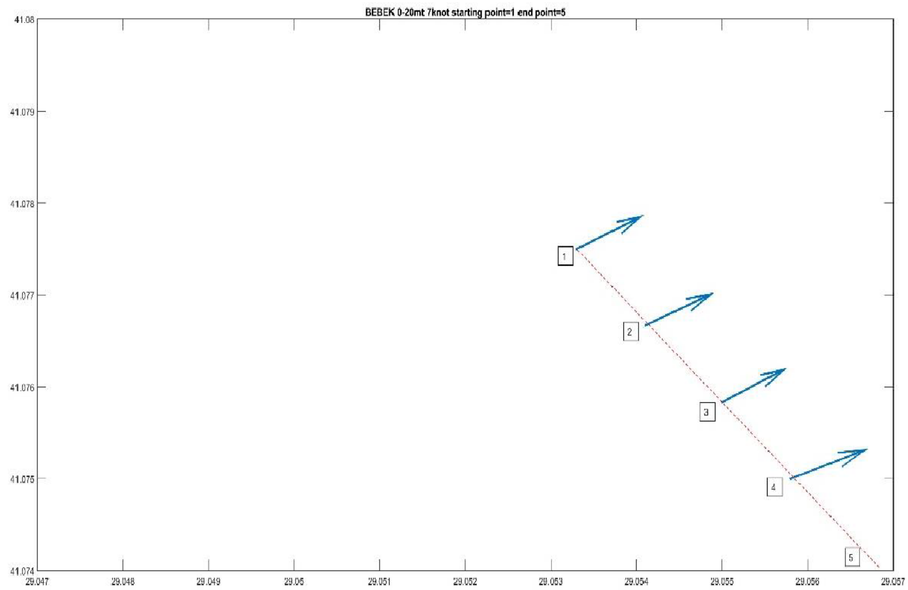

Figure 11. 0-20 meters current effect to the ship which is moving from the Sea of Marmara to the Blacksea.

5. A Vessel is 100 in LOA and has a 21 meters draught and 7 NM speed. Also, two different sea-level currents affect the Vessel and navigation from Blacksea to the SoM at a route of 201,06 ° Figure 12.

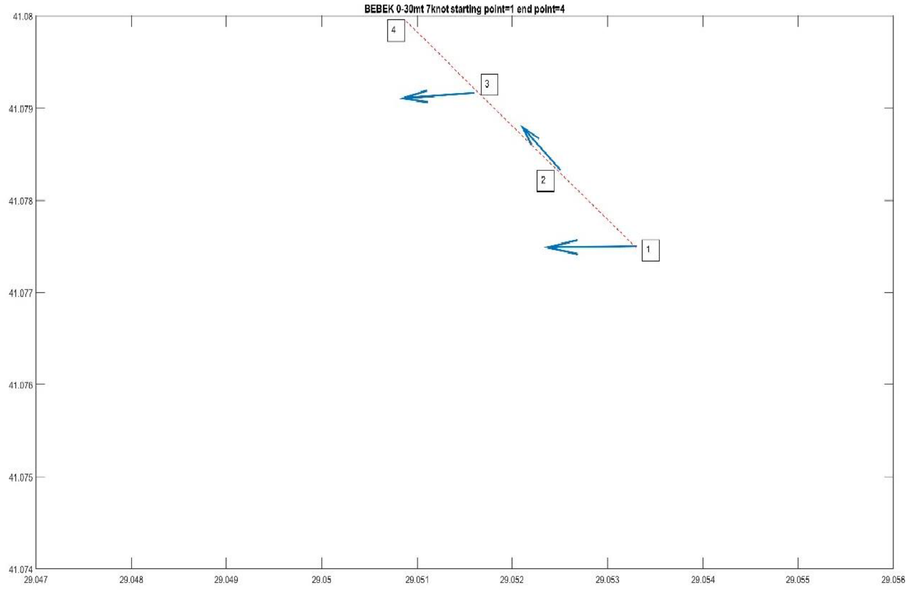

Figure 12. 0-30 meters current effect to the ship which is moving from Blacksea to the Sea of Marmara.

