OIL SPILL ALONG THE TURKISH STRAITS SEA AREA; ACCIDENTS, ENVIRONMENTAL POLLUTION, SOCIO-ECONOMIC IMPACTS AND PROTECTION

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TURKISH MARINE RESEARCH FOUNDATION

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PREFACE

Oil spill and ship-originated pollution is one of the core issues for many years due to the importance of the protection of the world oceans and seas. Oil contamination from the ships and shores are not negligible amount as well.

Turkey, surrounded by four different seas, has experienced some major ship incidents, mainly in the Turkish Straits System, more particularly in the Istanbul Strait. You might freshly recall that thousands of tons of oil dispersed over the sea and some evaporated to atmosphere during the Independenta and Nassia incidents. That was also a real inferno for the local people.

It is already known that ecological catastrophes will continue for many years after the incidents. I remember that I was writing to Financial Times about this and it appeared in that renowned newspaper on 15 January 2004 like this: “Istanbul Strait is a place for refreshment, for drinking Turkish coffee, for fishing - not a dangerous oil tanker route”. After more than a decade, supertankers still thrill us in the Istanbul Strait with huge amount of oil in their tanks.

The idea of this book is to present how Turkish waters are under the threat of oil spills, even though several extra precautionary measures have been taken recently. In fact, Turkey has a longest coastline in the Mediterranean and Black Sea, which makes it more responsible to prevent any kind oil contamination.

I congratulate my colleagues, Dr. Selma ÜNLÜ and Dr. Bedri ALPAR, for their invaluable effort to compile and edit this very comprehensive book. Besides, I am very grateful to all the authors who contributed to this book with their effort, namely, their time and extended knowledge.

Fighting with pollution is not simple and detailed information is of utmost importance. I believe that this book will fill the gaps in knowledge necessary for preventing oil pollution in the Turkish Straits System.

Prof. Dr. Bayram ÖZTÜRK
Director, Turkish Marine Research Foundation (TÜDAV)

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CONTENTS

"The waves swam like the mountains in the froth of Bosphorus, often climbed up over the clouds and seemed to fill the boat. No one thought he could get away with it anymore. Because death was wandering over the ship and in the clouds, as if it says he came nearby. Even though the waves were so terrible, they would quickly become docile when a clever and experienced pilot keep the helm."

Rhodesian Apollonius

INTRODUCTION

The Turkish Straits Sea Area (TSSA) is a long water passage that is consisted of the Sea of Marmara, an inland sea within Turkey's borders, and two narrow straits connected to neighboring seas. With a strategic location between the Balkans and Anatolia, the Black Sea and the Mediterranean, and dominated by the continental climate, the region hosted many civilizations throughout the centuries. This makes the region among the busiest routes in the world, with sea traffic three times higher than that in the Suez Canal. The straits are the most difficult waterways to navigate, and witnessed many hazardous and important collisions and accidents throughout history. In addition, this area has vital roles as biological corridor and barrier among three distinctive marine realms. Therefore, the region is rather sensitive to damages of national and international maritime activities, which may cause severe environmental problems.

This book addresses several key questions on chapter basis, including historical accidents, background information on main dynamic restrictions, oil pollution, oil spill detection and clean-up recoveries, its impacts on biological communities, socio-economic aspects and subjects with the international agreements.

This book will help readers, public, local and governmental authorities gain a deeper understanding of the status of oil spill, mostly due to shipping accidents, and their related impacts along the TSSA, which needs precautionary measures to be protected.

CHAPTER 1

HISTORY OF ACCIDENTS AND REGULATIONS

This chapter underpins the history of the maritime accidents along the Turkish Straits Sea Area (TSSA), history of regulations, transition regimes, evaluation of the Montreux Convention and its effects. As the TSSA is a unique maritime route for the Black Sea riparian countries, it is particularly vital for the transportation of huge amount of goods. The total number of the cargo vessels and oil tankers passing through the Istanbul and Çanakkale Straits in 2017 was more than 8800 and 9500, respectively. Although the Turkish Straits are among the World's busiest sea-lanes they are still governed by the Montreux Convention, signed on 20 July 1936. Extremely congested marine traffic (~200 vessels per day with ~25 carrying hazardous cargo) makes the Turkish Straits extremely vulnerable to shipping accidents. The total amount of hazardous cargo passing through the Istanbul and Çanakkale Straits in 2017 was 147 and 167 million tons, respectively. More than 400 large and small accidents have been recorded in the İstanbul Strait for the last 70 years, most of which resulted in loss of lives and severe environmental damage. Approximately 175,000 tons of oil spilled into the TSSA from 1979 to 2003. Most of the maritime accidents along this route caused by rather difficult navigation routes of the straits, congested marine traffic, strong currents, bad weather conditions and poor visibility. Another common reason for the maritime accidents along the Turkish Straits was the unexpected problems with ship's steering gear mechanism, and human errors resulting from improper human-technology interaction. The number of accidents declined drastically depending on fast technology development, e.g. ship propulsion systems, and especially on the implementation of maritime traffic regulations of the Straits, signed on October 8th, 1998. New Vessel Traffic Services System, which can take immediate physical actions by observing the vessels and planning traffic organization, have increased the safety of the straits and thus achieved a significant decline in sea accidents.

Hasan Bora USLUER

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REMARKABLE ACCIDENTS AT THE ISTANBUL STRAIT

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1. Introduction

The Turkish Straits sea area (TSSA) is consisted from the İstanbul Strait, the Sea of Marmara and the Çanakkale Strait. This area is one of the most important routes of oil transportation, mainly from the Black Sea, including Khazar Sea, to the Mediterranean Sea. The İstanbul and Çanakkale Straits are among the busiest and dangerous maritime routes, mostly caused by the energy transportation, after the Strait of Malacca between the Indian Ocean and the Pacific Ocean. The TSSA, especially for last 20 years, turned into one of the most important and key status of shipping of world seaborne oil trade. In future, parallel to the increasing of international trade volume of the Black Sea countries, connected with the Danube-Rhine and Danube-Main inland waterways, the number of companies using the TSSA will continue to increase. There have been many important collisions and other type of accidents occurred along the Turkish Straits; especially near Istanbul where more than eighteen million people inhabits. All type of accidents in the straits can be turned into terrible disasters, affecting directly not only the innocent passage at the strait but also the city life along its Asian and European coasts. Maritime accidents, whatever are their nature, are nightmares of seafarers. Shipping accidents (collision, breaking up, grounding, breakdown, stranding, fire and explosion) become even more critical due to oil spillage (Chapman and Akten, 1998; Akten and Gönençgil, 2002; Akten, 2006). The major purpose of this chapter is to present the most remarkable ship and shipping accidents in the TSSA and their most characteristic effects.

2. Most Remarkable Accidents

The most damaging and well-known examples occurred in the Turkish Straits are listed below.

2.1. Collision between M/T World Harmony and M/T Petar Zoranić

On December 14th 1960, Istanbul residents had been asleep without being aware of what would happen after a few hours. The residents of the Bosphorus woke up at 2:30 am with a great explosion. The 33,000-ton Greek ship, World Harmony, was moving from Piraeus to Russia's Novoroski Port to load fuel. The 26,000-ton Yugoslavian tanker Peter Zoranic, who departed from Tuapse Port, Russia, was carrying 12,000 tons of gasoline and 10,000 tons of oil on his way to Hamburg. The two tankers met between the shores of Kanlıca and İstinye, one of the narrowest passages of the Bosphorus. The Yugoslavian tanker would pass through the İstanbul Strait traffic rule, signalled and asked for directions. Two ships collided and the fire on the Yugoslavian tanker lasted 56 days (Figure 1). 18,000 tons of oil spilled, causing serious environmental pollution. Fire lasted for some weeks suspending the transit traffic with the loss of 51 lives (Usluer, 2016).

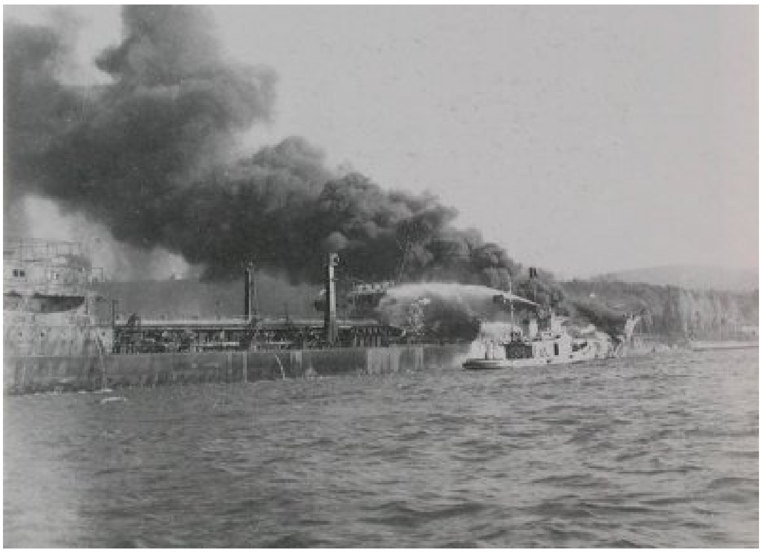

Figure 1. M/T World Harmony is burning after the collision ((from www.Geçmiş Gazete; Usluer, 2016).

2.2. M/V Arhangelsk Collision at Baltalimanı

Russian flagged bulker ship M/V Arhangelsk that was heading from the Black Sea to the Marmara Sea, lost her control, carrying no pilot, and collided to the historical buildings at the coast of Baltalimanı on September $4^{th,}$ 1963 (Figure 2). A young girl died when she was sleeping in her bed due to collision (Usluer, 2016).

Figure 2. A picture of M/V Arhangelsk at the next day news (from www.marinetraffic.com/).

2.3. Collision between M/T Lutsk and M/T Kransky Oktiabr

Hazardous collision happened with two Soviet flagged tankers, M/T Lutsk and M/T Kransky Oktiabr in front of the Kızkulesi (Maiden) Tower on March 1st 1966. After the collision nearly 1850 tons oil spilled in the Istanbul Strait. 1850 tons oil fired and reached to the Karaköy ferry pier. Both Turkish ferry Kadıköy and the Italian ferry St. George were burned (Akten, 2010). One passenger on the Kadıköy ferry died (IMFD, 2015). Meanwhile the Karaköy ferry pier burned and damaged.

2.4. Collision between Galatasaray Boat and M/V Aksaray

The passenger boat Galatasaray and M/V Aksaray had collision on July 3rd, 1966 (Figure 3). Thirteen passengers from the Galatasaray boat lost their lives (Usluer, 2016).

Ölüm Motoru dün çıkarıldı

TEKNEDE, KAYIP 7 KİŞİDEN ÜÇÜNÜN CESEDİ BULUNDU

Kaptanın Cesedi de Motorda idi

ON beş gün önce Yeni köy önlerinde tomruk yüklü "Aksaray" motoru ile çarpışarak batan "Yeni Galatasaray" motoru, dün çıkarılmış ve kayıp yedi kişiden ancak üçünün cesedi motorun içinde bulunmuştur.

Ölüm motoru yüzdürüldükten sonra içine giren balık adamlar, motorun salon kısmında bankların altına sıkışmış Refik Aydemir ile Nazım İlaldı'nın tanınmıyacak hale gelmiş cesetlerini bulmuşlardır.

NASIL ÇIKARILDI?

Daha sonra başaltına giren dalgıçlar burada da ölüm motorunun kaptanı Dursun Ali Ayaz'ın cesedi ile karşılaşarak hepsini motorun güvertesine taşımışlardır. Savcılık burada cesetlerin kimliklerini ve üzerlerinden çıkan eşyayı tespit etmiş, teknenin dümeni ile gaz

(Devamı Sa. 7, Sü. 3 te)

ÖLÜM motoru "Yeni Galatasaray„ dün yapılan on saatlik bir çalışma sonunda yüzdürülmüş ve kayıp olan cesetlerden ancak üçü bulunabilmiştir. Kaptan Dursun Ali Ayaz'ın cesedi de bunlar arasındadır. Yukarıdaki resimde, "Yeni Galatasaray„ maçuna ile su yüzüne çekilirken görülüyor. (Foto: Haber Ajansı - Ergin KONUKSEVER)

(ÖLÜM MOTORU İLE İLGİLİ DİĞER RESİMLER 8 İNCİ SAHİFEDEDİR.)

Figure 3. Disaster's news the day after the collision (from www.Geçmiş Gazete).

2.5. Collision between Fishery Boat Bereket and M/T Ploesti

Romanian Flag's tanker M/T Ploesti and Fisher Boat Bereket had collision on November 18th 1966 (Figure 4) with the loss of eight lives from the Bereket Boat (Usluer, 2016).

ROMEN TANKERİ BOĞAZ'DA BİR MOTORA ÇARPTI

BATAN MOTORDA 7 KİŞİ BOĞULDU

Romen tankeri motora arkadan bindirdi

Figure 4. News on the disaster the day after the collision (from www.Geçmiş Gazete).

2.6. M/T Ancona collision at Rumelihisarı

Italian flag's tanker M/T Ancona had lost control and crushed at summerhouse near coastline of Rumelihisarı on July 1st, 1970. After the collision, the house was ruined and five person lost their lives and six injured (Usluer, 2016).

2.7. Collision between M/F Turan Emeksiz and M/V Söylemezler

Istanbul Municipality ferry Turan Emeksiz (Figure 5) and M/V Söylemezler had collision on July 28th, 1972 with the loss of four lives and 25 injuries (Usluer, 2016).

Figure 5. M/V Turan Emeksiz was retired after 46 years of service (from www.modelteknikleri.com/).

2.8. Collision between M/T Independenta and M/V Evriali

Independenta tanker accident occurred in the southern approaches of the İstanbul Strait on November 15, 1979. The Independenta was a brand new ship, launched in 1978 in the Romanian shipyards, 147,631 deadweight tonne, 283 m long, 46 m wide and 22 m deep except for the superstructures. She was traveling from Libya to Constanta, with a load of 96,000 tons of crude oil that is not fully loaded. As proceeding to enter the İstanbul Strait, she collided with the Greek ship Evrialy about 4 miles off the Haydarpaşa breakwater. The Greek ship was carrying 7400 tons of steel from Zhdanov to Mediterranean. Due to collision, two ships fired for the following 27 days continuously (Figure 6). It is reported that 43 persons died, more than 95,000 tons of crude oil was spilt and burned for days (Baykut et al., 1987; Etkin, 1997). The marine pollution damaged severely to the marine ecosystem. An area of 5.5 km in diameter was coated with thick tar. The mortality rate among marine species was estimated at 96 % in the area. The wreckage of the tanker remained in Haydarpaşa for many years and continued to pose a danger to the cruise. Car ferryboat named "Hürriyet" crashed on April 19th 1983, and was damaged. The city of İstanbul survived barely 7 years after the crash.

Figure 6. M/T Independenta fire after the collision (from https://onedio.com/).

2.9. Collision between TCG Meltem and RFS XACAH

Turkish Naval Forces patrol ship TCG Meltem (Figure 7) collided with Soviet Navy, Auxiliary type, Naval Academy Ship XACAH nearshore Kadıköy on September 24th, 1985. After the collision, TCG Meltem had damaged and sunk in the Marmara Sea. Five Petty Officers died (Usluer, 2016).

Figure 7. The Patrol Boat TCG Meltem was divided into two by the crashing Russian ship and then sank (from https://seyler.eksisozluk.com/).

2.10. Collision between M/T Blue Star and M/T Gaziantep

M/T Blue Star was loaded high tonnage ammoniac liquid, had terrible collision between M/T Gaziantep, which stand on anchorage area at Turkish Strait, at October 29th 1988. After the collision, severe water and air pollution occurred due to 1000 tons of ammonia spilled into the environment.

2.11. Collision between TCG Saldıray and M/T Akademik Vekua

Turkish Naval Forces Submarine TCG Saldıray (Figure 9) and Soviet Flagged M/T Akademik Vekua collided in front of the village of Sarıyer on March 24th 1990.

Although TCG Saldıray (Figure 8) terrible damaged, it was lucky that no life was lost (Usluer, 2016).

Figure 8. TCG Saldıray submarine of the Turkish Navy (from https://turkishnavy.net/; Usluer, 2016).

2.12. Collision between M/T Jambur and M/V Da Tung Shang

March 29th 1990, Iran flagged tanker M/T Jambur and China flagged ship M/V Da Tung Shang clashed off the coast Sarıyer in the Istanbul Strait. Huge part of Jambur had damaged and 2600 tons oil spilled to the sea. After the collision, M/T Jambur had grounded on shallow water.

2.13. Collision between M/S Rab Union-18 and M/V Madonna Lily

In 1991, Lebanese flagged M/V Rab Union-18, collided with Philippines flagged M/V Madonna Lily, under the second (Fatih Sultan Mehmet) bridge of the Istanbul Strait. Even Madonna Lily survived by small damage, Rab Union-18 sunk together with more than 21,000 sheep onboard (Figure 9). Most of the sheep drowned causing serious environmental damage. Thirty persons from Rab Union-18 were survived; two died.

İSTİHBARAT SERVİSİ

TEHLİKE SAÇIYOR

BALON GİBİ

Figure 9. News about the collision (from https://www.denizcilikbilgileri.com/).

2.14. Collision between M/T Nassia and M/V Shipbroker

On March 13th 1994, the crude oil tanker M/T Nassia and bulk carrier M/V Shipbroker both of them Cyprus flagged, clashed off the coast Rumelikavak. Nassia was loaded with 98,500 tons of Russian crude from Novorossisk to Genoa. Collision occurred at the Black Sea entrance of the İstanbul Strait. Bulk carrier Shipbroker on ballast passage from Chalkis to Novorossisk reported to have a locked rudder, which was caused by a generator blackout. Shipbroker caught fire, and ran aground on the Asian shore (Figure 10). The Nassia fire lasted more than a week. The İstanbul Strait closed partly or suspended to maritime traffic for several days. The Shipbroker burnt totally. The fire also spread on to the freighter more than 25 crewmembers died. This collision also caused heavy environmental damage. 9,000 tons of oil spilled into the sea while 20,000 tons of oil burnt during 4 days. Over the sea, fish from several species and cetaceans were stranded and sea birds were killed (Usluer, 2016).

Figure 10. Nassia fire (TRT Archives).

2.15. M/T Sea Selvia grounded at Southern entrance of Istanbul Strait.

10 July 1998, Greek flagged tanker M/T Sea Selvia was heading from Novorossiysk harbour to Augusto harbour, loaded 81,000 tons crude oil, was grounded. Survival operation took more than a day (Figure 11).

Figure 11. M/T Sea Selvia grounded (from Turkish Straits Vessel Traffic Service).

2.16. M/T Crude Gulf grounded at Southern entrance of Istanbul Strait.

25 August 1998**,** Greek flagged tanker M/T Crude Gulf grounded at same point with M/T Sea Selvia (Figure 12). M/T Crude Gulf, loaded with 140800 tons of crude oil so it was greater threat than M/T Sea Selvia for Istanbul Strait and marine ecosystem.

Figure 12. M/T Crude Gulf grounded (from Turkish Straits Vessel Traffic Service).

2.17. M/V Semele collision with M/V Sipka

7 November 1999**,** Belize flagged vessel M/V Semele (Figure 13) was heading from Black Sea to Marmara Sea collided with Bulgarian flagged vessel M/V Sipka which was stand on the anchorage area. Shortly after the collision, Semele sunk fast and spilled 10 tons oil into the İstanbul Strait.

Figure 13. M/V Semele (Usluer, 2016).

2.18. M/T Volganeft-248 grounded at Florya

On 29th December 1999, a Russian flagged carrier M/T Volganeft-248 grounded offshore Florya, with about 4,000 tons of fuel oil. It split into two pieces (Figure 14). As a result, 1578 tons of oil spilled (ITOPF 2000; Otay and Yenigün 2000; Oğuztimur and Parlak 2002). Decontamination operations took about two years.

Figure 14. M/T Volganeft-248's stern part after the collision (from Turkish Straits Vessel Traffic Service).

2.19. M/V Gotia Stranded at Bebek Point.

6 October 2002**,** Maltase flagged vessel, M/V Gotia stranded at Emirgan Dock area of the İstanbul Strait. M/V Gotia was collided with the Emirgan Pier. Shortly after the accident, more than 18 tons oil spilled into the water. It caused serious environmental damage to the marine ecosystem, the boats in the marina and the infrastructures at the coastline.

2.20. M/V Svyatoy Panteleymon at Bebek Point

10 November 2003**,** Georgian flagged cargo ship GGC Svyatoy Panteleymon was collided with Anadolufeneri. The ship broke into two pieces (Figure 15). More than 500 tons of oil spilled and caused pollution (İBB, Deniz Hizmetleri Md., 2018).

Figure 15. M/V Svyatoy Panteleymon’s stern part after the collision (https://denizhizmetleri.ibb.istanbul/kurumsal/hakkimizda/).

2.21. M/V Hera sank at Southern entrance of Istanbul Strait.

13 February 2004**,** M/V Hera was heading from Yujniy to Diliskelesi, Gulf of İzmit (Figure 16). Due to heavy weather conditions, she sunk at the southern entrance of the İstanbul Strait with the loss of 19 lives. Approximately 11,750 tons of coal and her own oil spilled into the sea.

Figure 16. M/V Hera was berthing (Usluer, 2016).

2.22. M/V Orçun-C Grounded at Northern Entrance of Istanbul Strait.

On January 19th 2010, Moldovian flagged M/V ORCUN C (Figure 17) grounded and broke into two parts due to storm weather at the northern exit of the İstanbul Strait (off the Kilyos point). Because of this accident, the ship's fuel has spread over 96 tons of fuel oil and 25 tons of diesel oil. This fuel oil and diesel mixture poured into the sea, within a few hours of the accident. It was spread over an area of approximately 4 km with the effect of strong northern winds and waves blowing in the form of a storm. More than 121 tons of fuel oil spilled and four recreational bays were polluted. Decontamination operations took more than two months.

Figure 17. Rescue operations of the M/V Orçun-C which was broken into two parts (http://www.denizhaber.com/deniz-kazalari/; Usluer, 2016).

3. Conclusion

Results of collisions and accidents along the Turkish Straits caused loss of many people lives, sunken ships and sea pollution. Following the increasing importance of energy transportation, transportation of hazardous goods and cargoes has been increased. This also effects to the local and international traffic along the TSSA. In addition, it will cause serious environmental problems on the surrounding area, affecting not only the city of İstanbul but also all of country that utilize the Straits.

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HISTORY OF REGULATIONS BEFORE REPUBLICAN ERA ALONG THE TURKISH STRAITS SEA AREA

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1. Introduction

The Turkish Straits were controlled by various states for centuries. Controlling the Straits was a very important strategic decision for the domination of maritime trade. With the transition regimes in the Turkish Straits, more clear information is revealed when the straits enter the sovereignty of the Turks.

2. Transition Regime in the Straits before Turkish Domination

It is stated that the Çanakkale Strait (Dardanelles) is more important position in the prehistoric times than the İstanbul Strait. An example of this is the Trojan War for the Çanakkale Strait. It is known that the war, which is an important place in Greek history, passed between the Greeks who wanted to open up to the Black Sea shores and the Trojans who held it in the hands of Dardanelles at that time. The Trojans made great efforts to prevent any kind of maritime expedition and trade. They were striving for the capture of the Çanakkale Strait, the gateway to this important route to the Black Sea in the Greeks. The Trojan War is not only a historical war but also the oldest battle to control on the Çanakkale Strait.

Although there are no rules for passage from ancient times, the region of the Straits has been regarded as a region that must be seized by the strong state of every period. The main reason for the Trojan wars is not the abduction of Helen by Paris but the capture of the Çanakkale Strait under the control of the Trojans (Özman, 2016).

After the death of Macedonian King Alexander the Great, the part of the strait of the demolished empire remained in the kingdom ruled by a king named Prpopontide, General Lisimakus, near the Central Gallipoli. It was the first kingdom that dominates the straits. The kingdom was torn apart for various reasons. The Pontus State, which had a strong navy among the shattered states, maintained its dominance over the straits and kept the passages under control. The control of the straits by the Roman state was captured by the Romans.

The Çanakkale Strait formed a dispute between the Persians and Athens and Sparta during the wars of Med and Polonez. Later on, the Çanakkale Strait had lost its importance with the spread of the Roman Empire to the Mediterranean, but once the city became the capital of the Eastern Roman Empire, the Straits had reached its old age (Turan, 2003).

Especially in order to trade the ships of the Italian Republics from the Mediterranean coast to the Black Sea settlements, Eastern Roman Empire, which took Istanbul as the capital in 300 and controlled the straits, made constant pressures by resorting to military force or through agreements (Özman, 2016).

During the reign of the Roman Empire, the Hun state, the Avars and the Persians had always attacked. Later on, while the attacks were carried out by the Arabs and Russians, the Romans protected the straits. It is known that in 1204 the Crusader army captured Istanbul's sovereignty with the help of the Genoese. This reigned until 1261, but then the Byzantines regained their dominance over the Straits by taking the city back.

Due to the importance of the Straits during the middle Ages, the attacks of Hun, Avars, Persians, Arabs and Slavs continued, but no success was achieved. Due to the strategic importance of the Straits, Byzantine Emperors gave importance to navies. In these periods, the trade ships of Venice, Pisa and Genoese were allowed to pass through the straits.

The Byzantine Empire began to lose power over time. The Byzantine Empire was trying to maintain its power against the outside by using its dominance over the straits but because of the IV. Crusade, the Latin Empire was established in Istanbul with the occupation of Istanbul.

In 1356, the Ottoman Turks reached the coast of Çanakkale and the European territory. The dominance of the Byzantine Empire over the Çanakkale Strait was taken largely by taking important points in the period of Orhan Gazi, the second sultan of the Ottoman Empire.

In the year 1390 by Yıldırım Beyazıt, military units were placed on the Çanakkale Strait. In the 1393, the Anadolu Hisarı was built. Yıldırım Bayezid besieged Istanbul in 1393 for the control of the İstanbul Strait. But the siege was not successful.

Fatih Sultan Mehmet ordered Rumeli Hisarı (1452) in the narrowest part of the Bosporus to stop the transportation to the Mediterranean from the Black Sea, and ordered that every ship passing through the İstanbul Strait be stopped and that a certain amount of passage was taken. The region where the Rumeli Hisarı was built was called Boğazkesen (Başyurt, 1998).

This situation was a precursor to Turkish domination in order to control the transitions in a sense for the İstanbul Strait. It was declared to all the states where ships that did not pay for passage would be sunk. Transitions along the Istanbul Strait were under the control of a single state. On October 26, 1452, the Ottoman Empire showed its determination to sink a Venetian ship that did not want to pay for passage charge. The decisiveness of the transitions was understood by the immersion of the ship of a powerful sailor state like Venice. The aid to the Byzantine state was prevented by the supervision of ship passages. This application lasted about a year.

On May 29, 1453, Fatih Sultan Mehmet conquered Istanbul and ended the Byzantine Empire. The control of the Çanakkale and İstanbul Straits was completely captured by the Ottoman Empire. The islands which were on the the west side of the Çnakkale Strait, were taken and equipped with military bases. In 1463, the Çanakkale Strait were armed from the Mediterranean against all kinds of threats.

After these conquests, Fatih Sultan Mehmet built the fortresses of Çanakkale and Kilitbahir by attaching importance to the work of Çanakkale Strait fortifications. Guards and catapults put guards here. Thus, the Turks have completely controlled the entrance and exit to the Straits (Tukin, 1999).

The Turkish Straits have actually started in the period when they entered the Turkish domination.

3. Transition Regime in the Straits During Turkish Domination

After the conquest of Istanbul by Fatih Sultan Mehmet in 1453, the Straits were completely dominated by the Ottoman Empire. In 1484, the Ottoman state conquered the Black Sea coasts and the Black Sea became a Turkish Lake. The Black Sea was now an inland sea and the decisions of the Black Sea were taken by the Ottoman State. The Ottoman Empire decided to close the straits of trade and warships of all other states. In this period, the absolute Turkish domination began.

From the taking of the Ottomans to Istanbul, the 1774 Küçük Kaynarca Treaty, the Straits, the rule of the Ottoman Empire, foreign states to be closed to trade and warships principle has been adopted (Toluner, 1996).

The Ottoman State began to use its right to regulate, allow, register and ban the foreign ships in the waters and to stop them from 1484 onwards by closing both straits.This principle, which banned the circulation of foreign ships in the Black Sea but not put into effect immediately (Tukin, 1999).

From 1535 onwards, the Ottoman Empire recognized the privilege of being able to pass through the straits to the merchant ships belonging to some states by capitulations. The Ottoman capitulations in this context, the French in 1535; in 1579 the British, in 1612 finally gave privileges that allow a free passage through the Straits to the Dutch merchant ship (Meray, 1968).

The ships of these privileges could only come to Istanbul. Black Sea shores were not allowed. In foreign states, they had to settle for only Istanbul trade. Trade in the Black Sea region was only under the control of Ottoman merchants. No foreign ship was allowed to enter. The Ottoman Empire tried to preserve the monopoly of this trade in the Black Sea until the last quarter of the 18^{th} century.

Until the 1774 Küçük Kaynarca Treaty, signed between the Ottoman Empire and Russia, the principle of the closure of foreign countries to trade and warships continued, with the exception of the privileges granted by the capitulations. With this agreement, the Empire granted Russian trade ships free passage from the Straits (Toluner, 1996). Thus, for the first time, the Ottoman Empire recognized an international treaty and the right to free trade from a strait to a foreign state (Erdaş, 1998).

With this treaty, Russia had the right to have both war and merchant ships travel freely in the Black Sea. One important point to be emphasized is that the Russians did not give this right of passage with the request of the Ottoman Empire at the end of a war. With this agreement, the domination of the Ottoman Empire in the Black Sea and along the Turkish Straits for about 300 years has ended.

4. Transition Regime in the Straits in the Period of Double Agreements

The 1768 war between the Ottoman Empire and Russia was ended in 1774, and won by Russia. The Russians passed the Danube in the Black Sea and succeeded in descending the Black Sea coast by seizing Crimea. In the Black Sea, the absolute dominance of the Ottoman Empire ended and the Black Sea was no longer a Turkish lake.

The agreement that ended the absolute Turkish rule on the Straits was signed on July 21st, 1774. With this agreement, Russian trade and warships took the right to pass freely through the straits. The Russian state was the first to receive the right to cross the Straits during the Ottoman period.

The right to cross the straits between the Russians and the Ottoman Empire was continued with the 1779 Aynalı Kavak Agreement, the 1792 Yaş Agreement and the 1798 Istanbul Agreement, respectively.

Again between the Ottoman Empire and Russia in 1789 in order to remain in force for 8 years under the secret treaty of Istanbul Treaty 2 and 4, all other foreign states of the Black Sea closed to the warships and the Straits only during the war period as an ally of the Ottoman Empire. It is foreseen to open to Russian warships (Özman, 2016).

Changes in the transition regime from the straits during the Ottoman Empire began after this treaty. Other states had been disturbed by this transcendent rule of Russia. It was a threat to other states that Russia wielded warships, as they wanted in the event of war.

With the 11th article of the agreement between the Ottoman Empire and England in the Ottoman Empire between the Ottoman Empire and the Ottoman Empire, the Straits of the Ottoman Empire agreed to not open to the warship of any state in peacetime. (Özman, 2016).

On June 25, 1802, the Paris Peace Agreement was signed between the Ottoman Empire and France. Another important aspect of this agreement, which recognizes each other's territorial integrity, is that the Ottoman Empire gave France the right to trade in the Black Sea (Uçarol, 1995).

By this treaty, the right to trade in the Black Sea coast in a second state had gained the right to pass through the straits. This situation continued to disturb other states. The first İstanbul Strait violation in the history of the Ottoman Empire was made by the British Navy. On February 19th 1807, a British War Squadron anchored the Çanakkale Strait and was anchored offshore Istanbul. The fleet, which had been anchored for a while, retreated on March 02, 1807. This event was the first time an incident occurred against the 1809 Kale-i Sultaniye treaty. It is also meaningful that the fleet, which caused this contradiction, belongs to England.

In the following years, the Ottoman Empire experienced various attacks and invasions. The purpose of these invasions was to force the Ottoman Empire into some certain agreements about the Straits. The most obvious example is the Edirne Agreement signed with Russia on September 14th, 1829. Accordingly, the straits would be open to the trade ships of all states when the Ottoman Empire was in peace. With this agreement, all countries providing peace with the Ottoman Empire were opened to trade in the Black Sea. The passage of warships was not allowed by the Ottoman government. The provisions of this agreement continued until the Hünkâr İskelesi Agreement, which was signed between the Ottoman Empire and Russia on July 8th, 1833. The agreement offers the acceptance of the Ottoman Empire. In view of the origin of the agreement, the Ottoman Empire accepted Russia's offer of help because of internal turmoil. The Russians did not withdraw from the Straits despite the turmoil and forbade the passage of straits between France and England.

The treaty of the Hünkâr İskelesi consisted of seven items, six open and one secret. The treaty signed an eight-year period, to be effective, the mutual assistance to each other as a threat to Russia and the Ottoman Empire bears the character of a contract based on the defense. However, according to this secret article, Russia has renounced the Ottoman Empire's aid to Russia, but in case of a danger in return, the Ottoman Empire's concession to close down the Çanakkale Strait in favor of Russia. This means that foreign warships could not enter the Straits in any way (Karal, 1995).

With this treaty, Russia reached the conclusion that it had longed for years and aimed to help. Because Because in the case of a war in Russia, which was important for the Straits was open to the ships of the open state against their warships (Uçarol, 1995).

This treaty had outraged the states of England and France. They lost the right of passage of commercial ships they gained on the Straits. At that time, the states of Austria and Prussia did not make any military attempts against Russia and the Ottoman Empire because they supported Russia. Russia and the Ottoman Empire were only protested. When the secret clauses of the Treaty were also revealed, the European States declared that they did not recognize this agreement by agreement.

The Ottoman Empire was not indifferent to these reactions. In 1838, the Ottoman Empire first allowed trade agreements with France and then France to allow commercial ships to pass through the straits. These agreements shadowed Russia's dominance over the straits.

The Hünkâr İskelesi treaty was the last of the bilateral agreements on the straits of the Ottoman state. Other agreements made after this agreement were made as multilateral agreements. In this case, the Ottoman Empire has started to lose its dominance over the straits and shows that it has no power and power as it used to be. The fact that the non-coastal states were a party to the agreements was a sign of the growing sea trade in the Black Sea.

5. Transition Regime in the Straits in the Period of Multiple Agreements

The Ottoman Empire, which had lost its dominance in the straits, also experienced internal turmoil. Because of the rebellion in Egypt, eyes were turned into this region. On July 13, 1841, the London Straits Convention was signed in order to reinstate sovereignty within the scope of Hünkar İskelesi in Russia, and to be open to other states, especially Austria, England, France, Prussia and Russia. With this agreement, it was decided to open the straits to all foreign trade ships. With this agreement, the superiorities of the countries on the passage of the straits ended. Again, the straits were closed to all warships.

It was envisaged that the regime introduced in the framework of the London Convention could be replaced by the common will of all the parties in response to the past, and thus the balance of the transitional regime from the straits was prevented from being spoiled by single or bilateral arrangements (Tukin, 1999).

With the London convention, the right to speak in the straits is now in the period of multilateral agreements. In this agreement, the right of inspection of the merchant ships was taken exactly from the Ottoman Empire. The only control right of the Ottoman Empire was about the passage of warships. The state allowed by the Ottoman Empire to allow the passage of warships was a threat to the security of the coastal states in the Black

Sea. This agreement was an agreement that formed the basis of the regulating regime for the transition from the straits to the First World War

The status of the Straits determined by the London Straits Convention signed on 13 July 1841 continued until the 1923 Lausanne Straits Convention (Şeref, 1995).

The London Straits Convention is of particular importance in that it was the first multilateral treaty (Austria, France, England, Russia, and Prussia) to regulate the legal regime of the Straits. This treaty was realized with the participation of all member states for European balance interests (Baltalı, 1973).

Depending on the wish of the Ottoman Empire had the power to open the straits to the warships of the state wanted. However, this situation had been violated from time to time. In 1844, Russia's warships went to the Far East using the straits. The Ottoman Empire was not involved in this transition.

In July of 1904, the Russian navy's Petersburg and Smolensk warships were passed under the guise of a merchant ship from the Straits. Britain sent a note to the Ottoman Empire and Tsarist Russia and protested the incident (Özdalga, 1965).

Russia clearly showed its discomfort from this agreement. In 1853, Russia launched a war by attacking the Ottoman Empire. The war ended in 1856 with the death of the Russian leader. On March 30th, 1856, the Treaty of Paris was signed, between the Ottoman Empire, Austria, England, France, Prussia, Russia and Sardinia. This agreement generally protects the regime of the London Convention of 1841. In addition, the Black Sea was added to the warships of all states. This situation took away the right of Russia and the Ottoman Empire to have a military ship in the Black Sea. Russia and the Ottoman Empire will not have a military shipyard on the Black Sea coast.

While the Black Sea was neutralized by the Treaty of Paris, the rights of the Ottoman Empire to possess a warship in the Sea of Marmara and in the Straits and to establish a shipyard were not touched (Harp Akademileri, 1997).

The Black Sea was neutralized by this agreement. This situation left the Ottoman Empire, especially Russian, in a difficult situation. Russia lost its power in the Black Sea. This was very disturbed by the Russians. At a time when European states were weak, Russia reported that other European countries did not recognize the provisions of the Black Sea. Although the European states did not agree with it at first, they accepted it later. This was not official until the Paris Treaty.

In order to abolish the provisions on the neutralization of the Black Sea, Russia sent a note to the European states in the aftermath of the 1870 German-French war and declared that it had annulled the provision. On March 13, 1871, the Treaty on the Black Sea was signed, between the Ottoman Empire, Germany, Austria, France, England, Italy and Russia. This agreement meant the return to the provisions of the London Treaty of 1841. The Ottoman Empire and Russia once again had the right to establish a ship in the Black Sea and to have a military ship. With this agreement, an atmosphere was provided for Russia's policies on hot seas. The Ottoman Empire, with the help of Russia, obtained the right to re-establish its territory.

Russia was not content with the possession of the battleship it received back in 1871 London treaty. Russia launched an uprising against the Ottoman Empire and in 1877 the Ottoman Russian war began. After the defeat of the Ottoman Empire, the Treaty of Ayastafanos was signed with Russia on March 3rd, 1878. With this agreement, all trade ships arriving and going to Russian ports were allowed to cross during peace and war. The Russian state guaranteed the status of supply and assistance with trade ships during the war with this treaty

The treaty of Ayastefanos was a treaty that was disturbed by European states. With the Treaty of Ayastefanos, Russia seemed to regain its former dominance in the Black Sea. For this reason, on July 13th, 1878, the Berlin Agreement revised the existing agreement. 1856 Paris and 1871 London agreements were made. The right to close the Ottoman Empire to warships was restored. This situation eliminated Russia's superiority with the Ayastefanos treaty. The Berlin Treaty was based mainly on the 1841 London Straits Agreement and was a continuation.

Britain's military activities in the Mediterranean again brought the Ottoman Empire closer to Russia. In 1884, the Ottoman Empire allowed Russia to pass unarmed military ships through the Turkish Straits. In this period, Russian military ships made crossings at various times from the Turkish Straits. This situation again brought up the issue of the Turkish Straits. European states were very uncomfortable with these transitions, especially the Britain.

In this period, the Ottoman Government signed an agreement with the Russian Embassy in Russia in 1891, allowing the Russian ships carrying the flag of the trade carrier to carry troops or prisoners between Europe-Russia and the Far East-Russia and signed the treaty with the other states, which had signed the treaties with the reported. In the face of this situation, Britain claimed that it did not have any objections to the treaties on the Straits but other states should benefit from the same right (Tugay, 1948).

Starting in 1904, the Russian - Japanese war again attracted attention to the Straits. Due to the existing agreements, the fleet of Tsarist Russia in the Black Sea was not able to enter the war through the Straits. The Tsarist Russia was able to pass the Russian volunteer fleets through the Straits under the trade ship's view (Ekinci, 2001).

After the defeat of the Tsarist Russia from the war with Japan, they had a series of talks on passing warships through the straits. In 1903 and 1906, there were negotiations with the Ottoman Empire to open the straits to Russian warships. The Tsarist Russia also met with Austria in 1908 and took the floor for the passage of the warships. In 1908, the Tsarist Russia had a secret meeting with England on the straits in the Baltic Sea. The Tsarist Russia met with Italy in 1909 and received support on the straits.

The transition regime in the Turkish Straits continued until 1911. Italy invaded Tripoli in 1911 and waged war against the Ottoman Empire. The invasion of the Italians occupied the coast of Tripoli in Italy on November 23rd, 1911 to break the power of the Ottoman Empire took the siege of the Çanakkale Strait.

On November 23rd, 1911, Italy blockaded the Çanakkale Strait. The Ottoman Empire mined the Straits and ensured the controlled passage of merchant ships. The Italian Navy, which continued the siege for five months, tried to pass through the Çanakkale Strait on April 18th 1912, but it failed with the intense fire from the Turkish forts. Thereupon the Ottoman Empire closed the straits completely. There were 335 trading vessels on both sides of the Çanakkale Strait. On 18 May, the Straits were opened to merchant ships on the reaction from Tsarist Russia and on the recommendation of opening the Straits from England. As a result, peace was made on the pressures and developments in the Balkans (Kamış, 1998).

After this development, the Balkan War started in October 1912. The transition of the Bulgarian state to the İstanbul Strait was supported by Germany and Austria. The UK suggested that the Turkish Straits should be turned into an autonomous region and controlled by an international administration, but could not find support. Russia, despite all its attempts, had not been able to obtain a privilege on Turkish Straits.

6. **Transition Regime in the Straits during the First World War**

The transition regime from the Turkish Straits continued to be implemented except for a few special cases after the London Straits Agreement. However, on 10 August 1914, the German ships of Goben and Breslau changed the course of the Çanakkale Strait to escape from the British. During this period, the Ottoman Empire was neutral and should not allow warships to pass. The fact that the British warships following the German ships were not allowed to cross the İstanbul Strait, eliminated the neutrality of the Ottoman Empire. The Entente States protested the situation.

In the face of this incident, Russia tried to reach an agreement with the Ottoman Empire in order to continue the Russian trade from the Allied Powers. The United Kingdom followed a tougher stance. UK decided to sink the ships departing from the Çanakkale Strait. On September 27th 1914, the Ottoman Empire decided to close the Çanakkale Strait on all ships. This decision 1841 had created a situation in the London Straits Treaty again.

The Ottoman Empire was not contented with this situation and announced that it had purchased two battleships belonging to the German army. The names of these ships were Yavuz and Midilli. When the Ottoman navy attacked Russian warships on October 28th 1914, the Ottoman army had de facto war.

With the entry of the Ottoman Empire into the war, the provisions of the international treaties on the Turkish Straits were repealed unilaterally. The provisions in these agreements regulate the peacetime regime of the Turkish Straits and recognized the right of the Ottoman Empire to unilaterally determine the regime of the Turkish Straits in event of war (Tukin, 1999).

At the request of Russia, on March 18th 1915, Britain and France wanted to reach the city of İstanbul by passing through the Çanakkale Strait. However, due to the Ottoman Empire's great determination and self-sacrifice, the Allied Powers could not cross the Çanakkale Strait. However, the defeat of Germany in the war was defeated in the Ottoman Empire. The Turkish Straits were then occupied by the Allied Powers.

On October 30th 1918, the Ottoman Empire was forced to sign the Treaty of Mondros. The provisions of this agreement were the opening of the Çanakkale Strait and the Bosporus to the ships of all countries. In addition, the Ottoman Empire would withdraw all the military elements in the Straits and the straits would be under the control of the Allied Power. This agreement ended with the 77-year-old London Straits Agreement. The Ottoman Empire's dominance over the straits ended with the armistice of Mondros. Transitional regimes of the Straits had been taken over by the Allied Power. This situation was the basis of the logistic activities necessary for the occupation of the

Ottoman Empire. The Ottoman Empire could only exist for border security in the region and could never interfere with transitions.

The plans of the Allied Power for the straits did not end with this agreement. On August 10th 1920, with the Treaty of Sevres, the coasts of the straits were taken from the Ottoman Empire. With this treaty brought the full liberty to the war and trade ships of all countries to the straits. The borders of the straits were extended from the Aegean region to the shores of Izmir. In addition, the maritime control within the Marmara Sea to the borders of Bursa and Kocaeli belonged only to the Allied Power. With this treaty, the Allied Power tried to control the most critical and trade-critical places of the Ottoman Empire. A Strait commission was established for the management of the straits with this treaty. The commission in question would have its own flag and budget. The Commission would regulate the passage of ships passing through the straits and carry out the guidance procedures. The Straits Commission, England, France, Italy, Japan, Greece and Romania would be found. The presidency of the commission would change among these countries. These countries would have two voting rights. The Ottoman Empire had no representative rights in this commission. The Ottoman Empire would not have a voice in the management of the city and the straits where its capital was located.

However, this agreement was not recognized by the Ankara government, and the implementation of the liberation war never took full implementation. The İstanbul Strait commission of the Allied Power remained a dream.

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TRANSITION REGIME IN THE TURKISH STRAITS DURING THE REPUBLICAN ERA

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1. Introduction

The Turkish Straits is a maritime road with geopolitical and geostrategic importance, due to the waterway connecting the Black Sea to Mediterranean. The İstanbul Strait, the Çanakkale Strait and the Sea of Marmara, which are included in the scope of the "Straits" in the Lausanne Straits Agreement, are the waterways of military importance and economically crucial to the countries with Black Sea coast. The security of the Turkish Straits that separates the Asia and Europe is of great importance to the Black Sea littoral states and Turkey.

When the transition regimes in the Turkish Straits were examined throughout history, it was seen that many agreements and regulations were made during and after the republican period, one of the periods where multilateral agreements were made on the straits.

The transitional regime in the Straits in the Republican period began with the Lausanne Straits Convention signed in addition to the Lausanne Treaty, which entered into force on 24 July 1923. The transitional principles of the Turkish Straits determined by the Lausanne Straits Convention continued until the Montreaux Straits Convention, signed in 1936. The Montreux Straits Convention, signed on July 20, 1936, was the contract that governs the transition regime in the straits that will last until the day.

The Turkish Sstraits are one of the most dangerous and challenging waterways in the world, with the strategic importance that it carries. Dense and dangerous strait traffic, the narrow and curved morphological structure of the straits in places; due to climatic factors such as current, eddy current, wind, fog and hydrographic conditions, becomes more risky (Özersay, 1999).

Increasing traffic density in the straits poses many risks in terms of the safety of the straits. These risks can cause sea accidents involving serious hazards in terms of life, property and environmental safety. With increased tonnage for the transportation of hazardous cargo in the Turkish Straits, Turkey is to take various precautions.

Turkey, in order to increase navigational and environmental safety in the Turkish Straits Regulation, Traffic Separation Schemes and the Vessel Traffic Service has taken a number of measures associated with each such system.

2. Transition Regime Constructed in the Lausanne Straits Convention

In addition to the Lausanne Peace Treaty signed on July 24, 1923, new arrangements were made for the status of the straits with the "Agreement to be issued by the Straits". By this contract, the Straits remained in force as a document regulating the transition regime in the straits until the Montreux Straits Convention entered into force on 9 November 1936. According to the agreement, the freedom of passage from the

Straits was regulated by separating merchant ships and war ships, and an international Straits Commission was set up for the implementation of this matter which is managed by the Turkish representative. Thus, Turkey's straits rights and powers were being largely limited and connected to a status with common will of lots of countries including Turkey (İnan, 1986). While passage through the straits are set free for the merchant ships, civilian aircraft, warships, war planes, in time of peace and in all the wars where Turkey remained completely neutral, without looking at whatever the flag is full transition freedom was given (Ülman, 1968).

3. Transition Regime Established in Montreux Straits Convention

Turkey understanding that it would not be possible to protect the rights and safety with the Lausanne Straits Convention signed at 1923, started to request the replacement of the existing straits status to suit the conditions of that time (Zengin, 2013). Turkey, seeing that the terms of the Lausanne Convention on the Straits was not met, requested the annulment of the said provisions from the League of Nations. As a result of these initiatives, on 20 July 1936, the Montreux Straits Convention, which is still in force today, was signed. The Straits Commission was removed with this contract, stated emphatically that the sovereignty of the Republic of Turkey in the Straits and the Straits were armed by Turkey (Ökten, 2008).

Montreux Convention that has strategical, economical and political importance for Turkey is one of the few multilateral agreements in force since the date of signing. If we will touch on some important items;

According to article 1 of the Montreux Convention in the Turkish Straits, the principle of freedom of movement and freedom of transport from the sea was adopted. According to the Article 2 of the convention, it is stated that, regardless of the vessels transiting[1] in the day and night, flags and loads, each ship will benefit full freedom from the strait without any procedure except for the health checks carried out under Turkish law in the framework of international health regulations. However, guidance and tugboat use is optional. In addition, the Turkish authorities have the power to exclude any taxes or duties from these vessels, except for health checks, lighthouse and buoys and rescue charges (Soysal, 1983). In the Montreux Convention, it has also been seen that there is not enough focus on life, property, environment and safety of navigation.

The current legal regime that regulates the freedom of navigation and voyage in the Turkish Straits is the Montreux Convention. The Turkish Straits are the sea areas where the freedom of passage is practiced. By fulfilling various obligations, merchant ships, benefit from this freedom of movement regardless of the day or night, regardless of their flag and cargo. Actually, the main measure of the freedom of passage in the Turkish Straits is sea navigation freedom (Montreux convention: m.1 and m.2/1). Today, however, freedom of passage is a innocent passage[2] when evaluated together with the

[1] *The transit regime is a norm that gives broader rights to ships, narrows its liabilities and thus restricts the powers of coastal states a bit more than the innocent passage (Aybay, 1998).*

[2] *The* innocent passage *is a transition that does not violate the security of the coastal state, peace, well-established order (1982 Maritime Law Convention, Article 19).*

elements of environment and safety, and there are elements of innocent passage (Akten, 2011).

- Making harmless navigation,
- Compliance with formalities,
- Obligation to pay taxes, fees (Montreux Convention, m.2/1 and 2/2),
- Obligation to fulfill notices (Turkish Straits Regulation, m.6; IMO Resolution A.851(20)).

When we take these factors into consideration, it turns out that according to the United Nations Maritime Law Conventions state has right to prevent the non-harmless transitional passage. This right in the Montreux contract can also be the case if the formalities are not respected (Akten, 2011).

The Montreux Straits Convention is discussed in more detail in the relevant section.

4. Developments Related to the Navigation Regulation in the Turkish Straits after the Montreux Convention

From the Montreux Convention, the volume of local maritime traffic has reached very critical dimensions as far as the day-to-day north-south traffic is concerned. In the meantime, with the increase of the tonnage of the vessels, the amount and diversity of the cargoes transported increased. In particular, the number of vessels carrying dangerous cargo passing through the straits has also increased. All these developments necessitated changes in the maritime traffic patterns in order to increase the safety of life, property, environment and navigation in the Turkish Straits.

The increasing density of sea traffic in the Straits caused the sea accidents in the straits to increase. These elaborate incidents have mobilized the authorities and the opinion of the technical committee established within the Ministry of Transport adopted the idea of passing the "Right-Hand Navigation Regime" instead of the "Left-Hand Navigation Regime" in effect in the straits and taking the traffic under control. Thus, the left-hand navigation system used for many years in the straits started to be used as a navigation system on the right from 1.5.1982.

5. 1994 Statute Regarding the Straits and Sea of Marmara Traffic Regime

This regulation was prepared on July 1, 1994 to carry out traffic regulation in order to ensure the safety of navigation, life, property and environment in the Straits and Marmara region. By 1994 the traffic separation scheme was established in the Straits and Marmara region. It is also stated that all the vessels in the region of the Straits shall be obliged to comply with the warning and supervision to be made to all kinds of navigation rules determined by this statute. It is stated that "*the vessels that will make the strait pass will give the Sailing Plan 1 (SP 1) for 24 hours to the strait mouth and for 2 hours or 20 miles to the strait mouth (whichever is earlier) VHF with Sailing Plan II (SP2) to the Traffic Control Station*". Traffic Control Centers and Traffic Control Stations were established for the application, supervision and operation of the reporting system. For the Turkish vessels whose length is 150 meters or more, the obligation to take pilot is imposed, while the foreign flag vessels are warned to take pilot in terms of security. In the strait passages of the ships, instead of the narrow channel navigation rule, the navigation rule in the traffic separation scheme is started to be applied in accordance with the COLREG (*"International Convention for the Prevention of Collision at Sea"*) Rule 10. In addition, in the 1994 regulation, the authority was given broad authority, to the measures to be taken by the ship's captains during the passage from the straits, the speed of the ships passing through the straits, the ship conditions being raised, the towing procedures, the technical situations of the ships to pass through the straits or under what circumstances[3]. The Traffic Separation Scheme and Reporting System established by the 1994 Straits Regulation was approved by the International Maritime Organization (IMO) with some rules.

There have been various objections by Greece and Bulgaria, especially Russia, to these arrangements for traffic safety schemes for securing the safety and order of transport in the straits, the size of vessels passing through the straits and the obligations for the cargoes they carry (Güneş, 2007). The Constitutional provisions on which these objections are based the requirements of articles 7 and 8 of the navigation plan I and II, article 29 of the relevant on large ships, article 30 of nuclear power, nuclear, dangerous, harmful cargo and waste ships, article 31of the relevant compulsory pilotage and article 24 for the stopping traffic by compulsory reasons (Özersay, 1999). There upon Turkey, reviewing the 1994 Regulations in 1998, has prepared a new regulation named "Turkish Straits Maritime Traffic Regulations entitled".

1994 The By-Law on the Turkish Straits Traffic Separation Scheme entered into force and there was a visible decrease in sea accidents. Especially according to the 1994 accident statistics, it was seen that in the first six months of 1994, there were 10 accidents in the Istanbul Strait, while the regulations went into effect and only 2 accidents occurred in the second six months of 1994 (Bakırcı ve Etyemez, 2005).

6. 1998 Turkish Straits Marine Traffic Regulation

Turkey has made some changes to the 1994 Regulations as a result of the interviews made in the IMO. With the 1998 Regulation, unlike the 1994 Regulation, serious changes were made in favor of commercial vessels. In the transitional order brought by the 1998 Regulation, the lower limit for large vessels was 150 m, while in the new regulation it was increased to 200 m. In the definition of deep draft vessels, the old statute was based on 10 m while the new one was raised 15 m. Thus, more ships passing through the straits would be able to switch subject to fewer restrictions (Toluner, 2004). We will touch on some other important items[4]**;**

Article 31 of the 1994 Regulation ruled that Turkish vessels of 150 m and greater had to take the pilot, creating a privileged position against the ships of other countries using the Straits. However, with the 27th article of the 1998 Statute, it was "highly recommended" that all the ships wishing to make a "non-stop passage" had to take the pilot.

Another change in the statute concerned the passage of ships carrying dangerous cargo. Article 42 of the 1994 Regulation states that when a large ship carrying a dangerous cargo enters the Istanbul Bosphorus, no other vessel of the same nature will be taken in.

[3] *For the text of the 1994 Regulations, see Official Gazette, Date: January 11, 1994. Issue 21815; See for Changes see Official Gazette, Date: 21.6.1994, Number: 21967.*
[4]*For the text of the 1998 Regulations, see Official Gazette, Date: November 6, 1998, Issue: Repetition 23515.*

However, in 1998 Regulation 25/c, there was a suspension of the strait traffic in a certain area so that certain vessels carrying dangerous goods or certain items could pass safely. Again in 25/d, after entering the Bosphorus for a certain distance, it was possible for a same kind of ship to enter the bosphorus. In addition, vessels with various length and draft, which has sail difficulty, are obliged to submit the SP-1 report within the periods specified in paragraphs a and b of article 25. In another item, the criteria for current and visibility in the Statute are set at different limits than the old statute.

One of the biggest differences between the new regulation and the former regulation is the use of non-stop transitional provision for transit. This difference further complies with article 2 of the Montreux Convention. The Montreux Convention foresaw the transit and freedom of navigation for merchant vessels as mentioned above. This regime is not a transit regime, it is a unique transit system (Turan, 2001).

Along with this arrangement, the Traffic Separation Scheme approved by the IMO and prepared for the Turkish Straits and the ship reporting system called the Turkish Straits Reporting System have begun to be implemented. With this application, a considerable decrease in the number of accidents in the Turkish Straits has been observed.

7. Other Developments Related to Navigation Safety in the Turkish Straits

The Turkish Straits Vessel Traffic Services System (VTS), supported by radar, was in operation in the straits on December 30, 2003 as part of efforts to increase the safety of the Turkish Straits, increase the safety of life, property and environment, observe the vessels, and take some physical measures in order to plan traffic organization. Firstly, with the VTS consisting of two centers; Istanbul Vessel Traffic Services and Çanakkale Vessel Traffic Services; significant contributions have been made by providing national and international rules related to maritime traffic in the Turkish Straits, contributing to the effective and rapid intervention in case of an accident, organizing traffic, providing navigation aid service and information service. The components added in 2008 were expanded to include the "*Traffic Separation Scheme*" in the Sea of Marmara and it was possible to monitor the ship traffic on the entire Turkish Straits (KEGM, 2018).

In order to increase the safety of navigation, goods, life and environment in the Turkish Straits area on the experience gained by passing of the Turkish Straits Vessel Traffic Services on 30.12.2003, some changes were made in this instruction and in 11.10.2004 it is combined with "*The rules that will be implied to the ships in case of Grounding, Break down and other accidents in the Turkish Straits Region*", a new "*Turkish Straits Maritime Traffic Regulation Implementation Instruction*" entered into force with the Ministry no. 28415 dated 26.12.2006. In the application instruction prepared for the purpose of being a more descriptive and detailed guide for the implementation of the articles of the Turkish Straits Marine Traffic Regulation; the regions between Kanlıca-Vaniköy in the Istanbul Strait and Nara-Kilitbahir in the Çanakkale Strait are defined as critical regions. If some of the articles of application instruction will be mentioned;

In article 3, it is stated that, in addition to the magnetic compass, the vessels passing through the Turkish Straits will operate properly in the Gyro Compass, Radar (s) and Automatic Identification System (AIS) as specified in SOLAS and its annexes. In article 4, it is stated that if the non-passing transit vessels are kept in the anchorage areas for more than 48 hours due to traffic organization and / or negative air and sea conditions made by the VTS Centers, their non-stop transit will not be ruined. In article 8, where the VTS temporarily suspends the traffic of the Straits either from one direction or from both directions; due to bad weather conditions or force majeure conditions, the criteria for the removal of vessels at risk to the Straits are explained. Article 12 states that all vessels carrying dangerous cargo, 500 GT and above for vessels and reserve vessels that pass through the Turkish Straits will have a P & I insurance. Article 14 refers to the transit rules of the vessels, except that the vessels carrying dangerous cargoes 200 meters or more in full length are temporarily suspended from the sea traffic during the passage through the straits and can be planned to pass through during the daytime period.

The fact that the density of sea traffic in the straits is so high, the increase in the length and tonnage of the ships, the increase in the number of ships carrying dangerous cargoes, the current and climate conditions make the Turkish Straits from the challenging sea areas. Within this scope, it is seen that many national and international regulations have been made in order to maximize the safety of navigation, life, property and environment in the Turkish Straits which are the most important waterways open to international maritime traffic. In particular, the 1994/1998 regulations regulating the transitional rules in the Turkish Straits, the VTS, which was inaugurated in 2003, and the revised implementation of these regulations in the following years have increased the safety of the straits and thus achieved a significant decline in sea accidents.

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THE MONTREUX CONVENTION AND EFFECTS AT TURKISH STRAITS

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1. Introduction

The term "Turkish Straits" is used to cover the Çanakkale Strait (Dardanelles), the Sea of Marmara and the Istanbul Strait (Bosphorus) in international regulations concerning these straits. Although the Sea of Marmara is a sea subject to inland water regime, this assessment becomes important in matters other than transportation. In terms of transition, the Çanakkale Strait, the Sea of Marmara and the İstanbul Strait, which connect the Aegean Sea and the Black Sea, have always been regarded as a whole (Toluner, 1996a,b). It is an international waterway with the feature of connecting two open seas. Due to this nature, transiting from the Turkish Straits is not national but international (Gündüz, 1998).

The total length of the Turkish Straits is 163.74 nautical miles, with the İstanbul Strait 16.64 nautical miles and the Marmara Sea 111 nautical miles and the Çanakkale Strait 37.1 nautical miles. The term Turkish Straits first took place at the beginning of the 1923 Lausanne Straits Convention and was repeated at the beginning of the 1936 Montreux Straits Convention. This term is used only for the purpose of joint transit regime from Istanbul Strait, Marmara Sea and Çanakkale Strait. However, this does not remove the separate geographical and legal assets of the three marine areas in question.

The main international waterways available in the world are; Suez Canal, Panama Canal, Kiel Canal, Danish Strait, Strait of Gibraltar, Strait of Magellan and Turkish Straits. The sum of the total settlements near canals and straits other than Turkish Straits is much less than the population of Istanbul. This situation dictates that Turkish straits should be more sensitive and special than other straits in terms of safety.

The Turkish Straits, since 1774 Treaty of Küçük Kaynarca has been the main focus of the problems and threats posed against Turkey and also have generally been a geographic reason increasing the jeopolitic and jeostrategic importance of Turkey (Soysal, 1994).

There is no general definition of strait in international law practice. However, judging from the evaluation of the teaching (Pazarcı, 2009), It is possible to state the legal definition of the straits as; "a natural sea route connecting two marine areas between land fragments". According to some characteristics of the Straits, there are two main groups: "national straits" and "international straits" (Pazarcı, 2001).

Article 37 and 45 of the United Nations Convention on the Law of the Sea (UNCLOS) states that "straits in the open sea or a part of the exclusive economic zone and another part of the open sea or exclusive economic zone, or the waterway connecting the open sea or the exclusive economic zone and the territorial waters of a state". Article 39 of the UNCLOS regulates the right of transit passage in the Straits for all ships within the scope of freedom of navigation (Akın and Bayer, 2018).

Transiting from the Turkish Straits, which is an international waterway, is not national but international regulation because it links two open seas (Gündüz, 1998). The term “Straits Open for International Navigation” is used in teachings and it is used as “*Straits Used in International Navigation*” “*(servant à la navigation internationale)*” in international law documents. The straits, subject to international legal rules, that link two open seas and one or more states with coasts and are included in the territorial waters of the entire coastal state / states, are described as international straits. On 9th April 1949, the International Court of Justice stated in "the Decision of the Corfu Channel Case" that "geographical situation" and "being used for international navigation" are the decisive elements in such straits (International Court of Justice Reports, 1949).

2. The Turkish Straits' Legal Position in the Lausanne Peace Treaty

The Republic of Turkey has entered a new era in Turkish Straits on completion of the acception and ratification process of the Lausanne Peace Treaty. The Lausanne Peace Treaty was signed on July 24, 1923 among France, Greece, Italy, Japan, Romania, Turkey, United Kingdom and Yugoslavia Governments. The 23rd Article contains the fundamental principles of the transitional regime of the Straits. The states which had signed the treaty with this article and the "Signature on the Procedure Subject to the Straits" (Lausanne Straits Convention) signed on the same day which had been attached to the treaty and having the same legal value as the treaty. The principle of freedom of movement on peace and war, sea and air access in the Çanakkale Strait, the Sea of Marmara and the Istanbul Strait had been accepted in the Lausanne Straits Convention. However, with the Lausanne Treaty, on one side the right of passage from sea and air was accepted. On the other side, the Straits Region was demilitarized and some rights was transferred to the "Straits Commission", a joint committee of experts, to which Turks as well as foreigners were involved.

Thus, the transitional regime the Straits was going to be subject to, had become subject to the international laws which was emerged not by the sole will of Turkey, but with common will of many states that had been continueing since 1841. According to the provisions of the Lausanne Straits Convention in this framework, the term "Straits" includes the "Çanakkale Strait”, “the Sea of Marmara” and “the Istanbul Strait". While the right of passage has been allowed for the merchant ships, civil airplanes, warships and war planes during the times of war and peace and in times of peace and in all wars where Turkey remained neutral (Akın and Bayer, 2018).

In the Convention, demilitarization of the Straits area was accepted and foreign states had the right to pass their war ships to the Black Sea. With 18th Article that was written to avoid creating a disadvantage for this situation in Turkey, meaning in order to ensure Turkey’s security, in case of any violance of right of passage or any threat of jeopardizing the security of demilitarized territories, the joint intervetion of the Contracting States, according to the decisions of League of Nations, was foreseen. However, later, the developing new political environment and rapidly evolving armament efforts in Europe, has caused the provision for ensuring the security of Turkey appeared to become inoperable. Against, besides changing political conditions, Japan’s, one of the countries that had assured security brought by the Lausanne system, leaving of League of Nations and quick decisions that has been encountered in international platforms, Turkey, in the note sent to the Contracting Parties in 11 April

1936, requested the changes it wants to be made in "Lausanne Straits Convention" to be discussed at a conference. Turkey has put forward the following considerations as grounds to request this change (Vank, 1998):

- The fast-growing arms race in Europe in the 1930s,
- Political situation's being changed compared to 1923, especially the insecure environment seen in Mediterranean causing an important threat to Straits, therefore, Turkey,
- The incompetent attitude of the League of Nations against Italy's attack on Abyssinia in 1933,
- The difficulty of the application of the security that the Lausanne system had brought to the Straits, especially after Japan had left the League of Nations,
- In Lausanne, only the regime to be applied during the times of war and peace was stated but the feeling of the threat of a war had not been mentioned and in such situations, the necessity of recognition of the self-defense rights in order for Turkey not to be defenceless.

Considering these reasons, to ensure the integrity of the country and the Straits, demilitarization, which is made by the Lausanne system that aims to end the provision at the request of Turkey, "the Lausanne Straits Convention" which was accepted by the remaining Contracting Parties to outside Italy. From 22 June to 20 July 1936, international conferences gathered in the city of Montreux, Switzerland, were dealt with and work began to organize a new legal regime for the Turkish Straits (Vank, 1998).

3. Legal Aspect of Turkish Straits Determined by Montreux Straits Convention

The Montreux Straits Convention[1] has the rules about organisation of the framework of protecting the transition in the Turkish straits, the security of Turkey and the security in Black Sea coast. The Convention had been signed between Bulgaria, France, Greece, Japan, Romania, Turkey, the United Kingdom, Union of Soviet Socialist Republics (USSR) (today Russia) and Yugoslavia on July 20, 1936, in Montreux, Switzerland, and entered into force on 9 November 1936 (Dz.K.K.lığı (Turkish Navy), 1966). The Convention was open to the participation of any State signing the Lausanne Peace Treaty, and Italy, on the occasion of which it took effect, signed the Convention on 2 May 1938. Japan, on 8 September 1951, declared that it had abandoned all the rights and benefits that might arise from the title of the state signing the Convention. After the collapse of Yugoslavia and the USSR (in 1991) and the acquisition of the Russian Federation and the status of the Contracting State of Ukraine, the present contract states of the Montreux Straits Convention are Bulgaria, England, France, Greece, Italy, Romania, Russian Federation, Turkey and Ukraine.

[1]"Istanbul Strait" is explained as "Blacksea Strait" in the official Turkish text of the Montreux Straits Convention, while it is stated as "Le Bosphore" in French text and "The Bosphorus" in English text.

The details of the important items of the Montreux Straits Convention has been stated below.

a. Major Articles of the Montreux Straits Convention

The Montreux Straits Convention consists of 29 articles, four annexes and one protocol. In the first part of the convention, the passage of trade vessels (Article 2-7), in the second part, the passage of war ships (Article 8-22), in the third part, the regulations concerning the passage of airplanes (Article 23) and in the fourth part, the general provisions (Articles 24-29) has been stated.

b. Provisions for the Transition of Trade Vessels

Article 2 of the Convention clarifies; the Straits are open to international navigation and will benefit from the right of passage and transit from the Straits without any procedure, regardless of day, night and flag. Pilot and tugboat services has left to be optional. However, services such as health checks, lanterns, light buoys and gate buoys, or other buoys have been compulsory during the transition. In the Montreux Convention, transit through the straits was arranged for three different conditions: peace, war and a near-threat of war.

According to Article 4 of the Convention, if Turkey is not belligerent in time of a war, regardless of flag and loads, all merchant ships, shall have a right of transit passage through the straits within the foreseen conditions in Article 2 (right of passage) and Article 3 (health certificate).

Article 5 of the said Convention declares that, in time of war, while Turkey is belligerent, merchant ships which are not belong to a country at war against Turkey, provided it does not help in any way the enemy, will benefit from right of passage of the Istanbul Strait. In case of Turkey's counting itself so close to a threat of war, each ship's entrance to the Straits during daytime and each passage from the straits, must be performed from the displayed route by the Turkish authorities and pilotage can be enforced if necessary but at free of charge, has been stated in Article 6.

c. Provisions Regarding Warships

Provisions relating to the passage of war vessels are located in the second part of the Convention. According to Article 10, when light waterships, small warships and auxiliary vessels connected to States which are or are not connected to the Black Sea at peace time if enter the Straits in the daytime and in conditions forseen in Article 13 and following articles, regardless of their flag, shall not pay taxes or fees and shall be given the right of passage. According to Article 11 of the Convention, the bordering states of the Black Sea are not subject to the limits of war ships' tonnage and class, these vessels can either pass on their own or in maximum two torpedoes.

According to Article 12 of the Convention; "it is forbidden for submarines to pass through the straits and leave the open seas. Limited rights have only be given to the states bordering the Black Sea, the submarines that had been built, repaired, restored or bought outside of the Black Sea, if have given notice to the Turkish Authorities in time, can pass on their own, during daytime and from the surface through the Straits".

According to Article 13 of the Convention, a preliminary declaration must be made through diplomacy to the Turkish Government so that war ships can pass through the Straits. The usual period of such preliminary notification shall be eight days for countries bordering the Black Sea and fifteen days for countries not coastal. This pre-notification will specify the location, name, type, number, and date of departure for the vessel to depart and, if necessary, for the return.

Article 14 of the Convention states that the maximum total tonnage of all foreign naval forces (warships, submarines, aircraft warships and large armored ships) that may be in transit in the Strait will not exceed 15,000 tonnes and that the forces may be no more than nine ships.

According to Article 15 of the Convention, the war ships, which are transit in the Istanbul Strait, will not be able to use the aircraft they may be carrying.

According to Article 18 of the Convention, the total tonnage that non-coastal states of the Black Sea can have in this sea at peace time will not exceed 30,000 tons, except in the conditions specified in the contract. Moreover, non-coastal states will not be able to stay in this sea for more than twenty-one days, regardless of the purpose of their presence in the Black Sea.

In time of war condition is explained in Article 19 of the Convention. If Turkey is not belligerent, warships in the Straits, with the conditions specified in Article 10 through the Article 18, will benefit from full freedom of transit passage and transportation. However, any warring state will be prohibited from crossing the Straits of war ships. War vessels acting according to a decision of the League of Nations; even if they belong to the belligerent states may pass freely from the Straits. If there is a mutual assistance treaty Turkey is a side to, even though the passing ships are belligerent ships, they can pass through the Straits.

Article 20 of the Convention states that, if Turkey is one of the warring parties in the event of a war, concerning the passage of warships, the right to act is fully recognized as Turkish Government’s will. According to this, Turkey can have the right to close the Straits for the other countries's warships or can remove the tonnage limit for the states that have not borders in the Black Sea.

In Article 21, in case Turkey consider itself in a very close threat of war, it is stated that Turkey has a right to apply the provisions of Article 20.

d. Provisions Regarding Aircraft Passage

Article 23 of the Montreux Straits Convention regulates aircraft transit. Turkish Government will show air routes for the transition of civilian aircraft from the Mediterranean Sea to the Black Sea and vice versa, except for the prohibited areas of the Straits. Civil aircraft will be able to use these routes by issuing a preliminary notice of three days in advance for occasional flights and a general preliminary notice stating the transition dates for regular service flights.

e. General Provisions

Article 24 states that the powers of the international commission established in accordance with the Lausanne Agreement of 24 July 1923 concerning the Straits regime have been transferred to the Turkish Government.

Article 28 explains duration and termination conditions of the Convention. According to the 28th Article, the duration of the contract will be twenty years from the date of entry into force whereas the right of transit passage will be an infinite number of years. If the Convention is terminated in accordance with the provisions of the said Article, the High Contracting Parties agree to represent themselves in a conference to determine the provisions of a new convention.

About the duration of the contract, in the 29th Article, it is stated that;

- Beginning with the entry into force of the convention, at the end of each five-year period, each of the high-ranking parties concerned may attempt to propose the amendment of one or more provisions of the convention,
- If there is no possibility of reaching a conclusion through diplomacy on these amendments; the high-level parties will be represented by a conference,
- Said conference shall decide by unanimity and four-thirds of the congruent high parties shall be sufficient.

4. Significant Features of the Montreux Straits Convention and Implementation of Marine Traffic Service Regulation in the Straits

The "International Bosphorus Commission" and the "demilitarized zone" established by the Lausanne Straits Convention were abolished by the Montreux Convention and the authorities of the International Commission were transferred to the Turkish Government. Turkish Straits that was unconditionally left to the sovereignty of Republic of Turkey with Montreux Convention, gained the status of an open international waterway transport. On the both side of the straits, which was demilitarized with Lausanne Treaty, Turkey’s right to make fortifications and contain soldiers is accepted (Ece, 2013).

In the Convention, right of passage is accepted for ships form the straits, during the peace time regardless of their flags and loads, day and night. However, unlike the harmless transit rights recognized by international customary law on war ships, the 1936 Montreux Straits Convention introduced restrictions on the total tonnages of the war ships, submarines, aircraft carriers and large armored ships, and their duration and tonnage in the Black Sea (Ece, 2013). Accordingly, the total tonnage of all foreign naval vessels that may be in the transit passage through the Istanbul Strait will not exceed 15,000 tons, and the forces will not be more than nine ships. The total tonnage of military vessels of non-coastal states in the Black Sea will not exceed 45,000 tonnes and war vessels of non-coastal states will not be able to stay in this sea for more than twenty one days. In any case, the war vessels transit in the Straits will not be able to use any aircraft that they may be carrying. The passage of military aircraft over the Straits is subject to the approval of the Turkish authorities and has the right to fly over the Straits, if they pass by the Turkish authorities. It is forbidden for planes and submarines to pass through the straits and leave the open seas. The Montreux Convention breaks down the passage of both merchant ships and war ships into three classes: peacetime, wartime, and war status (Ece, 2013). Thus, even in the case of closing war, about the passage of the warships form the Straits, Turkish Government is given the right to act in its own will.

According to Article 34 of the UNCLOS, titled "The legal regime of the open sea waters of international navigation”, coast to the straits use their sovereignty or authorities in accordance with the conditions laid down in this chapter and other international rules of law. Article 37 of the UNCLOS is about transit passage. Transit passage is applied to the straits used for international navigation between the open sea or a part of an exclusive economic zone and the other part of the open sea or another exclusive economic zone. According to Article 38 of the Convention entitled "the right to transit"; all vessels and planes in the straits envisaged by Article 37 of the aforementioned Convention shall enjoy the right of transit without an obstruction (UNCLOS, 1982).

In Article 17, it is expressed that all countries, whether or not coastal to the straits, shall consent to the innocent passage of international ships navigating through their territorial waters. According to paragraph 1 of the 19^{th} article of the UNCLOS, "the transition is innocent unless it harms the peace, order or safety of the coastal state". The passage of a foreign ship shall be deemed to have harmed the peaceful order or safety of the coastal state if any of the activities specified in paragraph 2 of Article 19 of this Convention has been carried out in its territorial waters. The passage becomes "harmful" if, according to clause h) of Article 19 of UNCLOS, any maritime accident that would occur during the passage of a ship is a threat to the environment, health and safety of life (UNCLOS, 1982).

Transit passage compared to innocent passage; is a transitional regime that gives wider rights to vessels, narrows its obligations more and further restrains the authority of the coastal state. Turkey, although is not a party to UNCLOS 1982, thanks to Montreux Convention, has been able to exclude the transit passage regime UNCLOS has been applying on other countries bordering the straits from its own straits. Thanks to Montreux Convention, Turkey has a much broader rights compared to other states that has a shoreline to Straits. The application of these restrictions to the innocent passage in the world or only in the Turkish Straits shows that the transit regime in the Montreux Convention is unique ("sui generis") (Toluner, 1996a, b).

Montreux Convention limits Turkey's sovereign rights in the Straits Area for transition only. Provided that they do not contradict the provisions of the Montreux Convention, adhere to general international principles and do not touch the essence of the right of passage through the Straits; in subjects that had not been regulated in the Convention such as prevention of marine pollution, arrangement of maritime traffic without damaging the principle of freedom, Turkey’s authority to police and jurisdiction of asking innocent passage and regulate the transition has been reserved (Toluner, 1996a,b). Turkey’s regulating without disrupting the passage through the straits or disrupting in the least possible way, in order to ensure navigation, safety of life and property and environmental security, is suitable to both Montreux Convention and the spirit of the international rules. Considering this, "Regulation on Marine Traffic Regulation of the Straits and Marmara Region" was enacted on 01.07.1994 in order to provide navigation, life and property safety and environmental safety in the Turkish Straits, and to reduce the risk of accidents and to regulate the marine traffic in this area. This regulation was revised in 1998 and reinstated as "Turkish Straits Marine Traffic Regulation". The "Traffic Separation Scheme" organized by the International Maritime Organization (IMO), organized according to the 10^{th} rule of the International Regulations for Preventing Collisions at Sea (COLREG 72), were established in the approach of the Turkish Straits and maritime traffic control stations were established in Istanbul and Çanakkale Straits and "Turkish Straits Report System (TUBRAP)" was created. Traffic in the Turkish Straits, ensuring the vessels navigate within the Vessel Traffic Disruption Schemes, reducing the risk of accidents, meteorological and oceanography etc. to ensure that data are given to the vessels immediately. "Turkish Straits Vessel Traffic Services (VTS)" has been established to provide services such as transportation services and has been operational since December 30, 2003 (Akten, 2005).

5. The Importance of the Montreux Convention

The main objective of the Montreux Straits Convention, which entered into force on 9 November 1936; Turkish Republic that regulates the Straits, reconciles the requirements of international maritime trade and the benefits of preserving the sovereignty, with this sovereignty rights. With the Montreux Straits Convention, a new transitional regime has been adopted from the Straits. The implementation of the new regime and control responsibility has been given to Turkey. In this convention, considering Turkey's security interests, on Straits' usage by warships, benefits of bordering the Black Sea has been stated. With the privileges similar to these, Turkey has established its security. If it were not for the Montreux Straits Convention; in any threat of war, Turkey, was not going to be entitled to prevent warships to pass through the Straits, hence not being able to provide its own security.In case of any war in the region, Turkey was not going to be able to remain neutral, strong states was going to have the right to allocate big warships in the Black Sea and this situation was going to affect coastal states negatively and was going to cause Turkey to be under various pressures. For this reason, the Montreux Straits Convention is an important agreement that provides the necessary balance in peace and security in the Turkish Straits region (Tosun, 1994).

6. Conclusion

The Turkish Straits have been a political, military and economic struggle throughout the historical process and have maintained the great interest of the great nations, preserving its great geographical significance stemming from its strategic position for centuries. From the 15th century, when the Ottoman State had the Straits to the beginning of the 19th century, it determined the legal regime of the Straits as the only sovereign power over the Straits. The legal regime of the straits was determined by various international treaties and the great states of the period tried to gain advantage over the straits in the direction of their own interests in accordance with the loss of power by the Ottoman State from the first quarter of the 19th century.

It always maintained the importance of the Turkish Straits and the Black Sea in terms of the dominant states of Great Britain, Russia, France and Germany, and great political struggles were experienced between big states on this matter. In this context, the Turks were fully dominant over the straits from 1484 until the 1774 "Küçük Kaynarca Agreement", and for the first time in the history in 1809 with the “Treaty of Kale-i Sultaniye (Çanakkale)”, the Straits were introduced to a two-sided arrangement. 1841 with the "London Straits Convention", the legal regime of the Straits began to be determined by multilateral arrangements. As a result of the Ottoman State signing the Mondros Armistice on October 30, 1918 with the Entente Powers, the Straits were occupied by the Entente States. It was the annex "Lausanne Straits Convention" to the Lausanne Peace Treaty, signed in July 24, 1923 for rendering to free passage through the Straits. With this contract, a structure namely "Straits Commission" was established for the control and management of the Strait and this structure had also been linked with an international statute including Turkey. Thus, rights and powers over the Turkish Straits on its territory in the newly established Republic of Turkey was limited, literally.

In the years of 1930s political process, Turkey recoursed to the League of Nations by evaluating that Lausanne Convention on the Straits can not meet her security needs. Thus, on completion of the process, Montreux Straits Convention was signed in 1936. With this convention still in force by eliminating "Straits Commission" the right to sovereignty over the straits to Turkey was recognized. Turkey by utilizing the right of this convention has armed the Straits region.

The Turkish Straits, which have maintained its geopolitical and strategic importance for centuries, is now the straits that have been recognized the most authorization for the coastal state among the international straits, thanks to the "Montreux Straits Convention. It is clear that this Convention is a major political achievement for the young Republic of Turkey, who struggled with the newly hatched liberation war andgreat poverty. The Montreux Straits Convention is a powerful agreement that has survived since 1936, when it entered into force, and still remains valid, despite the period of big wars and crises, and the dissolution of the Soviet Socialist Republics and the Yugoslavia.

7. Evaluation

The Montreux Straits Convention, in force for 82 years, is the second most important political treaty for the Republic of Turkey after the Lausanne Peace Treaty. Montreux Convention, which is in force in this long process, ensured the security of the states bordering the Black Sea as long as the security of Turkey and the Turkish straits, and has become a symbol of stability in the Black Sea. Since the signing of the treaty on July 24, 1923, the contracting states have always been able to end up the convention, but none of the contracting states have been requested to do so till today. This suggests the idea that the contract is seen as an equilibrium at the same time.

If any of the signatory states now give the French Government a preliminary notice containing a request for termination of the contract, the contract will remain in force for two years from that date and then terminated. The French Government will inform the Contracting Parties of the preliminary request for dissolution. If the contract is terminated, the Contracting States will represent themselves in a conference to determine the provisions of a new contract as they agreed. A new contract may be signed at the conference to be held or the conference may end before reconciliation is reached. The problems that may arise from not signing a new contract are obvious. If a new contract can be signed which will determine the transit regime from the Turkish Straits, free transit and transportation conditions will be applied according to these new legal conditions.

However, a new conference to be convened for the reorganization of the passage from the Turkish Straits is likely to involve the United States, even though it is not one of the contracting states of the 1936 convention, and may even want to assume an active role. As is known, the United States continues to show flag and presence in the world's oceans with its fleet and armed forces. The USA has shown that it wants to implement the principle of freedom and continuity of international transport in its widest way without any limitation in the Turkish Straits and similar straits, in order to ensure that the scope of movement of its own fleet is not narrowed by its approaches to date. The fact that the United States, which its existence in the Black Sea depends on the conditions of the Montreux Straits Convention, has experienced in the past that it wants to have a say in the Black Sea. It is known that the USA is still in the same desire today. The US, politically standing against Turkey on many issues, especially Syria policy, has been implementing clear economic pressures since 2018. It is seen as a strong probability and evaluated that the USA would execute a policy against Turkey in a new conference to be held on Turkish straits. It should always be kept in mind that, in the probable new conference to be held on the Turkish Straits, decisions are likely to be contrary to Turkey's sovereign rights and it would not be possible that security needs would be met in accordance with the desire of Turkey.

If the Montreux Straits Convention is terminated and a new contract can not be concluded, there is the possibility of an instability period. However, in the Turkish Straits, as well as the sovereign state of Turkey's police and judicial powers to innocent passage is expected to continue as the authority to make.

Regulating the transition from two national straits with an internal sea, the Montreux Straits Convention, has combined the rule of the freedom and continuity of international transportation with the authorisation of Turkey. From this perspective, this contract, creating rights and obligations for states that use of the straits along with Turkey and Black Sea littoral states, is a political as well as legal document.

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EVALUATION OF THE MONTREUX CONVENTION IN THE LIGHT OF RECENT PROBLEMS

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The Turkish Straits have great political, economic and strategic importance. This importance is due to their geographical situation and the political interests connected to them. (Bilsel, 1948).The passage regime was regulated by the *Montreux Convention Regarding the Regime of the Straits* of 20 July 1936, which is legally considered to be one of the most important treaties concluded for the newly established Turkish State. The conclusion of the Treaty was regarded (Toluner, 2006) as a success in terms of Turkish diplomacy, as it was the peaceful amendment of the 1923 Treaty on the *Regime of the Straits of Lausanne*. (Meray, 1973). As noted by Gülsün Bilgehan "*Montreux Convention which was signed in July 1936 and gave control to Turkey, in the last days of İnönü's life, even on his deathbed, has been one of the most important symbols of independence*". (Bilgehan, 2015)Turkey's sovereignty and its full control over the Straits shall be turned over only after the Montreux Convention has been ratified.

Lausanne Convention on the Regime of the Straits had certain articles that restricted Turkey's sovereignty and security in the Straits. A 25-kilometre area on either side of the Straits was declared a demilitarized area and Turkey could not keep soldiers in the field in question. Due to the feeling of insecurity against Russia (not Turkey), it was not given up for demilitarization and a commission consisting of the United Kingdom, France, Italy and Japan under the auspices of the League of Nations (L.N.) was established to protect to Turkey against threats.

With the Lausanne Peace Treaty, the principle of freedom of transit and navigation, by sea and by air, in time of peace as in time of war, in the strait of the Dardanelles, the Sea of Marmara and the Bosphorus was accepted (art.23).

The passage through the Straits according to the Lausanne Convention, prepared in line with this principle, briefly regulated as follows: commercial vessels and aircraft would use complete freedom of navigation and passage by day and by night in peacetime; Turkey would have the right to control such vessel and aircraft traffic in wartime. There would be limitations on the passage of war ships and aircraft. These would not be greater than that of the most powerful fleet of the littoral Powers of the Black Sea existing in that sea at the time of passage.

The L.N., due to its own failure proved ineffective. Seeing its safety in danger, Turkey wanted to change the Straits regime at the London Conference on Disarmament for the first time in 1933. However, this suggestion was not welcomed (Meray and Olcay, 1976).

Turkey fulfilled the Lausanne Straits Convention's conditions in a peaceful way on the one hand, but her demand for changing the Convention was revealed in an appropriate manner in diplomacy (Erkin, 1968).

Italy, a member of the Straits Commission, attacked Ethiopia in 1935 and started the Dodecanese Islands armament. At the same time, Turkey considered that the time had come for the amendment of the Straits Convention and began to want fortifying Çanakkale. In 1933, Japan too, occupied Manchuria and withdrew from the L.N. Thus Turkey, while trying to change the Straits Convention signed at Lausanne, and based on the thesis *rebus sic stantibus*, demanded the reorganization of the Straits regime with a note given to the concerned governments. (Toluner, 1987). On this call, a Conference was held on 22 June 1936 in Montreux and the Convention was signed.

The Straits Commission was abolished by this Convention and the Commission's functions and powers were transferred to Turkey. The demilitarized zone on both sides of the straits was re-militarized. The night the Convention was signed, the Turkish army took over the control of the region. But here it should be underlined that the re-militarized zone is the "*Straits Region*". For the purposes stated in Article 1 of the Convention, the Straits Region is the "*Dardanelles, the Sea of Marmara and the Bosphorus*". This thesis is also assumed in the re-militarization of the Straits. It cannot be said that Lemnos and Samothraki islands are within the scope of the Straits. Apart from the fact that they are subject to the same demilitarization regime in Article 6 of the Lausanne Straits Convention, the source and purpose of the demilitarization obligation between the Straits and North Aegean islands is not the same.

Paragraph 1 of the preamble of the Montreux Convention of 1936, has been specified as "*desiring to regulate transit and navigation in the Straits of the Dardanelles, the Sea of Marmara and the Bosphorus comprised under the general term "Straits" in such manner as to safeguard, within the framework of Turkish security and of the security, in the Black Sea, of the riparian States, the principle enshrined in Article 23 of the Treaty3 of Peace signed at Lausanne on the 24th July, 1923*".

The purpose of the Montreux Convention is to regulate transit and navigation in the Straits in such a manner as to safeguard, within the framework of Turkish security and of the security in the Black Sea of the riparian States. Subsequent provisions of the Convention confirm and describe this principle in a concrete and detailed manner (Versan, 2006).

Its provisions are applied according to the distinction of the time of peace, time of war and the imminent danger of war and merchant vessels and vessels of war. The Montreux Convention basically accepts the *freedom of transit and navigation* by sea in the Straits and this principle limits Turkey's sovereignty due to freedom of transit and navigation. However, the passage of vessels of war, whether belonging to Black Sea or non-Black Sea Powers and in peace time and war time, are subject to the various restrictions such as tonnage, time and restriction of passage. Already the most sensitive and important part of the Convention is the chapter on the provisions of war ships. The Montreux Convention which has been in force for 82 years, has been applied by Turkey precisely and carefully both during the peacetime and the wartime and throughout Cold War period, in spite of the 1945 and 1946 Soviet notes (Özçelik, 2013). Turkey annually informed the signatory states of the Convention on the vessels passing through the Straits, the annual report titled Announcement of the Movement of Vessels Through the Turkish Straits and forwarded these reports to them without delay (Ünlü, 2002).

However, serious tensions have appeared in our region from time to time, although not caused by Turkey, and so the Turkish Straits issue became a current issue again. We can list the reasons for this as follows: *The problems that originated from*

Convention's becoming obsolete, the war vessels that can pass through the Straits, the increase of the Straits' traffic and cargoes carried by, the size of the vessels, the problems that may arise if the provisions regarding the amendment and termination of the Convention are passed on, the Montreux Convention and the Canal Istanbul connection.

Let's now consider each of these reasons. The first one is an assertion that has been mentioned relating to every new problem relevant to Montreux. Although the political, technological and legal fundamental changes that have been taking place since 1936 cannot be denied, these views have no legal basis. (Toluner, 2006) That is to say that, today the L.N. does not exist, but the United Nations (U.N.) has taken its place. However, the U.N. cannot fulfil the supervisory function (Article 21) of the L.N. in accordance with the Montreux Convention. But the fact that the disappearance of the L.N. does not mean that the supervision provided with the Convention is over. There are some procedures for this. (Toluner, 1989).

The United States (U.S.A.) and China, which have taken places in the U.N. system, are not part of the Montreux Convention. The U.S.A. attended the Lausanne Conference with observer status for the purpose of expressing its views, but it is not party (Howard, 1947)Hence, it is not true that it has not recognized the borders of Turkey. Lausanne is a treaty that identifies the border of Turkey. As a treaty that creates "*objective legal status*" (Toluner, 2005-2006), Lausanne yields results in non-party states. For this reason, as well as the States party to the Montreux Convention, the third States are obliged to comply with the provisions of the Treaty. The U.S.A. attended the conference with observer status and was able to oppose Russia's "*closed sea*" view. Therefore, if the passage regime changes, its "*relevant party*" title is recognized. (Toluner, 2006)

New ship classes emerged after 1936. This led to a number of different perceptions in terms of the comments of the contracting parties. The Montreux Convention, in particular, interpretation of the class of warships, is very important in terms of Turkey, which is in the position of being the supervisor of the Convention (Kurumahmut, 2009). In time of peace, light surface vessels, minor war vessels and auxiliary vessels, whether belonging to Black Sea or non-Black Sea Powers, and whatever their flag, shall enjoy freedom of transit through the Straits without any taxes or charges. (Montreux Convention, art.10) For the purposes of the Convention, the definitions of vessels of war shall be set forth in Annex II to the Convention. The definition is based on the limitations of the London Naval Treaty of March 25th, 1936 (London Naval Treaty, 1936). Today, however, weapons in vessels conforming to this definition are much more dangerous.

Aircraft carriers and submarines[1] (art.12) cannot pass through the Straits. The fact that in 1976 Turkey allowed the transit of the Kiev, through the Straits caused the protests among the NATO allies, including the United States of America (U.S.A.). Kiev was the first aircraft carrier constructed completely by the Union of Soviet Socialist Republics (U.S.S.R.) according to them. "However, having been quite aware of the fact that violating the Montreux Convention would not be good for its own benefit, the U.S.S.R. classified the Kiev as a heavy anti-submarine cruiser instead of an aircraft carrier." A similar crisis happened in 1991 when the *Admiral Kuznetsov*, passed through

[1] *The only exception is a submarine that is newly purchased or repaired, or war ships that visit Turkish ports.*

the Straits. Although this ship looked like a classical aircraft carrier in terms of its structure, the U.S.S.R. classified it as a heavy cruiser due to some weapon systems deployed on the ship. Some NATO member countries put serious pressure on Turkey not to allow this ship to pass through the Straits, but they did not succeed in this effort. Unlike Kiev-class ships, the *Admiral Kuznetsov* did not pass through the Straits again after leaving the Black Sea in 1991. In addition, objects like the Varyag and Leiv Eiriksson oil platform, which cannot move with their own propulsion, have passed through the Straits. Since they were not categorized as a ship and thus their transit was not subject to the provisions of the Montreux Convention. Therefore, the conditions of transit must be determined by agreement. (Toluner, 2006)There is no definition of "ship" in the Montreux Convention. All ships except for war ships were considered as commercial vessels.[2] (art.7) The Annex II is an also integral part of the Convention. Article 8 of the Convention refers to the characterization of war vessels and the definition of tonnage calculations in accordance with this Annex. Since aircraft carriers have been removed from the capital ships, their transit as an aircraft carrier will be contrary to the spirit of the Montreux Convention. In disagreements on whether or not a ship is an aircraft carrier there will inevitably be a dispute concerning the interpretation of the Annex II provisions. In this case, neither Turkey nor any of the other party can allege that its view is to be binding on the other party. In this regard, an agreement must be reached, and initiatives should be taken through diplomatic channels.

The solution, which has been discussed in various circles, is to make an analysis according to what is mentioned here and, in the Convention, because the parties, agreed to be attached to the definition the Annex II. If the Annex is seen to be outdated, it can be changed. The partial amendment procedure in article 29 of the Convention may be introduced. Therefore, here it is not possible to eliminate the parties' intentions based on principles other than those in the Annex.

If such an event occurs, Turkey’s obligation is to detect and report this event to the other contracting parties. This is not a guarantee but a supervision obligation. Turkey is not obliged to guarantee the execution of the treaty provisions such as the use of force to prevent passage.

Since the Turkish Straits are located on energy routes, the U.S.A. has tried alternative ways to control the Black Sea many times, and this Convention is intended to be dissolved and amended in various scenarios (Oğan, 2006). After the terrorist attacks on the Twin Towers on September 11, 2001, the U.S.A. carries the desire to have a warship in the Black Sea by requesting that the task force of maritime operations[3] to be enlarged to include the Black Sea. Turkey, however, contested this initiative by specifying that Black Sea Naval Cooperation Task Group (BLACKSEAFOR) can do it. The task of the *Operation Active Endeavour* is to keep the maritime transport trails under

[2] *The term "merchant vessels" applies to all vessels, which are not covered by Section II of the present Convention*.

[3] *Operation Active Endeavour (OAE) is a NATO effort to combat terrorism, whose aim and current functions are to deter, protect against, and detect terrorist activity in the Mediterranean. OAE’s area of responsibility was initially the Eastern Mediterranean, but since March 2004 its remit was extended to cover the whole area of the Mediterranean.*

surveillance and, if necessary, take action against suspicious ships. Currently, this function in the Black Sea is fulfilled alone under the name of *Black Sea Harmony*[4] by Turkey and evolved into a multinational operation with the participation of Russia, Ukraine and Romania. Along with these developments, Turkey and Russia have agreed that the Black Sea should not become a new field of struggle for global forces and that the Montreux Convention should not be amended in any way. Both Turkey and Russia have obviously and clearly expressed their determination on this subject. (Özbay, 2013)

The Montreux Convention became an issue in 2008 due to developments in Georgia. Russia recognized South Ossetia and Abkhazia who wanted to separate from Georgia. On the other hand, Georgia attacked the separatist Ossetians. As the Russian troops came to help Ossetians, there was a collision between Georgian and Russian troops in South Ossetia. The US used the *USS McFaul (a destroyer)*, the *US Coastguard Cutter Dallas (*a coastguard ship) and the *USS Mount Whitney* (a command ship) to transport humanitarian aid to Georgia in the Black Sea. The U.S.A. also made a probe to pass two giant hospital ships (*USNS Mercy* ve *USNS Comfort*) through the Straits based on article 18 (d) of the Convention. Despite the fact that no formal requests were made to Ankara for the passage of these two giant hospital ships through the Straits, the Turkish Foreign Ministry stated that the passage of the ships concerned was not in line with the Montreux Straits Convention and did not allow it. The US government did not welcome this situation. Many American warships that wanted to aid Georgia actually shuttled between the Mediterranean and the Black Sea due to restrictions imposed by Montreux.