6. A Vessel is 100 in LOA, with a 21 meters draught and 7 NM speed. Also, two different sea-level currents affect the vessel and navigation from the Sea of Marmara to Blacksea with a route of 21,06 ° in Figure 13.

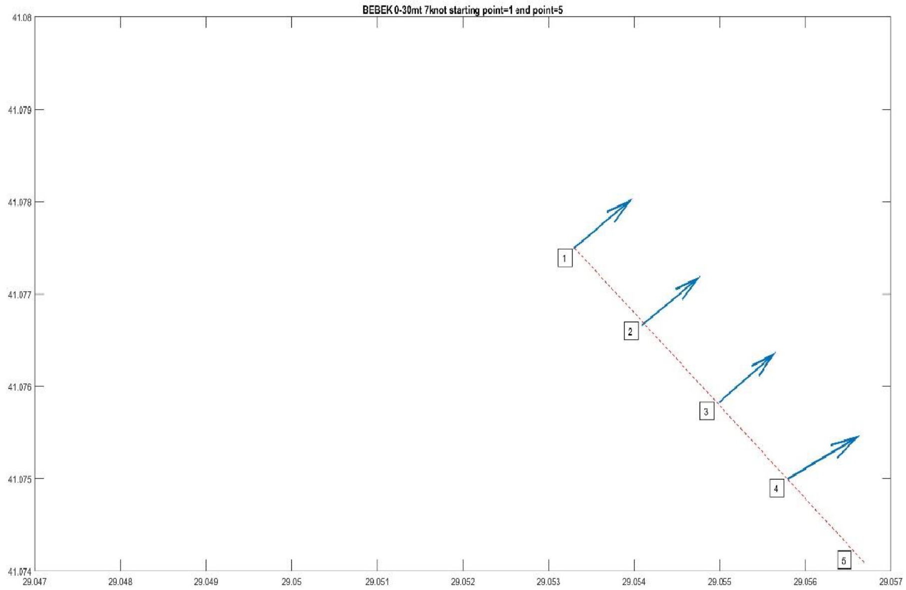

Figure 13. 0-30 meters current effect to the ship which is moving from the Sea of Marmara to the Blacksea.