Another crisis erupted during NATO's missile shield program to protect Europe against ballistic missiles originating from the Middle East. The U.S.A. Navy is equipped with ballistic missile prevention capability. The Black Sea is the best place to deploy these ships for shooting enemy ballistic missiles. The U.S.A. has the desire to deploy these vessels to represent the floating team of the missile shield program in the Black Sea. These points created a big debate. Restrictions on the provisions of tonnage and duration in the Montreux Convention have prevented American ships from being deployed under the NATO missile shield program.

In the dispute that began between Ukraine and the Russian Federation, Montreux has come back on the agenda. The Russian Foreign Minister has argued that the requirements of the Convention have not been fulfilled, as the length of time the US war vessels opened to the Black Sea through the Turkish Straits has been extended several times in contradiction to the Convention. The Turkish Foreign Ministry, responded that the claim that the ship *USS Taylor* has been in the Black Sea for more than 21 days is correct, but the said ship has been inactive due to damage, and the results of the repair efforts are failing, so that the ship was pulled over to the Aegean. According to Ministry the extension of time was reported to the Russian Federation and other signatories on time (Rapport Annual, 2014). Also, the other US warship *USS Truxtun* changed the date of its return through the Straits after entering the Black Sea, but this time it was not over 21

[4] *Black Sea Harmony is a naval operation initiated by Turkey in March 2004 in accordance with UN Security Council Resolutions 1373, 1540 and 1566 aimed at deterring terrorism and asymmetric threats worldwide. It is similar to the NATO-led Operation Active Endeavour in the Mediterranean, and aims at ensuring the security of the Turkish Straits.*

days in total and the Convention has not been violated in any way. In contrast, the Russian Foreign Ministry spokesman said that the explanation was satisfactory, and the issue was off the agenda (Yalçınkaya, 2014; Habertürk, 2014).

The increase of the Straits' traffic and the hazards caused by the size of the ships and the cargoes carried. According to the Ministry of Transport, Maritime and Communications 87 thousand 593 vessels have used the two straits as a transit route in 2017 (Deniz Haber Ajansı, 2017; Habertürk, 2012). While the number of vessels passing through the Straits between 2002 and 2007 increased, the number of ships passing through the Straits decreased due to the launch of the Baku-Tbilisi-Ceyhan Oil Pipeline in 2006 and the global economic crisis in 2008 (Deniz Haber Ajansı, 2017). In addition, there is intense local maritime traffic in the Bosphorus. The number of ferries and boats that cross between the two sides of the Istanbul in one day exceeds 2500. Moreover, numerous fishing boats and private sea vessels use this water continuously.

During the past years, not only the ship traffic has changed, but also, after technological developments, the sizes of ship have grown, and the quality of the cargo they carry has also changed. An important part of the vessels passing through the Turkish Straits carries toxic, dangerous and explosive substances (crude oil, ammonia, liquefied gas, radioactive substances, hazardous wastes etc.). Montreux does not contain any provision for pollution since the existing conditions did not yet constitute an environmental risk when the Convention was concluded. However, as a coastal state Turkey can use the power of the issue (Toluner, 2011). In addition, the Convention only limits the authority of the state to transit and navigation. There are no restrictions on the authority of the police and the judiciary[5] (Meray and Olcay, 1976). Turkey, while using these powers reserved at the Montreux Conference, should consider the generally accepted international law of the sea envisaged for straits in the same geographical conditions and it must resort to the innocent passage regime filling in the gaps of the Convention (Toluner, 1994). The current transit regime in present law is a concept that entered international law after the 1982 Convention. At the time when the Montreux Convention is concluded, the valid regime in such straits was innocent passage (Toluner, 1994).

Thus, jurisdiction on issues that are not within the scope of the Convention was reserved. (Toluner, 1989) When the preparatory works were examined, Turkey opposed practices that could touch the innocent passage and sovereignty (Meray and Olcay, 1976) and specifically retained its administrative and judicial jurisdiction over the Straits. (Meray and Olcay, 1976).

Representatives of the Turkish Delegation submitted a draft convention text, consisting of 13 articles, to the Montreux Conference on 22 June 1936. Article 12 of this draft, which concerned freedom of passage and navigation reflected Turkey's concern that none of the provisions of the Convention should by interpretation be broadened so as to breach Turkey's sovereign rights. The main concern of the Turkish Government was to retain administrative and judicial jurisdiction (Meray and Olcay, 1976). Turkey, by implementing policing or executive enforcement jurisdiction which was retained in the Montreux Conference, will also consider the general rules of international law of the sea

[5] *During the Conference, the desire to keep reserved these powers has been declared several times by Turkey.*

for the straits of this kind of geographical location. It can evaluate the innocent passage according to these rules and use the rights recognized by the international law to the coastal states. The gaps of the Montreux Convention must also be filled in the framework of these rules (Toluner, 1994; Özbek, 2004).

What kind of regulation does general international law of the sea rules provide? Current issues at this point can be addressed mainly by referring to the regulatory and enforcement powers of the coastal state and in particular the rules of safety of navigation and preservation of the environment. These are more common in terms of environmental protection and navigational standards. In this sense, in accordance with general international rules of law, States bordering straits may adopt laws and regulations governing international safety and maritime traffic, and other disposal of oily and hazardous wastes. They can accept sea-lanes and traffic separation schemes to ensure passage safety (1982 Convention, art. 22). The coastal state shall consider the recommendations of the competent international organization and comply with the generally accepted international law in the designation of sea-lanes and the prescription of traffic separation schemes.

The aforementioned generally accepted rules are the International Regulations for Preventing Collisions at Sea, 1972 (International Regulations for Preventing Collisions at Sea, 1977); The International Convention for the Prevention of Pollution of Ships, 1973/78 (United Nations Treaty Series , 1973) (United Nations Treaty Series, 1983); provisions concerning ship-based pollution of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (United Nations Treaty Series, 1977); The International Convention for the Safety of Life at Sea, 1974 (United NationsTreaty Series, 1980). These are regulatory treaties and contain provisions that are both technical and practical in their field, rather than those related to jurisdiction. By the time they have been concluded, they have left the subject of such jurisdiction to general international law in order to be able to capture developments and apply uniform rules (Tütüncü, 2007).

In this respect, Turkey adopted the Regulations on Maritime Traffic System for the Marmara Region in 1994, which aims to ensure safety of navigation and to establish traffic separation schemes. The main elements of the Regulation are gathered in three main headings such as report request, establishment of traffic monitoring stations, and traffic separation schemes. Some of the provisions of the Regulation reiterate the regulations in the rules already existing in the legislation (Arts.17, 27, 43 and so on) or practically applied and not met with objections (Arts.17, 27, 43 and so on). Some are new. The Regulation and its traffic regulations, while are generally regarded as a positive development, have been debated and criticized, as some items have not been reconciled with the Montreux Convention. It has been found that the Regulation, especially Articles 29 and 30, cannot be reconciled with the Montreux Convention. Taking this criticism into consideration, the Turkish Straits Marine Traffic Regulation (Official Gazette, 1998), which is a regulation containing new provisions, has been prepared and put into effect in 1998. The Regulation, as expressly stated, is based on the Montreux Convention and the spirit of Montreux. The arrangement in which the Regulation intended is nothing more than the authority that the law recognizes to coastal states to provide passage security and to regulate maritime traffic. In October 2012, an application directive related to the traffic in the Straits was put into effect. With this directive; the passage of dangerous cargo tankers and large ships, some rules of insurance documents have been introduced.

The Vessel Traffic Services System (VTS)[6] (Committee on Coastal State Jurisdiction Relating to Marine Pollution, 2000)created in this framework was also reported to IMO in 1997 and entered service in 2003. In 2008, the existing coverage of the system was expanded to include the Sea of Marmara. It provides information services, navigation assistance services, traffic regulation services and also helps to ensure regular and safe passage of information. With the implementation of the Turkish Straits Regulation and the Vessel Traffic Services System (VTS), accidents in the Turkish Straits have been greatly reduced and the successful implementation of the system has been beneficial to the navigation safety of the Turkish Straits. (Ece, 2013; İnan, 2014; Güneş, 2007). These arrangements were opposed by the International Maritime Organization (IMO), most IMO members and the European Union countries did not support these discussions and were eventually removed from the IMO agenda in 1999 (İnan, 2014).

Reports on the navigational order provided for in the Regulations on Maritime Traffic System also contain information on the cargoes of the vessels. The general principles of international law and conventions like the Basel Convention (The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal), to which Turkey is a party, give Turkey the right to request information regarding the cargoes of the ship.

Recently, the fight against terrorism within the scope of the international regulations has strengthened Turkey's position in this respect. For example, after September 11, 2001, *the Code of International Ship and Port Security (ISPS) Code*[7] (ISPS Code, 1998), *The International Convention For The Suppression of Unlawful Acts of Violence Against The Safety of Maritime Navigation (SUA)* (United Nations Treaty Series, 1988) and *its 2005 Protocol* (IMO, 2005) and NATO's security-related initiatives[8] are in this scope.

The 1998 Regulation has not prevented the freedom of passage envisaged in the Montreux Convention. There is no such thing as absolute freedom in the Montreux Convention. Unrestricted passage of this kind cannot function in terms of the purposes of the Convention. Turkey's regulatory measures are appropriate arrangements to the essence of the Montreux Convention and also facilitate safe passage through the Straits. Seeing the benefits of a globalized economy, the international community must also take an approach that promotes regulatory action, acknowledging the need to address environmental conditions in a global context. The same approach should also apply to

[6] *VTS is a service performed by a competent authority designed to improve the safety and effectiveness of ship traffic and to protect the environment. In 2000, IMO acknowledged that these systems are the main objective of future policies and represent the future.*

[7] *This service is carried out by the General Directorate of Marine and Inland Water Regulation. Turkey has been party to the Convention and Protocol.*

[8] *Operation Active Endeavour. Under Operation Active Endeavour, NATO ships patrolled the Mediterranean and monitored shipping to help deter, defend, disrupt and protect against terrorist activity. It was one of eight initiatives launched in response to the 9/11 terrorist attacks against the U.S.A. in 2001. It was terminated in October 2016 and succeeded by Sea Guardian.*

our Straits. States benefiting from the Straits, rather than just criticizing with economic concerns, there should be support for Turkey's security and environmental protection regulations.

Problems that may arise if the Convention has been amended and terminated: The Convention has been signed by Turkey, United Kingdom, France, U.S.S.R., Greece, Bulgaria, Yugoslavia, Romania, Japan and Australia. Italy, which did not participate in the conference, signed the Montreux Convention on 2 May 1938. Japan is no longer among the parties, although the text of the Convention has not actually changed. In this context, as the successor of the United Kingdom, the Republic of Cyprus has also attempted to become party by applying to the French government, which is the depositary state of the Convention. However, the Turkish Foreign Ministry has objected to this attempt (Toluner, 2007; Hoffmeister, 2006).

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A HISTORICAL VIEW ON TECHNICAL DEVELOPMENTS ON SHIPS AND EFFECTS OF TURKISH STRAITS

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1. Introduction

After the industrial revolution, instead of work force, machine power has been used. Especially in the 19th century, steam power was used in industry. The use of steam power has affected marine transportation. Vessels, which are used extensively for commercial ships, have been able to carry sea transportation between the distant locations. The coal usage caused air pollution. Heavy air pollution in the UK has caused respiratory diseases.

The fact that the Istanbul Strait was an important transit point in all ages continued in the 19th century. With the replacement of steam ships to diesel engines, transportation costs have decreased. The coal is replaced by fuel oil or diesel oil. Today, approximately 90% of the propulsion systems of the ships are carried out with diesel engines.

The development of ship propulsion systems has affected the Turkish Straits, which is one of the most difficult maritime transit zones in the world. In addition to different cargo vessels such as dry cargo ships, chemical, LPG-LNG crude oil tankers, passenger ships, military ships also pass their passes according to the Montreux convention rules.

2. Developments in Ship Propulsion Systems

The development of diesel engines has continued from the 19^{th} century until today. With the increase in diesel engine performance in commercial terms, 20-30% fuel economy has been provided in the last 30 years. Fuel economy and efficiency have directly affected air pollution in recent years.

In the second half of the 2000s, ship-induced air pollution has gained importance. Air pollution caused by exhaust gases from ship chimneys is being tried to be reduced by Annex VI of MARPOL (2009).

It is applied to the main engines of both existing ships and newly produced ships using various alternative methods for NOx emissions from ships. In this way, air pollution is reduced by reducing NOx amounts. Systems such as SCR, EGR, circulating and reducing NOx have started to become widespread.

For the SOx gas, another important greenhouse gas that causes air pollution, it is aimed to reduce the sulphur content of the fuels used by the vessels. In particular, greenhouse gases cause a significant environmental problem due to the adverse effects of acid rain.

Mass of the heaviest CO_2 gases released into the atmosphere, incorrect or incomplete combustion of CO gases formed consisting of black smoke also affects Turkish Straits.

It is planned that the amount of sulphur contained in the fuels used by years will be reduced from 1.5% to 0.1% from special emission control areas. According to Figure 1, it is aimed to reduce the sulphur content in the fuel from 4.5% to 0.5% in all regions except the special emission zones.

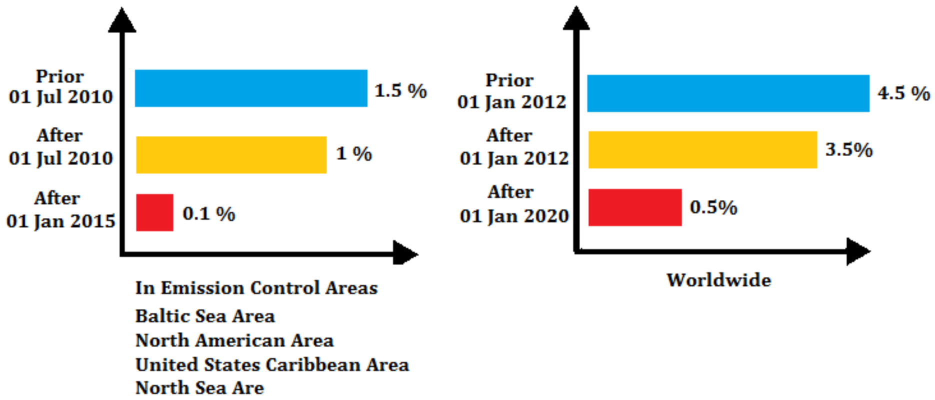

Figure 1. Fuel sulphur content limits (MARPOL Annex VI)

Today, the use of alternative fuels will become widespread in the near future, while the amount of fumigates in the fuels to be used today is low. Turkish straits are also affected by International Maritime Organization rules. In particular, both the reduction of air pollution and safe navigation are obligatory.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
İstanbul	54880	56606	54396	51422	50871	49798	48329	46532	45529	43544	42553	42978
Çanakkale	48915	49913	48978	49453	46686	45379	44613	43889	43582	43230	44035	44615

Figure 2. Annual statistics of the passing ships through the Turkish Straits from 2006 to 2017 (DTGM, 2018).

Passing ships via the Istanbul and Çanakkale Straits, which are more than 40000 annually, shows how environmental and safety requirements are important

(Figure 2). Considering the fact that this number, 420 vessels daily, is realized by the passage of passenger ships between Europe and Asia, the safety of the nearby cities becomes very important. In particular, a minor problem in the main engine and propulsion systems during the passing of merchant ships will cause a major accident.

3. Developments in Ship Auxiliary Machines

Two of the most important factors concerning the passage of the ship from the ship aids are the diesel generators and steering gear. Malfunctions that may occur in the generators that are required to produce the electricity needed by the ship will cause the ship to become blackout. For this reason, it is necessary to have emergency generators on board and the generators that are not used should be ready in case they can be activated at any time.

The traffic flow of the Turkish Straits must be complete from the technical point of view as well as the natural causes such as fog and current conditions. Therefore, regular maintenance of the vessels is required according to the planned maintenance system. ISM (International Safety Management) requires continuous testing of critical equipment and monitoring of working hours. It is important for the ship personnel to be ready for all kinds of scenarios that may occur during the crossing and to take the necessary training. Helm is the important auxiliary equipment that causes throat traffic and accidents in ships.

Hydraulic comes from the word Hydra, which means Greek ‘‘water’’. Water has been obtained from rivers since the first ages of history through mills. In the 17th century, French physicist Pascal found his laws. These laws laid the foundations of hydraulics. One hundred years later, the Swiss physicist applied the Bernoulli equations to examine the fluid in the pipe. With the industrial revolution, hydraulic has been used in various applications.

Marine hydraulic application began in 1906 with the use of pressurized oil in USS Virginia ignition systems.

Nowadays, hydraulic power is used in ships on cargo cranes, iron windmills, hatch covers and steering gear. In addition, hydraulic power is used in valve systems with hydraulic actuators. In particular, hydraulic power is used for the movement of steering systems. Steering gear, which is the most important equipment that determines the direction of the ship in starboard directions, is very important for throat traffic. Although steam power was used in 1950s, hydraulic systems are used in different tonnage ships (Andrew, 1991).

A hydraulic or electro-hydraulic steering system is shown in Figure 3 as;

- Rudder actuators,
- Power units,
- Hydraulic pumps and valves,
- Auxiliary equipment

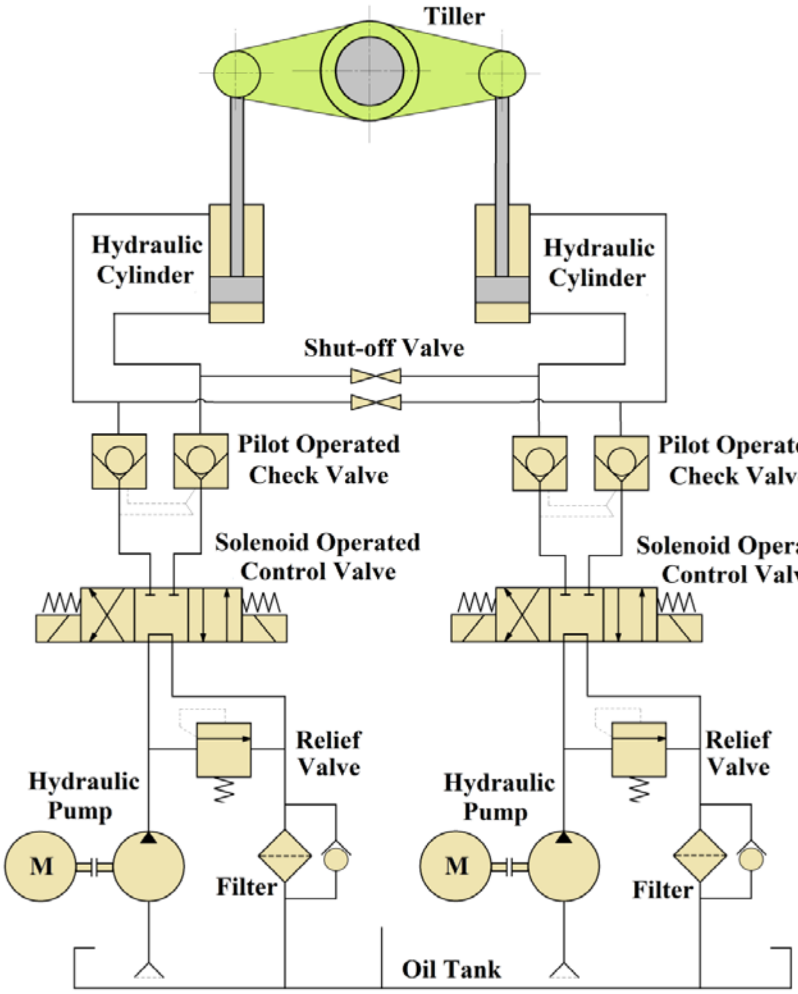

Figure 3. Steering gear structure (designed by author)

The hydraulic fluid is in a closed tank. There are two or four cylinders in the system. Hydraulic pumps and directional control valves in the system are controlled and oil is applied to the cylinder. With the power of the hydraulic piston, the steering gear is moved.

Over time, the standards for steering gear have changed. Various changes have been made in accordance with international maritime organization and class rules. In particular, SOLAS has obliged to equip at least two hydraulic cylinders.

The steering gear is expected to operate between 35 degrees pier and starboard in maximum speed and deep draft conditions. The rudder rig must be able to move from a 35-degree starboard to 30 degrees to 28 seconds. The steering gear must be controllable during an emergency.

4. Conclusion

Today, the main reason for the accidents in Istanbul Strait by the media is shown as steering gear. However, it is not easy for the system to fail. In case of negative situation in steering gear, in-ship trainings should be made for emergency position. The rudder must be tested before entering the strait. Necessary checks should be made, especially in the waiting periods of iron.

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CHAPTER 2

GEOGRAPHY, BATHYMETRY AND HYDRO-METEOROLOGICAL CONDITIONS

This chapter provides an outline of the background information regarding the geographic, bathymetric restrictions and hydrodynamic conditions along the Turkish Straits Sea Area. Wind and wave climate of the region has been reviewed. The Turkish Straits are not so shallow for navigation but their shape and seabed morphology are physical constraints defining the water exchange between the adjacent marine realms. Strong surface currents and eddies along the straits, limited maneuvering space due to sharp turns, and unpredictable weather conditions make it difficult to navigate through the Turkish Straits safely. Therefore, all kind of geologic, hydrographic, oceanographic, and meteorological data will be crucial for environmental researches and used for maritime transportation. Sea bottom topography along the İstanbul Strait, for example, reveals physical constraints that sailors have to pay attention during their navigation. Oil cannot dissolve in water, so its fate depends on the dominant oceanographic and hydro-dynamical conditions. Wind driven waves and currents move oil onto shore. Oil waste interacts with sediments, depending on its texture, and causes contamination along the coast. Research on the oceanographic conditions and water dynamics along the Turkish Straits Sea Area started with the early developments in the late 19th and early 20th centuries. Modern oceanographic measurement and systematic research programs, which could be merely established in the 1970's, have revealed general and widely different characteristics of the circulation system along the Turkish Straits Sea Area and the neighboring basins. Therefore, the circulation of the Sea of Marmara is coupled to the flow dynamics at both of the straits. The roles of two sills and a contraction in the İstanbul Strait, as well as the single contraction in the Çanakkale Strait, are understood in the establishment of two different water exchange regimes along these straits. As the current and wave conditions must be known in advance for safe navigation, hydrodynamic and wave climate characteristics of the region have been outlined. Numerical modeling of the currents along the Turkish Straits, which are rare natural phenomena of two-layer flow with opposing currents, is a necessary tool especially for predicting the paths of the oil spills.

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GEOGRAPHIC AND BATHYMETRIC RESTRICTIONS ALONG THE TURKISH STRAITS SEA AREA

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1. Introduction

The Sea of Marmara, connecting main maritime, highway, railway and air routes, is a crucial geopolitical region for transportation. For centuries, this inland sea has been one of the world's busiest crossroads of trade, civilization and legends. To the west, it is connected to the Aegean Sea via the Çanakkale (Dardanelles) Strait. To the north, it opens to the Black Sea through the İstanbul Strait (Bosphorus).

2. Geography of the Turkish Straits Sea Area

The term "Turkish Straits Sea Area (TSSA)", when practised in a geographical sense, is the contiguous elements of the İstanbul Strait, the Sea of Marmara, and the Çanakkale Strait (Figure 1). The TSSA is bounded by a hypothetical drawing between Kumkale (Çanakkale) (26°11'E) and Arıburnu (Eceabat) on the west that is also the western cut-off of the Çanakkale Strait from the Aegean Sea (IHO, 1953). The Sea of Marmara begins from a line joining the towns of Gelibolu (Gallipoli) and Çardak (26°43'E), describing the eastern termination of the Çanakkale Strait as well. The easternmost point of this inland sea is at the end of the Gulf of İzmit (29°57'E); which is also a waterway for oil carrying tankers. It is 48 km long and 2-3 km wide at the narrowest place. Including the gulf, the Sea of Marmara is 278 km long, and 75 km wide at the widest place. The Karanlık Bay in the Çanakkale Strait, where the River of Küçükmenderes discharges, is the most southern point of the TSSA (40°N). The Black Sea exit of the İstanbul Strait, defined by a hypothetical drawing between the Rumelifeneri and Anadolufeneri, is the northernmost (41°13'N) point of TSSA (IHO, 1953). The border between the Sea of Marmara and the İstanbul Strait is taken as a hypothetical line drawn between the Ahırkapıfeneri, a historical lighthouse still in use, and the Haydarpaşa Port, a general cargo seaport, ro-ro and container terminal.

The strategical geographic position turned the TSSA into a center of main terrestrial and marine transportation routes, and continuously hosting many civilizations throughout the centuries. It is a unique water route connecting the Black Sea countries to the Mediterranean world, which lies at the crossroads of three continents – Europe, Africa, and Asia. Through the centuries, it has led to the enrichment of the region parallel to the population growth in urban areas. Indistinguishably, the number of sea vessels and tankers traversing the TSSA increased significantly, depending on the increasing exports from the Black Sea countries mostly to the Middle East and North Africa. As of today, the TSSA is one of the world's busiest waterways.

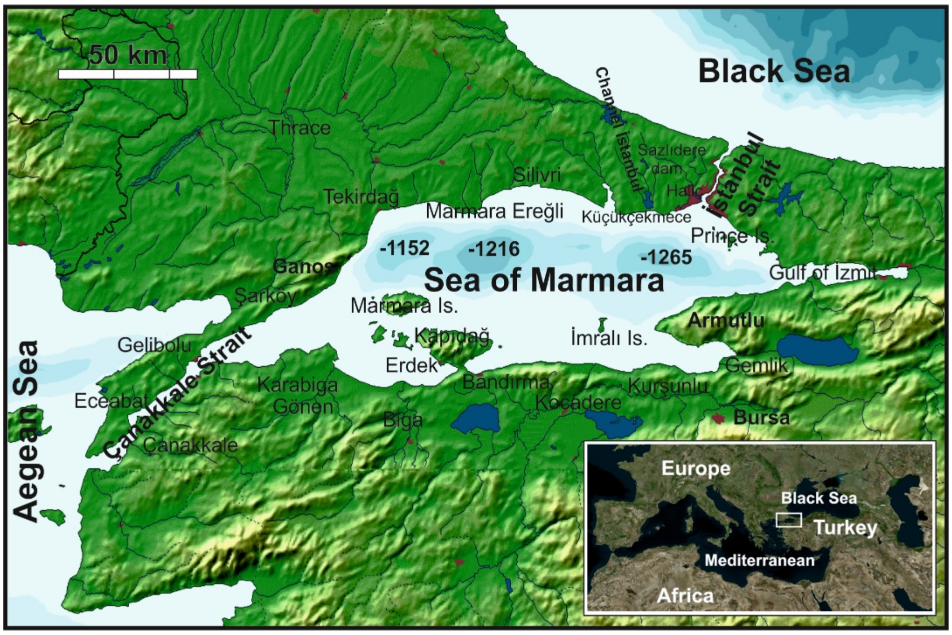

Figure 1. Location map of the Turkish Straits Sea Area (TSSA).

The surficial area of the Sea of Marmara is 11,200 km^2, excluding the Turkish Straits. The shelves, widespread at the southern margin, cover 57% of the total surface. The shelf is almost absent off the mountainous regions of Ganos and Armutlu Peninsula; two tectonically active elements. The continental slopes occupy almost 37% of the sea. The submarine canyons and valleys extend down to the -900 m water depths on the continental slope off Kapıdağ and Silivri. The deep-sea trough are about 6% of the total area and are located in a narrow and long trough oriented parallel to the main W-E trending tectonic strike. Three large and deep troughs are lined up along the tectonic lineament, and separated by some ridges in saddle shape. The maximum depths of the western (Tekirdağ), central (Orta) and eastern (Çınarcık) troughs, or basins, are 1152, 1276 and 1265 m, respectively (Yüce, 1993). The terraces scattered at different heights and the characteristic land and seafloor topography are because of the eustatic movements occurred in the Marmara (Sea/Lake), as well as dynamic and variable tectonic activities along the TSSA.

3. Coastal Landforms

The TSSA is widely surrounded by plateaus, with mountains and plains scattered among the relatively flat highlands. Characteristic narrow and long valleys observed between the towns of Eceabat and Gelibolu are formed by alluvial deposits in the paleo-rivers. The coastal plains around Şarköy extend parallel to the shore. The lagoons and plains on top of the alluvial deposits cover broad-base valleys between Tekirdağ and Istanbul, two biggest cities in Thrace. Coastal plains disappear at the surroundings of the İstanbul Strait. The plateau zone dominated along the southern coast is frequently interrupted by mountainous masses. The large alluvial plains formed by the Biga and Gönen creeks and those at Kocadere and Kurşunlu, east of Kapıdağ Peninsula, are the main geomorphological units on that plateau. In the south, plains extends along the river valleys and coastal strip towards the Gulf of Izmit (Güneysu, 2000).

The coastal zone of the Sea of Marmara is a 930 km-long dynamic area bearing various types of coasts and appearances shaped under the control of different natural agents (Erinç, 2001). The most common types are high and rocky coasts; with upper beach or backshore backed by cliffs; mostly shaped by waves and currents. As the rising sea level partially drowns coast, typical ria-coasts are formed along the Çanakkale Strait and the southern coasts of Istanbul, including 7.5 km long and 750 m wide primary inlet of the İstanbul Strait; the Haliç (Golden Horn) estuary.

The northern coastline is smoother and apparently less intended than the southern one. Compared to the eastern and southern coasts, the bays along the northern coast are small. The shoreline is shaped like two large arcs, meeting at the coastal headland of Marmara Ereğli. Steep and occasionally eroded cliffs take place at the edge of the Ergene plateau, with narrow shores and beach strips in front of them. On the contrary, low coastal plains and relatively wide beaches are dominated at the stream mouths, placed on broad to very broad valleys. The Ganos mountainous mass in the west interrupts this view; there a stretch of high and steep rocky shores descends abruptly into the sea. High coastal zone to the west of village Barbaros was composed of sequential fault facets. The lagoons of Büyükçekmece and Küçükçekmece are formed by the closure of old coves with sets. Under intensive anthropogenic pressure, most of the shores between Tekirdağ and İzmit have lost their natural appearance. Moreover, many new recreational areas and coastal infrastructures were added by performing coastal fillings (Güneysu, 2000).

The Gulf of İzmit is a 50 km long and narrow industrial area, separating the Kocaeli Plateau from the Samanlı Mountains. Low-lying beaches, partly interrupted by high-cliff coasts, are dominant. To the north, high shores and occasional cliffs take place on the Kocaeli Plateau, mostly split by short rivers. The eastern coast is low lying with marsh fields and alluvial deposits transported by the Yuvacık and Çuhahane creeks. The southern coast is intersected by deltaic protrusions; the alluvial deltas of Hersek, Lâle and Dilderesi (Güneysu, 2000).

The southern coast of the Sea of Marmara is more indented with patterns that are more diverse. The notched shores of the Kapıdağ Peninsula between the Gulf of Bandırma and Erdek Bay is high. This region is rather rich in water resources; fed by the streams of Susurluk, Gönen and Biga. There are large, low and straight coastal plains at the mouths of the rivers and submerged delta plains in the nearshore. The coasts of the Kapıdağ Peninsula is characterized by erosional coasts (N and SE), and depositional coasts (S and SW) (Gazioğlu et al., 2014). W and SW coasts are low alluvial areas, with a group of islands separated by shallow waters. Sandy sea bottom of the Erdek Bay is connected gradually with the southern Marmara shelf. At the SE coast, broader plains are located at the base of smoothly undulating mountains. The SE shoreline lies parallel with active tectonic lineaments, cutting the Belkıs isthmus. The Gulf of Gemlik is a tectonic trough developed in front of the shores under the control of an active fault belt. Narrow inward-curving inlets take place in front of small creeks and they are connected with small capes. Finally, ria-type northern coasts of the Kapıdağ Peninsula, open to waves, have high scarps that are intersected by deep and dense valleys. They are formed by C-shaped inlets, sandy beaches and coastal plains behind the inlets. These inlets are relatively small and highly convex. To the west inlets become bigger and wider, forming U-shape inlets. Outside the elevated coasts of the Kapıdağ Peninsula, the southern coasts form E-W linear extensions. The coastal belt extending between Karabiga and Gemlik is composed from younger marine deposits.

The Çanakkale Strait is a NE-SW-oriented 61 km long and narrow (max. 6.0 km) depression lying between the Biga and Gelibolu peninsulas. The narrowest part is 1.2 km between Kilitbahir and Çanakkale. The Çanakkale Strait is less indented than the İstanbul Strait. The length of its Anatolian (Asian) coast is 94 km; that is 16 km more than the Rumelia (European) coast between Seddülbahir and Gelibolu. There are local coastal plains along the short streams flowing to the strait. The coastal plains at Çardak, Umurbey and Lapseki provide fertile lands for farming. Low-lying coastal flats are also dominant at the Aegean Sea exit, with a delta formed by the Küçükmenderes River (Güneysu, 2000).

The Sea of Marmara has 38 islands, mostly belong to the Istanbul and Balıkesir provinces, and islets. They are gathered in two archipelagos, except a few scattered ones (Ertek, 2016). The Prince Islands archipelago, NE part, is a cluster of nine islands. The South Marmara Archipelago, including the Kapıdağ Peninsula that is connected to the mainland with the Belkıs isthmus, rises on the southern Marmara shelf. The most pronounced islands with inhabitants are Marmara, Paşalimanı, Avşa, Ekinlik and Koyunada. Meanwhile, there are many partly sunken and abandoned ghost ships along the TSSA coasts, posing serious environmental risk.

4. Oceanographic Conditions

Oceanographic data defines the bodies of sea, when practised in the sense of meteorological features, physical and chemical characteristics, environment dynamics and pollution, and transfer these deterministic data to mariners later on (Usluer and Alkan, 2016, 2017). The TSSA is sensitive to climatic changes. Taking into account the most characteristic meteorological features, it is a transition zone between the climate zones of "summer-dry Mediterranean" (hot / dry summers and mild to cool / wet winters) and "year-round wet, oceanic Black Sea" (warm/wet winters and cool to cold / wet summers) (Baltacı et al., 2015).

Modern and extensive oceanographic measurements along the TSSA started at the end of the 1970's. The first results on the fast counter flowing fluxes through the narrow Turkish Straits, responds of seasonal and inter-annual changes over the Black Sea, were presented by Ünlüata et al. (1990). Further studies indicated that the Sea of Marmara interacts with the neighbouring seas. The water exchanges in its straits are stratified turbulent flows, with important variabilities in and exit of the straits due to mixing and hydrodynamic processes. The instantaneous net volume transports through the İstanbul Strait, however, may have 3 times variability than mass balance estimations (Sözer, 2013).

The jet currents develop in southern exit of the İstanbul Strait and control the flow system in the entire Eastern Marmara Sea; superimposed on the “quasi-permanent surface circulation” in the Sea of Marmara (Chiggiato et al., 2012). The decisive role of the jet stream depends on the seasons and meteorological conditions. In addition, wind-stress forcing causes small-scale eddies with short-term variations.

The astronomical tides in the TSSA are low (Alpar and Yüce, 1998), while the average seasonal sea level variations in summer and winter are twice of the monthly averages (Yüksel et al., 2008). The sea level oscillations are highly variable along the coasts; changing from several days to weeks depending on the dominant winds along the system and partly on the barometric pressure over the Sea of Marmara. The sea level difference between the Black Sea and the Sea of Marmara controls the flow system and blockage events of upper and lower layers (Tutsak et al., 2016). Even though the recent studies have shown that the exchange flows are rather complex dynamically, the blockage of upper layer usually occurs in winter when the southwesterly winds of approaching storms are dominated (Gündüz and Özsoy, 2016). Majority of winds blow are from NE, while waves in the Sea of Marmara mainly come from SE. The blockage of lower layer is due to increasing of sea level in the Black Sea, usually in spring.

Due to its landlocked characteristic, the wave energy in the Sea of Marmara is rather low (Erdik and Beji, 2018). High-resolution numerical modeling of the currents along the Turkish Straits and in the Sea of Marmara, under the control of widely variable meteorological conditions, is an essential work particularly in prediction of paths of oil spills in case of maritime accidents (Beji and Erdik, 2018).

5. Submarine Geomorphology and Sediment Texture

Equivalent of land terrain, bathymetry is the most fundamental property of the seas. Bathymetric data is also very important for submarines to update their position without surfacing (Clarke, 2018). According to the International Hydrography Office (IHO), who is responsible for all bathymetric measurements of their members, hydrography involves measuring bathymetry and detecting all kind of navigational hazards in the sea. In normal conditions, this is done with research vessels operating single or multibeam echo sounders and special sonars; occasionally integrated with satellite monitoring. Shorter range and high-resolution geophysical systems are particularly important in exploring coastal geomorphology especially along the shallow areas and narrow straits, such as the Istanbul Strait, which is more shallow and indented, compared to the Çanakkale Strait (Figure 2). Based on long-term measurements, its geometry and submarine constructions, beyond other forcing mechanisms, define the hydrographic conditions of this strongly stratified two-layer system and the spatial and temporal changes of its currents, including reverse flow and secondary current systems (Yüksel et al., 2003; Özsoy, 2016).

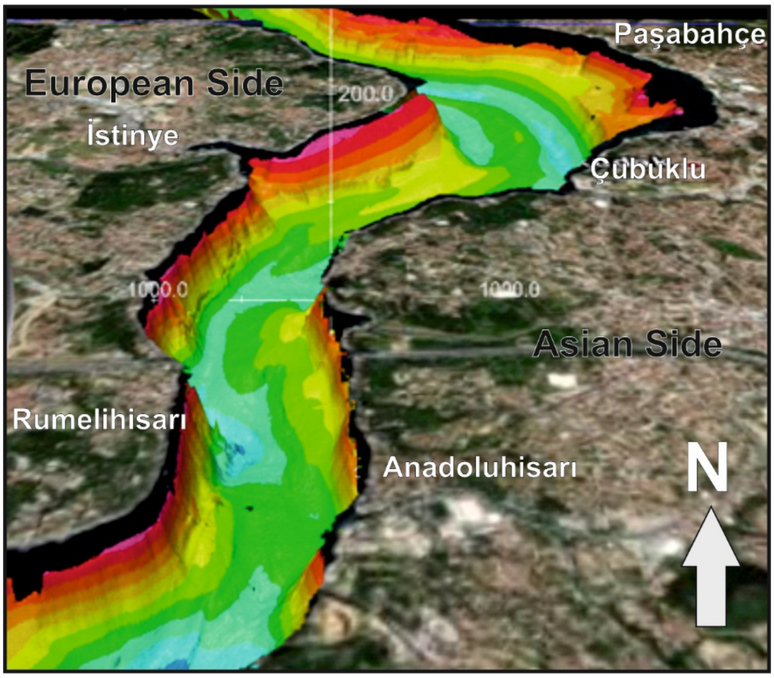

Figure 2. 3D view of the İstanbul Strait, a 30 km long S-shaped trough with steep banks and embayments (modified from Usluer and Alkan, 2016).

5.1. İstanbul Strait

The Istanbul Strait is bordered by the Europe in the west and the Asia in the east. Interestingly, the length of the Rumelia (European) coast is 55 km; that is 20 km more than the Anatolian (Asian) coast. Lack of equivalence between the coasts turns the lifeblood of the historic city of İstanbul into "the world's narrowest strait used for international tanker navigation" as stated in Disha Experts (2017). The narrowest part is 700 m wide between Kandilli and Aşiyan; there two amazing Ottoman fortresses have been built to cut the strait and as symbols of power (Figure 3). Surface currents coming from the Black Sea intensify at the narrows. Other narrow parts to navigate, with variable cross sections, extend between the towns of Arnavutköy and Vaniköy (800 m) and between the promontories of Tokmak (İstinye) and Çakal (Kanlıca).

The coastal structure is steeper and elevated in the areas where the strait becomes narrower (ONHO, 2000). Harbours and drowned river valley estuaries were formed in the stream mouths along the strait (Aydın, 2002). The shallowest part of the İstanbul Strait occurs at its N half. Shallow sand banks, for example, changes seafloor profile offshore Umuryeri and Paşabahçe (İncirkoyu). In fact, ships coming from the Black Sea have a tendency to travel faster than other directions (Altan, 2017).

The trough also becomes shallow at the southern exit off the tip of the Sarayburnu promontory; -28 to -32 m above the sill between Tophane and Şemsipaşa. This is a complex sand bar flanked by deeper (-40 m) channels, deepening gradually off Ortaköy, and turning this part of the strait to the most productive in terms of the kinetic energy potential (Öztürk et al., 2017). The deepest part of the strait is in front of Kandilli (-105 m) where it meets the contraction (Özsoy, 2016). The average depths are 70-80 m at the northern sector of the strait. A sill ~2 km north of the northern limit of the İstanbul Port (i.e. a line drawn between the Anadolufeneri and Rumelifeneri) is elevated up to -62 m water depth inside the natural canyon. The hydrodynamic behaviour of the Strait, including critical transitions at hydraulic controls, supports the maximal-exchange regime (Sözer and Özsoy, 2017).

From all appearances and coupling with the adjacent basins, the İstanbul Strait has really different and special geographic, hydrographic, oceanographic and meteorological conditions that could be easily influenced from seasonal differences. When considered in a geographical sense, the Turkish Straits are not only the narrowest sea passages of the world but also have many dangerous sharp turns (Akten, 2004; İstikbal, 2006), especially for shuttle tankers and container ships. Various sharp turns and narrows, such as the one between Kandilli and Aşiyan with an angle of 45° (Figure 3a), cause rapid changes in currents in addition to well-known mainstream currents. The current speed can reach 8 knots off the Yeniköy Point; where a sharp turn (70°) must be made at high speed by the vessels coming from the Black Sea (Figure 3b).

According to the hydrographic data from ONHO, sea bottom topography along the İstanbul Strait reveals first order physical constraints (i.e. sand banks, shallows, protected estuaries and inlets) that sailors have to pay attention during their navigation. On the basis of the year 2017 database released by the Transportation Ministry, 42,978 vessels (a total of 599,324,748 gross tons) passed through the strait; 24,059 with pilot help, 26,111 as innocent passage vessels, 4005 longer than 200 meters, 436 lower than 500 gross tones, and 8832 tanker. Almost one fourth of those vessels are crude oil tankers.

The İstanbul Strait is mostly influenced by the winds blowing from the NE sector (Beji and Erdik, 2018). Short-term changes mainly occur in autumn and winter. Strong winds and adverse surface currents, from the Black Sea to the Sea of Marmara, make navigation difficult particularly during spring and autumn. On the other hand, the mean sea level of the Black Sea is higher than that of the Sea of Marmara by a few ten cm, in normal conditions. Therefore, the upper layer in the İstanbul Strait reflects the typical properties of the Black Sea whilst the lower layer below 20-to-30 m water depth shows the Mediterranean characteristics. The upper layer carries the low salinity outflow from the Black Sea and the highly saline bottom layer flow from the Mediterranean into the Black Sea. The surface currents, which can reach 6-8 knots mostly during the persistent northerly winds and peak river discharges into the Black Sea, affect manoeuvrability of the ships coming from the Black Sea severely. The freshwater influx from the Black Sea also controls the current system mainly in spring and summer. The surface currents are most responsible for grounding and stranding (55% of all casualties) along the strait (Figure 4). At the southern exit, the current can reach at least 2.5 ms^{-1} at one m below the surface under extreme conditions (Yüksel et al., 2008). The jet-like flow at the strait's southern termination is effective above the lower water mass, and interestingly enough it controls the basin-scale anticyclonic gyre in the eastern Sea of Marmara (Beşiktepe et al., 1994).

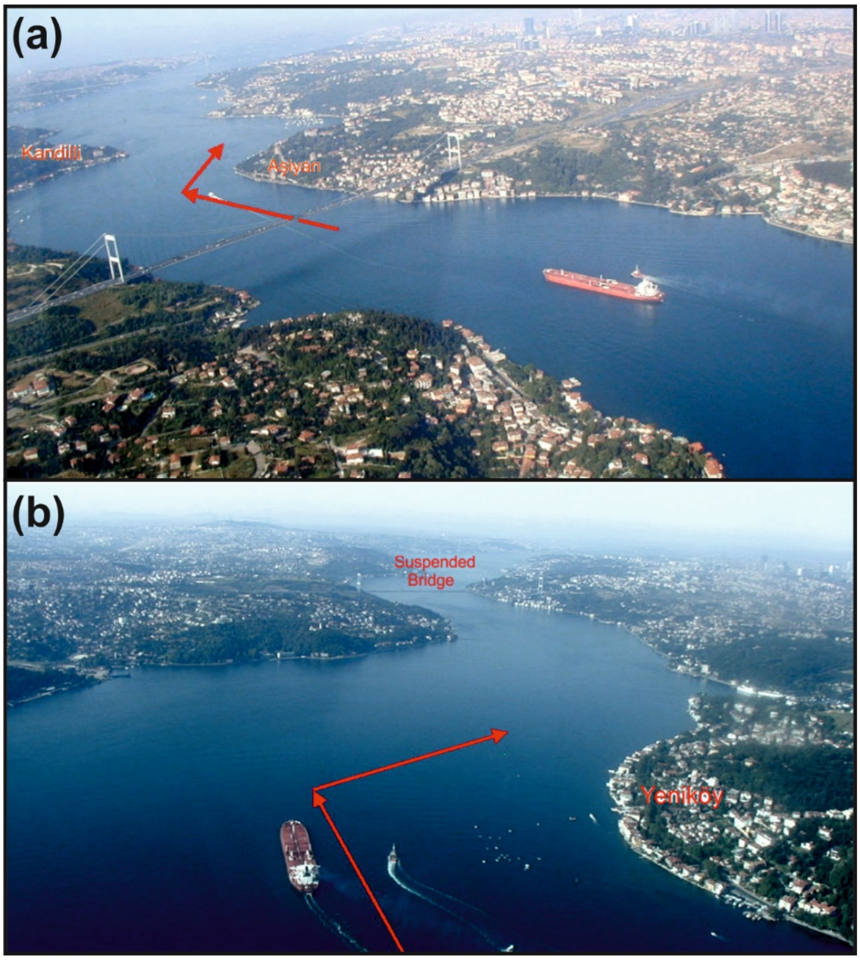

Figure 3. a) The narrowest part of the Istanbul Strait between the towns Kandilli and Aşiyan. See also double bends with high collision probabilities. b) Sharp turn offshore Yeniköy headland, where collision diameter and the cross current effect increases during manoeuvres, therefore, causing stranding and grounding casualties (modified from AFCAN, 2018).

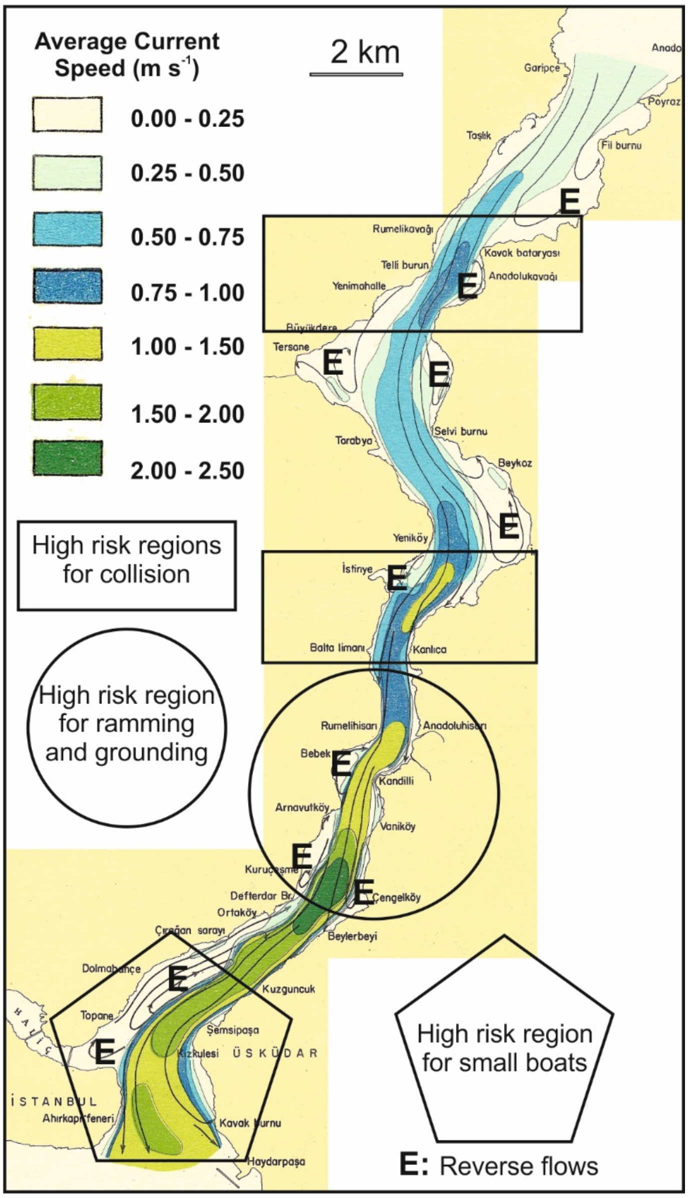

Figure 4. Average current velocities along the İstanbul Strait. See also maximum risk zones of collision, ramming and grounding (modified from ONHO, 1997, Mıhçakan et al., 2003; Otay and Özkan, 2003). Fog is common during the winter and early spring months with frequent closure for transit vessels and even for small passenger boats.

In contrary, persistent southerly winds minimize surface current flow, and may reverse its direction to the north on occasion. This event is known as “Orkoz” and it may reach almost to the Black Sea exit, then slackening in the order of a day (Akten, 2004).

In case of upper layer blockage, the current structure turns into three-layer case (Yüksel et al., 2008).

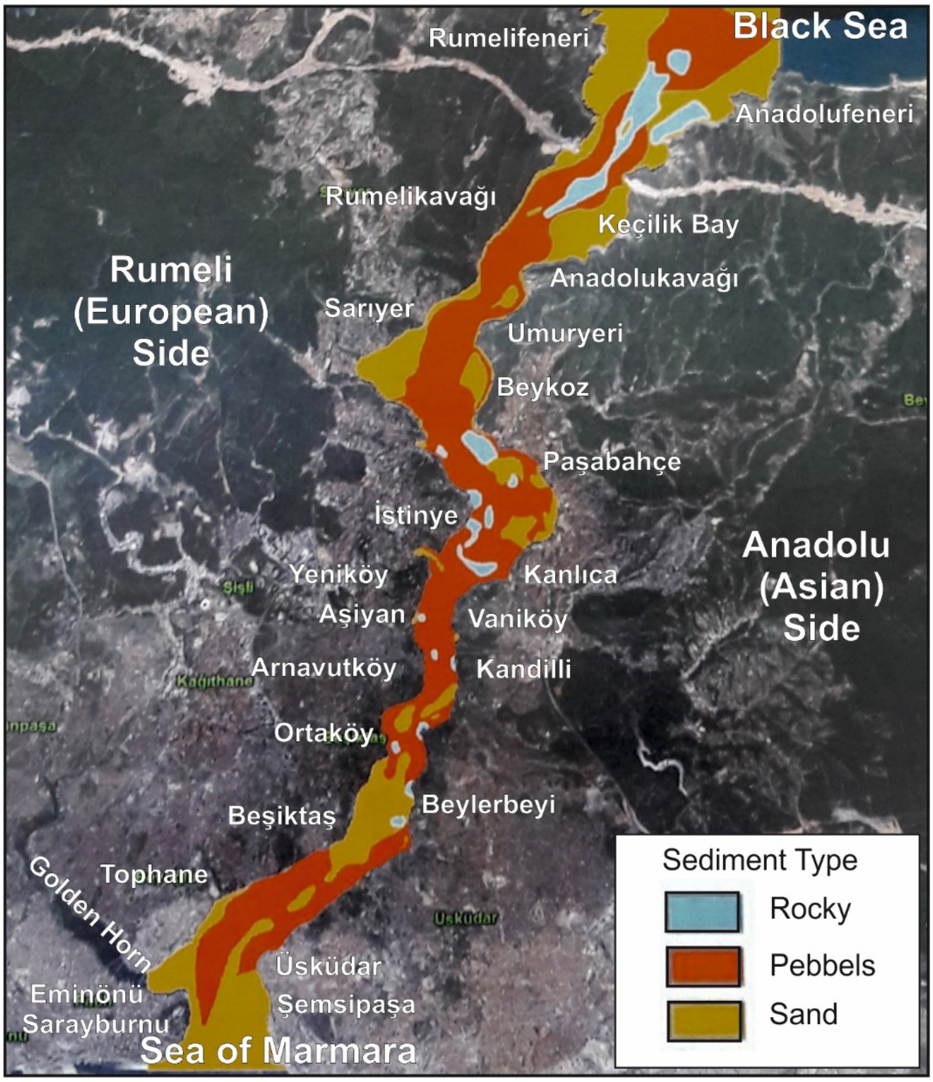

Figure 5. Generalized distribution of the sea-bottom sediment texture along the İstanbul Strait (modified from Eryılmaz et al., 2000).

Less cohesive materials accumulate under current control, while cohesive materials accumulate in regions such as bays or gulfs where the current is weak. The seafloor sediments along the İstanbul Strait are formed by detritic material, which are transferred by various size streams (e.g. Kabakoz, Göksu, Küçüksu, Çengelköy (Bekar), Beylerbeyi, Garipçe, Sarıyer (Hünkar), Büyükdere, İstinye, Alibey etc.). The sediment distribution consists of three main units; blocky rocks, gravels and sands. Blocky-rocky structures are dominated along the shallow banks, along the mid-line of the strait between the towns of Anadolufeneri and Anadolukavağı, and partly between Beykoz, Kanlıca, Yeniköy and Kandilli (Figure 5).

Sand dominated detritic sediments are distributed offshore Anadolufeneri and Rumelifeneri, especially at water depths of 10-20 m. The band representing the sandy deposits becomes narrower southward (Figure 5). The sand material becomes coarser off the coast, as well as in the Keçilik Bay and Sarıyer, then changes to poorly sorted gravelly sand with increasing depth, and distributed at the water depths of -20 to -50 m. The gravelly deposits are distributed broadly through the midline of the strait, from Anadolufeneri to Kandilli. To the south, relatively fine-grained gravelly sand material dominates between Kandilli, Beylerbeyi and Ortaköy. The same unit is also dominant between Üsküdar and Kadıköy, down to -50 m water depth (Aydın et al., 2002).

On the European side, along the coastal line between Beşiktaş and Eminönü, the gravelly sand spread out in a narrow strip parallel to the shore and down to -20 m water depth. Gravelly sand unit continues down to Kandilli-Beylerbeyi, and then gradually changes to sandy gravel unit that is distributed in a large area from Beylerbeyi to Üsküdar and Eminönü. The silty sand unit is piling over the pebbly sandy units broadly distributed between the depths of 10-50 meters from the south end of the İstanbul Strait to Üsküdar. Fine-grained (silt and clay) materials are dominant in areas such as the bay where the energy is low along the strait (Figure 5). Muddy sands spread at the entrance of the Golden Horn estuary (-35 m water depth), while fine-grained clayey, silty muds are dominant in the central and inner sub-basins. As biogenic material, shells, shell fragments, various plant residues, organism residues are located in the sediments (Eryılmaz et al., 2000). The deep currents at the southern exit, driven by the sea floor topographic restrictions, control sediment transport and re-build them at suitable places on shelf (Alpar et al., 2014a). The sand ridges along the channel banks control the sediment pathways, and may present risk for navigation (Alpar et al., 2014b).

5.2. Çanakkale Strait

Between the highlands of Anafartalar to the north and the Biga ridge to the south, the Çanakkale Strait has an average depth of -55 m, and reaches a depth of -90 m in the narrowest central section (ONHO, 1994). It constitutes a shallow sill at about -70 m between two deep marine realms (Alpar et al., 1996). It has a winding shape subdivided into three morphological regions: a) NE-SW-oriented relatively straight northern region, b) Nara Passage, and c) NE-SW oriented southern region (Gökaşan et al., 2008). At the northern region, the average water depth is -70 m. Both sides of the strait have submarine plains at an average depth of -50 m. The through, however, extends along to the coast of the Biga Peninsula, and then merges with the Şarköy Canyon which is NE-SW oriented. The Nara Passage is the deepest (-113 m) part of the strait. The narrowest part of the Çanakkale Strait is between the towns of Kilitbahir and Çanakkale. The southern region is the widest part of the strait with an average depth of -60 to -70 m, just before the Aegean exit, which becomes narrower and deeper once more (-90 m).

The morphology of the Çanakkale Strait controls the hydrodynamic characteristics of the two-layered flow system; a surface currents coming from the Sea of Marmara towards the Aegean Sea, and a more saline compensatory undercurrent flowing in the opposite direction. The surface current is effective from sea surface to -20 to -25 m water depth. It reaches up to 3.5-4.0 knots at the Aegean exit, especially in the narrows of Çanakkale and at the headland of Kumkale. The surface current slackens at the wider parts of the strait, as well as close inshore on the southern side. The hydrodynamic behaviour of the Çanakkale Strait show greater freedom in its response, if compared to that in the İstanbul Strait. This is because of the submaximal nature of the control existing only at the Nara passage, the only hydraulic control along the Çanakkale Strait where the lower and upper layers are mixed intensely (Özsoy and Altıok, 2016).

The nature and distribution of the bottom sediments depends on the interaction of the channel geometry and flow conditions. Coarse-grained sediments are distributed in the narrow parts where high-energy currents prevail; e.g., the Çanakkale and Nara passes (Alpar et al., 1999). In addition, terrigenic materials transported by the rivers and coastal abrasion determine sediment texture especially in shallow areas up to -10 m water depth. Widespread deposits of sand and silty sand are dominant at the lowlands close to river mouths and on the edges of coastal plains. On the other hand, block, coarse gravel and pebbly sand occur as rather narrow stripes along the steep shores. Rocky sea bottom may occur along high shores, especially noses. Mussels grow in very dense clusters on such type of coasts. Coarse-grained materials decrease with depth toward the center of the strait while the ratios of silt and clay increase.

Sea bottom sediments in the Çanakkale Strait can be classified simply into two different granulometric units; sand dominated and mud dominated (Figure 6). Gravelly and sandy materials are dominant in shallow areas mostly down to -10 to -20 m of water depth along the shores (Eryılmaz et al., 2001). They are distributed broadly in the middle and southern end of the strait. As water depth increases, fine-grained silty sand and muddy sand units become dominant. They spread in broader areas in the middle part of the strait (Eceabat - Nara), as well as the zone below -50 m water depth amid the towns of Kumkale, Seddülbahir and Çanakkale (Figure 6). Biogenic materials (shells and their fragments) in the actual sediment along the Çanakkale Strait are rather small if compared to those at the İstanbul Strait.

5.3. Channel İstanbul

A shipping canal, known as the Channel İstanbul, will be established linking the Black Sea and the Sea of Marmara. The main purpose of this mega project, which is scheduled for completion in 2023, is to route traffic from the İstanbul Strait, which is a maritime chokepoint for the energy market of Black Sea riparian countries, some 30 km to the east, accommodating 160 vessels on daily basis (2.4 million barrels of oil per day). The project will also help to minimize threats posed by potential maritime accidents by easing traffic on the İstanbul Strait and to preserve the natural life by reducing pollution due to anchored ships waiting to pass the strait (Kundak and Baypınar, 2011). Without any sharp turns, the massive channel will be 45 km long, “trespassing” on the Sazlıdere

Dam and the natural lagoon of Küçükçekmece, which is protected by the Master Plan of İstanbul.

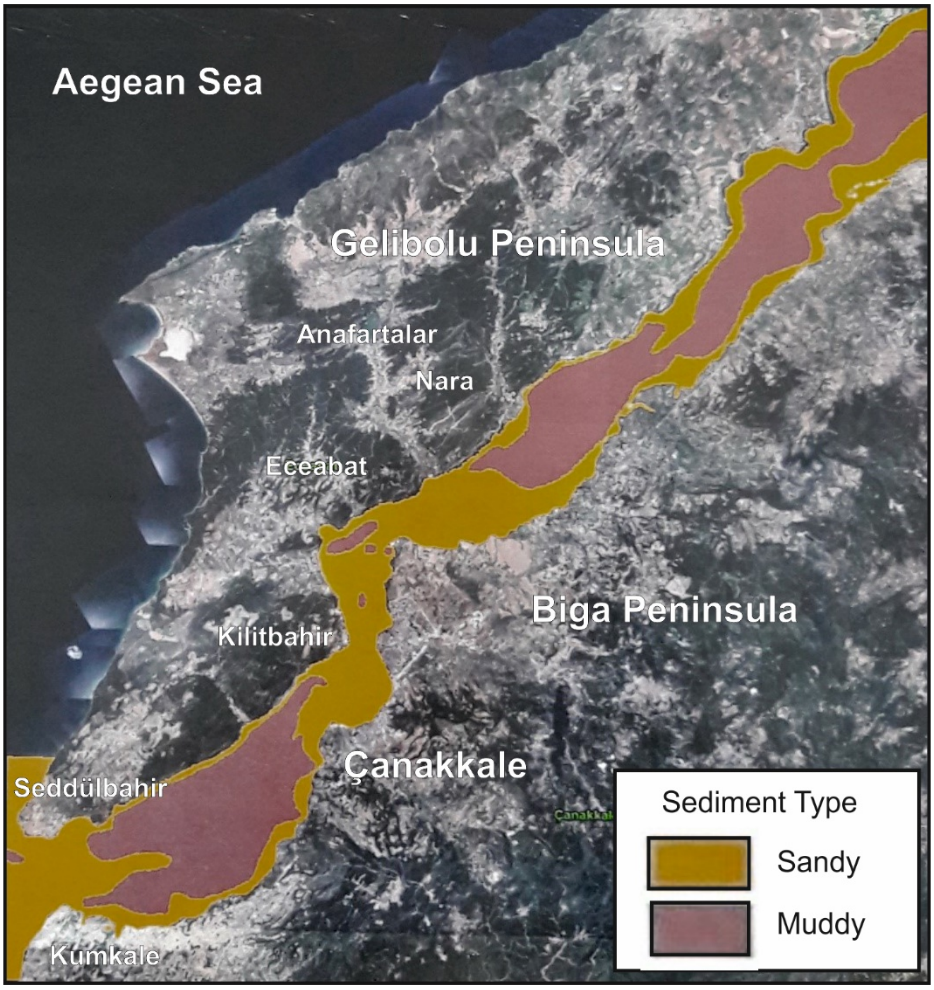

Figure 6. Generalized distribution of the sea-bottom sediment texture along the Çanakkale Strait (modified from Alpar et al., 1996; Eryılmaz et al., 2001).

The Channel İstanbul will be 150 m at its narrowest part and at least 25 m deep. For such a depth (<30 m), the lower layer is almost absent and the annual average flow rate of the Black Sea water, actually depends on the relative difference of the mean sea levels, is calculated 4000 m^3s^{-1} (Akman, 2016).

From ecological point of view, the quality of water is expected to deteriorate because the new canal is expected to decrease oxygen level in the Sea of Marmara in long-term (Öymen et al., 2011). In contrast to the weak lower layer current component in the Channel, the currents at the exit of the Sea of Marmara will be intense (Sözer and

Özsoy, 2017). New exchange regime that will be established between the adjacent seas will evidently disturb their natural equilibrium, by increasing the nutrient rich lower-layer flux in the İstanbul Strait. In long-term, such an extra injection is expected to be critical for the interior mixing processes of the Black Sea. Meanwhile, new marine traffic conditions will evidently increase noise pollution that may change underwater acoustical structures (Tombul and Alpar, 2016). New artificial islands, which will be built in the Sea of Marmara using 1.5 billion cubic meters soil material excavated from the channel, will create another question that has been discussed by environmentalists. In accordance with international law, on the other hand, states are obliged to use their countries in a way that will not harm other states or allow them to be used (Tütüncü, 2017).

Beyond its ecological dynamics, this mega project must also be examined thoroughly by taking into account its financial dimensions, political outcomes, and energy marketing needs. The estimated cost, for example, is a minimum of $20 billion and it is not much clear how to persuade ships to pay a fee to bypass the İstanbul Strait. The Channel İstanbul will not be subject to the international agreements still in force today; e.g. the Montreux Convention (Arslan, 2018) that is a master key providing necessary balance for the Black Sea's regional security (Kesici, 2015; Gazioğlu et al., 2016). Even the channel cannot much help decreasing the cruise time between the seas, it may reduce the waiting time of the anchored ships, if no waiting at Çanakkale. Inevitably, this will reduce pollution at the locations used for anchoring (Sucuoğlu, 2014). On the other hand, an increment of the petroleum products transferred along the Channel İstanbul contradicts with Turkey's aim; that is to become a central energy hub connecting intercontinental pipelines (Şahin, 2017). The expected pros and cons of the Channel İstanbul Project must not be evaluated based on the same criteria. In this context, it should not be omitted that the prospective earnings and benefits expected in the near term might be turned into irreversible losses in the long term.

6. Conclusion

Even the statistics show a slow decline in maritime accidents, vessels passing through the TSSA account for many maritime accidents and threaten environment. In this context, the most vulnerable are the narrow and shallow straits; considering their shape, seabed morphology and physical constraints defining the water exchange regime between the adjacent seas. Therefore, all background information on the geographic and bathymetric restrictions along the TSSA will be crucial for all types of environmental researches and maritime transportation. Sea bottom topography along the İstanbul Strait, for example, reveals physical constraints that sailors have to pay attention during their navigation and affect directly the large currents flowing through the main channel. The knowledge of hydrography, i.e. bathymetry, morphology of seafloor landforms, anthropogenic impacts, sediment types and their movements, needs expensive and quantitative geological and geophysical studies of the seafloor, such as sediment sampling, diving, and acoustical applications.

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HYDRODYNAMICS AND MODELLING OF TURKISH STRAITS

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1. Introduction

The beginning of scientific oceanographic research may be traced back to the in situ measurements of Count Luigi Ferdinando Marsili in the Adriatic Sea, Aegean Sea, and more importantly in the Sea of Marmara and the İstanbul Strait between 1679 and 1680. Marsili's measurements are termed scientific because they were accurately described by referring to specific geographical locations and time. Marsili collected surface and deep-water samples and determined the seawater densities of samples, which were found to agree with present-day values within 10% to 20% uncertainty. Marsili also measured the current speeds and the depth of the current direction reversal in the İstanbul Strait, which are again in agreement with the present-day measurements. Furthermore, based on the experimental data collected in the İstanbul Strait, Marsili put forward a theory on the cause of the two-layer flow at the strait and demonstrated its validity by laboratory experiments (Pinardi et al., 2018).

Virtually centuries passed until oceanographic measurements were done again in the region between 1918 and 1921 by the German oceanographer Alfred Merz. Merz's measurements of flow velocity and salinity in the İstanbul Strait was reported later by Möller (1928). In the 1940's and 1950's, nearly two decades after the establishment of the Turkish Republic, the Turkish researchers began stepping in to the field of oceanography. Ulyott and Ilgaz (1944) and almost a decade later Pektaş (1953) carried out some rather limited measurements in the İstanbul Strait with scanty means available at the time. In a related work, Pektaş (1956) interpreted the effect of Mediterranean water to the Black Sea.

In the early 1980's Çeçen et al. (1981) and Sümer and Bakioğlu (1981) made quite important contributions from theoretical and computational point of view by mathematically describing the hydraulics of two-layer flows and applying the equations to the İstanbul Strait.

The 1990's saw an outburst in studies concerning the Turkish Straits System. Ünlüata et al. (1990) presented an in-depth review of the subject besides giving assessments of fluxes. Oğuz et al. (1990) made numerical computations of exchange flows in the İstanbul Strait. Latif et al. (1991) reported observations of the Mediterranean inflow into the Black Sea while the role of the Sea of Marmara in coupling these two water bodies were treated in Beşiktepe et al. (1994). Özsoy et al. (1995) investigated fluxes and mixing processes in the Black Sea and a review of exchange flow characteristics and mixing in the İstanbul Strait was given by Özsoy et al. (1996). Effects of the Turkish Strait System on the Black Sea can be found in the reviews by Özsoy and Ünlüata (1997, 1998).

Altıok (2001) carried out a comprehensive study of current measurements in the İstanbul Strait and later re-examined the findings in Altıok, Sur and Yüce (2005). Özsoy, Latif, and Beşiktepe (2002) analyzed the currents using the measurements in the İstanbul Strait. Gregg and Özsoy (2002) considered the flow, water mass changes, and hydraulics of the İstanbul Strait. Güler et al. (2006) carried out a field study in the İstanbul Strait for measuring short-term and long-term current profiles at selected locations. In-depth reviews of the hydrography and water fluxes of the Turkish Straits System can be found in Özsoy and Altıok (2016a, b). Finally, Jordà et al. (2017) give a very extensive review of the Mediterranean Sea heat and mass budgets with special emphasis on the Turkish Straits System and the Strait of Gibraltar. Numerical modelling issues of the straits are also treated with actual simulations.

2. Turkish Straits

The Turkish Straits System is composed of the İstanbul Strait (Bosphorus) and the Çanakkale Strait (Dardanelles). The system comprises a region extending from Aegean Sea to Black Sea with the Sea of Marmara encompassed as shown in Figure 1. Thus, the Turkish Straits System connects essentially Mediterranean and Black Sea through two narrow and long straits.

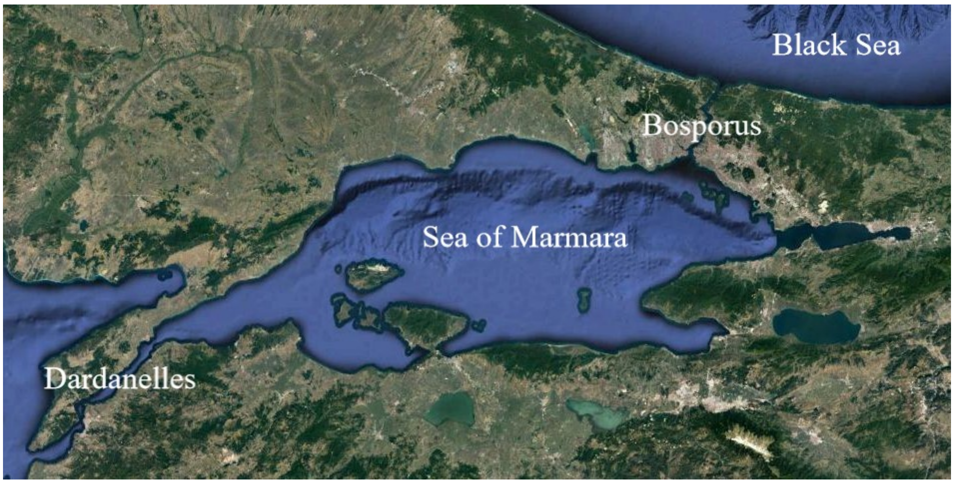

Figure 1. Sea of Marmara connecting Mediterranean and Black Sea via Çanakkale and İstanbul straits.

The İstanbul and Çanakkale Straits have unique features of two-layer flows, which may be compared only with the Gibraltar Strait. The İstanbul Strait is approximately 35 km in length and only 700 m wide in its narrowest pass. The Çanakkale Strait is relatively longer, 75 km, and wider, 1300 m in the narrowest (Figures 2a, b).

Figures 2a, b. İstanbul Strait (left) and Çanakkale Strait (right).

The southern exit of the İstanbul Strait opens to the Sea of Marmara while a deep channel continues north where it meets with the complex southern sill of 30 m depth flanked by deeper channels of 40 m depth on either sides. The water depth throughout the strait ranges from 30 m to 100 m with a mean depth of approximately 60 m while the width varies within 700 m to 3500 m. The Çanakkale Strait, on the other hand, connects the Aegean Sea to the Marmara Sea, with two near right-angle turns at the narrows of the Nara Pass. The depth ranges between 60 m to 80 m with a mean of approximately 70 m.

Both the İstanbul Strait and the Çanakkale Strait have two-layer stratified flow system. The upper-layer currents carry the lighter Black Sea water southwards while the lower-layer currents carry the Mediterranean water northwards. Thus, a system of two-layer opposing currents is maintained. Thicknesses and velocities of both layers show appreciable spatial and temporal variations. Geography of the straits, the wind conditions, and hydraulic controls dictated primarily by local depths all contribute to the overall flow characteristics and variations.

The two-layer system of the straits is principally established by two mechanisms. In the upper layer, the currents are driven by water level differences such as the 20-40 cm higher Black Sea versus the Sea of Marmara; hence, the flow arises from the pressure difference and termed barotropic. In the lower layer, on the other hand, the basic driving mechanism is the density difference of the two layers and the flow is said to be baroclinic. These two different mechanisms are elucidated below in a separate part by a simple hydrostatic model. It must also be indicated that strong shear between the opposing currents generates a turbulent mixing layer. In realistic modeling, the effect of this mixing layer must definitely be included.

In the southern part of the İstanbul Strait, following the narrowest section, the surface currents generally exceed 1 m s^{-1} and reach 2-3 m s^{-1} at the southern exit. Similarly, surface currents of around 1 m s^{-1} occur past the narrow sections of the Çanakkale Strait such as Nara Pass (Özsoy and Altıok, 2016a).

A rather well known occurrence in the İstanbul Strait is the short-duration blocking of the flows in the upper or lower-layer due to extreme values of sea-level differences. For instance, it is argued that a sea-level difference of less than 10 cm would block the upper-layer while a level difference of 50 cm would block the lower-layer. Naturally, not only sea-level differences but also barometric pressure, winds, and net water fluxes all contribute to dynamical forces creating blocking conditions (Oğuz et al. 1990). Accordingly, the lower layer is now and then blocked in spring and summer, with increased Black Sea influx, which is primarily due to the northerly winds. On such occasions, the southerly currents of the Black Sea virtually overwhelm and flush out the Mediterranean water. On the other hand, the upper-layer blocking events, called *Orkoz*, coincide with the reversal of the net flow in response to the southerly winds, called *Lodos*, in the fall and winter (Özsoy and Altıok, 2016a).

The exchange flow rate in the İstanbul Strait may be estimated by considering the water budget of the Black Sea. In other words, the net water flux through the İstanbul Strait is dictated by the rate of mean sea-level change and the water masses flowing in and out of the Black Sea. The annual average fluxes are computed from the Knudsen relations expressing a steady-state mass and salt budget. For the İstanbul Strait the annual average upper- and lower-layer fluxes are estimated as 650 km^3 $year^{-1}$ (20,600 m^3 s^{-1}) and 325 km^3 $year^{-1}$ (10,300 m^3s^{-1}), respectively. These values are quite in agreement with the calculation based on the long-term salt budget of the Black Sea, which gives a ratio of 2 between the outgoing and incoming mass fluxes. Thus, the mean net water flux leaving the Black Sea may be approximately estimated as 650 - 325 = 325 km^3 $year^{-1}$ (10,300 m^3s^{-1}) (Özsoy and Ünlüata 1997).

A 10-year monthly-measurements campaign of direct measurements of water fluxes in the İstanbul Strait at the two ends of the Strait were carried out by Altıok and Kayışoğlu (2015). The results of the measurements produced mean fluxes for the upper layer 12,540 m^3s^{-1} and the lower layer 8100 m^3s^{-1} hence a net flux of 12,540-8100=4440 m^3s^{-1} at the northern exit of the İstanbul Strait. The corresponding values at the southern exit are 13,320, 7900, 5420 m^3s^{-1}, respectively. Increase in the upper-layer flux and decrease in the lower-layer flux as we move from the north to the south reveal a net flux injection into the upper layer from the lower layer. On the average, the net flux must be conserved between the two ends of the Strait. This expectation is however only approximately fulfilled as the upper, lower layer and net flux differences are respectively found to be 13,320-12,540=780 m^3s^{-1}, 7900-8100 = -200 m^3s^{-1} and 780-(-200) = 5420-4440 = 980 m^3s^{-1}, a net increase in the southern exit flux. This relatively small violation of conservation of mass is of course due to instrumental and methodological inaccuracies involved in the measurements. Finally, if we calculate the upper and lower-layer averages of the two ends we have 12,930 m^3s^{-1} for the upper layer and 8000 m^3s^{-1} for the lower layer hence giving the ratio as 12,930/8000=1.6, somewhat less than expected value 2.

Relatively recent flux measurements for the İstanbul Strait (Jarosz et al., 2011) and for the Çanakkale Strait (Jarosz et al., 2012) have been reported. Tables 1 and 2, adapted from Özsoy and Altıok (2016b), show the measured values for the İstanbul and

Çanakkale Straits, respectively. Note that positive values indicate flow in the southward direction while negative values indicate the flow in the northward direction.

Table 1. Flux values for the İstanbul Strait.

Layer	South (m^3s^{-1})	North (m^3s^{-1})	Difference South-North
Upper	+14,071	+11,875	+2217
Lower	-10,564	-8018	-2559
Net	+3508	+3857	-342

Table 2. Flux values for the Çanakkale Strait.

Layer	South (m^3s^{-1})	North (m^3s^{-1})	Difference South-North
Upper	+36,329	+25,560	+10,844
Lower	-32,129	-14,473	-17,673
Net	+4200	+11,087	-6829

When Tables 1 and 2 are compared, it is first noted that the net flux difference for the Çanakkale Strait is approximately 20 times greater than that of the İstanbul Strait. Indeed, the difference of -6829 m^3/s is such a large value that it is comparable in magnitude with the layer fluxes. Such great variation between two ends raises questions concerning measurement accuracies and crosswise flow variations for the Çanakkale Strait. The relatively wider cross-sectional areas of the Çanakkale Strait is probably responsible for this big discrepancy, which must ideally be zero, when the net effect of precipitation and evaporation is dismissed.

On the other hand, the net flux difference for the İstanbul Strait is relatively small hence establishes confidence for the measured flux values. Considering the mean values of the north-south fluxes of the upper and lower layers for the İstanbul Strait, we have +12,973 m^3s^{-1} and -9291 m^3s^{-1}, respectively. Using these mean values gives for the upper to lower flux ratio as 1.4, which is even less than the ratio 1.6 calculated from the measurements of Altıok and Kayışoğlu (2015).

3. A Simplified Hydrostatic Model of Two-Layer Flow

Çeçen et al. (1981), besides presenting a very comprehensive in depth treatment of hydraulics of two-layer flow in the İstanbul Strait, suggested a very simplified hydrostatic model to understand the physical mechanism laying behind. Although drastically simplified in many aspects this hydrostatic model offers good insight into the physics of any such two-layer systems. Generalizing for arbitrary canal length and water level heights this idea is mathematically formulated here. A simple one-dimensional two-layer model of the İstanbul Strait is considered in Figure 3.

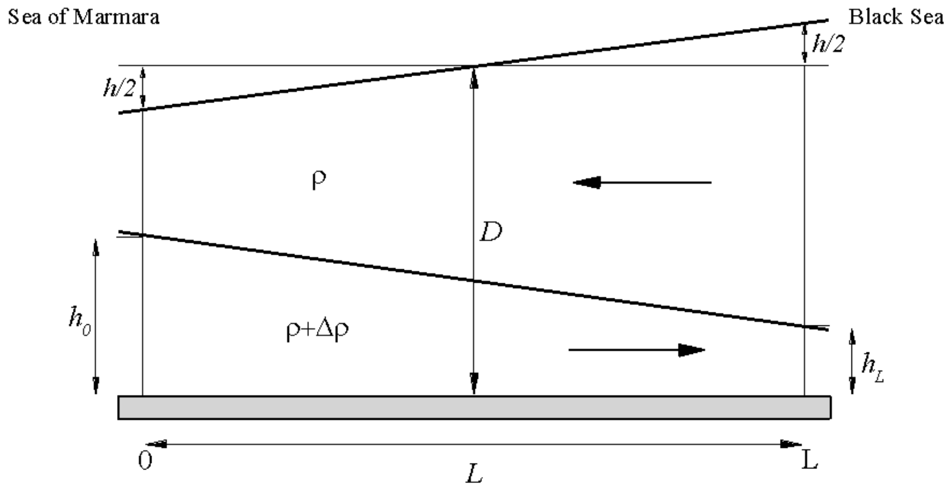

Figure 3. A one-dimensional two-layer idealization of the İstanbul Strait.

Here, the total length of the canal is denoted by L, the depth in the mid-canal is D, the total water level difference between the Sea of Marmara and Black Sea is h, the lower layer height at the side of the Marmara Sea is h_0 and at the side of Black Sea is h_L. Finally, upper and lower layer densities are denoted by ρ and $\rho + \Delta\rho$, respectively. Considering the upper and lower layers separately in terms of the hydrostatic pressure distributions one gets the sketches below.

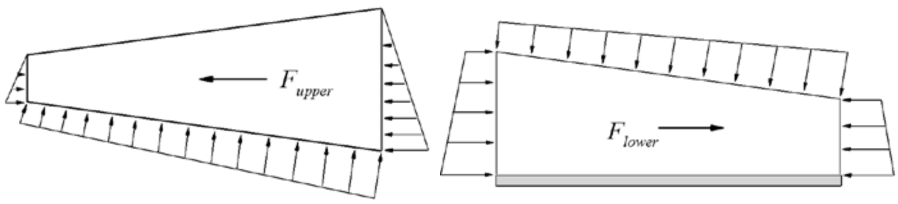

Figure 4a, b. Pressure distributions for the upper (left) and lower (right) layers.

Using the notation given in Figure 3 the net horizontal hydrostatic forces for the upper F_u (to the left) and lower F_l (to the right) layers for a unit canal width (into the paper) are formulated as given in Beji (2008).

$$F_u = \rho g h \left[D - \tfrac{1}{2}(h_0 + h_L)\right]$$

$$F_l = \rho g \tfrac{1}{2}(h_0 + h_L)\left[\frac{\Delta\rho}{\rho}(h_0 - h_L) - h\right]$$

Note that the net pressure force F_u is calculated by taking the left direction positive while F_l is calculated by taking the right direction positive.

Let us examine the above expressions with reference to the physics they imply. Considering F_u first, it is obvious from Figure 3 that $D > \frac{1}{2}(h_0 + h_L)$ always. Therefore, as long as the water level is higher on the Black Sea side compared to the Marmara side as shown in Figure 3 and denoted by the positive quantity h, the upper layer force $F_u > 0$ hence there is a net hydrostatic force acting to the left, namely from the Black Sea side to the Marmara side. It is crucial however that there is a positive water level difference $h > 0$ to have a positive F_u; that is, the flow is essentially driven by the water level difference h and there is no force when $h = 0$. This kind of flow, which is driven by the pressure difference due to water level difference, is called barotropic flow. Thus, the upper layer flow is barotropic.

For the lower layer on the other hand, to have a positive F_l, the terms inside the square brackets must be positive or non-zero as the other multiplier $\frac{1}{2}(h_0 + h_L)$ is always positive. To make the terms inside the square brackets positive it is necessary that;

$$\frac{\Delta\rho}{\rho} > \frac{h}{(h_0 - h_L)}$$

indicating that the density difference $\Delta\rho$ must be above a certain ratio in order to maintain a positive force hence a flow in the lower layer. Thus, in the lower layer, the density plays a decisive role in driving the flow and such flows are called broclinic.

This simplified hydrostatic model then has revealed the most important physical aspects of the two-layer flow observed in the İstanbul Strait or alike straits. The upper layer flow is driven by surface water level difference and is called barotropic while the lower layer flow is driven by density difference and is called baroclinic.

The above treatment may be carried out further to estimate the flow speed ratio of the layers. Newton's second law of motion states that $F = ma$. For the present case the mass values for the upper and lower layers for unit width can be computed easily as

$$m_u = \rho L \left[D - \frac{1}{2}(h_0 + h_L)\right]$$

$$m_l = \rho L \frac{1}{2}(h_0 + h_L)\left(1 + \frac{\Delta\rho}{\rho}\right)$$

Since $a = F/m$ the ratio of the upper layer acceleration to the lower layer acceleration is

$$\frac{a_u}{a_l} = \frac{F_u/m_u}{F_l/m_l} = \frac{h}{\left[\frac{\Delta\rho}{\rho}(h_0 - h_L) - h\right] / \left(1 + \frac{\Delta\rho}{\rho}\right)}$$

Note that for the upper layer acceleration is solely dictated by the surface level difference h while for the lower layer the positive acceleration is only possible for large enough $\Delta\rho/\rho$ ratio as indicated before. For constant acceleration the velocity is simply $v = at$ therefore, the accelerations ratio may be taken as velocities ratio $a_u/a_l = v_u/v_l$. Taking the typical values from the measurements used for a typical computation in Çeçen et al. (1981) of Figure 5.5 for the İstanbul Strait, we set $h = 0.33$ m, $h_0 - h_L = 35$ m, $\Delta\rho/\rho = 0.014$ and use the above expression for a_u/a_l to obtain

$$\frac{v_u}{v_l} = 2.09$$

which is in nearly perfect agreement with the well-known theoretical ratio of 2 stated based on mass conservation estimates (Ünlüata et al., 1990). It must however be emphasized that the above excellent agreement is essentially fortunate for two reasons. First, due to the term in the denominator the ratio of accelerations is quite sensitive to the values substituted. Second, this simple hydrostatic model does not contain any mechanism of shear stresses in the mid-layer and bottom to slow down the system and does not account for velocity heads (dynamic effects). Nevertheless, despite these missing parts, the hydrostatic approach clearly reveals the parameters controlling physical mechanisms of flow for the different layers and produces acceptable, even good results for the ratio of flow velocities. Finally, in this connection the ratios obtained from actual measurements as 1.6 (Altıok and Kayışoğlu, 2015) and 1.4 (Jaresz et al., 2011) must also be discussed. These ratios are smaller than the theoretical value of 2 by around 25%. The above formulation, when interpreted from a different view, may shed some light into this somewhat large difference. As noted before the denominator of a_u/a_l is sensitive to small changes in h, $\Delta\rho$, h_0, and h_L. Then, small variations in these terms may cause relatively big variations in the ratio a_u/a_l hence in the ratio of fluxes. In other words, small variations of basic parameters driving the flow amplify the ratio. This sensitivity, together with other factors unaccounted, may well be the main source of differences between the theoretical estimate and the measured values.

4. Numerical Modeling of Currents

Two-layer opposing-current structure of the İstanbul and Çanakkale Straits has always been a source of interest for oceanographers, hydraulic engineers, and more recently computational fluid dynamists. As indicated above the upper layer flow is maintained by water level difference whereas the lower layer flow is due to the density difference between two layers. The simple hydrostatic model has clarified these points by developing mathematical formulations capturing the essence of physics involved. To take the modeling further not only the hydrostatics but also hydrodynamics must be taken into account. Apparently, the first step in this direction was taken by Çeçen et al. (1981) who clarified the two-layer mechanism from hydraulic point of view and presented a mathematical model with a computer algorithm numerically solving it. Oğuz and Sur (1989) gave a two-layer numerical treatment of the Çanakkale Strait. Oğuz et al. (1990) applied the shallow-water equations to the modeling of two-layer-flow in the İstanbul Strait. This model takes into account the variations in canal width but is essentially one-dimensional and the solution proceeds only along the canal length, which is taken straight. Beji, Dikili and Barlas (2008) expressed the two-layer shallow-water equations in curvilinear boundary-fitted coordinate system and solved numerically by finite-difference approximations for simulating currents in the İstanbul Strait. Figure 5 shows a sample computation of one-dimensional two-layer opposing flows over a ridge on the bottom.

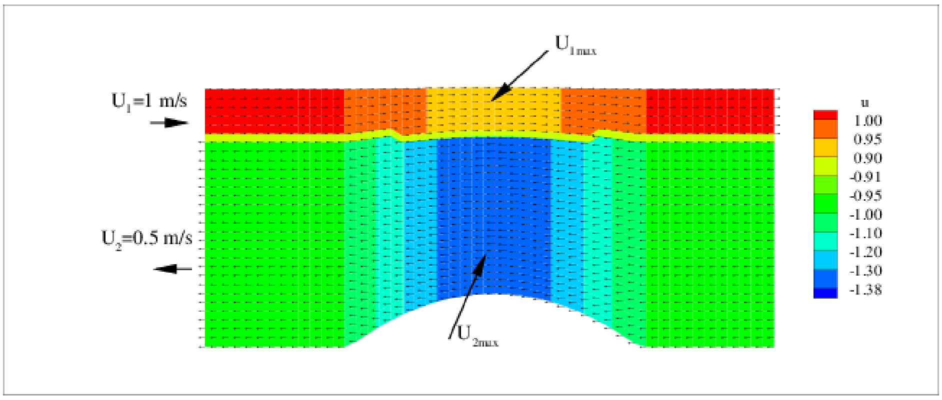

Figure 5. Velocity variations over a ridge for two-layer steady opposing currents.

Actual geographic representation of the İstanbul Strait used for numerical simulations in Beji, Dikili and Barlas (2008) is shown in Figure 6.

Sannino, Sözer and Özsoy (2015) presented results of the numerical modeling of currents in the Turkish Straits System. In the study, the MITgcm (MIT General Circulation Model) is employed with a high-resolution non-uniform grid system. The ability of MITgcm to capture the two-layer exchange dynamics both in the Straits and in the Marmara Sea is found to be quite satisfactory. Further, Sözer and Özsoy (2017) verified numerically the existence of the hydraulic controls responsible in establishing maximal exchange regimes as theoretically predicted by Farmer and Armi (1986).

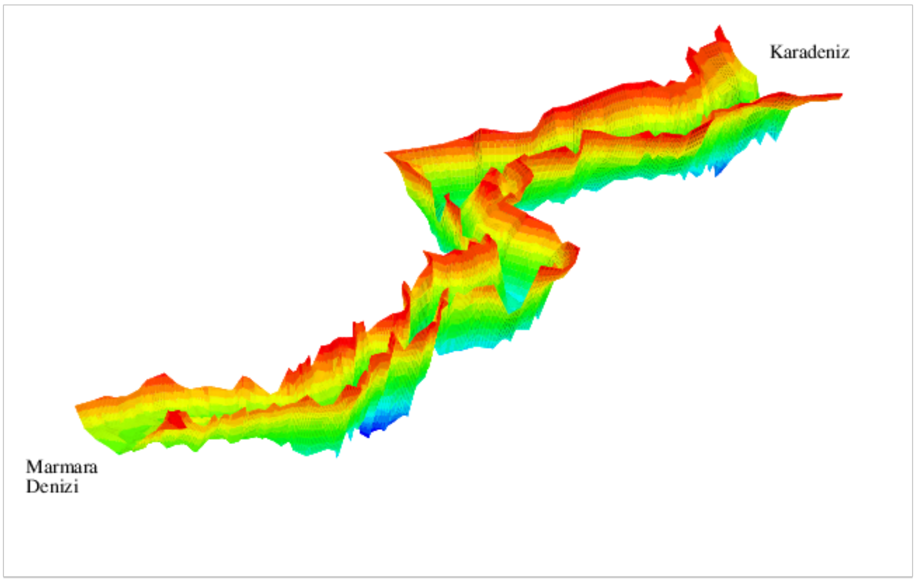

Figure 6. Perspective view of the İstanbul Strait bathymetry as used in simulations.

5. Conclusions

Hydrodynamics and modeling of the Turkish Straits have been reviewed with particular emphasis on the physical mechanisms driving the two-layer flow. Volume flux measurements in the Straits are recapitulated and discussed with reference to theoretical considerations based on conservation laws. A simple hydrostatic model, based on the suggestion made in Çeçen et al. (1981), is formulated for mathematically elucidating the physics laying behind two-layer flows. The formula derived for the ratio of the layer velocities produces meaningful values despite the extremely simplified approach adopted.

Numerical modeling of the currents in the internationally important seaways of the Turkish Straits is necessary especially for predicting the paths of the oil spills or pollutants in case of a sea accident. From the point of view of hydraulic engineering, the Turkish Straits are rare natural phenomena of two-layer flow with opposing currents. The usual approach of modelling such currents is to use the vertically integrated continuity and momentum equations with shallow-water approximations. However, as the effects of cross flows are realized more as a result of measurements, more sophisticated simulation tools such as the MIT General Circulation Model come into use (Sannino, Sözer and Özsoy, 2015).

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WAVE CLIMATE IN THE SEA OF MARMARA

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1. Introduction

The Sea of Marmara (SM) is located at one of the busiest shipping lanes in the world and the surrounding area is an important industrial region. The industrial and commercial investment in the region constitutes more than half of the entire Turkish enterprise. Despite the significant importance of the region in economy, commerce, tourism and transportation, coastal engineering applications are relatively lagging behind. For instance, while in coastal and offshore activities accurate prediction of wind induced waves is quite an important aspect, presently wave measurements are very scare for the SM. Lack of such essential data adversely affects the reliability of engineering works. In this work, estimation of wave heights and periods in the SM are reviewed.

The SM is a small enclosed water body situated roughly between 40º20’N and 41º00’N latitudes and 27°00’E and 29°20’E longitudes. It serves as a connecting basin between Black Sea and Aegean Sea through the Bosphorus and Dardanelles. The SM is an actively used seaway with high navigation traffic and important coastal constructions. The surface area is approximately 11,350 km² with a 240 km length and a 70 km width. The deepest point of the SM is in Çınarcık trough in the east and its depth is 1270 m. The area covering the SM with the location of TPIC buoy is given in Figure 1 while the bathymetry of the SM is shown in Figure 2.

Accurate prediction of wind wave characteristics is of vital importance in ocean and coastal engineering practice. Despite this importance, the literature on wave climate is quite limited because long-term wave measurements are difficult and expensive. Lack of essential data decrease the reliability of coastal and offshore engineering designs. In many engineering applications in the region, it is therefore necessary to employ simplified wave prediction approaches for wave hindcasting. Although such approaches greatly reduce the cost of estimation these methods should be used with caution. Etemad-Shahidi et al. (2009) compared three simplified wave prediction methods and tested their performance using data from Lake Ontario and Lake Erie (North America). The results indicate that the simplified methods typically underestimate the wave parameters. Similar findings are also reported by Saçu et al. (2018) and Akpınar et al. (2011).

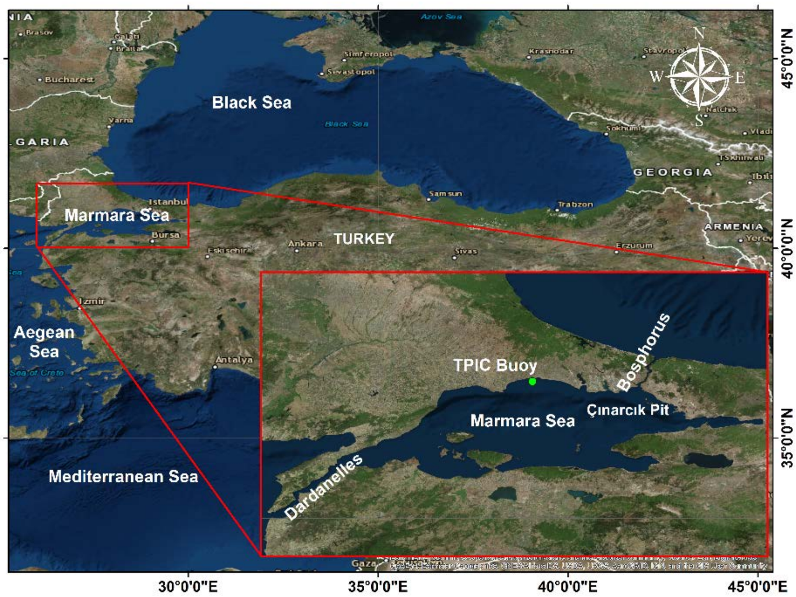


Figure 1. Map of the SM and location of TPIC buoy

Erdik and Beji (2018) analyzed wave height and wind velocity distributions for the SM using the wave and wind measurements collected by Turkish Petroleum International Company (TPIC). This work is among the few studies that statistically analyze the quite valuable one-year-duration data for wind, wave height and energy conditions in the SM.

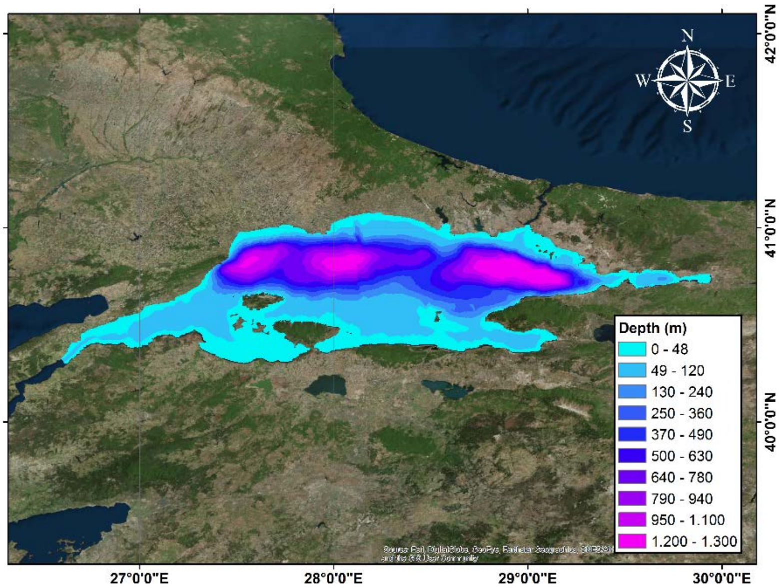


Figure 2. Generalized bathymetry of Sea of Marmara.

The measurements reveal that wave heights are relatively low due to the inland characteristics of the SM. Saçu et al. (2018) tested the performance of simplified wave prediction methods in the SM and compared the results with those given in the literature by using error statistics. Widely used CEM, Wilson, JONSWAP and SMB methods are used to predict the hourly significant wave height.

Abdollahzadehmoradi et al. (2014) computed wave energy potential of the SM for the year 2012 by using MIKE 21 SW, forced with ECMWF wind data with a resolution of 0.125° in longitude and latitude. The model was calibrated by using the wave measurements collected by TPIC for 2 months. According to this study, wave energy in the SM was classified in the lower energy category. The highest rate estimated was for Çınarcık pit zone as 0.84kW m^{-1} for the year 2012.

Kutupoğlu et al. (2016), who employed a SWAN model to predict wave conditions, carried out computations for the SM. The model results were calibrated by the use of one-year-long wave measurements at TPIC location. Short-term wave data measurements performed in 1990 and 2003 at Marmara Ereğli and Ambarlı regions were also employed for validation purposes.

Some researchers investigated tsunami generation and propagation in the SM. Beji and Aldoğan (2001) developed a new Boussinesq-type wave model for the simulation of long water waves generated by a possible fault movement in the Çınarcık Basin in the northeast region of the SM. Later, using the same model Beji (2004) presented the results of various seaquake scenarios for the SM. Güler et al. (2018) investigated tsunami wave attack on Haydarpaşa breakwater by using Volume-Averaged Reynolds-Averaged Navier-Stokes solver, IHFOAM, developed in OpenFOAM® environment.

2. Study area and description of wave parameters

Majority of studies to estimate wave climate in the SM have employ one-year wave data of TPIC, which is collected quite close to the northern shores of İstanbul depicted in Figure 1. The dataset consists of "spectrally based significant wave height H_{m0}, maximum wave height H_{max}, mean wave direction, peak period T_p, mean wave period based on the first moment T_{01}, wave period based on the second moment T_{02}, wind speed, wind direction". The wave parameters are described in terms of the spectral moments m_i of the energy density spectrum $S(f)$:

$$m_i = \int_{fmin}^{fmax} f^i S(f) df \qquad (1)$$

where, $H_{m0} = 4\sqrt{m_0}$, where $m_0 = \int S(f)df$ represents to the zeroth-order moment in equation (1). The spectral wave periods are defined by

$$T_{ij} = \left(\frac{m_i}{m_j}\right)^{\frac{1}{j-i}} \qquad i < j \qquad (2)$$

According to equation (2) the mean wave period based on the first moment is given by $T_{01} = m_0/m_1$; likewise, the mean wave period based on the second moment is $T_{02} = \sqrt{m_0/m_2}$.

3. Wind and wave climate analysis in the SM

Erdik and Beji (2018) examined the wind data collected from TPIC buoy for a period of approximately one year between February 2013 and January 2014. As is seen in Figure 3, 56% of the winds predominantly blow from the NE. Wave rose graph containing all waves at TPIC buoy is plotted in Figure 4. Majority of waves are observed to come from the SE band. From all available data collected by TPIC, 90% of the measured wave heights are equal or less than 0.55 m whereas only 1% of the wave data measured is higher than 1 m. 68% of the total collected time period waves propagate from the SE band. The highest waves were observed to come from the S-SSW directions. The meaningful wave heights were taken into account only for winds blowing from the band between 101.25°-258.75°, considering the location of the measurement buoy and the associated fetch lengths in Figure 5. Based on the meaningful wave sector (101.25°-258.75°), wave rose graph for the frequency of wave direction is plotted in Figure 6. According to the meaningful wave heights, 86% of the measured wave heights are equal or less than 0.50 m whereas only 2% of the wave data measured is higher than 1 m.

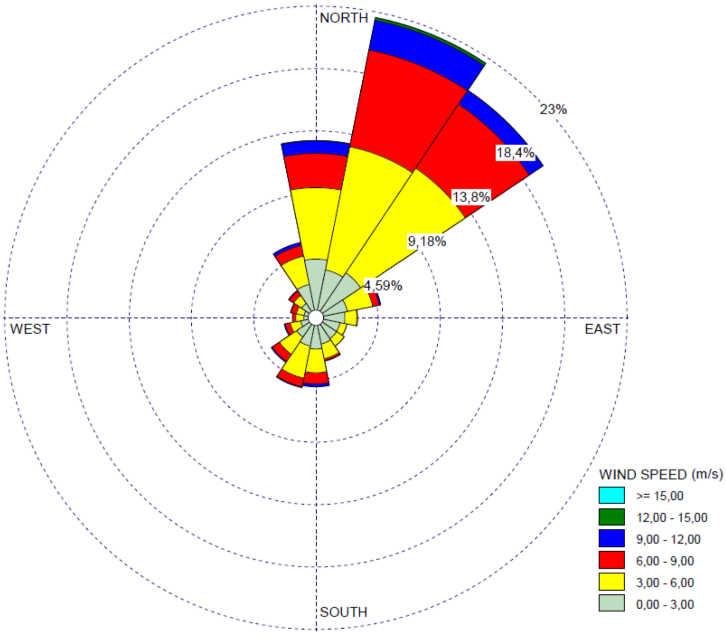


Figure 3. Wind rose diagram for TPIC buoy.

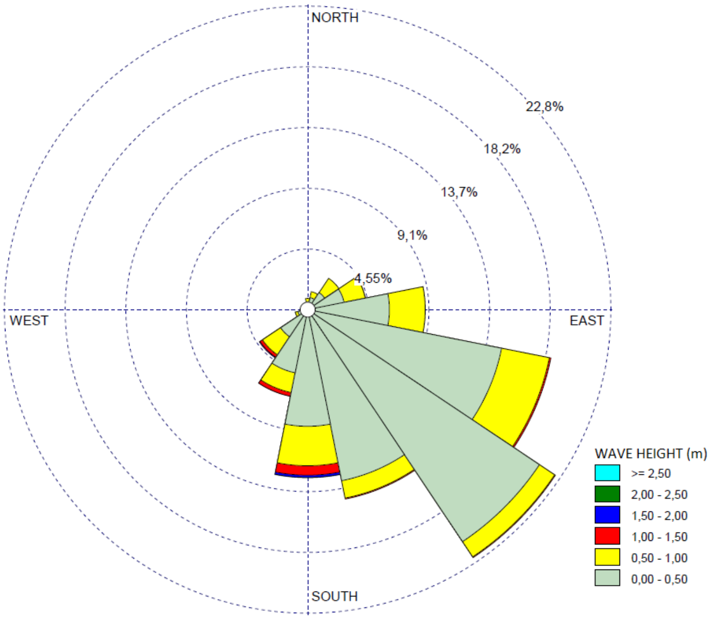


Figure 4. Wave rose diagram for 16 cardinal wave directions at TPIC buoy.

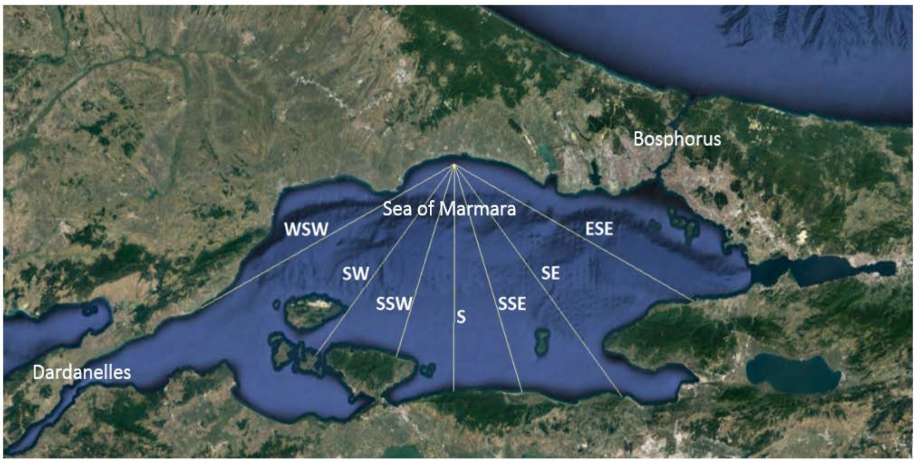


Figure 5. Fetch lengths for TPIC buoy.

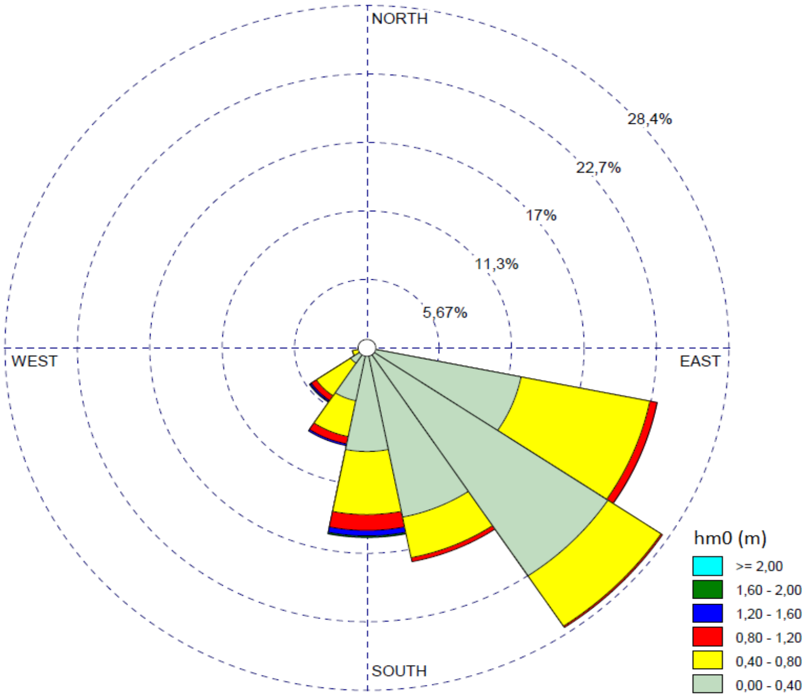


Figure 6. Wave rose diagram for TPIC buoy.

Figure 7 shows the relationship between the risks level and wave height amounts on the horizontal axis. The risk level is defined as the exceedance probability for a given wave height. It is obvious from this figure that as the risk level increases wave height amounts decrease. For practical risk level ranges, say 1% and 10%, wave heights correspond to 1.13m and 0.55m, respectively.

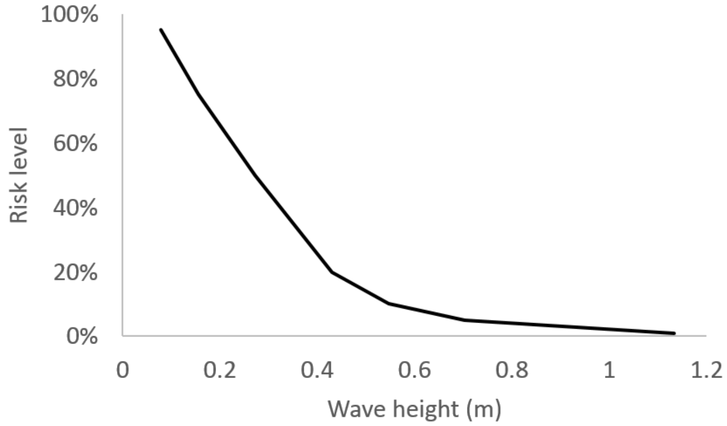


Figure 7. Wave height-risk level relationships at TPIC buoy for sector 101.25°-258.75°.

Joint probability density function of the significant wave height H_{m0} and mean wave period T_{02} are calculated and plotted in Figure 8 for the meaningful wave measurement sector taken between 101.25° and 258.75°, where the frequency of occurrence is scaled to 1:10000. The solid lines represent constant wave steepness, $H_{m0}/L_{m0} = 2\pi H_{m0}/gT_{02}^2$ for 1/20 (blue) and 1/40 (red). Herein, $gT_{02}^2/2\pi$ represents wavelength computed for deep-water waves. Battjes (1972) indicates that limiting wave steepness range from 1/16 to 1/20 in random waves. Similarly, all waves measured fall below wave steepness of 1/20. The most frequent wave has $H_{m0} = 0.25$ m and $T_{02} = 4$ s. The highest waves occur for $H_{m0} = 2$ m and $T_{02} = 5$ s and for a total duration of 13 hours per year.

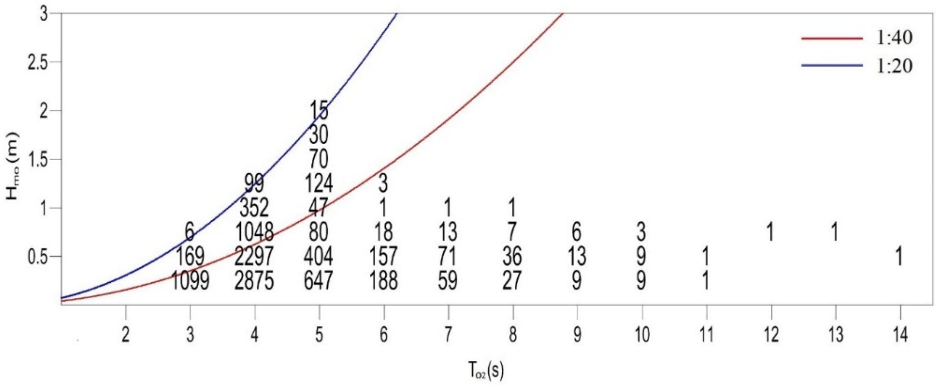
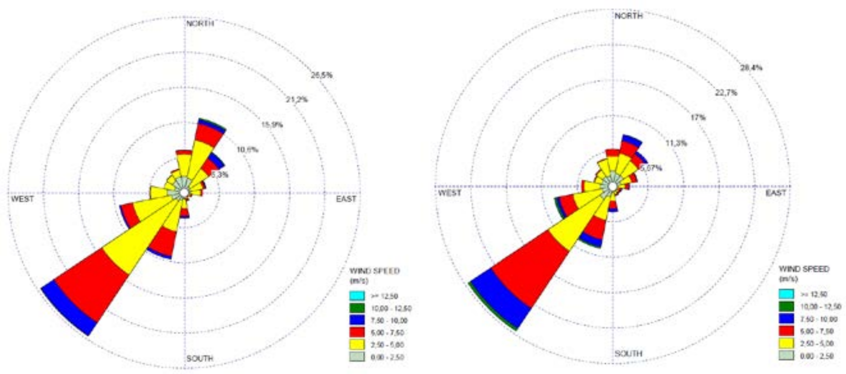


Figure 8. Joint distribution of H_{mo} and T_{02}.

Saçu et al. (2018) compared the measured wind data at TPIC buoy with ERA Interim and Cera-Sat data for the closest location to the TPIC buoy for the same period (Figure 9). ERA Interim and Cera-Sat data yield similar results; however, the direction is basically opposite of that given in Figure 3 for the TPIC buoy.



(a) (b)

Figure 9. Predicted wind data for (a) ERA Interim (b) Cera-Sat.

Saçu et al. (2018) also estimated the wave heights at TPIC location by using simplified wave prediction methods as CEM, Wilson, JONSWAP and SMB. They later compared the predicted wave heights with observed ones of TPIC and concluded that simplified wave methods tend to underpredict the significant wave heights. Similar findings were also reported by Etemad-Shahidi et al. (2009) and Akpınar et al. (2011). Comparison of the methods shows that the WILSON method is more accurate than the others in predicting wave heights at TPIC location in the SM.

Kutupoğlu et al. (2016) employed a SWAN model to predict wave conditions in the SM. In this study, the ERA Interim winds from the ECMWF and the CFSR winds from the NCEP are employed as wind forcing for comparison purposes. ERA Interim data set has a spatial resolution of 0.100ºx 0.100º and a 6-hour temporal resolution while CFSR dataset a has spatial resolution of 0.2045º x 0.2045º and a 1-hour temporal resolution. They concluded that the peaks of the winds were underestimated by both CFSR and ERA Interim wind datasets although the CFSR predicts much better than with the ERA Interim. Similarly, SWAN model using the CFSR winds has better prediction performance in the wave height peaks; although both of the wind sources underestimated the wave-height peaks during the storms.

4. Conclusion

Wave climate for the Sea of Marmara (SM) has been reviewed. Based on one-year-long measurements collected by Turkish Petroleum International Company (TPIC) in the SM, for the most frequent wave the wave height and period are $H_{m0} = 0.25$ m and $T_{02} = 4$ s while for the highest waves $H_{m0} = 2$ m and $T_{02} = 5$ s. Total duration of highest waves is 13 hours per year. These results are in agreement with Abdollahzadehmoradi et al. (2014) who have computed that the wave energy in the SM is very low.

Simplified wave prediction methods tend to underpredict the significant wave heights in the SM (Saçu et al., 2018). The highest rates are calculated around Çınarcık trough zone as 0.84kW m^{-1} for the year 2012. The peak values for wind speeds are also underestimated by both CFSR and ERA data sources, although the CFSR wind data set gives better results compared to ERA (Kutupoğlu et al., 2016). As these sources underestimate the peak wind speeds, the SWAN model used for the SM likewise underestimated the wave height peaks during the storm conditions. Nevertheless, use of the CFSR wind data provides somewhat better prediction performance for the wave height peaks.

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CHAPTER 3

OIL POLLUTION, DETECTION AND RECOVERY

This chapter summarizes how the collection of reliable evidences is important immediately following each individual maritime accident. The most important factors obtained from chromatographic techniques are the concentrations and diagnostic rates of petroleum compounds. The choice of diagnostic rates should be based on a particular spill state, including type of oil, weather conditions, abundance and distribution of the target compounds. It is important to estimate accurately the environmental damage caused by any oil spill and take the necessary measures. In this case, important factors such as the type of oil spill, the amount of spilled oil, the physical properties of the area, the time (season), the region's biota and the exposure of other pollutants to the area should be determined urgently. Laboratory and in-situ studies conducted during the last 20 years indicate new technological advances in assessing the impacts of oil spills. Remote sensing technology, for example, provides quick and low-cost analysis of large areas. The studies given in this chapter act as a guideline for developing coastal management strategies and clarify the complexity of oil spill disasters. The main objective of clean-up operations is to reduce the effects of oil pollution. Therefore, this chapter also examines appropriate response methods and techniques for containment and physical, chemical and biological responses of recovery. Sample clean-up applications for some major maritime accidents along the Turkish Straits Sea Area have been introduced. In addition, theoretical information about dispersants, their benefits and applications in the marine environment, potential effects, trade-off of risks have been discussed.

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OIL POLLUTION AT SEA AND COAST FOLLOWING MAJOR ACCIDENTS

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1. Introduction

The major marine environment pollutant is oil, and it is of great importance in terms of their amount of space occupied. Being a complex natural mixture of carbon and hydrogen, it may also contain nitrogen, sulfhur and oxygen, nickel, and vanadium. The density of oil is less than water. If it is deposited on seabottom, its toxicity and partly smothering effect cause harm to marine life (Smith 1971).

The thickness of the layer formed by the spilled oil on the water surface is inversely proportional to the residence time of the water surface. However, this also varies according to the type of oil (Table 1). The low-molecular-weight hydrocarbon molecules containing twelve or less carbon atoms of the spilled oil product rapidly evaporate. Evaporation also depends on all kind of water movements in the sea. As the molecular weight of petroleum hydrocarbons decreases and polarity increases, their solubility in water increases. Figure 1 schematically represents the fate of oil spilled on the sea surface, identifying key processes such as evaporation, dissolution, biodegredation and sedimentation (Kim et al., 2013 and references there in; Gross et al., 2014). Crudes and heavy fuel oils are complex mixtures of various hydrocarbons ranging from paraffins, aromatics, naphthenes, and resins to asphaltenes. Long chained paraffins tend to crystallize when cooled down, which leads to severe sedimentation. The type of oil, wind direction, waves, water turbulence and sea temperature are the main factors affecting the surface distribution of spilled oil. Fuel Oil 6, known as “bunker oil or heavy fuel oil”, has a low weathering capacity. It is highly persistent, with the potential for long-time sediment and coastal contamination. When the temperature of the water is lower, it often leads to formation of pancake-like tar globs. Tarballs washed up on shore are difficult to remove from contaminated surfaces (Figure 1). They can be stored in coastal recreation areas, under the control of tides and waves, and may be mix with coastal sediments or, in some cases, embedded in layers beneath beach sediments (sedimentation), as in the cases of *Volgoneft 248* and *Orcun-C* tanker accidents.

It is important to accurately estimate the environmental damage caused by any oil spill and then take the necessary measures. In such cases, important factors such as the type of oil spill, the amount of spilled oil, the physical characteristics of the area, the time (seasons), the biota and the exposure of other pollutants to the area should be determined urgently.

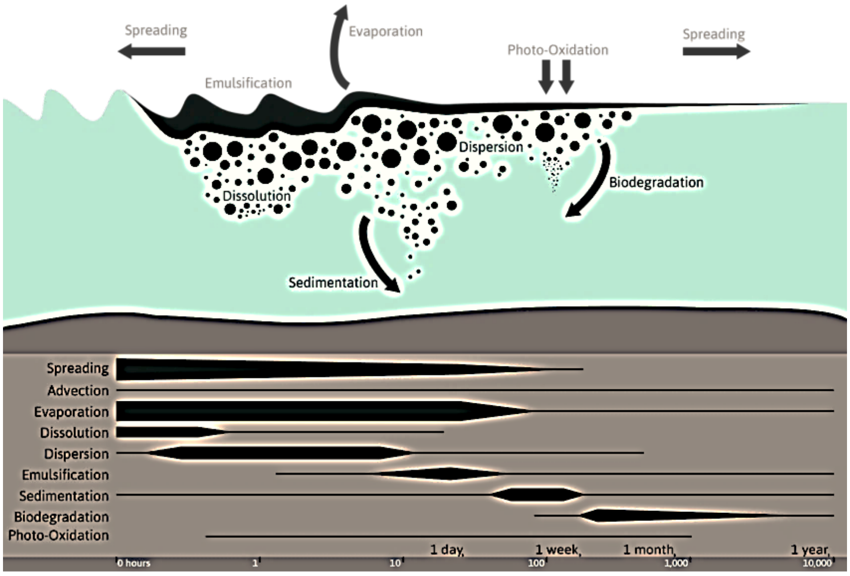

Figure 1. Time-dependent behavior of oil spills in marine environment (http://www.greenpeace.org/new-zealand)

Table 1. Petroleum hydrocarbons can be moved away from point of origin by various processes (http://www.greenpeace.org/new-zealand).

Input Type	***Persistence***	***Evaporation***	***Emulsification***	***Dissolution***	***Oxidation***	***Horizontal Transport or Movement***	***Vertical Transport or Movement***	***Sedimentation***	***Shoreline Stranding***	***Tar balls***
Gasoline	days	H	NR	M	L	L	L	NR	NR	NR
Light Distillates	days	M	L	H	L	M	H	L	L	NR
Crudes	**months**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**H**	**M**
Heavy Distillates	**years**	**L**	**M**	**L**	**L**	**H**	**L**	**H**	**H**	**H**
Vessel operational	months	M	L	M	L	M	L	L	L	M
Two-stroke engines	days	H	NR	M	L	L	L	NR	NR	NR
Atmospheric	days	H	NR	M	M	H	NR / NR	NR	NR	NR
Land based	U	M	L	L	L	M	M	M	NR	U

H = high; L = low; M = moderate; NR = not relevant; U = unknown

International oil transportation (crude oil and petroleum products) is expected to increase by 2.9% in 2018 after an increase of 2.6% over the same period last year (Maritime Sector Reports, 2017). Since the 1990s, in parallel with the increase in the oil transferred to the ports in the Black Sea, the number of ships carrying hazardous cargo and oil passing through the Turkish Straits has increased significantly. Therefore, the Turkish Straits Sea Area (TSSA) has become much more risky. There is no any other accident in the world that a woman sleeping in her bed was killed by a ship (M/V Arhangelsk, 1963). Many maritime accidents resulting in oil spills affected marine ecosystem and human life along the TSSA largely. The Nassia accident was the second most important tanker accident in the TSSA, which is a sensitive waterway, to understand the size and importance of the risks and risks of tanker transport in a realistical way. Nowadays, since 1994, in almost all large-scale accidents, both local and private institutions and scientists have gained important experiences and knowledge during field pollution monitoring, instant emergency responses and following clean up. Since each accident may have its own characteristics, the lessons learned from these cases played crucial roles in taking scientific decisions by scientists and institutions for specific cases.

The studies of the last twenty years have shown new important technical advancements for assessing impacts of oil spills both in laboratories and on field. Dissolved or dispersed oil in water has potentially toxic effects to marine organisms (Bejarano et al., 2006; Guitart et al., 2008), so it is essential to understand oil composition and concentrations in seawater in assessing the environmental impact of oil spills. In present, the analytical techniques used to reveal the amount of pollution are rapidly developing because the effects of oil pollution are well understood and predictable. GC/MS/MS, FTIR, HPLC and UVF techniques are widely used for the qualitative and quantitative determination of petroleum hydrocarbon-based oil spills. A common practice in the literature for the quantification of oil spills in various matrices (such as water, sediment and biota); is generally used as a reference substance for use of ship spilled oil (Erhardt and Petrick, 1989; Ünlü and Güven, 2001; Ünlü et al., 2009). Similarly, in the hydrocarbon pollution studies of TSSA accidents (such as *Nassia, TPAO*, *Volgoneft-248*, *Gotia* and *Orçun-C*) that occurred between 1994 and 2010, standard curves and amprical equations of reference substances were used for various qualitative and quantitative laboratory analyses (Ateş Duru, 2018 *see this Chapter*).

In this article, a review of the research expeditions of some important tanker accidents in the TSSA between 1979 and 2010 and summary evaluations of the oil impurities are given.

2. Observations performed in sea and shoreline after major accidents

2.1. Case 1-M/T Independenta oil spill *(Southern Entrance of Istanbul Strait*)

At the entrance to the İstanbul Strait, the Libyan tanker Independenta, carrying the Libyan crude, and the Greek tanker, Evrialy, collided. It was one of the largest historical accidents causing heavy sea and air pollution in the İstanbul region and the Sea of Marmara (Usluer and Oğuzülgen, *see Chapter 1*), even bigger than the Exxon Valdez spill in Alaska. After the explosion on 6 December 1979, approximately 64,000 tonnes of Libyan crude oil was spread over the Sea of Marmara, and approximately 30,000 tonnes of fuel burned (Baykut et al. 1980; Etkin, 1997). The crude oil, partly tarred, spread over the water surface and up to the shores of Beykoz and Büyükdere with the effect of Lodos, and deposited to the sea bottom because of density increment (Baykut, 1980). The highest amount of particles in the air reached up to 1000 mg m^{-3}, four times of the maximum limit value defined by the World Health Organization (WHO), due to the long-lasting combustion of crude oil on the ship (Kor, 1979). Unfortunately, there has not been any adequate monitoring study on the effects of oil pollution on water, sediment and biota of the İstanbul Strait and the Sea of Marmara. The only scientific result of this accident (Baykut et al., 1980) was obtained using Ultraviolet, FTIR and GC methods. The seabed was covered with a thick layer of tar, with an average concentration of 46 g m^{-2} (Baykut et al., 1980). Furthermore, the mean oil concentration in seawater, down to the termocline layer at -50 m depth, was estimated 84 ppm. The tanker wreck remained off the Haydarpaşa train station for many years and posed a danger for both the environment and regional maritime traffic. Only seven years later, the area was cleared from the wreck of Independenta. This accident was an important experience in understanding the risks of the TSSA in terms of tanker transportation.

2.2. Case 2-M/T Nassia Oil Spill *(İstanbul Strait)*

At the end of the 80s, the increment in the Caspian oil transportation threatened the Turkish Straits directly. The Istanbul Strait had to witness a new historical accident in March 1994. The crude oil-loaded tankers from the Black Sea, the Greek-flag Nassia, which had just entered the Bosphorus, collided on the Hamsi Port-Filburnu line with Greek ship Shipbroker sailing from the Sea of Marmara to the Black Sea (Figure 2). The tanker was carrying 98,600 tons of crude oil, with also 600 tons of fuel oil and 250 tons of diesel oil in her machine room. After the collision, 9000 tons of Soviet crude oil was immediately spilled in the strait. After the accident, volatilization of the volatile oil components took place, but most of the oily particles were stranded along the shores of the Black Sea and the İstanbul Strait. Most of the oil in the water is naturally dispersed by local winds and strong surface currents. Although the cleaning studies had started immediately, it lasted during the following spring and summer.

This was the first environmental case study in which detailed hydrocarbon analyses were applied to the water and sediment samples as well as to some selected marine organisms in the laboratories of the Institute of Marine Sciences and Management, the Istanbul University (IUDEBİEN). In this monitoring survey, started one month after the accident, a total of 10 points were sampled from the Black Sea, İstanbul Strait and the Sea of Marmara; cruises in April (21-27), July (05-11) and September (23-28) (Doğan et al., 1995). Dissolved and dispersed hydrocarbons in seawater and sediment samples measured fluorometrically in April varied from 12.1 to 24.9-μgL^{-1} and from 28 to 130 μgg^{-1} (dry weight) Nassia oil equivalents (Doğan et al., 1995). Approximately six month after the Nassia oil spill, Total polyaromatic hydrocarbon concentrations have been reported to decrease gradually in seawater (max.1.3 μgL^{-1}), but have increased after sedimentation (max. 270 μgg^{-1}) (Doğan et al., 1995; Güven et al., 1996).

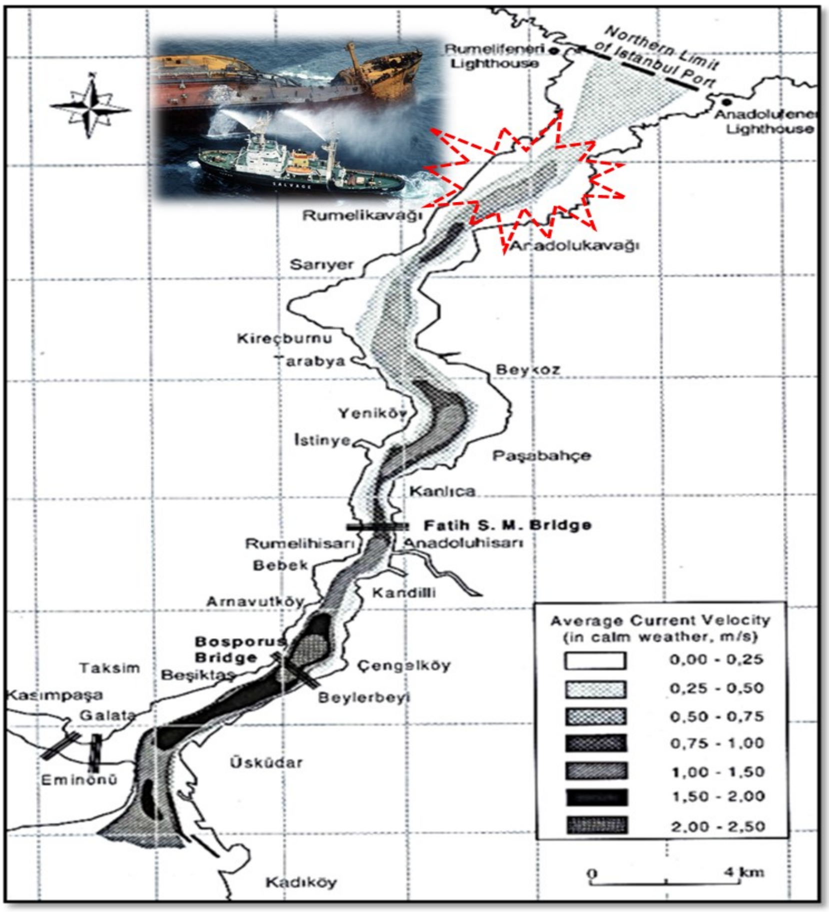

Figure 2. Location of M/T *Nassia* tanker accident in the İstanbul Strait. Superimposed on the average current velocities along the Strait given by ONHO (1997).

Fresh oil inputs, similar in appearance in the chromatographic analysis to heavy fuel oil, were found at several sampling stations in the İstanbul Strait and the Sea of Marmara during the surveys (Okuş et al., 1996). It may be suggested that such inputs come from industrial sources or heavy ship traffic using these waters. The absence of any known background data on petroleum hydrocarbon pollution in the accident area was an important deficiency. The low levels of Nassia oil detected are considered unlikely to have had any significant long-term impact on subtidal or pelagic marine communities, either or no detectable minor short-term effect on subtidal and benthic communities in the region. Highly dynamic nature of water movements and vertical water mixing in the İstanbul Strait were likely to have been the main factors in promoting natural dissipation of the spilled oil and in minimizing their environmental impacts.

2.3. Case 3-*M/T TPAO* oil spill *(Tuzla Shipyard, NE part of Sea of Marmara)*

On February 13, 1997, *TPAO*, a national tanker, was burned at the Gemsan Shipyard in Tuzla, NE part of the Sea of Marmara, while it had been anchored for repair (Photo 1). Before the accident, the total amount of fuel on the ship was 621 tons, mostly Tupraş-650 Bunker Fuel oil and 35-m^3 Tupraş 400 diesel in ship tanks (Okuş et al., 1997; Sarıkaya et al., 1998). A minimum of 214.3 tons of oil spilled into the sea. 173 tons of the spill oil were collected, against 41.3 tons (55% of total) remained in the marine environment. Approximately 25% of the remained oil was evaporated and 20% collapsed into the sea bottom forming tar balls (Okuş et al., 1997; Sarıkaya et al., 1998). The pollution spread over a large area due to local winds and longshore currents. After the accident, ship fuel has a significant impact on a 6-km^2 area. The monitoring studies for marine life were merely impossible in the inner bay for about 7 days due to the heavy oil slicks.

The amount of total petroleum hydrocarbon (TPH) in water, sediment and biota in the affected area was investigated by the IUDEBİEN, for the next year. According to the results given by Doğan et al., (1998), the amount of dissolved and dispersed hydrocarbons detected in surface water off a nearby shipyard (Hidromak) where the ship is anchored was 86.9 mgL^{-1} only 20 days after the accident, which was well above the limit value given in the literature (13 μL^{-1}; Zhijie, 1990). However, it was close to this limit value 11 months later (23.2 μL^{-1}).

Approximately one month after the TPAO oil spill, the highest dissolved and dispersed hydrocarbon values were 33.2 $\mu g\ L^{-1}$ in sea water, 423.0 μgg^{-1} (dry weight) in sediment and 2067 μgg^{-1} (wet weight) in mussel samples (Doğan et al., 1998; Ünlü et al., 2000). Extreme mortality of larvae and fish eggs have been reported as well (Okuş et al., 1997; Doğan et al., 1998). Normal conditions have only been detected nearly 7 months after the accident (Okuş et al., 1997, Doğan et al., 1998; Ünlü et al,. 2000). However, the traces of pollution continued in the biota one year after the accident, high amounts of TPH (1965 μgg^{-1} wet weight, *TPAO* oil equivalent) were determined in the collected mussel samples. Using the fingerprint of the ship fuel, the first illuminating results were obtained about the presence and similarity of *TPAO* fuel fingerprints in water, sediment and mussel samples. The fingerprint analyses carried out approximately one year later have shown the presence of footprints of the spilled oil in the mussels collected from the accident area (Doğan et al. 1998; Ünlü et al., 2000).

The absence of background data on hydrocarbon pollution in the accident area was a critical deficiency. However, in order to monitor the spread of pollution outside the port, historical TPH series, established in two stations 8 km away from the accident area since 1995, had been important base data in evaluating the oil spill effects (Sarıkaya et al., 1998; Doğan et al., 1998).

Photo 1. *TPAO* tanker was burned at the Tuzla Gemsan Shipyard (*photo by S.Ünlü*).

2.4. Case 4-M/T Volgoneft-248 oil spill *(Florya, S coast of Istanbul)*

Russian flagged tanker *Volgoneft-248* (4,039 DWT), loaded 4,365 tons of fuel from Bourgas/Bulgaria and anchored off the Ambarli fuel oil terminal to unload her cargo. In small hours on December 29th 1999, chain cables came off due to the heavy southerly persistent winds and the vessel split into two about one km away from the Florya shores. The bow part sank into the sea at once and the aft side of the vessel drifted and then grounded at the shores of Menekşe District, Küçükçekmece. Because of the accident, 1,279 tons of fuel oil existing in fore tanks 5 and 6 spilled into the sea. Due to the 2,073 tones existing in tank 4 at fore side and 1,013 tonnes of fuel oil existing in tanks 7 and 8 at the aft side spilling into sea until the divers closing the holes at fore side, 3,086 tonnes of fuel oil spread into the area (ITOPF, 2000). The fuel oil spilled into the sea spread into 7-km^2 area along the shoreline rapidly in a few hours under the influence of heavy storm winds and relevant waves (Figure 3). The oil inundated 2 to 10 m in some coastal areas, and its thickness reached 5 cm in surface water (ITOPF, 2000). To avoid leakage of the remaining fuel oil, a series of barriers were used (Otay and Yenigün, 2000). The beaches close to accident area were covered with gravelly sand and concrete platforms, between restaurants, seaside cafes and summerhouses. The fuel oil, which is thick and adhesive in low temperatures during winter months, filled in the spaces between sand grains at the bottom, and sandy sea bottom was saturated with fuel. Thus, great part of the fuel oil floating at shore was covered up with sand and spread in sheets over the sea bottom along the shore. It was observed that fuel oil accumulation was high at the Menekşe beach zone. Great amount of fuel oil in decayed condition and in the mussel shells smeared to the fuel oil drifted to the shore under the effects of heavy southerly winds dominated from January to March. Starting from the very beginning of the accident, fuel oil smeared many living creatures in the marine ecosystem, and then to the sea birds that were affected badly and mostly died.

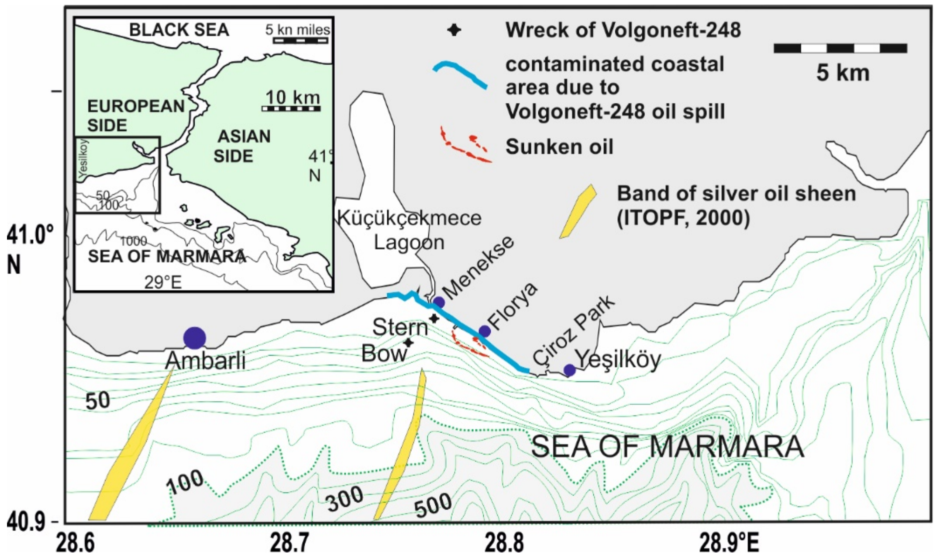

Figure 3. Contaminated coastal areas due to *Volgoneft -248* oil spill

The highest level of oil in seawater was 2.17 mg L^{-1} at the time of accident. Later the oil concentrations decreased to 88.5 µg L^{-1} on January 3rd 2000, and to normal values (0.3-1.5 µg L^{-1}) after the clean-up procedures (Doğan et al., 2006). In different stations, TPH levels were found over the limit value of 100 µgg^{-1}, that is 10-44 times the limit value (10µgg^{-1}) defined for sediment.

Consequently, the petroleum pollution as of accident date in five-year period was investigated in details. Other detailed characteristics of this specific accident were given by some other researchers (Gülbey and Su, 2002; Alpar and Ünlü, 2007; Taş et al., 2011; Kanburoğlu and Hürzat, 2013; Taş, 2018, *see Chapter 4*; Duru Ateş, 2018, *see this Chapter*; Yüksek and Gürkan, 2018, *see Chapter 4*).

2.5. Case 5-M/V GOTIA oil spill *(Emirgan Pier, İstanbul Strait)*

On October 6, 2002, *M/V GOTIA*, carrying 163 metric tons of fuel oil in her fuel tanks, rammed into the Emirgan Pier (Figure 4). A fuel tank started leaking oil, which are transported by longshore currents rapidly, contaminating seawater, boats and infrastructures (Photo 2).

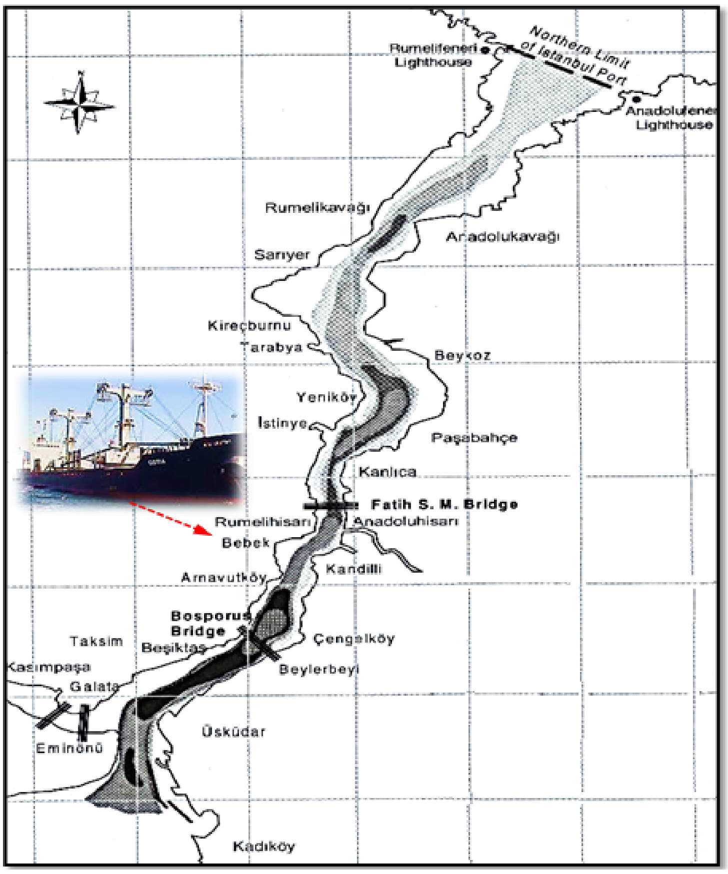

Figure 4. Location of M/V *GOTIA* tanker accident in the Istanbul Strait. Superimposed on the average current velocities along the Strait given by ONHO (1997).

Although the amount of oil spill was estimated as 20 tons, the biggest damage was caused by those trapped in the small bays along the İstanbul Strait (Barla et al., 2003, Otay and Yenigün, 2003a; Otay et al., 2003b). The surface of the sea is covered with heavy oil layers immediately after the accident. Although the oil layers at the sea surface were surrounded by barriers, the pollution escaped through some gaps between these barriers and, resulting unstable results in scientific measurements. In addition, the distribution of oil layers has changed continuously with the effect of regional wind and currents. During the first days of the accident, heavy oil pollution stuck in the İstanbul Strait (between Arnavutköy and İstinye) depending on the wind and currents, and then diffused into the Sea of Marmara four days after the accident.

Photo 2. The oil slick contaminated the infrastructures including piers, seawalls and waste barriers *(photo by S.Ünlü).*

The spread of spilled fuel into the İstanbul Strait, into the Golden Horn and to the Sea of Marmara was investigated by IUDEBİEN research team for the next 70 days and results of the laboratory analyses was given by Barla et al. (2003) in detail. In laboratory, 286 samples (279 seawater, 6 mussel and 1 algae) were analyzed for UVF analysis. In addition, fingerprint methods were performed with GC/MS in 200 samples to determine the origin of pollution (Barla et al., 2003).

On October 10th 2002, four days after the accident, the highest levels of pollution in seawater were reported 813.5, 27.4 and 7.3 mgL^{-1} in Arnavutköy, Yenikapı and Golden Horn estuary, respectively (Barla et al., 2003).

When the results of the oil pollution-monitoring project of the Straits System, which was initiated by the IUDEBİEN research team in 1994, were compared, the amount of pollution caused by *GOTIA* accident exceeded the normal values. In the area closer to the Istanbul Strait exit (off Sarayburnu), the amount of TPH increased to 175mgL^{-1}. The increment is about 180 times. The annual range of oil pollution time series in the strait were 1.35-85.7, 1.39-66.8, 0.81-45.3, 1.02-52.8, 1.84-44.5, 0.41- 68.7 and 1.87-48.9µgL^{-1} from 1996 to 2002 (İSKİ, 2002). While the seawater TPH levels at the Sea of Marmara exit of the İstanbul Strait were measured 0.41-85.7µgL^{-1} between the years of 1996 and 2001, it was 27.4 mgL^{-1} on the dates following the accident. The increament is about 30 times.

It is known that the surface current in the İstanbul Strait is controlled by strong Black Sea currents in normal conditions. Therefore, although the traces of pollution caused by the fuel of GOTIA ship in the were terminated at the end of 70 days, by mixing with the waters of the Sea of Marmara (Barla et al., 2003; Güven et al., 2004). In addition, the maximum amount of oil pollution in the contaminated mussels was reported as 198.2 µgg^{-1}, wet weight (Barla et al., 2003; Güven et al., 2004).

Case 6-M/V ORÇUN C Oil Spill

(Kilyos-Istanbul, Black Sea entrance to the Istanbul Strait)

On January 19, 2010, the ship named M/V ORÇUN C was stranded at the Kilyos, and broken by severe storm. With this accident, 96-tonnes F06 fuel oil and 25-tonnes diesel oil are spread over the sea surface. Within a few hours after the accident, the spilled fuel oil and diesel mixture spread over an area of 4 km, with the effect of persistent northern winds, strong waves and rip current formations (Beji and Barlas, 2017), and created serious environmental pollution at the sea and the coastline. Recreational areas, restaurants, and camping areas have been affected. The beaches, rocks and pebble coastline region are dominated by sandy habitat. Algae diversity is distributed close to the coastline. It is an extremely important field for fishing and species diversity. In addition, because the fish with high economic value is on the migration route, the region is also important in the maintenance of fishing activities (such as trawler and purse hunting).

The fuel oil invaded into the shore 2-to-10 meters during the next few days after the accident and it stayed 2 cm thick at the sea surface. The fuel oil accumulated in layers at the Uzunya Beach and coastline of the Bays of Cennet and Bara with the effect of waves (Photo 3-5; Ünlü and Yüksek, 2010). MARE Sea Cleaning Services started emergency response procedures on the first day of the accident. On 20 January 2010, the monitoring and damage assessment commission established by the Governorship of Istanbul immediately initiated the damage assessment studies for the removal of the shipwreck and environmental pollution. In order to determine the traces of pollution and damage on the affected coastline, Institute of Marine Sciences and Management (IUDEBİEN) of Istanbul University organized four research expeditions. In order to determine the marine biota exposed to oil pollution, especially in the affected shoreline and in the areas where the ship was stranded, macrobiobentic and algae species were determined by diving in SUKUBA, sampling and taking photos in areas close to the shore.

Fourteen days after the accident (1 February 2010), the first survey was carried out and seawater samples were taken from 40 sampling points (Figure 5). Detailed information about sampling and analysis is given in Ünlü and Yüksek (2010).The sampling stations were 100 to 250 m away from the shoreline. The fuel oil from the seawater samples at the Uzunya Beach varied between 8.57 and 126.3 μgL^{-1}. The TPH levels in the coastal water sample taken from Güvenburnu and around the ship wreck were 10.64 and 21.96 $\mu g\ L^{-1}$ *ORCUN-C* oil equivalents, respectively (Ünlü and Yüksek, 2010).

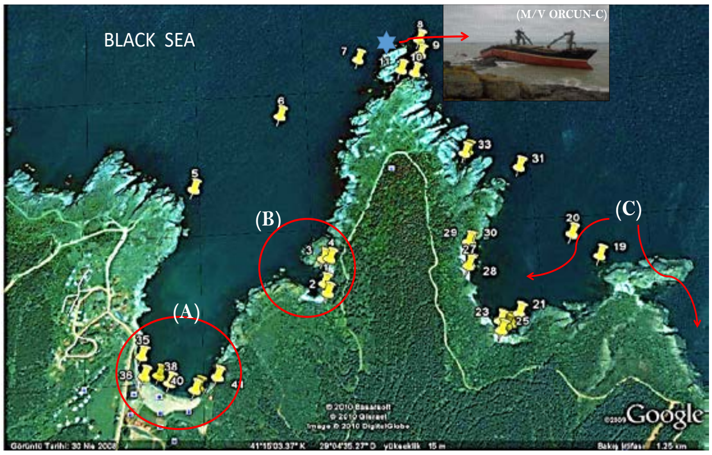

Figure 5. Location of the *ORCUN-C* tanker accident and sampling zones; (A) Uzunya Beach, (B) Cennet Bay, and (C) Küçükbara and Büyükbara Bays

Photo 3.The layers of oil carried onto the Uzunya Beach under the strom waves and rip current formations after the accident of the tanker (*photo by Selma Ünlü*).

It was found that the amount of fuel oil contaminated in the coastal seawater samples of the Büyükbara Bay ranged between 17.34 and 1049 µgL^{-1} and the water taken from the pond formed amid the coastal rocks was found to be 55.1 mgL^{-1}, dry weight, *ORCUN-C* oil equivalents. In the Küçükbara Bay coastal water, the fuel oil level was between 4.84 and 63.8 µgL^{-1}. In literature, the acceptable limit level for coastal waters is 5 µgL^{-1} (Law, 1981). The values found in the coastal waters of Uzunya Beach were 1.7-to-25.2 times higher than the limit value. On the other hand, the amount of pollution detected in the coastal waters of the Uzunya Beach was 2.1 times of the limit value and 4.4 times in the sampling by the wreck. Acceptable values were found 2.4 times in the Cennet Bay, 209.8 times in the Büyükbara Bay and 12.7 times in the Küçükbara Bay.

Photo 4. Oil and trash layers transported by waves in the Cennet Bay (*Photo by Selma Ünlü*).

Photo 5: Oil and trash layers transported by waves in the Küçükbara Bay (*photo by Selma Ünlü*).

The high TPH values obtained at the Uzunya Beach and Cennet Bay reflected pollution collapsed in coastal sands. The limit value for clean coastal sediments is suggested as 10 μgg^{-1} by Literathy et al. (1992). Accordingly, Uzunya Beach and coast sand at Cennet Bay exceeded this limit value 1.18 and 1.69 times, respectively. The traces of the accident are much worse along the coastline of the Bara Bay. The TPH levels detected in the sediments of the Küçükbara and Büyükbara Bays were between 0.1-102.8 mgg^{-1} dry weight, *ORCUN-C* oil equivalent (Ünlü and Yüksek, 2010).

On 05.03.2010 (44 days after the accident), TPH values, 194, 13.2 and 17.3 times of the maximum limit value, were determined in the sediment samples recovered from the Uzunya Beach (Figure 6), Bays of Cennet and Büyükbara. Due to the high TPH values detected in the sand of Uzunya Beach, the number of sampling points was increased on 10.04.2010 in order to get information that is more detailed.

Figure 6. Location of Uzunya beach sand samples, March 05, 2010.

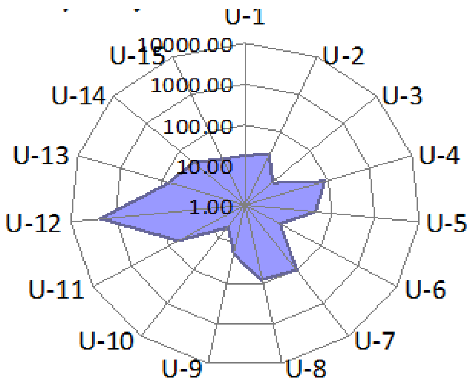

Figure 7. The TPH levels (μgg^{-1}, dry weight) from the sand samples in the Uzunya Beach, dated 05.03.2010.

The amount of fuel oil pollution in seawater sampling from various points of Uzunya Beach has changed between 8μgL^{-1} and 270.5μgL^{-1} (Figure 7). The detected values are usually above the limit value. It is thought that this situation was caused by the formation of high-energy areas by occasional mixing of the coastal waters with the Uzunya Beach sand.

On 10.04.2010, (82 days after the accident) in the area of Uzunya Beach sand sampling area, it was determined that there were tar structures under the sand and varying in size. The high values detected in this recreational area reflected that the oil pollution collapsed in sand due to fuel oil carried in the very first days of the accident and collapsed there.

In the sampling of 32 points in the Uzunya Beach sand (Figure 8), very high TPH levels were determined. The amount of TPH levels detected in the sampling layers of approximately 7 cm thickness were between 0.005and 5.56 mg g^{-1} (Figure 9). The values determined in the seawater and sediment samples from the Cennet Bay were between 23.8-475.9 µgL^{-1} and 30.9 -64.4 µg g^{-1},dry weight, respectively (Ünlü and Yüksek, 2010).

Figure 8. Location of the Uzunya Beach sand samples-10 April and 27 May 2010

On 27.05.2010 (127 days after the accident), for the purpose of damage assessment assessment of the current situation in the coasts, the fourth trial expedition was conducted. The TPH values in the seawater were generally determined as 0.7-4.3 times the limit. The oil pollution in Uzunya Beach sand did not fall below the limit (10 µg g^{-1}; Literathy et al., 1992) recognized for the clean coastal sediment accepted in the literature, and it was distributed between 10-100 µgg^{-1}(dry weight, *ORCUN-C* oil equivalent) (Figure 10).

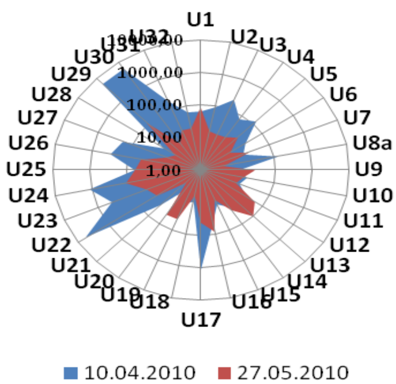

Figure 9. The comparison of TPH levels (µgg^{-1}, dry weight) in the Uzunya Beach sand samples

Although TPH levels are not known in seawater and sediments before spill in the study area, at the end of 127 days, it was concluded that the level of oil contamination in the region reverted to background levels because the quantities determined were generally close to the recommended levels for near-shore environments.

The effects of such accidents, which cannot be seen clearly in short term, can be taken into control in long term. Since they have effects on ecosystem and aquaculture potential, the balance of biodiversity, water quality and anoxic conditions must be monitored. Total bacterial, phytoplankton meso zooplankton, fish eggs and larvae, macro benthic species, fish distribution and fishing should be monitored periodically in order to determine the effect of petroleum contamination in the studied area.

3. Conclusions and Suggestions

Based on the global results of maritime accident studies as well as those occurred in the TSSA, the impact of an oil spill on the marine life is not directly related to the spill size. A small leak in an ecologically sensitive region may have long-term adverse effects. The effect of oil spill on marine environment is not directly related with the size of contamination, but rather with the type of oil, its hydrocarbon content, and local ecosystems. The accumulation and degredation of oil spills mainly depends on several factors; e.g. seabottom characteristics, tidal energy, waves, rip currents, coastal dynamics, morphological and meteorological conditions (Li and Boufadel, 2010). All these factors especially played important roles in oil-spill accidents occurred along the TSSA, since they determined long or short-term retentions of oil spill over the sea and shoreline.

Annual monitorings of the TPH levels in seawater after some major accidents occurred in the TSSA have revealed that the oil pollution decreased clearly in most of the cases. This shows how immediate sampling is crucial after an oil spill to avoid underestimation initial toxicological conditions and environmental impacts.

One cannot consider that TPH studies in seawater may not much critical if they compared to PAH studies. An accurate assessment of TPH pollution at the polluted region, however, may help employing remediation of the impacted site successfully.

The spilled oil in some major accidents along the TSSA, was removed from seawater rather quikly, such as the cases of *Gotia*, *Nassia* and *Orçun-C*. However, in some regions, continuous rise of oil concentrations in seawater indicates that the shoreline could be a secondary source of spilled oil and thus continuously affect the adjacent water column and the marine organisms living there.

Regional monitoring programmes need to be continued in all marine environments to describe concentrations and distributions of hydrocarbons at sea surface, in sediments and biota. Tar-monitoring programs should be initiated in the critical coastal zones of the TSSA affected by natural resources and oil spills.

In conclusion, the knowledge and experience learned from historical oil spill events will be guide for similar type of future pollution cases.

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FORENSIC FINGERPRINTING IN OIL SPILL SOURCE IDENTIFICATION AT THE TURKISH STRAITS SEA AREA

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1. Introduction

Oil pollution, a significant concern in the marine environment, is caused by oil spills from tanker accidents, bilge water of ships, oil refineries, leakage from drilling processes and industrial and municipal wastewater. Since oil pollution is not only the reason of instant physical harms for marine wildlife but also specific components, such as higher molecular weight polyaromatic hydrocarbons (PAHs) can have toxic effects on ecosystem with their persistence in the environment for long terms, it is dramatically important to monitor environmental pollution continuously and untargeted (Yeo et al., 2017). Oil spills have been identified as a major environmental issue, which pollutes marine environments for more than 40 years (Wang et al., 2006). Figure 1 illustrates the oil spill numbers for spills over than 7 tonnes from tankers from 1970 to 2017 (ITOPF, 2018). Besides, residues of oil spill affecting the beaches is a common global problem (Han et al., 2018).

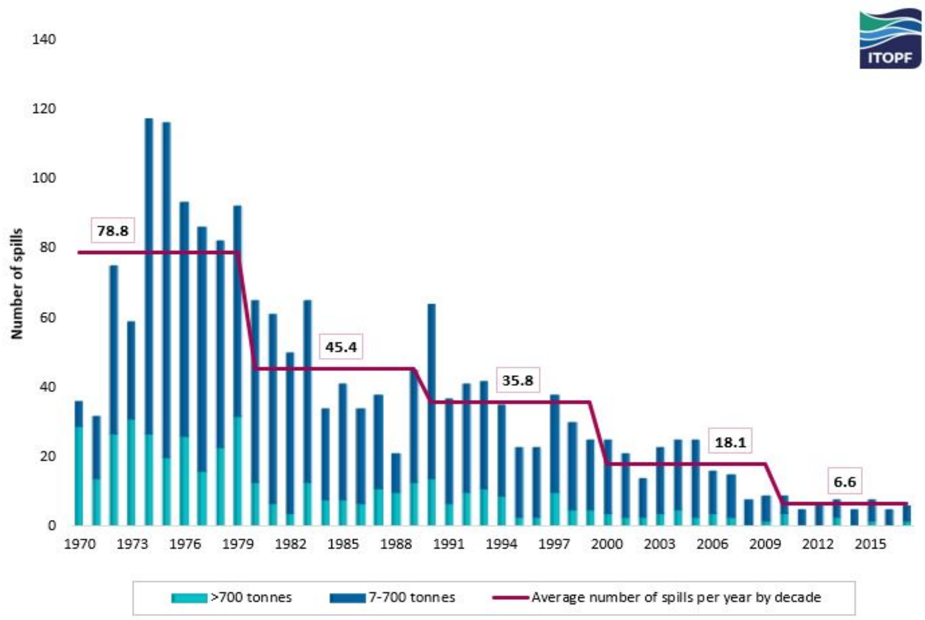

Figure 1. Number of oil spills over 7 tonnes from 1970 to 2017 (originally obtained from ITOPF, 2018)

Due to the growth of global economy, about 80% of trade of crude oil and petrochemical products, and 70% of imports from European countries, are carried out by sea. 20 % of the world's crude oil trade is realized through the Mediterranean.

According to the United Nations Environment Program (UNEP) assessments, around 360 million tons of crude oil are transported daily in the Mediterranean, while 100-150 thousand tons of crude oil or petrochemical derivatives are mixed with seawater. Accidents cannot be prevented, although the rules to be observed during the transport of hazardous substances by sea are determined by international agreements (MARPOL 73/78) (Yalçın Erik, 2017). Most of these products are produced and/or transported in the marine environment and industry and regulators work together to prevent oil spills however, a considerable amount of oil still gets spilled. Consequently, disastrous accidents cause public and regulatory enquiry. Diminishing the oil spills environmental impact, oil spill response resources are regulated, adjusted and become more available worldwide to respond to spill immediately (Prince et al., 2017). Since the 1960s, several oil spills around the whole world were occurred including Exxon Valdez (Prince William Sound, Alaska, 1989), Amoco Cadiz (Brittany, France, 1978), Castillo de Bellver (Cape Town, South Africa, 1983) and BP's Deepwater Horizon Oil Spill (Gulf of Mexico, 2010) that also caused extensive media attention. Because of Exxon Valdez incident there has been immense attention of attention and public outrage that lead to the Oil Pollution Act of 1990, which put liability on the responsible parties to prevent damages of oil spills and clean the polluted environment (Meyer et al., 2018).

The geography of Turkey, which is located at the crossroads between Europe and Asia, allows Turkish harbors to handle important amount of cargo between the Western and the Eastern points. In addition, shipping is the general method of transportation for Turkey's imports and exports, and most of Turkey's foreign trade has been carried by maritime transportation (İncaz, 2017). Strait of Istanbul (Bosporus) and Turkish Straits Sea Area (TSSA) (Figure 2) have a critical role in Turkey and in the world since a huge number of marine casualties have been occurred in. The risk of oil spill and tanker accidents is increased because of the navigation directions of commercial maritime transportation at the south exit of the Strait of Istanbul and near the north coast of the Marmara Sea. The threat of accidents also causes the increase of environmental pollution risks affecting shorelines, fishing activities and tourism, etc. (Alpar and Ünlü, 2005, Ünlü, 2016). Several marine accidents approximately over 450 marine accidents occurred in the Istanbul Strait and the reasons of collisions are strong currents, poor visibility, and engine failure. Some of the most serious sea accidents, which resulted in environmental pollution and damage, are as follows Petar Zoranić (Kanlıca, 1960), Independenta (Haydarpaşa, 1979), Jampur (Sarıyer, 1990), TPAO (Tuzla, 1997), Volganeft-248 (Florya, 1999), Gotia (Emirgan, 2002) and Orçun-C (Kilyos, 2010).

The identification of oil spills is mostly based on characterization of petroleum-derived products (PDPs) which has a growing importance in environmental science. Oil spills that are induced by accidents or illegal intentional operational discharges are common; however, an exact source determination is not simplistic for all the time. The type of spill should be analyzed and differentiated for identification of the source, evaluation of hazard level and employment of the appropriate treatment for cleanup (Ferreiro-Gonzalez et al., 2017). The crude oil has similar or different contents and properties due to the oil platform, oil well, depth of collection and different mixed ratios. In addition, ships are loaded with the crude oil from several oil platforms and they transport it to the land. Therefore, the spilled oil is often the mixture of numerous oil wells on these oil platforms. In addition, the complex sea circumstance is available. Considering all of these conditions not only the spilled oil identification but also management of oil spill accidents become more difficult (Sun et al., 2009). Moreover, weathering processes can affect and change the chemical composition of spilled oil. These processes are occurred when crude oils and its derivatives are unintentionally discharged to the environment. After the release, they are immediately subject to processes such as evaporation, dispersion, dissolution, adsorption on suspended materials, emulsification, microbial degradation and photo-oxidation, etc. (Wang et al., 2011; Gros et al., 2014). Because chemical compositions are variable, chemical fingerprints for each oil are unique which provides a basis for identification oil spill source (Wang and Fingas, 2003).

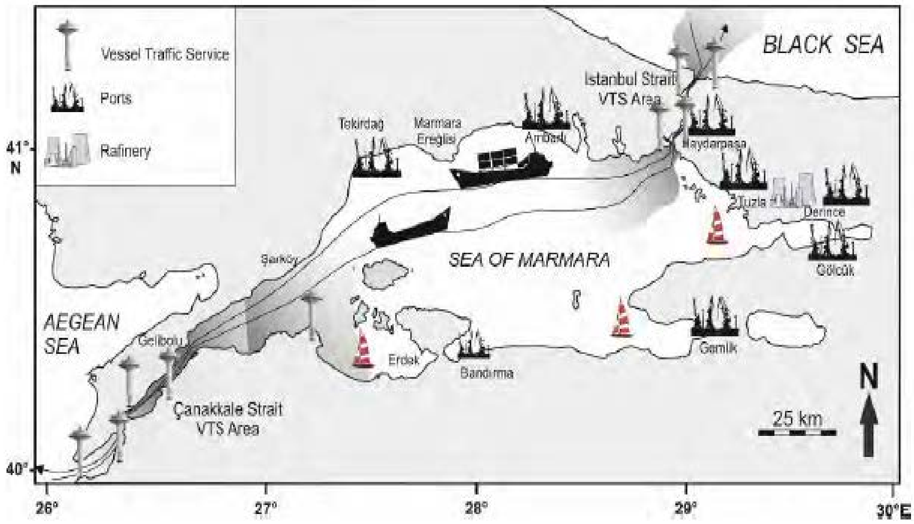

Figure 2. The Turkish Straits Sea Area (TSSA) (Ünlü, 2016).

Environmental damage assessment can be applied by characterizing spilled oils in samples from complex contaminated environment and identify its known sources. This will help to predict the potential long-term environmental impact of oil spills and to decide appropriate responses for spill and to take efficient clean-up actions. Besides, chemical composition characterization and oil spill identification of sources have a critical role for settling liability arguments (Wang et al., 2009). Valuable chemical fingerprinting data can be obtained with successful forensic investigation and examination of petroleum contaminants (Wang et al., 2011).

Oil spill identification has been performed with analysis of biomarker compounds that determined the content and distributions of PAHs of spilled oil.

Through the last years, various instrumental techniques including high-performance liquid chromatography (HPLC), gas chromatography-flame ionization detection (GC/FID), and gas chromatography-mass spectrometry (GC/MS) have been applied for the investigation of PAHs in petroleum (Wei et al., 2018).

Forensic fingerprinting of oil source was actually used in petroleum geochemistry afterwards it was adapted to investigate oil spills. The origin of oil residues from environmental samples were characterized by comparison to a known or suspected oil source with the help of analytical chemistry. Oil source fingerprinting is an effective qualitative standardized method for oil spill response. Conversely, quantitative oil source-fingerprinting method is an emerge need to have a supplemented addition for the qualitative determinations. The compounds defined as oil biomarkers are used for oil source fingerprinting and they are mostly crude oil constituents. Oil biomarkers that are universal in petroleum products and crude oils are polycyclic aliphatic hydrocarbon molecules. These compounds have resistance according to environmental weathering conditions (physiochemical and biological changes). Impart unique ratios in oils of different maturities and geographic sources (Meyer, 2016).

In this study, the summary of oil spill and its environmental effects was given firstly, and then the main principles of forensic fingerprinting method and its stages were briefly discussed. The core part of this study is forensic fingerprinting in oil-spill source identification at the TSSA. Therefore, the significant examples of national accidents and applications of these techniques were given as case studies to understand and examine forensic fingerprinting in oil-spill source identification at the TSSA in details. This study mainly focused on the accidents *TPAO*, *Volganeft-248* and *GOTIA* and the unknown oil spill in Haydarpaşa Port.

2. Biomarkers in Crude Oil and its Derivatives

Analytic techniques including gas chromatography/mass spectrometry (GC/MS) have target oil constituents that can be categorized into four basic groups:

"(1) individual saturated hydrocarbons like the isoprenoids and normal alkanes; (2) polycyclic aromatic hydrocarbons (PAHs); (3) sulfur heterocyclic aromatic hydrocarbons and related alkylated homologs; and (4) oil biomarkers that are polycyclic aliphatic" (Peters et al., 2005).

The significantly important groups of hydrocarbons in crude oil and its derivatives for performing fingerprinting method are biological markers or biomarkers. "Biomarkers" term is used for weathering resistant hydrocarbons. These complex molecules, found in rocks, sediments and crude oils, derived from previously living organisms and have high molecular weights tend and relatively recalcitrant nature. Because of these properties, biomarkers have a concentration that increases relative to other oil constituents used as internal markers to investigate the loss of the less stable oil components. They have a significant role to characterize, differentiate, correlate, and to identify the source in environmental forensic methods to investigate oil spills. These biomarkers are used to obtain valuable information and they are efficiently helpful for fingerprinting methods since they are composed of organic compounds, which are building blocks of living organisms and have modest or no structural transformation when compared to parent molecules. When fingerprinting biomarkers are investigated, the findings show that they contain *o-pentacyclic triterpenes, such as hopanes, regular and rearranged steranes, and mono- and tri-aromatic steranes.* Oil biomarkers are classified in to these three groups. However little residual-range hydrocarbons are found in middle distillates, including diesel fuel, jet fuel, home heating oil, or kerosene. Therefore, it is important to recognize the type of oil product that is being examined and to select the most appropriate biomarkers of fingerprinting for researchers (Wang et al., 2006; Meyer, 2016; Anton and Oudijk, 2016). There are two different ways of utilization of biomarker in oil pollution studies. These two types are petroleum biomarkers (molecular fossils) and biological biomarkers. Petroleum biomarkers are alicyclic hydrocarbons, which have persistence on geologic time scales and are generally related with specific evolutionary occurrences like the appearance of flowering plants. Biological biomarkers are the molecules that found because of biochemical responses to pollution, which is still detectable, such as the cytochrome P450 enzymes found in detoxification pathways (Aeplli et al., 2014; Short and Springman, 2016). Numerous biomarkers can be appeared in altered carbon ranges of crude oils. C_{19} to C_{35} of terpane distribution are used to obtain GC/MS chromatograms of terpanes (*m/z* 191) biomarkers. The abundancies of C_{29} *αβ*- and C_{30} *αβ*-pentacyclic hopanes and C_{23} and C_{24} tricyclic terpanes are higher. For steranes (at *m/z* 217 and 218), C_{27}, C_{28}, and C_{29} 20S/20R homologues, are mostly dominant and the epimers of *αββ*-steranes, among the C_{20} to C_{30} steranes is often apparent. The Scotia Light (API = 59), which is very light, is unalike from most of crude oils and C_{19}–C_{35} biomarkers, which are specific this type of oil, are found in trace amounts (Wang et al., 2006).

3. Forensic Fingerprinting Method

After oil spill occurs and spilled oil goes into the marine environments, it effuses and separates into numerous parts of aquatic systems, specifically biota, seawater and sediment. Cleaning procedures were effective to remove oils that were visible however, oil residues still stayed in the multimedia environments (Yim et al., 2012). Biogenic, pyrogenic and petrogenic hydrocarbons are found in the marine environment because of anthropogenic activities and natural sources. The chemical fingerprinting of spilled oil and its residues are geochemically evaluated of the outcome and effects of the oil spill to distinguish them from the background (Yu et al., 2018). Oil source fingerprinting can be defined as an environmental forensics technique that applies analytical chemistry for comparison of oil spilled samples to a suspected oil source. An important incident that caused a fire and a major oil spill occurred at U.S. Strategic Petroleum Reserve Complex in West Hackberry, LA. On September 21, 1978. After this incident, Overton et al., (1981) performed forensic fingerprinting technique firstly to investigate the effects of spilled oil on environment. Naturally, occurring oil biomarkers that are ubiquitous and stable hydrocarbon are utilized for oil forensics (Wang et al., 2006).

3.1. Oil Sample Preparation

The oil samples are extracted and prepared by several methods such as Soxhlet, sonication, accelerated solvent extraction and supercritical fluid. Several of these samples have been promulgated by "the US EPA and American Society for Testing and Material (ASTM) as oil-contaminated soil extraction and analysis methods such as ASTM Methods 3328 (ASTM, 1997a) and 5739 (ASTM, 1997b), and some EPA 600 (EPA, 1983 and 1986) and 8000 series Methods (EPA,1997)" (Wang et al., 2006). Oil hydrocarbons are extracted and separated according to the "*like-dissolves-like*" principle. Monitoring extraction efficiency are generally obtained with the addition of surrogates. Columns made of glass are frequently utilized equipment for sample cleaning and fractionation before biomarkers investigation with GC/MS (Wang et al., 2006).

3.2. Chromatographic Analysis

Currently, the analysis of oil hydrocarbons can be applied by various instrumental and non-instrumental techniques including high-performance liquid chromatography (HPLC), thin-layer chromatography (TLC), size-exclusion HPLC, ultraviolet (UV) and fluorescence spectroscopy, infrared spectroscopy (IR), gas chromatography (GC), gas chromatography–mass spectrometry (GC/MS), isotope ratio mass spectrometry, supercritical fluid chromatography (SFC), and gravimetric methods. GC methods are the most used one among all these techniques. For example, capillary GC/MS is used to analyze the oil biomarker compounds and polycyclic aromatic hydrocarbons. Quality-assurance control measurements achieve in getting the data accuracy and precision, and the improvements in computer technology lead to increased laboratory data handling capability (Wang et al., 1999). Since the mass spectrometer has a high sensitivity and capability to elucidate structures of compound, it has long been accepted as the most powerful detector for a gas chromatograph. Nowadays, most environmental and oil forensics laboratories used GC/MS (e.g., benchtop quadrupole GC/MS, GC/MS-MS, high-resolution GC/MS, and GC-ion trap/MS) as the principal and routine techniques to analyze a widespread range of petroleum hydrocarbons like biomarkers. The oil biomarker compounds even if they are in trace amounts can be separated, identified and quantified by the new-generation GC/MS techniques. In these techniques, the main novelty is the combination of spectral resolution by MS, chemical separation by capillary column GC, and computerized data preprocessing (Wang et al., 2006).

3.3. Characteristic Fragment Ions of Biomarkers

For a better investigation of chemical fingerprinting studies both the biomarker components and the properties and abundances of petroleum, petroleum and / or its derivatives used during the correlations should be well known (Yalçın Erik, 2017). In addition, it is helpful to understand biodegradation resistance of biomarker for tracing and identifying the source of spill. The identification of oil source and correlation the oil spill in natural environment can be applied by the help of the susceptibility of biomarkers (Yu et al., 2018).

Therefore, it is important to understand the biomarkers for chromatographic techniques. Mainly, MS fragment ions are used for characterization of main biomarker groups and they can be listed as follows (Wang et al., 2007); alkyl-cyclohexanes (*m/z* 83*);* methyl-alkyl-cyclohexanes (*m/z* 97*);* isoalkanes and isoprenoids *(m/z* 113, 127 and 183); sesquiterpans (*m/z* 123); adamantaneler (*m/z* 135, 136, 149, 163, 177 and 191); diamantas (*m/z* 187, 188, 201, 215 and 229)*;* tri-tetra-penta-cyclic terpenes (*m/z* 191)*;* 25-norhopans (*m/z* 177, 28 and 30)*;* bisnoicopanes (*m/z* 163 and 191)*;* steranes (*m/z* 217 and 218)*;* 5 α (H) styrenes (*m/z* 149, 217 and 218)*;* x-diasteranes (*m/z* 217, 218 and 259)*;* methyl steranes (*m/z* 217, 218, 231 and 232); monoaromatic sterans (*m/z* 253)*;* triaromatic sterans (*m/z* 231).

4. Major Case Studies of Forensic Fingerprinting in TSSA

It is important to understand and evaluate bioprocesses of hydrocarbons by examining of the contaminant concentrations. Besides, the obtained information has an essential role for ecological risk and impact assessment and management of marine environment with contaminant input (Ünlü and Alpar, 2009). Commonly, to identify and quantify the marine contaminants chemical fingerprinting analysis methods are performed.

The findings of earlier oil spills are useful to plan for future possible oil spill disasters. However, this has so many challenges as consequences are uncertain due to the geographic, societal, ecological, and temporal circumstances in which the catastrophe occurs (Chang et al., 2014). Therefore, applying the chemical analysis to comprehend oil spills is difficult and compelling. In Turkey, mainly in TSSA, numerous significant studies of forensic fingerprinting were implemented successfully and hence remarkable results were obtained for port and seashore impurities. The major oil spill accidents in TSSA and applications of the forensic fingerprinting method were given in details in the following sections.

Application 1) *TPAO* Tanker Accident

Ünlü et al., (2000) reported their study that examined the polluted environment in Tuzla Bay caused by oil spill of TPAO Tanker accident. TPAO Tanker accident was happened on 1997 in Tuzla Bay and 214.3-ton oil was spilled and affected seawater and coastal area of Tuzla. Moreover, 250-ton oil was burnt, 173-ton oil was recovered from seawater however, and 41.3-ton oil polluted seashore and marine environment of Tuzla Bay. After the accident, samples of seawater, sediment and mussels were collected to investigate the pollution. Ultraviolet fluorospectrophotometric (UVF) analysis was performed to find oil concentration.

Identification of oil source was implemented by chemical fingerprinting technique using GC/MS analysis with the markers dibenzothiophene (DBT, *m/z* 184.03) and methylated C1-DBT (*m/z* 198.05). These markers were used to compare the peaks in (Figure 3) fingerprinting chromatograms of TPAO tanker oil (Figure 4) and the collected samples (Figure 5, for mussel sample).

The highest oil pollution was found for seawater and sediment as 33.2 mgL^{-1} and 423.0 μgg^{-1} (dry weight), respectively on the first day after the oil spill. For the mussel samples, the highest oil pollution concentration was found as 2066 μgg^{-1}(dry weight) after 3 months of accident. Besides, the results showed an increase of oil concentration after the accident and it was decreased irregularly.

The comparison of oil concentration values with literature figured out the occurrence of higher oil pollution in Tuzla Bay. When the fingerprinting chromatograms of tanker oil and mussel samples were investigated, the similarity of DBT and methylated C_1-DBT peaks were obtained that screening the origin of oil pollution as TPAO tanker oil. These results demonstrated the effectiveness of fingerprinting method for environmental pollution and source determination.

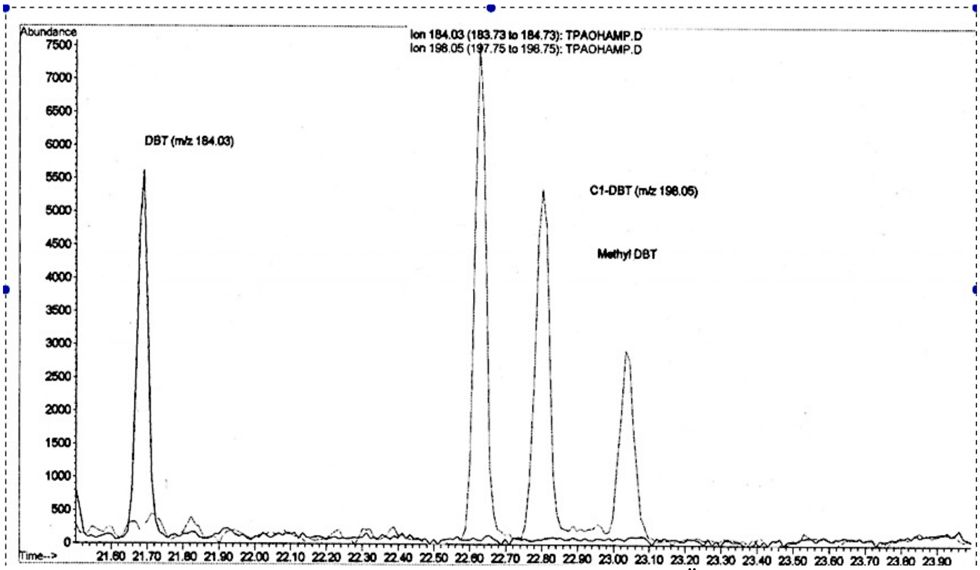

Figure 3. GC/MS chromatogram of TPAO tanker oil (Ünlü et al., 2000).

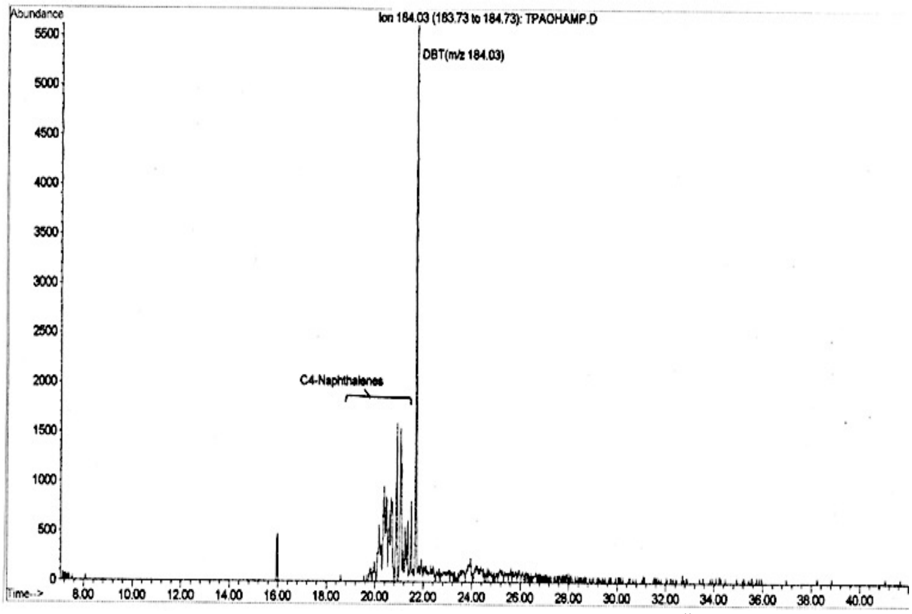

Figure 4 Fingerprinting chromatogram of TPAO tanker oil (Ünlü et al., 2000).

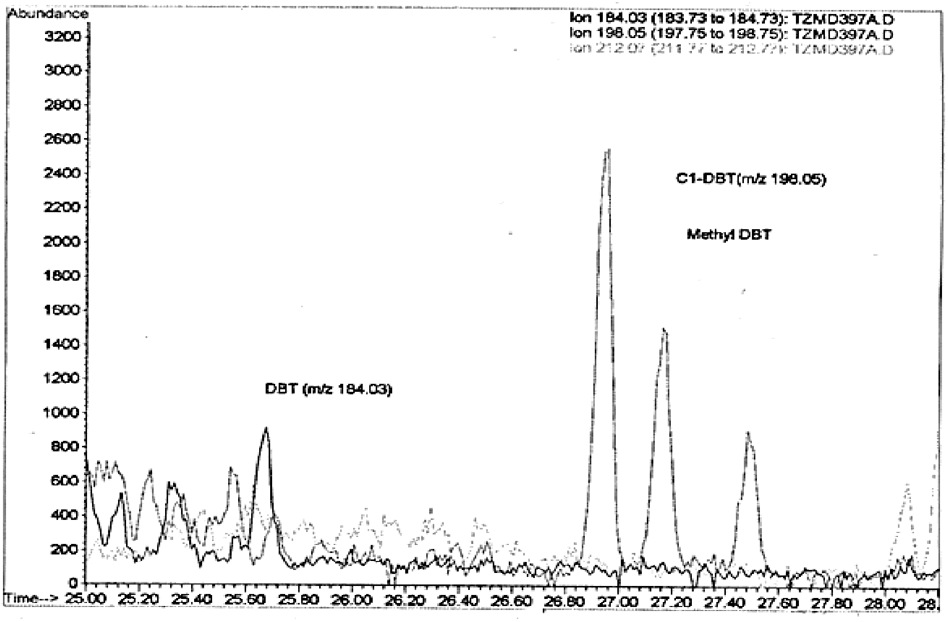

Figure 5. Fingerprinting chromatogram of mussel sample (Ünlü et al., 2000).

Application 2) *GOTIA* Ship Accident

The *GOTIA* Ship Accident occurred on October 6, 2002 at Emirgan quay and resulted in 25 tons of oil spill. The marine environment was contaminated by oil spill. Bebek, Istinye, Yenikapı, Golden Horn, Sarayburnu and Galatasaray Island were affected by the spill and the seawater, mussel and algae samples were taken from these areas (Güven et al., 2004).

GC/MS analysis was performed to investigate the oil components of about 200 samples. The fingerprinting chromatogram of *Gotia* oil was shown in Figure 6. n-Alkane markers were observed in whole samples from sampling stations. The fingerprinting chromatograms of all samples and *Gotia* fuel were almost identical. The analysis results were helpful for oil-spill source identification.

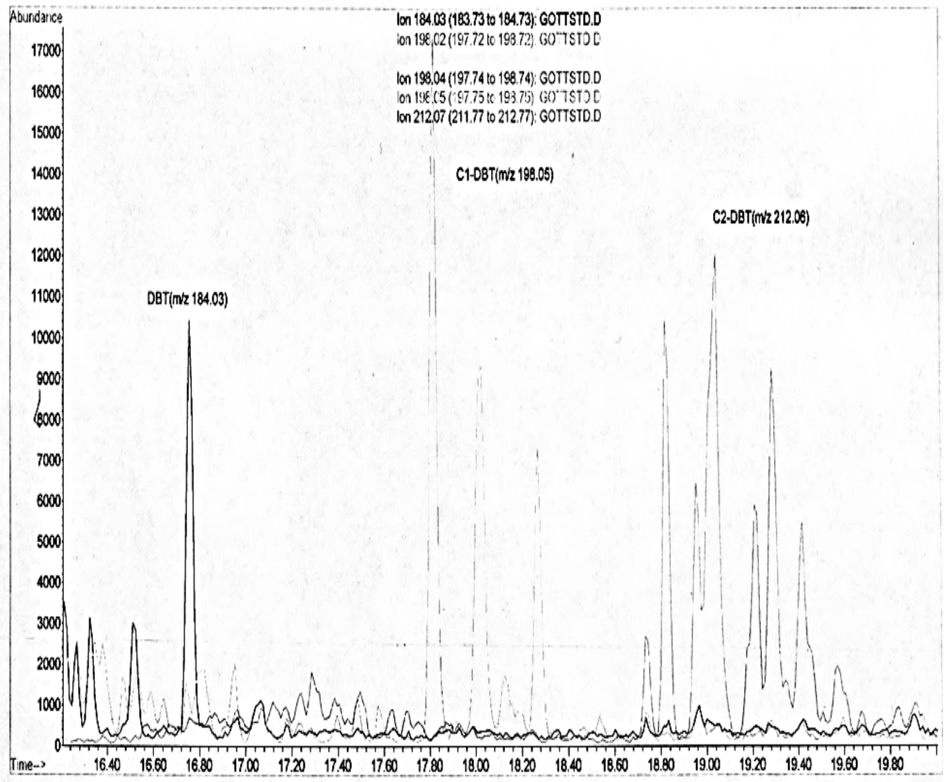

Figure 6. Fingerprinting chromatogram of *Gotia* ship oil (Güven et al., 2004).

The GC/MS profiles samples from different sampling stations (Figures 7, 8 and 9) were given for different dates that indicated the continuous oil contamination.

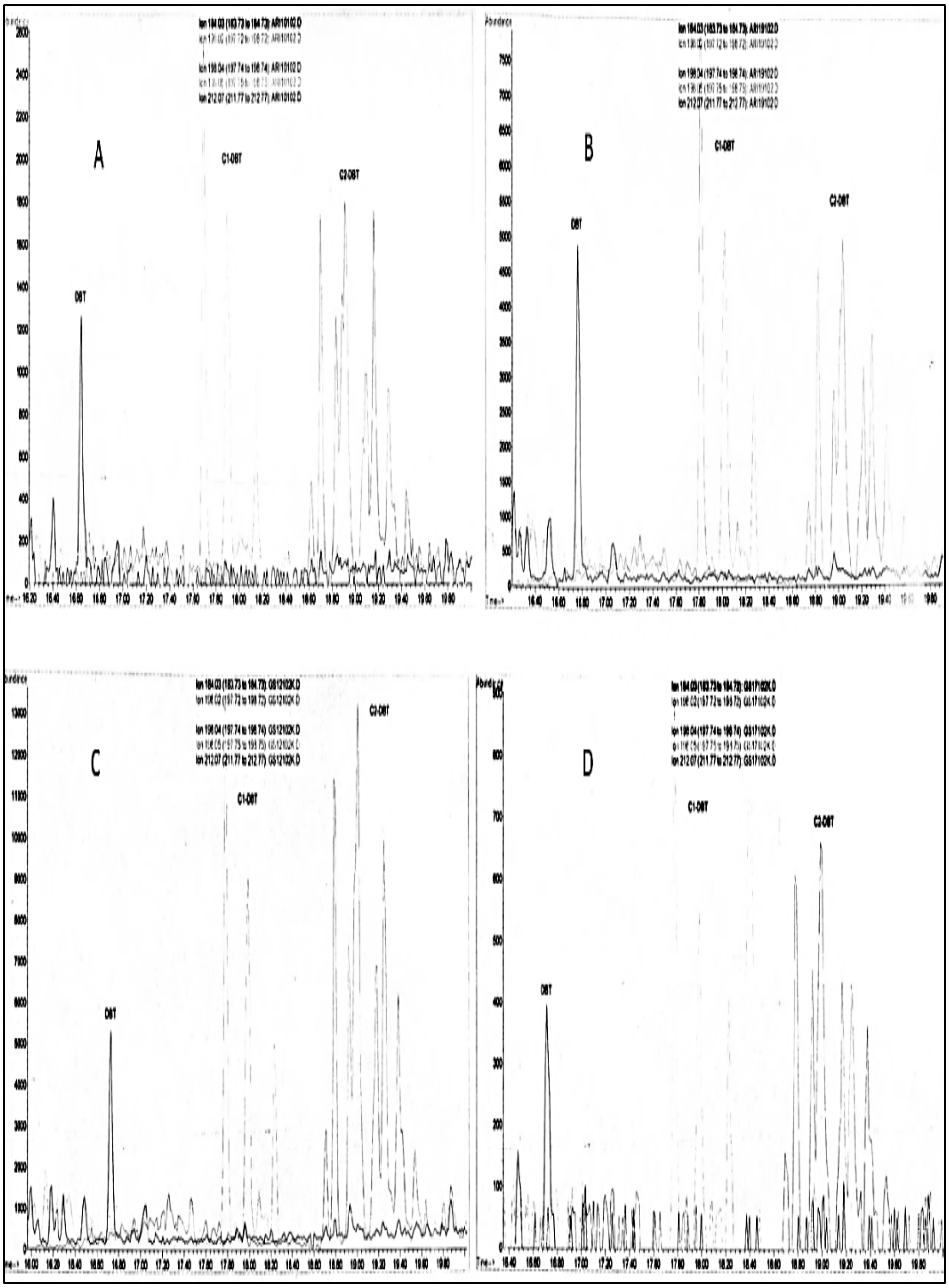

Figure 7. Fingerprinting chromatogram of contaminated samples from different sampling stations after *Gotia* ship accident Seawater sample collected; **A)** from Arnavutköy on October 10, 2002 **B)** from Arnavutköy on October19, 2002 **C)** from the Galatasaray Island on October 16, 2002 **D)** from the Galatasaray Island on October 21, 2002 (Güven et al., 2004).

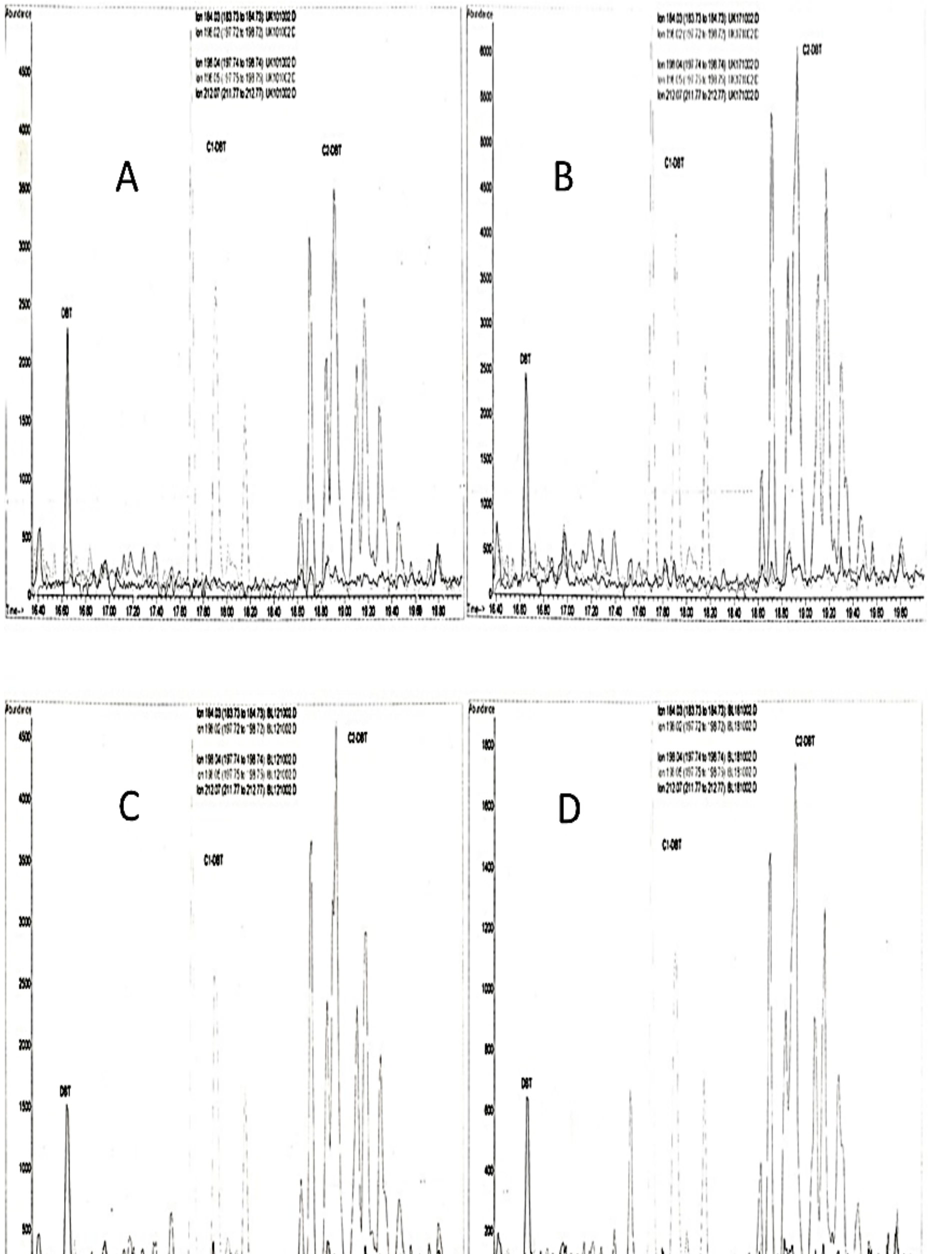

Figure 8. Fingerprinting chromatogram of contaminated samples from different sampling stations after *Gotia* ship accident Seawater sample collected: **A)** from Unkapanı on October 10, 2002 **B)** from Unkapanı on October 17, 2002 **C)** from Balat on October 12, 2002 **D)** from Balat on October 18, 2002 (Güven et al., 2004).