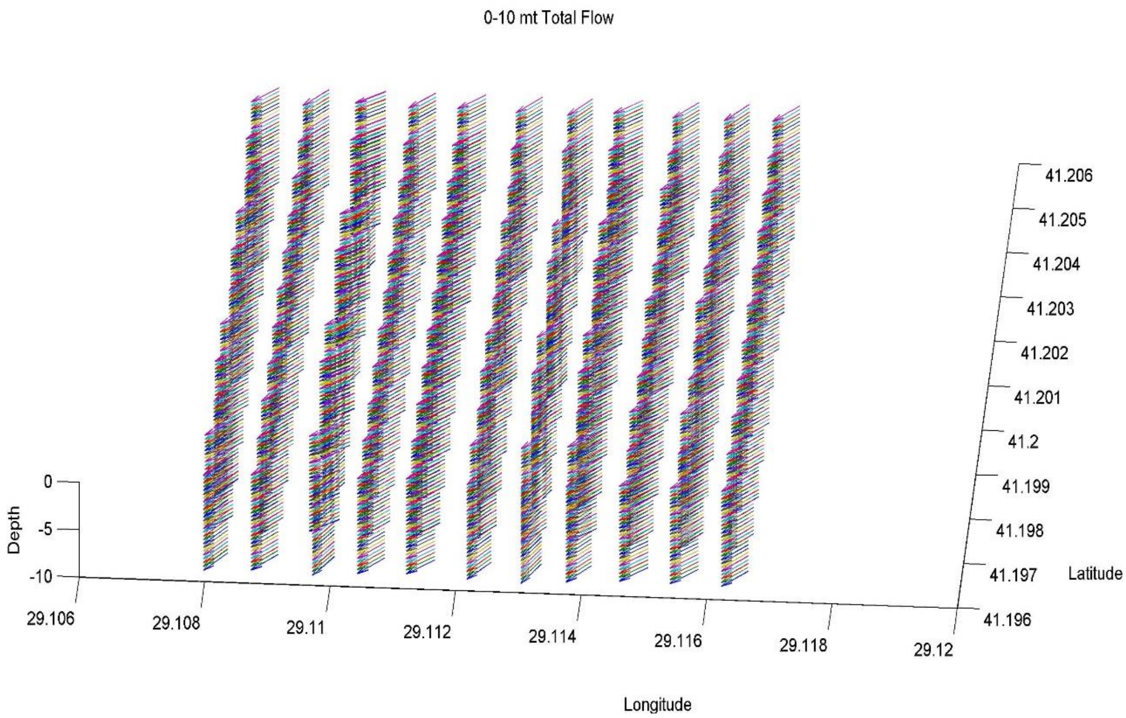

Figure 14. 0-10 mt flow diagram and vessel influence area

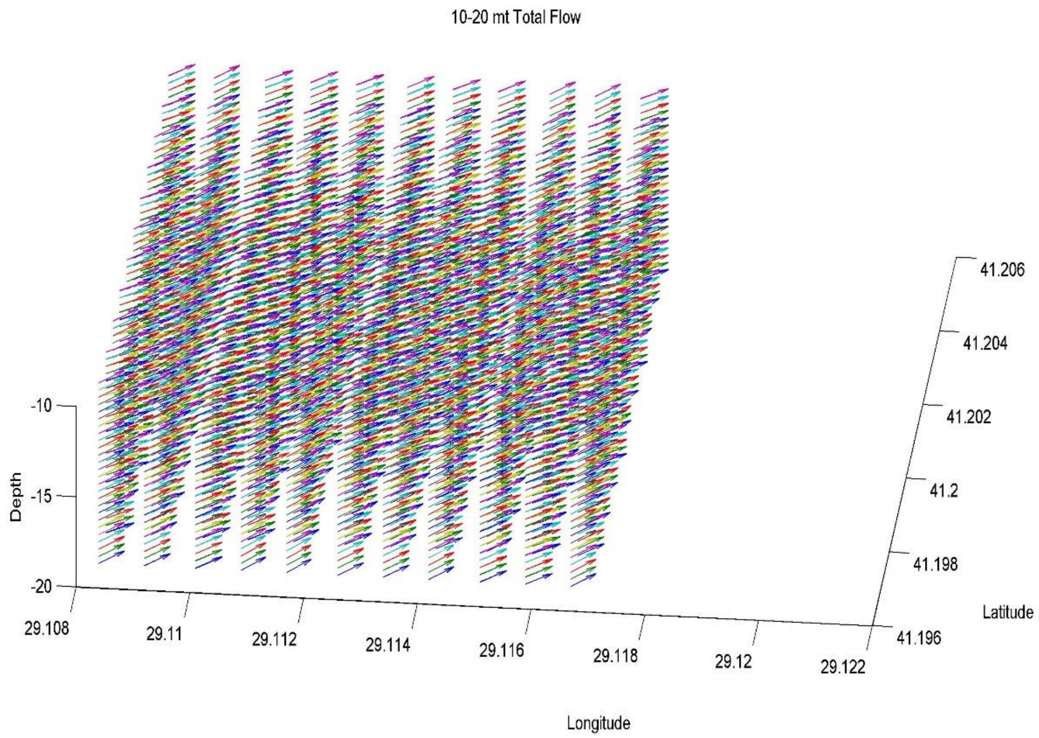

Figure 15. 10-20 mt flow diagram and vessel influence area

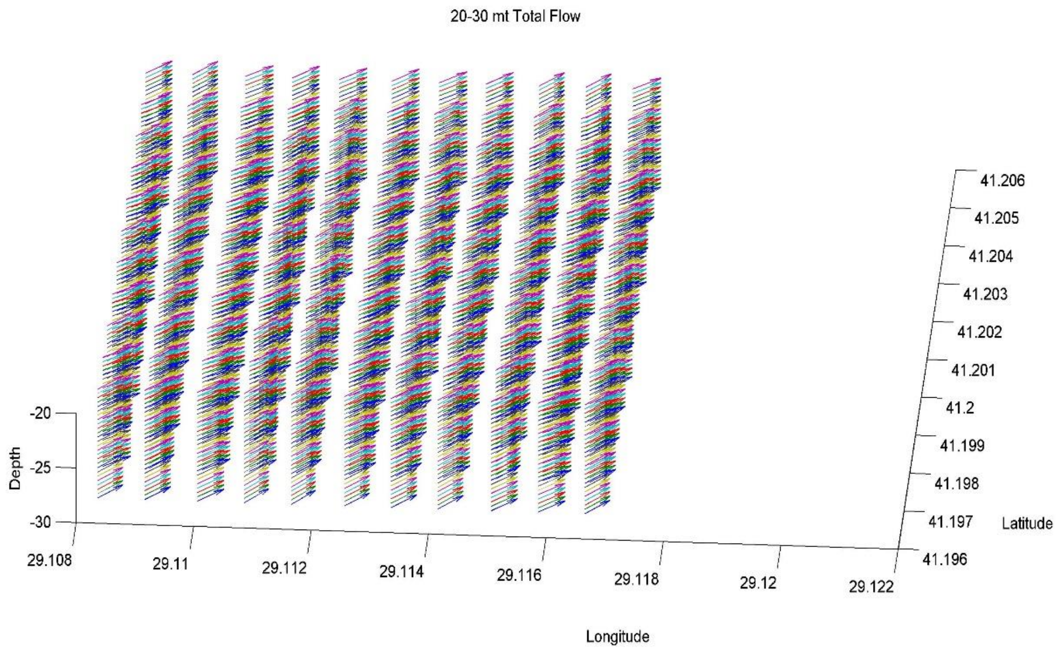

Figure 16. 20-30 mt flow diagram and vessel influence area

CONCLUSIONS:

The Turkish Straits Sea Area is significant because it is a bridge connecting the continents and the seas. Even if the number of passing ships decreases over the years, their tonnage and LOA's increase. Different water columns and flow directions have been determined because the Turkish Straits have a natural valley feature and the chemical differences between the Blacksea and the Sea of Marmara. This feature adversely affects the navigational safety of ships passing through the straits. As of 2018, although the tracking and measurement systems of the General Directorate of Coastal Safety are working, no system made continuous measurements before. Therefore, the high-precision estimation can be made with the predictive analytics method, which is used in the study with the data measured in the past and their comparisons in successive years.

The main questions of the study are "Can current and marine science parameters are measured or estimated before navigation, if possible?" if the answer is yes; "Can estimates be used for navigational safety?". As a result of the study, the estimations were at the level of accuracy with high precision. Therefore, the answer was yes. Seasonal currents have shown differences and can predict their effects on ships in the Turkish Straits. While it is possible to use all effects by combining all parameters for safe navigation, providing more helpful information about the safety of navigation to public authorities and all ships in the strait will help prevent accidents in the sea area with a very high probability of an accident.

Compliance with Ethical Standard

Conflict of Interests: The authors declare that for this article they have no actual, potential or perceived conflict of interests.

Ethics Committee Approval: Ethics committee approval is not required for this study.

Funding Disclosure: *The authors received no financial support for the research, authorship, and/or publication of this article.*

Acknowledgments: This article was produced from Hasan Bora USLUER's Ph.D. thesis which was supervised by Prof.Dr. Güler Bilen ALKAN and Prof.Dr. Osman TURAN titled "Investigation about benefits of effective using vessel traffic system-VTS at the Turkish Straits (Türk Boğazlarında Gemi Trafik Hizmetlerinin Etkin Faydalarının İncelenmesi)" written at Istanbul University, Engineering Faculty, Maritime Transportation and Management Engineering Department.

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