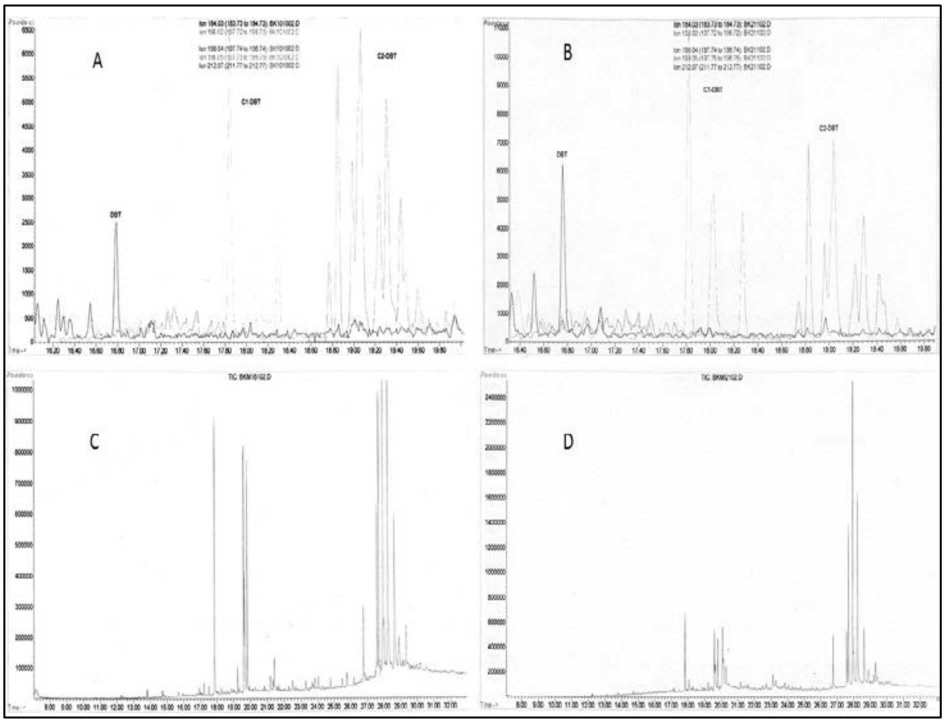

Figure 9. Fingerprinting chromatogram of contaminated samples from Bebek sampling stations after *Gotia* ship accident; **A)** Seawater sample collected on October 10, 2002 **B)** Seawater sample collected on October 21, 2002 **C)** Mussel sample collected on October 16, 2002 **D)** Mussel sample collected on October 21, 2002 (Güven et al., 2004).

Application 3) *Volganeft-248* Tanker Accident

The Russian ship *Volganeft-248* was broken into two pieces on December 29, 1999. The ship's cargo was heavy fuel oil of 4365 tonnes. When the accident occurred, the ship was at anchor off the Ambarlı Terminal. This accident resulted in discharged of 4365 tons crude oil and 1579 tons fuel oil. It took more than 4 months to clean the beaches.

Since the most polluted parts were Florya; Menekşe and Çiroz Park, the samples (pelagic tar) were collected from these places in April, December 2003 and February 2004. These samples were named as leg 1 (April 2003), leg 2 (December 2003) and leg 3 (February 2004). GC/MS-SIM technique was employed to identify the oil spill source in the collected samples (Alpar and Ünlü, 2007). GC/MS chromatogram profiles C_0 to C_3 *m*-phenanthrene isomers at *m/z* 192, 206, and 220 were given in Figure 10. The comparison of tar samples collected from leg-1 and reference oil sample indicated the chemical similarity of these samples. Consequently, phenanthrene isomers showed different fingerprinting patterns for the samples from leg-2 and leg-3. Besides, C_3 *m*-DBT isomers were used to compare the mass fragmentograms of tar samples and reference oil. The ratios were found as 1.36, 1.35, 0.91 and 0.83 for reference oil, leg 1, leg 2 and leg 3, respectively.

These findings provided valuable information for the efficiency of cleaning processes that continued approximately 3 to 4 months afterward the accident. Additionally, the fingerprinting technique was useful to understand the remaining oil contamination for this accident, which also caused a continuous oil spill because of the sunken oil.

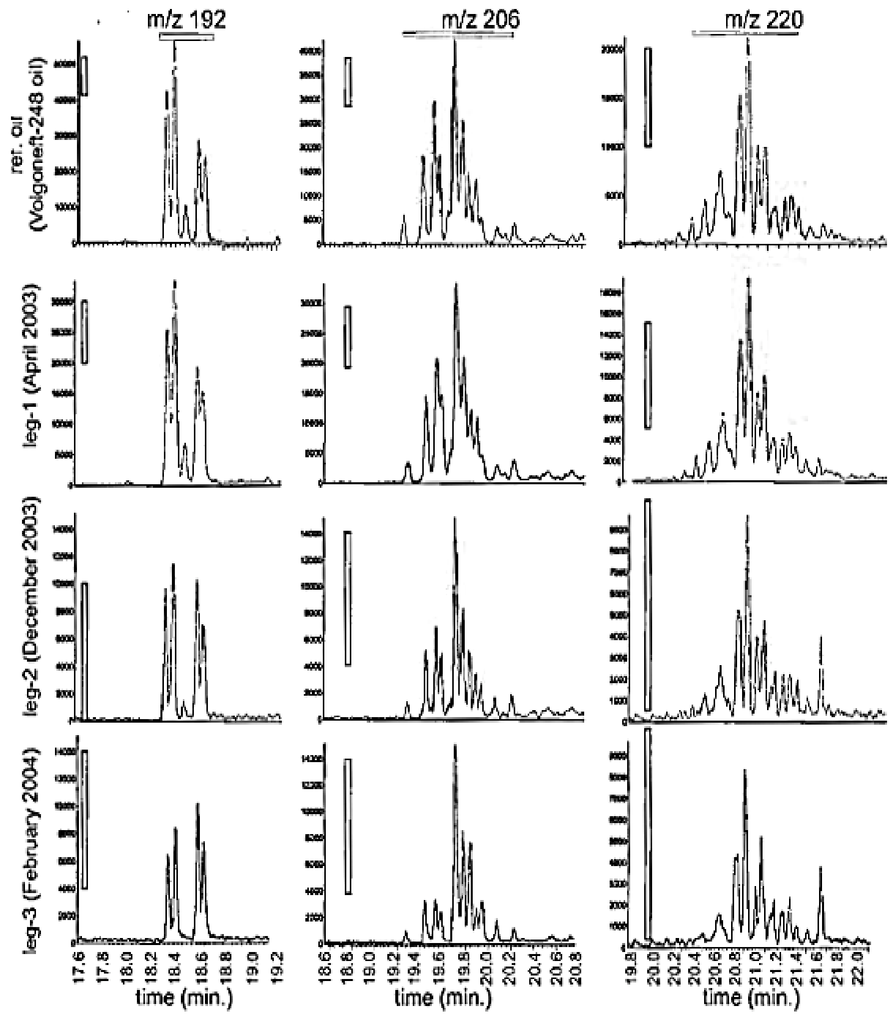

Figure 10. Comparison of ion monitoring chromatograms at *m/z* 192, 206 and 220 for *Volgoneft-248* oil and tar samples (from Alpar and Ünlü, 2007).

Application 4) Unknown Oil Spill in the Haydarpaşa Port

Haydarpaşa Port (Figure 2), which is located on the Anatolian side of the Strait of Istanbul and the most important sea trade point of the Marmara Sea, is the main reason of PAHs in marine environment around the port and it is responsible of most oil pollution in TSSA. Fuel oil spill from ships and vehicles, cleaning of tanks, operations of de-ballasting and bilge wastewater cause oil pollution in Haydarpaşa Port. In the study of Ünlü (2007) to understand and characterize the chemical composition, and identify the source of oil spill, UVF method and GC/MS analysis using fingerprinting techniques were performed.

The samples of contaminated seawater from Haydarpaşa Port and two ships were collected on September 23, 2004. n-Alkane distribution analysis (*n-C_8 through n-C_{33}, pristine (Pr) and phytane (Ph)*) was achieved by GC/MS-SIM method. The markers alkylated phenanthrene homologues (*m/z* 178, 192, 206 and 220) and alkylated dibenzothiophene homologues (*m/z* 184, 198, 212 and 226) were used for comparison. The scope of this work was correlation sample of spill oil and samples taken from two ships by chemical composition analysis. The hydrocarbon distribution of all samples were investigated and ion chromatograms of *m/z* 85 ions demonstrated n-alkanes and isoprenoid distribution (Figure 11). The chromatogram revealed the similarity for samples of oil spill and Ship 2.

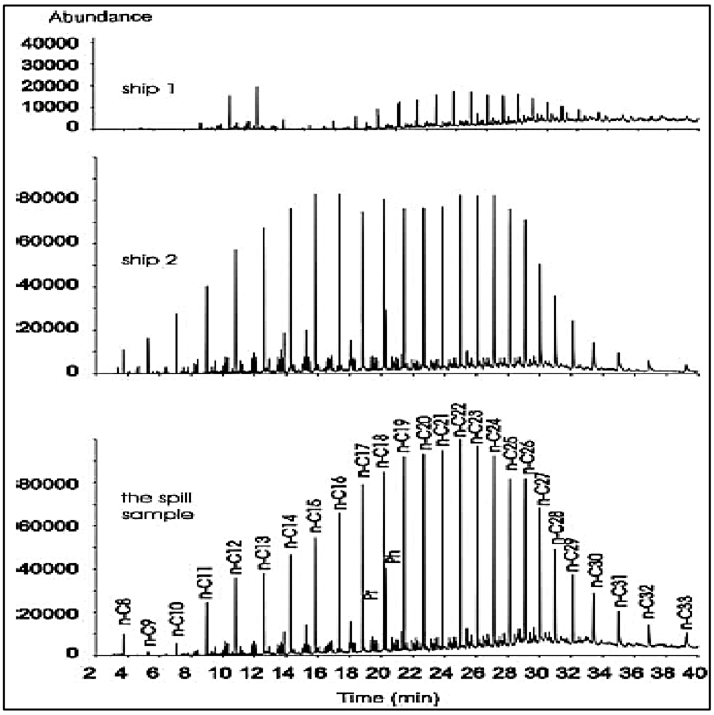

Figure 11. Fragmentograms *m/z* 85, a characteristic ion for n-alkanes and isoprenoids of contaminated seawater from the Haydarpaşa Port and two ships (from Ünlü, 2007).

The samples for both ships had GC/MS profiles that were almost identical to each other and were presumably oil. The only difference was the higher n-alkanes abundance of Ship 2 sample in the diesel carbon range C_8 to C_{28}. The distribution profiles of the Phenanthrene (Phe) and DBT isomers, which had a high resistant to degradation, were given in Figure 12. The elucidation of these analysis results figured out the chemical similarity of suspected spill sample and the sample of ship 2. The mass fregmantograms of samples of oil spill and two ships were compared by using C_3 m-DBT isomers. The ratios of C_3 m-DBT isomers (*m/z* 226) were found as 1.0, 0.65 and 1.0 for samples of petroleum residue from seawater and samples from ships 1 and 2, respectively (Figure 13). With this study, important findings were obtained with the chemical fingerprint method to find the source of the pollution caused by the ships. This work would be used as a reference for related environmental researches.

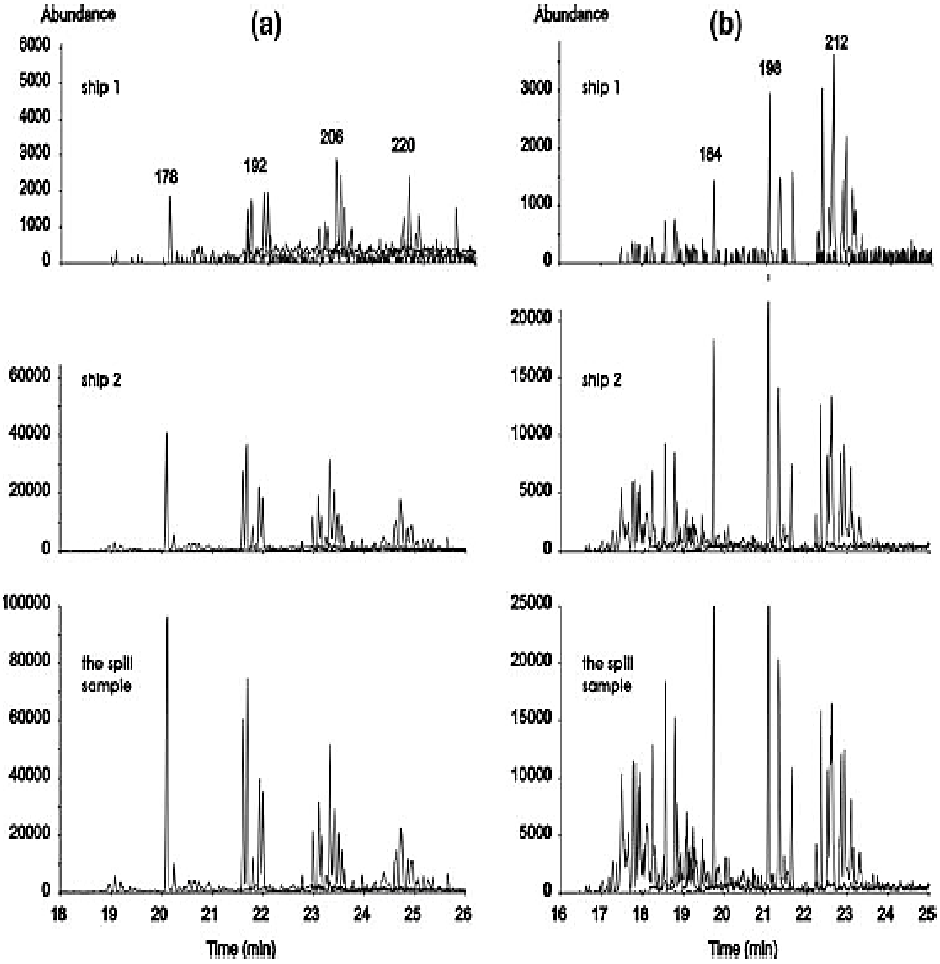

Figure 12. (a) *m/z* 178+ 192+ 206+ 220, **(b)** *m/z* 184+ 198+ 212 summed mass chromatograms showing the dibenzothiophenes in samples, using GC/MS (from Ünlü, 2007).

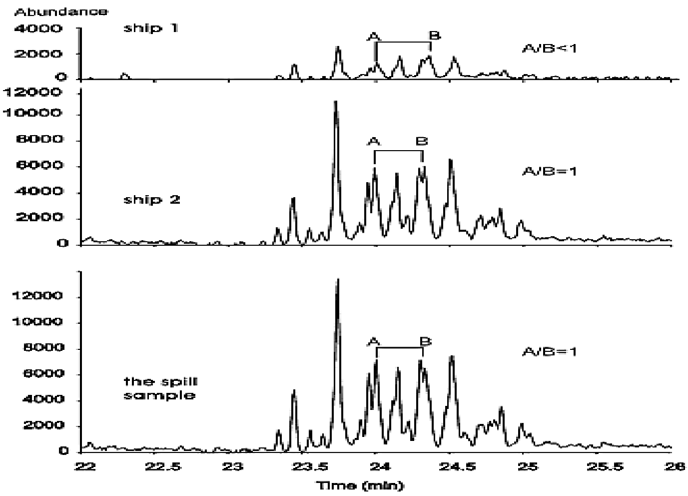

Figure 13. The mass fragmentograms of the spill sample, Ship1 and Ship 2 samples were compared by using ratios of C_3 m-DBT isomers (*m/z* 226) (from Ünlü, 2007)

5. Conclusions

The requirement of energy increases according to the modern world demands so there is a growth for the consumption of crude oil and its derivatives. These petroleum products have the probability to release to marine environment accidentally or purposely. Therefore, the risks of major oil spills for marine and coastal ecosystem rise since the oil is transported by long travels along worldwide sea routes. Moreover, the oil spill has significant global impacts on socio-economic conditions, tourism, etc. Especially, the Turkish Straits Sea Area, which has dangerous geographical properties and is under ever increasing oil tanker traffic, have high risks of environmental pollution that caused by oil spills. The chemical analysis or forensic chemistry studies that can also referred as chemical fingerprinting have a vital role to understand, identify and quantify such spilled or discharged oil in marine environment. Besides, the analysis is helpful to figure out the source of oil that is significantly important for response and cleanup systems. For the forensic evaluation of oil, spill-using biomarkers are mostly performed with gas chromatographic and molecular chemical characteristics investigation. GC, GC/MS, GC/FID, GC/MIS-SIM and LC-MS techniques are mainly used for this investigation. The chemical fingerprinting approach to identify the petroleum residues after the oil spills in TSSA is discussed in details by giving major cases in this study. Considering the high dangers of oil spill in TSSA, applying chemical analysis and responding the environmental pollution using these data have a great importance. In future, TSSA will be encountered possible accidental oil spills with the increased demand of oil and its transportation by sea. Since characterization of spilled oils and monitoring the effects on marine and coastal ecosystems are significant tools to carry out environmental impact assessment, the presented data in previous works would be a valuable guide to researchers to apply similar environmental researches.

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OIL SPILL DETECTION USING REMOTE SENSING TECHNOLOGIES-SYNTHETIC APERTURE RADAR (SAR)

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1. Introduction

Marine environment and ecosystems have been threatened by oil spills occurring on the sea surfaces which are mostly result of either accidents or cautious oil discharges from the ships. Integration of satellite based data and in situ observations are widely used to monitor and detect oil spills (Solberg, 2012). Visible and infrared-based remote sensing observations are significantly affected by atmospheric conditions; moreover, there are also spectral similarities between oil and water in specific parts of the visible region of the electromagnetic spectrum. Although oil presents slightly larger reflectance than water in the visible and near infrared region; it does not exhibit characteristics absorption or reflectance features; such as, thin oil layers seem in similar colour. These limitations should be overcome by using different remote sensing systems to accurately detect and map the oil spills (Fingas and Brown, 2018; Gazioğlu, 2018; Leifer et al., 2012). Although hyperspectral data and analyses are thought to be promising in determining oil pollution, processes that examine specific spectral regions are known to not increase discrimination. Laser fluorosensors are another alternative remote sensing technology to detect oils considering the fact that after the interaction of oil compounds with ultraviolet light; some light energy is absorbed and extra energy is released as visible light (Brown, 2017). However, in addition to being used as remote sensing technology, it is necessary to define numerous features related to the marine environment. The fact that optical systems and laser fluorosensors, under any circumstances, fail to perform in a suitable, acceptable and efficient manner, allows the Synthetic Aperture Radar (SAR) systems to be preferred to provide high standards under all conditions (Doğan et al., 1998). Active remote sensing systems such as SAR have been commonly used to detect oil spill with their advantages of covering wide areas, operating in all-weather conditions either day or night (Şeker et al., 2013). SAR images could complement aircraft observations to cover larger areas in a short time and cost-effectively. Slicks on the sea surface are effective in dampening capillary waves (cm wavelength) therefore having smoother surface conditions in contrast to approximate sea surface conditions. In order to prevent oil spills and cope with oil spill based disasters, it is important to have an oil spill surveillance system. Location and extent of oil spills could be determined promptly and accurately using remote sensing technologies which in turn provide valuable information to monitor oil spills and minimize their damages to ocean ecosystem.

Both oil spills and slick impostors (e.g., variable surface wind stress, rain cells, turbulent wakes caused by ships, fresh water slicks) might be detected as a dark formation on the SAR images (Fingas and Brown, 2014). In most cases it is impossible to differentiate between oil slicks and look-alike phenomena just using SAR intensity values. Several researches have been focused on distinguishing the look-alikes from the oil spill (Genovez et al., 2017). Oil spills mixed with look-alikes in classification procedure while using oil spill detection algorithms are categorized as below (Solberg and Solberg, 1996):

- Thin, piecewise-linear slicks
- Low-contrast slicks in homogeneous sea
- Slicks on a very heterogeneous background

In general, sea state and/or wind conditions are important parameters impacting the ability of SAR to detect oil spills. Moderate wind speed required to cause surface roughness variation between sea surface and slick. Typically, 3 m s^{-1} to 10m s^{-1} wind speeds are the most accepted limits. The acceptable range of wind speed depends on oil type and the age but more over it is strongly related with the incidence angle and radar frequencies (Bern et al., 1992). X-band SAR data is provided better results and preferred over C and L-band for the detection of oil spills. The contrast amount between oil and water is changing with respect to the wavelength of the SAR system. The biggest contrast is obtained in X-Band, moderate in C-Band and the smallest in L-Band. However, a recent research illustrated that low-noise L-Band system could be able to detect oil slicks successfully. Incidence angles ranging between 20 ˚ and 45˚ for X or C-Band systems would provide an optimum measurement configuration for oil spill cases (Marzialetti and Laneve, 2016). In calm and light breeze conditions in which wind speed is smaller than 3m/s and wave height is smaller than 0.3 m, it is not possible to differentiate oil from water. Ideal conditions to identify oil spill is known as gentle strong breeze conditions, in which 3m/s<wind-speed<10m/s and 0.3m<wave height<3 m. It is not also possible to identify oil spills in storm conditions with very huge wave speeds.

Different wave polarizations exist in SAR systems based on vertical (V) and horizontal (H) electromagnetic wave propagations. Some studies had suggested VV polarization data could provide the best results for the detection of oil spills (Masuko et al., 1995 and Girard-Ardhuin et al., 2003). Incidence angle is significantly impacting the HH polarized data compared to VV polarization. Therefore, VV is preferable in most oil spill detection case whereas HH could be appropriate in very light wind conditions and for the accurate detection of ships. (Lehrer 2014, Migliaccio et al., 2015). Some of the available SAR satellite systems are shown on Table 1.

Table 1. SAR Satellite Systems

Satellite	Operation	Band	Polarisation	Swath (km)	Resolution (m)
TerraSAR-X	2007 -	X	Dual-pol	10-100	1 -40
COSMO Skymed 1-2	2007 -	X	Quad-pol	10-200	1 -100
RADARSAT-2	2007 -	C	Quad-pol	25-500	1 – 100
RISAT-1-2	2012 -	C	Quad-pol	10-223	1 – 50
KOMPSAT-6	2013 -	L	Quad-pol	5-100	0.5 - 20
ALOS-2	2014 -	L	Compact	25-350	1 - 100
SENTINEL 1A-1B	2014 -	C	Dual-pol	20-400	5 - 80
PAZ	2015 -	X	Dual-pol	10-100	1 - 15
NovaSAR-S	2015 -	S	Tri-pol	15-750	6 - 30
SAOCOM	2015 -	L	Quad-pol	20-350	10 - 100
Radarsat Constellation	2018?	C	Compact	14-500	1 - 50

2. Radar Image Processing

Several researches have been conducted to analyse different image processing algorithms to improve the accuracy of supervised and semi-supervised techniques for object detection and classification. Generally processing steps include speckle removal Tripathi et al. (2017), edge detection Zhang et al. (2010), texture analysis Zhou et al. (2009) - feature extraction Schvartzman et al. (2016), Mera et al. (2017) and finally classification algorithms Vijayakumar et al. (2016) and Taravat et al. (2013).

a. Speckle Removal

Radar images are subject to receive strong speckle noise as a result of coherent processing of radar echoes. The presence of speckle noise impacts the quality of the spatial details and makes the classification step more difficult. Thus an effective speckle removal filtering is required as a pre-processing step before applying any other image processing method. The objective of speckle removal filter is simple:

- To suppress the multiplicative noise in homogenous regions
- To preserve the edges, image details and the texture features

Many of the speckle removal filters (Lee, Kuan and Frost) which are adaptive filters operate by smoothing over a fixed window to minimize the mean square error based on the statistical characteristics of SAR image and the speckle. Studies show that the statistical filters can reduce the speckle better but the detail of the image is greatly lost. Some hybrid methods are also suggested which combines Frost speckle filter with Relaxed Median Filter (Radhika and Padmayathy, 2011).

Most commonly used filters in literature are briefly mentioned below (Huang and Genderen, 1996) and (Argenti et al., 2013):

Box Filter: Typical low-pass filter, which removes the noise with high frequency spectrum as well as smooth the details (Fuk-kwok and Held, 1983).

Median Filter: Non-linear filter derived from maximum likelihood estimation principle; assuming that the signal is contaminated by additive noise with Laplace distribution (Richards 1993).

Lee Filter: It is a local-statistic filter. The goal is minimizing the minimum mean square error (MMSE) by linearizing the multiplicative noise using the local statistics. Depending on the variance of the noise, the smoothing operation is applied if the variance is low but it is not suitable for high variance. This filter preserves details in low and in high contrast at the same time (Lee 1980, 1983).

Frost Filter: Frost filter parameters use local area parameters that depends on the local coefficient of variation defined as the ratio of local standard deviation to the local mean of the noisy image. It convolves the pixel values to replace the central pixel with the values of weighted sum of neighbourhood. (Frost et al., 1982)

Kuan Filter: It implements the Linear MMSE filter solution starting with a nonstationary scene where the signal has nonstationary mean and variance. Unlikely with Lee there is no approximation involved (Kuan et al., 1985, 1987).

Enhanced Frost and Enhanced Lee: In order to preserve the texture information, Lopes et al. (1990b) applied the enhancement. If the local coefficient of variation is below a lower threshold, the pixel value is calculated by taking the average of the filter window. If it is above the higher threshold then the pixel value keeps the same. In the case of having, the local variance between two thresholds then impulse response is used as a convolutional kernel to determine the pixel value.

Lee-sigma filter: This filter assumed that data has Gaussian distribution. The pixels within the standard deviation range are replaced with the average of all pixels in the moving window (Lee, 1983).

Gamma Map Filter: In order to minimize the loss of texture information Maximum A Posteriori (MAP) filter is proposed by Lopes et al. (1990a) where the Gamma distribution is used to estimate the speckle noise characteristics. The original value is also assumed to lie between the local average of the window and its actual value.

Choosing the optimum speckle filter size has also huge impact on speckle reduction. As the window size of speckle filter increases speckle in the image reduces, but as window size increases details in the image might be lost (Argenti et al., 2013). Best filter window size is considered in Dasari and Anjaneyulu (2017) based on three indices: i) Speckle suppression index ii) Equivalent Number of Looks, and iii) Speckle Suppression and Mean Preservation Index and all of these indices are derived from by using mean standard deviation and variance of the image. In Samad and Mansor (2002) it was showed that Lee filter with size of 7x7 is the best filter to detect dark slick in the Radarsat-1 Standard 2 Beam mode with HH polarization image while removing the speckle it preserves edge and the texture of the dark slick very well. The same study showed that using the Kuan filter size of 11x11 is the appropriate filter to improve ships detection in Radarsat images.

b. Edge Detection

Generally, this step is applied to differentiate the dark spots from the neighbouring seawater. Edge detection is used to outline the edges between water and oil. Different segmentation methods have been used to identify edges of the oil slicks. Markov random field (MRF) based segmentation Lankoande et al. (2005) and Multiscale MRF segmentation Jiao and Wen (2009) based on the statistical properties offer a good performance on image segmentation. Local and global thresholding algorithms are used in Solberg et al. 2007, Garima et al. (2015) to detect the dark spots. Dutta et al. (2018) proposed amalgamate approach to combine over-segmented regions to form meaningful dark objects. Some other techniques such as Adaptive Thresholding, Fuzzy clustering, Region Growing, Multiscale Segmentation and Mathematical Morphology can also be used in this step.

Auto Associative Neural Networks (AANN) can be used to extract polarimetric and textural features from SAR images. It provides the optimal input for the segmentation by increasing the contrast between the possible dark object and the background (Frate et al. 2017).

The segmentation step using Artificial Neural Network (ANN) outperformed edge detection segmentation and adaptive thresholding approaches (Singha et al., 2013). It is also indicated that using separate neural networks for both the segmentation and classification stages perform better accuracy over single input neural networks (Singha et al., 2013).

c. Feature Extraction

Surface characteristics are investigated in feature extraction step using different approaches. Such features like geometric shape, contrast with surrounding areas and contextual information are used to characterize the dark spots. To distinguish the oil slicks from look-alikes those features have to be extracted and used as inputs. Oil has a uniform and smooth texture whereas surrounding sea surface is a less uniform a smooth in terms of texture. Texture information provides useful input to separate Look-alikes from oil spills. Some research have been conducted on shape based analysis which is suggested as useful approach to separate oil spills from look-a-likes due to the unique shape characteristics of oil spills. Most commonly used methods in feature extraction are distributed in four categories (Genovez et al., 2017):

- Statistical: Backscattering parameters
- Textural: Grey Level Co-occurance matrix (GLCM)
- Geometrical: Geometry of the polygons
- Polarimetric: Polarization mode

In order to detect the oil slicks, different number and types of features are used among the researchers : Solberg and Theophilopoulos (1997) used 11 features, Fiscella et al. (2000) used 14, Keramitsoglou et al. (2006) used 14, recently Chehresa et al. (2016) used 74, while Mera et al. (2017) used 52 features. Most commonly used features from the majority of those studies are presented on Table 2 (Genovez et al., 2017).

Table 2. Commonly used features.

Statistical	Textural	Geometrical	
Mean	Second Moment	Area	Rectangular Fit
Std deviation	Contrast	Length	Compactness
Median	Correlation	Width	Degree of Skeleton Branching
Maximum	Dissimilarity	Border Length	
Minimum	Entropy	Asymmetry (Polygon)	Perimeter
Asymmetry	Homogeneity (GLCM)	Density	Shape Factor
Kurtosis	Mean (GLCM)	Shape index	Complexity
Mode	Std deviation (GLCM)	Elliptic Fit	

The ranking of the 10 most important features are presented in Genovez et al. (2017) as: 1. Median, 2. Mean, 3. Mode, 4. Minimum, 5.Maximum, 6. Mean (GLCM), 7. Rectangular Fit, 8. Homogeneity (GLCM), 9. Asymmetry (Polygon) and 10. Density.

d. Classification

The final stage of oil spill detection is the classification in which oil slicks are identified using the features extracted in the previous step. Several classifiers have been applied for the detection of oil spills such as Mahalanobis Distance Classifier, Maximum Likelihood, Fuzzy Logic, Generalized Additive Model, Support Vector Machine, Artificial Neural Network, and Tree-based techniques (Xu et al., 2014):

Mahalanobis Classification: This algorithm is a direction sensitive and it assumes all class covariance are equal. Based on the distance threshold all the pixels are classified to the closest region. Different patterns can be distinguished by using the correlation between variables (Topouzelis et al., 2009).

Maximum Likelihood: It is the most commonly used algorithm for pixel-level processing, however segmentation result can also be used with a region-based approach. It requires a training data set to maximize the likelihood function by choosing the model parameters (Ahmad and Quegan, 2012).

Fuzzy Logic: This method estimates the contribution of each class in the pixel. All pixels are belonging to a class with a membership degree that uses non-linear techniques. In order to predict the dark areas as oil, a model has to be created with the inputs that give known outcomes (Garcia-Pineda et al., 2008; Robson et al., 2006).

Penalized Linear Discriminant Analysis: Penalized version of LDA is proposed to solve high dimensional discriminant problem, since it maintains the advantage of LDA while adding shrinkage to the discriminant vectors. It is less time-consuming comparing to others. Penalized LDA can simultaneously select predictors and estimate the change of mean classification error rate. By using the posterior probabilities of different classes, the model can predict the class membership (Fiscella et al., 2000).

Generalized Adaptive Model: GAM is an extension of generalized linear models. It provides a modeling approach that combines powerful statistical learning with interpretability, smooth functions, and flexibility. It is used for capturing nonlinear, unspecified relationships between original predictor variables and the response variable (Hastie, 2006).

Support Vector Machine: The SVM technique is supervised learning model that seeks the optimal separating hyperplane between binary classes. The goal is to find the support vectors, by using minimum number of training samples. It is used effectively in geomorphological modelling (Moguerza and Muñoz, 2006; Mountrakis et al., 2011; Brekke and Solberg, 2008).

Artificial Neural Networks: They are efficient tools for modelling the relationship between complex input and output responses. Class memberships can be directly estimated from posterior probabilities. Multilayer perceptron (MLP) is one of the most commonly used classifier among the ANNs (Zhang, 2000; Topouzelis et al., 2007; Frate, et al., 2000).

Tree Based Ensemble Techniques – Bagging: In this classifier, in order to improve the prediction all the individual classification trees are combined. Based on the binary decisions, the input dataset is split into subsets by the Classification trees. Bagging is capable of training the separate trees based on samples of dataset. Majority voting and averaging among the trees determines the predicted classes (Breiman, 1996; Knudby et al., 2010).

Tree Based Ensemble Techniques – Bundling: In order to build classification trees, Bundling allows the integration of the predictions of arbitrary classifiers trained as an additional predictor variable, which is more efficient than bagging (Hothorn and Lausen, 2005).

Tree Based Ensemble Techniques – Boosting: In this technique accuracy is improved by mixing the output of tree-based classifiers. Using the weighted voting among the trees, makes it possible to predict the labels and allow the evolution of trees over time (Friedman, 2001).

3. Case Study I - Supervised

A supervised object-oriented classification is applied to discriminate oil slicks by using segmentation techniques and fuzzy classification method. The model has been developed in the eCognition Software environment. The detailed presentation of the methodology can be found in the Topouzelis et al., (2007) and Karathanassi et al., (2007). The model involves filtering, segmentation, dark formation detection, feature extraction and the fuzzy classification steps. The performance of the simplified version of the methodology is demonstrated on TerrSAR-X sample dataset from Gulf of Mexico, USA (Figure 3). The data acquired in single polarization VV on 10 July 2010 for the Deepwater Horizon oil spill. The data is collected in Stripmap mode with the resolution of 3m.

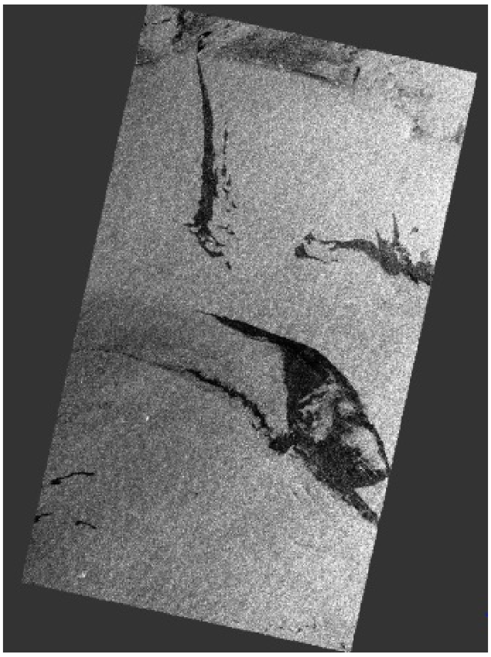

Figure 3. TerraSAR-X, Stripmap mode, VV, sample data.

a. Object Based Classification Model (Topouzelis et al., 2007)

The model based on capturing the statistical properties of the dark areas. Segmentation is performed at two different scales; coarse and small scales. Coarse scale is used for to estimate local contrast threshold for each large segment. Each small segment's statistical values are compared with the threshold of the big segment. Dark areas on the image are detected by using threshold algorithm in two stages. In the first stage, objects with high contrast and low brightness values relative to neighbours were distinguished. At the second stage threshold that is defined by using mean and the standard deviation of the large segment is compared with the mean value of each small object by using empirical statistical formula Karathanassi et al., (2007). Once the dark areas are detected several features can be derived. A set of 10 features was introduced in (Stathakis et al., 2006). Following the feature extraction step, the classification step is performed by using fuzzy logic algorithm. Fuzzy rules are used to express the characteristic of the oil spills according to the features given by the condition. The model steps are shown in Figure 4.

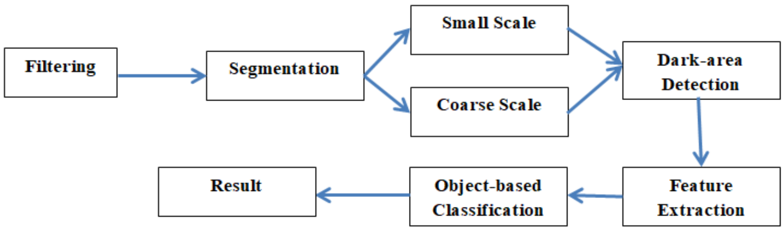

Figure 4. Flow diagram of the used model.

b. Model implementation on TerraSAR-X Dataset

The original data is divided into three images, one for training and the two for the testing of the model. Each image contains a certain number of dark objects. Filtering was done by using Sigma Lee filter with 7x7 window size to remove the speckle noise from each image. 8-bit filtered TerraSAR images are imported to the eCognition Software. It was also proposed in Karathanassi et al. (2007) to use different kind/size of filter and imported them as a different image layer to the model.

Multiresolution segmentation is performed at two different scales in order to produce large and small objects. To detect the dark areas the two stages thresholding algorithm is performed. The first stage uses the high contrast and low brightness to neighbour feature values to characterize the dark areas. Second stage uses the formula Karathanassi et al. (2007) given below:

$$\frac{Mean_{Big} + St.Dev_{Big}}{2} + \frac{Mean_{Big}}{St.Dev_{Big}} - Mean_{Small} \geq 0$$

Where $Mean_{Small}$ is the mean value of the fine detailed segmentation, $Mean_{Big}$ is the mean of the coarse scale objects and $St.Dev_{Big}$ is the standard deviation of the coarse scale objects.

Two features out of a set of 10 features Stathakis et al. (2006) are considered: first one is the object power to mean ratio which can be formulated as the ratio between standard deviation and the mean values of the object. Second, one is the mean Haralick texture; it is calculated as the average of the grey level co-occurrence matrices of the sub objects. Fuzzy rules are applied to every feature selected to perform the classification and oil spill detection. To increase the performance of the model for distinguishing the oil spill from look-alike, other features proposed at Stathakis et al. (2006) should be considered.

c. Classification Results

Training and testing images classification results are shown at Figure 5 and Figure 6. Detected dark objects which aren't classified as oil spills are shown in red while the possible oil spills are shown in green at the result image.

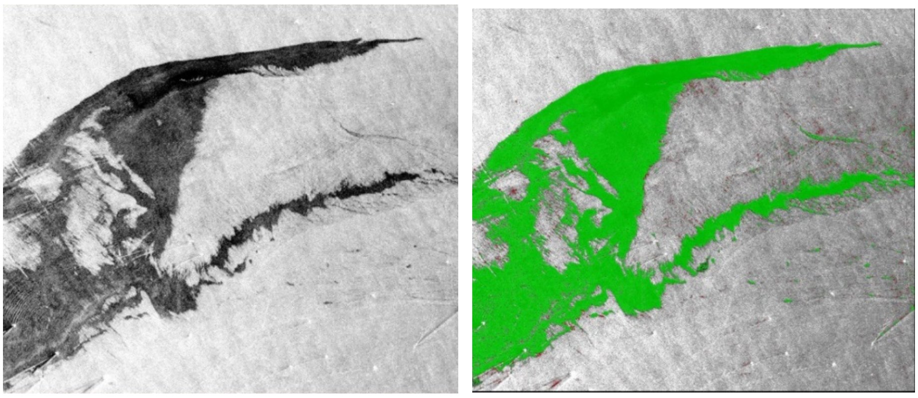

Figure 5. Training data set and the oil slick result.

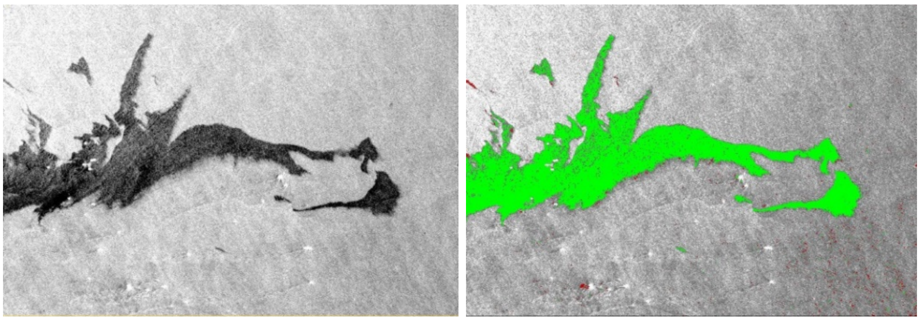

Figure 6. Testing data 1 and the oil slick result.

4. Case Study II – Semi-supervised

In 2017 Ennore oil spill was occurred outside Kamarajar port in Ennore India. The spill occurred on 28 January 2017 when empty tanker collided with a loaded oil tanker. Sentinel 1A in Interferometric Wide (IW) acquisition mode data is acquired in dual polarization VV VH on 29 January 2017. High-resolution (40mx40m) Level-1 Ground Range Detected (GRDH) product is chosen for oil spill detection to be used in ESA SNAP Platform.

SNAP uses Adaptive Thresholding Algorithm for oil spill detection. The dark spots are detected using an adaptive method. First the local mean backscatter level is estimated in a large user defined window size, if the value is lower than the detecting threshold (user defined) then the area is detected as dark spot. Contiguous detected pixels are clustered into a single cluster. Clusters, which are smaller than user selected minimum size, are eliminated. For dark spot detection, following parameters can be defined by user:

- *Source Bands:* User can select one or more bands to produce multi-look image
- *Background Window Size:* To compute the local mean backscatter level, the window size in pixels has to be set
- *Threshold Shift (dB):* The detecting threshold for black spots, which is compared with the local mean backscatter level within the window.

To improve the accuracy, different types of speckle filters can also be applied to the data before the oil-spill detection step. Original amplitude image (dB) of VV polarized data is shown at Figure 7.

Sigma Lee filter with 7x7-window size is applied to the original image to remove the speckle noise. Following the speckle removal filter step oil spill detection algorithm is applied. Parameters are set to 256 pixels for window size and 0.1 sq. km for minimum cluster size. Different threshold levels are tested to detect possible oil spills. The result is shown at Figure 8 and Table 3.

Applying a speckle filter gives better accuracy for detecting the oil slicks. Taking different parameters for the threshold algorithm would also affect the performance of the algorithm.

Table 3. Different Thresholds and oil probability.

Oil Spill Mask	Threshold (dB)	Decision
Green	1.0 dB	Very Low Probably Oil
Dark Blue	2.0 dB	Low Probably Oil
Light Purple	2.5 dB	Probably Oil
Purple	3.0 dB	High Probably oil

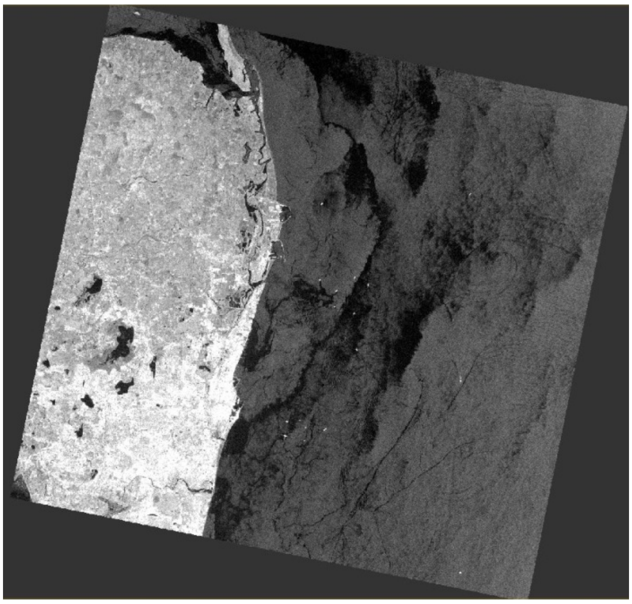

Figure 7. Original amplitude image (dB) from GRDH VV polarized S1A data.

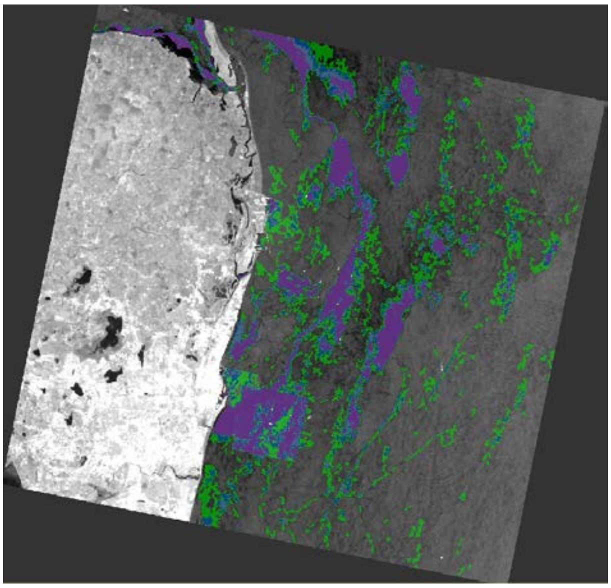

Figure 8. Window size is set to 256. Four oil spill masks for four different Thresholds are shown on the filtered amplitude image (dB).

5. Conclusion

Satellite based SAR systems provide a cost effective solution to monitor oil spills over large water bodies with their advantage of being operable in all weather conditions and during day and night. Data obtained from optical sensor can provide complementary information for oil spill monitoring specifically under clear weather conditions. In addition, hyperspectral sensors have great potential for detailed identification of materials and better estimation for oil spill monitoring. Laser fluorosensors mostly mounted on aerial platforms could be also used for the identification of oil spills. However, it is not possible to cover large areas with areal platforms which is a drawback for these systems. On the other hand, the effectiveness of such systems is very high in rapid intervention-based approaches and they enable the intervention teams and equipment to be used in a very effective way to prevent pollution.

It is not possible to provide all the information needed for oil spill surveillance by using just a single sensor. Therefore, integrated usage of different remote sensing sensors and platforms is a good approach to create a valuable solution for oil spill monitoring and detection. In this study, SAR based satellite systems are examined in detail to illustrate their potential for oil spill detection. The impact of the spills depends on the type and amount of oil, location, term, water depth, meteorological conditions and oceanographic features. Remote sensing technologies could aid to distinguish spills before they cause extensive damage. In the case of larger accidents, remote sensing images allow easy review of the extent of oil spills. Successful study had to use contextual information like wind, bathymetry and presence of algae. Biogenic film, grease ice, wind front areas, wind sheltering, rain cells and shear zones can cause false alarms and resulted in look-a-likes. Polarimetric SAR is an alternative data source to better identify oil slick and biogenic slicks. Oil type and thickness information is also important for an accurate detection. Speckle noise can affect radiometric quality. Good radiometric resolution is also another parameter that should be considered for reliable oil slick detection. Satellites with higher spatial resolution and more frequent revisit capabilities are expected to improve in terms of better oil slick detection, identification, oil type recognition and volume estimation.

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THE ROLE OF SAR REMOTE SENSING TO DETECT OIL POLLUTION AND EMERGENCY INTERVENTION

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1. Introduction

Marine pollution, particularly oil has a dangerous effect, which may play a permanent role in the ecosystem and habitat of marine. Fauna and flora of marine environment are very fragile against the toxic effects of oil (Kennish 1996; Güven et al., 1998). Many kinds of birds, which spend their most of the time on the sea surface for feeding, are vulnerable to oil spill -related contamination. It may cause to die because of disease, starving or contrary to this feeding oil-contaminated food. According to the wind and type of the oil, spillage of it may spread on both offshore and coastline. Especially it is crucial for the cities that have cultural heritages and recreation areas along the coast. It may effect economical point of view not only on touristic attraction but also on seafood production. Fishery and mariculture industries are one of the main incomes for most of the coastal area. Contamination of seawater may lead to drop commercial fishing. Additionally, it can be risky for public health problems due to consumption of affected seafood. Therefore, it may cause to withdraw the truth in the market industry. The economical loss follows the social problems in the community in the long-term period (Kennish 1996; Doğan et al., 1998; ITOPF 2011a; ITOPF 2011b; Gazioğlu et al., 2013).

Oil spillage pollution occurs because of oil discharge from ships or offshore platforms and accidents. During the production of the oil, waste part of the production is discharged into the sea, which damages the natural form of marine environment. Additionally, tanker accidents play another role. However, it is noticed that tanker accidents had less contribution comparing to intentional spillage of oil. This comes in existence mostly risky areas where marine transportation traffic has a high level of density (Arias and Marcovecchio, 2017).

Sensors located on different platforms such as aircraft, helicopter, satellite, space shuttle, and UAV have been widely used for remote sensing observations (Gazioğlu et al., 2017). The study of remote sensing composed of a wide range of research and applications such as Earth sources forest, agriculture, inland water, geology, land use/cover, ocean monitoring. Water covers approximately 71% of Earth surface and about 95% of this is composed of oceans (Gazioğlu, 2018). Thus, it has an important role in life on Earth as a big part of the environmental circle particularly the dynamics of water.

To oil spill-related emergency situations, dynamics and behavior of the oil spill and its spatial distribution are needed to be monitored. To this purpose, frequent data and rapid mapping are required to take action against its irrevocable consequences.

Remote sensing has been widely used for oil-related situations such as determination of illegal discharge of oil and slick trajectory, detection and monitoring of oil slick, countermeasures and mitigation of the effect of the spill (Fingas, 2015). It becomes more vital especially due to its frequent acquisition opportunities, which provides wide area monitoring. It provides local governments to global organizations to determine the location and extent of the spill for rapid risk assessment and to take preventive measures.

This chapter provides an overview of oil spill identification by remote sensing, giving information on both electro-optical image systems and microwave sensors. This study particularly focused on utilization of active Synthetic Aperture Radar (SAR) satellite systems and widely used extraction methods.

2. Electro-optic remote sensing

Interaction of oil with a specified range of electromagnetic wavelength may provide us to describe oil over water even cloud has a disadvantage on optical images of passive systems while using temporal acquisitions. Passive systems measure the reflected radiation that consists of three main range knows as Visible (VIS), Near Infrared (NIR) and SWIR (Short Wave Infrared) sensors. VIS region approximately has a range of electromagnetic spectrum from 400nm to 700nm.

A methodology was developed by Adama et al. (2009) to exploit the separability of oil spill using Visible and NIR (VNIR) imagery of MERIS and MODIS sensor. The study reported that NIR bands performed the best to discriminate sun glittered oil free sea and oil spill. Taravat and Del Frate (2012) studied the feasibility of band rationing to detect oil spill using Landsat ETM+ data acquired over the Gulf of Mexico. They computed a wide variety of combinations of bands and applied pixel based multilayer perception neural network classifier. It is concluded that the ratio of 660 nm and 560 nm, the ratio of 825 nm and 560 nm, a difference of 660 nm and 560 nm, and normalized 480 nm provided the best results. Fingas and Carl (2014) presented the generalized reflectance values for water and oil for the VNIR bands and it shows that the discrimination of water and oil is not very extensive. Moreover, VIS part of remote sensing may be problematic due to the confusion of sun glitter with oil. Pisano et al (2015) indicated a methodology that detects oil spills using NIR sunglint radiance imagery of MODIS data, which has a spatial resolution of 250km. Kolokoussis and Karathanassi (2018) applied Sentinel-2 imagery for two test sites, which one of them is a natural oil outflow, and the other one is spill due to a tanker. An object based image analysis was conducted using different fuzzy rule sets and decision valued for the selected features and oil spills were detected.

In addition to VIS, NIR and SWIR sensors Thermal Infrared (TIR) sensors have been also used to delineate oil from water. TIR bands have a wavelength, which ranges between 8 and 14μm. Whether the oil is thicker than it is expressed as hot in TIR bands. While it gets thinner it will appear cooler, and when the oil is thinner than it cannot be detectable (Fingas and Brown, 2014). Cai et al. (2007) presented a study using ASTER data over Hainan Province China. Their results indicated that oil spillage has a lower surface temperature while comparing to the drilling materials. Xing et al. (2015) studied Deepwater Horizon at the Gulf of Mexico where the industrial accident happened in 2010. They used Landsat-7 ETM+ and Landsat-5 TM data and presented that sea surface has higher surface temperature than the oil covered surface.

3. Microwave remote sensing

As a form of electromagnetic radiation, microwaves have relatively longer wavelengths than visible and infrared ranging from 1 mm to 1 meter. The frequencies of the microwave bands are often designated as letters as given in Table 1 (Lillesand et al., 2015). Among the sensors, microwave sensors are becoming in the front rank for oil spill detection. However, active microwave sensors are much more far common than passive sensors.

Table 1. Wavelength ranges for SAR systems

Bands	Wavelength (cm)	Frequency range (GHz)
P	30-100	0.3-1
L	15-30	1-2
S	7.5-15	2-4
C	3.75-7.5	4-8.0
X	2.5-3.75	8-12
Ku	1.7-2.25	12-18
K	1.1-1.7	18-27
Ka	1.1-0.75	27-40

3.1 Passive microwave sensors

Passive microwave instruments (radiometers) operate in the radar frequency and record thermal radiation emitted by objects and converted to a brightness value (Richards, 2009). It generally collects energy ranging between 0.15 and 30 cm while thermal infrared part of the electromagnetic radiation changes between 3 to 14μm (Jensen 2014). Measurements through sensors carried out under almost all weather conditions, day, and night. Passive devices are operated both from space and from the ground have been used for weather and climate purposes (Jensen, 2014). The passive sensors may cover large areas and the relative thickness of oil slick can be measured using passive sensors (Fingas, 2013). However, the spatial resolution is not good for oil spill detection. Oil spills emit strong microwave radiation and it looks brighter than the background water, which seems darker. This might change depending on the thickness of the oil slick or wavelength of the radiometer (Pelyushenko, 1995).

The emitted energy by the Earth is relatively weak and for the recording of this weak energy, a sensor having a large Instantaneous field of view (IFOV) is required. Thus, the resolution of the passive microwave sensors has spatial resolutions at kilometers level due to having large IFOV (Jensen, 2014). Even oil has stronger emissivity, satellites have a lower spatial resolution, which is about kilometer levels, and it is more convenient to acquire data by the airborne sensor (Brekke and Soldberg, 2005). Calla et al. (2013) studied Special Sensor Microwave/Imager (SSM/I) at 19.3

GHz frequency for the detection of oil spill occurred in Bombay High Area, Arabian Sea. It is noticed that in both vertical and horizontal polarizations indicated a rapid decrease of oil spill brightness temperature comparing to oil free surface.

3.2 Active microwave sensors

The wide range of optical satellites has made it possible to utilize the different application. However, usage of optical data for oil detection depends on some certain circumstances such as weather conditions, type of oil, look angle, the roughness of sea surface (Lavaca et al., 2017, Fingas and Brown, 2018). Synthetic Aperture Radar (SAR) sensors have the ability to acquire images both day and night, which is a major advantage over passive sensors. This gives the opportunity to observe high latitude regions, north and south poles. It works also under all weather conditions which is another advantage over optical data especially cloud covered days or typical regions such as tropical parts of Earth. Because it has been preferred to optical data and commonly used for ocean related studies.

The fundamental of Radio Detection and Ranging (RADAR) is based on radiation of electromagnetic waves, in another words radio-frequency wave. The basic principle of the RADAR system is that it transmits an electromagnetic wave to Earth surface in a given direction and detects backscattered wave. The sensor located on a platform which can be either airborne or space borne called side looking (airborne) radar (SLR or in case of airborne SLAR) (Lillesand). Differently, from the optical region of the electromagnetic spectrum, radar systems collect backscattered radiation from the surface. It is known as radar backscatter or radar cross-section (RCS) $\sigma 0$ (sigma naught) with units of decibels (dB) (Lillesand, 2015).

SAR sensor measures the complex backscattered signal. The source of the variability of backscattering depends on the sensor and target parameters. Wavelength, polarization, and incidence angle are the sensor parameters. Roughness conducts the scattering pattern as surface scattering (i.e. water, soil, rock) and volumetric scattering (i.e., forest, vegetation) which occur according to the target structure. Dielectric constant (moisture content) of the target conducts the strength of the scattering.

Man-made and metal objects such as urban buildings, bridges, dams, etc. and terrain slopes towards sensor resulting in very high backscatter values and appear bright white features in the image due to corner reflection. Rough surfaces and dense vegetation gives high backscatter values and they appear as bright gray to gray range die to diffuse reflection (Figure 1). Average rough surfaces and agricultural crops have moderate backscatter values with gray to dark gray in the images. Smooth surfaces such as calm water, dry terrain or road give low backscatters due to specular reflection and they appear dark in the images.

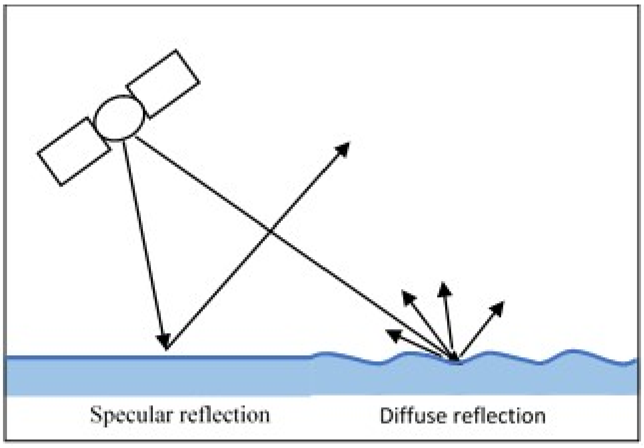

Figure 1. Response energy of SAR on different surface structures.

The dominant backscatter of an electromagnetic wave from the ocean surface is called Bragg scattering. The scattering wavelength is one-half the radar-transmitted wavelength. The backscatter of the sea surface is affected by polarization, incidence angle, wavelength and wind. The microwave part of the electromagnetic spectrum covers a wide range of wavelength comparing to the visible and infrared bands. As mentioned in Table 1 above, there are several bands. Among them short wavelengths as Ka, K and Ku bands placed on airborne systems. Space borne platforms mostly have X, C and L bands. Depending on the SAR wavelength, energy interacts in a different way with the targets. Thus, the different wavelength can provide different information. Table 1 summaries the current satellites and their wavelength information.

Polarization is the property of the microwave signal, which defines the orientation of the energy. Radar sensors send and record the polarized energy, which is filtered in a single plane as horizontal (H) or vertical (V). The transmitted and backscattered energy may be recorded in various types. If the antenna both send and receive horizontal polarization are known as HH signals. Similarly, those both sent and received in vertical polarization called VV signals. HH and VV polarized combinations are called like polarized. There are also configurations, which send H and receive V or vice versa recordings called HV and VH configurations, which are called cross-polarized imagery (Sulvilan, 2008; Şeker et al., 2013; Jensen, 2014). Compact polarimetry is another type, which transmits circularly polarized signal and receives two orthogonal equally coherent polarizations. The combinations are both right circular transmit, and horizontal (RH) or vertical received (RV) while an electric field of wave rotates clockwise (Touzi, 2009). Like the wavelength, the polarization plays an important role. Ground surface responses changes according to the orientation of the signals and different information may be gathered utilizing different polarimetric data (Richard, 2009). SAR systems have a different combination of polarization and these can be single polarization (either HH, VV, HV or VH) dual polarization (HH and HV, HH and VV, or VV and VH) or full polarimetric (HH, VV, HV, and VH) options (Lillesand). However, not all the satellites have these combinations (Table 2). The incidence angle is the angle between the radar energy and the normal to the ground surface. The incidence angle may change from near to far range, which affects the viewing geometry of the targets. Increase in incidence angle may cause a rapid decrease in scattering while the surface is smooth. Contrary to this, when there is a rough surface backscatter decreases slowly while incidence angle increase (Behari, 2005). Lin et al. (2008) noticed that local wind might play an important role on radar backscatter, which cause small-scale sea surface roughness while the incidence angle is varying from 15 to 70. Kwon and Li (2012) stressed that visibility of oil spill is optimum while wind speeds changes between 3 to 10 ms^{-1}. Because of backscattering behavior, oil spill appears dark in SAR images (Figure 2). However, natural phenomena such as low wind, organic films, rain cells, upwelling, and algae may also look like dark patches, which are called look-alikes spillage (Mera et al., 2012; Kwon and Li, 2012).

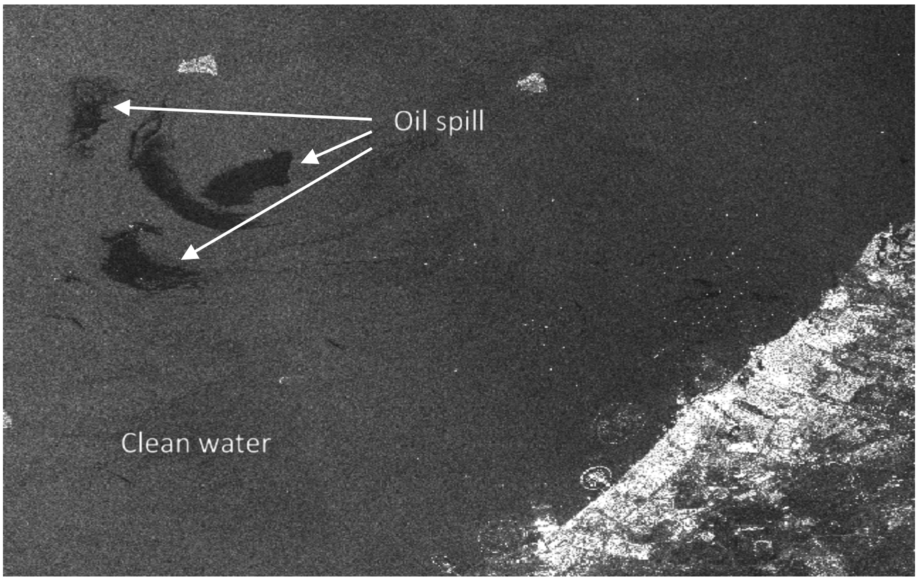

Figure 2. A radar satellite image of an oil spill example. Oil-spill appears as dark at the upper left of the image, and ships and urban appears as white in the image (Sentinel-1A image acquired on 20170308).

Various SAR satellites have been operated for the observation of Earth surface. First spaceborne SAR satellite, which provided L-band data for the public domain, was Seasat launched by NASA in 1978. The Shuttle Imaging Radar Experiment A (SIR-A), SIR-B and SIR-C were conducted by NASA in 1981, 1984 and 1994, respectively. SIR-A and SIR-B had L-band and HH polarization, while SIR-C had multi-polarization and multi-frequency capacity. First S-band satellite ALMAZ-1 which had HH polarization was launched by the former Soviet Union in 1991.

The European Space Agency (ESA) designed two twin satellites and launched its first SAR satellite European Remote Sensing Satellite (ERS-1) in 1991 and ERS-2 in 1995. Both satellites have C-band and VV polarization and approximately 30m ground resolution with 35 days revisit capability. Using both ERS-1/2 also supported Tandem mission, which conducted one-day revisiting period. They completed their missions in 2000 and 2011 respectively. In 1992, Japan Aerospace Exploration Agency (JAXA) launched the Japanese Earth Resources Satellite (JERS-1) which designed to carry optical and L-band SAR sensor with HH polarization. Canadian Space Agency (CSA) launched C-band and HH polarized RADARSAT-1 in 1995. It had the highest spatial resolution among the SAR satellites having different incidence angle options (Jensen, Lillesand). ESA launched Earth observation mission Environmental Satellite (ENVISAT) in 2002 with 10 sensors on it. Advanced SAR (ASAR) provided C-band dual polarimetric data since 2012. As an advanced version of ERS, satellite ASAR offers multi-resolution, large swath wide and variety of look angle. In 2005, JAXA launched a new generation satellite called Advanced Land Observing Satellite (ALOS), which have both, optical and SAR sensors. Phased Array L-band Synthetic Aperture Radar (PALSAR) instrument had L-band with full polarimetric imaging capacity until 2011(Rosenqvist et al., 2014).

New generation SAR satellites operate multi-satellite constellations such as TerraSAR-X/Tandem-X/PAZ of DLR and Spain, Cosmo-SkyMed-1/4 of Italy and Sentinel -1A/1B of ESA (Table 2). TerraSAR-X, which was launched in 2007, is the first bi-static radar, which provides 1m resolution images at X-band (DLR, 2010). DLR launched second mission TerraSAR-X add-on for Digital Elevation Measurement (TanDEM-X) in 2010 to generate high resolution and high precision global DEM. The second SAR satellite of CSA RADARSAT-2 was launched in 2009 as a follow -on mission of RADARSAT-1. It operates same frequency (C-band) but the advanced spatial resolution and full polarimetry. COnstellation of small Satellites for Mediterranean basin Observation (COSMO-SkyMed) is the Italian SAR satellite system, which operates at X-band. Within this mission, Italy launched four satellites in 2007, 2008 and 2010. It provides short revisit time for continues observation. A Single satellite can revisit the same region at 16 days while it is below 12 days using constellation. Radar Imaging Satellite-2 (RISAT-2) is an X-band SAR satellite mission of Indian Space Research Organization (ISRO). It was launched in 2009 and still an active satellite, which provides 1m resolution imagery. ISRO launched RISAT-1 in 2012 and it completed its mission in 2017. It provided data in single, dual, quad and circular polarization with C-band wavelength.

Korea Aerospace Research Institute (KARI) launched Korea Multi-Purpose Satellite-5 (Kompsat-5) in 2013. It operates X-band SAR imagery in 1m spatial resolution and has single polarization options. JAXA launched in 2014 ALOS-2 that is follow on satellite mission of ALOS-1. It has L-band sensor and advanced revisit time and spatial resolution comparing to ALOS-1.

Table 2. Current SAR Satellite missions (summarized from directory.eoportal.org/)

Satellites	Country/ Agency	Launch year	Wavelength	Revisit time (day)	Incidence angle (°)	Resolution (m)	Swath width (km)	Polarization
TerraSAR-X / TanDEM-X	DLR	2007/ 2010	X (3.1 cm)	11	15-60	1-16	10-300	Single, Dual
RADARSAT -2	CSA	2007	C (5.6 cm)	24	10-60	3-100	20-500	Single, Dual, Quad
COSMO-SkyMed 1/2	Italy	2007	X (3.1 cm)	16	20-60	1-100	10-200	Single, Dual
COSMO-SkyMed 3/4	Italy	2008/ 2010	X (3.1 cm)	16	20-60	1-100	10-200	Single, Dual
RISAT-2	ISRO	2009	X (3.1 cm)	14	20-45	1-8	10-120	Single
Kompsat-5	KARI	2013	X (3.2 cm)	28	20-45	1-20	5-100	Single
ALOS-2	JAXA	2014	L (22.9 cm)	14	8-70	1-100	25-350	Single, Dual, Quad
Sentinel-1A/B	ESA	2014/ 2016	C (5.5 cm)	12	20-46	5-100	20-400	Single, Dual
Gaofen-3	China	2016	C (5.5 cm)	29	17-50	5-500	5-650	Single, Dual, Quad
PAZ	Spain	2018	X (3.1 cm)	11	15-60	1-15	10-300	Single, Dual
SAOCOM-1A	Argentina	2018	L (23.5 cm)	16	20-50	10-100	40-350	Single, Dual, Quad
NovaSAR-S	UK	2018	S (10 cm)	4	16-75	6-30	25-750	Single, Dual, Quad

Sentinel satellites were launched under the ESA's Copernicus program. Currently, Sentinel-1 has two satellites Sentinel-1A and Sentinel-1B, which were launched in April 2014, and 2016, respectively. Recently, Sentinel-1 plays a major role in remote sensing community due to being free-of-charge policy by ESA Copernicus program. More details about Sentinel satellites are given in the next section. Gaofen-3 was launched in 2016 by China. It is a multi-polarized C-band satellite, which provides 12 imaging modes and variety of spatial resolution imagery from 1m to 500m. In 2018 Spain launched X-band SAR satellite PAZ, which joined DLR's TerraSAR-X/TanDEM-X constellation to provide reduced revisit time. SAR Observation and Communications Satellite (SAOCOM), which is the second L-band satellite, was launched by Argentina in 2018. The details of the current active satellites are summaries in Table 2.

There will be more SAR satellites following next decade. ESA's next mission will be Biomass (Biomass monitoring mission for Carbon Assessment) which will operate P-band for forest biomass purposes (Fletcher et al., 2012). NASA-ISRO Synthetic Aperture Radar (NISAR) mission is a co-operation between NASA and ISRO. It will be the first satellite, which is going to operate dual frequency as L-band and S-band. It would enable of 12 days repeat pass full polarimetric data acquisition (NASA 2018). DLR has planned to launch L-band TANDEM-L satellite, which will have revisit time of 16 days and full polarimetric data.

With this data, it is expected to update seasonal and yearly DEMs, produce better forest high, deformation, ice structure and soil moisture information (Moreira et al., 2015). CSA has planned to launch RADARSAT Constellation Mission (RCM), which will operate three identical small satellites. The revisit time is going to be 12 days, however, using three satellites it is going to decrease to four days. It will enable to acquire multi polarimetric data including compact polarimetry at C-band (Dabboor et al., 2018). Since the launch of SEASAT in 1978, which is the first satellite used for gathering imagery from the ocean environment and the first civilian satellite, SAR data has been started to use for monitoring oceans. Following the SEASAT, it has been continued to monitor both the ocean and land surface with many of the active satellites such as ERS-1&2, RADARSAT-1&2, ENVISAT, ALOS, TerraSAR-X.

Until now, hundreds of studies published using SAR imagery for oceanographic studies. These studies related to ocean surface waves and spectra, wave refraction and breaking, wind speed and direction, upwelling, sea ice, ocean currents and current gradients, oceanic internal waves, marine atmospheric boundary layers, underwater topography, and detection of ships and wakes are just some of the examples where SAR imaging is used for oceanographic studies (Bayindir et al., 2018). In the literature, it is also proved that oil spill detection by using

SAR images is one of the important oceanographic studies. SAR imagery has proved to be a useful tool for detecting oil spills on water surfaces as well. Some of those studies presented in the last decade were summarized in Table 3.

Table 3. Studies related to oil spill detection using various SAR data in the last decade.

Data	Band/Polarization	Objective of methodology	Validation	Accuracy	Reference
ERS 1/2 SLC	Full resolution SAR VV-polarized C-band images, is presented and discussed. The SAR images were	A new study on the three GK distribution parameters, as descriptors of low backscattering areas and small dominant scatterers in marine single-look complex (SLC) SAR images, is presented	The K probability density function (pdf) has been found to be a particularly useful model for sea amplitude statistics on SLC SAR images.	The experimental results demonstrate the physical consistence of the model.	Migliaccio, M. et al. 2007
TerraSAR-X ERS-2 ENVISAT-ASAR RADARSAT -1 ALOS PALSAR	X, C and L bands with HH, VV,and Full polarisation options	To discuss the technical functionalities of TerraSAR-X from the emergency response perspective, describing its technical abilities in terms of a damping ratio, radiometric accuracy, and noise level with reference.	Describing its technical abilities in terms of a damping ratio, radiometric accuracy, and noise level with reference to the actual Hebei Spirit oil-spill incident.	There are distinct advantages of using X-band TerraSAR-X data for oil-spill detection compared to the data obtained at other available frequencies.	Kim, D. et al. 2010
UAVSAR	L-band, Full polarization	The study proposes two approaches. First one is based on polarimetric parameters (correlation coefficient, cloud entropy, mean scattering angle and anisotropy). The second one uses the poalrimetric image	The image captured from the video camera which is onboard UAV was used for the validation.	The results were compared qualitatively and the results confirmed the similarly of the shapes between proposed results and the video camera	Liu P. et al. 2011
ENVISAT-ASAR WSM (Wide Swath Mode)	VV-polarized images	Segmentation; an adaptive thresholding algorithm was applied for detecting oil spills based on SAR data and a wind field estimation.	Image testing, visually inspecting.	Image testing revealed 99.93% pixel labelling accuracy. Detected oil spills 75% Successfully filtered 66.7 % look-alikes Correctly labeled pixels 99.93% mislabeled pixels	Mera, D. et al. 2012

Table 3. Studies related to oil spill detection using various SAR data in the last decade.

Data	Band/Polarization	Objective of methodology	Validation	Accuracy	Reference
Radarsat-2 and TerraSAR-X	Radarsat-2: C band and Quad-pol TerraSAR-X : X band VV and HH polarization	To further, investigate the potential of polarimetric features with respect to their ability to detect and characterize oil slicks on the ocean surface.	An evaluation of the data with respect to improved detection and characterization of three oil slicks with different chemical properties have been initiated using statistical properties.	The co-polarization channels are more reliable for oil spill characterization than cross-polarization channels for which the signal is often hidden below the	Skrunes, S. et al. 2012
TerraSAR-X	Dual HH-VV	Polarimetric features; as geometric intensity, copolarization power ratio, span proved to be more discriminative than other polarimetric and	Support vector machine.	Classification accuracy of 90% oil spills and 80% for look-alikes.	Singha, S. et al. 2014
ERS 1/2	C-band, VV polarimetry	A methodology of oil spill discrimination from alike appearance was proposed. A set of 95 eigenvalues from 9 shape features were selected for the analysis.	In the dataset slicks are marked and the other dark locations are considered as oil look-alike. For the performance of the approach different methods were used with same dataset and	ANN based classification method achieved the best accuracy which reached up to 94% using 50 selected eigenvalues.	Guo Y. and Zhang H.Z., 2014
RADARSAT-1	C-band, HH polarimetry	To compare different classification techniques for oil-spill detection.	Support Vector Machine (SVM), Artificial Neural Network(ANN), tree-based ensemble classifiers (bagging, bundling and boosting), Generalized Additive Model (GAM) and Penalized Linear Discriminant Analysis	Overall, the bundling technique best (i.e. bagging) by 1.5 percentage points, and the worst (i.e. ANN) by 15 percentage points.	Xu, Linlin et al. 2014

Table 3. Studies related to oil spill detection using various SAR data in the last decade.

Data	Band/Polarization	Objective of methodology	Validation	Accuracy	Reference
ENVISAT-ASAR	C band	An evaluation of the data with respect to improved detection and characterization of three oil slicks with different chemical properties have been initiated using statistical properties.	ANN and Decision three classification methods used	Image testing revealed upto 95.1% candidate labeling accuracy	Mera, D., et al.2014
DLR ESAR airborne	L-band, Full polarization and C-band HV and HH	An experiment was conducted using frequency, polarization and view angle of the sensor.	Ground based information was collected including location, boat velocity and water samples.	L -band VV polarized data achieved better contrast between oil and water than C band HH polarized data. It is indicated that wider view angle of L-band provided better option to discriminate oil.	S.K. Sasamal and M.V. Rao, 2015
ENVISAT-ASAR	C-band, VV polarimetry	It is aimed to detect oil spills and their frequency using multi-temporal data over Caspian Sea. It is noticed that wind has a dominant effect on the appearance of the oil.	Detected oil pollution frequency was used to approximate probable oil spill location.	After segmentation of SAR data discrimination was conducted through visual analysis	Bayramov E. and M. Buncroithner, 2015.
TerraSAR-X and RADARSAT-2	X and C bands with Full polarization	An automatic oil spill detection approach was presented for the monitoring of offshore platform originated pollution. Ten polarimetric features were calculated for the analysis.	Same samples of training and testing data are verified and limited samples was collected from platform.	Pixel base neural network classification was applied and %20 of initial training set was used for testing. Different images are used as source for the training and testing dataset.	Singha S., R. Ressel 2016

Table 3. Studies related to oil spill detection using various SAR data in the last decade.

Data	Band/Polarization	Objective of methodology	Validation	Accuracy	Reference
RADARSAT-2	C band-quad-polarimetric	Using polarimetric synthetic aperture radar (SAR) remote sensing to detect and classify sea surface oil spills, for the early warning and monitoring of marine	The results show that oil spill classification achieved by deep networks outperformed both support vector machine (SVM) and traditional artificial neural networks (ANN) with similar parameter settings, especially when the number of training data	SAE achieved the highest classification accuracy (lowest testing error) among all the algorithms on different sample sizes. DBN achieved a close performance to SAE.	Chen, G. et al. 2017
ENVISAT-ASAR	C-band, VV polarimetry	The study compares feature selection methods (Correlation-based feature selection, Consistency-based filter, Information Gain, Relief and Recursive Feature Elimination for Support Vector	A five-fold cross-validation using training set was used for each classification, it did not used an independent set for the validation.	The results indicated that SVM-RFE approach provided the best accuracy (87%) and kappa coefficient (74%)	Mera D., 2017
ALOS PALSAR	L band, HH+HV or VV+VH	Change Detection of Sea-Surface Oil Spills	The correlation coefficient change statistic and the intensity ratio change statistic algorithms are used.	Intensity ratio change statistic performs significantly better compared to the correlation coefficient change statistic for detection of the oil spill, especially	Bayindir, C. et al. 2018

3.3 Oil-spill surface extraction from Sentinel-1 data

Sentinel-1 Data

The Sentinel-1 satellites, which carry C-band, 5.6 cm radar wavelength (5.405 GHz) Synthetic Aperture Radar (SAR) sensors, have a revisit time of 12 days. Using both Sentinel satellites the repeat cycle will be 6 days, it will be 3 days using repeat frequency at the equator and they provide approximately 1 day at the Arctic. Sentinel satellites can provide co- and cross-polarized data, and their incidence angle values vary between 20° and 45°. There are four image acquisition modes: Stripmap (SM), Interferometric Wide swath (IW), Extra Wide swath (EW), and Wave (WV). Four levels of products Level-0 unfocused raw data, Level-1 focused and georeferenced slant range Single Look Complex (SLC), Level-1 Ground Range Detected (GRD) which is a focused, georeferenced, multi-looked and projected to ground range with an Earth ellipsoid model SAR data, and lastly Level-2 Ocean Swell spectra (OCN) (ESA 2013). The products of the Sentinel are provided in Standard Archive Format for Europe (SAFE) format. For both IW and EW modes of the products multi-looking is conducted on each burst of all sub-swaths. The resulting image is a merged form of all bursts as GRD image. Multi-looking reduces the speckle in images while cause to degradation in spatial resolution.

In this study, Sentinel-1 data were acquired over Arabian Gulf and downloaded from the open access ESA Data Hub during ascending mode on 20170308 (https://scihub.copernicus.eu). In the study, IW mode, GRD product of Sentinel-1A (S1A_IW_GRDH) which contains both VV and VH polarizations was used (Figure 3). IW has a 250 km wide swath, which operates in three swaths using the Terrain Observation with Progressive Scanning SAR (TOPSAR). The incidence angle of the S1A data approximately changes between 30.72° and 40.24°. It is a multi-looked product, which has a square pixel spacing of 10mx10m.

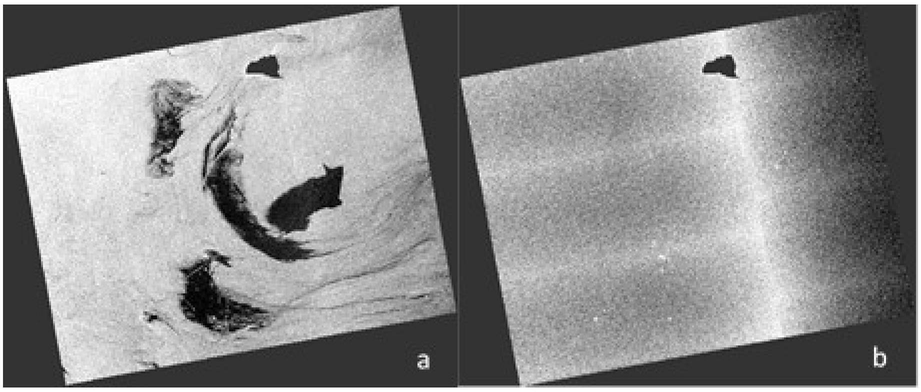

Figure 3. a) VV polarized and, b) VH polarized Sentinel-1A.

Although, different approaches discussed the possibility of delineation of oil spill using multi polarization and multi frequency as mentioned in the previous sections here we used single frequency and single polarized SAR data to express the performance of free-of-charge Sentinel-1 for oil spill extraction. Even acquired Sentinel data has both VV and VH polarization the dark object belongs to the oil spill is not visible in VH polarized data (Figure 3).

Methodology

For the analysis, we applied the pre-processing steps given in the flowchart (Figure 4) using open source tools of Sentinel Application Platform (SNAP) software (SNAP, 2018).

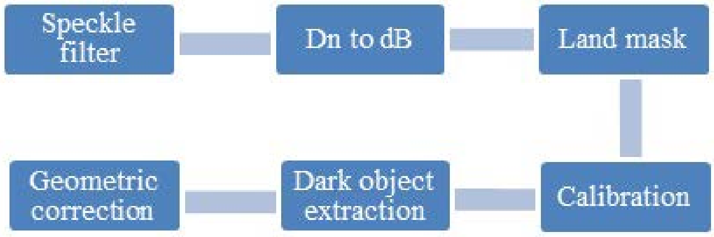

Figure 4. Flowchart of processing steps.

Speckle noise, which causes to prevent information extraction, may be introduced in an image during constructive and destructive interference. It has a salt and pepper effect, which appear bright and dark spots in radar images. Speckle filter can be useful to reduce the noise effect. The σ° data were filtered using the Lee Sigma filter with a kernel size of 7x7 is applied to reduce the speckles. The filtered image has better contrast and it provides brighter values in the sea and lower values with a dark appearance in the oil-spilled region (Figure 5). Linear sigma naught values are converted to dB. SRTM 3 sec DEM is used to mask the land from water. Calibration represents radar backscatter of the ground surface. The radiometric calibration was performed to convert digital pixel values of VH amplitude into sigma naught (σ°) values that can be directly related to the radar backscatter of the scene. Oil-spill extraction operator of SNAP was used to delineate oil from water. A threshold shift value of 3.5db and 4000-background window size was applied for the study. The satellite data are projected to ground range using an Earth ellipsoid model. SRTM 3 sec DEM is applied to correct SAR geometry to produce a geocoded map.

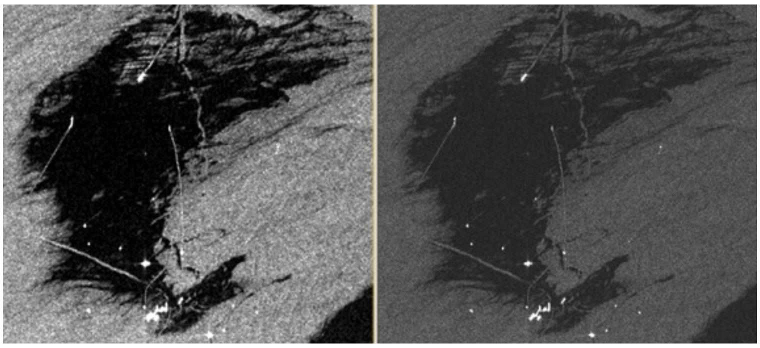

Figure 5. Filtered (a) and original (b) images.

For the analysis backscatter values was evaluated. The variation of the backscatter values over the oil spill and its environment assessed selecting three area of interest (AOI) regions (Figure 6-a). The result indicated that backscatter values range approximately between -19 dB and -28 dB at AOIs for oil spill regions, while values vary changes between -5 dB and -22 dB (Table 4). The standard deviation of the AOIs for oil spill has lower values comparing to water values. The extracted oil spill is calculated approximately 323.5 km2 (Figure 6-b).

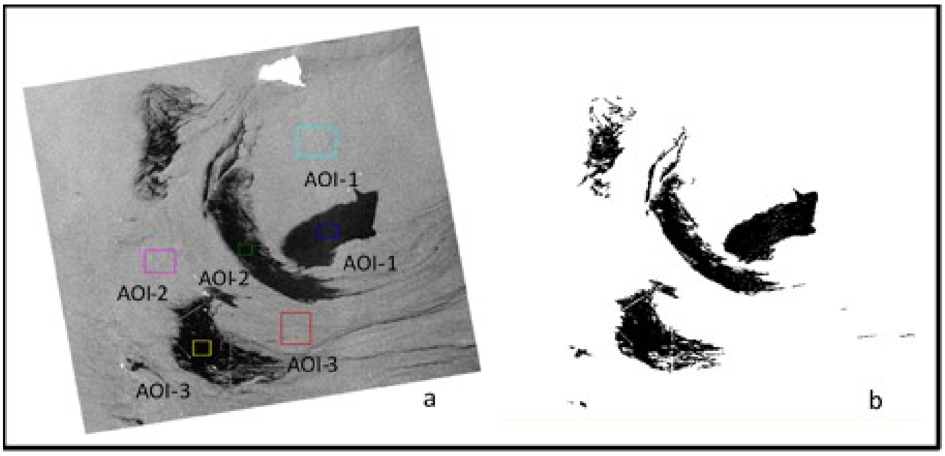

Figure 6. AOIs of selected regions (a), Oil spill detected regions (b)

Table 4. Backscatter values for selected AOI

VV	Oil			Water		
	AOI-1	AOI-2	AOI-3	AOI-1	AOI-2	AOI-3
Min (dB)	-26.51	-27.47	-27.38	-21.59	-21.31	-22.12
Max (dB)	-19.22	-22.32	-23.24	-5.60	-10.96	-12.69
Mean (dB)	-24.07	-24.93	-25.27	-18.21	-18.39	-19.09
St.Dev	0.60	0.56	0.56	0.69	0.69	0.72

An accuracy assessment analysis was conducted to evaluate the result. A set of 300 points are randomly distributed on the SAR images and their accuracies are estimated. Overall accuracy and kappa statistics are calculated from an error matrix, which checks the agreement between the extracted result and reference data (Lillesand et al., 2015). The results gave high overall accuracy, which reaches up to 95.7%, and the kappa coefficient is extracted as 0.8985. The producer and user accuracies are determined as 86.73% and 100% for the oil spill and 100% and 94.05% for water classes, respectively.

3.4 Discussions and Conclusions

Advances in space borne technology will continue to contribute oil spill monitoring in near future. Especially new generation of SAR satellites and constellations provide short time revisit over Earth for surface observation which is critical for the rapid response of oil spill. In this chapter, an overview of the use of remote sensing data for oil spill pollution monitoring was examined. Especially details of active microwave remote sensing were given for better understanding of oil spill detection using space-borne SAR data.

As emphasized in the literature, review different approaches have been developed using high resolution to lower resolution SAR satellite images. As Sentinel mission of ESA supports open source policy, we applied extraction of oil spill for rapid analysis using SNAP approach. The results are expected to be useful for rapid monitoring to mitigate environmental disaster.

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OIL SPILL RECOVERY AND CLEAN-UP TECHNIQUES

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1. Introduction

While maritime transport carries around 90% of the world trade, oil spill incidents can be inevitable in sea transportation routes. The main objective of oil spill response and clean-up operations is to reduce the effects of oil pollution. Therefore, it is essential to determine appropriate response methods and techniques for each case. Although each and every case have different roots and nature, there are three main response categories: physical response or mechanical recovery which is carried out with skimmers, sorbent materials and booms, chemical response, such as use of dispersants and in-situ burning and biological response known as biodegradation.

2. Equipment

2.1. Booms

Containment booms are deployed to bring under control the spread of oil to minimize the environmental impacts, which may turn into a serious pollution source for shorelines and other resources. The main purpose of the use of containment booms in oil spill response is to collect dispersed petroleum products in a certain area, so recovery may become easier. Moreover, they can be used to direct oil slicks along planned paths, and in rare cases, isolate oil slicks for in-situ burning.

A boom consists of mainly two part, the floatation camber which floats on the surface of the water, and the skirt part which provides a barrier. Therefore, they should have enough flexibility for waves and rigid formation for spreading oil. Booms before any other oil spill equipment, are used in the first place when responding the oil slicks. However, it is important to know which type of the containment booms is appropriate, as they are in various configurations. Table 2 indicates some differences among types of boom.

Table 2. Characteristics of Various Boom Types (ITOPF, 2012a)

Type of Boom	Area of Usage	Storage
Fence Boom	Ports, marinas etc.	Bulky
Inflatable Boom	Offshore and inshore	Compact
Permafence Boom	Ports, marinas etc.	Bulky
Foam Boom	Inshore	Bulky
Shore Sealing (Water-Ballast Boom)	Protected intertidal shores	Bulky

Fence Boom

Fence booms have fence-like structure and impermeable properties. They do not absorb oil in water, and have lightweight and smooth design. Accordingly, they are deployed around ports, docks, harbours and marinas. In order to store them, they can be fold up or wrapped around reels.

Figure 2. Fence boom by Mare Sea Cleaning Services Inc.

Inflatable Boom

Inflatable booms have higher buoyancy to weight ratios than other types of booms, and consequently, they are commonly benefitted in open waters. Since they can be installed in a short span of time and take small place, they are effective for offshore pollution. Furthermore, they show high resistance to weathering and physical effects. There are two types of these durable booms. One is pressure-inflated, in other words, it requires blower, and the other is self-inflated which hooks up a spring or coil. In order to deploy them, its spring or coil component should be triggered. Figure 3 is a picture from an oil spill scene where inflatable boom was already deployed.

Figure 3. Inflatable boom by Mare Sea Cleaning Services Inc.

Permafence Boom

Permafence booms as it is derived from the word “permanent” are long-lasting designs, which require less maintenance than other types of booms in the sheltered area of water, especially in ports and marinas. With its custom rubber-made structure and durable floater material, spilled oil can be easily collected and disposed. Figure 4 shows an example of Permafence boom.

Figure 4. Permafence boom by Mare Sea Cleaning Services Inc.

Foam-Filled Boom

Foam-filled boom consists of the cylindrical foam with high buoyancy properties. They are stored in containers or certain places to be set up when required. They are particularly preferred in estuaries, and can be quickly transported and installed. The design of cylindrical foam offers more stability and durability than the fence type booms in adverse weather conditions. Figure 5 illustrates an example for the foam boom.

Figure 5. Foam-filled boom by Mare Sea Cleaning Services Inc.

Shore Sealing (Water-Ballast Boom)

Shore sealing or beach sealing booms are favourable in shallow and tidal waters. As they are filled with air and water, air-filled part buoys the boom whereas water-filled part ensures ballast. They are particularly installed in an attempt to secure beaches from oil spill. An example of a water-ballast boom can be seen in Figure 6.

Figure 6. Water-ballast boom by Mare Sea Cleaning Services Inc.

2.2. Skimmers

Skimmers are mechanical equipment that collects and removes oil from the surface of water. Common design can include a conveyor belt, which transfers the spilled oil to the contaminant container. Nevertheless, there are other types of skimmers applying suction, and weir skimmers which rely on the gravitational force during the collection of the oil residues. Because of their vulnerability to wind and waves, they are more useful in calm waters. Overall, there are three types of skimmers: oleophilic, suction and weir skimmers.

Oleophilic Skimmers

Oil adheres to certain parts of the skimmers, which are designed like disc, drum, brush or rope. Although various designs enable the use of skimmers in different oil spill scenarios, oil should be removed from skimmers through rubbing or compressing contaminated parts after each use. Table 3 summarizes the oleophilic skimmers according to their usage areas and specifications.

Suction Skimmers

Working principle of the suction skimmers is similar to the vacuum cleaners. They recover oil from the surface of water, and then send them to the storage tanks by pumps. They perform best in calm waters where booms and barriers are surrounded the oil slicks.

Table 3. Skimmers according to application areas (ITOPF, 2012b).

Type of Skimmer	Effectiveness	Oil Condition	Sea State	Debris Resilience
Disc	High yield	Medium-viscosity oils	Low waves, little entrained water	Susceptible to clogging
Rope mop	Low yield	Medium-and heavy-viscosity oils	Very little or no entrained water	Tolerance to debris and ice mass
Drum	High yield	Medium-viscosity oils	Low waves, little entrained water	Susceptible to clogging
Brush	Moderate yield	Light-, medium-, and heavy viscosity oils	Little entrained water	Only tolerance to small debris
Belt	Low to moderate yield	Medium-and heavy-oils	Little entrained water	Only tolerance to small debris

Weir Skimmers

The floating weir skimmers consist of a barrier at the oil-water interface. Oil flows into the skimmer's reservoir over its barrier and is discharged through the hoses. Because of its design, any debris or object can clog its discharge pipes.

2.3. Sorbent Products

Sorbent products, which are commonly water-repellent, are used to absorb or adsorb oil and oil-based products on water. Absorbent materials collect and keep fluid via its molecular structure leading to swelling of the sorbent product. On the contrary, adsorbent materials are insoluble and liquid is drawn up by capillary force, but they do not penetrate the material. Sorbent products are generally used to relatively in small-polluted areas and clear away last traces of oil when skimmers become noneffective. After clean-up process, used materials should be disposed in authorized treatment plants.

Sorbent products are classified into three categories based on material: natural organic, natural inorganic and synthetic sorbents. It should be considered that various cases require specific applications, as material selection should meet the need. Table 4 outlines overall features of the sorbent materials.

Table 4. Advantages and Disadvantages of Different Sorbent Materials (ITOPF, 2012c).

	Sorbent Material	Advantages	Disadvantages
Bulk	Organic-sawdust, paper-pulp, feather, straw, wool Inorganic-vermiculite, pumice Synthetic-polypropylene	Abundancy Low cost	Ineffective at bad weather conditions Difficult to recover Discharge of oil-sorbent mixture is limited
Enclosed	Enclosed bulk materials in nets or meshes	Greater surface area than continuous boom	Booms made of organic material can easily sink Structural deficiencies of booms
Continuous	Synthetic-polypropylene	Long-term storage Quick deployment High oil recovery ratio	Limited efficiency for weathered or more viscous oils
Fiber	Synthetic-polypropylene	Competent for weathered and more viscous oils	Ineffective for light and medium oils

While oleophilic and hydrophobic properties are applied to all sorbent materials, there are various types of products diversified based on their oil retention capacity as well as floatability.

Sorbent Barriers

Sorbent barriers or booms are made of absorbent material, which collect and retain oil in their pores. They can absorb fluid up to 15 times their own weight. In calm weather, due to its flexible structure it can be installed smoothly in the areas where pollution is thin layer.

Sorbent Pads

Similar to the sorbent barriers, they absorb oily products as well as vegetable oils and solvents whilst repelling water. They can be deployed on land or water, yet they are suited for small spills in enclosed areas. Polypropylene is a common material for these products. Thanks to their high buoyancy, they are able to float on water even when they are fully absorbed.

Sorbent Granules

They involve renewable materials, such as sawdust, pieces of pumice stone. After each use, they should be recovered with nets.

2.4. Other Equipment

Oil Storage Tanks

Oil storage tanks are needed to store the recovered oil from polluted area. Variable designs are available for different purposes: towable, pillow, and quick tanks.

Boom Reels

Reels are used to deploy booms promptly in oil spill response. They can be portable or fixed on the ground or vessel. Operating mechanism of boom reels can be manual, hydraulic or electrical.

3. Dispersants

Since water is a polar molecule, whereas oil is nonpolar, they do not mix simply. Therefore, floating oil on the water surface is an often-encountered situation after oil spill incidents. However, waves can stir oil, which results in two different phenomena: natural dispersion or water-in-oil emulsification. Natural dispersion occurs when waves disperse the oil slick and create the oil droplets, yet these suspended oil droplets stay for a short time and rise to the water surface subsequently. On the other hand, emulsification can also happen because of the movement of waves that compels the water droplets to integrate with the oil droplets. This emulsion is more viscous than the oil alone and causes difficulties in collecting by the skimmers (IPIECA, 2001).

In contradistinction to mechanical recovery and in-situ burning methods, dispersants can be applied in wide range of cases. Especially for extreme circumstances, which mechanical recovery techniques remain incapable and in-situ burning is inapplicable, such as offshore oil spills, dispersants can be considered. Although they are useful for removing oil, net environmental benefit should be assessed prior to any application. Tradeoff analysis is a significant procedure, which involves risk evaluation between the floating oil on the water surface and the potential damage to aquatic organisms.

Dispersants are mainly surface-active agents known as surfactants. Surfactants essentially decrease the interfacial tension between the oil and water layer. A dispersant molecule consists of two parts: oleophilic and hydrophilic. The oleophilic part engages with oil, and the hydrophilic part attracts water. Dispersant application in water was depicted in Figure 7.

An effective parameter for the selection of dispersant is called HLB, which stands for hydrophile-lipophile balance. The degree of zero HLB indicates only lipophilic group, and the degree of 20 expresses solely hydrophilic group. For industrial application, the degree of HLB between 9 and 11 is preferred, as they are more hydrophilic (National Research Council, 2005).

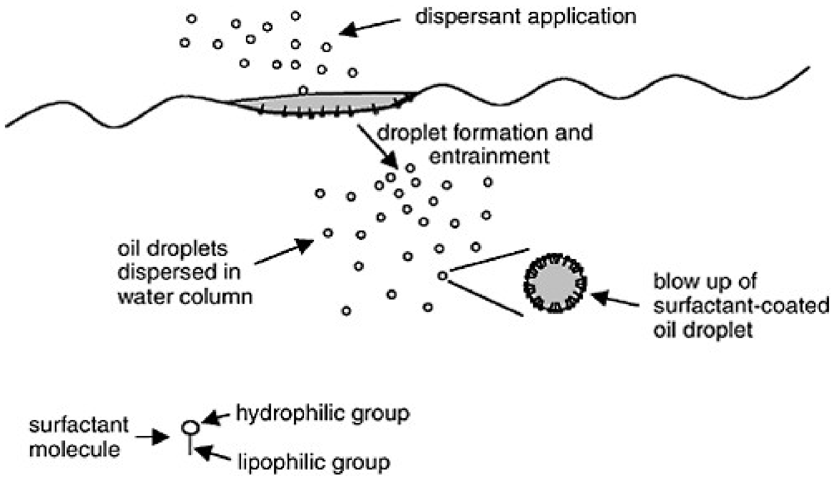

Figure 7. Dispersant application (National Research Council, 2005)

Use of dispersants prevents the formation of oil slicks and accelerates the degradation of oils by natural in-situ microbes. Since decrease in the size of oil droplets leads to increase in the surface area, microbes can integrate with the droplets more. Microbes involved in the degradation process are mainly fungi and bacteria; however, it is not a process driven by a single microbe, rather communities of them degrade oil (The American Academy of Microbiology, 2011). It is because petroleum products contain thousands of compound, and different compounds are degraded by different microbes. As shown in Table 5, effectiveness of the dispersants depends on the type of oil, as they disperse more rapidly lighter products, such as gasoline, than heavier products (API Energy, 2011).

Table 5. Type of oil and dispersion effects (API Energy, 2011)

Type of Oil	**API**	**Natural Dispersion**	**Chemical Dispersion**
Gasoline, Ker	>45	Rapid	Inadvisable
Diesel, Heating Oil	35-45	Moderate-Rapid	Rapid
Alaskan Crude Oil, Gulf of Mexico Crude Oil	17.5-35	Moderate-Slow	Rapid
Heavy Fuel Oil, Venezuelan Crude Oil	10-17.5	Slow	Moderate
Oil Sand, Bitumen, Asphalt	<10	Little or None	Inapplicable

In response action to the *Deepwater Horizon* oil spill which is the largest accidental oil spill in history, dispersants were applied in unprecedented scale. The brand name of the applied disparsant was COREXIT^{TM} which was produced by NALCO Environmental Solutions LLC. Actually there were eight oil dispersant brands registered by the National Contingency Plan, but due to the production capacity and insufficient stocks of other dispersants, COREXIT^{TM} remained the only dispersant. Two different formulations of COREXIT^{TM} were selected to apply, COREXIT^{TM} 9527A and COREXIT^{TM} 9500A. For 84 days more than 6 million litters of dispersant were sprayed both from planes and vessels (The National Oceanic and Atmospheric Administration and Coastal Research Response Center, 2012).

COREXIT^{TM} EC9500A is composed of mainly propylene glycol, organic sulfonic acid salt and dearomatized hydrocarbon solvent, whereas COREXIT^{TM} EC9527A differs in formulation with 2-butoxyethanol instead of dearomatized hydrocarbon as well as in concentration of ingredients (NALCON Environmental Solutions LLC, 2016; NALCON Environmental Solutions LLC, 2016).

It is worth noting that COREXIT^{TM} 9500 was listed as preapproved dispersant according to the draft of the Use of Regulations of Dispersants in Turkish Waters written in 2011. In the same draft it was also stated that dispersants can be applied not less than 100 tons of oil and the desired location should be at least 1 mile off the coast. Furthermore, it is not permitted to apply when oil's kinematic viscosity is higher than 10000 cSt. In addition, other factors determine the use of dispersants in Turkish Waters, such as temperature, water depth and salinity concentration.

4. In-Situ Burning

In-situ burning is a fast and effective method to remove floating oil from the water surface. It is an exothermic reaction, which converts hydrocarbons to CO_2 and water. It can be applied to limit oil from spreading over sensitive areas. In fact, it should be considered as a final option when other methods (mechanical recovery, dispersants) fail. Therefore, it is strictly regulated by the governmental authorities and preapproval before any in-situ burning action is essential.

Controlled in-situ burning was applied in a few cases, including the *Exxon Valdez* and BP *Deepwater Horizon* spills (Mabile, 2013). Advantages and disadvantages of this method were summarized in Table 6, and accordingly net environmental benefit analysis should be made before attempting any action. Important point is that combustion gases of each hydrocarbon derivative can vary, thus, primary health risks should be evaluated individually (ExxonMobil, 2014).

As explained by ExxonMobil (2014), response action should be carried out from upwind and the thickness of oil layer should be at least 2 mm for sufficient combustion. In some cases, accelerant such as highly flammable oil can be used to start ignition. Moreover, emulsified oil is difficult to ignite, so newly spilled oil should be preferred. The most important point is that fire-resistant boom should be made of robust material, for instance, stainless steel can be used. Mineral-based fibers and ceramics are lightweight materials, which are easy to handle, but they are not durable against fire. On the other hand, chemical herders can be applied instead of fire-resistant booms. These are surfactants, which restrict oil slicks in certain areas.

Table 6. Advantages and disadvantages of in-situ burning (ExxonMobil, 2014)

Advantages	**Disadvantages**
Rapidly removal of large amounts of oil	Difficulties during ignition of emulsified and weathered oil
A quick cleaning method for oily wastes	Greenhouse gas emission
Cleaning with a single ignition	Risks associated to safety
Suitable for any water environment	Residue formation
Respons option independent from day and night	Need for fire booms

5. Bioremediation

In oil-spill response techniques there are various methods implemented as physically (skimmers, sorbent pads), chemically (dispersants, in-situ burning) and biologically. Biological methods, also known as bioremediation, is the degradation of hydrocarbons by the microorganisms present in the water (Prince et al., 2003). Because of the natural oil seeps, some microbes can break down the long-chained carbon molecules founded in oil. Bioremediation using this natural phenomenon offers a long-term sustainable solution where other methods are found insufficient, especially when oil is weathered. In addition, it is widely accepted that it played a crucial role in both the cleaning operations of the *Exxon Valdez* and BP *Deepwater Horizon* spills (Atlas & Hazen, 2011). There are several bioremediation strategies, such as land farming, composting, bioventing, bio slurping and use of bioreactors (Macaulay and Rees, 2014). Among them, bioaugmentation and biostimulation are the most applied bioremediation methods.

Bioaugmentation is the addition of indigenous or exogenous oleophilic microbes to amplify the degradation of oil (Cosgrove et al., 2010). In general, 70 genera of bacteria and fungi can degrade hydrocarbons (Bragg et al., 1994). According to Macaulay et al., yields of crude oil components to biodegradation are in order from high to low: Alkanes, Light aromatics (MAHs), Cycloalkanes, Heavy aromatics (PAHs), Asphaltenes. Moreover, certain microbes prefer straight-chained alkanes, whereas others favour polynuclear aromatic hydrocarbons (Adams et al., 2015).

In some studies, it was suggested that combination of microbes with different characteristics could yield higher in degradation of hydrocarbons. Nevertheless, these exogenous microbes could not succeed in because of the competition with indigenous organisms. On the other hand, there are studies suggested the harvesting of the cultures of indigenous microbes from oil polluted areas, and reintroduction of them (Macaulay & Rees, 2014).

In addition to bioaugmentation, biostimulation triggers the growth of indigenous microbes in polluted area by introduction of limiting factors. It is either enhancement of co-metabolic activities or intensification of degradation process. The microbes that degrade oil in water require certain nutrients as well as electron acceptors, such as water, oxygen, nitrogen, and phosphorus (Hazen, 2009).

Addition of ammonia, urea, nitrate, and nitrous oxide increases nitrogen level; this was a case in the *Exxon Valdez* spill, where fertilizers were applied (Atlas and Hazen, 2011). Furthermore, the organic and the inorganic forms of phosphate (Hazen, 2009) boost phosphorus concentration.

Overall, bioremediation is a group of processes providing ecological solutions and promising environmental ameliorations applied in the cases of oil spills in waters. The challenges related to bioremediation may be overcome with improvement of modelling and monitoring in marine ecosystem.

6. Protecting Sensitive Resources

According to the UNSD Glossary of environmental statistics (1997) "*Vulnerability is a measure of the extent to which a community, structure, service or geographical area is likely to be damaged or disrupted, on account of its nature or location, by the impact of a particular disaster hazard*". In light of this information, environmental vulnerability of a certain area is an evaluation of the ability to tolerate and recover.

Areas required specific protection for their biological resources are more susceptible to suffer damage because of the pollution created by the oil spills. Their sensitivity lies at the bottom of the cultural, economic and environmental priorities. Since they provide natural habitat for endangered species and sustain sensitive ecosystems, the risk analysis and sensitivity mapping for these areas should be done prior to any oil spill incident (IPIECA et al., 2011).

Before reacting to any oil spill, it is significant that pros and cons should be evaluated, because not all response methods are convenient in the sensitive areas. Therefore, in the first step, assessment of the risks and impacts should be made. In addition to this, equipment supply should be done promptly and adequately, even can be stored in the related area as a precaution. Consequently, organizational ability gains more importance for such cases.

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TURKISH STRAIT SEA AREA, CONTINGENCY PLANNING, REGULATIONS AND CASE STUDIES

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1. Introduction

Decision-making is the important issue to select the most appropriate and effective response strategy to combat an oil spill incidence for minimizing the ecological, socio-economic and cultural impact of spill events. In addition to this, the other important issue is the preparation step that can be possible by the development of a safe and effective response strategy for contingency plans and incident management.

In some jurisdictions, the oil-spill response strategy is largely determined or prescribed by national policy, regulation or guidance. Oil spill response contingency planning and response program run by the Ministry of Environment and Urbanization the framework of 5312 announcements "Law on Emergency Response and Compensation for Damages of The Marine Environment with oil and Other Harmful Substances "in Turkey. Within the Ministry of Environment and Urbanization, a Department Presidency works on the subject of Marine Pollution in Turkey. The Department of Marine and Coastal Management, which operates Under General Directorate of Environmental Management, is responsible for marine pollution and its direct duties and authorities; In order to protect the sea. The tasks and responsibilities of this department about oil spill are the preparation of national and regional emergency response plans, approval of coastal facility and port emergency response plans, and coordination of the shoreline cleaning affected by pollution in the sea.

Within the Ministry of Transport and Infrastructure, there is a Directorate of Maritime Affairs working for marine pollution. The tasks and responsibilities of Maritime Environment Directorate within the scope of Maritime Transportation General Directorate are the establishment of national-regional emergency response centers, supervision of coastal facility training and practices, supervision of authorized-emergency-response companies and to ensure the real oil-spill response operations.

There is the three-tiered structure for oil spill response and preparedness as given below Table 1 in Turkey as well as the world. As seen from Table 1, the response levels are separated from each other based on the possibilities and capabilities of a shoreline facility or a ship within the scope of the Law. As a result of the risk assessments of shoreline facility emergency response plans, spillage amounts were determined for each level.

There are some responsibilities of shoreline facilities as given below by the framework of 5312 announcement.

- To prepare a risk assessment and emergency response plan (contingency plan)
- To train their emergency response team

- Sea pollution response drills per 6 months
- Shoreline facility marine pollution liability insurance
- To purchase pollution prevention equipment
- To be prepared to respond in a possible pollution and to keep the equipment determined in the plan: For level 1, ports may be prepared for their response. But those who are at risk of level 2 and 3 have to deal with authorized emergency response companies.

Table 1. Three-tiered structure for oil spill response and preparedness in Turkey

Tier Explanation	Responder	Operation Coordinator	Response Time
Tier 1: This shall include events that may occur because of operational activities on a coastal facility or on board and which may lead to small-scale pollution. A shoreline facility or a ship within the scope of the Law can control pollution with its own resources and capabilities.	A shoreline facility or a ship within the scope of the Law	Port manager	In one hour
Tier 2: Medium-scale incidents that can be responded and controlled by regional resources and capabilities in cases where a ship or a vessel within the scope of the Law is inadequate.	Regional Emergency Response Center	Governor	In three hours
Tier 3: Covers large-scale events resulting from serious accidents at sea and / or coastal facilities.	National Emergency Response Center	Minister of Environment and Urbanism	In three hours

Regional and National Emergency Response Plans of Turkey was prepared by TÜBİTAK (The Scientific and Technological Research Council of Turkey) in 2010. The aim of the project is to determine the most appropriate methods for emergency response centers to interfere with marine pollution, which may occur with oil and other harmful substances. These plans include detailed information on actions of preparedness and response as given below:

- Communication methods, information procedures and responsibilities of emergency response staff have been determined for all 28-seaside cities.
- The current pollution situation of Turkish waters and environmentally sensitive areas in coasts have been determined and environmentally sensitive mapping has been completed.

- A database -containing the effects of with oil and other harmful substances on the marine environment-has been created to increase the effectiveness of the response strategies. All the data obtained in the project are working together with a decision support system in the Geographical Information System.
- By creating sensitivity maps on Turkish coasts and Turkish waters, risky and less risky regions were determined, and a risk management system was established because of these studies.

2. The Recent Big Oil Spill Incidents in Turkey

2.1. M/V Volgoneft 248 Accident

During a storm on 29 December 1999, the Russian tanker VOLGONEFT 248 broke into two part at an anchorage area İstanbul in the Sea of Marmara, as can be seen in Figure 1. The break occurred across tank 5 and 6, and all the oil contained therein was spilled: 1279 tons and affected more than five kilometers of shoreline. The stern section with two intact tanks (7 and 8) containing 1013 tons was driven aground the storm, but after refloating in early January the oil was discharged ashore without further spillage. The bow section with four full tanks (No. 1-4) sank at 30 meters of waters with 2073 tons of oil. Most of the oil in bow tanks was recovered in February 2000 and the entire bow section was lifted from the seabed in May 2000. In light of these events, the total amount of the spill quantity is 1.578 tons (Kanburoğlu and Hürzat, 2013).

The Ministry of Environment has overall responsibility for dealing with pollution. Monitoring and Coordination Commission was established by the Governorship of Istanbul. A Contingency plan has been developed by the Ministry of Environment, The Undersecretary for Marine Affairs, The Turkish Coast Guard and the city governors. Government-owned equipment was mainly operated by the Coastal Safety and Ship Salvage Administration.

Five sub-working commissions were established on the Volgoneft-248 marine accident.

1) Sub-commission for monitoring and monitoring of clean-up work
2) Sub-commission for the detection of ecological damage
3) Sub-commission of damage to public property
4) Legal sub-commission
5) Sub-commission for the detection and examination of costs

In early in January 2000, a local clean-up contractor was appointed by the P&I Club to carry out the shoreline clean-up operation in accordance with a plan prepared by ITOPF and implemented with the agreement by the Crisis Committee.

Figure 1. M/T VOLGONEFT 248 broke into two parts at an anchorage İstanbul in the Sea of Marmara. The bow section with four full tanks (No. 1-4) sank at 30 meters of waters with 2073 tons of oil.

2.1.1. Phase 1: First Action Plan

According to the first action plan, the start of the study was determined as 06.01.2000 and the end date was determined as 13.03.2000. Shoreline clean-up work was performed with 133 inexperienced man using with simple hand tools, as can be seen in Figure 2. Areas subject to heavy pollution have been given priority and rough cleaning work has been carried out for all concrete and beach areas. However, due to heavy winter conditions, which caused pollution of the cleaned areas with sunken waste, the works have been postponed. Over two months the bulk of the oil had been collected and 4556 tonnes of waste removed for disposal. The coastal strip from the Küçükçekmece / Avcılar border (from the location of the funfair) to the end of the Florya-Kıraz breakwater was cleaned.

Figure 2. Shoreline clean-up work with simple hand tools

2.1.2. Phase 2: Second Action Plan

In phase 2, the beaches were cleaned using rakes and manual sieving techniques. Contaminated man-made and concrete surfaces were cleaned - stone, sand, scallop shells were collected by shovels and then washed with washing machines In some areas in the sandy areas, a thick layer of sand under the sand was cut into pieces and placed in bags. After the rough cleaning, the sand was sifted and the waste remaining on the sieve was put into plastic cases (Figure 3). In the rocky areas, wastes were removed by hand hoe and hand shovel. Sorbent boom was deployed to prevent oil pollution on the sea surface Figure 4).

Figure 3. Sieving of oil-polluted sand.

Figure 4. Shoreline clean up.

2.1.3. Phase 3: Third Action Plan

Cleaning work of waste on a concrete platform (attached to the platform fuel-oil, mussels shells, stone, moss, sand etc.) was carried out. Then the platforms were washed with washing machine. Sorbent boom was deployed to prevent secondary oil pollution on the sea surface. The washing work continued until 28.10.2000.

The entire area was re-contaminated, including the areas that were washed by southwest winds, and the work on cleaning the waste from concrete platforms and sandy areas was initiated. Wastes on concrete platforms are taken by shovel and scraper (Figure 5). In the sandy areas, the stones were removed by digging and the sand on the beach was shoveled with a shovel and rake. In some areas of the sandy areas, there was a layer of fuel oil about 50-80 cm below the sand and cut and shoveled. In rocky areas, the wastes between the rocks were collected by hand hoe, hand shovel, and scraper, and the stains on the rocks were cut with cuts and brushed with steel hand brushes. Cleaning of wastes after lodges and wave movements was increased by increasing the number of workers.

Figure 5. Bagging of polluted soil

2.1.4. Phase 4: Forth Action Plan

Pollution seemed to never end up, because there was plenty of sunken oil, yet to be surveyed. Therefore, first, surveys have been carried out on the seabed and the areas where waste is located in the areas determined by this survey are marked with buoys. It is also displayed with an underwater camera. The first ties of the study were about 40 m offshore and 3 m depth. Because the type of waste in the form of oil in the form of mussels by the hammer minimized and pouched wastes were removed to the shore by the land team after being placed in synthetic sacks were transported by hand trolley and placed in plastic crates IZAYDAS transported here licensed trucks (Figure 6).

Figure 6. Beach clean-up.

Approximately 200-450 m out of the shore and the sea surface depth of about 6-9 m in areas of the sea bottom, and in some places, the sand is 10-15 cm below the thickness of the maximum thickness of 40 cm and up to 40 cm fuel oil layer (sand, water, mussel shell in areas where it is mixed with materials etc.,) the wastes taken by divers with hand shovels are bagged and thrown into the steel cage basket (Figure 7). When the basket is full, it is taken to the boat and the waste is put into synthetic bags by the land team and then transported to the shore by boat (Figure 8). On the shore, the waste is transported by pickup and placed by another team in order to store it in plastic crates temporarily.

Figure 7. Diving operation.

Figure 8. Collection of wastes.

2.1.5. Waste Disposal

Within the framework of all action plans, 6863,378 tons of waste (526 truck waste) were transported to IZAYDAS (Disposal Facility in İzmit) by licensed trucks for temporary storage as a result of the studies carried out until the end of October.

2.1.6. Ecological Effects

The ecological result of this accident has been deaths of up to 90% in seabed species. These species include various types of moss and coral, starfish, mollusks, crustaceans, fish species. At least 3,000 gulls, ducks, and cormorants were found dead. As Florya is used for tourism purposes, restaurants and cafes in the region have suffered economic losses. Brown, red and green mosses were found on both sides of the İstanbul Strait before the accident. After the accident, only eutrophic resistant green algae were able to be present. Brown algae species living in rocky areas have reached the point of extinction.

2.1.7. Conclusion

In the VOLGONEFT 248 tanker accident, the incident was intervened on the same day and the Action Plan was prepared and connected to the operation in a short time. However, the cleaning of the operation with the launching of the coastal and coastal bands caused re-contamination of the areas that were cleaned due to the meteorological conditions and wave movements of the unspecified amount of wastes found in the form of precipitation on the seabed. Operational priorities should be better set up. After finishing the rough cleaning on the coast, it would be a more appropriate solution to start the bottom run. After the end of the bottom work, the coasts were cleaned again and then the fine cleaning was carried out.

2.2. M/V Orcun C Accident

M/V ORCUN C anchored offshore close to Kilyos coast and caught in severe weather conditions on 19 January 2010. The ship drifted towards the Kilyos Güven Cape and grounded with 96 tons of fuel oil and 25 tons of diesel oil bunker. She suffered few cracks in the hull of cargo holds and fuel tanks along with the bridge. This resulted in the sudden release of oil from the fuel tanks. Due to severe weather conditions (minimum 7 Beaufort), an emergency response on the sea could not be executed.

MARE Sea Cleaning Services were on site on January 19 at noon. The following findings were obtained after the first survey and first action plan was prepared on January 22 (Kanburoğlu and Aydınkaya, 2010).

- The slight amount of oil was floating on the sea around the wreck (Figure 9).
- Oil containment around the ship was impossible due to severe weather conditions.
- The beaches of Uzunya, Cennet, Küçük Bara and Büyük Bara Bays were covered by oil slick with 0-20 cm (Figure 10).
- Transportation between base station (Uzunya Beach) and other bays was impossible with sea vehicles to severe weather conditions. In addition to that, transportation with land vehicles, including tractors was obstructed by damage rough forest road.

Incident Crisis Committee was established by the Ministry of Environment and Forestry, The Coastal Safety and Ship Salvage Administration and the Istanbul University, Institute of Marine Sciences.

2.2.1. Planning and Decision Making

To be able to plan effective response strategies pollutes areas should be observed closely from sea and shore but it was impossible due to severe weather and sea conditions. Therefore, a model airplane with an integral camera was used to watch pollution development in the first days of the operation when the weather conditions allowed. Due to severe weather conditions, response operation could not be conducted on the sea but only ashore.

Operation timetable:

- Emergency response (between 19 and 22 January 2010): all of the stranded oil was aimed to be collected urgently.
- Clean up (between 23 January and 16 March 2010): Remained contaminant oil on rocks and in some cavities were collected.
- Rehabilitation (between 17 March and 12 April 2010): Rehabilitation of the beaches was completed.
- Termination Period (between 13 April and 15 July 2010): Additional clean up for Uzunya Beach was demanded by the Incident Crisis Committee.

Figure 9. Oil pollution around the wreck.

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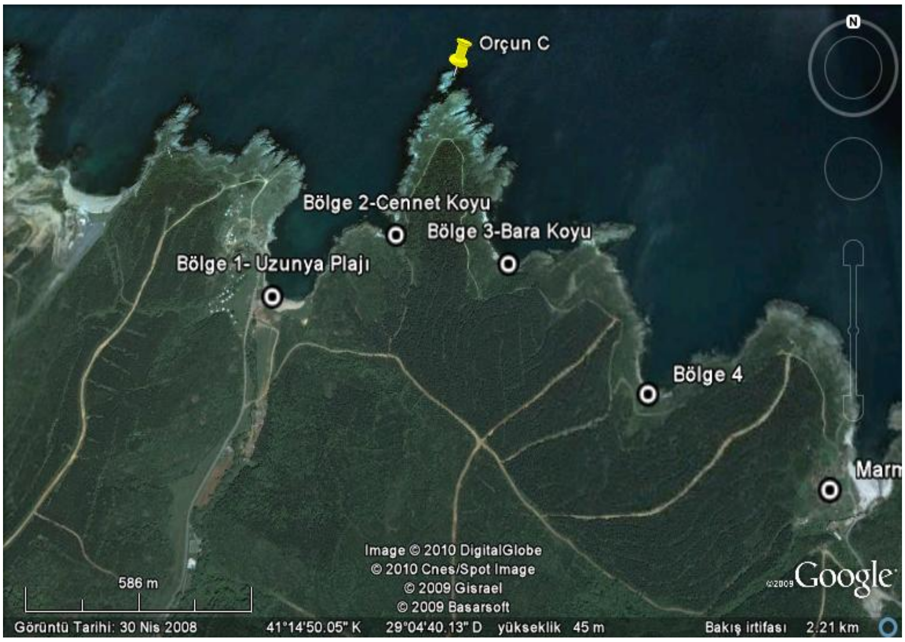

Figure 10. Polluted bays and wreck.

2.2.2. Cleaning of Uzunya Beach

150 meters long and up to 40 meters wide Uzunya beach was covered by oil patches (thickness up to 10 cm), contaminated seaweed and debris (Figure 11). The former waterbed of Uzunya Stream behaved like a good oil containment area where oil was accumulated significantly (Figure 12). In addition to these, a significant amount of oil was seen under the terrace in front of the Uzunya Restaurant.

The clean-up accumulated oil in the former waterbed of Uzunya Stream and under the Uzunya Restaurant terrace was executed on January 20th and completed on January 23rd due to the storm. The storm caused the secondary pollution on the beach and terrace and cleaning works of there was completed in two weeks (Figure 13 and 14). The main temporary storage area was prepared behind of Uzunya beach due to its easement access (Figure 15).

2.2.3. Cleaning of Cennet Bay

Oil slick thrown by stormy waves on the rocks were smeared on, especially the back sides of the rocks. The shoreline was covered by a thick layer of oil and an oil slick was floating near-shore and a big pile of contaminated debris was all over the sandy-gravelly-rocky beach (Figure 16).

The clean-up teams of the Cennet Bay were divided into two because of it consists of two beaches surrounded by rocks. The clean-up operation of this site was started on January 21st and lasted with rehibition period until April 12th (Figure 17).

2.2.4. Cleaning of Küçük Bara Bay

The sandy parts of the Bay were covered by the oil slick and contaminated debris. Oil patches thrown by stormy waves splashed on the porous rocks and some oil slick was floating near-shore (Figure 18).

The clean-up operation of this site was started on January 21st and lasted with rehabilitation period until April 12th (Figure 19). Remaining oil on the rocks and in the cavities was collected.

2.2.5 .Cleaning of Büyük Bara Bay

The sandy beach of the bay was moderately contaminated compared to the other bays. However, there is morphological formation on the east side of the bay, which was heavily contaminated as a natural pool covered with a rocky and coarse-grained sandy coastal texture (Figure 20).

The clean-up operation of this site was started on January 22nd and lasted with rehabilitation period until April 12th (Figure 21).

2.2.6. Rehabilitation Period

After the clean-up, the rehabilitation period -consisted of three steps given below -was started on March 17th and lasted until April 12th (Figure 22-23).

1. Remaining oil on rocks was scraped off with spatula manually
2. Rocks were washed with pressurized hot water
3. Sorbent boom and pads applied to absorb oily wash water to prevent secondary pollution

Figure 11. Polluted Uzunya Stream Bed

Figure 12. Polluted Uzunya Beach

Figure 13. Cleaning of Uzunya stream bed.

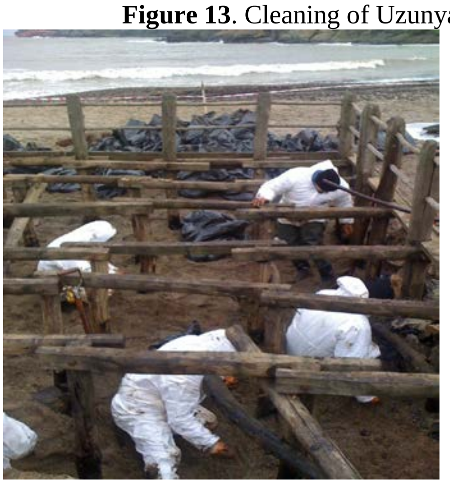

Figure 14.Cleaning of Restaurant Terrace

Figure 15. Temporary Storage Area

Figure 16. Polluted Cennet Bay

Figure 17. Cleaning of Cennet Bay

Figure 18. Polluted Küçük Bara Bay

Figure 19. Cleaning of Küçük Bara Bay

Figure 20. Polluted Büyük Bara Bay

Figure 21. Cleaning of Büyük Bara Bay

Figure 22. Sorbent boom deploy around the rocks

Figure 23. Washing rocks with hot pressurized water

2.2.7. Waste Management

Uzunya Beach was selected as the main waste storage area due to access easement. Waterproof covers were placed on the ground to prevent secondary pollution. Black waste bags filled with oil and contaminated material and they put in barrels or big bags (Figure 24). Due to environmental conditions, sea operation could not be executed. This caused a low calorific value of waste that was reported as 1485 kcal kg^{-1} by the waste disposal facility. This means that the total amount of oil recovered from the site is 42 tons, which is 43.7 % of the spilled oil. On the other hand, the total amount of waste collected was 268 tons.

3. Conclusion

As in earlier response operations, MARE oil spill experts have conducted their observations and researches during this operation period as given below

- Importance of Oceanography of the Area, the morphology of the cost and meteorological conditions: the behavior of oil under the interaction of current and wave actions with the varied morphology, not disregarding also its textural variety of the coastline.
- Effect of peripheral conditions on pollution development and response operations: rocky and cliffy forms of shoreline narrow sandy beaches and surface currents determined the amount of oil stranded and held on the coast.
- Characteristic of the spill and conclusions deducted: MARE team believes that similar knowledge compiled by our collages elsewhere in the world, there may be a chance to produce new approaches in combating with oil spills.
- Importance of logistic support: Most parts of the polluted shoreline were not accessible even by off-road vehicles or from the sea by vessels, therefore all equipment should have to be carried to work site by walking (Figure 25 and 26).

Figure 24. Preparing temporary waste storage area.

Figure 25. Heavy equipment transportation by manually.

Figure 26. Poor condition earth road.

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DISPERSANT RESPONSE METHOD TO INCIDENTAL OIL POLLUTION

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1. Introduction

Recently, the pollution of the world's oceans has become interesting a matter of increasing international concern. Nevertheless, a significant amount of pollution is caused by shipping and maritime activities generally. The best-known cause of oil pollution is that arising from tanker accidents (IMO, 1998). More than 90% of world trade is carried by shipping industry. Maritime trade brings benefits for consumers across the world (https://business.un.org).

Turkey has geopolitical important location between Europe and Asia with Turkish Straits are the only way between Black Sea and Mediterranean Sea connection. Turkish Straits System is very busy natural channels with national and international maritime traffic and their loads are mainly dangerous goods, like crude oil and its products and many types of chemicals. There are more than 50.000 ships are passing through Turkish Straits Systems to reach Black Sea. Increase in the volume of maritime traffic on the Straits and the Sea of Marmara have increased the risk of the maritime incidents since 1948 the number of ship accidents have been recorded as around 700 (Birpınar et al., 2009; AMM, 2010; AMP, 2011).

Decreasing accidental oil pollution, many national and international laws, regulation and legislation have been issued. Turkish Law 5312, titled "Law Pertaining to Principles of Emergency Response and Compensation for Damages in Case of Pollution of the Marine Environment by Oil and Other Harmful Substances" was enacted on October 21, 2006. "Law 5312 pertains only to emergency response for marine pollution caused by petroleum and other harmful substances. National and regional contingency plans were to be prepared considering this act. Guidelines, which will be required during and after an emergency response, were prepared to support for the implementing parties. Guideline related with "Definition and the suitability of the use of dispersants in emergency response situations", were prepared" (AMP, 2011).

The use of chemical dispersant has been regarded as one of several possible response options for use open water marine spills in some areas of the world (EMSA 2010, IPECA 2001, REMPEC 2011). Dispersants, liquid mixtures of solvents and surfactants, are used to remove oil slicks from the surface into water column in the form of small oil droplets (NRC 1989, CEDRE, REMPEC 2011). The use of chemical dispersants to reduce the potential damage caused by spilled oil reveals some fundamental questions about its effectiveness and usage practices. The situation of using chemical dispersants to combat oil spills has been a matter of discussion for both governments and industries in many countries for a long time.

This paper provides theoretical information about dispersants and their application in the marine environment. It is also intended to document on the potential effects and the trade-off of risks and benefits of dispersant use as oil-spill response with a special focus on the situation in Turkey.

2. Behavior of Oil Spilled at Sea

Action of waves caused natural mixing processes when spilled oil is on the sea surface. These are the formation of water in oil emulsions and natural dispersion. Both of them are relevant to the effectiveness of all response techniques including dispersant application and the behavior of spilled oil (NRC 1989).

If the crude oil is spilled, it spreads on sea surface to form layer called "oil slick". These slicks are then degraded by several natural processes these are; spreading, advection, evaporation, dissolution, dispersion, emulsification, photo-oxidation/photolysis, sedimentation and biodegradation, which may all occur simultaneously in different degrees (Figure 1).

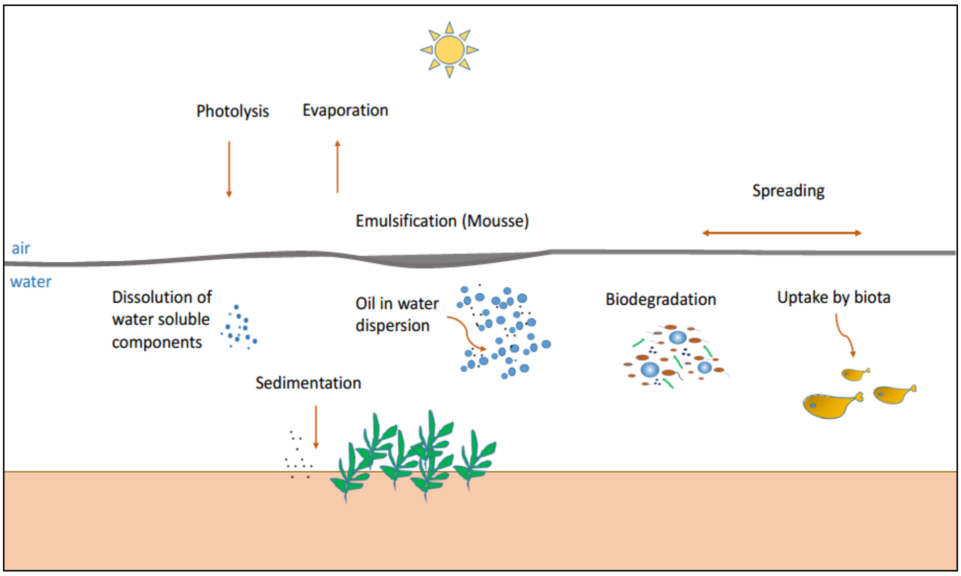

Figure 1. Oil weathering processes (ITOPF, 2014)

Misha and Kumar 2015 explained, "*evaporation is the first mechanism of oil removal from the sea surface. It is faster than dissolution process and evaporate most of the volatile fractions of the crude oil within a few hours of spillage. Emulsification is formed results due to wave breaking and sea surface turbulence. The mixing action of the waves can cause water droplets into the oil to form water-in-oil emulsion, is called chocolate mousse. The emulsion viscosity is than the oil and the volume can eventually increase by up to four times that of the spilled oil, because of contain up to 75 % water, by volume. Evaporation and emulsification are the key processes that modify the viscosity and density of an oil slick*". Dissolution of crude oil into the sea increases the toxicity of seawater (Riazi and Roomi, 2008).

3. Potential Effects of Spilled Oil

Oil spilled in marine environment can potentially have negative effects on a variety of ecological and socioeconomic resources, depending on the spilled area. Major incidents can be severe impact to the environment in a short time and causing serious adverse effect to ecosystems and to the people who leave near the contaminated coastline. The impacts of the oil spills have been studies and documented in the scientific and technical literatures for many years. The fate and effects of the oil pollution in the marine organism vary from sudden deaths to chronic effects or undetectable effect (system still effected but the level is not measurable). In time, in a global scale, natural recovery processes are able to repair damage and returning the system to its normal function. The recovery process can be accelerated by removal of the oil from marine environment as soon as possible.

Oil may affect marine organisms by some ways. Such as; smothering on their body, acute or chronic toxic effects, ecological changes some key organisms may loss from a community and settles opportunistic species, damaged environment and the consequent elimination of important species. In general, light oils can effect on organism toxically while heavy oils can smothering effect on organism (ITOPF, 2011). Species living in the marine environment, which is from planktonic to mammalians, can effects from oil spill in different ranges. Organisms, such as bacteria, phytoplankton, zooplankton, eggs, larvae, suffer extremely high levels of mortality. Different life stages of fishes have different susceptibility such as juvenile stage is more fragile than adult. Mortalities have occurred with very high specially localized concentrations of dispersed oil in the water column in storm conditions with the release of substantial quantities of light oils into breaking surf along a coastline (ITOPF, 2011). The effect of sea birds and mammalians from oil spill is mostly fouling of plumage/fur. The plumage/fur acts to trap warm air against the skin, providing buoyancy and insulation. Oil may blocked this mechanism and finally hypothermia cause mortality.

Leahy and Colwell, 1990; Atlas and Cerniglia, 1995; Prince et al., 2013 reported, "*biodegradation of oil can be considered useful to the microorganisms to supply energy source. Nevertheless, there could be some toxic effects on marine life caused by exposure to water soluble components transferring from oil droplets to the water or by ingestion of the oil droplets by filter feeders organisms, which may be preyed by larger organisms. The serious toxic effects is proportional to exposure and can range from sub-lethal effects that are often reversible, up to lethality for some individuals. Many marine microorganisms have metabolize and degrade chemical compounds in oils. Biodegradability is explained by biochemical oxidation*". The different chemical compounds in crude oils will be decomposed at different rates and to different extents by naturally occurring degrading microorganisms (Lindstrom and Braddock, 2002; Campo et al., 2013). The recovery periods of the environment from oil spill is listed in ITOPF (2011) which is week/months for planktonic organism, 1-2 years for sand beaches, 1-3 years for exposed rocky shores, 3-5 years for saltmarsh, 10 years and greater for mangroves.

4. Oil Spill Response Options

The principles of the responses are the same to prevent or limited contact with the ecological and socio-economic resources that might be affected. "*Further benefits are* *to protect human health by minimizing the exposure of responders and local communities to oil. This is achieved by clean-up oil from the sea surface and preventing it from reaching the shorelines*". There are four methods for responding spilled oil. According to oil type, spilled area, weather and sea condition one or more may applied together for suppling more effective clean-up (NOAA, 2013).

a) Mechanical response. This response technique based on collecting spills from sea surface and coast by using skimmers, booms, sorbents etc.
b) Chemical response by using dispersants. Transfers the surface floating oil into the water column as tiny droplets and let them these droplets to microbial, chemical and UV degradation naturally.
c) In-situ burning. "This response method commonly features the collection of accidently spilled oil on a water surface in a so-called "fire boom", followed by the ignition of the oil slick and thereby removing the oil from the water surface" (Buist et al., 1999)
d) Natural response by doing nothing for letting them waves, rocks and currents work. Natural response work perfect in a suitable weather, sea and topography conditions. In 1993, tanker Braer was grounding because of severe storm. The bad weather condition was help spilled oil (85.000 tons of Gullfacks crude oil) dispersed naturally with minimal environmental and fisheries impact (IPIECA, 2015).

5. Chemically Dispersion (Dispersants)

Dispersants, which are used for oil spill, are blends of surfactants in solvents. Surfactants (or surface-active agents) are chemical compounds, which consist of hydrophilic and oleophilic parts (Figure-2). Surfactants play role as a 'chemical bridge' between oily materials and water and enable these two phases to mix with each other more easily.

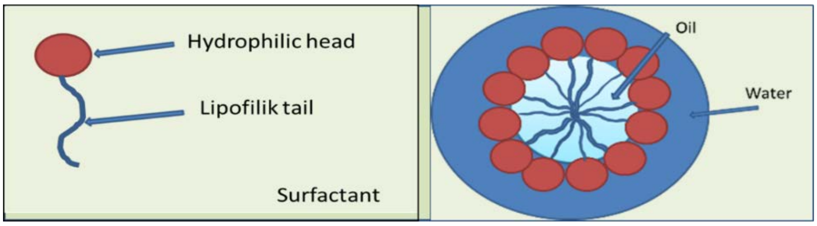

Figure 2. Schematic view of surfactant and localization between oil/water interfaces (modified from IPIECA, 2001).

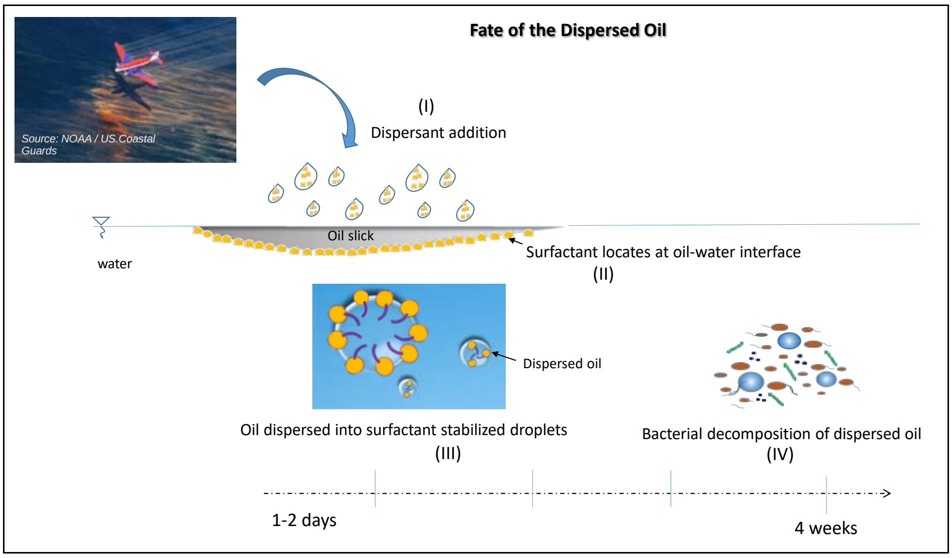

Figure 3. The fate of dispersed oil.

The purpose of using dispersants is to transfer the oil from the surface into the water column to form of very small droplets. The action of dispersants is described in Figure 3. "The surfactant allows the breaking, or cresting, wave to convert a much higher proportion of the oil volume into tiny oil droplets. The small oil droplets will be stayed in the upper few meters of the water column by the water movement associated with any wave action. The low buoyancy of the small oil droplets causes them to rise very slowly through the water and they are continuously pushed back down into the water column by the downward motion of the water" (EMSA, 2009).

5.1. Types of Dispersants and Functions

There are many natural and artificial surfactants. Soup is a surfactant, which is used every day to clean dirt and fats from skin and other surfaces. The first synthetic surfactants were developed in early 1950s and 1960s and increased rapidly. There are huge number of possible combination of surfactants available; EMSA (2009) reported "*petrochemical ethylene oxide (EO) which is often used in the form of PEGs (polyethylene glycols of various molecular weights) to presence a water-soluble part to oily material. Solvents are used to dissolve the surfactants (some of them are solids) and to reduce the viscosity (many surfactants are high viscosity liquids) thus, the dispersant may be sprayed on to the spilled oil*".

Types of dispersants are generally classifies in three groups: Traditional, conventional and concentrate dispersant (Table 1). After incident, oil/water interaction will be triggered to increase emulsification formation so dispersion capacity of the dispersant will decrease until to the dysfunction of dispersants. Types of dispersant and specification are given in Table 1. Oil viscosity does not control dispersant effectiveness by itself. Oil composition, weathering and emulsification, dispersant type and dispersant application rate are also very important factors that affect dispersant performance (Table 2). Emulsification formation is directly related with time.

Table 1. Type of dispersant and Specifications (IPIECA, 2005)

Name	Equipments for Application	Solvent type	Recommended Application Rates	Recommendations	Availabilities
Industrial detergents	From ship No dilution	Light aromatic hydrocarbons		Too toxic to used dispersant	Not used in present
Conventional Dispersants (Second generation)	From ship No dilution, no additives	Aliphatic hydrocarbons	High application rate 30-40% volumes of spill volume **OR** one unit dispersant to 2-3 unit oil	Low toxicity, high application rate	Present
Concentrated Dispersants (Third generation)	From ship With dilution	Oxygenate (glycol ethers and aliphatic hydrocarbons)	1 unit dispersant per 20-30 unit oil	Low toxicity, high application rate Mixed with water and sprayed only ship	Present
	Ship and/or aircraft No dilution, no additives		Low application rate 1 unit dispersant per 20-30 unit oil **OR** 3-5% dispersant for spill	Low toxicity Low application rate, used without dilution	Present

Table 2. Acceptable viscosity limits for oil to used dispersant (IPIECA, 2005).

Viscosity (cSt)	Explanation
<500	Dispersion is easy with concentrated dispersants. Application is possible with or without water
<5000 >500	Dispersion is possible with concentrated dispersants and applied without water
<10000 >5000	Dispersion is sometimes possible with a concentrate applied neat but you had better check on part of the slick whether the dispersant is effective before extending the treatment to all of the slick
>10000	Dispersion is impossible

5.2. Advantages and Disadvantages of Dispersants

The hydrocarbon-type dispersants used in the past and they have had adverse effects on the environment due to their toxicity. However, IMO/UNEP, 1995 reported, "*New generation dispersants used today and they are significantly less toxic than the oils they disperse. One needs to define the place of dispersants in a general response to oil spills at sea. The usage of dispersant is done by balancing that their advantages and disadvantages and comparing these with other available response techniques. Such a net* *environmental benefit analysis (NEBA) should consider all necessary environmental conditions and implications. The possible adverse effects of the usage of dispersants might be balanced by the gains that result from keeping other parts of the environment clear of oil. No single response method will be one hundred per cent effective for all oils under all conditions; each has its limitation*". Table 3 presents the advantages and disadvantages of using dispersants in oil pollution response.

6. Contingency Plan for Using Dispersants

IMO 2005 reported "*Oil spill contingency planning is a compulsive process for effectively dealing with potential oil spills. Oil spill incidents are very difficult to resolve and potential damages can be significantly reduced using a well-organized and tested oil spill contingency plan. Contingency plans enable the structure for the management and implementation of response operations. The aim of a contingency plan should be based on what is known as a 'tiered response' framework. The plans ensure quick response reflects the scale of the particular spill risk*". Negative environmental impacts may be avoided by adopting a means of identifying sensitive areas and resources, determining the high-risk regions susceptible to oil pollution and consequently developing a strategy that is set out in a national contingency plan. Contingency plans should contain the national policy with respect to dispersant use. It should be recognized that "time" is the most formidable adversary when considering the use of dispersants: Once, spilled oil has weathered significantly; the increase in viscosity will most probably render dispersant use ineffective. The window of opportunity for dispersant use is often no more than 24-48 hours from the moment of spillage. Contingency plans should therefore allow for a rapid response, if the circumstances are appropriate and various planning criteria are met (IMO, 2005).

The contingency planning process is very important in the identification of those areas where dispersant can or cannot be used, based on environmental resources sensitivity and hydrological conditions (depth, current, distance offshore etc.) If such information is set out on operational maps, it allows responders to take a quick decision on dispersant use (IMO, 2005).

Table 3. Advantages and disadvantages of the dispersants (IMO/UNEP, 1995).

Advantages	Disadvantages
Dispersants can be used in stronger currents and greater sea states,	By introducing the oil into the water column, it may adversely affect some marine organisms which would not otherwise be reached by oil,
It is often the quickest response method,	If dispersion of oil is not achieved, effectiveness of other response methods on oil treated by dispersants may decrease,
By removing the oil from the surface it helps to stop the wind effect on the oil slick's movement that may otherwise push the surface slick towards the shoreline,	Dispersants are not effective on all types of oil under all conditions,
It reduces the possibility of contamination of sea birds and mammals,	If used on shore, it may increase the penetration of oil into the sediments,
It inhibits the formation of water-in-oil emulsions,	It introduces an additional quantity of extraneous substances into the marine environment,
It increases the surface area of oil that is available for natural degradation.	There is a limited time window when dispersant can be used.

6.1. Oil Spill Response Decision Tree and Net Environmental Benefit Analysis (NEBA)

When an oil spill occurs, time is very important particularly about the use of dispersant. A procedure recommended by IMO (IMO-UNEP 1995) for deciding whether dispersants should be used is shown in the Figure 4. If we look to the figure, we can see the first step is to collect as much information as possible on the oil spill. This includes estimates of the size and location of the spill, the current and predicted weather/ wind conditions and characteristics of oil and this mean the type of oil and its properties. IMO-UNEP 1995 reported, "*The benefits and damages of dispersant use, compared with other feasible response alternatives and no intervention should be taken into account when deciding if dispersants should be authorized. This is the main point of net environmental benefit analysis (NEBA). NEBA is the instrument used to ensure the best response options are chosen for a given spill scenario. It involves consideration and judgement to compare the benefits of using different oil spill response techniques, and recommendations as to the preferred tactics from experienced response/NEBA practitioners*". In NEBA process, the expected effectiveness of all options in contingency plan such as spill size, location, logistic situation and weather conditions are evaluated.

IPIECA 2015 reported "T*he first step of NEBA during oil spill contingency planning is to consider where the spilled oil is and, how it will drift under the influence of currents and wind; many different types of oil-spill computer models exist to support this. The next stage is to judge the influence rate from the spilled oil. The efficiency and feasibility of the response kit should be reviewed. This covers the response methods, the availabilities of their utilization and how much oil they can recover or treat. If areas under threat include oil-sensitive coastal habitats, the role of oil spill response at sea is to try to prevent the spilled oil from reaching these habitats*".

6.2. Risk Assessment and Opportunity Window

It is necessary to determine the nature and distribution of the resources at risk from an oil spill, with particular reference to their sensitivity to dispersed oil. The decision at the planning stage whether to include dispersants as a possible response option will be influenced by the risk of a spill occurring in the area and the type and distribution of resources that could be affected by an oil spill. IMO-UNEP, 1995 reported that "*the risk assessment should determine:*

a) Type of spilled oil and whether dispersants will be an effective response option,
b) Quantity of spilled oil, which will determine the quantity of dispersant required and the most suitable application method, and
c) *Location of the oil spill, which will also determine the most suitable application method given the time needed to reach the spill*".

These resources may have high economic or natural values or a combination of the two (IMO-UNEP, 1995). Natural resources includes sea birds, sea mammals, mud/sand flats, salt marshes, mangroves, coral reefs, shrimp, fish nurseries and spawning grounds. Some economic resources are; marinas, harbors, ports, dry docks, water intakes, fishing grounds, shellfish beds, fishing fleets, aquaculture practices, beaches.

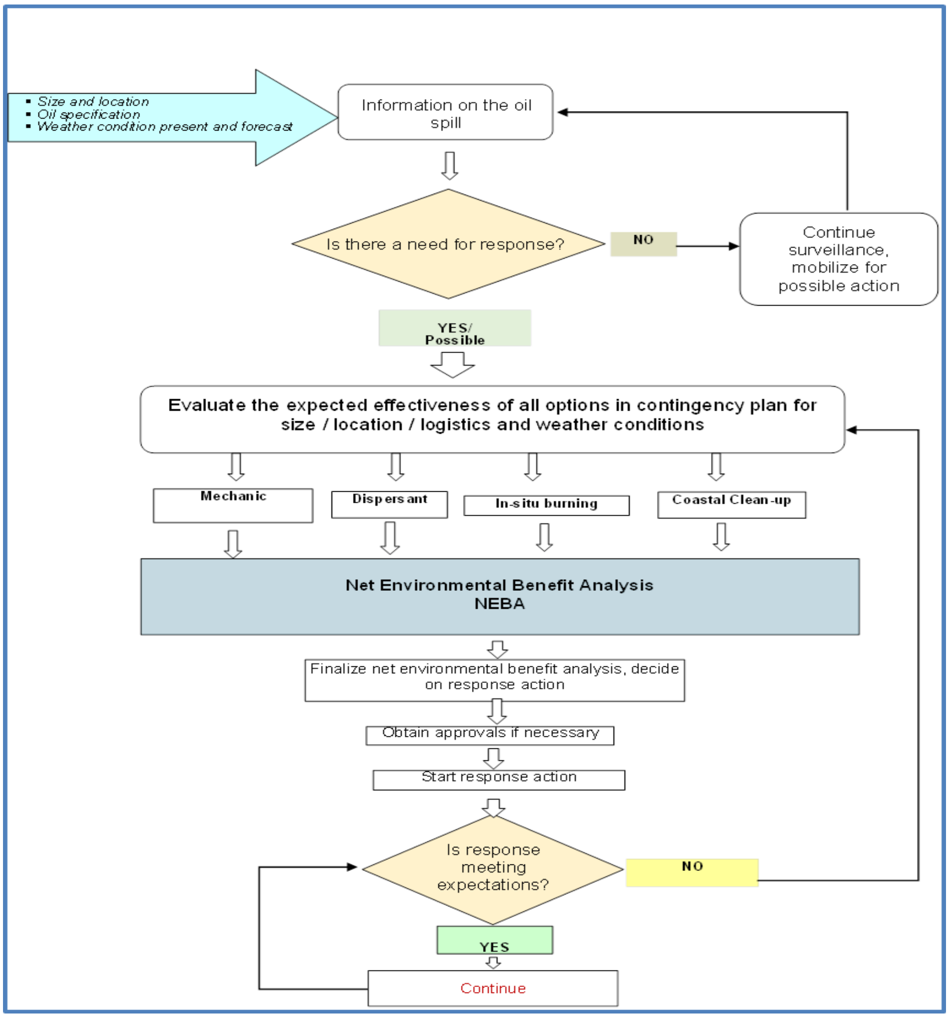

Figure 4. Oil-spill response decision tree (IMO-UNEP, 1995).

At the contingency planning stage, it is necessary to decide the advantages and disadvantages of using or not using dispersants in a specific area at a particular time of the year. This should be done whether the use or non-use of dispersants is likely to give the greatest overall benefit to the marine environment. To conduct NEBA, it is essential to have lists to determine protected areas in order of the protection priority that they should be given. IMO-UNEP, 1995 reported that "*when drawing up such a list, both natural and economic resources should be considered. In general, endangered species, highly productive areas, sheltered habitats with poor flushing rates, and habitats that take a long time to recover should receive top protection priority*". It should be recognized that each oil spill poses different circumstances and the decision of whether or not to use dispersants when how and why should be confirmed on a case-by-case basis.

The most effective, environmentally preferred, and cost effective spill response belong to the following factors: chemistry of the spilled oil, quantity, spilled location, response time, environmental conditions, and effectiveness of available response technologies at various degrees of oil weathering.

Nordvic, 1999 reported "C*rude oils and oil products differ greatly either physical or chemical properties, and these properties will change with time during a spill event as weathering occurs. These changes of the oil properties with time have direct effects on oil removal and recovery capabilities, and in conjunction with environmental factors, mandate the identification and estimation of time windows-of-opportunity and selection of different response methods and technologies". Time window, which is called* ***opportunity window****, a highly targeted process, that the selection of response methods will be more efficient, cost effective, technically correct, and environmentally sensitive and appropriate. "Utilization of multiple response methods and technologies such as mechanical, natural, dispersant and burning is a strategy that require a rapid and scientifically based decision-making tool and an integrated decision making process. To succeed maximum environmental and cost benefits of response strategies, response tactics and technologies must be chosen to fit the time window-of-opportunity for different response methods and associated technologies. The window strategy provides scientifically and well documented reasons for planning and decision making activities and will provide decision makers with greater legal protection by providing justification for selection of 'best effort' response tools*".

6.3. Application and Monitoring

Dispersants can be applied from aircraft, helicopters, ships or individual small pumps. For an successive treatment, the dispersant must be applied onto the spill. This can only be achieved by using specialized equipment that has been routinely serviced. During dispersant spraying operations, it is necessary to check the results and effects of the dispersant treatment. BAOAC, 2009 explained, "*In the initial stage of a dispersant spraying operation, surveillance may be restricted to aerial observation. Sometimes, aerial observation is sufficient as the dispersant can produce a visible plume of dispersed oil just below the water surface; this is an orange to light brown or dark brown cloud. This cloud appears more or less quickly depending on the sea and weather conditions. However, recent field experiments have shown that enhanced oil concentrations can occur in the water column following dispersant use, without the appearance of plumes. Therefore, subsurface oil concentrations should be measured in addition to the conventional aerial observations. There is a code identified at the Bonn Agreement for the oil appearance related with slick thickness*" (Table 4).

According to the Bonn Agreement (2009) dispersant should not use response technique to clean oil;

1. "In shallow waters less than 10 m depth, because the cloud of dispersed oil will be exposed to the seabed and expose benthic organisms (those that live in the mud and sediment) to high concentrations of dispersed oil.
2. Directly above marine filter feeders such as shellfish that eat plankton and may ingest the dispersed oil droplets.
3. Directly above corals, sea grass and fish spawning areas as these may be highly sensitive to dispersed oil.

4. In the vicinity of fish cages, shellfish beds or other shallow water fisheries due to the increased risk of 'tainting' (oily taste of fish and shellfish).
5. Close to industrial water intakes and desalination plants, which are normally protected by fixed booms, since dispersed oil will pass under the booms and may contaminate heat exchangers, or may result in the forming of halo-methane".

Table 4. Adopted the Bonn Agreement Oil Appearance Code (BAOAC, 2009).

Code	Description	Layer thickness interval (μm)	L km^{-2}
1	Sheen (silver / grey)	0.04 – 0.30	40 - 300
2	Rainbow	0.30 – 5.0	300 – 5,000
3	Metallic	5.0 – 50	5,000 – 50,000
4	Discontinuous true oil color	50 – 200	50,000 – 200,000
5	Continuous true oil color	> 200	>200,000

Bonn Agreement (2009) explained; "*A monitoring operation should consist of measurement of subsurface oil concentration and surface oil/emulsion situations. It is necessary to monitor subsurface oil concentration with a continuous measurement device. Measurement of oil concentration before and following application will give an indication of the effectiveness of dispersants in promoting transfer of oil into the water column. Surface sampling of the oil slick to measure water content and viscosity will indicate the degree of weathering of the surface oil. Dispersant spraying process should be ended at the point when orange or brown plumes no longer form, and when subsurface sampling suggests that the oil is no longer amenable to dispersants*".

7. National Emergency Response Plans and Status of Dispersant Usage in Turkey

Turkish national law 5312, titled "Law Pertaining to Principles of Emergency Response and Compensation for Damages in Case of Pollution of the Marine Environment by Oil and Other Harmful Substances" was enacted on October 21, 2006. "Law 5312 pertains only to emergency response for marine pollution caused by petroleum and other harmful substances". National and regional contingency plans (2008-2011) were prepared supported by Ministry of Environment and Forest considering this act. Within the scope of the project, "guidelines, which will necessary during and after an emergency response, were prepared to support for the implementing parties". One of the guidelines is related with "Definition and the suitability of the use of dispersants in emergency response situations". However, the use of dispersant in Turkish Sea's has not been included in the national regulations and remained unclear for the actors responsible from combating with oil spill accidents.

Nationally, there is only rule acceptable for the ministry that, no one can use dispersant without permission of the Ministry of Environment and Forest. There is no rule for the selection, types and usage of the dispersants in Turkish coastal waters. However, there is a draft dispersant regulation is prepared in 2011. In general, dispersant approval criteria of England, France, Germany and Denmark are valid in Turkish waters (Table 5).

Table 5. The politics of the some countries for dispersant applications (EMSA, 2010)

Countries	Primary responds method	Confirmation authorities	Dispersant Testing	Approved Dispersant lists	Dispersant Stock Pile
France	Chemical dispersant is allowed.	No	Yes Tests measure, effectiveness, toxicity and biodegradability are performed.	Yes 22 dispersants are approved. (Bioreico R93, Corexit 9500, Inıpol IP90 Nu Cru etc.	1500 Ton
Germany	Mechanical containment and recovery	Federal Ministry of Transport, Building Housing	No	No	No
Turkey	Not identified	Ministry of Environment and Forest	No	Dispersants pre-approved all by England, France, Germany, Netherlands and Denmark can be used in Turkey without further testing.	Not identified

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CHAPTER 4

THE EFFECTS / IMPACTS OF OIL SPILL ON BIOLOGICAL COMMUNITIES – INCLUDING SAMPLING AND MONITORING

This chapter aims to give detailed information of oil spills on biological communities and their habitats with various published work for major case studies in global scale. Oil spill effect on microbial communities, phytoplankton, zooplankton, macrophytes, macrobenthos, fishes, birds and marine mammals are reviewed. Depending on the size and location of the oil spill, many elements of the environment can be affected. Those effects range from lowest to violent. Oil spills can have a significant impact on temporary animal and fish habitat loss. Heavy oils can affect various organismal functions such as respiration, nutrition and thermo regulation. At the same time, the entire ecosystem may temporarily change due to chemical components and elements of spilled oil, which are toxic to the environment A case scenario for a potential oil spill exposure in Arctic shows how seriously ecosystem can affect with all biological components. Generally, oil spills in a water environment are rapidly decaying compared to its effects on land.

Since oil-spills, especially along the TSSA, are of major and regular concern for the country, Turkey is a signatory nation to the MARPOL 73/8 and Bucharest Conventions. In this respect, contingency plans are developed to deal with accidental spills. However, there are still considerable uncertainties about the quantities of illegal discharges of harmful substances, especially in the Western part of the sea, where ship traffic via the İstanbul Strait is heaviest. Large amounts of oil spill caused by tanker accidents may have serious alteration on the ecosystem starting from the decrease of oxygen exchange between the sea surface and atmosphere. Monitoring strategies and possible action plans are proposed as its best for TSSA. Additionally, the only research study on the major oil spill, Volgoneft-248, 1999 occurred in the Sea of Marmara are examined and the study results on phytoplankton, ichthyoplankton and benthic communities are given in details.

Nazlı DEMİREL

MARINE MICROORGANISMS AND OIL SPILL

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1. Introduction

Marine oil spill is leakage of petroleum hydrocarbons into the marine environment and in general caused by accidents in the extraction, transportation or various other industrial activities of petroleum. According to International Tanker Owners Pollution Federation, approximately 5.73 million tonnes of oil were spilled between 1970 and 2017 (ITOPF, 2018). Worldwide known oil spill accidents like Prestige (2002 - 63,000 tonnes), Exon-Valdez (1989 - 37,000 tonnes), Deepwater Horizon (2010 – 680,000 tonnes) and many others have damaged marine ecosystem in different levels.

Turkish Straits System (TSS) also affected by oil spills during the past decades. Some of major oil spill accidents are, Independenta (1979 - 94,000 tonnes), M/T Jambur (1990 – 2,600 tonnes), Nassia (1994 – 20,000 tonnes), Volgoneft-248 (1999 – 1,500 tonnes) and Svyatoy Panteleymon (2003 – 230,000 tonnes) (Akten, 2006; Birpinar et. al., 2009; Turan, 2009). Some of these accidents caused serious environmental problems. Most recently, on 12th of January 2017 an oil spill was detected in the Bay of Izmit, eastern part of the Sea of Marmara. It was estimated that 90 to 100 tons of oil had been spilled, of which 60 tons were cleaned-up. Following the spill, Turkish Ministry of Environment and Urbanisation fined the port 2.1 million Turkish Liras over the damage inflicted by the oil spill (Turkish Ministry of Environment and Urbanisation, 2017).

Even though number of oil spill decline globally (ITOPF, 2018), they are still an important source of marine pollution and have negative effects on marine ecosystem, human health and economy. Short-term ecological impacts included the creation of hypoxia closer to the surface causing marine organisms to die or flee (Lee, 2011).

In the current chapter, we reviewed marine microorganisms (especially marine bacteria) and oil spill from both sides. First, effects of oil spills on the microbial diversity and secondly ability of microorganisms to clean up oil spills (biodegradation and bioremediation).

2. Effects of Oil Spills on the Bacterial Diversity

Oil spills can seriously affect the marine environment and depends on the fate of the oil. Physical and toxic impacts of petroleum are significant, and have negative impacts on marine organisms in different levels. In general, the effects of oil toxicity depend on a multiple factor. These include quantity and type of oil spilt, exposure routes and regimen, the ambient conditions and the sensitivity of the affected organisms and their habitats to the oil (Saadoun, 2015; ITOPF, 2011; US National Research Council, 2003).

The impact of oil pollution on marine bacterial diversity has been studied in controlled marine environments (micro- or mesocosms) and in situ filed experiments after oil spill accidents. Many studies suggest that structure and diversity of the dominant bacterial community changes substantially after marine oil spill events.

Molecular studies after Deepwater Horizon oil spill in the Gulf of Mexico show that *Gammaproteobacteria (Oceanospirillales, Colwellia, and Cycloclasticus)* and *Alphaproteobacteria*, predominate the bacterial communities of marine sediment and deepwater oil plume (Hazen et al, 2010; Baelum et al., 2012; Mason et al., 2012). Similarly, oil contaminated beach sand studies showed highly contaminated samples had higher abundances of *Alpha*- and *Gammaproteobacteria* sequences (Kostka et al., 2011; Lamendella et al., 2014). Another study by Liu and Liu (2013) were evaluated bacterial community structures in oil mousses collected on sea surface. They were reported that oil mousse samples were predoiminated by *Erythrobacter, Rhodovulum, Stappia,* and *Thalassospira* members of *Alphaproteobacteria*.

Alonso-Gutiérrez et al. (2009) asseseed effect of oil spills on the bacterial diversity after 12 months of Prestige oil tanker accident in the northern Spain. They were reported that, samples taken from supralittoral zone (sand and rock) were prevalent by *Alphaproteobacteria* and *Actinobacteria* members. In another study Jiménez et al. (2007) conducted a field experiment in the upper intertidal zone of Cantabrian coast. According to their 16S rRNA PCR analyses, bacterial community was mainly composed of *Alphaproteobacteria* (Rhodobacteriaceae and Sphingomonadaceae) and *Gammaproteo-bacteria* (Chromatiales and Halomonadaceae).

Micro- or mesocosms experiments reported similer results compare to field studies. Microcosm experiments from Albanian seawaters suggestd that the load of petroleum caused the increase in total bacterial diversity along with a strong selection for microorganisms belonging to marine hydrocarbon degraders *Alcanivorax* and *Cycloclasticus* (Cappello et al., 2007). In another study, Yakimov et al. (2005) reported that increased levels of hydrocarbons and mineral nutrients dramatically changed the initial diversity of the microbial community. Only bacterial phylotypes affiliated with *Proteobacteria* and Cytophaga-Flavobacterium-Bacteroides (CFB) division were detected at the sediment samples. According to experiments by MacNaughton et al. (1999), oil treatment encouraged the growth of gram-negative microorganisms within the *Alphaproteobacteria* class.

There are several studies on effects of oil spill on marine organisms in the TSS after oil spill events including phytoplankton, macrozoobenthos, macroalgea and fishes (Güven et al., 1995; Öztürk et al., 2001; Taş et al., 2011). Comparably less is known about effects of oil spills on the bacterial diversity in the area.

3. Biodegradation and Bioremediation of Oil Spills

The sources of environmental pollution originating from petroleum hydrocarbons have been increasing all over the world, necessitating the development of techniques for removing them from the natural environment. The biodegradation of petroleum can be as short as 2-5 years with the studies which are made by intervention with the addition of nutrient or bacteria and biologic improvement (bioremediation), while the primary mechanism in petroleum disturbance is 5-10 years in nature as a primary mechanism (Korda et al., 1997). Thus the bioremediation methods are gaining in importance and have been the subject of aquatic microbial ecology studies in recent years (Bouwer and Zehnder, 1993; Cohen, 2002; Chanelli, 1991). The studies are under way to remove petroleum pollution by using capacities of bacteria to break up petroleum hydrocarbons in the world. The selection of suitable bacteria and whether the selected bacteria are suitable for the area exposed to oil hydrocarbon degrading are important study headings. Natural bacteria isolated from the marine environment are an important factor in increasing the efficiency of bioremediation studies if these bacteria are used against successful petroleum hydrocarbons and against potential petroleum pollution in the same area. Biodegradation of pollutants in the environment is a complex process that is associated with seasonal, environmental conditions and the composition of the local microbial community as well as the existing pollutant (Atlas and Bartha, 1992).

The degradation of oil spills the environment and the natural clearing of the environment, are related to the environmental conditions of the bacteria such as nutrients; carbon, nitrogen and phosphorus, oxygen and temperature as well as the differences in metabolic decomposition of petroleum derivatives (Atlas, 1981).

After the oil entered the marine environment, it changes such as diffusion to the water surface, evaporation, emulsification, aggregation in the bottom sediments, oxidation and fragmentation with living organisms, photolithic oxidation (Atlas, 1975; Dibble and Bartha, 1979, Atlas, 1981, Leahy and Colwell, 1990, Atlas and Bartha, 1993, Demir and Demirbag, 1999, Rahman et al., 2002).

Temperature is one of the factors affecting the physical and chemical composition of petroleum, the structure of the microbial community and the rate of hydrocarbon metabolization by microorganisms (Atlas, 1981). At low temperatures, the viscosity of petroleum increases, the volatility of short chain toxic alkanes decreases and the solubility in water decreases, the start of biodegradation is delayed. Biodegradation rates also decrease with decreasing temperature (Atlas, 1975). Seawater temperatures range from -2 to 35°C (Floodgate, 1972).

It was recorded that the neutral value of the pH value is 7, which is the optimal value for biodegradation in the study of soil samples (Salmon et al., 1998). Dibble and Bartha (1979) observed an optimal pH value of 7.8 for the mineralization of soil with petroleum wastes. The pH is considered to be a negative effect on the ability of the microbial population to break down hydrocarbons in circumstances where the endpoints are present. (Rahman et al., 1999, Rahman, 2002). The pH value in marine environment does not change much. The pH value is generally between 7.6 and 8.1 and is not considered an important environmental parameter that would prevent biological degradation in the marine environment. The degradation rate was positively associated with the low pH value in the laboratory studies (Anon, 1991).

Oxygen is one of the most important variable for microbial degradation of hydrocarbons. Oxygen generally are required during the initial decomposition period of hydrocarbons (Anon, 1991). In marine and freshwater ecosystems, there are no oxygen-restrictive conditions in the upper part of the water column (Leahy and Colwell, 1990).

Nutrients such as nitrogen and phosphorus are the most critical factors affecting the biodegradation rate in seawater. Although petroleum is rich for microorganisms in carbon need, they are inadequate in terms of mineral nutrients that support microbial growth. Marine ecosystems and other ecosystems are generally inadequate in terms of these nutrient salts. Because other microorganisms competing with petroleum-degrading species consume these substances (Anon, 1991).

In the marine environment, bacteria and fungi play an important role in the biodegradation of oil. Bacteria and fungi that break down hydrocarbons are very common in environments such as the sea, freshwater and soil (Atlas and Bartha, 1973). It is known that 70 species of bacteria and fungi have been detected in the degradation of oil hydrocarbons (Atlas, 1981; Anon, 1991). Leahy and Covell (1990) found that the most important hydrocarbons degrading bacteria found in soil and marine environments are *Achromobacte*r, *Acinetobacter*, *Alcaligenes*, *Arthrobacter*, *Bacillus*, *Flavobacterium*, *Nocardia* and *Pseudomonas* (Figure 1). Harayama et al., (2004), reviewed changes in the structure of microbial communities in marine environments contaminated by a real oil spill and in laboratory experiments that mimic such environments. *Alcanivorax* and *Cycloclasticus* were identified to be responsible for biodegradation of alkane and various aromatic hydrocarbons, respectively.

One of the most important aspects of bacterial pollution related to petroleum pollution is the use of biologic healing which is one of the methods of petroleum removal and the metabolic activities of microorganisms to clean polluted environments (Watanabe, 2001). The success of this technology depends on the experience and knowledge gained through the definition of the media properties that can be applied all over the world. It is well known that the biological remediation method has a great deal of power in removing pollutants, but it still continues to work on the principles and techniques of this method (Vidali, 2001).

Various strategies such as the type of petroleum and the characteristics of the poured area are greatly influencing the clearing strategies of oil spillage in the seas. Many approaches and technologies have been developed to control oil spills in seas and freshwater ecosystems.

The application of the biological remediation method is carried out by two methods, fertilization and seeding. Fertilization is made by the addition of nutrients such as nitrogen and phosphorus to the medium to accelerate the growth of local microorganisms in the environment. Seeding is accomplished by adding microorganisms to contaminated areas (Anon, 1991). In some cases, the biological activity needed to break down a contaminating factor in a contaminated area may not be achieved in that area. In this case, microorganisms that have been previously identified and isolated from other regions, can be added to the contaminated area. These microorganisms are defined as "exogenous microorganism". In order for the exogenous microorganisms to be able to carry out this fragmentation, it is important to achieve success in ensuring that the environmental conditions in the new region are compatible with the isolated region. (Anon, 2002).

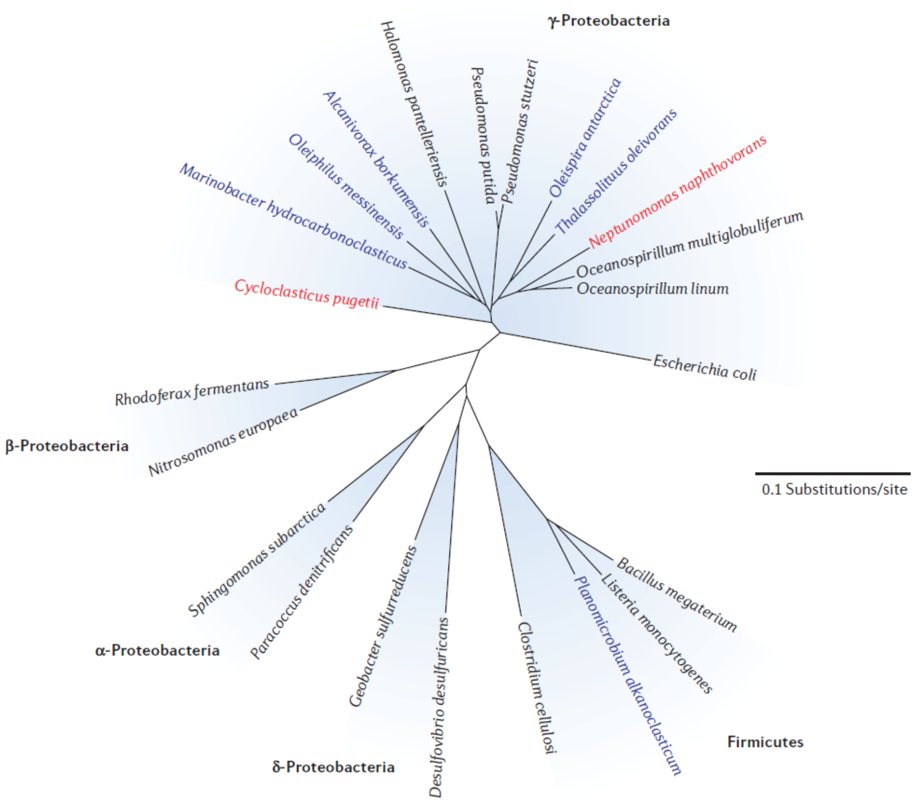

Figure 1. A phylogenetic tree of aerobic hydrocarbon-degrading bacteria. (blue = saturated hydrocarbon-degrading bacteria, red = polycyclic aromatic hydrocarbon-degrading bacteria, black = do not degrade hydrocarbons) (Head et al., 2006).

The introduction of hydrocarbons into water containing nutrients at low concentrations can lead to unsuitable carbon / nitrogen or carbon / phosphorus ratios for microbial growth (Atlas, 1981). For this reason, in order to accelerate the biodegradation which is a natural process, the addition of nitrogen and phosphorus to the medium in which the natural microorganisms that break down is performed is being done.

After the Exxon Valdez crash in Alaska in 1989, Prince William Sound islands and Alaska gulf coast are covered with of the oil. Bacteria isolated from the same area (*Pseudomonas* spp., *Vibrio* spp., *Alcaligenes* sp.) and their mixed cultures have been used successfully for the removal of the oil in the environment (Chanelli, 1991). This success achieved with the bacteria isolated from the accident area in Alaska has gained a special importance in this field study and it has become more important to identify species that are candidates for biologic improvement by identifying natural bacterial isolates of specific regions with different geographical areas in oil pollution open areas.

4. Hydrocarbon-degrading Ability of Bacteria Isolated from Turkey's Marine Environments

The Sea of Marmara is under pollution effects from Black Sea originated and ship-borne sources as well as being affected by many terrestrial pollutants caused by domestic and industrial waste and being vulnerable to possible accidents of oil tankers. It is a unique area of study in which we can examine the bacteria-petroleum relationship. There are many studies focusing on the determination of bacteria that degradating the oil hydrocarbons in seawater and sediments in The Sea of Marmara.

Altuğ et al. (2007) have examined the natural isolates', isolated from the Sea of Marmara and the Lagoon of Ölüdeniz, behavior against petroleum hydrocarbons. They have identified *Klebsiella pnemoniae, Serratia marcescens, Enterobacter cloace* and *Escherichia coli* from these marine environments. They have reported that *Serratia marcescens* had the highest resistance for oil hydrocarbons (Altuğ et al., 2007).

Çardak et al. (2007) have isolated *Escherichia coli, Bacillus subtilis, Pseudomonas aeruginosa, Vibrio fluvialis, Serratia marcescens, Klebsiella pneumoniae* strains from seawater and refinery soil. They have studied the ability of these strains to break down petroleum hydrocarbons. They reported that as the most capable strains *V. fluvialis* and *K. pneumoniae* than on other seawater isolates.

In a study the bacteria which were isolated potentially hydrocarbon polluted areas from the Sea of Marmara were tested with respect to their oil degradation effect with an aim to detect the best candidate strains for furthers bioremediation studies (Çiftçi, 2008; Çiftçi and Altuğ, 2010). The single cultures of 112-*Enterobacter sakazakii* has been reported as the best candidate species between bacteria isolated from the studied area.

Altuğ et al. (2011, 2012) have isolated from the Sea of Marmara, Black Sea, the Northern Aegean Sea of Turkey and refinery soil samples total 103 wild bacterial strains. These strains have investigated out with the aim of determining the degradation capacity. *Pseudomonas aeruginosa* BR03, *Escherichia coli* MDK04, *Staphylococcus haemolyticus* GA01, *Bacillus subtilis* BR02 and *Vibrio fluvialis* MD03 have reported as the potential candidates.

In a study, the 39 bacterial strains known to be resistant to petroleum hydrocarbon isolated from various Turkey's marine environments were investigated and the strains' mixed cultured oil degradation rate was recorded as 80% (Altuğ et al., 2016; 2018).

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ESTIMATED EFFECTS OF OIL SPILL ON PHYTOPLANKTON FOLLOWING 'VOLGONEFT-248' ACCIDENT (SEA OF MARMARA)

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1. Overview of Studies on the Effects of Oil Spill on Phytoplankton

Phytoplankton are primary producers and play an important role in marine ecosystem. They are also sensitive to changes in environmental factors and water pollution. Because of their quickly response to the changes of physical and chemical characteristics of water, they have been considered as indicator organisms in water quality monitoring studies. Many studies revealed that the oil contamination have various effects on phytoplankton ecology and distribution (Batten et al., 1998; Ozhan et al., 2014a). Several tanker accidents occurred around the world have been proved the effect of oil contamination on the marine ecosystem including phytoplankton community.

The literature review on studies of oil spills demonstrates that the effects of oil contamination on the phytoplankton growth and distribution may be negative or positive. Previous studies have showed that crude oil increase phytoplankton growth and biomass (Batten et al., 1998; Ozhan et al., 2014b). But, it was not proved that this was caused by an increase in photosynthesis or a decrease in zooplankton grazing (Johansson et al., 1980). Elmgren et al. (1980) suggested that stress caused changes in species composition and increase in biomass. Ozhan et al. (2014a) suggested that oil spill stimulated phytoplankton growth.

Some researchers have been reported that petroleum hydrocarbon compounds decreased the photosynthetic activity (Goutz et al., 1984; Tomajka, 1985). In additon to toxigenic effects of crude oil on phytoplankton (Paul et al., 2013), oil films on surface can reduce light penetration and limit photosynthesis (González et al., 2009). Short-term adversely effects on phytoplankton were usually observed in high concentrations of toxigenic compounds. The previous studies indicated that oil concentrations up to 1 mg L^{-1} may stimulate the growth of phytoplankton, 1 and 100 mg L^{-1} may inhibit the growth, and over 100 mg L^{-1} inhibits the growth completely (Ozhan et al., 2014a). However, some authors reported that the level of inhibition was associated with both type and oil concentration (Gordon and Prouse, 1973). Ozhan et al. (2014a) were found that dinoflagellate species were more tolerant at lower oil concentrations (<1.2 ppm), while diatoms were more tolerant at higher concentrations.

2. The Oil Tanker 'Volgoneft-248' Accident

The Russian oil tanker 'Volgoneft-248' was broken into two parts, due to a strong southerly gale, about 1 km off the coast (north-east of the Sea of Marmara) in 29th December, 1999. The bow part of 'Volgoneft-248' oil tanker, which was carrying 4365 tons of heavy fuel oil, sank at once and the aft side grounded at shore. The spilt fuel oil into the sea was 1579 tons and covered the shore by the south-westerly winds within a short time after accident. The layer of fuel oil reached to 2–10 m in wide in some areas and 5 cm thick at sea surface. The fuel oil in large quantites drifted and covered up the shore and also spread over the sea bottom. The oil tanker was surrounded by barriers in order to avoid leakage of oil. After cleaning operations, the oil was removed and delivered to the receivers (Güven et al., 2006). The fuel oil in the sunken tanks was largely recovered (Alpar and Ünlü, 2007).

3. General Characteristics of the Study Area

The study area is located at the northeastern Sea of Marmara (Küçükçekmece Bay) connecting to Küçükçekmece Lake with a channel. This area includes the entire region offshore Florya, where occurred Volgoneft-248 oil tanker accident. The sampling depths in the study area varied between 6 and 78 m. The Turkish Strait System has a heavy maritime traffic. The ship-originated pollution is one of the important problems in those marine coastal areas (Doğan and Burak, 2007). The continuous passage of cyclonic systems with typical southerly winds in winter affect the region, posing the high pollution risk along the northern coasts of the Sea of Marmara (Alpar et al., 2003).

There is a two-layered structure in this area according to temperature and salinity profiles. Salinity varied between 21.5 and 26 and temperature ranged from 6 to 26ºC at the upper layer. Salinity was 38.5 and temperature was 14.5 ºC at the lower layer below 40 m. Surface salinity values were higher in winter during the southerly winds. Surface water salinity decreases due to the flow of water from the Black Sea in summer (Tas et al., 2011). The oil concentration in sea water reached to the highest level (2.17 mg L^{-1}) at the time of accident and five days later it decreased to 88.5 µg L^{-1}. The oil concentrations in sea water decreased to the normal values (0.3-1.5 µg L-1) after the cleaning operations (Tas et al., 2011).

4. Phytoplankton Abundance and Composition

Phytoplankton abundance in the oil-contaminated area varied between 2×10^3 and 195×10^3 cells L^{-1} from January 2000 to January 2002 (Figure 1). After five days from the oil spill, the phytoplankton abundance was very low and no any diatom species was observed in surface water, while the dinoflagellate species were only present. The diatom abundance increased to 38×10^3 cells L^{-1} in February 2000 (Figure 1and 2). There was a significant increase in dinoflagellates dominated by *Prorocentrum micans* in May 2000 and their abundance reached 70×10^3 cells L^{-1} (Fig. 2, Table 1). It was observed the low phytoplankton abundance (max. 29.5×10^3 cells L^{-1}) in August 2000 and January 2001 (Figure 1). The oil concentration increased significantly (121.5 µg L^{-1}) at the surface water of St.7 in August 2001 during the cleaning of the bottom settled petroleum due to mixing of oil in the sea water. As a result of this, the phytoplankton abundance decreased to 3×10^3 cells L^{-1} (Figure 1). The most important change in phytoplankton community was detected in January 2002 with a diatom increase (Figure 1and 2). During this increase, *Pseudo-nitzschia delicatissima* and *P. pungens* were the dominant species and reached to 155×10^3 and ~52×10^3 cells L^{-1}, respectively (Table 1).

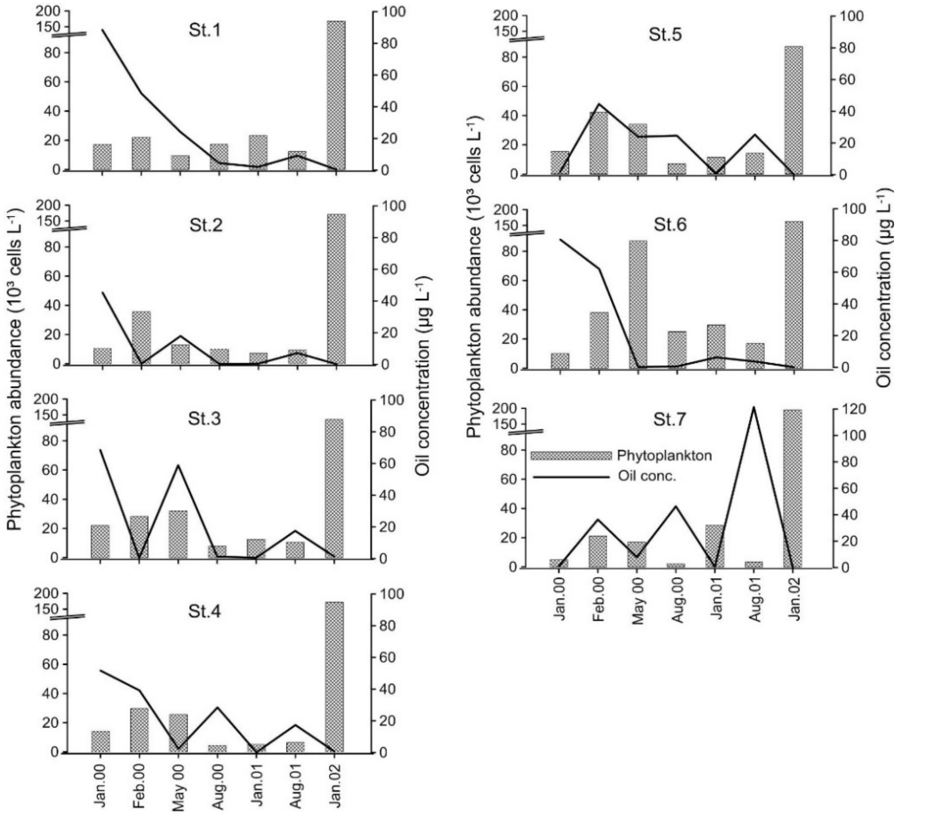

Figure 1. The phytoplankton abundance and oil concentration in surface water.

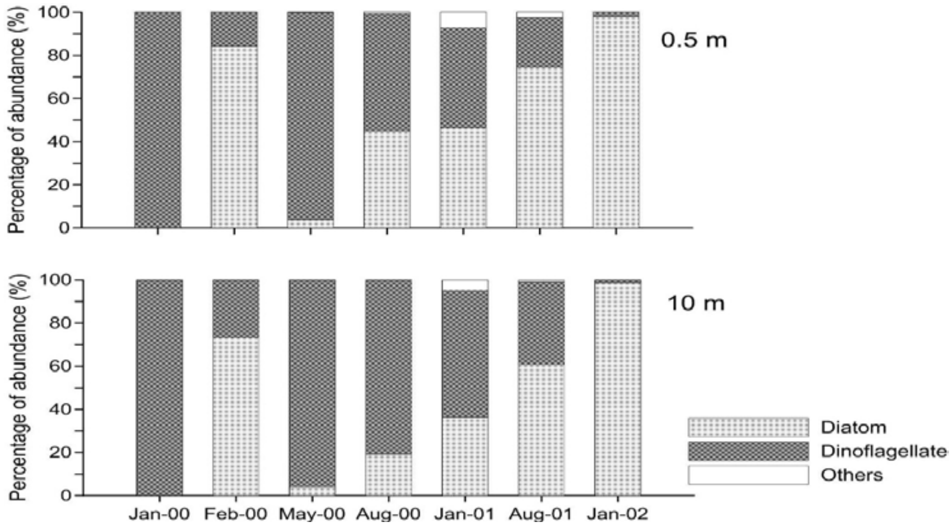

Figure 2. Percentage of abundance in phytoplankton groups during the sampling period.

Table 1. The most abundant phytoplankton species and maximum abundances in surface water during the sampling period.

Species	Months	Abundance (10^3 cells L^{-1})
Diatoms		
Detonula confervacea	Aug. 2000	14.0
Pseudo-nitzschia delicatissima	Jan. 2002	155.0
Rhizosolenia setigera	Feb. 2000	10.0
Thalassionema nitzschioides	Aug. 2001	7.0
Thalassiosira rotula	Jan. 2001	6.5
Dinoflagellates		
Prorocentrum micans	May 2000	70.0
Tripos furca	Jan. 2000	8.2

During the study period, a total of 71 phytoplankton taxa belonging to five taxonomic classes were detected in surface water samples. Most of these (94%) consisted of diatom (35 taxa) and dinoflagellate species (32 taxa). Other species (4 taxa) were phytoflagellates (Table 2). Only two diatom taxa were found in the first samples in which oil concentrations was the highest. However, number of dinoflagellate species was the highest (22 taxa). The most frequent species observed in the phytoplankton community were *Coscinodiscus* sp. and *Rhizosolenia hebetata* from diatoms; *Prorocentrum micans, P. scutellum, P. triestinum, Protoperidinium* sp., *Scrippsiella trochoidea*, *Tripos furca* and *T. fusus* from dinoflagellates. The species number increased from 24 to 38 taxa after two months following oil spill (Table 2).

The most important result in this period was a significant increase in diatom species (from 0 to 21) in February (Figure 3 and Table 2). The species number in dinoflagellate was higher in May and August 2000, while diatom species increased in August 2000 with the decrease in oil concentration in the study area. The number of diatom species increased to 23 after two years, when the lowest oil concentration was measured in sea water. The number of dinoflagellate species varied between 14 and 22, while the number of diatoms were between 2 and 23 during the study period (Figure 3 and Table 2). The average species diversity index (H') varied between 1.32 and 3.11 in the study area. Following the oil spill, H' was 2.15 in surface water, however it rapidly increased to 3.11 after two months (February 2000). The H' values decreased significantly in May 2000 and January 2002, due to the dominance of dinoflagellates (Figure 3).

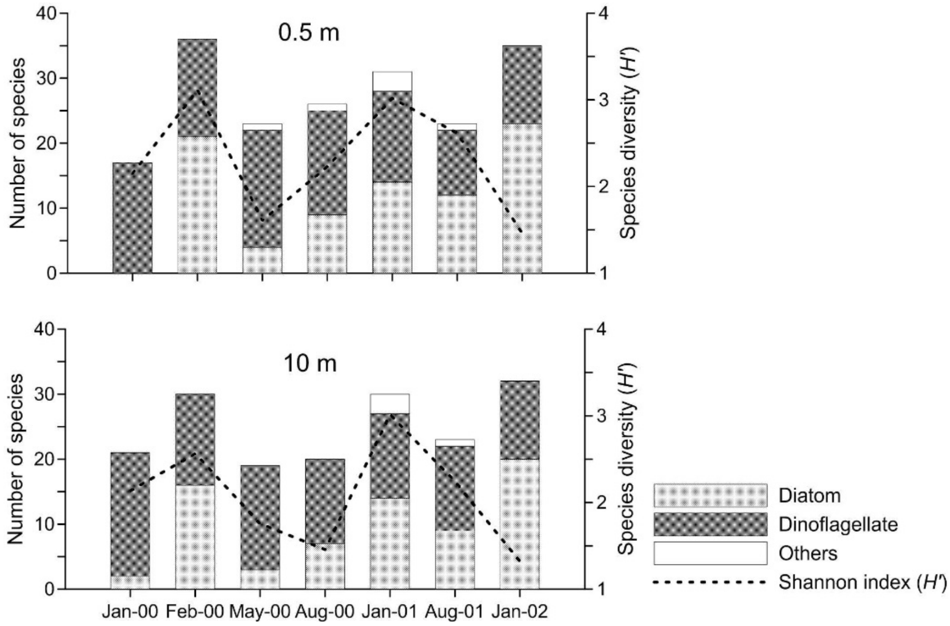

Figure 3. Temporal variations of the number of phytoplankton species and Shannon diversity index.

Table 2. The list and temporal distribution of phytoplankton species following "Volgoneft-248" oil spill during the sampling period.

Species	J.00	F.00	M.00	A.00	J.01	A.01	J.02
Bacillariophyceae							
Chaetoceros affinis		+	+				+
Chaetoceros curvisetus			+			+	+
Chaetoceros diadema		+					
Chaetoceros holsaticus		+	+				+
Chaetoceros tortissimus							+
Chaetoceros sp.		+	+		+		+
Coscinodiscus concinnus		+		+	+		+
Coscinodiscus perforatus					+		
Coscinodiscus radiatus		+			+		+
Coscinodiscus sp.	+	+	+	+	+		+
Dactyliosolen fragilissimus				+		+	+
Detonula confervacea			+	+	+		
Ditylum brightwellii		+			+		+
Guinardia delicatula					+	+	
Guinardia flaccida					+		
Hemiaulis hauckii						+	
Leptocylindirus danicus		+		+	+	+	+
Leptocylindirus minimus		+			+	+	
Navicula sp.			+		+		+
Nitzschia longissima		+			+		
Proboscia alata		+				+	+
Pseudo-nitzschia delicatissima							+
Pseudo-nitzschia fraudulenta							+

Pseudo-nitzschia pungens		+		+			+
Pseudosolenia calcar-avis				+		+	
Rhizosolenia hebetata	+	+		+	+	+	+
Rhizosolenia setigera		+			+		
Skeletonema costatum		+				+	+
Stellarima stellaris							+
Thalassionema nitzschioides		+		+		+	+
Thalassiosira decipiens		+					
Thalassiosira eccentrica		+		+	+		
Thalassiosira rotula		+	+	+	+		+
Thalassiothrix frauenfeldii						+	+
Thalassiothrix longissima		+					+
Dinophyceae							
Akashiwo sanguienea					+		
Dinophysis acuminata	+						
Dinophysis acuta	+	+		+	+	+	
Dinophysis caudata	+						+
Diplopsalis lenticula					+	+	
Gymnodinium sp.	+	+	+	+	+		
Heterocapsa triquetra				+			+
Noctiluca scintillans	+	+	+	+			
Oxytoxum oxytoxoides						+	

Species	**J.00**	**F.00**	**M.00**	**A.00**	**J.01**	**A.01**	**J.02**
Oxytoxum sp.	+	+	+		+		
Phalocrama rotundatum	+	+		+			
Prorocentrum compressum	+			+		+	+
Prorocentrum gracile			+		+		
Prorocentrum micans	+	+	+	+	+	+	+
Prorocentrum scutellum	+	+	+	+	+	+	+
Prorocentrum triestinum	+	+	+	+	+	+	+
Protoperidinium claudicans			+	+			
Protoperidinium conicum			+				+
Protoperidinium depressum	+	+	+	+		+	
Protoperidinium divergens	+		+	+	+		
Protoperidinium pallidum	+		+				
Protoperidinium pellucidum	+		+			+	+
Protoperidinium pentagonum		+					+
Protoperidinium punctulatum	+	+	+				
Protoperidinium sp.	+	+	+	+	+	+	+
Protoperidinium steinii	+	+	+	+			
Scrippsiella trochoidea		+	+	+	+	+	+
Tripos furca	+	+	+	+	+	+	+
Tripos fusus	+	+	+	+	+	+	+
Tripos horridum					+		+
Tripos trichoceros	+		+			+	
Tripos muelleri	+	+	+	+			
DICTYOCHOPHYCEAE							
Dictyocha fibula					+	+	
Dictyocha speculum			+		+		
Octactis octonaria					+		
EUGLENOPHYCEAE							
Eutreptiella sp.				+		+	

5. Conclusion

The impacts of oil contamination on marine ecosystem have been revealed by the past studies. It is well known that the oil settled to the sea bottom affect on the benthic organisms. However, the effect of the oil contamination on phytoplankton is not well known, due to the natural variability in the ecosystem affecting on phytoplankton. A recent study reported that oil spills may stimulate the growth of phytoplankton (Ozhan et al., 2014a). The toxicity of oil on phytoplankton can vary with physical conditions such as temperature and light, and nutrient-limited conditions (Ozhan et al., 2014b).

The oil concentration in seawater after Volgoneft-248 oil spill was much higher than the values accepted. The effects of oil pollution on marine ecosystems were investigated in many regions around the world. The oil contamination can affect the photosynthetic activity due to light limitation in coastal stations. Furthermore, the tar ball formation caused by oil sedimentation negatively affect the phytoplankton cells settling down together (Guven et al., 2006). A large amount of the spilled oil sedimented to the sea bottom and mixed with sand by suspended particulate matter in the water column (Alpar and Unlu, 2007).

Seasonal variations in phytoplankton in the northeastern Sea of Marmara were previously investigated by some researchers (Uysal 1996; Balkis 2003; Deniz and Tas 2009). Unlike the other studies, in this study has been studied the estimated effects of oil spill on phytoplankton after "Volgoneft-248" tanker accident. The lack of diatom species in surface water following oil spill indicated that high oil concentration in sea water may inhibit the growth of diatoms. Increase in diatom abundance and species number after two months coincided with the decreased oil concentration. Dahl et al. (1983) reported that the growth of diatoms inhibits by crude oil. It is considered that the low oil concentration in seawater may favor the growth of diatoms. This indicated that diatoms could be more sensitive to high oil concentration than the other phytoplankton species.

One of the important result of this study was the abundance increase in diatoms and diversity two years later, when the oil concentration decreased to the lowest level. This suggests that low oil concentrations in seawater may not inhibit the growth of diatoms. Phytoplankton studies carried out in the Sea of Marmara suggested that the diatoms increase in late winter-autumn, while dinoflagellates in late spring-summer (Balkıs, 2003; Deniz and Tas, 2009). The winter increase of diatoms was also suggested by Okus and Tas (2007). The findings of this study on seasonal variation of phytoplankton were generally consistent with the other studies. However, the low phytoplankton abundance when compared to the other studies indicated that the negative effect of heavy oil pollution on phytoplankton in the study area. As a result, heavy oil contamination may affect negatively the growth of phytoplankton due to the oil films on surface water which reduce light penetration along the water column. Furthermore, the effect of oil pollution may also vary by the sensitivity of species to the available environmental conditions.

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INTERACTIONS BETWEEN ZOOPLANKTON AND OIL SPILLS: LESSONS LEARNED FROM GLOBAL ACCIDENTS AND A PROPOSAL FOR ZOOPLANKTON MONITORING

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1. Introduction

Zooplankton as one of the key components of pelagic food web plays an important role in biogeochemical cycles and fish recruitment. Several groups of zooplankton are the most important grazers of the pelagic realm, providing the transfer of trophic energy to higher levels. Zooplankton is also one of the major functional groups in the biological pump through transferring organic matter to the deep ocean by fast sinking fecal pellets and carcasses and also through nitrogen regeneration during diurnal vertical migration patterns (Ruhl and Smith, 2004). The effectiveness of biological pump is crucial for the global change, through providing long term storage of atmospheric carbon dioxide converted to biomass by phytoplankton. Several zooplankton species are considered as indicators of changing environmental conditions and climate change (Hays et al., 2005) and therefore long term zooplankton datasets are very important in evaluating the health and status of aquatic ecosystems (Richardson, 2008; Coma et al., 2009).

Marine pollution as a global environmental problem is significantly correlated to increasing maritime activities and exploitation of natural resources under the sea bed. In addition to discharge of hazardous substances, maritime activities elevate air pollution and spread of alien species. It has been reported that >90% of the foreign trade of Turkey is realized through maritime transport (İncaz, 2007). Among all shipping routes in Turkey, Turkish Straits System (TSS), is the foremost important one with an estimated ship transit crossings of over 45.000 per annum (Ünlü, 2016). Therefore although all Turkish seas are subject to oil pollution risk (as recently seen in Foça/İzmir in August 2018), impacts on zooplankton will be discussed over TSS, since the region possess the highest risk of oil pollution due to the basin's semi-enclosed characteristics, dense shipping, high population at the coasts and presence of heavy industry including the nation's largest oil refinery facilities

Petroleum products are considered among most important pollutants in the oceans. Main sources of petroleum pollution in the sea are primarily due to tanker accidents, ballast water discharge, ship traffic, refinery facilities, tanker oil loading/unloading facilities, oil production, terrestrial pollution and industry (Güven et al., 2004). Oil spills constitute a small fraction of crude oil discharge into the sea, however they have severe and long-term impacts on marine life (Almeda et al., 2013a; 2013b). The Deepwater Horizon Oil spill in 2010 at the Gulf of Mexico clearly demonstrated how severe marine ecosystems could be effected from a major accidental oil spill.

Despite ecological importance of zooplankton in the marine environment, our knowledge on the relationship between zooplankton and oil pollution is very limited, and no information exists in Turkey where oil spills are frequently occurring due to dense maritime activities. This chapter is aimed to summarize effects of oil spills on zooplankton through revisiting available published work all over the world and outline a monitoring strategy targeting the assessment of oil spill impacts on zooplankton, in case a major spill happens in Turkish seas.

2. Overview of Studies on Effects of Oil Spill on Zooplankton

Oil affects zooplankton through different mechanisms. As a planktonic organism, zooplankton's swimming ability is not strong enough to overcome waves and currents to avoid crude oil spills. Moreover the same physical forces accumulating oil slicks also potentially force zooplankton into much polluted water masses following oil spills. After marine oil spills, crude oil droplets varying from 1 to 100 µm in diameter are generated by currents and waves (Mukherjee and Wrenn, 2009). These droplets suspended in water column are frequently within the prey size preferences of major zooplankton species (Hansen et al., 1994). There are historical data showing that zooplankton can consume oil droplets (Gyllenberg 1981; Lee et al., 2012; Almeda et al., 2013a) and they were observed in zooplankton fecal pellets (Lee et al., 2012). Some components of crude oil, such as polycyclic aromatic hydrocarbons (PAHs), can be highly toxic to zooplankton and through bioaccumulation they can effect higher trophic levels (Almeda et al., 2013b). Therefore, due to the key role of zooplankton in marine food webs it is very important to know the interactions between crude oil and zooplankton in marine environment to understand the effects of oil spills in the pelagic realm.

Oil pollution effects zooplankton communities in different levels depending on various factors such as life stage, species, size, amount of oil pollution, exposure to crude oil and physicochemical properties of the water column (Almeda et al., 2013a; 2013b). These effects include lethal and sub-lethal effects, such as a feeding disorders, narcosis and developmental and reproductive alterations. Furthermore, accumulation of some polycyclic aromatic hydrocarbons (PAHs) as demonstrated in experimental conditions provided evidence on the role of zooplankton in PAH cycle in the food web (Berrojalbiz et al., 2009).

Our knowledge on impacts of oil spills on zooplankton significantly increased with intensive research conducted after the Deepwater Horizon accident that led to dispersion of ~780 000 m^3 of crude oil (Adcroft et al., 2010). During surface spills most of the volatile components evaporate into the atmosphere thus decreasing the toxicity, however the release of oil at 1.5 km depth caused rapid dissolving of water-soluble fraction of crude oil (Reddy et al., 2012). It has been noted that zooplankton exposed to such underwater plume is exposed to over 200 ppm hydrocarbon concentrations, a significantly high number when compared to ppm range detected in untreated surface spills (Clayton et al., 1993; Lichtenthaler and Daling, 1985). One of the most important factors affecting exposure of zooplankton to oil spills is utilization of dispersants. The earliest dispersants used in 1960's (e.g. Torry Canyon spill in 1967), considerably increased the environmental damage during oil spills, as a result of the toxicity of the applied dispersants (Nelson-Smith, 1972; Almeda et al., 2014b). This observations led to development of less toxic dispersants, however dispersion of crude oil into smaller fractions led to a higher ingestion by plankton and therefore a higher contribution to the pelagic food web (Figure 1). As an example during DWH oil spill approximately 6.4 million liters of dispersant (Corexit 9500) were used and studies showed that oil was taken up by zooplankton, and much of the ingested oil was in the form of dispersed oil (Lee, 2013).

Another case study shows the impacts of extensive dispersant use following the Ixtoc accident in the Gulf of Mexico, causing a four-fold decrease in zooplankton abundance 3 years after the spill (Próo et al. 1986). Analyzed samples showed that zooplankton had grazed on the dispersed oil suspended on fine sediments (Casey et al., 1980). Experimental studies also confirmed drastic effects of dispersants on zooplankton, such as the mesocosm study by Jung et al. (2012) demonstrating an elevated decrease in zooplankton when exposed to oil treated with dispersant rather than untreated crude oil, through affecting the feeding, growth and reproduction of crustacean zooplankton.

Some of the oil spill studies showed that, zooplankton abundance and community structure did not appear to be affected beyond several weeks following the event (Varela et al., 2006; Abbriano et al., 2011), probably as a result of high fecundity and short generation times of zooplankton species. However natural seasonal variability and patchy distribution is probably the main factor effecting an accurate determination of the in-situ effects of oil spills on plankton.

3. Proposed Monitoring Strategy in Case of an Oil Spill

Plankton samplings following an oil spill should be initiated as quickly as possible. Zooplankton samples should be collected by vertical hauls of a WP2 net with 200 µm mesh size. While sampling oil slicks should be avoided in nets since they will accumulate condensed zooplankton in the bucket and prevent accurate identification of the taxa. All samples should be preserved with addition of borax–buffered formaldehyde solution to a final concentration of 4%. If possible tows should be performed in duplicates and a fraction of the samples should be separated for biochemical studies. Any supporting environmental data, such as temperature, salinity, chlorophyll a, PAH, pH, should be collected simultaneously with zooplankton data. During the sampling campaigns, if available, closest location with any time series data should also be sampled in addition to the affected areas to provide comparable data with earlier studies and discriminate between natural and spill oriented fluctuations. Samplings should be carried out around the spill area following the trajectories of the spill and a distance based sampling program should be emphasized. Multi-layer net tows at some stations would provide information on lower layer dynamics, however main concern should be the upper layer. If possible CTD profiles should be evaluated to designate the upper and intermediate layer. If this information is not available 15m to the surface, and 3 meter above the bottom to 30 m depth tows should be taken. Temporal resolution of the sampling should be as frequent as possible in the first weeks of the spill; however biweekly or monthly sampling program would be adopted for the latter periods.

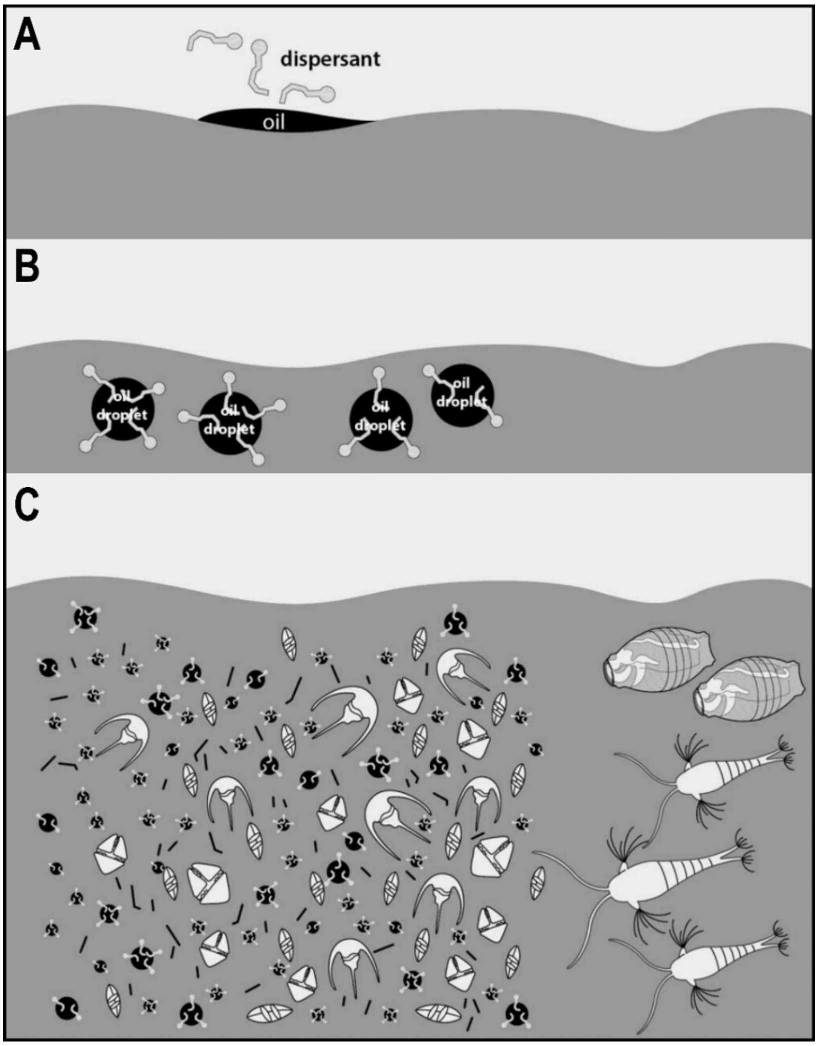

Figure 1. Effects of dispersants on oil slicks and pelagic food web (after Lee, 2013) A: application of dispersant, B: formation of crude oil droplets C: dispersed oil mixed with phytoplankton and grazed by zooplankton.

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THE EFFECTS OF OIL SPILL ON THE MACROPHYTOBENTHIC COMMUNITIES

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1. Introduction

The macrophytobenthic communities are affected by harbours, urban, industrial, tourism, agriculture activities and oil spill, especially. It was recorded some major oil spills around the World, i.e., Torrey Canyon in 1967, Independenta in 1979, Exxon Valdez in 1989, Erika in 1999, and Prestige in 2002 (Turan, 2009).

Several studies had been made about the impacts of the oil spill on macrophytobenthic communities. Fukuyama et al., (1998) investigated the effects of "Exxon Valdez" oil spill on the benthic communities, and recovery times for these communities. The effects of oil spill on the benthic vegetation and invertebrate communities of Niva and Keibu bays (Finland) was studied by Kotta et al. (2007). Lobón et al. (2008) were studied the impact assessment on intertidal, macroalgal assemblages of 'Prestige' oil spill by comparing abundance data obtained before and after the spill.

Marine benthic macroalgae (marine seaweeds) and marine angiosperms (seagrasses, marine flowering plants, marine phanerogams) are very important biologic elements in the benthic community of the seas. Seagrasses are angiosperms that live in marine environment. They exist at littoral areas through the world. (Duarte, 2001). Seagrasses are ecologically similar to each other but can be taxonomically different. Therefore, seagrass families may not be related to each other (Waycott et al., 2006). Seagrasses have less species in number than marine algae, but despite that they have a great biomass in Mediterranean Sea ecosystem. *Posedonia oceanica* reproduce vegetatively and also if the habitat is suitable sexually with seeds. Seagrass habitats has important ecological and economical roles on ecosystem. Seagrasses which consists of roots, stems and leaves are ideal biotopes for survival, protection and reproduction of organisms (Boudouresque and Meinesz, 1982; Meinesz et al., 1991). These biotopes are very productive areas for fisheries. 50 fish species identified living in *P. oceanica* meadows. 56 % of these species are permanent, 22% are randomly and the 22% is rarely seen species. These species are mostly belonging to the families Labridae, Scorpenidae, Serranidae and Centracanthidae (Harmelin-Vivien, 2000). They enrich seawater with oxygen with photosynthesis. Their long leaves, the horizontally extending rhizomes and roots capture the suspended solid matter and sedimentation, regulate substratum movements and maintain the coastline. *P. oceanica* attached to the substratum with its roots and their dead leaves collected on shore protects the coast from erosion (Boudouresque and Meinesz, 1982; Cirik and Cirik, 1999). They form dense meadows on the seafloor, for this reason they are called seagrasses. Epiphytic and ephibiont species living on seagrass leaves are the food source of marine herbivorous organisms (Cirik and Cirik, 1999).

Considering all these characteristics, seagrasses are among the most important species for the Mediterranean ecosystem. However, the habitats of these species have been destroyed because of increasing population, pollution, industry, illegal trawling and etc. Besides, the dumping work for building roads and coastal development on the coastline also threatens the seagrasses and the organisms live in them. This species has been taken to the protected species list for these reasons (Grissac, 1989; Meinesz et al., 1991; Boudouresque et al., 1994; Larkum and Hartog, 1989). Seagrass meadows (such as *Posidonia oceanica*, *Zostera noltii, Cymodocea nodosa* communities), which play a crucial role in the Mediterranean ecosystem with their biological and ecological functions are negatively affected by the above mentioned activities, the deposition of epiphytic organisms on them is increasing and the reef barriers formed by the remains of these plants are gradually becoming rare. Especially in recent years it has been observed that *Caulerpa racemosa*, an alien-invasive marine plant, has developed in places where seagrass meadows have disappeared (Meinesz et al., 1991; Boudouresque et al., 1990; Peirano et al., 2005).

In total, 668 marine benthic macroalgae [378 Rhodophyta (red algae), 165 Phaeophyceae (brown algae) and 125 Chlorophyta (green algae)] have been reported from Turkey by Taşkın et al. (2018a). And, five marine angiosperms have known in the coasts of Turkey (Akçalı and Cirik, 2015; Taşkın, 2018). Marine macrophytes (marine algae and marine angiosperms) are divided to two main ecological groups (tolerant and sensetive). The brown algal genera *Cystoseira*, *Padina*, the red algal genera *Corallina*, *Jania*, the marine angiosperms *Posidonia*, *Zostera*, *Cymodocea*, etc., are known sensetive taxa while the brown algal genera *Ectocarpus*, *Dictyota*, the green algal genera *Ulva*, *Cladophora*, the red algal genera *Polysiphonia*, *Laurencia*, etc., are known tolerant taxa in marine communities.

Turkey has four coastal areas: The Black Sea, the Sea of Marmara, the Aegean coast and the Mediterranean coast. The Sea of Marmara connected to the Aegean Sea by the Dardanelle Strait and to the Black Sea by İstanbul Strait Strait. The Sea of Marmara is high marine traffic area (Taşkın et al., 2018b). Several studies including or dealing only with the anthropogenic disturbance on the marine flora have been made in Turkey. However, the effects of oil spills on the macrophytobenthic communities were less studied.

2. Macrophytobenthic Communities in the Turkish Straits Systems (TSS) and Near Area

Marine flora of the Sea of Marmara was investigated by Aysel et al. (1991; 1993), Yüksek and Okuş (2004), Turna and Ertan (2005), Taşkın (2008; 2012; 2013a; 2013b; 2014a; 2014b; 2016), Taşkın et al. (2003; 2006; 2012), Taşkın and Öztürk (2007), Cirik et al. (2010), Cirik and Akçalı (2013). In total, 501 marine macroalgae (132 Phaeophyceae, 279 Rhodophyta and 90 Chlorophyta) were reported in the Sea of Marmara by Taşkın et al., (2018a).

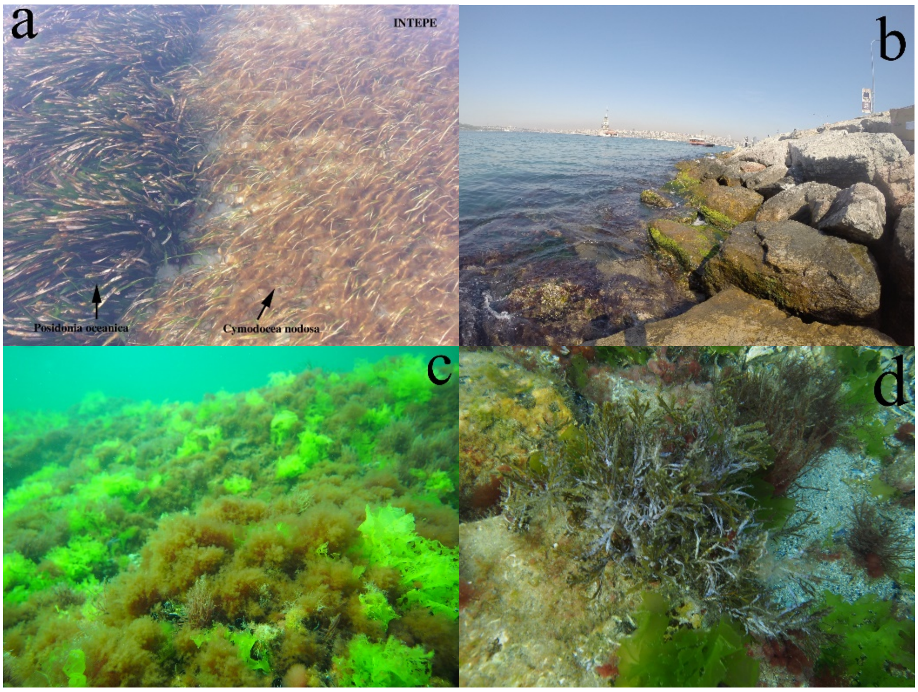

Figure 1. Marine angiosperms Posidonia oceanica and Cymodocea nodosa in the Çanakkale Strait (a). Marine algal vegetation in the Istanbul Strait (b). The filamentous and sheet-like algal communities in Princes Islands (c). The sensitive brown alga Cystoseira foeniculacea f. tenuramosa distributed in Princes Islands (d).

Four different macrophytobenthic communities known in the Sea of Marmara: (1) the brown alga *Cystoseira*, (2) calcareous algal (*Corallina* spp., *Phymatolithon* spp.), (3) marine angiosperms (especially, *Posidonia oceanica* and *Cymodocea nodosa*), (4) the paranchymatous, filamentous, and siphonous algal communities (*Ulva, Codium, Ceramium*, etc.). The sensetive macrophytobenthic taxa (*Cystoseira* spp., marine angiosperms, calcareous algae, etc.) are common in the Çanakkale Strait (Figure 1a). Istanbul Strait and near area were impacted by the anthropogenic activities, and the paranchymatous, filamentous, and siphonous algal with calcareous algal communities are dominant here (Figure 1b-c). The sensitive brown alga *Cystoseira foeniculacea* f. *tenuramosa* is distributed in Princes Islands (Figure 1d). Many alien and invasive marine algae (i.e. the green alga *Codium fragile*, the brown alga *Colpomenia peregrina*, the red alga *Polysiphonia morrowii*) were introduced to the Sea of Marmara via ships and ballast water (Taşkın, 2008; 2014a; 2016).

3. Effects of Oil on the Macrophytobenthic Communities

Oil is still used as an important energy source today. Large amount of oil and its by products are transported all around the world with commercial vessels. Therefore, oil and derivatives related accidents are occasionally encountered in various regions. That’s why, the shipping routes should be carefully monitored particularly at ecological hot spots (Macinnis-Ng and Ralph, 2003). The authorities should formulate action plans for an accident (Thorhaug, 1992).

Güner and Aysel (1996) reported that marine accidents (oil spills, etc.) might have destructive impacts on the growth and reproduction of macroalgae. The effect of oil and its derivatives on marine organisms depends on its toxicity, density, amount and how long it comes into contact (IPIECA, 2005). Kelp forests and marine angiosperms grow in shallow waters and are characterized by high biodiversity and productivity. The plants were reported as not particularly sensitive to elevated concentrations of hydrocarbons in IPIECA's report (2015), but many of the animals that live in these habitats are, including juvenile fish (IPIECA, 2015). However, Patrick and Dixon (1976) reported the depressive effect of oil exposure on algal photosynthesis and demonstrated the effect by experiment in laboratory bioassay in direct application using experimental flasks and manipulative field chambers. Low concentrations of oil may reduce fertilization in brown alga *Fucus* spp., 0.2 ppb of oil concentration inhibits the germination of *Fucus distichus* subsp. *Edentates,* gametes and zygotes were completely killed at concentrations of 20 ppm (Fukuyama et al., 1998). The in-situ observations showed that, recovery of *Fucus* after the Exxon Valdez oil spill was reduced or did not occur on rocks with tar (Fukuyama et al., 1998). In the Exxon Valdez accident in 1989, the seagrasses on the coastline disappeared. After ten years of this accident it is been declared that, the *Zostera marina* density was decreased (Juday and Foster, 1990; Dean et al., 1998).

After the oil spills in 1978 (Amoco Cadis) and 1989 (Exxon Valdez), the seagrass meadows were affected negatively. The seagrass leafs turn into white and destroyed after the The Exxon Valdez oil spill (Juday and Foster, 1990). Taylor and Rasheed, 2011 stated that, flowering shoots and density of the seagrass leaves had declined as a result of the oil spill.

Seagrasses spread through the coastline in shallow depths. Therefore, they are vulnerable to natural and anthropogenic effects (Waycott et al., 2006). This is the reason why seagrass beds play a significant engineering role in controlling coastal biogeochemistry (Jones et al., 1997). Seagrasses has a major role on chemical and physical structure of water column and sediment because they form a thick layer between them (Marba et al., 2006).

The oil and its derivatives have two major effects: susceptibility and vulnerability. Susceptibility is a direct effect of oil and related to substances on seagrasses and associated organisms. Some cleaning chemicals are also very toxic on marine organisms. Vulnerability is related to the distance of the seagrasses to potential hazard. (Ziemann et al., 1984).

Seagrass on deeper waters may not be exposed to oil as the oil generally floats in the surface. However, seagrass on shallow water is highly at risk of being affected by oil components in case an oil slick reaches the area. Seagrass may be exposed to oil.

Seagrass beds effects from petroleum in two ways; smothering and toxicity of water-soluable fractions. Oil and its derivatives can damage seagrass meadows in many ways, including (Wilson, 2010; Runcie et al., 2004; Howard et al., 1989):

- Smothering cause direct mortality of seagrasses due to decreased growth rates, blackened leaves,
- asphyxiation or poisoning cause direct mortality;
- Photosynthetic stress;
- Secondary effects like lack of food sources or habitat loss;
- Mortality of juveniles inhabiting in seagrass beds as a nursery ground
- Sub-lethal amounts of oil and its derivatives penetrates into body tissues and may reduce the tolerance to stresses (Ziemann et al., 1984).

The use of dispersants has a negative effect on photosynthesis of seagrasses. The influence of dispersed oil on seagrasses is more vigorous than undispersed oil (Wilson, 2010).

Zostera marina affected directly from the Amoco Cadiz oil spill in 1978. Most of the meadow had blackened leaves. But this was a short term impact. The individual number and species of benthic invertebrate fauna, inhabited in seagrasses, decreased. However, with the exception of Amphipoda, healing was relatively fast (Jacobs, 1980).

4. Conclusions

Bigano and Sheehan (2006) reported that the Turkish Straits are the major danger point for oil tankers. Turkish Straits Systems (TSS) are narrow straits with heavy marine traffic and this is why there is a possibility to have accidents during transition by vessels, especially during bad weather (Ünlü, 2016). Major marine accidents and oil spills in the Sea of Marmara were summarised by Ediger et al., (2016).

The filamentous, sheet-like and calcareous algal communities are common in the İstanbul Strait while the sensetive macrophytobenthic taxa (brown alga *Cystoseira* spp., calcareous algae, marine angiosperms *Posidonia oceanica* and *Cymodocea nodosa*, etc.) are common in the Çanakkale Strait. To increase the knowledge of the effects of the oil spills (before and after accidents) on the macrophytobenthic communities detailed studies should be carried on the coast of Turkey. Oil spills may have results as reduced reproduction and germination of marine algae and angiosperms. To assess the effects of the oil spills on the macrophytobenthic communities, some sensetive taxa (*Cystoseira* spp., *Corallina* spp., *Posidonia oceanica*, *Cymodocea nodosa*, etc.) can be key species for the ecological function in the Sea of Marmara and the Turkish Straits Systems.

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POTENTIAL IMPACTS OF OIL SPILLS ON MACROZOOBENTHOS IN THE TURKISH STRAITS SYSTEM

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1. Introduction

Benthic invertebrates occur from intertidal coastal areas to the deep sea; some of them are mobile while others live sessile (immobile) on the seafloor. Macrozoobenthic species are simply defined as the invertebrates contains organisms larger than 0.5 mm. They live primarily on the surface of sediment or substratum (epifauna) or burrow into or below the sediment (infauna). Both infaunal and epifaunal invertebrates are essential food sources for larger invertebrates, demersal fishes and mammals. Macrobenthos are important associations by their contribution to marine ecosystem stability, because they have a direct function in the nutrient cycle, detrital decomposition, pollutant metabolism and secondary productivity in the sediment (Kroncke and Reissi, 2010). Bioturbation activities (sediment restructuring and aeration, transporting and mixing of sediment particles) of macrobenthic organisms directly affect structure of sediment and benthic ecosystem (Kristensen et al., 2012, Gilbert et al., 2015). They play important role in the determination of environmental quality status, because they respond very quickly under natural and anthropogenic pressures (Pearson and Rosenberg, 1978). Because of their limited mobility, different life styles, high diversity and abundance, they are used as ideal biological indicators of different types of pollution in the marine ecosystems. Since they have predominantly sessile life style, they are exposed to all kind of disturbance and sediment contamination and have varied response to stress depending on the species durability (Gómez Gesteira and Dauvin, 2005).

2. Evaluation of Current Status of Macrozoobenthos in the Turkish Straits System

The pioneer studies in the Sea of Marmara and the Turkish Straits were performed by Forskal (1775), Colombo (1885) and Ostroumoff (1896). The early investigations in the area were done in 1900s by Turkish and foreign scientists (La Greca, 1949; Demir, 1952-54; Caspers, 1968, Rullier, 1963; Tortonese, 1959, Ünsal, 1975; 1981; Balkıs, 1994). Among them, Demir (1952-1954) was the first Turkish scientist who studied on macrobenthic species in the Turkish Strait Systems and reported 417 species. The studies focused on taxonomy and ecology of macrobenthic species were done in 2000s to date by various authors (Gillet and Ünsal, 2000; Topaloğlu, 2001, 2016; Albayrak et al., 2004; Topaloğlu et al., 2004; 2016; Çınar et al., 2009; 2011, 2015a; Çınar and Petersen, 2011; Bakır et al., 2011, 2016; Artüz et al., 2013, 2014; Topçu and Öztürk, 2013; Kurt-Sahin, 2014; Mülayim et al., 2015a, b; Açik, 2016; Albayrak and Çağlar, 2016; Topçu and Özalp, 2016; Çinar and Giangrande, 2017; Erdoğan-Dereli et al., 2017; Meriç et al., 2018).

Recently, numerous new species have been identified in the region. Çinar and Petersen (2011) described new genus *Fauvelicirratulus* for Cirratulidae family of

Polychaeta in the Sea of Marmara. Additionally, 9 polychaetes, *Levinsenia demiri*, *L. tribranchiata*, *L. kosswigi*, *L. marmarensis*, *Prosphaerosyllis marmarae* (Çınar et al., 2011), *Marphysa cinari* (Kurt-Sahin, 2014), *Polydora brunneopunctata* (Çınar et al., 2015a), *Cirrophorus turcicus* (Erdoğan-Dereli et al., 2017) and *Pseudobranchiomma marmariensis* (Çinar and Giangrande, 2017); amphipod *Megamphopus katagani* (Bakır et al., 2011); ostracod *Cytherella maremensis* (Artüz et al., 2013) and decapod *Stereomastis artuzu* (Artüz et al., 2014) were described as new to the science. Up to date, a total of 2372 benthic species have been reported from the Turkish Straits System, of which 76 species belong to Porifera, 123 to Cnidaria, 401 to Polychaeta, 811 to Arthropoda, 598 to Mollusca and 363 to other benthic systematic groups (author's database).

3. Impacts of Oil Spill on Macrozoobenthos and Possible Community Responses of Macrozoobenthos to Oil Pollution

There is no study performed on the impacts of oil spill on macrozoobenthic communities along the Turkish coasts. For this reason, published studies around the world have been reviewed to understand the effects of oil spills on zoobenthic communities.

The benthic community structure and interactions between species can highly affect the toleration of the benthic system to environmental variables (Gilbert et al., 2015). This variability is partly explained by lifestyle differences and nutritional strategies between depositors and carnivores (Venturini and Tommasi, 2004). Oil spills potentially affect marine pelagic system (sea surface and water column) and benthic system (sea bed and coastal zone). Benthic communities are effected by oil spills in various ways, such as through changing of habitat structures, suffocation and/or poisoning of flora and fauna, and removal of the key species that may indirectly affect other components of benthic ecosystem (Baker, 2001, *in* Herkül and Kotta, 2012). Deposit-feeding and burrowing benthic invertebrates are severely impacted by chronic exposure to hydrocarbons in disturbed sediments and they build shallower burrows to avoid sediment-bound oil (Culbertson et al., 2007). It has been known that the pollution of crude oil and refined petroleum hydrocarbon originating from oil spills in coastal sediments generally causes significant structural changes in macrobenthic communities (Gilbert et al., 2015). Kingston (1992) mentioned that if the concentration of hydrocarbons in the sediment is higher than 50 ppm, the structure of the community can be affected and changed (Gómez Gesteira and Dauvin, 2005). These changes are usually related to the reduction of diversity depending on the proportion of opportunistic and tolerant species (Gómez Gesteira and Dauvin, 2000). Besides the concentration, components and toxicity levels of crude oil and the structural properties of the sedimentary (grain size distribution, organic matter content, porosity etc.) can modulate the response of the community. For the recovery of the benthic ecosystem after oil spills, oil concentration and its toxic properties must decrease to tolerated levels. Thus, the pressure on the ecosystem will reduced, the species can replace and colonize. Exposed shores which are usually under the influence of waves, are recovered faster than sheltered shores. Several studies have reported that rocky shores are usually fully cured in 3 to 4 years, while subtidal ecosystems may take up to 15 years to recover (Burns et al., 2000; Kingston, 2002; Culbertson et al., 2008 *in* Schlacher et al., 2011).

Macrozoobenthos are known to be sensitive or tolerant to oil spills. Dauvin (2000) stated that the ratio of hydrocarbon-sensitive species in the association is important because the effect of disturbance would be related the proportion.

In generally, four main phases are present for soft bottom macrobenthic communities after an oil spill: (a) a stage of rapid mortality of sensitive species (e.g. amphipods, echinoderms), (b) a stage of low species diversity and densities, (c) a stage of high density of opportunistic species (e.g. polychaetes and oligochaetes), and (d) a stage of a low diversity and density of opportunistic species after recolonization of sensitive species (Gómez Gesteira and Dauvin, 2005; Kingston et al., 1995; Hawkins et al., 2002 *in* Herkül and Kotta, 2012). Elmgren et al. (1983) and Dauvin (1987) reported rapid mortality of amphipods after oil spill. Dauvin (1987) also emphasized that weak dispersion capacity and low fecundity of amphipods cause their low colonization after oil spill. Gómez Gesteira and Dauvin (2000) also mentioned that Amphipoda (Crustacea) species, especially *Ampelisca* spp., are sensitive and they can be consider as indicator species for oil pollution while Polychaeta (Annelida) species are generally tolerate oil pollution in the sediment.

The dense population of opportunistic polychaete *Capitella capitata* was found in the sediment after "Florida" oil spill which was a major oil accident and causing serious damage to the benthic ecosystem (Sanders, 1980). The second and third year after oil spill, tolerant species *Mediomastus ambiseta* was identified in the area and replaced *C. capitata*. Dauvin (2000) studied soft bottom *Abra alba* and *Melinna palmata* community of the Bay of Morlaix (western English Channel) twenty year after "Amoco Cadiz" oil spill in April 1978. The author noticed that the community was not highly affected by the pollution and this was explained by the absence of sensitive species in the present community. The tolerant polychaete *Chaetozone setosa* and only two opportunistic polychaetes *Mediomastus fragilis* and *Tharyx marioni* were sampled after the spill (Dauvin, 2000). Elmgren et al., (1983) reported that "Tsesis" oil spill effects on the zoobenthic communities in the Baltic Sea. Although total abundance of all species of amphipod genus *Pontoporeia* and polychaete *Harmothoe sarsi* was drastically declined, bivalve *Limecola balthica* (cited as *Macoma balthica*) was more resistant and showed little or no mortality. The authors also mentioned that the meiofauna also was strongly affected: ostracods, harpacticoid copepods, turbellarians and kinorhynchs showed reductions in abundance, while nematodes were more resistant and not affected. Herkül and Kotta (2012) indicated an increase in abundances of opportunistic species (oligochaetes and polychaete *Hediste diversicolor*) following the oil spill. They also reported that the abundances of sensitive species such as amphipod *Bathyporeia pilosa* and bivalve *Limecola balthica* (cited as *Macoma balthica*) was decreased. Unlike Elmgren et al., (1983), they considered *L. balthica* as sensitive species.

4. Monitoring and Sampling Methods of Macrozoobenthos during/after Oil Spill

The use of benthic macroinvertebrates in the assessment of the ecological status of coastal and transitional waters is legislated and mandatory in the European Union by the requirements of the Water Framework Directive (WFD: 2000/60/EC) and the Marine Strategy Framework Directive (MSFD: 2008/56/EC) (Borja et al., 2009;

Zampoukas et al., 2014). Recently, "Providing Standardization in Marine Monitoring Project" was completed in collaboration with the Ministry of Environment and Urbanization and TÜBİTAK Marmara Research Centre. The aims of the project are to standardize the monitoring programs and to implement the monitoring strategies in order to assess pollution levels and ecological quality of the coastal and the transitional waters in our seas. The 12 guides prepared within the scope of the project are the first guides in line with the Marine Strategy Framework Directive (webdosya.csb.gov.tr/db/ced/menu/ deniz_izleme_klavuzlari_20180516024237.pdf). The guidelines are based on the Turkish regulations, the European Union Directives and marine monitoring and evaluation programs and monitoring matrices carried by European countries. Among these guides, Chapter 4 include Benthos Monitoring Guide.

The information of sampling techniques and monitoring of macrozoobenthos during or after oil spill is scarce. The basic principles of sampling oil spill were reported by Smith (1979). According to the author, the sampling includes two parts: (1) Sampling program to estimate the total effect; (2) Repeated sampling to investigate response over time. The samples should be collected in a grid pattern covering the affected area and the control side. All obtainable ancillary data which can be used to select subsamples for biological and chemical analysis, such as depth, slickness, color and odor of sediment should be collected. Both control and affected stations should be carefully matched for sediment type and depth. Smith (1979) also stated that the sampling plan is based on well-known classical sampling procedures. The sampling methods of macrozoobenthic species depend on substratum type of the bottom. In classical sampling, soft bottom communities are sampled by using Van Veen Grab or Box Corer, hard bottom communities are sampled by using 20x20 cm quadrant. Sediment samples should be taken as three or five replicates to perform statistical analysis. For preservation of the material, benthic samples are sieved with a 0.5 mm mesh and the retained fauna are put in jars containing 4% seawater–formalin solution (hexamine or borax buffered). In the laboratory, the material is sorted according to major taxonomic groups under a stereomicroscope and preserved in 70% ethanol (Koçak et al., 2017).

In order to determine the ecological status of the benthic ecosystem, various benthic indices (Shannon-Weiver's diversity index (H′), BENTIX, AMBI, M-AMBI, MEDOCC e.g.) are used over the world (author's database). While M-AMBI has two metric other biotic indices are based on one metric (relative abundances of ecological groups). Çınar et al., (2015b) developed a benthic index, TUBI (TUrkish Benthic Index), for the Turkish coasts. TUBI was formulated using two metrics; the Shannon-Weiver's diversity index (metric 1) and the relative abundance of three ecological groups (sensitive species, tolerant species and opportunistic species) (metric 2). The metric 2 considers these groups with different weights and eliminates sensitive species in the calculation. Since TUBI is used to evaluate and monitor the effects of organic disturbance on benthic assemblages, it can be used after any potential oil spill to determine affected benthic zone.

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THE ANTICIPATED EFFECTS OF OIL SPILL ON FISH POPULATIONS IN CASE OF AN ACCIDENT ALONG THE TURKISH STRAITS SYSTEM – A REVIEW OF STUDIES AFTER SEVERAL INCIDENTS FROM THE WORLD

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1. Introduction

Fish species are extremely diverse in Mediterranean and Black Seas because of the heterogeneity of the seas with respect to hydrography, bathymetry and productivity (Zenetos et al., 2002) but also to the varying cultural, social and economic conditions across the Mediterranean coastline (Papaconstantinou and Farrugio, 2000; Stergiou et al., 2016). Nearly 400 species of fish, crustacean, and molluscs are being exploited by numerous fishing gears and methods in the Mediterranean Sea, yielding over one million tonnes of catches according to official statistics (FAO, 2016). Classical fisheries science maintains that when there are more fish in the water, sustained catches could be obtained with much less fishing effort and much less impact on the ecosystem (Beverton and Holt, 1957; Murawski, 2010). The potential catch increases do not account for interactions among species such as prey-predator relationships and competition for resources (Horbowy and Luzenczyk, 2016), changes in the fishing tactics and new fisheries regulations (McGarvey et al., 2016) as well as human factor, environmental changes and climate forcing (Alheit et al., 2014) may also play a role in fish population dynamics.

FAO (2003) states ecosystem approach to fisheries (EAF): "*(…) the purpose of EAF is to plan, develop and manage fisheries in a manner that addresses the multiplicity of societal needs and desires, without jeopardizing the options for future generations to benefit from marine ecosystems*" (FAO, 2016).

There are two types of barriers indicated for implementing ecosystem approach under major knowledge gaps which are defined as deficiency of scientific understanding of the ecosystem dynamics including human factor and science as basis for management (Hansson et al, 1999). On the other hand, if time series of fishing pressure and biomass change namely fisheries reference points for fish stocks can be assessed, a baseline for stock status can be achieved and lead to focus on how stocks can be affected by other ecosystem components in the past for evaluating existing literature and can be affect in future hypothetically.

It is generally accepted that Exxon Valdez oil spill (Peterson et al., 2003) and the Deepwater Horizon disaster (Crone and Tolstoy, 2010; Kerr et al., 2010, Langangen et al., 2017) were caused suffering of fish populations. Overall post spill analysis of a few major events constitute our basic understanding on the consequences of oil uptake by fish stocks (Peterson et al., 2003; French-McCay, 2004; Incardona et al., 2014; Carroll et al., 2018). Among them, short-term monitoring studies conducted right after the disasters, conclude that oil spill influences to populations evolve almost solely from acute mortality (Peterson et al., 2003). For example, according to Rice et al. (2001), oil impact to fishes was anticipated mainly on testing acute toxicity for short term (~4 days) laboratory exposures to the water-soluble fraction with majority of 1- and 2- ringed aromatic hydrocarbons (PAHs), through acute narcosis mortality at ppm concentrations. However, Peterson et al. (2003), assume this as an old paradigm and described an emerging appreciation on oil toxicity as, fish embryos' long-term exposure to weathered oil (3- to 5- ringed PAHs) at ppb concentrations which causes populations to have indirect effects like growth abnormalities and behavior with long-term effects on mortality and reproduction.

Whilst only few studies have exhibited enhanced mortality of fish as a consequence of oil spills (IPIECA, 1997; Hjermann et al., 2007; Fodrie et al., 2014), fish stocks which spawning areas or egg and larval distribution extensions, close to oil spillage location are considered to be especially vulnerable (Hjermann et al., 2007; Rooker et al., 2013, Langangen et al., 2017).

Besides being an exceptional marine ecosystem, Turkish Straits System (TSS) is a very important marine transportation route. However, the heavy maritime traffic through TSS gives rise to accidents and consequently oil spills, which can toxify this peculiar environment. According to Bozkurtoğlu (2017), there have been over 40 heavy accidents occurred in the İstanbul Strait since 1960.

The aim of this study is to draw attention to an oil spill accident's potential in initiating a sequence of destructive alterations and finally leading to collapse of delicate fish stocks. We tried to gather available knowledge of oil spill effects on fish species, considering the changes in their bio-ecological situations. In the scope of several studies conducted after major oil spill incidents worldwide, we target to present a basic guide for scientists and authorities to intervene efficiently and to evaluate the effected fish populations properly in case of an accident along the TSS.

2. Importance of the Subject Area in terms of Fish Diversity, Species Bio-ecology and Fisheries Industry

From north to south; the İstanbul Strait, the Sea of Marmara and the Dardanelles Strait constitute the Turkish Straits System which is unique as a transitional zone between the Mediterranean and the Black Sea, owing to its geographical and hydrological characteristics. It extends along, a corridor, as a barrier, or/and an acclimatization zone for marine life (Öztürk and Öztürk, 1996). The Sea of Marmara functions as a barrier by limiting the dispersal of high saline Mediterranean species and/or low saline Black Sea species. The Sea of Marmara is also a substantial biological corridor for many migratory species of fish including economically important and endangered species, also marine mammals and birds. As an acclimatization zone, some Mediterranean species adjust to the conditions of the Black Sea and/or the Black Sea species to the Aegean Sea (Öztürk, 2006).

Fishes of the Turkish Straits System: According to current studies, the Sea of Marmara hosts 257 fish species and it is the third in terms of species diversity, after Aegean Sea and the Mediterranean coasts of Turkey (Bilecenoğlu et al., 2014).

Fishery in the Sea of Marmara covers about 8% of Turkish marine fish production and largest part of this rate belongs to the small pelagic species. 10% of the small pelagic fish catch in Turkey is obtained from the Sea of Marmara. The most abundant small pelagic species are anchovy (*Engraulis encrasicolus*), European pilchard (*Sardina pilchardus*) Mediterranean horse mackerel (*Trachurus mediterraneus*), European sprat (*Sprattus sprattus*) amd Atlantic horse mackerel (*Trachurus trachurus*). Additionally, there are economically important large pelagic predators like swordfish (*Xiphias gladius*), tuna (*Thunnus thynnus*), bluefish (*Pomatomus saltatrix*) and bonito (*Sarda sarda*). Main demersal fishes can be listed as whiting (*Merlangius merlangus*), surmullet (*Mullus surmuletus*), goatfish (Mugilidae spp.), European hake (*Merluccius merluccius*), anglerfish (*Lophius piscatorius*) and salema (*Sarpa salpa*) (Demirel and Gül, 2016).

A total of 49 fish species from the Sea of Marmara are protected under several international protocols (Bern, Bonn and Barcelona) and/or listed in IUCN Red List, with the highest 4 conservation status; Critically endangered (CR), Endangered (EN), Vulnerable (VU) and Near threatened (NT) (Table 1.).

These 49 species are extracted from:

- Appendix II (Strictly Protected Fauna Species) and Appendix III (Protected Fauna Species) of Bern Convention as known as: "Convention on the Conservation of European Wildlife and Natural Habitats" (https://www.coe.int/en/web/conventions/full-list/-/conventions/treaty/104),

- Appendix I (Endangered Migratory Species) and Appendix II (Migratory Species Conserved Through Agreements) of Bonn Convention as known as: "Convention on the Conservation of Migratory Species of Wild Animals (CMS)" (https://www.cms.int/en/species),

- Annex II (List of Endangered or Threatened Species) and Annex III (List of Species Whose Exploitation is Regulated) of Barcelona Convention as known as: "Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA / BD)" (UNEP/MAP-SPA/RAC, 2018a,b)

- IUCN Red List of Threatened Species (Table 1.) (https://www.iucnredlist.org/search)

The Sea of Marmara as a Spawning Area: Owing to its high nutritious content and high density of plankton, the Sea of Marmara represents a spawning and nursing habitat of many species. Economically valuable fishes like Atlantic mackerel (*Scomber scombrus*), bonito and bluefish enter the Sea of Marmara for breeding and feeding and spend a part of their life here (Demir,1961; 1969; 1975). Eggs and larvae of 21 fish species have been determined in the area according to a doctoral dissertation and master thesis as well as final reports of research projects (Yüksek, 1993, Okuş et al., 1998; Demirel 2014).

Table 1. Fish species from the Sea of Marmara, protected under several international protocols (A.: Appendix/Annex, *: Economically important).

Scientific name	**Common name**	**IUCN status**	**Bern A.II**	**Bern A.III**	**CMS A.I**	**CMS A.II**	**SPA/BD A.II**	**SPA/BD A.III**
Hexanchus griseus	Bluntnose sixgill shark	NT						
Carcharodon carcharias	Great white shark	VU	+		+	+	+	
Lamna nasus	Porbeagle	VU		+		+	+	
Alopias superciliosus	Bigeye tresher shark	VU				+		
Alopias vulpinus	Common tresher shark	VU				+		+
Scyliorhinus stellaris	Nursehound	NT						
Galeorhinus galeus	Tope shark	VU					+	
Mustelus asterias	Starry smooth-hound							+
Mustelus mustelus	Common smoothhound	VU						+
Prionace glauca	Blue shark	NT		+		+		+
Dalatias licha	Kitefin shark	NT						
Oxynotus centrina	Angular roughshark	VU					+	
Centrophorus granulosus	Gulper shark							+
Squalus acanthias	picked dogfish	VU				+		+
Squatina oculata	Smoothback angelshark	**CR**					+	
Squatina squatina	Angelshark			+	+	+	+	
Dipturus batis	Blue skate	**CR**					+	
Dipturus oxyrinchus	Longnose skate	NT						
Raja asterias	Starry ray /skate	NT						
Raja clavata	Thornback ray / skate	NT						
Raja radula	Rough ray / skate	**EN**						
Gymnura altavela	Spiny butterfly ray	VU					+	
Chimaera monstrosa	Rabbitfish	NT						
* *Acipenser gueldenstaedtii*	Danube sturgeon	**CR**				+		
* *Acipenser nudiventris*	Fringebarbel sturgeon	**CR**				+		
* *Acipenser stellatus*	Starry sturgeon	**CR**		+		+		
* *Acipenser sturio*	Atlantic sturgeon		+		+	+	+	
* *Huso huso*	Beluga		+	+		+	+	
* *Alosa fallax*	Twaite shad			+				+
* *Anguilla anguilla*	European eel	**CR**				+		+
Hippocampus guttulatus	Long-snouted seahorse		+				+	
Hippocampus hippocampus	Short-snouted seahorse		+				+	
Syngnathus abaster	Black striped pipefish			+				
* *Epinephelus marginatus*	Dusky grouper	**EN**		+				+
* *Pomatomus saltatrix*	Bluefish	VU						
* *Trachurus trachurus*	Atlantic horse mackerel	VU						
* *Dentex dentex*	Common dentex	VU						
* *Pagellus bogaraveo*	Blackspot seabream	NT						
* *Sciaena umbra*	Brown meagre	NT		+				+
* *Umbrina cirrosa*	Shi drum			+				+
Labrus viridis	Green wrasse	VU						
Ponticola syrman	Syrman goby			+				
Pomatoschistus minutus	Sand goby			+				
Zosterisessor ophiocephalus	Grass goby			+				
* *Thunnus alalunga*	Albacore	NT						
* *Thunnus thynnus*	Atlantic bluefin tuna	**EN**						+
* *Xiphias gladius*	Swordfish							+
Balistes capriscus	Grey triggerfish	VU						
Mola mola	Ocean sunfish	VU						

3. Major Oil Spill Accidents and Studies on Affected Fish Populations

Exxon Valdez Oil Spill (EVOS), 1989: According to Peterson et al. (2003), before EVOS, in case of a contamination, mainly short-term monitoring studies and acute toxicity observations on laboratory-tolerant species were conducted in order to construct risk assessment models to anticipate ecological effects of PHCs. Peterson et al. (2003) also suggest a change on the prevailing practices used to assess ecological risks of oil other toxic sources and note that ecosystem-based toxicology should be developed for a better understanding and prediction on chronic, delayed, indirect long-term threats and impacts. There are studies documenting consecutive events affecting the survival or reproduction of organisms indirectly, following sub-lethal exposures. Sub-lethal consequences such as abnormal development in the early life stages of fish species were revealed by controlled laboratory studies. Oil exposure led to reduced growth rates in salmon fry, Pink salmon survival was also decreased indirectly, due to size dependent predation in the marine stage of their life cycle (Rice et al., 2001; Willette et al., 2000). Heintz et al., (1999) demonstrated, returning pink salmon (which had been exposed to oil previously in 1993, while they were embryos and fry) have reduced survival for their embryos. This is an impressive example to the reproductive impairment from sub lethal dosing. Definitive experimental studies revealing sub lethal exposure as a reason to compromised survival and reproduction, adjust our knowledge on xenobiotics exposure during sensitive early stages in vertebrate development causing increased mortality and reproductive deterioration in later life stages by means of endocrine perturbation and abnormalities in development (Arkoosh and Collier, 2002). Abnormal development occurred in herring and salmon after exposure to the Exxon Valdez oil (Marty et al., 1997; Carls et al., 2001).

Prestige Oil Spill (POS), 2002: Martínez-Gómez et al., (2006) declare that there were no studies conducted in the northern Iberian Shelf with biomarkers of contaminant exposure or impacts on fish. They aimed examine series of biomarkers on fish species after the accident in order to determine impairment from toxicity, and to find out the effectiveness of the chosen biomarkers in *L.boscii* (four-spotted megrim) and *C.lyra* (dragonet), to be evaluated for bio monitoring programmes along the area. In conclusion they explained the applied biomarkers in these two demersal species can be used to determine various biological responses among regions of Iberian shelf. The results also show, *C. lyra* and *L. boscii* as favorable target species to be evaluated in biomonitoring programmes. The findings also suggest that oxidative stress increase in *L. boscii* may be caused by oil spill which led to exposure of hydrocarbons.

Deepwater Horizon Disaster (DHD), 2010: After the last major US oil spill (the 1989 EVOS in Alaska), developing fish embryos were exposed to be mostly sensitive to crude oil which is very toxic. The northern Gulf of Mexico where DHD took place, embraces important spawning and rearing habitats for many economically and ecologically valuable pelagic fish species like; mahi mahi (Figure 1), yellowfin tuna and bluefin tuna king, greater and lesser amberjack, and Spanish mackerels, sailfish, cobia and blue marlin, Yellowfin tuna (*Thunnus albacares*) and greater amberjack (*Seriola dumerili*) are very important for commercial fisheries. As well, Atlantic bluefin tuna (*T. thynnus*) was petitioned for the list under the US Endangered Species Act. Unfortunately the oil leakage into the ecosystem from the damaged DH/MC252 overlaps with the temporal spawning season of these pelagic fishes. The loss of early life phases of these and other pelagics, due to oil contamination in spawning habitats is a crucial issue for fisheries management and conservation (Incardona et al., 2011).

Regarding the results of their study, Incardona et al., (2011) declared the developing spawn (embryos and larvae) of large pelagic predator fish species were found to be potentially exposed to PAHs derived from crude oil. PAH induced cardiotoxicity that fish embryos are especially vulnerable, and abnormalities in heart physiology and morphology can lead to acute and delayed mortality. With their high aerobic demand, cardiac function is specifically crucial for fast-swimming pelagic predators. They have also indicated that, the cardiac development of local fishes, as being exceptionally delicate to and reliable indicator of crude oil effects should be focused on during vulnerability determination studies in different ocean habitats, including the Arctic.

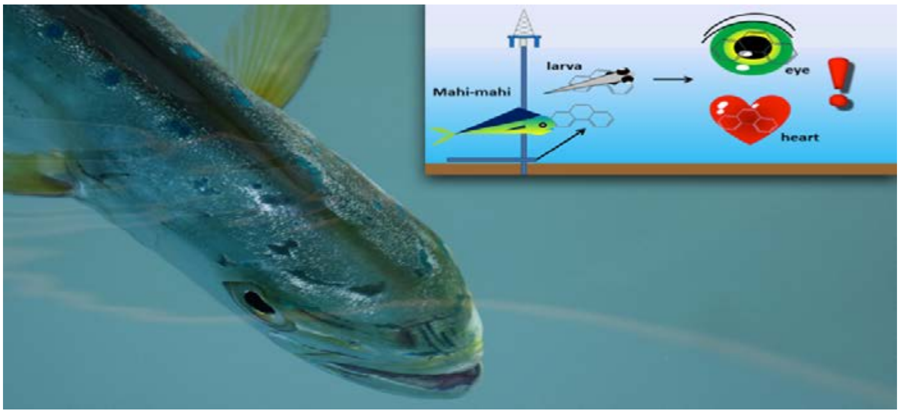

Figure 1. Study on the effects of oil spill exposure on mahi mahi (*Coryphaena hippurus*) after Deepwater Horizon accident (Xu et al, 2016).

4. Major Accidents in the Sea of Marmara and Necessary Strategy for Monitoring

Bozkurtoğlu (2017), pointed out the intense maritime traffic through the İstanbul Strait as having a potential to cause considerable ecological threats to the local environment. However, after a numerous accidents occurred, we still have a very few knowledge on the effects of oil on local fish populations.

Independenta / Evriali (Romanian tanker / Greek freighter - 1979): collided at Haydarpaşa. An enormous explosion occurred. The tanker sank and spilled approximately 94,000 tons of oil, 30,000 tons of which kept burning for days. Wreck stayed grounded and affected the area for some years. Crude oil sank to the bottom covering an area of approximately 5.5 km in diameter. Large amounts of dead fish were found in the Sea of Marmara (Baykut et al., 1985; Öztürk et al., 2006; İstikbal, 2006; Bozkurtoğlu, 2017). Following the Independenta/Evriali marine collision in 1979, which caused significant economic and ecological damages particularly for fisheries (damage of fishing nets, boats) fifteen fishery cooperatives were compensated with the total amount of 291,500 USD (Öztürk and Balcıoğlu, 2017).

Blue Star / Gaziantep (Panama tanker / Turkish crude oil tanker – 1988): Blue Star was loaded ammoniac and huge quantities of ammoniac polluted the area (İstikbal, 2006).

Nassia / Shipbroker (Southern Cyprus oil tanker / Southern Cyprus bulk carrier - 1994): collided at the northern entrance of the İstanbul Strait. 20 thousand tons of oil spilled into the Black Sea, İstanbul Strait and the Sea of Marmara. The tanker burned for several days. Thick oil and pitch covered the coastline, bays and beaches. Many marine mammals were found dead along the area as well as benthic organisms and sea birds (Öztürk et al., 2006; İstikbal, 2006).

Volganeft 248 (Russian oil tanker - 1999): grounded and broke in two and sank at the southern entrance of the İstanbul Strait. 1,200 tons of fuel oil spilled and caused 90% mortality of marine life. Black goby (*G. niger*), common sole (*S. solea*), flathead grey mullet (*M. cephalus*) and tub gurnard (*C. lucerna*) were among the marine organisms found dead along the polluted area (Öztürk et al., 2006; İstikbal, 2006; Bozkurtoğlu, 2017).

Gotia (Russian oil tanker - 2001): collided to Emirgan Harbour wall. 22 tons of oil spilled into the İstanbul Strait and exterminated all mussel beds (Güven, 2002).

Svyatoy Panteleymon (Georgian cargo ship - 2003): grounded close to Anadolu Feneri, northern entrance of İstanbul Strait. 220 tons of diesel and 260 tons of fuel oil spilled into the sea contaminating the fishing grounds of up to 2 miles off the shore. Spawning areas of commercially important demersal fish species like sole, flounder and turbot were spoilt (Öztürk et al., 2006; Bozkurtoğlu, 2017).

5. Conclusion

Fishes are one of the vital constituents of marine ecosystem. Especially, small pelagic fishes have an important role in this system, regarding their interaction with both lower and upper trophic levels of the food chain (Palomere et al., 2007). Small pelagic fish species, like pilchards and anchovies, stand in a fundamental position during transferring energy in food webs. They often constitute the main bond between primary (phytoplankton) and secondary (zooplankton) production and large predators. This trophic position is called the 'wasp's waist' since small pelagic fishes feed on many species and are eaten by many species. They are also short living species, with highly vulnerable egg and larval recruitment to changes in atmospheric and oceanographic conditions (FAO, 2016). Having 10% of the small pelagic fish catch of the country, the Sea of Marmara needs a special attention for the protection of its inhabitants. Among 257 fish species, 49 of them are evaluated vulnerable for protection and conservation. Angelsharks (*Squatina* spp.), first degree endangered species are known to distribute and consider the Sea of Marmara as a breeding zone (Yüksek, 1993), 17 species have high economic value such as; Atlantic horse mackerel (*T. trachurus*), common dentex (*D. dentex*), brown meagre (*S. umbra*), dusky grouper (*E. marginatus*) and Atlantic bluefin tuna (*T. thynnus*) etc. These sensitive species' populations may suffer rather badly from an oil contamination with regard to their status. Any stock decrease or even collapse may cause huge problems economically and environmentally.

In order to guide the authorities in determination of the short-term oil spill response and related operations, Bozkurtoğlu (2017), aimed to constitute a mathematical model predicting oil spill mobility on the surface waters. A basic yet operative transport model was established to lead civil protection authorities in the arrangement of contingency plans for İstanbul Strait and to manage and clean oil spills effectively. Bozkurtoğlu (2017) studied on three main subjects:

a) The speed of the spilt oil until it reaches the shoreline in certain circumstances
b) Directions of the spilt oil's dispersion until it reaches the shoreline
c) Time span the spilt oil remains in the region

Results of the model reveals that in case of an oil spill in İstanbul Strait, the contamination is likely to reach both European and Asian coasts in a couple of hours. An oil slick originated from a spill in the northern entrance of the strait can spread through İstanbul Strait and reach both eastern and western sides in 1-2 hours and the southern end in only 8-10 hours. Thus it is important to act immediately and to carry out an emergency action plan in accordance with the procedures gathered from scientific simulation studies.

Regarding the results of many studies conducted after major oil spill incidents we can clearly see, fish populations are subject to contamination from oil and other related chemical compounds those enhance acute, chronic and/or delayed diseases, also mortality, that can still be observed even in the decades following the exposure. Therefore reviewing all existing knowledge on bio-ecological characteristics of fish populations and performing monitoring studies to understand effects of a possible oil spill exposure is crucial.

For this reason, following information for fish populations and accident pattern should be taken into consideration:

a) Spatial structure of natural mortality,
b) Spawning season and regions,
c) Behavior of fish larvae such as vertical migration,
d) Current speed and direction to understand water movement,
e) Location and covered area of the oil spill,
f) Toxic level of various oil-components,
g) Sensitivity of species and their life stages of different toxicity.

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ESTIMATED IMPACTS OF AN OIL SPILL ON BIRD POPULATIONS ALONG THE TURKISH STRAITS SYSTEM

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1. Importance of Turkish Straits System for Bird Populations

The Turkish Straits System holds two marine Important Bird Areas (mIBAs) namely, Istanbul and Çanakkale Straits (Figure 1).

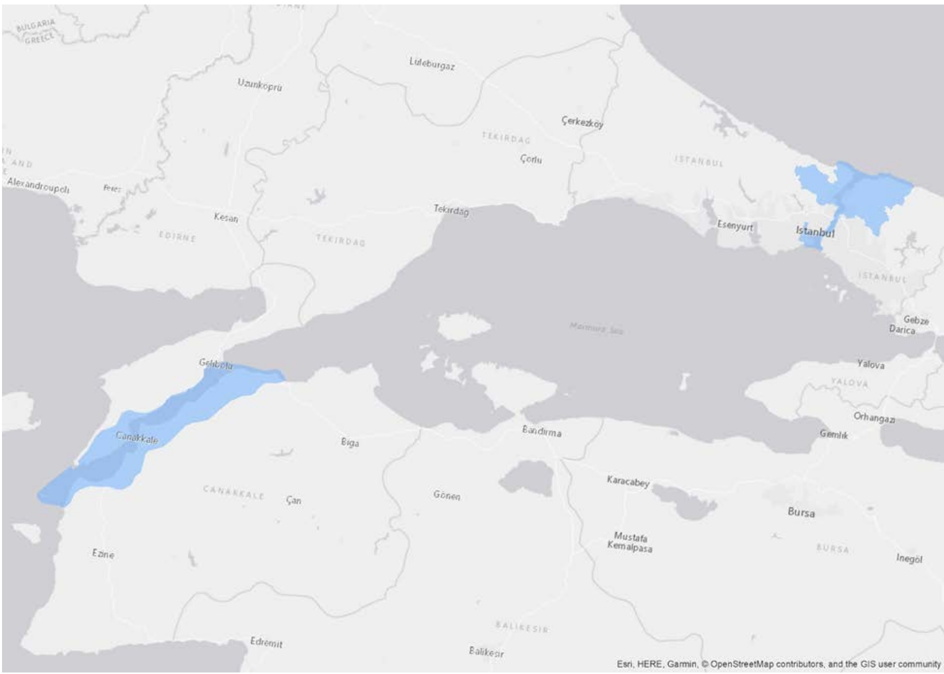

Figure 1. Marine Important Bird Areas within the Turkish Straits System.

Both mIBAs have international importance for Yelkouan Shearwater *Puffinus Yelkouan* (Acerbi, 1827) which is categorized as a Vulnerable Species by The International Union for Conservation of Nature (IUCN) Red List of Threatened Species (BirdLife International, 2016). The global population of the species was predicted as 15.337-30.519 pairs equating to 46 to 92 thousand individuals according to their population assessment covering entire ranges of the species (Derhé, 2012). However, a recent study by Şahin et al., 2015 reported 75 to 90 thousand individuals from an early February count at Istanbul St mIBA. This relatively recent study once more put an emphasize on the importance of Turkish Straits System for bird populations. İstanbul Strait mIBA is also important for resident *Phalacrocorax aristotelis* (Linnaeus, 1761) (ca. 450 ind.), wintering Great Cormorant (*Phalacrocorax carbo* (Linnaeus, 1758)) (ca.

3.456-10.000 ind.), wintering Black-headed Gull (*Larus ridibundus* Linnaeus, 1766) (ca. 15 thousand ind.) and passage Mediterranean Gull *Larus melanocephalus* Temminck, 1820 (ca. 14,000 individual) populations (BirdLife International, 2018).

2. How Oil Spills Effect Birds

Seabird populations are among most vulnerable to oil spills than most other marine animals due to their behavior such as foraging, distribution, and breeding behavior. In order to follow spilling, crude oil floating on the surface water causing seabirds to become smothered with oil and immediate mortality (Camphuysen and Leopold, 2004). Mass mortalities of seabirds are common as an adverse impact of oil spills with tens of thousands of birds stranding dead (Castege et al., 2007). The most common species of birds that live near the coast and other bodies of water such as ducks, pelicans, gulls, yelkouans, shags and terns are most affected. When the oil reaches the shore, shorebirds such as plovers, avocets, sandpipers and oystercatchers as well as migratory birds can be harmed significantly.

The impact of oil spills can be investigated as direct (short-term) and indirect (long-term) impacts.

The most obvious way oil affects birds are by coating their disrupting feather integrity displacing insulating air between feathers leading to loss of water-proofing, thermal insulation, and buoyancy (Jenssen, 1994). Thus, the seabirds would unable to dive or fly to forage for food. As a result of starvation, fat reserves deplete, and, in the end, hypothermy affects birds severely which leads to definite mortality.

Ingestion of oil via preening and feeding leads to exposure to toxic polycyclic aromatic hydrocarbons (PAHs) which can constitute up to 30% of total hydrocarbons. Long-term effects of ingestion of oil on seabirds include pathological changes at organ and system level (Troisi et al., 2016). Ingestion of oil also has adverse effects on reproduction systems of seabirds which leads to a reduction in hatchability and eggshell thickness. Also, cases of malformed chicks are reported after oil spills (Helm et al., 2015).

Long-term impacts of oil spills are degradation of breeding, foraging or staging habitats and bioaccumulation in the food web. Seabirds use a variety of marine habitats during their lifecycle. Many species such as terns, gulls breed on coasts forming relatively large colonies. Coastal waters are used as staging areas or foraging areas which are crucial for a healthy population. Moore (2018) reviewed long-term ecological impacts of marine oil spills from fifteen different incidents around the world and on different habitat types. His findings show that it takes up to a decade for a coastal habitat to totally rehabilitate from a severe oil spill. Long-term impacts of oil spills are still an unknown area of study for marine scientists and need long-term monitoring at species, trophic, habitat and phenology level.

The earth witnessed mass deaths of seabirds at specific oil spills around the world. Among these most destructive ones are the Deepwater Horizon, Exxon Valdez and Prestige incidents.

Deepwater Horizon oil spill on 20 April 2010 discharged oil continuously into the Gulf of Mexico for 86 days. During the spill about 6.7×10^8 liters of liquid petroleum into the Gulf, approximately 3.3×10^8 liters covered the sea surface (McNutt et al., 2012). Haney et al., 2014 estimated the mortality of seabirds as 200.000 using an exposure probability model.

Exxon Valdez accident happened on 24 March 1989 on Bligh Reef, Northeastern Prince William Sound causing $41x10^6$ liters of crude oil spill. Murres *Uria aalge* (Pontoppidan, 1763) had the highest number with a rate of 74%. Moreover, it is tated that one colony of 129,000 murres individuals from the Barren Islands could be eradicated. Another 7.000 birds were retrieved between 1 August and 13 October (Piatt, 1990). Wiens et al., 1996 predicted the total seabird mortality of 100.000 to 300.000 birds using a model based on 11 survey cruises between June 1989 and August 1991.

As a result of the split in the hull of Prestige oil tanker on 13 November 2002, heavy bunker oil off the coast of Galicia were spilled, Northwest Spain. Following the next 6 days, approximately 19.000 tons of oil was spilled. Moreover, a further 40.000 tons of oil were released even after it sunk. Although, 340 European Shags *Phalacrocorax aristotelis* (Linnaeus, 1761) were found dead after the incident the reproductive success of the coastal seabirds dropped by 45 percent in oiled European Shag colonies (Velando et al., 2015). Moreover, Prestige oil spill is reported to adversely affect reproductive performance of Kentish Plovers *Charadrius alexandrinus* Linnaeus, 1758.

3. The Vulnerability of Marine Important Bird Areas within the Turkish Straits System

In order to better understand the vulnerability of mIBAs within the Turkish Straits System; each of the mIBAs should be investigated taking into account each of the IBA trigger species in a spatiotemporal manner.

Among the trigger species, the Yelkouan Shearwater which is a Vulnerable Species is quite important. Although the species is reported to use straits system in large numbers especially during first two weeks of February (Şahin et al., 2015), in 2018 cases of Yelkouan Shearwater bycatch in large numbers (ca. 5 birds min-1.) by anglers were reported beginning on April 17th. This bycatch incident continued for about 20 more days revealing a mass movement pattern throughout the İstanbul Strait mIBA (Doga, 2017). This phenomenon revealed that the population in the straits system should be monitored in a more effective way. It can be considered that if an oil spill occurs during such a phenomenon or during the reported migration period of the species, it can have devastating impacts on this globally vulnerable species.

Wintering congregations of Great Cormorant and Black Headed Gull also disperse along the İstanbul Strait mIBA. So, the vulnerability from a possible oil spill increases during wintering season because such a spill will increase the number of direct mortalities by coating and ingestion by preening.

European Shag is the only breeding seabird within the Turkish Straits System that trigger a mIBA. The shags which are social seabirds form breeding colonies near the protected walls and rocks beneath sea structures such as breakwaters. Oil spills have impacts on breeding colonies by covering the available habitat directly and by altering the reproductive system of individuals which leads to thinning in eggshells and malformed chicks. Also, they have long-term impacts on shag colonies which can lead to a full collapse of the breeding population.

As a result, the mIBAs within the Turkish Straits System are vulnerable to oil spills year long. The spatiotemporal structure of the incident may lead to a significant mortality for globally threatened seabirds or collapse of a breeding colony.

4. Conclusion

It is obvious that the Turkish Straits System which is home to two globally important mIBAs is quite vulnerable to oil spills because of the high amount of tanker traffic throughout the system. The impact of a possible oil spill would be a crisis in the population of a globally threatened species or can lead to the collapse of numerous breeding colonies of seabirds. On the other hand, when the technical infrastructure to overcome such an incident is considered, the impacts of the spill can be more than predicted. Thus, the following points are advised to mitigate the damage to seabirds and their natural breeding, foraging, staging and wintering habitats:

- A GIS-based fine-scale mapping of seabird breeding colonies throughout the Turkish Straits System should be conducted,
- A network of volunteers from local fishermen and bird enthusiasts should be trained as an emergency response team for handling and transportation of the seabirds to seabird rescue and rehabilitation centers,
- An expert seabird rescue and rehabilitation center should be established, and capacity of the center should be maintained,
- An overall action plan for the Turkish Straits System for a possible oil spill should be prepared in a participatory manner,
- Periodical exercises should be implemented involving relevant stakeholders to build their capacity,
- Expert workshops should be organized with the attendance of international experts to transfer know-how and transfer knowledge.

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THE EFFECT OF OIL SPILLS ON CETACEANS IN THE TURKISH STRAITS SYSTEM (TSS)

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1. Introduction

Cetaceans (dolphins and whales), are charismatic species, thus often seen as flag species in the marine conservation. Their existence indicates the healthy ecosystem of oceans, which means clean and quiet water, little human disturbance, abundant prey fish, etc. In the Turkish Straits System (TSS), connecting the Aegean Sea and the Black Sea, there are three cetecean species found regularly, namely, common bottlenose dolphin (*Tursiops truncatus*), short-beaked common dolphin (*Delphinus delphis*), and harbour porpoise (*Phocoena phocoena*). There have been records of striped dolphin (*Stenella coeruleoalba*) and Risso's dolphin (*Grampus griseus*) in recentl years (Dede et al., 2011), but they are not common in the TSS.

Although the population structure of these species in the TSS is not fully understood yet, it is clear that these animals move within/through the TSS between the Aegean Sea and the Black Sea, mainly following the prey pelagic fish, such as sprats and anchovies (Ozturk and Ozturk, 1996). These three species are all listed in the IUCN Red Data Book as Endangered (EN) or Vulnerable (VU). The Black Sea subspecies of harbour porpoise, *P. phocoena* ssp. *relicta* is EN (Birkun and Frantzis, 2008), Mediterranean subpopulation of bottlenose dolphin is VU (Bearzi et al., 2012), Black Sea subspecies of bottlenose dolphin, *T. truncatus* ssp. *ponticus*, is EN (Birkun, 2012), Mediterranean subpopulation of short-beaked common dolphin is EN (Bearzi, 2003), Black Sea subspecies of short-beaked common dolphin, *D. delphis* ssp. *ponticus*, is VU (Birkun, 2008). They are under high antropogenic stress caused by fishing (both bycatch and fish depletion by overfishing), pollution (chemical, noise and marine litter) and martime traffic (Dede et al., 2016).

2. Impacts of Oil Spill Disaster on Cetaceans Community

Regarding the effect of oil spill, in spite of the importance and popularity of the cetaceans, there has been few studies available except the cases of Exxon Valdez accident in Prince Willian Sound, Alaska and Deepwater Horizon oil spill in the northern Gulf of Mexico. The former case is well documented in Loughlin (1994). This incindent in 1989 resulted in mass mortality of marine mammals, including killer whales, *Orcinus orca*, and its impact is still continuing after more than two decades (Helm et al., 2015). In the case of Deepwater Horizon in 2010, the stranded bottlenose dolphins suffered adrenal disease, lung disease, and poor health condition at a higher rate than those in the control region (Venn Watson et al., 2015). Helm et al. (2015) indicated that the greatest threat of oil spill is probably acute respiratory injury if they are close to the oil spill site as well as incidental ingestion of oil and chronic respiratory exposure which can be the long-term damaging effect on cetaceans living in the coastal waters. As seen in these two cases, the most vulnerable animals are those in the coastal areas and the impacts can last for many years after the incidents, compromising health as well as survival and reproduction.

3. Conclusion

The TSS is one of the busiest waterways in the world, with more than 50,000 vessels per year passing through it. This makes the liklihood of accidents and oil spill quite high. In fact, there have been many accidents of vessels, such as Nassia in 1994, Volgoneft in 1999, to name a few (Ozturk and Ozturk, 2000). The direct observation of cetacean mortality, however, was reprorted only by Ozturk (1995) on the incident of Nassia. He reported that two bottlenose dolphins and eight harbour poopoises were found dead after the Nassia collision. There have been no other reports of stranded cetaceans after marine accidents in the TSS. This may be due to the fact that cetaceans are not found in the TSS constantly. Recent studies have shown that cetaceans are sighted most frequently during spring-summer period (Dede et al., 2014; Akkaya-Bas et al., 2015). If vessels accidents which leads to oil spill happen during that period, cetacean mortality can be substantially high. Thus it is necessary to keep monitoring cetaceans in the TSS. Some monitoring studies already started such as (Balcıoğlu et al., 2018). In case of such accidents, it is also important to continue monitoring on a long-term basis as the impact of oil spills can be seen long after the accidents.

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CHANGES IN THE ICHTHYOPLANKTON AND BENTHOS ASSEMBLAGES FOLLOWING VOLGONEFT-248 OIL SPILL: CASE STUDY

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1. Distribution of Fish Eggs and Larvae

Fish eggs and larvae are typically vulnerable to toxic oil compounds due to their small size, poorly developed membranes and detoxification systems as well as their position in the water column (Langangen et al., 2017). Some researchers have shown that oil or oil compounds (mainly polycyclic aromatic hydrocarbons, PAHs) at low concentrations can kill or cause sub-lethal damage to fish eggs and larvae Sub-lethal effects include (Hicken et al., 2011). The few existing in situ studies of fish mortality at spill sites indicate sub-lethal effects or elevated mortality of eggs and larvae (deBruyn et al., 2007).

The shoreline area around the city of İstanbul has experienced maritime accidents frequently due to its being located in Turkish Strait System (TSS) that has a very busy maritime traffic. It is incontrovertible that tanker accidents cause great losses in terms of economy when the significance of the Strait of İstanbul (SOI) in Turkish fisheries was considered. This study represents an assessment of the impact of an oil spill on fish egg and larvae.

Russian-registered oil tanker named as Volgoneft-248, sailed through the SOI from the Burgaz Harbour in Bulgaria and anchored off the Ambarlı oil terminal (Northeast of the Sea of Marmara) while carrying 4365 metric tons of fuel oil. She divided into two parts as a consequence of strong Southerly gales and her anchor was broken free by wind force in 29 December 1999. The bow part sank right after the dividing 1 km off the shoreline, and the aft part was drifted and grounded at Küçükçekmece Menekşe coast (Güven et al., 2005). Following the incident, 1279 tons of fuel oil split into the sea and washed ashore within a few hours due to the wind and wave actions, thus polluted a 7 km coast area at length. The fuel oil pollution on the sea surface achieved 5 cm on the shoreline. It was stated that the pollution initially affected most of the living species, particularly caused lethal impact on seabirds (Güven et al., 2005).

2. Materials and Method

Samplings were conducted in 7 stations due to distribution pattern of fuel oil in order to assess the impact of the fuel oil on fish eggs and larvae following the cleaning studies via R/V ARAR (Figure 1) in a time period starting from December 30th 1999, January 3rd 2000, February 23rd 2000, May 23rd 2000, August 15th 2000, January 26th 2001, August 10th 2001, January 25th 2002, April 20th 2003, respectively.

Ichtyoplankton samples were collected with 500 µm mesh sized Nansen type plankton net with a 57 cm diameter. Formaldehyde solution at 4% concentration was used for fixation procedure. Taxonomic identification was carried out by using Nikon SMZ-U stereomicroscope until species or genus level with the help of literature by

D'ancona (1956), Dekhnik (1973), Russel (1976), Demir (1961; 1969; 1975), Lee (1966), Mater and Çoker (2004), Yüksek and Gücü (1995).

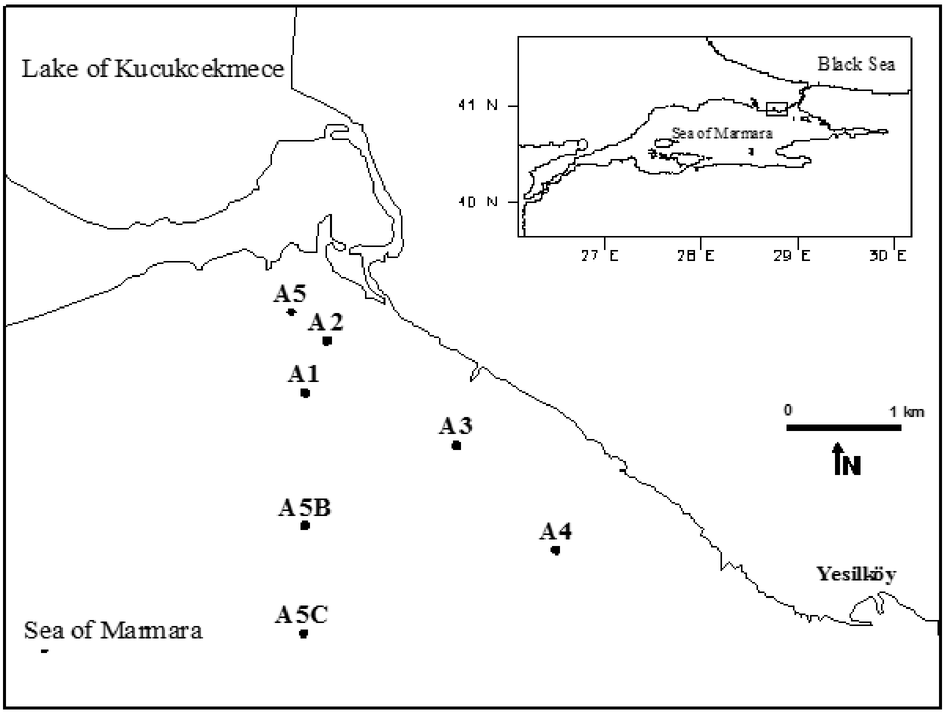

Figure 1. Study area.

3. Results and Discussion

Michel and Fingas (2015) stated that fish egg and larvae are much more sensitive to oil pollution than adult individuals are. The toxicity of petroleum hydrocarbon however depends on the water salinity and temperature and the amount of the nutrition that contaminated (Michel and Fingas, 2015), therefore data of salinity and temperature of the seawater was in situ recorded.

A permanent two-layered structure occurs in the water bodies of the Sea of Marmara (SOM) in the regions that are deeper than 20 m, and lower layer has salinity at ~38 psu and a stable temperature at 14ºC. The salinity of the upper layer increased until ~24-26 psu due to southerly winds in December 1999, January 2000 and 2001 (Güven et al., 2005). Temperature in the surface layer was 6º C in January 2002 and 26º C in August 2001 (Güven et al., 2005).

The result of taxonomic identification showed that there were 21 species of bonny fishes during sampling period and within all region under abovementioned circumstances. It was observed that 8 of the species occurred during cold and all 21 species occurred during warmer months (Table 1). Dominant species of fish egg and larvae of cold and warm seasons were *Sprattus sprattus* (sprat) and *Engraulis* *encrasicholus* (anchovy), respectively. A previous study showed a consistent seasonal pattern in terms of species occurrence in the same area in 1990.

According to the results, again *S. sprattus* was the dominant species within the following days of the accident when larvae abundance was considerably high (~ 38-140 ind/10 m^{-2}) but the vital rate calculated as to be lower than 50% in fish eggs. However, the larvae abundance that was measured as to be high in following days, reduced immediately four days after the spill in the area except fort the station A1 (Figure 2). The cause of reduction in larvae abundance that larvae was rather affected from oil pollution is originated from the swimming and feeding ability of larval phase as abovementioned.

Vital rate of the fish eggs is higher in initial phases (I-III) while it is low in embryonic phases, meaning loss was greater in developed phase than in initial phases of eggs. The decrease that continued until August 2000 in the abundance of egg and larvae thus caused by the adverse effects of oil on particularly developed phases of eggs and larvae.

Recruitment was observed in total abundance starting from August 2000; subsequently abundance and diversity achieved their highest values in August 2001 (Figure 2, 3 and 4) The spawning period of those; *Trachurus mediterraneus*, *Mullus barbatus*, *Callionymus* sp., *Symphodus* sp., *Scorpaena porcus*, *Blennius* sp., and *Gobius* sp., species of which habitats are coastal areas, is known to be in summer, caused such increase.

As an overall consequence, higher abundance of fish egg and ratio of transformation from egg to larvae were observed when oil pollution significantly decreased in August 2001 (Figure 2, 4 and 5).

When we consider winter season, it was recorded that abundance of egg and larvae remarkably heightened in January 2002 when the oil had been mostly removed from the surface, in contrast with previous winters (Figure 2, 3 and 5). The impact of an oil spill on fish populations has been ignored for many years, though some studies indicated significant knowledge of the matter. Langangen et al., (2017) stated that spatial variations in natural mortality might cause alternative effects of an oil spill on recruitment of fish populations, particularly on fish egg, larvae and juvenile phases.

This case study showed a consistent but inverse relationship between fish egg/larvae and oil hydrocarbon concentration; abundance of ichtyoplankton rapidly decreases in high concentrations of oil, increases again with the decrease of oil concentration (Figure 5).

A significant increase in the number of eggs and larvae since 2001 has clearly demonstrated the negative impact of oil pollution on fishing areas. The tanker accidents have high risk for Turkey, especially in terms of fishing and sensitive ecosystems such as İstanbul Strait and this risk is a crucial problem which must be solved in our country.

Table 1. Species list of total area.

Species List	Dec 99	Jan 00	Feb 00	Mar 00	Aug 00	Jan 01	Aug 01	Jan 02
Sprattus sprattus (Linnaeus. 1758)	*	*	*			*		*
Engraulis encrasicholus (Linnaeus. 1758)				*	*		*	
Sardina pilchardus (Walbaum. 1792)				*				
Sardinella aurita (Valenciennes. 1847)							*	
Dicentrarchus labrax (Linnaeus. 1758)				*				
Liza aurata (Risso. 1810)					*			*
Trachurus mediterraneus (Aleev. 1956)							*	
Mullus barbatus (Linnaeus. 1758)							*	
Merluccius merluccius (Linnaeus. 1758)				*			*	
Merlangius merlangus (Linnaeus. 1758)						*		
Gaidropsarus mediterraneus (Linnaeus. 1758)	*		*	*		*		*
Serranus hepatus (Linnaeus. 1758)				*	*		*	
Callionymus sp.				*			*	
Symphodus sp							*	
Scorpaena porcus (Linnaeus. 1758)					*			
Blennius sp.							*	
Gobius sp.					*			
Uranoscopus scaber (Linnaeus. 1758)							*	
Trigla lyra (Linnaeus. 1758)				*				
Microchirus variegatus (Donovan. 1808)					*	*		
Solea vulgaris (Quensel. 1806)							*	

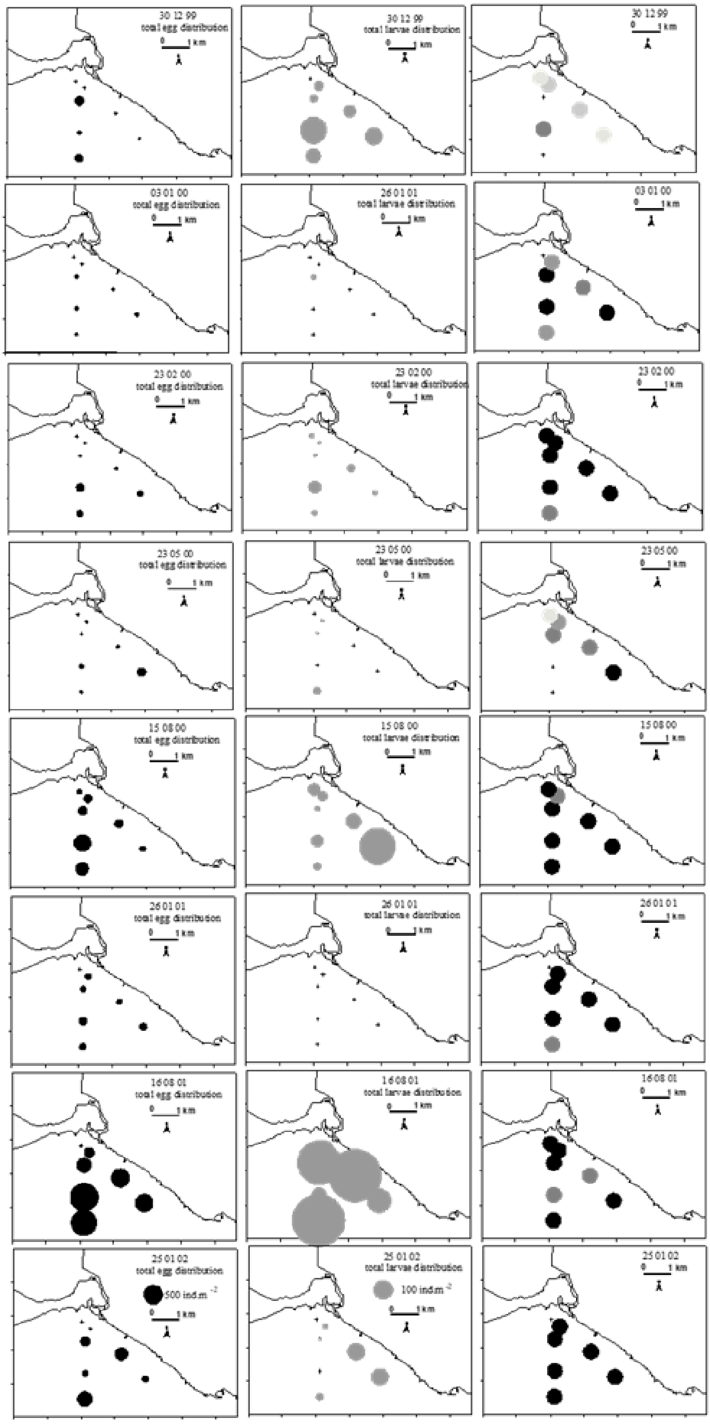

Figure 2. Distribution of fish and larvae abundance during sampling period.

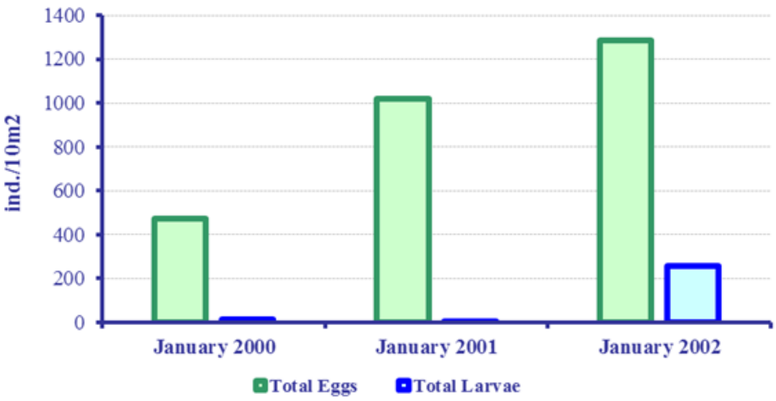

Figure 3. Total fish egg and larvae abundance in winter between 2000-2002.

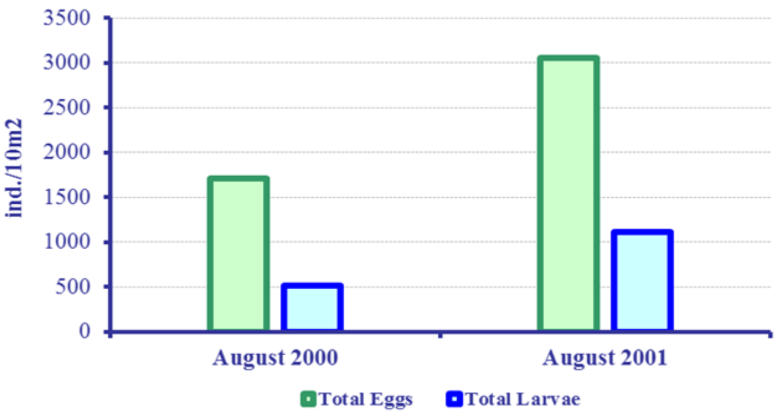

Figure 4. Total fish eggs and larvae abundance in summer between 2000-2001.

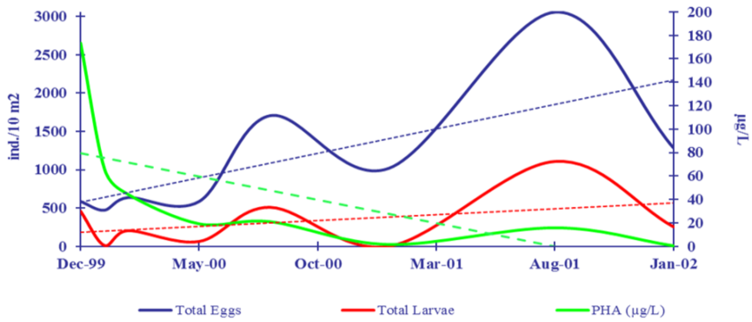

Figure 5. Total fish eggs and larvae abundance, and petroleum hydrocarbon concentration (µg g^{-1}) during sampling period.

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ASSESSING THE INITIAL AND TEMPORAL EFFECTS OF A HEAVY FUEL OIL SPILL ON BENTHIC FAUNA

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1. Introduction

The precipitated fuel oil at the sediment may cause long-term residual contamination and massive fatal effects on the zoobenthic communities (Alpar and Ünlü, 2007; Teal and Howarth, 1984). Particularly a total elimination of all species from an area was stated by Gray (1979) as to be the most dramatic effect of pollutants. Such incident occurred in late 1999 and early 2000 following an unfortunate fuel oil tanker accident caused by strong Southerly gale in the Sea of Marmara in November 1999. A total number of 3,086 tons of fuel oil spill from Volgoneft-248 was recorded, and the spilled oil washed onto the shore within few hours because of the strong southwester winds and expanded through a 7 km coast area along the Northern coast (Florya) (Güven et al., 2005). The marine flora and the fauna of the area thus lethally affected from the oil pollution directly.

The degree of the disturbance level and the recovery time of the sea bed communities are depended on the qualitative and quantitative particularities of the oil, geographic and hydrographic conditions of the shore areas such as; being exposed to wave, tide and wind actions or being sheltered, and sediment and habitat type of the seabed (Kingston, 2002). In this study, in terms of the subjected pollution effects on the zoobenthic communities, it is not possible to clarify if a full recovery occurred within approximately 3 years of monitoring program because there is no available previous data on the status of the seabed community. Nevertheless, there are some evident alterations in the community structure to distinguish the oil pollution impact, such as a rapid disappearance of the hydrocarbon sensitive species like amphipods, similarly as Dauvin (2000) stated. The aim of this study is (i) to understand the initial effects of the oil spill on zoobenthos, (ii) to interrogate if a "recovery" could be mentioned and (iii) to discuss the impact assessment methods.

2. Materials and Method

The Sea of Marmara (SOM) is an enclosed sea that connects the Black Sea and the Mediterranean via two narrow straits, thus the straits that had river like characteristics are one of the most crowded, dangerous and hazardous waterways in the world (Köse et al., 2003). The area where the accident occurred is located in the Northeast part of the sea that is open to wind and wave actions and has rocky, fine sand and muddy sediment type (Güven et al., 2005). The sampling sites were chosen according to the distribution of the fuel oil (Figure 1). And the time period was defined as to be in 30th of December (T1), December 30th 1999 (T2), January 3rd 2000 (T3), February 23rd 2000 (T4), May 23rd 2000 (T6), August 15th 2000 (T9), January 26th 2001 (T14), August 10th 2001 (T21), January 25th 002 (T26), April 20th 2003 (T41), respectively.

A total number of 62 macrozoobenthic samples from 7 stations (A1, A2, A3, A4, A5, A5B and A5C) were collected simultaneously with the monitoring studies between December 1999 and April 2003 (Figure 1). In order to assess the initial effects of the oil spill samplings were conducted first four following mounts of the accident then sampling periods were lessened to 2 times per a year representing the summer and winter seasons. Samples were preserved in 4% formalin solution and the taxonomic groups were identified until the possible lowest level of taxon tree. Additionally, hydrocarbon levels (µg g^{-1}) in sediment were also measured in the stations and given in the technical report and below (Güven et al., 2005).

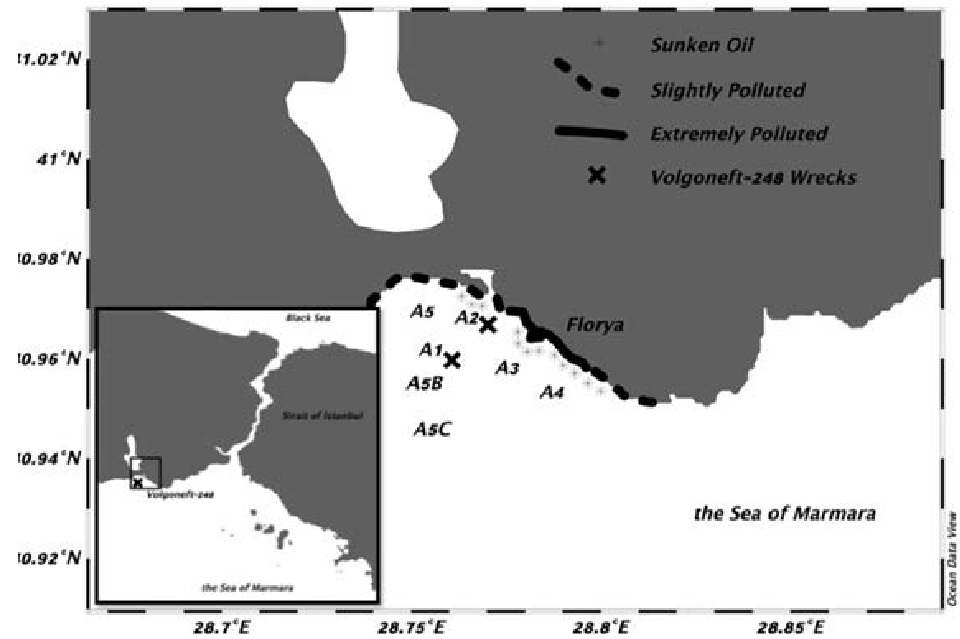

Figure 1. Study area and pollution magnitude**.**

As a common indicator of the biological diversity, Shannon-Weaver Diversity Index (H' log2 based) was calculated via using Primer 6 software. Polychaete/Amphipod ratio (I=log10 [Polychaeta abundance/Amphipoda abundance+1]), an index designed to measure the effects of oil pollution (Xu et al., 1999), is given and the index values are considered according to their being greater (polluted) or lower (non-polluted) than 1. Ecological Quality Status (EQS) was calculated by AMBI (Borja et al., 2000) and M-AMBI (Borja et al., 2004; Muxika et al., 2007) by using AMBI Software Version 5.0 and TUBI (Turkish Benthic Index) (Çınar et al., 2015) by utilizing the ecological group listing of the species in AMBI software.

The biological data were subjected to double square root transformation in order to reduce the individual number of the most abundant taxa. Similarity matrixes were obtained by using Bray-Curtis Index in PRIMER 6 Software and a Multidimensional Scale (MDS) technique was carried out for all sampling sites and periods in order to see the processes in community structure. Spearman Rank

Correlation was implemented between hydrocarbon levels and abundance, biodiversity and biomass values.

3. Results

The identified taxa distribution in all stations and years consists of 70 species, 12 genus and 2 family levels. The most frequent species among all stations and sampling periods is *Mellinna palmata* (46.77%) and it is followed by *Nephtys hombergii* (14.52%) and *Mytilus galloprovincialis* (11.29%).

In terms of total abundance, a mass decrease occurred in all the stations in the first following months. The stations of A1 and A4 are represented by maximum 7-5 (A4 and A1, respectively) and minimum 0 individuals until the 41st month (April 2003). There is no annual or seasonal cycle observed in those stations (Figure 2). In the 41st month, the individual numbers occurred to be much higher than previous years and *Ampelisca diadema* represents dominance in both stations.

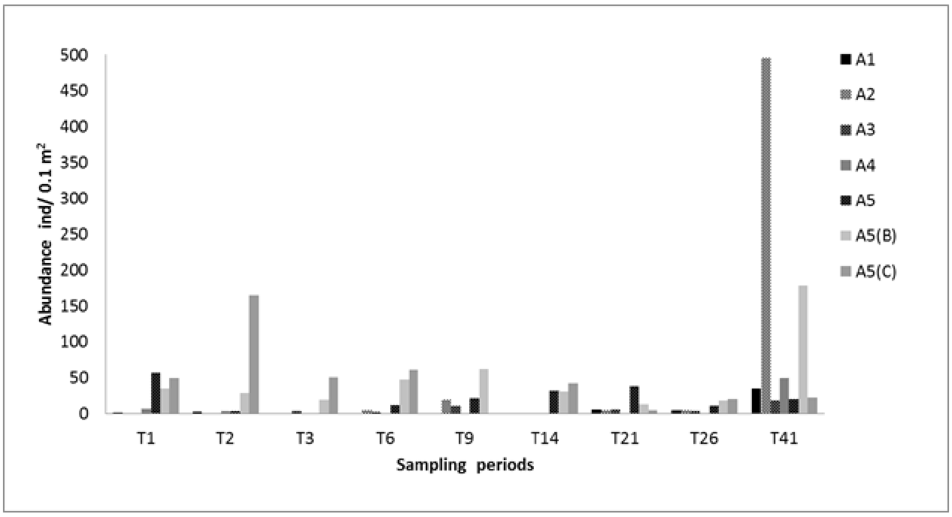

Figure 2. Total abundance of macrobenthic fauna during sampling period.

The stations located in the upper layer of permanent stratified waters of the SOM, A2 and A3, had almost a complete disappearance in terms of macrobenthic fauna, represented by 1 or 2 individuals alive until the first August after the accident when 20-12 (A2 and A3, respectively) individuals occurred. However, the following summer did not cause an increase in total abundance in both stations and (T21) again until the spring in 2003 (T41). The dominant species is an opportunistic polychaete, *Prionospio* sp. with 236 individuals and followed by an indifferent polychaete species *Spiobranchus triqueter* with 140 individuals in station A2 in April 2003. There was not an increase in abundance in station A3 as much as in A2 but still relatively higher abundance observed with 19 individuals mostly represented by a species from phylum Spincula, *Aspidosiphon muelleri* (8) and a species from Bivalvia, *Thyasira flesuosa* (5). There is only one station among the shallow stations which is the shallowest (6m) A5 that had presented an abundant community after four days of oil spill then the abundance decreased directly in following months in the station, however an improvement took place in spring (T6) right after the first winter (T1, T2, T3) and continued increasingly in first summer (T9), second winter (T14) and second summer (T21), then again a decreasing occurred in third winter (T26) followed by an increasing abundance in 4th spring (T41). The abovementioned event demonstrates an annual cycle, which is an indicating status for a “slightly affected” area according to Gesteria and Dauvin (2000). Frequently, bivalves *Mytilus galloprovincialis* and *Chamelea gallina* have been observed in the station A5.

The macrobenthic fauna in deeper stations of A5B and A5C which are relatively distant from highly contaminated shoreline, on the contrary have not disappeared totally yet continued to having an abundance with the dominance of *M. palmata* which is also the most frequent species of both and thus all stations. However, suspiciously a considerably lower value in the individual number has been observed in second summer period (T21).

Within the stations near to shoreline (from A1 to A5) some living crustaceans (decapods and only one individual belongs to genus *Ampelisca*) observed in stations A5 and A2 following the first two months after the spill then a total disappearance occurred in the abundance until the first August (T9). Such a case is evident for a destructive effect of oil on amphipods, particularly for the genus *Ampelisca*, which are known to be sensitive to hydrocarbons (Gesteria and Dauvin, 2000; Teal and Howarth, 1984). Although there is not an available previous data of the macrofauna of the benthic life within the region the individual that survived from the spill at the early stages is an indicator of an existence of amphipods before the accident.

An increase in the crustaceans was detected in summer periods however mostly consists of decapods until the 41st month when amphipods (mostly *Ampelisca diadema*) came to exist as a half of the considerably higher crustacean abundance (Figure 3).

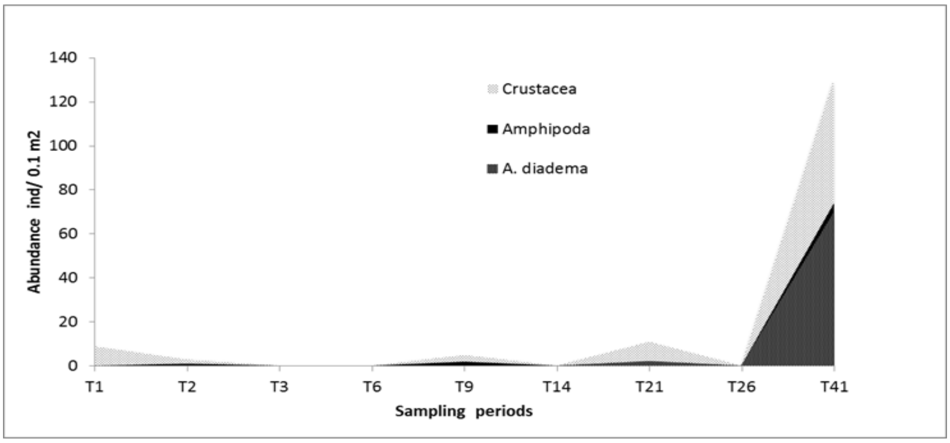

Figure 3. Crustacea, Amphipoda and Ampelisca diadema abundance in stations A1, A2, A3, A4 and A5.

The polychaetes represent the 63.3% of total abundance within all the years and stations in the area. More than half of the abundance belongs to the stations A5(B) and A5(C) which are relatively distant to the polluted coastline and have considerably higher individual number all along the sampling periods (Figure 4 and Figure 5). As we mentioned above, *Melinna palmata* is the most frequent species, however it is not always the dominant group among polychaetes, particularly it was dominated by or equally abundant with opportunistic species in station A5(B) in summer and spring periods. The stations of A5(B) and A5(C) have substantially affected the total Polychaeta abundance while being inefficient on opportunistic species abundance as Figure 4 and Figure 5 show.

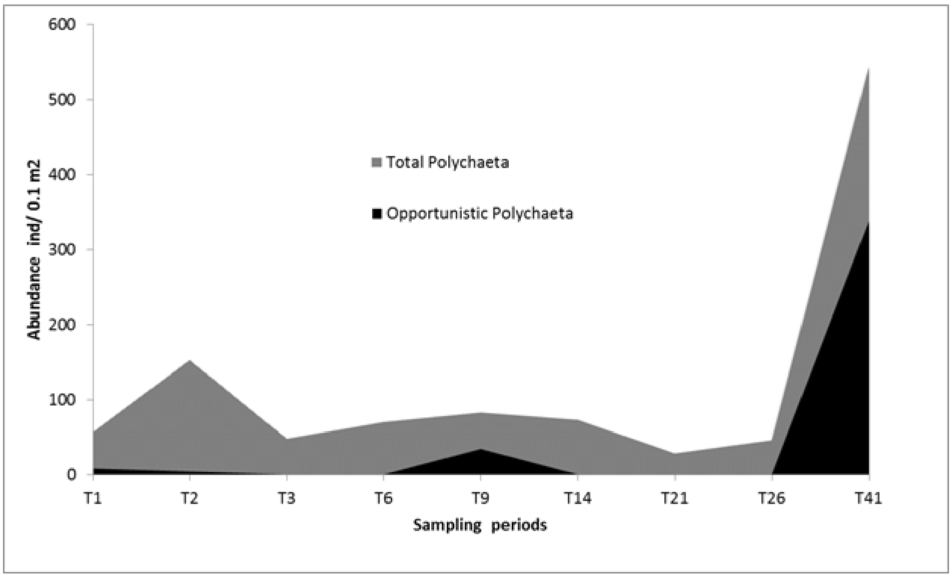

Figure 4. Total and opportunistic Polychaeta abundance in all stations (A1-A5C).

The Polychaeta abundance gradually decreased within 3 months and totally vanished in T3 in the area located close to the shoreline (A1-A5) (Figure 5), gradually increased subsequently in T6 and T9 though still not with a high number of individuals. The increase in T9 depends on the stations A2 and A5 those have *Serpiula vermicularis* and *Aphelochaeta multibranchis* (an opportunistic species) as dominant species, respectively. Once again *M. palmata* is responsible for the next increase in T21 within the stations A1 and A4, likewise in T26. Nevertheless, in T41 *Spiobranchus triqueter* and *Prionospio* sp. (an opportunistic species) in the station A2 are the fundamental reason of the high abundance.

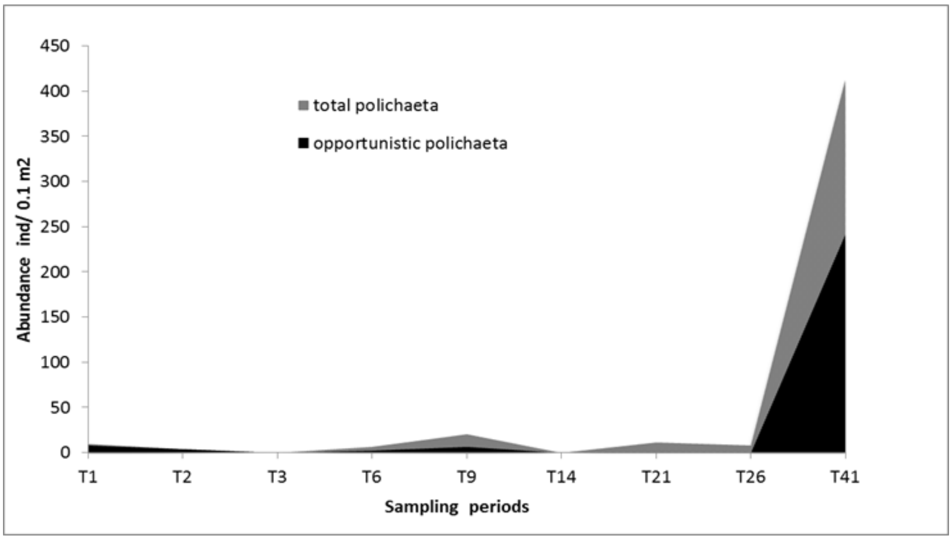

Figure 5. Total and opportunistic polychaete abundance in stations A1, A2, A3, A4 and A5.

Mollusca is the secondary group after polychaetes and frequently appeared as Bivalvia. *Mytilus galloprovincialis* is the most frequent species among the group and additionally is the most abundant. However, most of the species and the individuals inhabited in the station A5. *M. galloprovincialis* is followed by *Mactra sultrorum*, *Modiolus adriaticus*, *Chamelea gallina*, *Nassarius reticulatus*, *Paphia aurea*, respectively. The increasing of individual numbers in this case was not observed periodically in summer terms unlike total abundance; however, an increasing pattern was explicit (Figure 6). There is one outstanding output that establishes an almost complete inexistence or appearance of only a few individuals of Mollusca in the stations of A1, A2, A5(B) and A5(C) until T41.

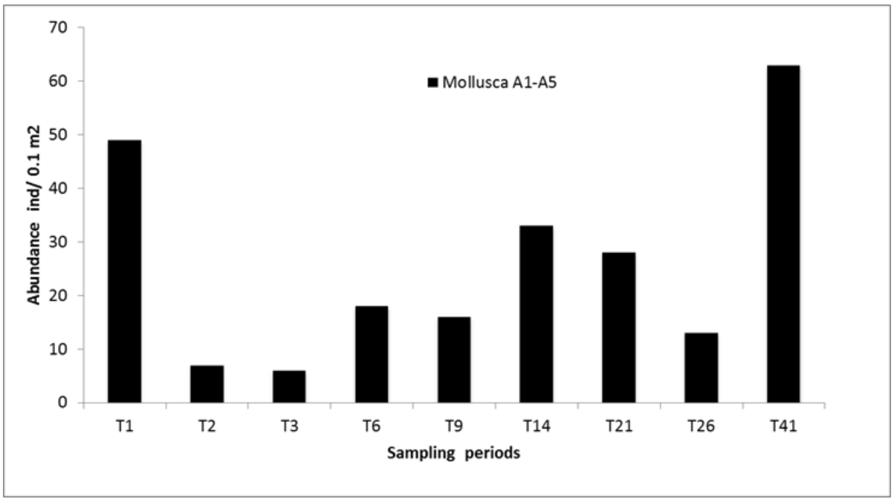

Figure 6. Total Mollusca abundance in stations A1, A2, A3, A4 and A5.

Polychaete/Amphipod ratio was considered as to be good indicator even for poorest communities that have at least a total number of 20 individuals (Dauvin and Ruellet, 2006). However, in this case there are numbers of sediment samplings that had not even one individual or had only a few, more less than 20 individuals, particularly of the stations A1, A2, A3 and A4. Actually there was only one sample that consists of 20 individuals and it belongs to the station A2 in T9 (August 2000). It can be seen in Table 1 that the results of the index $\log_{10}$ (Opportunistic Polychaete/Amphipod +1) could not even been calculated due to inexistence of either or both opportunistic Polychaeta and Amphipoda species until T41.

The index values can solely be considered in T41 (April 2003) for all stations. Neither a fluctuation nor a pattern was detected during samplings; nevertheless, some values that indicate “not polluted” status in stations A5 in T2 and in A3 in T9 and T21 as their being correspond to summer period. Approximately 3 years (in T41) after the spill, index values can be seen in all stations except for the station A5(C), and most of them have values less than 1 except for A2 in which station index value is greater than 1.

The status of the Polychaete/Amphipod ratio may be described as recruitment for the area that had been affected from oil spill.

Table 1. Opportunistic Polychaete/Amphipod ratio. Indication of ** represents the existence of only opportunistic polychaetes.

Stations	DEC 99	JAN 00	FEB 00	MAY 00	AGU 00	JAN 01	AGU 01	JAN 02	APR 03
A1	-	-	-	-	-	-	-	-	0.06
A2	-	-	-	**	-	-	-	-	1.90
A3	-	-	-	**	0	-	0	-	0
A4	**	**	-	-	-	-	-	-	0
A5	**	0	-	-	**	-	**	-	0
A5B	-	-	-	-	**	-	-	-	0.41
A5C	-	-	-	-	-	-	**	-	-

4. Diversity and Ecological Quality Indexes

It is simply may not be the most proper identification of a community structure when we measure biodiversity in an area that has not even one species/individual. However, it obviously will lead to better judgment in continuous measurements after an impact. In this case, it can clearly be seen that biodiversity could only been detected at considerably low values (<1.5, mostly <1) in some stations (Figure 7) following the 3 months after spill. The station A5 exhibits a better diverse community structure in compare with other stations and the highest diversity in T41. Some diversity values that higher than 1.5 starts occurring after the first spring (T6) when diverse station number also increased, and values became higher in first summer (T9), and all stations showed diversity values greater than 1, with the exception of A4, in T41. There is a temporal variation that is an expected situation in the SOM, which is “higher diversity in summer term”. However, diversity decreases in T21 compared to T9.

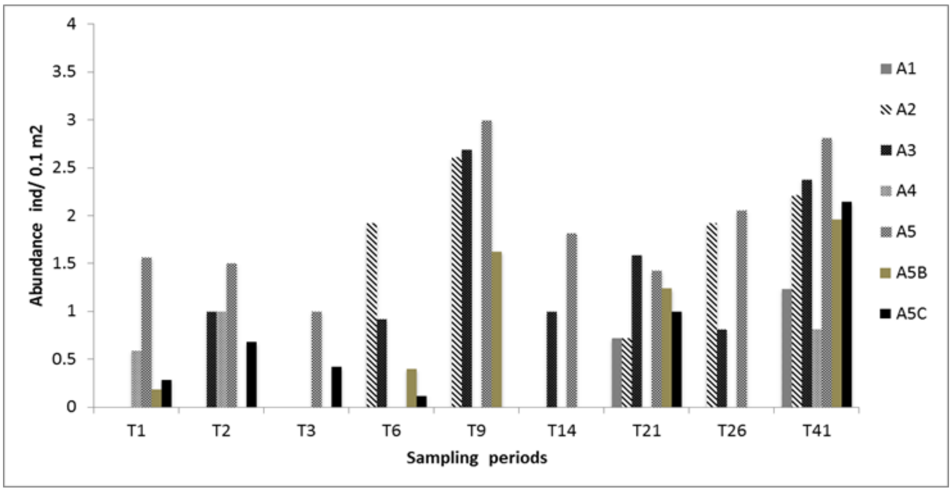

Figure 7. Biodiversity (H') values during sampling period.

AMBI, M-AMBI and TUBI indexes were applied only for T41, because T41 was considered as having enough community parameters in terms of abundance, richness and diversity. Besides, M-AMBI and TUBI measures both ecological group percentages and diversity in their calculation. According to AMBI, all stations indicate mostly "good" and "high" quality (A3 and A5) and the results are more consistent with M-AMBI values that also indicated only two stations as to be in "moderate" status (A1 and A4). In line with two other indexes, TUBI scarcely showed a deviation from "good environmental status" and indicated "moderate", "good" and "high" status for the area in 41st month of the spill. Although A1, A2 and A5C represented "moderate" status according to its classification boundaries (Çınar et al., 2015), the index values are considerably closer to "good" level (Table 2).

Table 2. Results of the EcoQ indexes, richness, diversity (H').

	A1	A2	A3	A4	A5	A5B	A5C
AMBI	1.72	1.23	1.18	1.50	0.50	3.18	2.21
M-AMBI	0.44	0.87	0.68	0.41	0.78	0.71	0.62
TUBI	2.82	2.69	3.21	2.88	3.91	2.06	2.71
Richness	5	15	8	5	9	13	8
Diversity	1.24	2.21	2.37	0.82	2.81	1.96	2.14

Ecological groups, on the other hand varied between second-order opportunistic and sensitive species and the percentages of them did not resemble among stations. When the area was discussed totally, species identified as being sensitive and indifferent to organic enrichment stand in the high percentage (Figure 8).

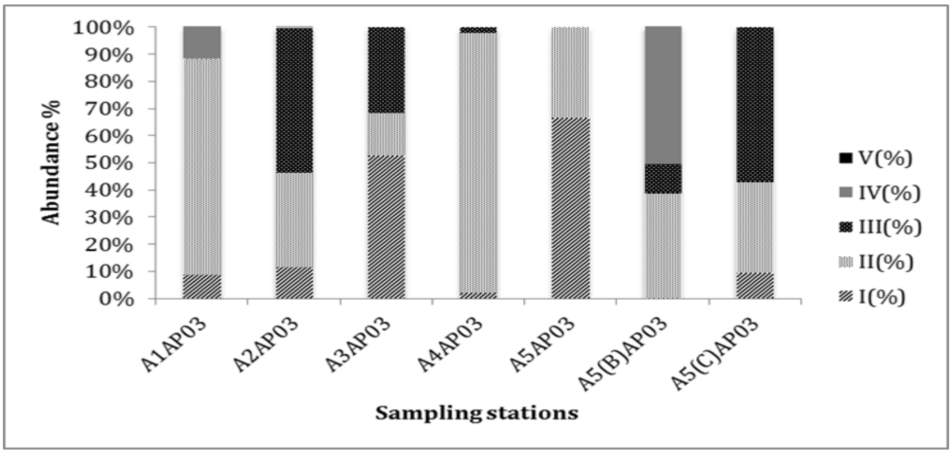

Figure 8. Ecological group percentage that species indicated in T41. Roman numbers are sensitive, indifferent, tolerated, second-order opportunistic first-order op. species, respectively from I to V.

Spearman rank correlation was computed between hydrocarbon level in the sediment (µg g^{-1}) and abundance, biomass and diversity (H'). The hydrocarbon level of the area within sampling stations and period is given in Table 3. The amount of hydrocarbons in the region increased gradually until T6, then decreased again gradually, and the highest levels were detected in A1 and A4 where had the permanent lower layer, after T9. There can be seen general increase in the amount of hydrocarbons in T14; additionally, hydrocarbon levels were always lower in summer periods. It is conspicuous that the station A5(C) (the deepest and the outermost) and A5 (the shallowest and innermost) had generally the lowest amount (Table 3) (Güven et al., 2005).

Table 3. Hydrocarbon concentration (µg g^{-1}) in the area during sampling period.

Stations	Bottom depth (m)	Sampling Period/ Hydrocarbon level (µg g^{-1})								
		T1	**T2**	**T3**	**T6**	**T9**	**T14**	**T21**	**T26**	**T41**
A1	27	62	65.2	73	8.6	54.5	185	-	66	9.36
A2	10	9.6	0.48	0.85	6.8	3.1	24.4	2.45	8.6	2.46
A3	15	16.2	100	79	74	10.7	92	0.96	-	4.24
A4	34	-	54.5	189	441	58	142	9.67	22.2	9.6
A5	6	23.6	1.53	1.97	-	4.8	7.95	3.92	-	0.54
A5(B)	51	13.4	1.42	8.6	70.5	10.25	44.4	-	6.4	4.48
A5(C)	75	6.5	8.7	13.6	2.55	2.38	12.75	1.52	5.12	0.54

The correlation results between hydrocarbon amount and abundance, biomass and diversity are -0.3928, -0.4277, -0.4033, respectively. There is an inverse and significant correlation between the variables according to the critical threshold value of 0.2500.

Non-Multidimensional Scaling (non-MDS) analysis result as to have 0.01-stress value after fourth root transformation had been applied to the community values in species and mixed taxonomic levels. The stress value indicates a "good" result (Kruskal, 1964), though neither periodic nor spatial pattern was observed in the scale in terms of resemblance. Nevertheless, the scale on right-hand corner displays the following months of the spill when the abundance was totally vanished or represented scarcely by one or two species. On the main scale, it can be observed that the community structure did not resemble among stations except for the stations A5(B) and A5(C) in which *Melinna palmata* was consistently abundant. Such circumstance reveals the community structure as not being steady, as being highly variable on the contrary for almost 3 years (Figure 9).

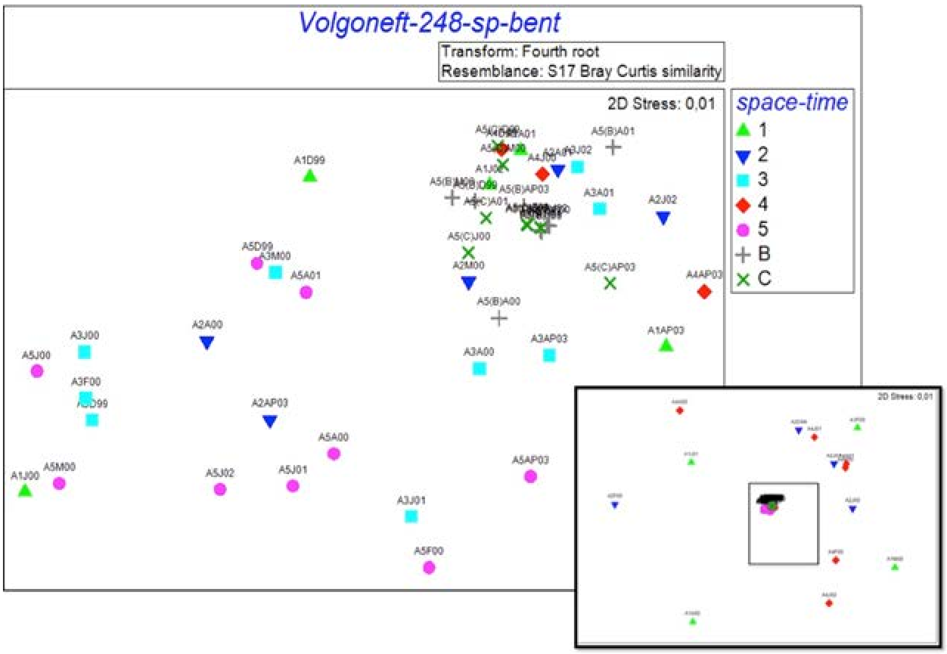

Figure 9. non-MDS diagram, data transformed with fourth root. Stress level is 0.01. General view is on the right corner, mainframe is focused.

Discussion

The heavy oil pollution from Volgoneft-248 (Alpar and Ünlü, 2007) affected the benthic fauna lethally, abundance and the diversity of species thus disappeared immediately after the accident. Such cases were reported by Armstrong (1979), Sanders et al. (1980) Dauvin (1998). However, oil pollution has not solely lethal effect on the populations, it additionally affects the feeding and breeding ability and immigration succession (Rinkevich and Loya, 1977; Armstrong, 1979; Sanders et al., 1980). Total abundance reduced swiftly in the area, as Elmgren (1983) reported, except for the distinct stations of A5(B) and A5(C) in which individual number reduced following of an increasing pattern in hydrocarbon concentration.

In the shallowest station of A5 (6 m) some living crustaceans, only decapods, and molluscs were obtained in T1, nevertheless in T2 abundance reduced to 4 individuals including one amphipod, from 57 per 0.1 m^2. However, amphipods were never obtained from the samples (A5) during all sampling periods, besides the crustaceans and molluscs returned to the station abundantly, such case may be an indication of an unsuccessful migration or alternatively an alteration of the community structure as Elmgren (1983) reported with a pre-spill data which was not available in this study.

Amphipods returned to or settled into the area in general in a time between T26 and T41 and dominated opportunistic polychaetes, except for in the station A2. Therefore, we simply cannot define a pattern or a certain time of the changes in Polychaete/Amphipod ratio as Gesteria and Duvin (2000) and Andrade and Renaud (2011) stated, because of the absence of either or both Amphipods and polychaetes (opportunistic or not). However, amphipod abundance became considerably higher in the area within the time when hydrocarbon concentrations decreased, thus such case indicates a recovery as Gesteria and Dauvin (2000) reported.

Biodiversity was not stated as to be the most suitable method to assess the oil impact on benthic fauna, though the correlation between diversity and hydrocarbon concentration indicated better status in time. Particularly, the exhibition of higher diversity by shallow stations, in which hydrocarbon levels decreased rapidly, which are additionally open to wave actions may be a good example of understating the mechanism of affected community structure. Yet, diversity achieved over a level of 2 only in four stations of seven and did not show a pattern that depended on distance but depth. Higher levels were in the upper layer or in the beginning of the permanent halocline layer where concentrations of hydrocarbons were low. The station A5(C), however is the deepest and the outermost zone that also have the lowest value of hydrocarbon concentration as in A5, has also high diversity. On the contrary, station A4 is; i) close to the polluted shoreline, ii) always with the highest amounts of hydrocarbon, iii) located in the lower layer where water mixing is usually limited and station A4 had the poorest diversity even in 41st month of the spill. Biodiversity is usually higher in summer, particularly in August, in the SOM. Although the number of the diverse stations increased in T21, the station exhibited higher diversity values in T9 than their values in T21. We considered this output as to be a consequence of remarkably higher hydrocarbon concentrations in the following winter (T14) of T9.

EcoQS, on the other hand represented acceptable conditions by AMBI that indicated not a deviation from good environmental status (GES). However, M-AMBI and TUBI were more consistent with richness and diversity and also with each other. According to TUBI values the area in total, except for A5, represented somehow a deviation form GES. The suitableness of the former index was discussed by Gürkan (2016) for the specific area located around the city of İstanbul, and reported as to be a good indicator for the EcoQS. In line with the indexes, first- order opportunistic species, such as *Capitalla capitata*, that are strong indicators of pollution have never been detected in the area, and second-order opportunistic species were scarcely half of the

Polychaeta abundance, such case was also reported by Dauvin (1982) after Amoco Cadiz oil spill.

Consequently, the settling of a complex community structure in this area took at least 3 years, excepting the station that has shallow waters. Kingston (1992) reported the most common effects of the oil pollution as a large increase in the abundance of only a few species. In this study, we cannot contribute to such case, because the area had finally a “significantly abundant” community 3 years after the spill. We however can affirm another common effect, which in this case will be the immediate absence of the abundance of total and/or oil sensitive amphipods, particularly *Ampelisca* genus. Since it was a challenging issue that there was not pre-spill data of the benthic fauna in the region, sometime between 26th and 41st months a recovery or the early steps of a recovery occurred. We simply should not establish a final diagnosis about the recovery word, not only because of the absence of a pre-spill data, significantly because of the absence of a long-term monitoring around the area. However, the SOM is a receiver of anthropogenic pressure that increased gradually in the following years. In this case, even if a long-term data would be available one could not be able to distinguish the exact impact of oil that might be responsible for the alterations in community structure. And as to the final aim of the study, a healthy assessing of the effects of oil pollution should not be based on a single index such as diversity, abundance or one of the EcoQS indexes. However, Polychaete/Amphipod index alone was not also adequate in terms of assessing the temporal changes in the community structure or defining the recovery time, in this case. When we consider all the community parameters here, it is merely possible to report that the area affected by heavy oil spill, established a beginning of a recovery 41 months after the spill.

Acknowledgement

This assessment study is based on the data collected under the project of “Monitoring of Petroleum Pollution of Volgoneft-248 (Güven et al., 2005)” We would like to thank all the project team for their remarkable work.

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CHAPTER 5

SOCIO-ECONOMIC ASPECTS

This chapter summarizes how the maritime accidents negatively affect physical/physiological and psychological health, causing various types of socio-economic problems. Socio-economic crisis and related concepts were investigated in this chapter. Oil spills exhibits toxic, carcinogenic and mutagenic effects. If one considers the environmental pollution caused by oil spill implications of the BP Deepwater Horizon Oil Spill, systematical investigation of empirical data related with oil spills are crucial in understanding the probable consequences of maritime accidents. In general crisis management, appropriate time management to have reliable data for making binding statements, awareness of companies, which are responsible of oil spill, for their requirements, consideration of human dimensions by public and private sectors, no highlighting of company financial loss during crisis, and focusing on solution-oriented efforts can be discussed as the significantly important consequences.

Oil spills have direct or indirect exposures of the absorption of crude oil and its components by orally, inhalation or through the skin to the human body. Occurrence of the effect of oil spills depends on the type of contact. Direct exposure of oils spills can be occurred by in contact with oil spill component, inhalation of contaminated air, and walking over the contaminated area. Indirect exposure can be occurred by swim in contaminated waters or consuming contaminated foods. Because of these exposures, there will be major health problems such as hematological, liver, respiratory, kidney and neurological dysfunctions.

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SOCIO-ECONOMIC ASPECTS OF OIL SPIL

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1. Introduction

All types of oils, which are common pollutant in the oceans, can be defined as a complex mixture of components with different physical, chemical and biological properties (White and Nichols, 1981). When an oil spill occurs on the surface of the seawater it undertakes a few changes that some of them enhance its natural dissipation while others cause it to persist. (White and Nichols, 1981). Every year the sea contamination is occured by oil approximately 3 million metric tons. Overflow and waste from industry, metropolises, and rivers transfer oil into the marine environment. Marine oil pollution mostly caused by ships that washing out the tanks or dumping bilge water. Approximately a third of oil pollution in the oceans is appeared because of ships. Although oil spills account for less than 15% of the total oil in the oceans, they are probably the most obvious form of oil pollution **(**The University of Rhode Island, 2018)**.** The increased number of oil tankers in the World cause the rise of the public's awareness for probability of an extensive oil spills happening and polluting the coastline. Oil spill cost is affected by the factors, which are complex and interrelated. Beisdes each spill includes a unique set of circumstances that determine great deal of cost.

2. Oil Spill Impacts

Oil has an important role in our world and the products of oil are extensively used in our everyday lives. Normally large-scale problems are not seen for the oil production process of getting the oil from deep below Earth's surface. However, it can be disastrous, when there is an oil spill. A few years ago the Deepwater Horizon oil spill, which was accepted as the major oil spill into marine in history of U.S., was occurred. The oil spill has started on April 20, 2010 and it continued for 87 days. Over 130 million tons of oil spilled into the Gulf of Mexico and not only marine life, coastal economie were affected, but also it presented dangers for human health (Friedl, 2018).

Oil spill impacts framework can be explained as related sequence of concerns or consequences, which come from the oil spill to its effects on society: the oil spill occurrence, features of the oil spill, impacts to ecosystems in the short- and long-terms, and effects on society related with human health, economics and social concerns (Figure 1).

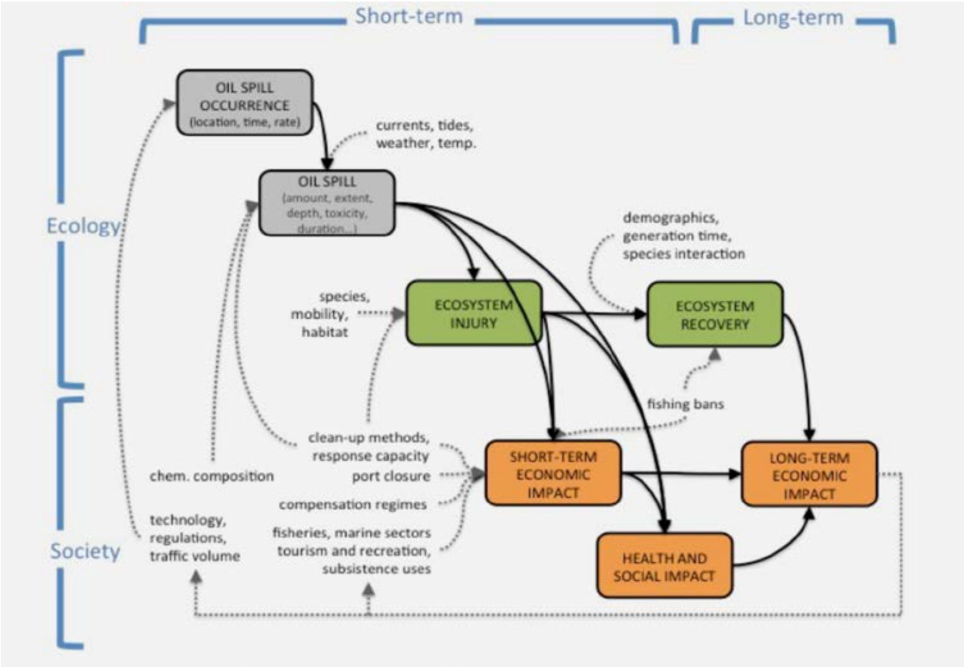

Figure 1. The framework of oil spill influences. BOXES = outcomes, lowercasen = variables, solid lines = linkages between oil spill occurrence and socioeconomic impacts, dotted lines= linkages between exogenous variables and outcomes. Grey boxes indicate oil spill outcomes; green boxes, ecosystem consequences; and orange boxes, societal consequences (modified from Chang et al., 2014).

3. Factors that Affect the Oil Spill Environmental Costs and Damage

Various elements of the environment may be affected by an oil spill. The formation of these elements also depends on many factors that also affect the environmental damage and costs of oil spill.

The cost of spills is influenced mainly by the following technical factors:

- Oil Spill Type
- Site of the oil spill
- Weather and sea conditions
- Ship safety features
- Amount of oil
- The local response capacity
- Termination of Clean-up
- Management of Response Operations

- ***Oil Spill Type***

Several individual factors define the importance and therefore the oil spill's final cost. Oil type is the most significant factor (White and Molloy, 2003). After oil spill spreads on the sea surface, its properties alter both physically and chemically. These changes of oil appear with different outcomes. For instance, heavy crude and fuel oils, and emulsified crude oils include a high ratio of non-volatile components and also their viscosities are high, they are persistent in the environment. As a result, cleaning these oils in the environment is challenging and the clean-up costs may be very astronomical. (Trang, 2006). Therefore, the cleaning operations of heavy oil spills have extreme difficulties, outspread widely and be expensive. The NAKHODKA (Japan, 1997) and ERIKA (France, 1999) can be given as examples for the above situation. These tanker oil spills are the most expensive of all the times. Oil spilled relatively small amounts for this incident about 17,500 tonnes of oil in the NAKHODKA accident and about 20,000 tonnes of oil in the ERIKA accident and also oil spill occurred particular distance from the seashore (White and Molloy, 2003).

- ***The Oil Spill Location***

The oil spill location is another significant factor for cleaning operations cost. A critically important factor for oil spill is the location for the impacts on natural and social resources, for the rescue team response, the economy and the environment. The location has impact on the oil behaviour and the route concerning to the hydrometeorological features such as currents, direction of wind, tides, waves and water depth of the spilled area. The cost of clean-up is also affected by the coast type, the closeness of a reserve, biologically sensitive regions, or a World Heritage site (Trang, 2006).

ERIKA and NAKHODKA incidents had very high charges because of enormous expenses for seashore clean-up. After these accidents, the oil spilled and caused the extensive shoreline contamination (400 km for the ERIKA and more than 1,000 km for the NAKHODKA. This was an outcome of the nature of the oil which was extremely persistent and spreading of oil from an incident place that had some distance from shore (White and Molloy, 2003).

- ***Sea and Weather Conditions***

Diminishing the consequences of an oil spill is essentially related with weather and sea conditions. A faster clean-up can be obtained with good weather conditions (Trang, 2006).

- ***Ship Safety Features***

When double-hulled ships and single-hulled ships are compated, it is realized that double-hulled ships are not highly inclined for accidents and also oil spill from these types of ships may have less expensive costs (Chang et al., 2014).

• ***Oil Amount***

The quantity of oil has a significant impact on the cleaning cost. Not only dispersion and movement but also the clean- up cost of oil increase with the higher amounts of oil spill. (Trang, 2006).

• ***The Local Response Capacity***

The response capacity of Rescue Center for spills is linked with the equipments including airplane, ship, buoy, rescue boat, oil containment, ship, and chemicals, the rescue teams that involves skilled and trained professionals and the awareness to rescue. Globally, the region attitude, the competent agencies and the media determine this capacity. When a spill occurs close to a touristic area, the pressure for overcoming the impacts becomes higher due to the pressure by the sector and the attention of the media. On the other hand, when the oil spill happens in the areas like mangrove swamps or salt marshes, which are ecologically important, they are generally ignored and have to be self-cleaned naturally. Similarly, oil spill on rocky shores is not cleaned up (Trang, 2006).

• ***Termination of Clean-up***

The evaluation of whole coastline clean-up processes should be performed continuously to confirm if these activities are still suitable when conditions change. The termination of operations should be applied if they are regarded as ineffective, unacceptably have additional harm for environment or economic resources, or there is a significant overcome of the costs with diminishing benefits (White and Molloy, 2003).

• ***Management of Response Operations***

The poor management and inadequate planning can result in the same mistakes that were made in the previous oil spills, avoidable environmental and economical damage and enormous costs. The response operations should be determined and perfomed based on technical realities, however they are also reacting to pressures and perceptions of policy, media and community. Therefore, this approach can also increase the incident costs that would not be considered as "reasonable" by the international compensation conventions (ITOPF, 2018a).

4. Oil Spill Clean-Up Costs

Oil combating efficiency is a combination of numerous activities and a model of cost for clean-up activities of oil spill is given in Figure 2.

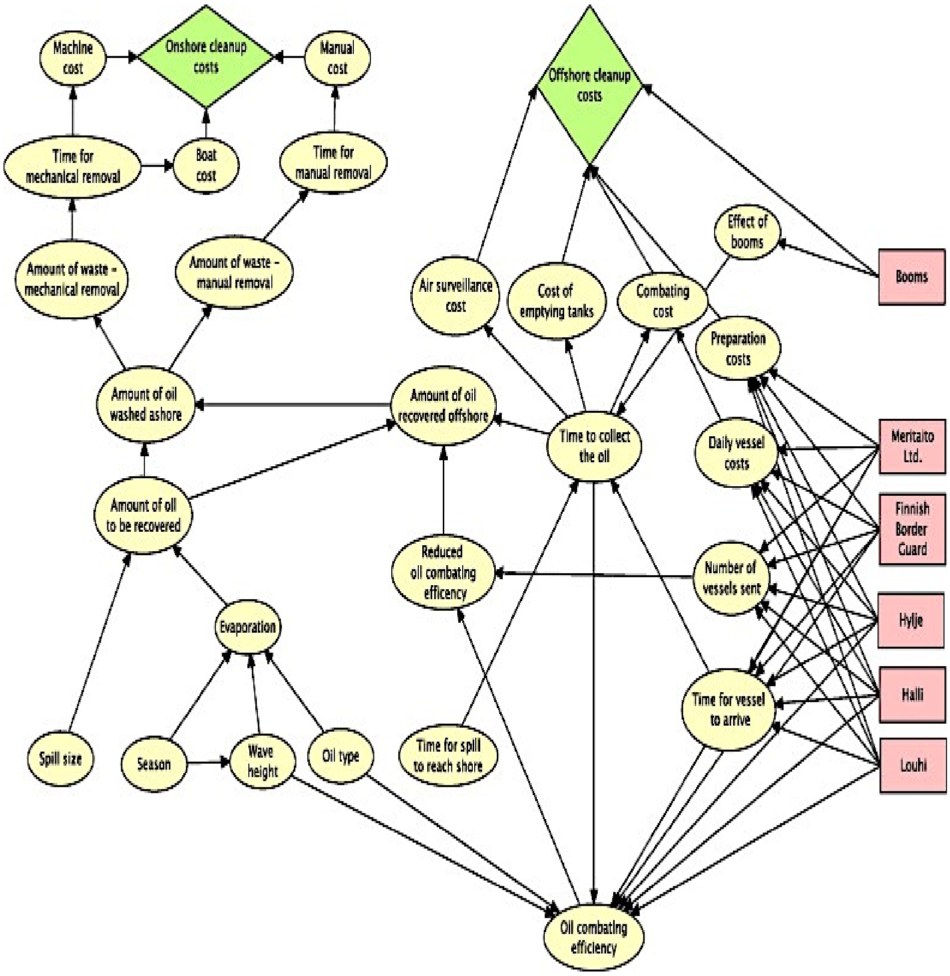

Figure 2. Clean-up cost model for oil spill (Montewka et al., 2013).

The cost of oil spill cleaning operations can be classified into two groups; the costs resulted from the offshore cleaning and the costs related to the onshore cleaning processes. Both group have its own interactions and stages separately (Chang et al., 2014).

5. The Main Sources of Oil Spill at Sea

Various altered methods of transportation such as pipelines, tankers, tank trucks and railcars are included in the 10–15 transfer of petroleum from the oil fields to the consumer. The storage of oil is carried out at refineries, terminals and transfer points along the route. There is a possibility of an accident through any of these steps including transportation, production and exploration and also storage periods (Michel and Fingas, 2016).

The percentage of reasons for oil spill are estimated by spill experts as 30–50% caused by direct or indirect human errors, and failure or malfunction of equipments are the reasons of 20–40% of spills.

Since different methods are used to collect the data, occasionally comparison of oil spill statistics can be misleading. Spills can be occurred by a wide range of sources and because of numerous causes. Pipeline spills are the major source of oil spills on ground and next important source is oil production facilities. There is an approximate relationship between the volume of spills and volume of oil controlled by these two main sources. The principal sources of spills on water are terminals/refineries and non-tank vessels corresponding to the occurrence of activities and handled high volumes (Michel and Fingas, 2016).

When we compare oil spills in coastal waters and spills in the open sea, it can be said that the impact of coastal oil spills is higher on the environment. This finding is deduced from the fact that the oil concetration decreases and oil effuses much faster over large fields. Furthermore, another reason is a greater dispersion of biological resources in the offshore than at the coastline.

In shoreline waters, there is a probability of catch up of oil in bays and fiords. The remaining time and the concentration of oil constituents in the seawater may toxically affect fish communities and other marine animals, specifically to larvae and eggs.

The main sources of oil spill are listed in Table 1 according to Bureau of Minerals and Petroleum of the Greenland Home Rule Government, (2006):

Table 1. The main sources of oil spill (Bureau of Minerals and Petroleum of the Greenland Home Rule Government, 2006).

Source	Percentage
Natural seeps from the subsoil	46%
Discharges during the operation of vessels and from activities onshore	37%
Release from vessels caused by accidents/incidents	12%
Oil spills in connection with exploration/exploitation	3%
Other sources	2%

6. International Trend of Oil Spill

Throughout the previous 48 years, the statistical data for tanker oil spills more than 7 tonnes demostrate a marked descendent inclination as illustrated in Figure 3. In addition, a high ratio of the oil spills are the results of a few huge spills.

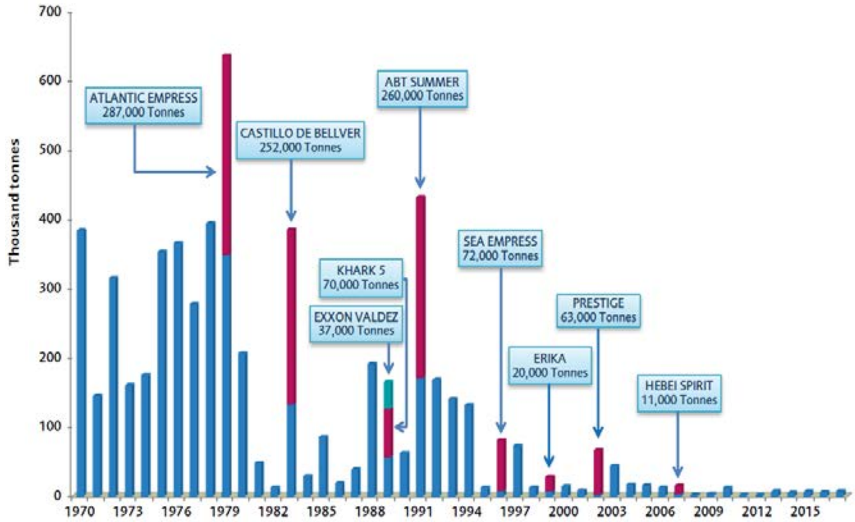

Figure 3. A few very large oil spills of ship accidents (ITOPF, 2018b).

The results of Atlantic Empres Accident in 1979 can be summarized as follows:

Resources lost from the Atlantic Empress oil spill (Figure 4) could have which equels fuelled a car for 64,350 years, fuelled a jet for 1,440,000 miles, 2,193,750 tanks, 58 trips around the globe, 35,100,000 gallons, 7,200,000 gallons of jet fuel and $85,000,000 (Counter Spill, 2018).

Figure 4. Atlantic Empress Oil Spill (from Counter Spill, 2018).

One of the significant factors of cost determination is the amount of oil spilled (International Tanker Owners Pollution Federation Limited - ITOPF, 2018a). The highest-priced oil spill accident in history is declared as the Exxon Valdez according to the ITOPF. US $2.5 billion were disbursed for cleanup cost in the region and estimated total costs were US $7 billion including claims settlements, penalties and fines (Center of American Progress, 2010).

On February 15, 1996, The Sea Empress accident occurred and the ship ran ashore at the entry of the port of Milford Haven, in South Wales, United Kingdom. The amount of spilled oil was 72 000 tons in this incident. Consequently, there was a contamination of 150 km of touristic shoreline, which had recreational activities, and holding numerous land-based and protected marine areas. The liability of ship-owner and intervention of the IOPC Fun were limited to 7.5 million pounds (8.5 million 2001 pounds), and to 51 million pounds (57.9 million 2001 pounds), respectively (Thébaud et al. 2004).

7. Oil Spill Examples and Lessons Learned

Knowledge for oil spill response is very experimental. There are lessons to be learned from past spill responses for on spill behaviour and efficiency of countermeasures, to have knowledge for dealing with potential spills in similar situations. Some of the largest and important oil spills are listed in Table 2.

Table 2. Selected oil spills and lessons learned (Michel and Fingas, 2016).

Spill name/ year	Size (tons x 1000	Location	Oil Type	Nature of spill	Some Lessons Learned
Gulf War Spill/1991	800	Arabian Gulf	Heavy crude	Act of war	Largest marine spill; affected 800 km of shoreline Long-term impacts in sheltered areas with no cleanup
Deepwater Horizon/ 2010	500	U.S. Gulf of Mexico	Light crude	Oil well blowout	Behaviour and fate of deep releases Submerged oil mat behaviour
Amoco Cadiz/ 1978	223	Brittany off France	Medium crude	Tanker grounding	Contamination of Nearshore sediments by natural oil dispersion Aggressive cleanup of marshes slows recovery
Prestige/ 2002	63	North of Spain	Heavy fuel oil	Tanker breakup	Long-term persistence very heavy fuel oil Need safe havens for stricken ships
Ixtoc I/1979	470	Gulf of Mexico	Heavy crude	Oil well blowout	First use of environmental Sensitivity mapping Value of oil spill trajectory models
Enbridge Pipeline/ 2010	4	Kalamazoo River, Michigan	Diluted bitumen	Pipeline rupture	Diluted bitumen sinks after several days weathering Many lessons on how to locate and recover sunken oil in rivers

8. Economic variables and consequences of oil spill

The effects of spill and the economic variables can be given as follows in Table 3.

Table 3. The effects of oil spill and the economic variables (Chang et al., 2014).

Category	Effects
Commercial fisheries and aquaculture	For fisheries the direct losses from product mortality, harvesting closures, loss of market demand, brand damage, etc
Commercial fisheries and aquaculture value chain	Based on direct losses, businesses that depend on commercial fisheries such as docks, processors, distributors, and supply companies lose product inputs and markets
Tourism industry	An oil spill can cause a brand damage for businesses providing accomodations, transportation, guides, activites (e.g. recreational fishing), tourism-related retail, etc. Beyond the direct oil spill zone, the market impacts can be seen.
Waterway usage	Waterway uses may be impeded or shut down by an oil spill, so the greater the use of a waterway, the larger the effect of its closure.
Other marine-based industries	Oil spills can have effects on industries that pump water for cooling and other processes, and transportation industries such as ferries and float planes.
Oil industry	Access to products or markets for the oil industry itself may be lost through affected waterways, and may be subjected to regulatory moratoria on operations.
Pure economic loss	Pure economic losses are financial damages that occur independently of direct damage and they may ripple across the economy, spreading to goods and services providers that depend on spending from affected populations.
Passive use and recreation	Significantly, an oil spill can be also resulted in non-market losses to natural environments and recreational opportunities.
Real estate	Due to adjacency to the spill, "Pure stigma" losses that devalue coastal or regional properties
Financial sector	Defaults from impacted businesses can affect lending and credit markets. Falling share prices may cause that shareholders may lose value. The economy may experience inflation.
Legal and research costs	Baselines and measure impacts are established with oil spills require interventions by the legal profession to negotiate claims, and extensive research
Municipal/regional government impacts	Increased demand for public service, direct administrative costs, loss of tax revenues, municipal/ regional brand damage, opportunity costs, loss of staff to cleanup efforts and political fallout are the factors affecting governments
Economies of scale	Marginal costs of additional oil decrease per gallon when initial costs are invested into a cleanup.
Recovery boom	The increases in spending related to the response and recovery can stabilize the short-term economic losses. Tourism businesses, retail, contractors, and local labor can all benefit
Expense savings	Reduce of spending on variable costs of production or services can stabilize the business losses (e.g., commercial fishers spend less on diesel, bait, etc.).
Tax revenues	Governments may experience short-term tax revenue rises on sales of goods and services according to increased recovery spending
Conservation benefits	If there is a limiting access to commercial fisheries and certain geographies, there may be conservation benefits to targeted species.

The numerical example to the economic effects created by oil spill are given in Table 4.

Table 4. Overview of estimates of natural resource damages and economic impacts of an oil spill from Line 5 in the Straits of Mackinac (Richardson et al., 2018).

Category	Economic Damages
Natural resource damages and restoration	$697,500,000
Economic impacts	
• Tourism	$ 4,823,082,926
Commercial fishing	61,050,000
Municipal water systems	233,090,000
• Coastal property	485,811,163
Total economic impacts	$5,603,034,089

More than $485 million present economic damages to coastal properties under the scenario is in charge. Additionally, the total estimate of potential economic damages from this scenario is more than $5.6 billion.

9. Onshore Activities

Vegetation and the terrain are affected by an onshore oil field in neigboring regions. Besides, the noise and the people employed in the oil spill area will affect the animals in the parts near the oil field and alongside transport corridors. Regulatory measures due to the immense amount of information of natural ecology and history can avoid many of these impacts (Bureau of Minerals and Petroleum of the Greenland Home Rule Government, 2006).

10. Economic Impacts Related to Tourism

Tourism can be defined as a key economic sector in most populated coastal areas of the world. There is a risk of disruption by the presence of oil in the water or on the shore, which have serious consequences if it happens just before or during the main tourist season. The business that have a serious dependence of coastline affected will be affected with a high extent (ITOPF, 2018c).

The perception and preferences of tourist visitors are the two main factors that define the influence of a spill on the tourism sector (Tourism Economics, 2011).

Oil spill also had a large impact on the tourism industry. For example, the findings of the study of Knowland Group in August 2010 showed that, cancellations had been experienced by 60 % of hotels from Alabama, Florida, Louisiana and Mississippi and 42 % of them were having difficulties of forthcoming booking actions by June 2010. It was informed that the cost of visitor loss through the end of 2010 reached $32 million, and losses through 2013 were estimated as $153 million only in Louisiana State. Tourism lost estimation and "brand damage" because of the oil spill affected the Gulf coastal economy up to $22.7 billion through 2013 (NRDC, June 2015).

11. The Effect of Oil Spill on Fisheries

Fisheries can be affected directly and indirectly by an oil spill (UNEP, 2018). The oil contamination risk of catch products may cause close of treasured fishing and shellfish regions for fishing activities for short or long time intervals. Oil contamination concentrations in fish, shellfish and crab tissue could exposure an important potential for inverse impacts on human health. Moreover, the human consumption of products from close coastline fisheries and aquaculture could be banned until the health experts and authorities declared the safety of these products. Indirectly, there will be a heavy loss for the fisheries sector if the consumers are not using or buying fish and shellfish from the area polluted by the oil spill. In addition, oil spill may damage boats and gear directly.

12. Damages in the Canning and Fish-processing Area

The regional industries of fishing activities and canning, which are comprehensively dependent on coastal fishing and shellfish, cannot carry any production processes or can operate daily just for few hours because of the fishing and shellfish extraction ban (Loureiroa et al., 2006).

13. Conclusion

Since the global utilisation of oil and oil derivative fuels has increased, the possibility of these products acute and chronic release into the environment has expanded. In addition, with the higher economic activity, there is a growth of the shipping acitivities and needs for ports which has influence on oil consumption and oil spill amount. A huge number of oil tankers uses the worldwide maritime navigations that are characterized by a combination of harsh conditions of shipping and a high density of regions, which have ecological and economical vulnerability. Therefore, the oil spill can cause a range of environmental risks, wide public concern and economical damages.

Today, a systematical investigation of the empirical data for oil spill is become a necessity to understand the consequences. Additionally, to figure out the effect of oil spill on general economy, the main sources, types, impacts, factors affecting environmental and economical costs of oil spill, its effects to different areas such as fisheries, tourism, etc., economic variables and global trend should be extensively studied.

Within this study, all of these significant aspects were discussed. In addition, the oil spill behaviour and effectiveness were analysed considering largest and important oil spill accidents. The understanding of oil spills has a great importantance and it will be beneficial to overcome the future oil spills environmentally and economically.

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EFFECTS OF OIL SPILLS ON HUMAN HEALTH

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1. Introduction

The use of fossil fuels has gained importance by the industrial revolution in the 18th century and the use of petroleum products has increased. Many new problems have arised during the extraction, transportation, refining, storage and incineration of crude oil. Numerous oil spills from pipelines, boreholes and transport vessels accidentally contaminate soil and groundwater, affecting various flora and fauna species and posing potential human health risk (D'Andrea and Reddy, 2013). The harmful effects of oil spills as a result of industrial activities (e.g. Exxon Valdez, MV Braer, Sea Empress, Nakhodka, Erika, Prestige, Hebei Spirit, Deep Water Horizon and Tasman Spirit etc.) have been investigated extensively in various marine species, especially in birds, and marine invertebrates. In addition, the acute, psychological, physical / physiological effects genotoxicity, toxic effects on immune and endocrine systems have been investigated in a limited number of human health studies. (Aguilera et al., 2010; Laffon et al., 2016). Crude oils have been classified in Group 3 by the International Agency for Research on Cancer (IARC) due to there is not sufficient evidence of carcinogenicity in humans, and also there is no evidence in experimental animals. On the other hand, fuel oil and petroleum products have been classified in Group 2B due to their possibly carcinogenic effect in humans (IARC, 1989; ATSDR, 1999).

2. The Chemical Composition of Crude Oil

Crude oil is a complex mixture of up to 17,000 organic compounds; hydrocarbons and their heteroatom (N, S, and O)-containing analogs, called non-hydrocarbons (Table 1). Composition consists hydrocarbon mixtures in particular to methane, in association with ethane, propane, butanes, and the pentanes and traces of inorganic gases, principally CO_2, nitrogen, and hydrogen sulfide. Hydrogen sulfide gas and contains traces of heavy metals, as well as nonvolatile polycyclic aromatic hydrocarbons (PAHs) can be released by cruide oil to environment and can contaminate the food chain. Hydrogen sulfide is a neurotoxic molecule and exhibits both acute and chronic toxic effects on the central nervous system (CNS). Components of crude oil shows different volatility, density, and solubility in seawater, and different levels of toxicity for marine species and humans (Solomon and Janssen 2010; Sammarco et al., 2013; Overton et al., 2016).

Table 1. The chemical composition of crude oil (Jeffrey, 1998; Overton et al., 2016; IARC, 1989; Rodríguez-Trigo et al., 2007; Ramirez et al., 2017)

	Chemical compounds	Toxic effects
1- Saturated hydrocarbons (%50-80) a) Alkanes	n-hexane, n-heptane, n-oktane, n-nonane	n-hexan: peripheral neuropathy
b) Cycloalkanes (%30-60)		
Monocycloalkanes	Cyclopentane and cyclohexane series	
Polycycloalkanes	Bicyclic sesquiterpanes, trycyclic diterpanes (abietane), steranes (cholestane), pentacyclic triterpanes (hopane, oleanane)	
2- Aromatic hydrocarbons (%50) Monoaromatic hydrocarbons	Benzene (%0.01-1) Alkyl benzenes (ethylbenzene, Toluene, xylenes) C_8-C_{11} aromatics	Benzene: acute symptoms (respiratory and neurovegetative), carcinogen (leukemia and/ or lymphoma) Toluen: central nervous system and neurological damage
Polycyclic aromatic hydrocarbons (PAHs)	Naphthalenes Phenanthrenes Fluoranthenes Chrysenes Dibenzothiophenes Naphthobenzothiophenes Indanothiophenes Pyrenes 5-6 Ring PAHs	Possible carcinogens. Endocrine alterations. Skin and mucosal irritants Benzo[a]pyrene is most toxic (pharynx and larynx cancers)
3-Heteroatomic Hydrocarbons (S, N, O contain)	Ethanethiol, thiophene, pyridine, quinoline, indoline, carbazole, fluorenone, phenol, dibenzofuran	Endocrine alterations, carcinogen
4- Asphaltene and resin (%28)		
5- Porphyrins		
6-Metals	Calcium, aluminum, magnesium, titanium, vanadium, strontium, barium, nickel, potassium, sodium, iron, molybdenum, tin, zinc, lead, copper, arsenic, mercury, cadmium	Endocrine alterations, carcinogen
7- biomarkers (These compounds are created during oil formation from the initial organic matter in the source rock. 17β-hopane is unchanged during normal weathering biodegradation and routinely used as a "conserved internal marker)	17β-hopane, steranes and triaromatic steroids	

Carcinogenicity, mutagenicity and toxicity in endocrine, immune and reproductive systems can occur during the drilling, refining and transportation processes of crude oil through exposure to highly toxic compounds. Highly toxic compounds in crude oil are summarized below.

2.1. Volatile Organic Compounds

2.1.1. Benzene

Benzene or benzol; an organic solvent in petroleum; is a colorless and sweet smell liquid. Benzene can be found as 1% in gasoline and 0.01-1% in crude oil and 15% in some crude oil condensates. The most important toxic effect of benzene is on the hematopoietic system; chronic exposure can cause leukemia (called acute myeloid leukemia) and/ or lymphoma. The chronic effect of benzene is bone marrow damage and may be associated with anemia, thrombocytopenia, leukopenia or a combination of these symptoms. Also, high dose of benzene exposure may lead to oxidative damage (Ramirez et al., 2017; ATSDR, 2007).

Leukemia and carcinogenic effects have been shown in epidemiologic studies due to chronic occupational benzene exposure in the industry. Aksoy et al. reported hematologic disorders in leukocytes including leukocytopenia, thrombocytopenia, and pancytopenia in the shoe manufacturing employees in Turkey, using adhesives containing benzene (benzene concentration in air from 30 to 210 ppm) (Aksoy et al., 1971).

In another study of Aksoy aplastic anemia or pancytopenia was observed in chronic benzene exposure and also lymphoma, myeloma, and lung carcinoma risks were remarked as a result of chronic exposure (Aksoy, 1989). In addition, 26 patients with acute leukemia or preleukemia were reported in Istanbul among 28,500 shoe and slipper workers exposed chronically to benzene from 1967 to 1973 (Aksoy et al., 1974).

Phenol, muconic acid, and S-phenylmercapturic acid are main urine metabolites of benzene and may be used as more sensitive and relaible biomarkers to determine benzene exposure in air at levels of 10 ppm or greater (other metabolites catechol, hydroquinone and 1,2,4-trihydroxybenzene are not specific indicators). Benzene adduct in cysteine groups of hemoglobin and protein were shown in rodents and DNA damage was detected in workers exposed occupationally to benzene. Also, immunotoxicity, neurotoxicity, reproductive and developmental toxicity, genotoxicity, and carcinogenicity of benzene have been identified in several studies. Benzene has been classified in Group 1 as carcinogenic in human by IARC and EPA (Environmental Protection Agency) (IARC, 1989; ATSDR, 2007; Bruckner et al., 2013).

2.1.2.Toluene

Toluene is avaliable in paints, thinners, cleaning agents, glues, inks, stain removers, and other products and gasoline contain 5-7% toluene by weight. Toluene vapors may be inhaled rapidly and distributed to the adipose tissues. Toluene is the most addicted solvent due to its euphoric effect. Toluene-abusing women’s children exhibits developmental toxicity such as microcephaly; similar to fetal alcohol syndrome, growth and skeletal retardations, defects in cardiac system and extremities, kidney and liver toxicity, neuropathology and embryopathy. Toluene has no effect on the hematopoietic system because of its different metabolic pathway from benzene. Also, it is not carcinogenic and/or mutagenic (Bruckner et al., 2013; Ramirez et al., 2013).

2.2. Polycyclic Aromatic Hydrocarbons (PAH):

PAH compounds contain two or more benzene rings. PAHs are mainly caused by anthropogenic activities including oil spills in oil refinery, fossil fuels combustions, forest fires, ındustrial production of carbon black, coal tar, asphalt, coal, and aluminum; and are originated by natural sources such as seepage of petroleum, coal deposits and volcanic activities. PAHs are present 10% of crude oil. Some PAHs are mutagenic and / or carcinogenic. 2-3-ring PAHs are not carcinogenic and have toxic effects on the respiratory, nervous and immune systems, but have been reported to have poor carcinogenic effects at high concentrations (Sammarco et al., 2013; Ramirez et al., 2017; Wickliffe et al., 2014). PAHs are soluble in lipids, absorbed from the gastrointestinal tract and accumulate in adipose tissues. Cytochrome P450 (CYP 450) enzymes biotransformed PAHs to electrophilic metabolites including diolepoxides, quinones and conjugated hydroxyl derivatives that covalently bonds to proteins and DNA (Abdel-Shafy and Mansour 2016).

The main toxic compounds in oil spills are PAHs and alkylated PAH derivatives. The different types and alkylated forms of PAHs cause disruption of endocrine functions. Naphthalene, fluorene, dibenzothiophene, phenanthrene, chrysene and alkylated analogs in crude oil were reported to cause *in vitro* significant changes in the production of sex hormones in MVLN-*luc* and H295R cell lines (Lee et al., 2017).

PAHs including benz[a] anthracene, benzo[a]pyrene, dibenz[a,h]anthracene have been classified as probably carcinogenic to humans by IARC (Group 2A) and benzo[b]fluorantene, benzo[j]fluorantene, benzo[k]fluorantene, dibenzo[a,e]pyrene, dibenzo[a,h]pyrene, dibenzo[a,i]pyrene, dibenzo[a,1]pirene, indeno[1,2,3-cd]pyrene and 5-methylcrisene have been classified as possibly carcinogenic to humans (Group 2B), (IARC, 2010).

2.3. Metals

2.3.1. *Arsenic*

Arsenic is a toxic and carcinogenic metalloid and can be taken orally with seafoods or drinking water and by inhalation route during industrial activities. It can cause liver, lung and bladder cancers, vascular diseases, hypertension and diabetes when taken orally. High-dose arsenic uptake (70-180 g) may causes acute death. The skin is the primary target organ in chronic arsenic exposure may cause a series of characteristic changes in the skin epithelium and characteristic arsenic-associated skin tumors include squamous cell carcinomas in keratosis. Liver damage develops with prolonged or chronic arsenic intake and also peripheral neuropathy occurs at repeated low doses. Arsenic has been reported to cause skin, lung, bladder, kidney, liver and prostate cancers and classified in Group 1 by IARC (Tokar et al., 2013; IARC, 2012; Ramirez et al., 2017).

2.3.2. *Lead*

Lead exposure in children and adults and long-term occupational exposure affect mainly the nervous system. Severe brain damage (encephalopathy) and kidney damage occur in adults and children with intense exposure to lead. The genotoxic effect of lead in human lymphocytes was demonstrated by the comet assay in various *in vitro* studies. The most serious effect of lead is on the hematopoietic system and porphyrins, coproporphyrins, δ-aminolevulinic acid and zinc protoporphyrin increases in urine. The inorganic lead has been classified in Group 2B by IARC (Ramirez et al., 2017; IARC, 1987; Tokar et al., 2013).

2.3.3. *Cadmium*

Cadmium is a carcinogenic and mutagenic transition metal and therefore its use has been limited in industry. Long-term inhalation of low levels cadmium in the air can cause mainly kidney damage and fractures. Occupational exposure is the main concern rather than acute exposure. It has been classified in Group 1 by IARC as cadmium is related to increase cancer risk (e.g. lung, prostate and liver cancer) (Tokar et al., 2013; Ramirez et al., 2017).

2.3.4. Mercury

Mercury, which is released from the municipal waste incineration plants, chlorine alkali factories, mining, metal (Hg, Au, Cu, and Zn) smelting process, and coal combustion contaminate to the environment. The organometallic compound methyl mercury is toxicologically important with other inorganic mercury compounds. Methyl mercury is an neurotoxic compound and mainly affects brain functions and cause cognitive symptomps (Tokar et al., 2013; Ramirez et al., 2017).

3. Effects on Human Health

Crude oil and/or its components may be absorbed orally, by inhalation or be absorbed through the skin to the human body. The effect of oil spills may occur directly or indirectly depending on the type of contact with the oil spills.

Direct exposure: Direct exposure to oils spills occurs close to where people live or work and where they may come incontact with oil spill components. Inhalation of air contaminated with petroleum products, and walking over the contaminated area for a long time can cause health problems.

Indirect exposure: Indirect expoure occur by swim in contaminated waters where petroleum products are dissolved or consuming contaminated foods. Some petroleum compounds may be more concentrated in the food chain due to bioaccumulate in living organisms. Human health effects are caused during petroleum exploration works, offshore oil production and transportation by exposure to hydrogen sulfide, volatile organic compounds and aromatic organic compounds. Major health problems such as hematological, liver, respiratory, kidney and neurological dysfunctions may occur as a result of a crude oil spill (D'Andrea and Reddy, 2014).

3.1. Acute Toxicity

Acute symptoms as eye itching and irritation (incidence 21-78 %), throat, skin and mucosa irritations, dermatitis, respiratory and nervous system problems, head pain, nausea, low back pain, migraine, anxiety, night sweating, cough, fatigue, diarrhea, mental and psychological effects have been reported in cross-sectional studies on cleaning workers of oil tanker accidents (Exxon Valdez, MV Braer, Sea Empress, Nakhodka, Erika, Prestige, Hebei Spirit, Deep Water Horizon and Tasman Spirit) (Campbell et al., 1994; Aguilera et al., 2010; Rodríguez-Trigo et al., 2010; D'Andrea et al., 2014). In addition, frequent asthmatic attacks, headache, fatigue, chronic cough diarrhea, dizziness, abdominal pain, back pain, and altered biochemical parameters (hemoglobin, hematocrit, creatinine, alkaline phosphate, aspartate amino transferase and alanine amino transferase) has been reported in clean-up workers (n=117) who occupationally exposed through the explosion of Deepwater Horizon oil drilling rig located in the Gulf of Mexico (April 2010) (D'Andrea et al., 2013).

The worst ecological disaster; the oil tanker Prestige sink off the coast of Galicia (Spain) led to thousands of people join to the cleanup of the contaminated areas being exposed to potentially toxic chemical substances. The general symptomps including headaches, back pain, respiratory system problems, muscles, skin, eye and throat mucosa membranes irritations has been reported in 266 voluenteer, 133 fishermen, 265 hire workers, 135 bird cleaners who participated in the cleanup. Throat irritation and respiratory system complaints have been the most common symptoms (Suárez et al., 2015; Rodríguez-Trigo et al., 2007).

Generally, petroleum distillates are poorly absorbed from the gastrointestinal tract and do not have a systemic toxic effect unless enter the body through inhalation. The primary systemic effect is lung injury and CNS damage. In addition cardiac arrhythmia develops by inhalation of volatile petroleum hydrocarbons. Hematotoxicity and nephrotoxicity have been reported due to acute high-dose exposure. In long-term exposure, neurophysiological and neurological effects have been observed. Sulfur compounds in fuels, especially H_2S, are highly toxic gases and can cause eye irritation, nausea, irritability, headache, insomnia, unconsciousness and death. The Erika oil spill contaminated beaches, rocks and birds, and eye irritation, skin irritation and dermatitis have been seen in volunteers and tourists (Baars, 2002; Solomon and Janssen, 2010).

3.2. Psychological Effects

Studies investigating the effects of crude oil on human health are limited. Although there have been 37 major oil spill accidents up to date, only 7 studies have been performed on physical and psychological impacts of oils spills on human health. General findings have indicated higher prevalence of posttraumatic mental and psychological disorders such as stress, anxiety, depression in the oil-exposed populations. Social/familial and economic supports have been reported to play an important role in the affected populations and communities (Laffon et al., 2016; D'Andrea and Reddy, 2014).

3.3. Genotoxic, Immunotoxic and Endocrine System Effects

Genotoxicity risk of crude oil components have been evaluated by the micronucleus technique (MN), comet assay and sister chromatide Exchange (SCE) test in various studies. MN technique is an assay to determine numerical and structural chromosomal abnormalities and frequently be performed because its short duration and cost effectiveness. Comet assay (single cell gel electrophoresis technique) is another sensitive and reliable genotoxicity test used for the detection of single and double strand DNA breaks in a single cell level. Sister Chromatid Exchange test (Sister Chromatid Exchange, SCE) is another sensitive test led to assess mutagenicity and carcinogenicity by staining morphological differentiation of sister chromatids (Aguilera et al., 2010).

Prestige oil spill (Galician coast, NW Spain, November 2002) is the worst ecological disaster of 37 oil tanker accidents in the world in the last 50 years. The oil tanker Prestige spilled 63,000 tonnes of heavy oil off the Galician coast of Spain, impacting more than 300,000 people join in cleanup activities, which lasted up to 10 months (Laffon et al., 2013). There are few studies on genotoxicity risk in humans related to oil accident. Laffon, Pérez-Cadahía and their colleagues assessed comprehensively the genotoxicity, immunotoxicity and endocrin toxicity in population exposed during clean up of the contaminated areas with Prestige oil spill. Prestige fuel oil has been classified in Group 2B by IARC (Laffon et al., 2014).

Laffon et al. (2006) performed comet assay and MN technique to determine the possible genotoxic effects associated with the exposure to Prestige oil, in 34 volunteers from University of A Coruña, who worked in autopsies and cleaning of oil-contaminated birds (150-500 hours), and assessed several DNA repair gene polymorphisms in this population. Their results suggest significantly higher DNA damage but not cytogenetic damage, in relation to the exposure time, and also certain exposure–genotype interactions (Laffon et al., 2006).

Pérez-Cadahía and colleagues evaluated the genotoxicity (comet assay, MN, SCE) in different individuals (n=110) including manual volunteers, hired manual workers and hired workers using high-pressure water machines who exposed to Prestige oil during cleaning labors. DNA damage were reported signicantly higher in exposed groups and also, gender, age and tobacco smoking were found related risk factors to genotoxicity (Perez-Cadahia et al., 2006).

Volatile organic compounds in the environment and heavy metals (Al, Cd, Pb, and Zn) in blood samples of exposed groups were analyzed and cytogenetic damage was assessed by SCE, and endocrine toxicity was determined by plasma prolactin and cortisol levels as biomarkers. Also, genetic polymorphisms of *GSTM1*, *GSTT1*, and *GSTP1* that are important in the detoxification of petroleum compounds were investigated. Prolactin and cortisol levels were found significantly low. Age, sex, smoking and GSTM1 polymorphism were found risk factors in predisposition to cytogenetic damage. These compounds were considered to be endocrine disrupter due to cause hormonal changes (Perez-Cadahia et al., 2007).

Genotoxicity and endocrine toxicity were reported in the large groups exposed in cross-sectional studies. Age and gender were found play role in genotoxicity and endocrine toxicity risk however, protective effects of protective equipments were less noticeable than expected. The role of polymorphisms in genes involved in metabolism and DNA repair (*CYP1A1*, *EPHX1*, *GSTP1*, *GSTM1*, and *GSTT1*) was investigated, and high DNA damage were reported with *CYP1A1* and *EPHX1* variant alleles, also *GSTT1* null genotype was found to have the protective effect on genotoxicity. The higher levels of Al, Ni, and Pb in the blood were considered to be biomarkers of exposure. Also, cortisol and prolactin levels were reported related to heavy metals (negative effects: Al, Ni; positive effect: Cd) in women (Perez-Cadahía et al., 2008a; Perez-Cadahia et al., 2008b; P érez-Cadahía et al., 2008c).

Follow-up genotoxicity assessment studies on oil spills have been carried out rarely. Genotoxicity risk were evaluated in fishermen who particiated the clean-up activities two years after oil exposure and no significant differences were found in MN frequencies Biern et al., 2015. However, chromosomal aberrations were significantly higher in exposed fishermen (Rodríguez-Trigo et al., 2010; Biern et al., 2015; Hildur et al., 2015) and respiratory adverse effect were reported (Rodríguez-Trigo et al., 2010).

Cytogenetic analysis was performed in exposed (n=91) and control subjects (n=46) 22-27 months after oil exposure and chromosomal bands breaks (2q21, 3q27, and 5q31) were reported to increase in peripheral blood lymphocytes. These type of damage (2q21, 3q27, and 5q31) were shown previously characterized with chronic benzene exposure that causes blood cancers (e.g., leukemia, lymphoma), (Monyarch et al., 2013).Endocrine and immunological parameters including plasma concentrations of prolactin, cortisol and cytokines, levels of neopterin, tryptophan and kynurenine, in participants 7 years after oil exposure were examined. Although results were not significatly from the reference values; cortisol levels were increased and kynurenine levels were decreased in exposed group (Laffon et al., 2013).

In the other cross-sectional study of the same authors, 7 years after the accident, the genotoxic effects were assessed by comet assay, MN test and T cell receptor mutation test in subjects (n=54) who were residing closed to the contaminated area by the accident and previously participated in the cleaning studies at least 2 months. Results showed no significant differences than control subjects (n= 50), (Laffon et al., 2014).

4. Conclusion

Crude oil spills occur in almost every region of the world. Accidents are environmental disasters that disrupt the ecosystem, pollute the environment and cause serious health and socio-economic problems. Both acute and chronic toxic effects were investigated in several human studies. In conclusion, crude oil spills negatively affect physical/physiological and psychological health, exhibits toxic effects on immune, endocrine, and reproductive systems and also has carcinogenic and mutagenic effects due to its reactive substances such as aromatic hydrocarbons, benzene etc.

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CRISIS MANAGEMENT OF OIL SPILL, A CASE STUDY: BP GULF MEXICO OIL DISASTER

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1. Introduction

On the evening of April 20, 2010, the Transocean Deepwater Horizon, a mobile drilling rig that worked for British Petroleum (BP) in Mexico's Macondo Prospect Bay, lost control of an exploration well and suffered a disaster boom. In the spring of 2010 and during the summer, the government immediately tried to take action to this biggest oil spill in United States history. Approximately 5 million barrels of oil were poured into the bay for about 3 months before the well was closed.

In this study, analyses of the environmental pollution by oil spill implications of the BP Deepwater Horizon Oil Spill and concern with this crisis currently and in the future were discussed in details. For this purpose, in this article, firstly, the crisis and related concepts were investigated and then the oil pollution caused by the terrible consequences of BP in the Gulf of Mexico was examined as a case study.

2. Common Causes of Spills

The causes of oil spills can be classified as human, company, and technology factors. These factors are listed below Table 1;

Table 1. Causes of oil spills (Department of Ecology State of Washington, 2010)

Human Factors	Company Factors	Equipment Factors
Poor situational awareness	Confusing or outdated procedures	Equipment not suitable for marine and/or commercial use
Complacency	Inadequate maintenance, repairs, training, or safety equipment	Equipment failure due to impact/overuse
Bad judgment	Lack of a spill prevention “culture”	Equipment failure due to normal wear and tear
Fatigue	Inadequate supervision	Equipment poorly designed, installed, or manufactured

3. Defining a Crisis

There are various definitions of crisis. In the Handbook of Crisis Communication, W. Timothy Coombs (2010) defines a crisis as “the perception of an unpredictable event that threatens important expectancies of stakeholders and can seriously impact an organization’s performance and generate negative outcomes”. Lerbinger (1997) defines crisis as “an event that brings, or has the potential for bringing, an organization into disrepute and imperils its future profitability, growth, and possibly its very survival”.

Chinese writing of the crisis word (Figure 1) contains the characters that represent danger and opportunity meanings. Considering this, it can be said that the crisis has both negative and positive approaches (Varoğlu, 2018).

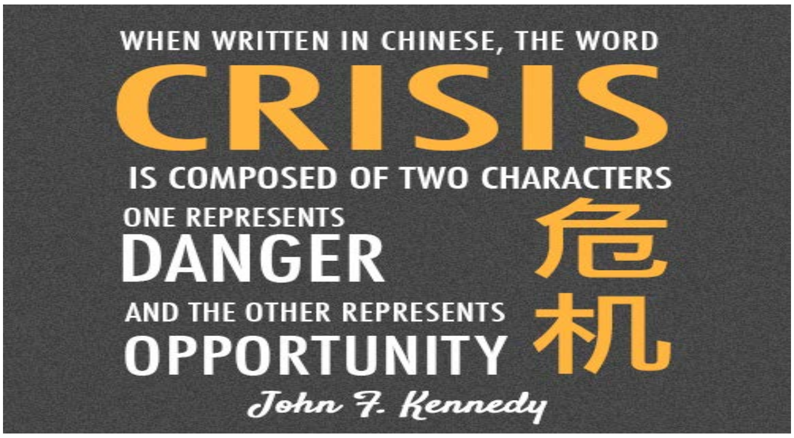

Figure 1. Chinese writing of the crisis

4. Types of Crisis

Various types of crises threaten the businesses and they become a major challenge for them. Main crisis events can be classified into five groups as follows; organizational, technological, internal and external threats, and natural disasters. All of these groups have festering and adventitious characteristics. Table 2 summarizes the crisis categories, definitions, and the potential crisis events.

Table 2. Crisis classification and definition framework summary (Spillan, 2018)

Categories	Definitions	Crisis Events
1. Organizational	These types of events have the potential to disrupt an organization’s day-to-day operations.	Serious industrial accidents, product malfunctions, loss of key records due to fire, systems breakdowns, or terrorist attacks
2. Internal Threats	These crises often originate from operational crises and can result in negative public perceptions.	These consist of corporate espionage, management corruption, embezzlement, and theft. Some examples are employee, and product recalls, and employee violence in the work place.
3. External Threats	These events refer to wrongful acts committed by an individual or organization	Government investigation resulting in is an example. Miscommunication can create other problems. Consumer lawsuits, terrorists attacks, poor publicity about events such as boycotts, product sabotage, and negative media coverage can affect a company’s profitability
4. Natural Disasters	These are caused by an act of God.	They include floods, tornadoes and earthquakes
5. Technology	These are events that have potential impact on the company’s technology system and operations.	Computer systems breakdowns, invasion by hacker, Virus or computer systems invasion by intruder

5. Crisis Management

Crisis Management (CM) can be defined as

“*the overall coordination of an organization’s response to a crisis, in an effective, timely manner, with the goal of avoiding or minimizing damage to the organization's profitability, reputation, or ability to operate and often involves the need to make quick decisions on the basis of uncertain or incomplete information*” (Grimmelt, 2017).

6. Response for Oil Spill

Although it is not reflected in the market price of oil spills, it still leads to the loss of valuable ecosystem services. Managers related with maritime are interested different responses to the elimination or reduction loss of these services.

“Oil spill response analysis *suggests that policy-makers should take a broad and holistic perspective in considering alternative oil spill responses. For example, conventional oil spill management aimed at reducing risks from pressures (e.g., operative requirements) could be complemented by approaches that are aimed at drivers (e.g., transition of fuel to liquefied natural gas) and/or the state of the environment (e.g., improving the resilience of the ecosystem)*” (Hasselström and Cole, 2013).

The available categories for oil spill response were listed in Table 3.

Table 3. A brief summary of available oil spill response categories: examples for measures, policy instruments, environmental governance, and main implementation level (Hasselström and Cole, 2013).

Examples of measures	Examples of policy instruments	Examples of environmental governance	Main implementation level
Measures aimed at underlying drivers			
Transition to natural gas fuel in shipping	Economic incentives to reduce use of fossil fuel, such as emissions trading or taxes	Institutions that implement the ETS or a CO_2 tax	International
Reduce fossil fuel demand	Information, forming of public's preferences, taxes	Institutions that implement the ETS or a CO_2 tax	All levels
Reduce transportation demand	Support for domestic and local markets, increased public transport	Eco-labeling institutions, Green infrastructure	National, Regional
Develop alternative energy sources	Supporting R&D of green energy sources	EU Directive on renewable energy (2009/28/EC)	All levels
Measures aimed at direct drivers			
Reduce shipping	(No existing policy instruments aimed at this driver)		
Reduce tanker traffic	(No existing policy instruments aimed at this driver)		
Measures aimed at pressures			
Limit tanker traffic in sensitive areas.	Establishment of protected areas	PSSAs under IMO	National, Regional
Improve technical standards	Requirements for double hulls, separated ballast tanks, etc.	IMO - SOLAS 1974	International
Improve spill response capacity	Oil response training drills, training of personnel	IMO – OPRC 1989	National, Regional, local
Safer navigation procedures	Regulatory requirements on navigation equipment, rules of the road, and operating procedures	IMO - COLREG 1972	International
Better trained crews	Regulatory requirements for training and credentials	IMO - STCW 1978 ILO 1976	International
Increase usage of piloting in harbors	Requirements (unsubsidized) or incentives (subsidies) for piloting services at local harbors	Paris MoU	National
Measures aimed at state of the environment			
Restore ecosystems	Environmental compensation requirements, efforts to reach GES	ELD, IOPC Funds, MSFD	National, Regional, International

Improve fishing regulations	Reduce fishing allowances, better enforcement of existing regulations (TAC), establishment of marine reserves	CFP (EU)	Regional, International
Environmentally-sensitive urban development	Incentives for compact urban growth, improved control of non-point pollution	Green infrastructure, Brownfields re-development, Espoo Convention	Local
Protect biodiversity	Fulfillment of environmental objectives on biodiversity	CBD	National, Regional, International
Measures to remove pollutants	Improved control and treatment of wastewater, expand capacity of treatment	BSAP	National, Regional
Promote coastal livelihoods	Government subsidies to fishing villages or to support tourism industry	Rural development assistance programs	National, Regional

"ETS: EU Emissions Trading System" "R&D Research and Development" "PSSA Particularly Sensitive Sea Area" "IMO International Maritime Organization" "SOLAS International Convention for the Safety of Life at Sea" "OPRC International Convention on Oil Pollution Preparedness, Response and Co-operation" "COLREG: Convention on the International Regulations for Preventing Collisions at Sea" "Paris MoU The Paris Memorandum of Understanding on Port State Control". "ELD Environmental Liability Directive" "MSFD Marine Strategy Framework Directive" "TAC Total Allowable Catch" "BSAP Baltic Sea Action Plan" "CBD Convention on Biological Diversity" "CFP Common Fisheries Policy"

7. Planning of Spill Oil Response Operations

Oil spill response processes can be successful by an effective planning which is the fundamental conception to have success. The applicable planning circumstances for oil spill response are listed in Table 4.

Table 4. The planning conditions for oil spill (PDAC, 2009).

No	Personnel responding to spills know their respective roles
1	Personnel respond to spills in a safe manner
2	Spills are dealt with on a timely basis
3	The proper mitigation technique is used
4	The spill and mitigation efforts are well documented and reported
5	Develop a response plan suited to spill scenarios applicable to the exploration project
6	Document this plan and ensure that spill responders are familiar with it
7	Solicit suggestions from staff familiar with local conditions
8	Review plans on a regular basis, or when the scope of the project change

8. Case Study: BP Gulf of Mexico Oil Spill

BP's Gulf of Mexico Platform has encountered with an incident that caused by an explosion at the oilrig on April 20, 2010. Because of this accident, 11 workers were deceased. After two days, numerous platforms sank into the Gulf of Mexico and almost 35 thousand barrels of oil spilled per day. The spilled oil induced a major environmental disaster and slaughter. BP established the crisis process, which is a management view for this environmental disaster and slaughter.

8.1. Stakeholders of the BP Oil Spill

The damages of oil spill can be caused by inhalation, physical contact and absorption. The animals that are living marine ecosystems has ulceration, lowered immune systems, skin irritation, organ damage and changes in behaviour because of the digestion of oil. As can be seen from the Figure 2, there are many stakeholders of BP oil spill. These are as follows:

Figure 2. Stakeholders of the BP Oil Spill (Brennan, 2013).

Chemical dispersants, skimming, burning and various other familiar techniques were by BP to diminish the quantity of oil that would affect coastline. These methods are organized according to above stakeholders (Figure 2).

The Deepwater Horizon Oil Spill affected the first stakeholders which were the workmen on the rig itself. During the rig explosion there were 126 people were on the platform, only 115 of them were evacuated (Cleveland, 2010).

8.2. Explanations of Crisis Period

Along with a BP crisis, CEO Tony Howard clarified that at least 20 days were required to stop the leak. However, the US President Obama gave 48 hours to BP to solve the problem before this statement.

The basic and necessary rule is to act quickly in times of crisis and there is no objection to this rule. However, it is also dangerous to make a binding statement without healthy data. Another BP manager said that he needed 10 days to stop the leak, but despite all efforts, the desired results could not be achieved over 100 days (İncaz, 2018).

8.3. Taking Responsibility

BP did not take whole responsibility from the beginning of the problem. Since the BP did not want to take responsibility, company has not been able to express enough statement that figured out their liability.

8.4. The Human Dimension of the Crisis Should Be Highlighted

BP should have made plans to immediately pay compensation to those who lost their lives and families in the explosion that caused the crisis. In addition, they should explain the sorrow of the incident and provide efficient information flow about the health status of the hospital.

8.5. Is The Cost Of Crisis To Be Spoken Repeatedly?

During the continuous crisis, BP talked about the costs of this incident to BP. Environmental organizations and authorities explained that the impact of leakage could be eliminated within years. BP was always willing to express these costs, and they express their sorrow for the loss of lives, also for their damage to nature. Regardless of their cost, BP would be better if they were ready to undertake it.

9.5. Who is guilty?

BP executives blamed the Transocean which a company that manages the Platform. Contrary, the CEO of Transocean place the blame on BP and the cement contractor Halliburton. Instead of blaming someone here, it could be focused on solution-oriented work and solve the problem and conduct an investigation with an independent research commission. This search process for guilty is a faulty crisis management reflex.

9. Conclusion

A set of explosions in the Gulf of Mexico shook the Deepwater Horizon oil platform on the night of April 20, 2010. The gas in the Macondo Well rose unexpectedly. Eleven crewmembers died with the explosion which cause the grieve of the nation. Millions of barrels were poured into the Gulf of Mexico in the following weeks. The federal government gave this cleaning activity to BP because the government authorities lacked the expertise to stop the spill. By the way, BP did not take any responsibility related with failure (İncaz, 2018).

The BP oil spill incident cannot be defined as the largest spill by volume, but it was one of the worse impacting disaster based on its location in the Gulf of Mexico that is close to the major metropolitan zones (Figure 3).

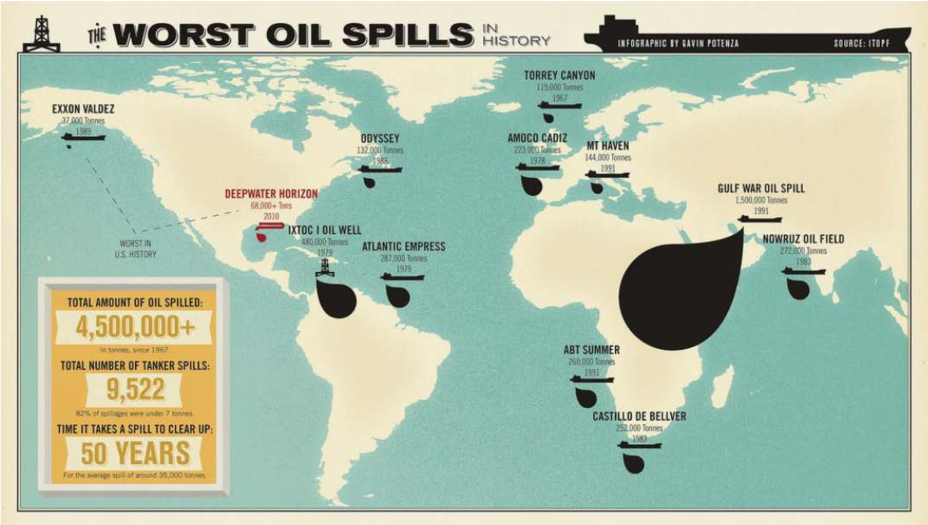

Figure 3. Oil spills by size (from Brennan, 2013).

The consequences of the BP crisis also for general crisis management can be listed as follows:

- If there is no robust data available, instead of making a binding statement, wait for an appropriate time or not to make such statements until healthy data is obtained.
- Both public and authorities expect from companies to take full responsibility and meet their requirements during crisis periods.
- In every crisis, human dimensions should be emphasized.
- Companies should not mention the costs arising from the company during the crisis.
- Instead of blaming someone or seeking guilty, they can focus on solution-oriented work and solve the problem and conduct an investigation with an independent research commission.

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CHAPTER 6

CONVENTIONS RELATING TO PREVENTION OF OIL SPILL

This chapter describes international conventions relating to prevention of oil spill and provides information on some of the applications on Turkey mainly the TSSA. Maritime transportation serves approximately 90% of worldwide trade by transporting great amounts of cargo safely and cost effectively. However, there are various risks of cargos transported by sea, especially environmental pollution. The international maritime vessel traffic in the TSSA is under the Turkish governmental control. The TSSA also plays a distinctive and important role in terms of security for supply of energy since about 3% of the international oil transport is achieved by tankers passing through the Turkish Straits. Considering all physical conditions and busy traffic, there is a high possibility of huge risk for a maritime incident that can be caused by oil tankers with hazardous cargo. Apparently, to protect the environment it is significant to ensure the decrease of oil spills as possible. The risk of oil spills can be reduced by introducing strict new legislation and stringent operating codes with the joint effort of government and industry. International Maritime Organization (IMO), which is a United Nations specific agency, is in charge to create maritime rules and establish the Conventions related with maritime transportation to prevent environmental pollution and guide all nations. The Conventions created by IMO are generally classified under four principal subjects as follows; maritime safety, marine pollution- oil spill, liability and compensation, other subjects. IMO has been adapting rules and regulations to prevent environmental pollution since 1958 such as “OILPOL (International Convention for the Prevention of Pollution of the Sea by Oil), MARPOL 73/78 (“International Convention for the Prevention of Pollution from Ships”), INTERVENTION (“International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties”), OPRC (“International Convention on Oil Pollution Preparedness, Response and Co-operation”), CLC (“International Convention on Civil Liability for Oil Pollution Damage”),” etc. The MARPOL 73/78 is the main global convention that includes prevention of environmental pollution caused by maritime vessels and currently includes six technical Annexes.

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INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION OF THE SEA BY OIL (OILPOL), 1954 AND ITS SITUATION RELATED WITH TURKEY

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1. Introduction

Maritime transportation carries a wide range of commodities in liquid or solid bulk forms. Liquid cargo carriage is by far the riskiest one since the consequences of incidents could be potentially harmful for maritime environment, human life and commodities. Tanker ships carry a wide range of petroleum products cargoes with varying specifications. In the event of liquid cargo spillage caused by tanker ship accident into the sea, it can pose catastrophic consequences. These consequences affect a wide range of targets such as human habitat, shore land, shores, fisheries, tourism, etc. (Akyüz et al., 2017). The extensive oil spill may spread out long range from the source of maritime accident. It may cause severe harms for marine habitat as sea water became contaminated by liquid petroleum. When oil spill residues reach coast line, it also affects human settlement on the cities. In sum up, the case of oil spill completely disturbs an entire marine and mainland ecosystem for a length of time. The International Maritime Organization (IMO) aim is to develop and maintain rigid rules and regulations to prevent pollutions such as International Convention for the Prevention of Pollution of the Sea by Oil (OILPOL), International Convention for the Prevention of Pollution from Ships (MARPOL), International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (INTERVENTION), International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC), International Convention on Civil Liability for Oil Pollution Damage (CLC), etc. (IMO, 2018-a). The OILPOL is one of the former conventions related to pollution prevention of the sea by oil.

In the literature, there have been various researches on pollution prevention in maritime industry. A set of comprehensive and robust methodologies have been proposed to minimize oil pollution in maritime industry (Gasparotti and Eugen, 2012). In last decades, catastrophic maritime disaster such as Torrey Canyon, Erika, Prestige, Exxon Valdez (Figure 1), Independienta, Erika, etc. were discussed in maritime industry since those accidents are considered as major oil spill incidents around the world (Çelik and Topcu, 2009). Marine ecosystem and coast lines were considerably affected.

Figure 1. Exxon Valdez oil spill incident- the largest oil spill disaster in USA (from AP photo/Al Grillo).

Maritime researchers have attempted to focus on their researches in different topics such as spill oil response (Ivanov and Zatyagalova, 2008; Peterson et al., 2003), risk assessment (Goerlandt and Montewka, 2015; Olita et al., 2012; Lie et al. 2012), pollution prevention (Mokashi et al., 2002), etc. One of the major oil spill disaster occurred in 2010 in the Gulf of Mexico. Deepwater Horizon oil spill discharged in excess of 6 million tons of oils into the sea. The oil spill residues affect marine ecosystem and marine creatures. After 85 days, it was finally capped (Reddy et al., 2012).

Since oil spills are considered as one of the main concerns in maritime transportation industry, this paper investigates technical background and application of OILPOL convention to prevent marine environment. In this context, the paper organized as follows. This section gives motivation and brief literature reviewing on oil spill and its effect on marine environment. Section 2 describes OILPOL convention in technical aspect. Section 3 discusses OILPOL convention and its situation associated with Turkey. The final section concludes research and recommend future studies.

2. International Convention for the Prevention of Pollution of the Sea by Oil (OILPOL)

OILPOL convention coming into force on July 1958 to deal with the sea pollution problem caused by oil product (Berescu, 2010). In the convention, oil products outlined as, diesel oil, crude oil, lubricating oil, and fuel oil. The convention perceived that most oil pollution was due to routine ship operations, for example, cleaning of the cargo tanks (IMO, 2018-b).

The normal practice in the early of 1950s was just washing and rinsing cargo tanks with fresh water and then pumping out the residues of oil mixture into the seawater.

The OILPOL convention consisted of 21 articles and 2 Appendix. The convention was organized and adopted by United Kingdom government in 1954. Then, the OILPOL convention is aimed to fulfill certain functions when implemented by IMO (IMO, 2018-b). Although IMO was established in 1958, just before adopting of OILPOL, the convention was effectively managed by IMO. The vault and Secretariat works in connection to the Convention were exchanged from the United Kingdom Government to IMO.

The main aim of the OILPOL convention was to ban dumping of oily wastes inside a specific separation from land and in 'special areas' where threat to the marine environment was particularly intense (IMO, 2018-b). The IMO extended the limits by adopting an amendment in 1962. The IMO, on the other hand, established a subcommittee on oil pollution to refer oil pollution issue under control of MSC (Maritime Safety Committee). According to the convention, it was established "prohibited zones" enlarged to minimum 50 miles from the closest shore line in which the release of oil or blends containing in excess of 100 sections of oil for every parts was prohibited; it required Contracting Parties to find a way to advance the arrangement of offices for the gathering of oily water and residues (Berescu, 2010). The OILPOL convention was rectified in 1962, 1969 and 1971 sequentially. In convention, it was aimed to prevent potential pollution caused by routine tanker operations and to evacuate oily wastes from machine areas, which are considered as the main causes of oil pollution from ships.

Though OILPOL convention was ratified in 1954, oil pollution prevention was not a major concern for the IMO. At that time, the world concentrated to the environmental outcomes of an increasingly industrialized society. In 1967, one of the most catastrophic maritime accidents, Torrey Canyon was aground while entering the English Canal. About 120,000 m tons of oil spilled into the sea. It was one of the greatest maritime disaster severely polluted maritime environment. At the end of Torrey Canyon disaster (Figure 2), questions related to the oil spill prevention were arisen. In addition, the exposed shortage was in the existing system to provide compensation following sea accidents at sea.

Figure 2. Torrey Canyon maritime disaster (from BBC.com).

Torrey Canyon disaster raised questions about the OILPOL convention and preventive measures. The IMO gave a call for urgent summit of its Council, which drew up preventive actions on legal and technical aspects of the Torrey Canyon disaster (IMO, 2018-b). In 1969, another amendment was recommended for the OILPOL convention covering a procedure known as “load on top” which had been introduced by oil industry. In this amendment, a special tank was introduced to pump the washings residues resulting from tank cleaning. On the other hands, the tankers size enlarged due to the increasing transportation demand in seaborne trade. The increasing amount of the chemical products being carried by chemical tanker ships highlighted attention into maritime environment protection. Many countries signed OILPOL convention felt that the convention was not adequate although numerous amendments and modifications had been done.

In 1969, the IMO focused on a new convention dealing with oil pollution matters, which would integrate the regulations contained in OILPOL. At that time, the Marine Environment Protection Committee (MEPC) was adopted under IMO. In 1971, the final amendment was conducted on OILPOL convention in which restricted the size of cargo tanks in all tanker types. Hence, in case of collision, grounding or damage to the vessel, just a limited amount of oil product could spill into the sea (IMO, 2018-b).

In 1973, the MARPOL convention was rectified and OILPOL convention was incorporated. Annex I of MARPOL convention covering regulation with respect to the prevention of pollution by oil was introduced. Annex I, indeed, expanded and improved on OILPOL in numerous way (IMO, 2018-b). The OILPOL convention was terminated once modified version of MARPOL convention came into force in 1978 (Canca, 2012).

3. OILPOL 54 and Its Situation Related with Turkey

Tanker shipments have been growing as the more than 30 percent of cargoes carried by seaborne trade are transported by tanker ships (UNCTAD, 2016). Since the Turkey is situated near the oil reserves of Caspian Sea and Middle East, the liquid cargoes carriage through Turkish Straits have been increasing gradually. In 2017, almost 8,800 tanker ships completed their passages through Turkish Straits (DTGM, 2018). Daily oil tanker transport up to 150 million tons per year high (Pamir, 2007). Increased shipping activity, in particular at Turkish Strait, can pose potential harm to property, life and sea environment. In the history, various maritime accident occurred through Turkish Strait and most of them resulted in catastrophic consequences such as major oil spills, wrecks, loss of lives and properties. The case of MT Independentia, MT Nassia, and MT World Harmony severely damaged to environment. More than 120 thousand tons of oils spilled out. On the other hands, three major maritime accidents (Table 1) occurred in the İstanbul Strait before MARPOL convention implementation. The OILPOL convention was in forced at the time of accidents occurred.

Table 1. Major oil spill disasters in Turkish Straits before MARPOL convention (Akten, 2006).

Date	Position	Vessels involved in accidents	Spilled quantity
1960	Istanbul Strait	MV World Harmony and MV Peter Zoranic	18,000 mts oil
1964	Istanbul Strait	MV Norborn and wreck of Peter Zoranic	Fire and oil spill
1966	Istanbul Strait	MV Lutsk and MV Kransky Oktiabr	1,850 mts oil

The OILPOL 1954; "*the convention shall apply to sea-going ships registered in any of the territories of a Contracting Government, except*

(i) ships for the time being used as naval auxiliaries;

(ii) ships of under 500 tons' gross tonnage;

(iii) ships for the time being engaged in the whaling industry;

(iv) ships for the time being navigating the Great Lakes of North America and their connecting and tributary waters as far east as the lower exit of the Lachine Canal Montreal in the Province of Quebec, Canada." (OILPOL, 1954).

In the light of convention articles, the OILPOL convention applied to major maritime accidents since Turkey is the signatory part of convention. In Article VI of OILPOL 1954: "*The penalties which may be imposed in pursuance of Article III under the law of any of the territories of a Contracting Government in respect of the unlawful discharge from a ship of oil or of an oily mixture into waters outside the territorial waters of that territory shall not be less than the penalties which may be imposed under the law of that territory in respect of the unlawful discharge of oil or of an oily mixture from a ship into such territorial waters."* (OILPOL 1954). This statement clearly stipulates penalties for oil or oil mixture spills into the sea. Therefore, penalties were imposed to cover damages caused by the oil spill disaster. However, damages to fishery, tourism, shorelines and marine ecology have yet to compensate due to the deficiencies in the current system of OILPOL convention.

Figure 3. World Harmony and Peter Zoranic maritime disaster at the Istanbul Strait (from beykozguncel.com).

Likewise, World Harmony and Peter Zoranic maritime disaster (Figure 3), Turkey faced with major problems in case of Lutsk and Kransky Oktiabr maritime disaster. Application of OILPOL convention gave limited control of the sovereign country. Therefore, financial fines were only applied for oil spill damages.

4. Conclusions

Maritime environment protection is one of the core topics in maritime industry. A maritime accidents causing oil spill would be catastrophic. The main effect of oil spills certainly causes unfortunate results on the marine ecosystem and humanities. Therefore, the IMO-regulatory body of maritime affairs- established a set of rules and convention to regulate the maritime transportation safely and environmentally friendly (Turan, 2009). The MARPOL convention is one of the most important regulation to prevention of pollution of marine environment. Prior to the MARPOL, the OILPOL convention was adopted in 1954 to cope with problem of pollution of the sea caused by oil product. This convention is the initial state of MARPOL. The convention aimed at dealing with accidental oil pollution through requirements designed to accident prevention on tankers to limit their consequences by implementing a series of control measures. It was applied from 1954 to 1978 where MARPOL came in to force. In this context, this paper discusses the OILPOL convention in technical aspects and its situation associated with Turkey.

Since OILPOL convention applied for a short period, its situation associated with Turkey was quite low. Three major maritime accidents occurred in Turkish Strait were discussed under OILPOL convention. As the articles and sanctions of OILPOL convention are very limited, their applications over major oil spills caused by maritime accident were inadequate. Therefore, Turkish government imposed a certain fine to cover damages. Due to the deficiencies of the current system of OILPOL convention, damages to fishery, tourism, shorelines, and marine ecology have been occurred.

In conclusion, the OILPOL convention is no longer applicable for maritime pollution prevention. The convention was replaced by MARPOL 73/78. However, OILPOL convention is the former convention regulate pollution prevention measures. This paper is expected to gain an understanding of underlying reasons, opinions, and motivations with respect to the OILPOL application in Turkey.

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INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973, AS MODIFIED BY THE PROTOCOL OF 1978 RELATING THERETO AND BY THE PROTOCOL OF 1997 (MARPOL)

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1. Introduction

A vital convention in prevention of marine pollution, mainly caused by ships due to the operational and accidental events, is MARPOL. Oil, noxious liquid waste, harmful materials in package form, dirty water discharging, waste, air pollutants and noise pollution are the most potent pollutions known.

Maritime transportation becomes more and more important every day. Safety and environmental protection events, which are important for the protection of the world's oceans and maritime businesses, have become a crucial issue. The maritime industry has been exposed to countless disasters for hundreds of years, but many international rules were born with these tragical events for constant lessons learned. The common aim of all of them is to prevent sea accidents, loss of life and injuries, damage to marine pollution and marine life.

In the beginning of the 20th century, oil pollution in marine life was a controversial issue and United Kingdom set a congress about marine pollution, which was concluded with "*International Convention for the Prevention of Pollution of the Sea by Oil (OILPOL)*" in 1954 and were adopted in 1969. "OILPOL Convention which came into force on 26 July 1958 and deal with marine pollution by *crude oil, fuel oil, heavy diesel oil and lubricating oil* and defined *prohibited zones, discharging criteria* for oil and oily mixtures. These convention was changed firstly in 1962 due to the need experienced. In 1969 and 1971, new rules and sanctions were set up which contained marine pollution from the tanker cargo operations and the disposal of oily wastes in engine area. In spite of these regulations and actions, more serious measures had to be taken about marine pollution with a growing industrial society" (Berescu, 2010).

In 1967, M/T Torrey Canyon hit the rock off the coast of Cornwall and grounded, approximately 100,000 tonnes of crude oil flowed and spread into the English Channel which was the first major marine pollution ever recorded up to this time. This disaster caused serious damage not only to the marine environment but also to the local people and the animals. The Torrey Canyon was an important milestone for regulations and conventions on marine pollution. After this disaster, International Maritime Organization (IMO) set an extraordinary session of its Council, which examined Torrey Canyon incident (Figure 1).

Figure 1. Torrey Canyon oil spill incident (The Guardian, 2017).

> "*In 1969, the IMO Assembly decided to convene an international conference to adopt a completely new convention, which would incorporate the regulations contained in OILPOL 1954 (as amended). At the same time, the Sub-Committee on Oil Pollution was renamed the Sub-Committee on Marine Pollution, to broaden its scope, and this became the Marine Environment Protection Committee (MEPC), which was eventually given the same standing as the Maritime Safety Committee, with a brief to deal with all matters relating to marine pollution. The conference was set for October-November 1973, and preparatory meetings began in 1970. Meanwhile, in 1971 IMO adopted amendments to OILPOL 1954, which limited the size of cargo tanks in all tankers ordered after 1972. The intention was that given certain damage to the vessel, only a limited amount of oil can enter the sea*" (IMO, 1998, p. 5).

Due to the increased tanker accident, a Conference on Tanker Safety and Pollution Prevention set in February 1978 and the protocol of 1978 MARPOL was adopted. Before the 1973 MARPOL Convention had not came into force, the 1978 MARPOL Protocol absorbed the main Convention. The convention 1973 and the Protocol of 1978 are combined with each other and MARPOL 73/78 entered into force on 2 October 1983 (Annexes I and II). The Protocol was amended the Convention and Annex VI were entrained in 1997, which came into force on 19 May 2005. MARPOL has been updated by amendments with accidents and technological developments through the years.

The Marine Environment Protection Committee (MEPC) is a part of IMO makes and submits amendments periodically (IMO, 2018). Table 1 shows MARPOL annexes.

Table 1. MARPOL Consists of 6 Annexes (IMO, 2018).

Annex	MARPOL
I	Regulations for the Prevention of Pollution by Oil
II	Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk
III	Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form
IV	Prevention of Pollution by Sewage from Ships (entry into force date 27 September 2003)
V	Prevention of Pollution by Garbage from Ships
VI	Prevention of Air Pollution from Ships (adopted September 1997 - not yet in force)

According to IMO Status of Treaties report, now 157 countries have agreed to the MARPOL 73/78 convention and it is 99.15% of the World tonnage. (IMO, 2018).

2. Implementation of MARPOL 73/78

In this section, MARPOL 73/78 rules and applications on ships were explained.

2.1. Annex-I

Annex I regulates the prevention of pollution by oil and the safely built of oil tankers, reduces the oil spillage due the accidental and operational pollution which was entered into force on 2 October 1983. It is mandatory for every oil tanker of 150 gross tonnage and every other ship of 400 gross tonnage and above which laid down for ships while discharging of oil into the water. "Special areas" for Annex-I were defined and these areas highly protected from pollution than the other navigational areas. These areas are delicate because of its oceanographical, ecological condition and to the particular character of its traffic. There are strict and compulsory requirements for the prevention of marine pollution that may be caused by petroleum / chemicals /garbage etc. Figure 2 shows an overview of Special areas.

Figure 2. MARPOL Annex I Special Areas (Marineguru, 2018).

There are two types of oil discharge monitoring and control system that can be used to prevent sea pollution due to cargo / ballast and bilge gaps.

The ODME (Oil Discharge Monitoring System) is for the control of the discharge of tank cleaning slops and dirty or clean ballast from normal cargo/ballast operation. As per Annex-I, all the oil tankers of 150 gross tonnage and above must have an approved Oil Discharge Monitoring System. This equipment must be operational, and type approved. Critical requirements take into account for oil mixture discharge from cargo space as below while discharging without special areas which present in Table 2.

Table 2. ODME discharging requirements (IMO, 2018).

	Requirements
1	The tanker must be on route.
2	The tanker must be 50 nautical miles away from land.
3	The rate of discharge of oil content does not exceed 30 litres per nautical mile.
4	The total quantity of discharge must not exceed 1/30000 of the total quantity of the residue formed cargo.

The other is oily water separators (OWS) or Oil Content meters (OCM) used for the control of discharge of engine room bilge water, which is known as the 15 ppm. Before discharging operation of bilge water, the oily water is separated through oil filtering equipment. This equipment must be operational, and type approved. (Table 3).

Table 3. Requirements for bilge water discharge (IMO, 2018).

	Requirements
1	The ship* is more than 12 nautical miles from the nearest land.
2	The ship* is proceeding en route.
3	The oil content of the effluent is less than 15 parts per million.
4	The ship* has in operation an oil discharge monitoring and control system, oily-water separating equipment, oil filtering system or other installation required by this Annex.
5	These restrictions do not apply to discharges of oily mixture, which without dilution have an oil content not exceeding 15 ppm.

*As per Annex-I, all the oil tankers of 150 gt and above and every ship of 400 gt and above other than oil tankers must have an approved Oily Water Separators. Critical areas are excluded from the tankers where the discharge is mixed with the oil load residue when unloading without special tanks. All ships take into account the discharge of bilge water from the engine room.

Designated classification society must approve The ODME and OWS with type approval certificate and operating manual of these systems must be keep on board. The system must record below information about operation and records must be keep on Oil Record Book for each space, stored on board at least three years.

- The location of operation (latitude and longitude)
- Date and time
- Total discharging quantity
- Discharging rate of pump
- Oil content of the discharged mixture in ppm

Annex-I, regulation 17 needs that the vessels (>400 gt) and oil tankers (>150 gt) must have the Part I of Oil Record Book which is about the operations on machinery space. The regulation 36 requires that every oil tanker oil tankers (>150 gt) and above must keep records with an Oil Record Book Part II (Cargo/Ballast Operations). Loading/discharging, crude oil washing, cargo transfers during the voyage, cleaning of cargo tanks, discharging of dirty ballast etc. should be recorded. Each operation has a letter code, which is used in the records in Section I and II of the Oil Record Book. The date, transaction code and items are added chronologically when the records are made. Each of the completed operations, officers on watch must sign and every completed page must be signed by master.

The Shipboard Oil Pollution Plan (SOPEP) used in emergency events and every (>150 gt) oil tankers and other ships over (>400 gt) should carry this plan onboard to prepare emergency oil pollution situations. International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC, 1990) also has the same function to prevent oil pollution with SOPEP. The plans have a standard format provided by IMO, which comprise systematic safety procedures to take actions for oil pollutions during the operations. The plan uses by ship’s crew during the emergencies and all instructions as simple as possible with clear instructions to understanding by the masters and officers. The manual should cover;

- Reporting procedures and requirements
- Emergency checklists
- Oil Spill types
- Pollution emergency team
- Duties of the team
- Clean up procedures
- Training and exercises plan for shipboard and shore-based personnel
- Ship plans and specifications
- Emergency contact lists

2.2. Annex-II

Annex-II sets up rules for the prevent of pollution by noxious liquid in substances in bulk and defines categorization of pollution by noxious liquid in four categories (X, Y, Z, and OS) and discharging procedures, carriage, stripping and underwater discharge requirements. It was entered into force on 6 April 1987. The categories of noxious liquid in substances according to IMO are given below (Table 4).

Table 4. Categorization of pollution by Noxious liquid in four categories (IMO, 2018).

Categ.	Definition
X	Noxious Liquid Substances which, if discharged into the sea from tank cleaning or de-ballasting operations, are deemed to present a major hazard to either marine resources or human health and, therefore, justify the prohibition of the discharge into the marine environment
Y	Noxious Liquid Substances which, if discharged into the sea from tank cleaning or de-ballasting operations, are deemed to present a hazard to either marine resources or human health or cause harm to amenities or other legitimate uses of the sea and therefore justify a limitation on the quality and quantity of the discharge into the marine environment
Z	Noxious Liquid Substances which, if discharged into the sea from tank cleaning or de-ballasting operations, are deemed to present a minor hazard to either marine resources or human health and therefore justify less stringent restrictions on the quality and quantity of the discharge into the marine environment
OS	Substances which have been evaluated and found to fall outside Category X, Y or Z because they are considered to present no harm to marine resources, human health, amenities or other legitimate uses of the sea when discharged into the sea from tank cleaning of de-ballasting operations. The discharge of bilge or ballast water or other residues or mixtures containing these substances are not subject to any requirements of MARPOL 73/78 Annex-II.

IMO has determined the criteria of discharging operations by classifying Noxious Liquid Substances according to their pollutant degree. Noxious liquid Substances transportation is different from transportation of oil and oil product, each chemical cargo has specific requirements and precautions which always consideration during the cargo operations (INTERTANKO, 2006). Antarctic region has been established as a special area for Annex-II and discharging of cargo are prohibited in this area.

> *"Where the provisions in this regulation allow the discharge into the sea of residues of substances in Category X, Y or Z or of those provisionally assessed as such or ballast water, tank washings or other mixtures containing such substances the following discharge standards shall apply:*
>
> *1. The ship is proceeding en route at a speed of at least 7 knots in the case of self-propelled ships or at least 4 knots in the case of ships, which are not self-propelled;*
>
> *2. The discharge is made below the waterline through the underwater discharge outlet(s) not exceeding the maximum rate for which the underwater discharge outlet(s) is (are) designed; and*

3. The discharge is made at a distance of not less than 12 nautical miles from the nearest land in a depth of water of not less than 25 metres" (IMO. MEPC. 118(52), 2004).

All cargo operations records should be maintained in Cargo Record Book and these operations (loading, discharging, tank cleaning etc.) procedures and technical instructions of specific equipments are indicated in Procedures and Arrangements Manual (P&A Manual) which is endorsed by the administration. Shipboard marine pollution emergency plan (SMPEP) has a standard format provided by IMO, which comprise systematic safety procedures to take actions for oil pollutions during the operations. The plan uses by ship's crew during the emergencies and all instructions as simple as possible with clear instructions to understanding by the masters and officers.

2.3. Annex-III

On July 1st 1992, an annex III has been published internationally on the prevention of pollution, which is caused by harmful substances in packaged form. There are no pollution categories in Annex-III different from Annex-II. In addition to package forms, this Annex also cover freight containers, tanks, wagons and similar types as mentioned by IMDG Code. A stowage plan of the ship determines the location of the harmful substances can be used. Copies of such documents with the ship until the discharge of harmful substances or stored ashore by a representative. Harmful substances should be maintained so as not to threaten the marine environment and the people on board and stowed. Necessary limitations on the amount that shall be moved due to the technical and scientific terms should be some harmful substances. Marking and labelling regulations for harmful substances in package form;

"1. Packages containing a harmful substance shall be durably marked with the correct technical name (trade names alone shall not be used) and, further, shall be durably marked or labelled to indicate that the substance is a marine pollutant. Such identification shall be supplemented where possible by any other means, for example, by use of the relevant United Nations number.

2. The method of marking the correct technical name and of affixing labels on packages containing a harmful substance shall be such that this information will still be identifiable on packages surviving at least three-month immersion in the sea. In considering suitable marking and labelling, account shall be taken of the durability of the materials used and of the surface of the package.

3. Packages containing small quantities of harmful substances may be exempted from the marking requirements" (IMO. MEPC. 156(55), 2006).

2.4. Annex-IV

Regulations for the prevention of pollution by sewage are included in Annex-IV which was entered into force on 27 September 2003. Sewage is manhole and waste from toilets and other containers used to store or store body waste discharged from the ship. Sewage is naturally rich in terms of both nitrogen and phosphorus, by promoting the growth of plants and algae excessive toxic algal "bloom", is created. When these plants and algae die, they are destroyed by bacteria that kill other marine life and eliminate oxygen in water. Sewage is also a source of pathogen such as viral hepatitis, cholera, typhoid fever and various gastrointestinal diseases. The Regulation on the Prevention of Pollution entered into force on 1 August 2005 and applies to the following new and existing ships (Table 5).

Table 5. MARPOL Annex-IV application criteria (IMO, 2018).

	Criteria
1-	400+ gross tonnage.
2-	Less than 400 gross tonnage certified to carry more than 15 persons.
3-	'New ship' is one for which the building contract or keel was laid on or after 27 September 2003 or delivered on or after 23 September 2006.
4-	Existing ships had to comply by 27 September 2008.

Sewage treatment plants requirements were set up by IMO in October 2006 (IMO. MEPC. 159(55), 2006). While discharging untreated sewage from tanks, the vessel should be 12 nautical miles from the nearest land (IMO. MEPC. 157(55), 2006). This annex enforced to ships which is detailed on how to handle or hold sewage on board and allow spill conditions to the sea.

Table 6. The sewage discharged into the sea is prohibited except for the some conditions (IMO, 2018).

	Criteria
1-	The ship operates an approved Sewage Treatment Plant approved by the flag state and does not produce waste, floating solids, and does not cause a change in the colour of the surrounding water.
2-	The vessel is discharged from a distance of more than 12 miles from the closest land and the sewage is discharged and not less than 4 knots (when the plant is stopped for maintenance).
	*This Annex applies to all new vessels (built after the date of entry into force of the Annex), less than 400 new vessels, which are certified to carry more than 400 gross tonnage and over 15 persons.

Five years after its entry into force, on 27 September 2008, the Annex will also apply to more than 400 existing vessels and more vessels certified to carry more than 15 persons. Master, "Annex-IV" and will prevent marine pollution in compliance with local or local laws and regulations. The sewage discharged into the sea is prohibited except for the some conditions shows in Table 6.

In July 2011, the MEPC 62 was adopted by the decision of MEPC.200 (62), the last amendment to Annex-IV, which entered into force on 1 January 2013. The amendment entails, among other things, a definition of the Special Area, as well as for the passenger ships while discharging of sewage in these areas and the relevant requirements for port reception facilities.

2.5. Annex-V

Annex-V contains general requirements for different types of garbage and aims to reduce the amount of garbage being dumped into the sea from the vessels. Even though Annex-V is mandatory for all ships, there are neither certification nor approval requirements. It was entered into force on 31 December 1988. More than 150 Countries have signed up to Annex-V. The amendments to Annex-V adopted at MEPC 70 will enter into force on March 1st 2018. According to the new regulation garbage category distribution as shows in Table 7.

Table 7. Garbage Category Distribution (IMO, 2018).

Category	Definition
A-	Plastics
B-	Food waste
C-	Domestic wastes
D-	Cooking oil
E-	Incinerator ashes
F-	Operational waste
G-	Animal carcasses
H-	Fishing gear
I-	E-waste
J-	Cargo residues (non-HME)
K-	Cargo residues (HME)

With this annex, all garbage must be kept on board and separated to be delivered to the shore facilities, except cargo waste, cleaning materials, food waste, additives and animal carcasses (IMO, 2018). The Table 8 below illustrates special areas for Annex V.

Table 8. Special Areas for Annex-V (IMO, 2018).

No	Area
1-	Mediterranean Sea
2-	Baltic Sea
3-	Black Sea
4-	Red Sea
5-	"Gulfs" area
6-	North Sea
7-	Antarctic area (south of latitude 60 degrees south)
8-	Wider Caribbean region including the Gulf of Mexico and the Caribbean Sea

The regulatory requirements under the Annex V presents in Table 9 according to vessel specification.

Table 9. Regulatory requirements for amendments to Annex V of MARPOL 73/78 (IMO. MEPC. 220(63), 2012).

	Regulatory Requirements
1-	Every ship of 100 gross tonnage and above, and every ship certified to carry 15 or more persons, and fixed or floating platforms shall carry a garbage management plan.
2-	Every ship of 400 gross tonnage and above, and every ship certified to carry 15 or more persons engaged in voyages to ports or offshore terminals of another Party, and every fixed or floating platform shall be provided with a Garbage Record Book; and
3-	Every ship of 12 metres or more in length overall, and fixed or floating platforms shall display placards which notify the crew and passengers of the ship's disposal requirements of regulations 3, 4, 5 and 6 of the Annex as applicable. The Administration may waive the requirements for Garbage Record Books for: Any ship engaged on voyages of one hour or less in duration which is certified to carry 15 persons or more; or, Fixed or floating.

2.6. Annex-VI

MARPOL 73/78 deals with not only sea pollution but also deals with air pollution from ships, which sets limitation for flue gas from ship exhaust (sulphur oxides "SOx", and nitrous oxides "NO_x"). The world faces with air pollutions and it leds to effects on the environment, for instance, acid rain and climate change. Annex-VI regulates ships exhaust gas, including SO_x and NO_x and the emissions of volatile organic compounds from tankers.

With the revised MARPOL 73/78 Annex-VI (Figure 3);

> "*Until 31 December 2019, for ships operating outside Emission Control Areas, the limit for sulphur content of ships' fuel oil is 3.50% m/m (mass by mass). The 0.50% m/m limit will apply on and after 1 January 2020. This will significantly reduce the amount of sulphur oxide emanating from ships and should have major health and environmental benefits for the world, particularly for populations living close to ports and coasts*" (IMO FAQ, 2018, p.1).

> *"Since 1 January 2015, the sulphur limit for fuel oil used by ships operating in Emission Control Areas (ECAs) designated by IMO for the control of sulphur oxides (SOX) has been 0.10% m/m. The ECAs established under MARPOL Annex VI for SOx are: the Baltic Sea area; the North Sea area; the North American area (covering designated coastal areas off the United States and Canada); and the United States Caribbean Sea area (waters around Puerto Rico and the United States Virgin Islands)"* (IMO FAQ, 2018, p.5).

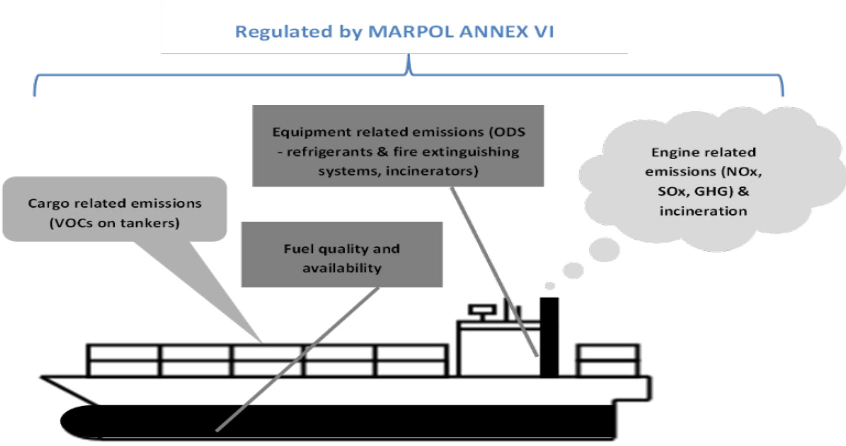

Figure 3. MARPOL 73/78 Annex-VI (IMO, 2015).

A basic and necessary calculation is EEDI (Energy Efficiency Design Index) and it is needed for various type of vessels. EEDI is an essential calculation (Figure 4) of energy efficiency indicator for the vessels, which enables an assessment of energy efficiency. A smaller value of EEDI is evaluated that a more energy efficient ship design and this assessment is valuable for sustainable development in maritime industry (Bolat and Bolat, 2017).

The Ship Energy Efficiency Management Plan (SEEMP) provides a suitable approach for companies to manage their vessels efficiency performance. The Energy Efficiency Operational Indicator (EEOI) as a control mechanism for verifying the SEEMP which provide to evaluate the efficiency of fuel consumption (IMO, 2018).

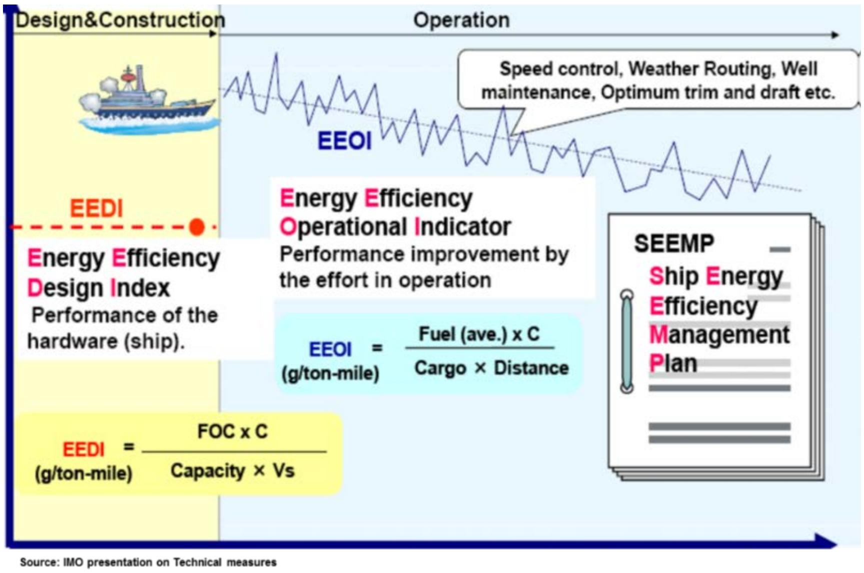

Figure 4. Frame work for energy efficiency (IMO, 2015).

3. Conclusions

For the hundreds of years, the marine industry has been encountered to several tragic events, which led to develop great improvements for international regulations. These events provided the establishment of maritime organizations, the introduction of rules, sanctions and standards, and the development of follow-up and control mechanisms. MARPOL 73/78 is the major international convention, which indented to prevent pollution from ships caused by operational or accidental causes. According to MARPOL 73/78, the main types of pollution which are caused by ships oil pollution, chemical substances, harmful substances carried in packages, sewage discharging, by the disposal of garbage, air pollution, noise pollution. MARPOL has been updated by amendments with accidents and technological developments through the years, which has six annexes. In this paper, MARPOL 73/78 Convention is tackled with historical background and Annexes with the applications on board are mentioned.

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APPLICATIONS OF MARPOL RELATED WITH OIL SPILL IN TURKEY

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1. Introduction

Maritime transportation is the shipment of cargoes by seaway. More than 80 percent of world trade is carried by commercial ships. Due to the nature of work, there are various challenges and hazardous situations may be born during carriage of cargoes such as oil spill (Akyuz et al., 2017). Various types of pollutants such as garbage, emission, plastics, noxious liquid and solid substances, sewage, oil spill etc. have serious impacts on maritime environment. The oil spill may be considered as the most catastrophic ones since its consequences affects a wide range of targets such as human habitat, shore land, shores, fisheries, tourism, etc. The widespread oil spill may spread out long range from accident source. This may result with harms for marine ecosystem at all. In order to prevent oil spill and minimize effects, maritime authorities such as IMO, Port State Control, Class Society, Flag State Control, etc.) adopted fundamental regulations such as MARPOL73/78 (International Convention for the Prevention of Pollution from Ships), BW (Ballast Water) Convention, Hong Kong Convention, etc. The MARPOL, is the main international convention, was accepted by IMO in 1973 to prevent pollution of the marine environment by ships Lloyd Register, 2005; Akyuz et al., 2017).

Figure 1. MV Costa Concordia incident (from www.dailymail.co.uk).

One of the tragic ship incidents concluded with oil spill disaster occurred a few years ago. MV Costa Concordia was agrounded and 32 passengers lost their life. A few amount of oil spill was observed after incident (Figure 1). The wreck removal of MV Costa Concordia took more than 2 years. At the end of salvage operation, various harmful materials such as scraps, batteries, debris, plastics, etc. scattered around the Island.

In the literature, over the past decades, researches through oil spill in maritime transportation has greatly expanded. In particular, studies on major oil spill disasters such as Torrey Canyon, Erika, Prestige, Exxon Valdez, Erika, etc. have widely discussed in maritime transportation (Celik and Topcu, 2009). Some of researchers discussed major emergencies such as collision, grounding, flooding, etc. and their consequences to maritime environment, in particular oil spill effect to human, marine environment and commodities (Goerlandt and Montewka, 2015). Likewise, another study was performed on potential economic damages of Prestige oil spill incident (Nova-Corti et al., 2015). In the study, economic effects of M/T Prestige through environment and population were assessed. Another study was also performed on oil spill impact of MT Prestige with respect to the ecological and economical (Figure 2) (Wirtz and Baumberger, 2007).

Figure 2. Coast of Galicia - Spain covered of petroleum after MT Prestige oil spill incident (www.alamy.com).

Lee and Jung (2015) presented a risk assessment research on oil spill pollution in Garorim Bay of Korea. In the paper, potential risks related to oil spill incident in Garorim Bay were evaluated. A wide range of risk analysis tools were introduced and discussed to prevent oil spill (Akyüz and Çelik, in press; Psarros et al., 2011; Lecklin et al., 2011; Eide et al., 2007). The consequences of oil spill incidents are deeply affecting marine ecological system. Consequences of oil spill can reach to involve fishery, population and tourism industries. The financial compensation cost of oil spill damages may reach billions of dollars (Akyuz et al. 2017). The tourism industry, in this case, can be strictly harm. As oil spill damages may pose potential harms to maritime environment, researchers on marine safety have been seeking advance measures to reduce effects of oil spills. The primary aim of this paper is to discuss application of MARPOL convention related with oil spill cases in Turkey. The paper proposes a qualitative approach into the problem to gain an understanding of underlying reasons, opinions and motivations with respect to the MARPOL application in Turkey.

2. MARPOL Convention

The MARPOL convention is by far the most important marine conventions for the prevention of maritime environment. The code was adopted on 1973 under Maritime Environment Protection Committee (MEPC) in IMO (IMO, 2006). The reason of MARPOL convention put into force was to response a spate of tanker ships accidents such as Torrey Canyon. After Torrey Canyon maritime disaster, the IMO decided to organize conference on maritime pollution prevention. The convention was modified by protocol of 1978 and resulting in the designation MARPOL 73/78. The aim of the convention is to reduce pollution over the seas associated with oil pollution (Peet, 1992). In the convention, it states "object is *"to preserve the marine environment through the complete elimination of pollution by oil and other harmful substances and the minimization of accidental discharge of such substances."* (IMO, 2006). The signatory countries are bound to follow requirements of MARPOL convention. The convention contains six main body (called as annex) with provisions for pollution prevention caused by ships. Special Areas were introduced and definite rules adopted on discharging of pollutants (IMO, 2018). The annexes of MARPOL73/78 are as follows.

Annex I

The aim of the Annex I is to regulate pollution prevention caused by oil. It entered into the force 1983. The annex I aims to preventing pollution caused by oil from operational measures as well as from accidental discharges. There was a significant amendment undertaken in 1992 where it was requested for owners of new tankers to design double hull (IMO, 2006). The revised form of Annex I was introduced in 2001 and 2003.

Annex II

MARPOL Annex II is dealing with noxious liquids substances pollutions. It aims to regulate for the control of pollution by bulk noxious liquid substances. The annex come into force in 1983. Almost 250 noxious materials were assessed and included via supplementary list to the convention. According to the annex, discharging of noxious substances residues can be permitted in case reception facilities under specific concentration (IMO, 2018). The annex clearly defines that it is not allowed to discharge noxious substance residues inside 12 miles of the nearest shore (IMO, 2006).

Annex III

MARPOL Annex III regulates prevention of pollution by harmful substances carried by sea in packaged form. The code was adopted in 1992. The annex consists of general requirements for packaging, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications. In code, the harmful substances defines as "*those substances which are identified as marine pollutants in the International Maritime Dangerous Goods Code (IMDG Code) or which meet the criteria in the Appendix of Annex III."* (IMO, 2018).

Annex IV

This annex handles rules and regulations for the prevention of pollution by sewage caused by ships. Since 2003, the code was applied. It contains some requirements to deal with possible pollution of the sea caused by sewage. According to the Annex III, it is not allowed to discharge sewage into the sea, except if the ship is fitted with approved sewage treatment plant or when the ship is discharging comminuted and disinfected sewage using an approved system in which performing more than three nautical miles from the nearest shore (IMO, 2018). If the sewage, on the other hand, is not committed or disinfected, then have a right to discharge at a certain distance in which 12 nautical miles away from the nearest shore (Peet, 1992).

Annex V

The aim of the Annex V is to set up rules and requirements for pollution prevention by garbage caused by ships. In 1988, the annex was accepted and implemented. The Annex V copes with numerous garbages. It specifies the distances from shore and the manner in which they may be disposed of (IMO, 2018). According to the Annex V, all form of plastic materials must be kept on-board, not be thrown overboard (IMO, 2006). In 2013, amendments to MARPOL Annex V came into force. According to the amendment, ships have new responsibilities with respect to the cargo classification. The amendment has already entered into the force.

Annex VI

This annex covers air pollution prevention caused by ships. Since 2005, it was applied. It sets limitations on sulphur oxide and nitrogen oxide emissions caused by ship exhausts and bans deliberate emissions of ozone depleting materials (IMO, 2018). According to the Annex, more stringent standards for SOx, NOx and particulate matter are determined for designated emission control areas. It also covers compulsory technical and operational measures on energy efficiency to decrease greenhouse gas emissions caused by ships since 2011 (IMO, 2018). In 2016, amendments to MARPOL Annex VI came into force. According to the amendment, fuel oil sulphur content shall be reduced 0.50% and it shall become effective on 2020. Hence, it is expected to reduce harmful emission to the atmosphere.

3. Applications of MARPOL in Turkey Related to Oil Spill Cases

Maritime is prior means of oil transportation. Particularly, tanker ships transport almost 60 percent of the oil consumed around the world (Burgherr, 2007). Turkey, on the other hand, is party to the international regime as it is a signatory to the IMO convention such as MARPOL, STCW, SOLAS, etc. The national maritime authorities such as regulatory bodies handling prevention, preparedness and response in the case of oil spill incident and addresses international commitments by enactment of the domestic laws (Turan, 2009). Due to the position of Turkey as a transit country between the oil exporting and importing countries, there is a congested vessel traffic in the Turkish Straits region covering south part of Çanakkale up to north part of Istanbul. Therefore, Turkey has faced many ship accidents resulting in oil spills incidents and there is always potential to experience a major oil spill. According to the maritime regulatory bodies of Turkey (The Undersecretaries of Maritime Affairs), more than 70 percent of maritime accidents happened in the Turkish Strait region. Table 1 shows important oil spill incidents in Turkish Straits.

Table 1. Important oil spill incidents in Turkish Straits (Akten, 2006).

Year	Area	Ships	Spilled quantity
1960	Istanbul Strait	MV World Harmony / MV Peter Zoranic	18,000 mts oil
1964	Istanbul Strait	MV Norborn and wreck of Peter Zoranic	
1966	Istanbul Strait	MV Lutsk and MV Kransky Oktiabr	1,850 mts oil
1979	South entrance of Istanbul Strait	MV Independentia and MV Evriali	20,000 mts oil
1980		MV Nordic Faith and MV Stavanda	
1982		MV Unirea	66,400 mts oil
1988		MV Bluestar and MV Gaziantep	1,000 mts ammonia
1990	Istanbul Strait	MV Jambur and MV Da Tung Shan	2,600 mts oil
1994	Istanbul Strait	MV Nassia and MV Shipbroker	22 mts oil
1999	Istanbul Strait	MV Semele and MV Sipka	10 mts oil
1999	Istanbul Strait	MV Volganef 248	1,500 mts oil
2002	Istanbul Strait	MV Gotia	20 mts oil
2003	Istanbul Strait	MV Svyatoy Panteleymon	230 mts oil

As depicted in Table, MT Petar Zoranic, which is transporting gasoline cargo, collided with the MT World Harmony at Kanlıca. Totally, twenty of ship crew died including Masters. Totally, 18,000 tons of oil spill was recorded. At that time, MARPOL convention has yet to adopted, therefore regulation of OILPOL convention was applied. Another important maritime accident occurred in 1990. MT Jampur collided with M/V Da Tung Shang (bulk carrier) at Sarıyer. The ship Jampur was carrying liquid gasoil cargo. About 2,600 tons of gasoil cargo polluted around Sariyer coastlines. In this case, Turkish maritime authorities applied MARPOL Convention Annex I. According to the Annex I, which regulates prevention of pollution by oil, the owners of ships paid money to cover penalties incurred under MARPOL Convention. In 1999, M/T Volganeft-248 incident, more than 1,500 tons of gasoil cargo spilled into the sea. The ship was grounded off the Florya Point (Figure 3). The cleaning operation of polluted coastal line of Florya took more than 2 years. The MARPOL Annex I applied for this case. Fines and penalties were imposed to cover damages caused by the oil spill disaster.

Figure 3. M/T Volgoneft 248 grounded off the Florya Point (www.mbl.is).

4. Conclusions

Oil spills can have a devastating impact on the maritime environment, human life and commodity itself. Therefore, oil spill has been considered as one of the major concerns of the maritime transportation. Because of a maritime accident, the seas became contaminated by liquid petroleum hydrocarbon and causing damages to the maritime environment. Moreover, oil spills damage beaches and marine ecosystem as well. In short, an oil spill completely disturbs an entire marine environment for a quite long period. In order to prevent aforementioned pollutions, maritime regulatory body- IMO- adopted MARPOL convention. The objective of the MARPOL convention is to minimize pollution prevention in maritime environment caused by ships. The MARPOL constitutes six technical Annexes. In this paper, application of MARPOL convention is discussed related with oil spill cases in Turkey since there were numerous severe ship accident occurred in the Turkish Straits. M/T Petar Zoranic and M/T World Harmony incident, M/T Jampur and M/V Da Tung Shang incident and M/TVolganeft-248 incident handled as the MARPOL application with related to oil spill.

In the view of findings, it was noted that MARPOL Annex I is of paramount for pollution prevention in maritime caused by oil. The annex I stipulates a number of new concepts such as a requirement segregated ballast tanks for new tanker ships, fitted with a double hull, oily water separator (15 ppm standard), application of "*Shipboard Oil Pollution Emergency Plans (SOPEP)*", keeping oil record book on-board ship, fitted with crude oil washing system (COW) for tanker ships. In conclusion, this paper provides to gain an understanding of underlying reasons, opinions, and motivations with respect to the MARPOL application in Turkey. Besides its theoretical insight, the paper contributes maritime safety professionals and marine researchers to understand MARPOL application during oil spill disaster.

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SHIP BORN OIL POLLUTION IN TURKISH STRAITS SEA AREA AND MARPOL 73/78

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1. Introduction

As the world's dependency on oil products kept increasing tremendously, shipping lanes became congested with tankers that also grew bigger in size and capacity. As the sea began facing much more serious oil pollution risks conventions like "The International Convention for the Prevention of Pollution of the Sea by Oil (OILPOL)" and "The International Convention for the Prevention of Pollution from Ships (MARPOL)" have been adopted to address those risks. The inadequacy of the measures has been demonstrated by some particular tanker accidents which results on the environment were catastrophic. Although oil is mostly transported safely, but in case of any collision its environmental effects are extremely high.

In 1967, the supertanker Torrey Canyon ran aground off the south-west coast of the United Kingdom and resulted an oil spill at up to 117,000 tonnes. French and English coasts were contaminated by oil and marine life incurred heavy fatality. Clean-up efforts and the recovery of affected area took years. In 1978 just one month after of "The Conference on Tanker Safety and Pollution Prevention" another supertanker Amoco Cadiz ran aground off Brittany in France. Ship was carrying 223.000 tonnes of oil and all of it with the additional 4000 tonnes of bunker oil spilled and covered more than 320 km of the Brittany coastline (Marinos and Yolanda-Alexia, 2017). These and some other tanker accidents with serious ecological consequences required the necessity of stricter measures and MARPOL was amended many times by lessons learned from these accidents in order to mitigate the risks. MARPOL 1973 was modified by the Protocol of 1978 and it calls as "MARPOL 73/78" at the latest. Annex I "Regulations for the Prevention of Pollution by Oil of MARPOL 73/78" entered into force in 1983 and Its purpose is preventing marine environment from oil pollution due to operational and accidental risks. It has 10 special areas, which are provided with a higher level of protection than other areas of the sea according to their oceanographic and ecological condition and marine traffic. Mediterranean and Black Sea were adopted as a special area in 1973 and entered in to force in 1983. Between two special areas, Turkish Straits Sea Area (TSSA) has importance in terms of application of measures for oil spill (IMO 2018b). TSSA is in important oil transport destination between Middle East/Russia and Western Europe/USA and there are important oil terminals in Marmara Sea which cause oil tanker traffic consequently increasing in ship traffic in TSSA increases the risk of ship born oil pollution. From past to present many maritime accidents have occurred in TSSA which caused catastrophic results (Doğan and Burak, 2007; Öztürk, et al., 2001). Turkey became party "MARPOL 73/78" by "the decision of the Council of Ministers dated 3/5/1990 and numbered 90/442" (Ministry of Transport Maritime Affairs and Communications, 2018).

2. Oil Spill and MARPOL

The world's first oil tankers were built around 1890s. With the advent of internal combustion engine, oil became a crucial resource and as the dependence to oil grew tanker numbers and sizes also grew together. While early tankers had around 300-500 tonnes of capacity by the 1960 tankers could now carry around 200.000 tonnes of oil**.** Approximately 2900 million tonnes of oil are transported by oil tanker ships every year around the world (ITOPF, 2017). Consequently, risks of ship born oil pollution increased in the world. The most important step towards the prevention of oil pollution caused by ships was taken in 1954 with "OILPOL Convention" (Mattson, 2006). By time, catastrophic ecologic consequences resulting from oil spills caused by accidents involving tankers motivated international community to adopt stricter safety measures. OILPOL was amended in 1962 and 1969 then after more comprehensive convention MARPOL was accepted by IMO in 1973. (e.g. Torrey Canyon disaster in 1967, Sea Star disaster in 1972) The 1978 Protocol of MARPOL was adopted as the result of major tanker accidents and sea pollution after 1973 (e.g. Urquiola disaster in 1976, Hawaiian Patriot disaster in 1977, Amoco Cadiz disaster in 1978). The Compound Convention entered into force on 2 October 1983.

Measures introduced by IMO for tanker building and operational matters provided to reduce the amount of oil spill in the event of an accident and operational pollution as from routine tanks cleaning operations (IMO, 2008). Some of the operational and construction regulations introduced by MARPOL in 1983 are detailed below;

- "mandatory traffic separation schemes"
- "international standards for seafarer training"
- "as a requirement for new oil tankers to be fitted with segregated ballast tanks, this was superseded by the requirement for oil tankers delivered from 1996 onwards to be fitted with a double hull." Double hull amendment was adopted by IMO in 1993 with lobbies of United States after Exxon Valdez disaster in Alaska in 1989 (Mattson, 2006)
- "allowable discharges of bilge water through the oily water separator (with the well-known 15ppm standard)"
- "oily waters from the cargo tanks, through the oil discharge and monitoring system" (IMO, 2008)

International Tanker Owners Pollution Federation (ITOPF) categorises oil spills by size as, <7 tonnes (low), 7-700 tonnes (medium) and >700 tonnes (large). Figure 1 shows the significance decline on oil spills from 1970s to 2010s in terms of medium and large spills in the world. This figure clearly reveals effect of "MARPOL 73/78" with downtrend of oil spill.

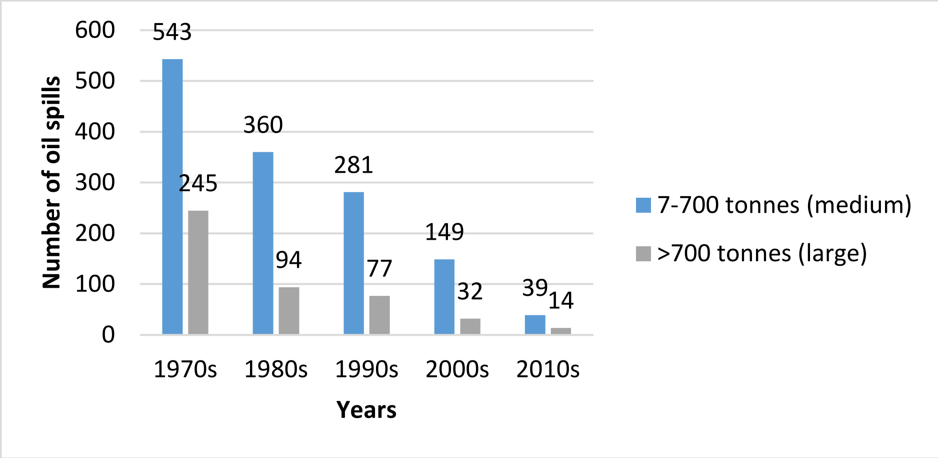


Figure 1. Number of medium and large spills per decade from 1970 to 2017 (*2010s have only 8 years of data)* (ITOPF, 2017).

Turkey became a party of “MARPOL 73/78 Convention only Annexes I, II and V by the decision of the Council of Ministers No. 90/442 dated 03rd May 1990 with published in the Official Gazette No 20558 dated 24th June 1990” (Ministry of Transport Maritime Affairs and Communications, 2018). Turkey issued “the Act No 5312 Law Concerning the Principles of Emergency Response and Compensation for Damages for Pollution of the Marine Environment by Oil and Other Harmful Substances” as a response on oil pollution matters on 11th of March 2005 (Official Gazzette No 25752, 2005). “The Ministry of Environment and Urbanisation” is responsible to take the necessary response measures and The Undersecretariat for Maritime Affairs is ultimately responsible regarding to oil pollution at sea (ITOPF, 2018).

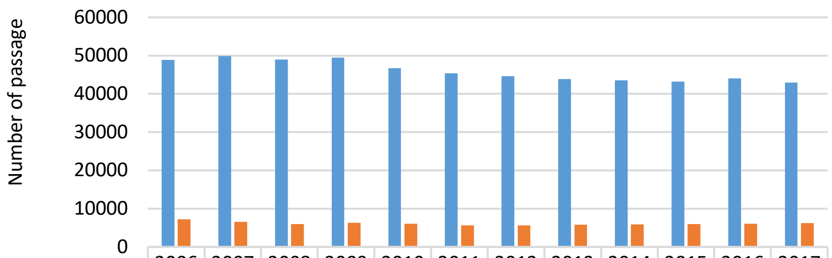
3. Ship Traffic and Oil Spill risk in TSSA

TSSA is formed by 60 km long The Çanakkale Strait and 30 km long Strait of İstanbul and the passage from the Black Sea to the Aegean Sea is carried out in 164 nautical miles including the Sea of Marmara. The narrowest point on the Çanakkale Strait is at the Nara Point with 1300 meters while the İstanbul Strait being much narrower and near Arnavutköy it drops about to 700 meters (Figure 2). Both straits have many sharp turns with strong and complex currents (Alpar et al, 2018, *see Chapter 3*). The water stratification and mean sea level differences between the Black Sea and the Aegean Sea control the main currents that can reach 6 to 8 knots and can seriously hamper the manoeuvrability of vessels in an already difficult and dangerous place to navigate. Furthermore, there are seasonal currents like “Orkoz” in the İstanbul Strait (Özsoy et al., 2000).

Figure 2. Narrowest point in the İstanbul Strait (Association Francaise Des Capitaines De Navires, 2018)

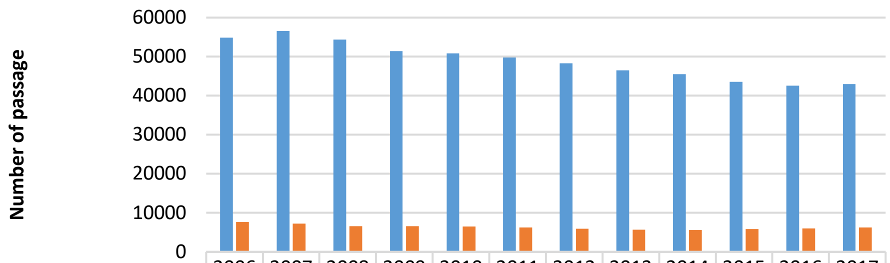
Ship traffic in the TSSA is very high. When Turkey agreed Montreux Convention Regarding the Regime of the Straits in 1936 only 17 ships passed daily, this figure is 120 ships daily after 80 years, it has increased almost 8 times (Republic of Turkey Ministry of Foreign Affairs, 2018). It should be also noticed that ships' GRT/NRT and DWT increased highly from 1936 to today.

TSSA, between The Eastern Mediterranean and Black Sea are located along a heavy oil traffic route between Middle East/Russia and Western Europe/USA so that TSSA is faced with consistent danger of oil spill (Cokacar, 2008). According to statistics of General Directorate of Merchant Marine approximately 49,000 ships pass from The İstanbul Strait per year and 13% of total passed ships are oil tanker in average of last 12 years. The statistics of The Çanakkale Strait in average of last 12 years display that approximately 46.000 ships pass from the Strait per year and about 13% of total passed ships are oil tanker (Ministry of Transport Maritime Affairs and Communications Directorate General of Merchant Marine, 2018). Both statistical data show that tanker passages are significant part in total ship passages in TSSA and consequently ship born oil pollution risks and their impacts are important. Figures 3 and 4 display the amount of all type ships and oil tanker passages from Çanakkale and Istanbul Straits, respectively.



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Number of vessels	48915	49913	48970	49453	46686	45379	44613	43889	43582	43230	44035	42978
Oil tankers	7204	6527	5990	6293	6017	5661	5656	5822	5875	6009	6041	6212

Figure 3. Number of all type ships and oil tanker passages from the Çanakkale Strait (Ministry of Transport Maritime Affairs and Communications Directorate General of Merchant Marine, 2018).



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Number of vessels	54880	56606	54396	51422	50871	49798	48329	46532	45529	43544	42553	42978
Oil Tankers	7659	7204	6564	6557	6464	6216	5913	5685	5587	5825	6033	6212

Figure 4. Number of all type ships and oil tanker passages from the İstanbul Strait (Ministry of Transport Maritime Affairs and Communications Directorate General of Merchant Marine, 2018)

While evaluating oil spill risk in the TSSA, it should be considered that some bulk carriers and container ships are loaded more heavy fuel for the ship itself than some tankers are loaded oil as cargo. Heavy fuel oils cause more damage in the marine area because of its more persistency (EMSA, 2004). In this reason, number of oil tankers passing from the TSSA is not only a criterion to evaluate oil spill risk. For instance, Turkey has suffered a number of bunker spills from non-tanker vessels particularly in the TSSA recently (ITOPF, 2018).

In addition to Southbound and Northbound innocent tanker passage from TSSA, there is also potential in the Sea of Marmara, which cause tanker traffic and port call with nine petrol terminals in the Izmit Bay (Figure 5).

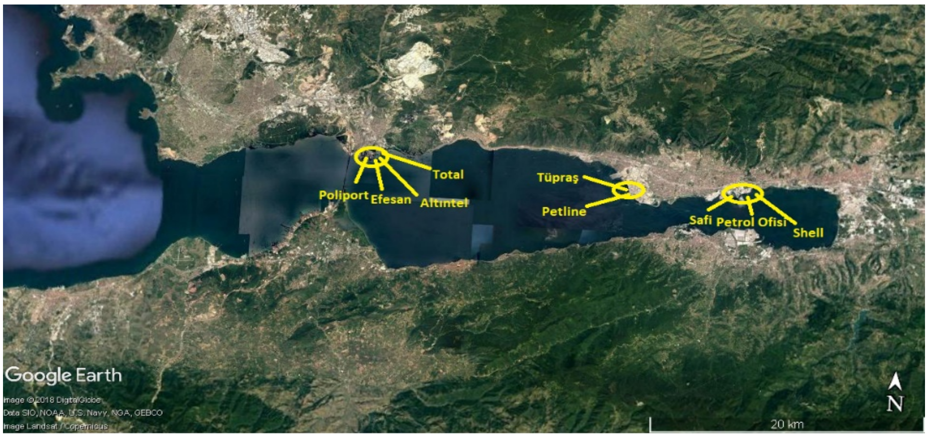


Figure 5. Petrol terminals in the Izmit Bay.

Over the course of years many accidents and consequently oil pollution occurred. The collision of tankers, Peter Zoranic and World Harmony near Kanlıca area in The İstanbul Strait in 1960 resulted the spill of 18.000 ton of oil. In 1979, the collision of Greek cargo ship Evriali and the biggest Romanian tanker Independenta at the southern entrance of the İstanbul Strait caused catastrophic results. Apart from human losses, 64,000 ton of oil spilled to the sea and the fire on board could not be put out for about one-month. Incident of Independenta is 12th largest oil spill among top 20 major oil spill incidents in the world and largest sea accident in Istanbul, causing heavy air and sea pollution (ITOPF, 2017; Öztürk et al., 2001). Another big collision in the İstanbul Strait occurred between tanker Nassia and bulk carrier Shipbroker in 1994, which caused 15,000 ton of oil spill. The collisions mentioned above show that plans without traffic separation along the TSSA caused a big collision risk. Establishment and development of TSVTS with its regulations provided lower risk for ship passage from TSSA. In the framework of above, two-way ship passage until 2005 along the TSSA caused to these big collisions in such an important place Istanbul as environmental, historical, economical and touristic. Collision risk is unavoidable in two-way ship passage when minor navigational fail combined with the effect of strong currents in the TSSA. Incident of Independenta occurred in the İstanbul Strait while Independenta sail on northbound passage from Haydarpaşa to Constanta and Evriali sail on southbound passage from Ukraine to Italy. In addition to this, incident of Nassia occurred in north entrance of the Istanbul Strait. After this accident IMO warned in 1994 that navigation through the İstanbul Strait about increasing potential risk to safe passage, environmental pollution and the well-being of local community (Aras, 2013). In the same year of Nassia accident, "*maritime regulation of the Turkish Straits*" and "*traffic separation scheme" based on "Convention on the International Regulations for Preventing Collisions at Sea 1972 (COLREGS)" were introduced urgently and IMO approved it in 1995 with the "rules and* *recommendations" recognizing to the Turkish authorities the right to suspend the one-way or two-way traffic in order to provide safe passage for large ships. (Republic of Turkey Ministry of Foreign Affairs, 2018). The maritime regulation for Turkish Straits was amended with regulation in November 1998. Thereafter instructions for internal application were added on the regulation in 2002 and the instructions were revised in 2006. In 1999, IMO confirmed that success of Maritime regulation of Turkish Straits. However, IMO strongly recommend to ships to get pilot while they are in innocent passage in TSSA because of difficult navigation conditions. Under COLREGS all these applications in TSSA supported to prevent the ship born oil pollution in terms of accident consequently supported aims of "MARPOL 73/78".*

In the light of above developments, Turkish Straits Vessel Traffic Services (TSVTS) has started to manage ship traffic along the TSSA on April 30th 2003, which is under management of Directorate General of Coastal Safety. Before TSVTS, Turkish Straits could be monitoring only by Automatic Radar Plotting Aids Radars (ARPA Radars). By establishing of TSVTS, AIS (Automatic Identification System) was integrated to ARPA Radar to monitor easier and notice the ship's name, type, speed exactly. In the first step TSVTS involved only the Straits of Çanakkale and İstanbul, thereafter "traffic separation scheme for the Sea of Marmara" was involved in 2008 (Directorate General of Coastal Safety, 2017). This system provides early interfere in case risk of collision, running down and grounding. In this way, TSVTS contributed to "*MARPOL 73/78*" in TSSA in terms of measures.

4. Conclusions

Catastrophic ecological results of tanker accidents motivated the international community to adopt more severe measures against oil pollution and from 1970 to present trend of oil spills decreased about 95% around the world (92% on medium spills and 94% on large spills). Another factor in play about tanker safety and oil spill risk in the TSSA is the adoption of one-way traffic in the İstanbul Strait in 2005 caused by the construction of MARMARAY, Bosphorus Tube Crossing. The positive feedback about the navigation safety helped to keep to one-way traffic after the competition of the works. As the world still relies on oil as an essential source of energy, transportation of large quantities of oil still present a grave threat to environment. As oil transportation continues to evolve, safety measures should be checked and updated simultaneously.

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INTERNATIONAL CONVENTION RELATING TO INTERVENTION ON THE HIGH SEAS IN CASES OF OIL POLLUTION CASUALTIES (INTERVENTION 1969) AND ITS APPLICATIONS RELATED WITH OIL SPILL IN TURKEY

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1. Introduction

Oil has indisputable benefits for humanity. Oil serves a wide diversity of purposes, which include heating, transportation, electricity, and industrial applications, and is an input into over 2000 products. Oil is a high enegy density abundant fuel, which is relatively easy to transport and store, and is extremely versatile in its end uses (O'Rourke and Connolly, 2003).

Oil is the most important place in the world economy has undoubtedly energy sources. On the other hand, oil resources are not balanced on earth. Approximately 60% of the world's oil reserves are in the Middle East. It is also the Middle East countries, which produce about 30% of the total amount of world oil production (Turan, 2009). Since oil is predominantly found in certain regions in the World, it must be carried to other areas. Transport is mostly done by sea transport and tankers. During the transportation of crude oil from the sea by tankers, many marine accidents and oil pollution ocur. Today, serious efforts are being made globally to prevent oil pollution and to be prepsred (Baylan, 2011).

Every person and society have the right to live in a clean environment. Protecting this right is the duty of both individuals and states. It is a requirement within the cycle of nature to make this right in writing and to move it to the international dimension.

The prevention of the problem of marine pollution has entered the international public agenda mainly in the 1960s. However, the attempts to prevent oil pollution from ships are older. This problem necessitates international cooperation because of its comprehensive structure and a problem that cannot be solved by national regulations alone. Since the 1920s, America and Britain have adopted special laws to protect their coast from oil pollution (Abdullahzade, 2009).

The event that created international awareness is the Torrey Canyon accident. On Tuesday (March 28th), the first major tanker disaster in history took place, damaging the natural and economic resources. Short term, there was cataclysmic local pollution. 31 million gallons of oil leaked from the ship and spread along the sea between France and England. From the South coast of Britain to the Normandy shores of France, most of the marine life in the area was damaged. There were no plans to challenge the spill (Hall, 2007).

In order to prevent the remaining oil contained on the ship from mixing into the sea and to minimize this contamination in the marine area adjacent to the shore, the shipowner agreed with a rescue and relief company to float the tanker and take it back to take it out of the rocky area. However, on 26th and 27th of March, the tank was divided into three parts and the incident became even worse. On top of that, the rescuer company abandoned the operation (Çörtoğlu, 2007). It was found that even after 8 years, the effects of oil pollution were observed.

In 1969, the owners of the tanker offered France and Britain 3 million pounds to meet the demands. He would also pay the private claimants fort he damage. Britain and France were in cooperation during the trial. The shipowner did not accept the goverment's demand for a loss of 6 million pounds. Torrey Canyon disaster initiated a struggle for scientists and lawyers (Demir et al., 2014). Gaps in international law have emerged on the authority of the intervention of coastal states to be affected by pollution.

When an accident occurred outside a country's jurisdiction, it was inadequate to explain the problems of international law, responsibility and compensation. The national legal systems had an approach that foresees compensation under the general rules of legal liability, which is based on the liability of the defect, which is not the objective but the cause of the damage. In addition, the identification of the international competent court in the events carrying foreign elements and the determination of the law to be applied by this court emerged as another important problem (Çörtoğlu, 2007).

A series of international conventions adopted under the leadership of International Maritime Organization (IMO) following the Torrey Canyon disaster formed the basis of the international maritime pollution responsibility and compensation regime. These contacts are like the rings of a chain and cannot be separated from each other (Demir, 2004).

Because of the studies carried out under the leadership of the International Maritime Organization (IMO), 1969 International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (INTERVENTION) was signed. The convention was signed in Brussels. With this convention, which came into force on 6 May 1975, it was aimed to take the necessary measures in the presence of a threat to the coastal strips of the states parties, which would lead to an important and imminent danger or oil pollution at sea. The convention foresees the prevention of oil pollution related to marine accidents, while the oil pollution caused by the normal activities of the vessels is excluded. The Convention consists of 17 articles and 1 appendix (Kaya, 2016).

"The Convention affirms the right of a coastal State to take such measures on the high seas as may be necessary to prevent, mitigate or eliminate danger to its coastline or related interests from pollution by oil or the threat thereof, following upon a maritime casualty. The coastal State is, however, empowered to take only such action as is necessary, and after due consultations with appropriate interests including the flag State or States of the ship or ships involved, the owners of the ships or cargoes in question and, where circumstances permit, independent experts appointed for this purpose. A coastal State, which takes measures beyond those permitted under the Convention, is liable to pay compensation for any damage caused by such measures. Provision is made for the settlement of disputes arising in connection with the application of the Convention" (IMO, 2018).

The Convention applies to all seagoing vessels except warships or other vessels operated or owned by a State and used on Government non-commercial service.

The “1969 Intervention Convention” applied to casualties involving pollution by oil. In view of the increasing quantity of other materials, mainly chemical, carried by ships, some of which would, if released, cause serious hazard to the marine environment, the “1969 Brussels Conference” recognized the need to extend the Convention to cover substances other than oil. “The 1973 London Conference on Marine Pollution therefore adopted the Protocol relating to Intervention on the High Seas in Cases of Marine Pollution by Substances other than Oil” (IMO, 2018). This extended the regime of the “1969 Intervention Convention” to substances which are either listed in the Annex to the Protocol or which have characteristics substantially like those substances (IMO, 2018).

INTERVENTION 69 countries are Belgium, Bulgaria, Denmark, Sweden, Estonia, France, Ireland, Italy, Slovenia, Germany, Latvia, the Netherlands, Poland, Portugal, Spain, Finland and the UK. These countries understand the importance of rapid intervention in case of oil seepage into the sea. An advanced country must ensure the safety of people and the nature of the border as well as ensuring the security of the border. The articles of this Convention are encouraged to cooperate on this issue under the conditions of the period in which they are prepared.

According to Article 1, in the event of a serious threat to the interests of the coasts and coasts in the case of oil pollution, which are expected to cause substantial damage, the States Parties shall take the necessary measures to prevent, mitigate or eliminate the threat. However, a measure cannot be applied to any warship or ships owned or owned by the state for commercial purposes (Kaya, 2016).

The convention states that any warship, or any other state now, is owned or operated, and those only ships, which are used for non-commercial services of the government, cannot be prevented. Thus, the mentioned ships were excluded from the convention. In the preparation of the convention, the term “marine accident” is also defined. The elements of the definition, collision of ships, grounding, and other accidents related to navigation are imminent dangers thet can cause material damage on board or cargo because of an event other than the ship.

The ship has been kept quite wide. Any kind of floating vehicle is used as a vessel, except the facility or equipment used in the exploration and processing of the seabed or ocean floor and the resources under the soil. Oil means crude oil, fuel oil, diesel oil, and lubricating oil.

"Relevant interests" are the interests of coastal states directly affected or affected by marine accidents. “These interests, maritime coastal, port or estuarine activities, including fisheries activities, constituting an essential means of livelihood of the persons concerned; tourist attractions, to ensure that the population living in the region is in good condition" (INTERVENTION 69).

2. Scope of INTERVENTION 69

The States Parties to this Convention agree to protect their people against damage or damage to the sea. They acknowledge that extraordinary measures can be taken to protect similar interests and that these measures will not affect the principle of freedom of the open seas. Measures to prevent or prevent the possible pollution of oil in the environment following a marine accident may affect the coastal state or the flag states differently. For this reason, in the third article of the convention, before taking any measures, it is said that the opinion of the other states affected by the marine accident, especially the flag state or its states, should be consulted. The coastal states that wish to have this view should be consulted by independent experts selected from a list whose names will be established by the organization. However, if the situation is urgent, time is more valuable. According to the convention, measures can be taken without giving any notification and without consulting the competent authority. Consultation negotiations are not required to continue. The coastal state should not endanger human life before or during the measures taken. People should be prepared to provide the help they may need. In the framework of the convention, the crew should cooperate and provide the necessary facilities without removing any obstacles to send their crew to their country. All such measures shall be promptly communicated to the States Parties, the recognized persons concerned and the Secretary General of the Organization.

As the list of experts mentioned is very sensitive, care must be taken to ensure that there is enough experience, training and qualifications. Neutrality is also an important criterion.

The level of damage or threat encountered must be well established. Measures to be taken should be at the appropriate level according to the damage. The fifth article of the Convention clarifies this issue. It states that the measures to be taken in order to achieve the foreseen purpose should not go beyond reasonable requirements, and should be terminated when the aim is reached (INTERVENTION 69).

Measures to be taken when oil pollution occurs or if this is possible may be costly. These cost items, cleaning costs, the determination and elimination of damage to natural resources after the accident, can be listed as research and this number can be increased (Küçükyıldız, 2014). Prevention of the spreading of oil, cleaning of the spilled oil, disposal of collected wastes, microorganism planting, incineration, water foam, sorbent handling, mechanical and chemical methods can be used. All of them are both costly and affect the natural environment in various sizes (Elver, 2016). For all these reasons, it should be checked whether the measures to be taken are proportionate to the damage. If such measures are not taken, criteria such as the likelihood of an unexpected loss and the degree of damage and the likelihood of these measures being effective, and the degree of damage likely to be encountered, should be considered.

The countries, which have signed the Convention, have agreed to pay compensation to the injured party to the extent that they have exceeded these reasonable measures in the context of their activities leading to the loss of reasonable measures. Furthermore, the seventh clause ensures that the rights, concessions or privileges of the Conventioning States shall not be prejudiced and shall not be an obstacle for the concerned or natural or legal person to carry out the remedies which are possible to apply.

As may be the case, the parties may not reach consensus on whether or not the compensation subject to the convention will be paid, how much will be paid and which party will pay. In such a case, the mediator may be engaged at the request of either party, as indicated in the annex of the convention. If this fails, the arbitral tribunal should be consulted. The relevant article of the INTERVENTION 69 convention stipulates that the party receiving the measures does not have the right to reject a request for settlement or arbitration court only on the basis that all legal remedies available to them under their domestic law are not exhausted.

Any State Party may be terminated at any time after the entry into force of the Convention. Upon the submission of the necessary documents to the Secretary General of the Organization, the termination procedure shall enter into force. It shall enter into force within one year from the date of deposit of the denunciation certificate or at the end of the period specified in the denunciation document.

There may be special and exceptional circumstances related to the administrative management of the subject area. The thirteenth article of the Convention explained the practices related to these cases.

"The United Nations where it is the administering authority for a territory, or any State Party to the present Convention responsible fort he international relations of a territory, shall as soon as possible consult with the appropriate authorities of such territories or take such other measures as may be appropriate, in order to extend the present Convention to that territory and may at any time by notification in writing to the Secretary-General of the Organization declare that the present Convention shall extend to such territory" (INTERVENTION 69).

The convention is also opening to be revised in time. In the event that at least one third of the parties, request it, one of the articles of the convention where a conference may be held to review or amend the convention.

Any amendment to the convention shall be notified to all States, which have signed the convention with the original copy. It is a process to be followed carefully in order to ensure that the applications are carried out without interruption and there is no conflict between the countries. A copy is also sent to the Secretariat General of the United Nations.

The first article of the intervention convention specifies both the scope and the basis. Although this article is the basis of the convention, it has not clarified many problems in terms of the competence of the coastal state. The intervention convention did not fully clarify how to determine whether the oil pollution or pollution threat that occurred when the ship was more distant from the coast was a serious and imminent threat. There is no limitation on the distance here. Furthermore, there is no clarity about the measures to be taken within the scope of the article. Measures are considered essential and they are based on objective criteria.

The scope of the measures to be considered as essential is not clarified in the scope of the convention. According to Deinstein, these measures can be reached by bombing or sinking the ship (Burcuoğlu, 2018).

3. Applications of Marine Pollution from Ships in Turkey and INTERVENTION 69 Convention

One of the main problems of the international system for the prevention of oil pollution from ships is that the international conventions on the issue have not been widely accepted by the states. Other important reasons are that the conventions, which cannot be put into effect for many years, cannot reach the majority that can be effective even after the entry into force, and most importantly, the existing regulations are not applied effectively by the states in practice. In this sense, it is surrounded by sea on three sides and the possibility that excessively affected or not affected by the oil pollution from Turkey, many years seems to behave shy or being insensitive included in the international system (Abdullahzade, 2009).

The Turkish Straits forms the boundary between the Black Sea and the Mediterranean Sea, and is the only maritime Access route between the two. Consequently, all seaborne crude oil from the Black Sea to reach the world market must pass through the Turkish Straits (Turan, 2009).

In paralel with the increase in the oil flow to the ports in the Black Sea, since the 1990s, the number of ships carrying hazardous goods and oil from the Turkish Straits has increased. Goods that are more dangerous are transported through the Turkish Straits than the pipeline, where most of the oil is transported. The amount of dangerous goods transported continues to increase every year (TC Dışişleri Bakanlığı, 2011). However, with the development of technology and construction techniques, the size and carrying capacity of the tankers have increased. When the capacity of the tankers increased, the number of tanker passing through the straits decreased recently. While 10000 tankers passing through the İstanbul Strait carried 143.939.500 million tons of dangerous goods in 2017, 8832 tankers carried 146.943.000 million tons (TC Dışişleri Bakanlığı, 2011).

Turkey is a key point for oil importing and exporting countries. The Turkish Straits have a heavy traffic. It also imports large quantities to meet its oil needs. Turkey has been the scene pretty much all of them due to accidents at sea. There will always be a large risk of oil spills. The Undersecretariat for Maritime Affairs reported that 80 out of 117 marine accidents occurred in the Turkish coastline in 2007 (68%) occurred in the Turkish Straits, thus demonstrating the big potential for the Turkish Straits to be subject to oil spills (Turan, 2009).

There have been many major marine accidents in history. Independenta Tanker accident occured in 1979. A huge fire broke out in the tanker a lasted for a month. It was said that most of the crude oil burnet together with the tanker. As a result, the total particle number of particles in the air during the fire reached 1000 mg m^{-3}. He also affected the naval structure of the Marmara Sea in a very serious way. The light components were vaporized immediately after the boiler, while the remaining 46 g m^{-2} tar layer collapsed to a bottom surface of 5.5 km radius. In this area, only nine marine species survived and the mortality rate was determined to be 96%. The debris waited for a long time to be lifted (Baylan, 2011).

The maritime environment has been severely damaged in the Nassia crash, which occurred on March 13, 1994, where approximately 20,000 tons of oil spread to the Black Sea, İstanbul Strait and the Sea of Marmara. The coast and many coves are covered with oil; the self-cleaning ability is limited to more than 1500 seabirds in the İstanbul Strait (Küçükyıldız, 2014).

Turkey, since 1958, is a member of the United Nations International Maritime Organization (IMO); it has become a party to some of the conventions related to the safety of the sea and the protection of the environment, an effective port state and flag state control (Küçük, 2012).

However, in Turkey these regulations were implemented quite late compared to the countries with large marine accidents. Before the law, there was no law regarding the direct response to oil pollution and preparedness. Despite the large tanker disasters mentioned above, the law was put into force in 2005. Although the Environmental Law No. 2872 required the establishment of a plan against environmental pollution, it did not specifically address oil pollution (Baylan, 2011).

With the amendments made in 2006 on the Environmental Law of 1983, significant changes have been made regarding marine and oil pollution. The first of these changes is to make the purchasing facilities in Article 11 compulsory. In the international field, the procurement facilities, which were brought to the agenda by the 1954 OILPOL Convention and which have been given particular importance in the 1973/78 MARPOL Convention, are an important issue for the prevention of oil pollution. The other important regulation is article 20 of the administrative penalties.

The first of the issues that could be criticized for the Environmental Law is that the Act does not refer to the exceptional circumstances that are kept in the provisions of the international treaty. Another issue is that there has been no distinction between commercial ships and warships and state ships used for commercial purposes in order to enforce the sanctions envisaged in the Environmental Law (Abdullahzade, 2009).

It is evident that domestic law may refer to international law, but some confusion may be encountered in practice.

Besides all these, yet Turkey is striving to become a member of the European Union, they tend to consider the community decisions. The European Union's sensitivity to the environment also stems from the stance of the European people. The right to live in a healthy environment is the most basic right. The decisions taken are produced based on this basic opinion.

The only provision directly regulating the hierarchical place of international conventions in Turkish law is the last paragraph of Article 90 of the Constitution. According to this provision, the international conventions entered into force according to the law are in force. They cannot be referred to the Constitutional Court with the claim of unconstitutionality. This means that it should be implemented by the Turkish authorities if the international agreements, which are designed to prevent pollution of the marine environment and to eliminate the damages caused by the pollution, are put into effect duly (Değirmenci, 2008).

Eightyseven countries have been party to the INTERVENTION 69 convention. Seventeen of these countries, as of January 2012, is the European Union. Turkey, on June 1st 2011 submitted to the technical unit. On 19 August 2011, it was submitted to the opinion of the institutions. Nevertheless, for the moment Turkey is not a party to this agreement.

The open seas constitute 2/3 of the world's oceans and 95% of the volume, while less than 1% of these areas are protected.

The freedom of open seas and the principle of sovereignty are valid in law. In addition, all states are equal. Equality has made it necessary to determine the procedures for the use of the high seas. No state has a property in the open sea (Misili, 2014). This right of freedom and unlimited access should be considered as having equal responsibility for the protection of these areas.

Joint efforts should be made on what to do to prevent these accidents, rather than how to compensate the damage caused by marine accidents.

In its waters, such as Turkey and lived in a country that has faced many accidents frequently with oil pollution, it should be much more sensitive to international agreements. It should move faster, even the pioneer.

The INTERVENTION 69 convention has some conceptually unclear statements, as mentioned above, but it encourages the parties to be faster if oil pollution or risk occurs. Minimizes the question marks in the application. It makes the intervention smoother.

Protecting every living thing's right to a clean and healthy life should be our common goal. States should also contribute to this common objective as a party to the conventions.

4. Conclusions

It is now accepted that marine pollution is a global problem. Oil pollution, the most difficult to compensate, has mobilized many countries to take common measures.

The mentioned INTERVENTION 69 permits necessary measures to be taken after consultation with the coastal state. The persons involved in this consultation shall include independent experts appointed by a joint decision. The coastal state shall be liable to pay the damages if it takes further action and results in harm. This convention exists for the resolution of disputes arising.

Turkey is still under evaluation. However, it would be beneficial for a country with such a risk to the environment to be a party to an agreement such as INTERVENTION 69.

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INTERNATIONAL CONVENTION ON OIL POLLUTION PREPAREDNESS, RESPONSE AND CO-OPERATION (OPRC) 1990 AND ITS APPLICATIONS RELATED WITH OIL SPILL IN TURKEY

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1. Introduction

Developments in the world economy continuously increases the demand for shipping services. From the perspective of petroleum products, world seaborne tanker trade volumes reached 3.1 billion tons in 2016. (United Nations Conference on Trade and Development-UNCTAD, 2017). In other words, tankers, as a primary source of petroleum products transportation, carry approximately 60% of the total oil consumed in the world marine transportation and it makes up 30% of the annual tonnage of all sea cargoes (Gutyulsak, 2017; UNCTAD, 2017). Increasing amounts of world seaborne trade and tanker traffic increases the possibility of accidental oil spills. Respect to the oil tanker spill statistics report published by International Tanker Owners Pollution Federation Limited (International Tanker Owners Pollution Federation Limited-ITOPF, 2018) in January 2018, nearly 5.74 million tonnes of oil were lost between the years 1970 and 2017 caused by tanker incidents. Although, there has been a significant reduction in volume of oil spilt through the decades as illustrated in Figure 1, it is still considered as a one of the biggest threats for the marine lives and habitats. For this reason, the potential threats of oil spill on marine lives and habitats need to be considered more comprehensively.

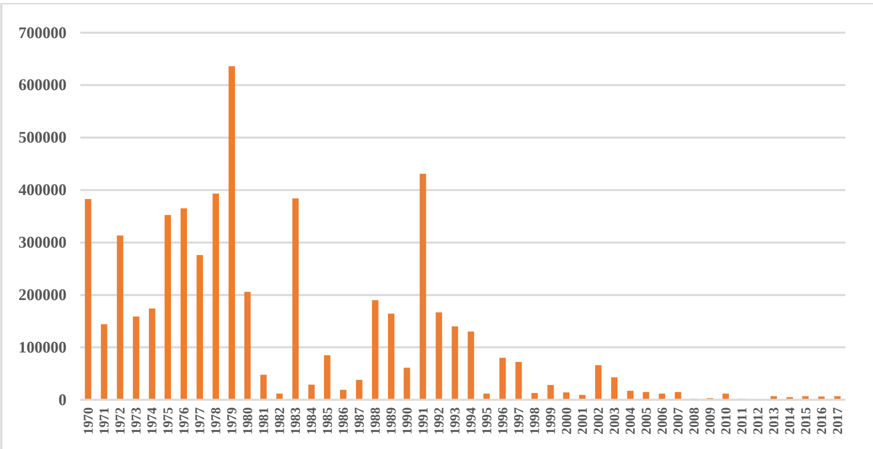

Figure 1. Annual quantity of oil spilt between 1970 and 2017 (ITOPF, 2017)

Respect to the different sources of marine oil spill, the ship-sourced oil spill is a distinct source of marine environment pollution in maritime operations (Xiong et al., 2015). Accidental or operational oil spill, or the intentional oily wastes discharges can be stated as main causes of ship source oil spill (Hassler, 2011; Knapp and Velden, 2011; Xiong et al., 2015). However, the accidental oil spill can be declared as the primary source for large-scale oil spills caused by collision, grounding, fire, explosion, hull failure, equipment failure, and others (ITOPF, 2018).

Throughout the history of sea borne trade, we have witnessed several catastrophic oil spills and the major ones that can be described as environmental disasters are presented in Table 1. In these major oil spills, the grounding of Torrey Canyon off Cornwall, England, in 1967 can be accepted as a milestone on the development of regulatory framework to prevent ship-sourced oil spill pollution through the enforcement of international conventions (Akten, 2006).

Table 1. Major oil spills since 1967 (ITOPF, 2017)

Ship name	Year	Spill size (tonnes)
Atlantic Empress	1979	287,000
Abt Summer	1991	260,000
Castillo De Bellver	1983	252,000
Amoco Cadiz	1978	223,000
Haven	1991	144,000
Odyssey	1988	132,000
Torrey Canyon	1967	119,000
Sea Star	1972	115,000
Irenes Serenade	1980	100,000
Urquiola	1976	100,000
Hawaiian Patrior	1977	95,000
Independenta	1979	95,000
Jakob Maersk	1975	88,000
Braer	1993	85,000
Aegean Sea	1992	74,000
Sea Empress	1996	72,000
Khark 5	1989	70,000
Nova	1985	70,000
Katina P	1992	67,000
Prestige	2002	63,000
Exxon Valdez	1989	37,000
Hebei Spirit	2007	11,000

Following with Torrey Canyon disaster, International Maritime Organization (IMO) enforced the most important convention on the prevention of ship source pollution, the International Convention for the Prevention of Pollution from Ships (MARPOL) (Turan, 2009). MARPOL is the main international convention defining regulatory requirements on marine pollution prevention caused by operational or accidental ship discharges. With the adoption of MARPOL, considerable decrease in the number of large-scale ship source accidental or operational oil spills has been provided. In forth coming years, to improve the capability of nations on oil pollution prevention, in October 1989, IMO Assembly unanimously adopted a resolution calling on the IMO to convene a diplomatic conference to consider the adoption of an international treaty instrument in addition to MARPOL (Edwards and Pascoe, 1991). Actually, this resolution was performed in pursuit of the Exxon Valdez disaster, which is accepted as the most expensive ship-source oil spill accident in history (Xiong et al., 2015) with the necessities of adequate and timely response to such an accident. IMO answered that call by adopting the International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC) in November 1990. The main objectives of the convention, respect to the Guide on Practical Methods for the Implementation of the OPRC Convention and the OPRC-HNS Protocol adopted by IMO in 2017, are as follows;

> "to facilitate international co-operation and mutual assistance in preparing for and responding to major oil pollution incidents, and require states to plan and prepare themselves by developing national systems for pollution response in their respective countries and by maintaining adequate capacity and resources to address oil pollution emergencies" (p.14).

It is clearly understood from the objectives that, the OPRC Convention promotes international cooperation at the global level in combating oil pollution, as well as reinforces regional arrangements, national oil pollution preparedness, and response strategies.

Within its 8312 km coastline, Turkey's coastal waters has a large variety of marine biodiversity and habitats. These bio-diversities in Turkey's coastline positively influence and contribute the economic, social and environmental well-being. On the other hand, with its critical geographical position and long coastline, a large volume of ship traffic moves through Turkey's territorial waters, as well as Turkish straits. However, extremely heavy traffic volume in territorial waters and Turkish straits threaten the marine ecosystem and environment. In addition, potential exposure to oil pollution incidents by ships in territorial waters can seriously impair Turkey's economic, social and environmental well-being. Over 1990s, Turkey has made great strides in improving its capacity to prevent and respond to marine accidents and associated pollution incidents. In June 1990, with the ratification of MARPOL Convention, a significant improvement was enabled to prevent ship-source marine pollution in Turkey. In July 2004, with the aim to improve effectiveness of the struggle against the ship-sourced oil pollution, Turkey ratified OPRC Convention. Following with the ratification of MARPOL and OPRC Convention, the national regulatory framework to fulfil the international commitment was constructed with adoption of the domestic laws.

The objectives of this chapter are to review the implementation requirements of OPRC Convention and application of OPRC 1990 related with oil spill in Turkey and present the regulatory framework and bodies in Turkey from the perspective of oil spill management. The rest of the chapter is organized as follows: the implementation requirements of the OPRC Convention is analysed in section two; application mechanism of the OPRC Convention is reviewed in section three: challenges and future opportunities of Turkey's oil spill management is discussed in section four.

2. Implementation requirements of OPRC Convention

In accordance with OPRC Convention (1990), the requirements of the convention are applied to ships, offshore units, seaports and oil handling facilities (OPRC, 1990). On the other side, the requirements of this convention shall not be applied to "any warship, naval auxiliary or other ship owned or operated by a State and used, for the time being, only on government non-commercial service" (OPRC, 1990). At this insight, States-Parties ratifying the Convention must shape their national regulatory framework, take necessary measures at the national level and regulate the operational processes of ships, offshore units, seaports and oil handling facilities in the manner of protection of marine environment.

The national regulatory framework based on the establishment of the OPRC requirements must be constituted to fulfil following areas (OPRC, 1990):

a. "Article 3: Oil pollution emergency plans",
b. "Article 4: Oil pollution reporting procedures",
c. "Article 5: Action on receiving an oil pollution report",
d. "Article 6: National and regional systems for preparedness and response",
e. "Article 7: International cooperation in pollution response",
f. "Article 8: Research and development",
g. "Article 9: Technical cooperation",
h. "Article 10: Bilateral and multilateral co-operation in preparedness and response",
i. "Article 12: Institutional arrangements such as information services, education and training, technical services and technical assistance".

To provide appropriate national regulatory framework in these areas, IMO has actualised significant implementation strategy in the manner of capacity building and institutional strengthening (Signhota, 1995). Additionally, various guidelines, manuals and model courses has been adopted by IMO to support establishment of national and regional regulatory systems in appropriate structure and to enhance the capabilities of personnel through relevant capability-building activities (Sainlos, 2004).

Besides shaping national regulatory framework, it is also quite important to establish a national oil pollution preparedness and response system for prompt and effective response to oil pollution for the contracting parties. Respect to the Guide on Practical Methods for the Implementation of the OPRC Convention and the OPRC-HNS Protocol issued by Sub-Committee On Pollution Prevention and Response (PPR) of IMO in 2017, the national oil pollution preparedness and response system shall comprise the designation of: "the competent national authority responsible for combating marine pollution incidents; the competent national operational contact point or points, responsible for the receipt and transmission of oil pollution reports; and the responsible authority in charge of cooperation and international assistance". The system must be suited with the needs of each contracting state and be structured on comprehensive involvement of all interested parties (Singhota, 1995). To that end, this system must include a national contingency plan which incorporates the organizational structure for cooperation and mutual assistance of public or private bodies for effective oil pollution preparedness and response (IMO-PPR, 2017).

On the other hand, adoption of approved oil pollution emergency plan for ships, offshore units, seaports and oil handling facilities under jurisdiction of Contracted Party of OPRC Convention is another important implementation requirement from the perspective of industrial stakeholders. Approval and co-ordination of the oil pollution emergency plan of each industrial stakeholder is undertaken by the national oil-pollution response system (OPRC, 1990).

The OPRC Convention obliges governments to shape their regulatory framework respect to international commitments, establish their unique national oil pollution response system with the relevant responsibility designation. The solely establishment of the system is not sufficient for effective implementation of OPRC. There are also other important issues to conduct its responsibilities effectively: provision of financing and equipped with competent staff of the system. At this insight, the OPRC Convention obligates governments to develop a systematic programme focused on training and exercising of relevant personnel and oil-pollution response organizations and industrial stakeholders. To meet the requirement of OPRC Convention on these issues, Contracted Parties need to build a comprehensive and systematic training programme in co-operation with interested organizations and industrial stakeholders (Singhota, 1995). Besides the establishment of training programme, development a suitable and sustainable national contingency plan makes a great contribution on the implementation of OPRC requirements in effective manner. In the development of national contingency plan, to facilitate involvement of all interested industrial stakeholders is quite important in implementation of OPRC Convention. The OPRC Convention is the first international convention, which expressly figures out the importance of involving industrial stakeholders in its implementation (Singhota, 1995). In addition, the importance of carrying out research and development activities is also emphasized to improve the capabilities and capacities of contracted parties, organizations and industrial stakeholders on major oil pollution preparedness and response.

3. Application mechanism of OPRC Convention in Turkey

Turkey become the party of OPRC Convention with the publication of the law on approving the participation to the convention in 2003. Following with the publication of this Law, to design the regulatory framework on oil pollution preparedness and response, Turkey enacted the "Law Pertaining to Principles of Emergency Response and Compensation for Damages in Pollution of Marine Environment by Oil and Other Harmful Substances (OSRL)" (OSRL, 2005) in 2005.

The main aims of the OSRL (2005), as stated in in article 1 of the law, are the determination (OSRL, 2005*)* of:

(i) “Principles concerning response and preparedness for eliminating the risk of pollution, or for reducing, containing, or eliminating pollution in emergency incidences stemming from ships or operations of coastal facilities”,

(ii) “Principles for determining and compensating for damages resulting from an incident”,

(iii) “Principles for fulfilment of international obligations”,

(iv) “Powers, duties, and responsibilities of the officials of institutions, organizations, ships, and facilities” (p. 9305).

Additionally, responsibilities and duties of national authorities for the implementation of OSRL provisions is defined in clause 2 of OSRL. According to clause 2 (OSRL, 2005):

> “The Ministry of Environment and Urbanisation is responsible for preparing emergency response plans, implementing emergency response plans in coastal areas, determining kind and impact of pollution, assessment of damage to environment and rehabilitation of the areas affected by post-incident pollution; The Undersecretary of Maritime Affairs (UMA) is responsible for implementing emergency response plans to prevent pollution of the sea as caused by marine vehicles, matters of preparedness and intervention in case of pollution, and matters of compensation for damage and notification of guarantees of financial; Turkish Coast Guard Command “is responsible for public order and law enforcement duties” (p. 9307).

To improve and clarify the implementation of the OSRL, OSRL Implementation Regulation (2006) has been prepared. The implementation regulations give comprehensive information on national preparedness and response system, responsibilities of the organizational bodies and their authorized personnel that have active role on preparedness and response to oil spill. Additionally, the content and the structure of the emergency response plans, national and regional contingency plans have been clarified. The national emergency response planning is structured on three response levels according to the size of the pollution and structured national oil spill response system is illustrated in Figure 2. According to OSRL Implementation Regulation (2006), Clause 3, Article 7, National Preparedness and Response System incorporates three response levels. Level 1 covers small-scale pollution response, level 2 covers medium-scale incidents response and level 3 covers large-scale incidents response.

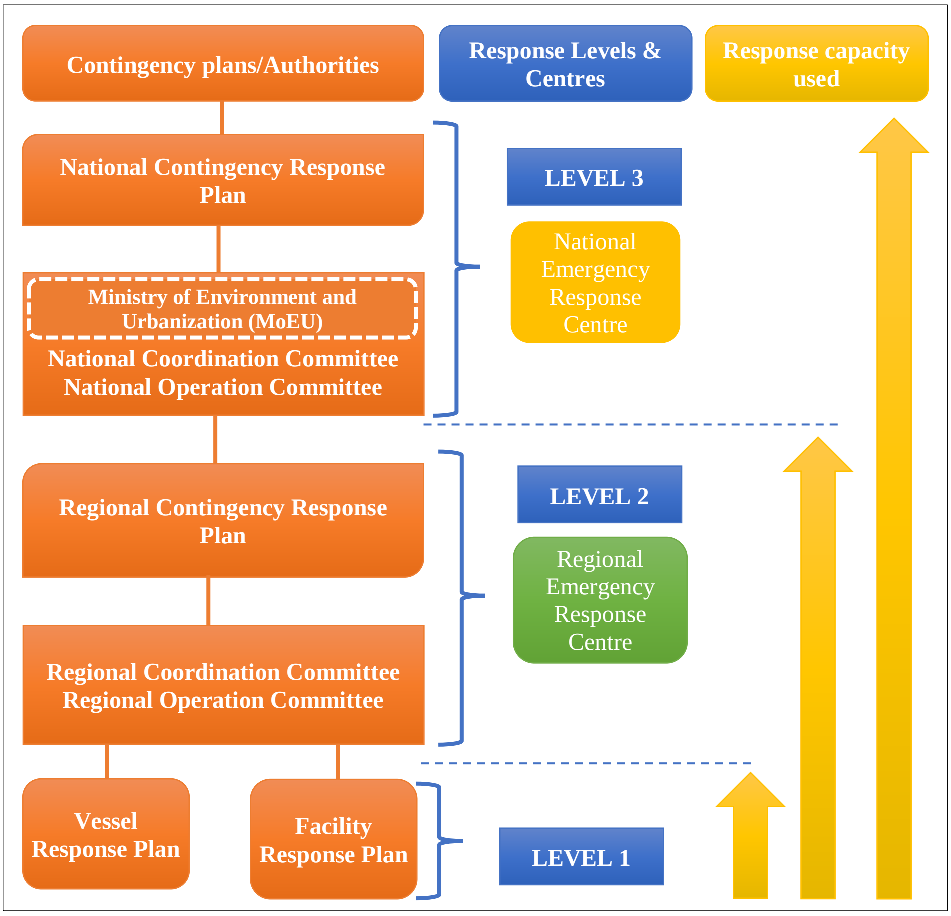

Figure 2. Turkish Oil Spill Response System (Turan, 2009).

In each described level, the necessary preparedness and response actions are implemented through the appropriate contingency plan. In the first level incidents, a coastal facility or a ship takes necessary response actions with its own equipment and capabilities following according to its' vessel/facility contingency plans.

In the second level incidents respect to the OSRL Implementation Regulation, Regional Coordination Committee (RCC) is responsible for the general coordination of the response activities. Regional Operation Committee (ROC) carries out technical and administrative planning and provides necessary technical and organizational supports to response oil-spill incidents within the shortest time in the areas of responsibility. With following the national and international scientific and technical developments, ROC makes capacity-building recommendations on oil spill response. Regional On-scene Coordinator (ROSC) works under the command of ROC. The response activities are carried out according to the Regional Contingency Plan (RCP) by ROSC. Operational groups work as a direct response team under the ROSC in response to pollution incidents.

In the third level incidents respect to the OSRL Implementation Regulation, Ministry of Environment and Urbanization is responsible general coordination authority of the response activities. National Coordination Committee (NCC) is responsible for providing technical support for the response activities. National Operation Committee (NOC) and National On-scene Coordinator (NOSC) are responsible for performing appropriate response activities under the coordination of Ministry of Environment and Urbanization. Support groups plan response activities, distribute tasks to relevant staff, coordinates with other heads of operations for the provision of personnel, material and equipment and gives report to National or Regional On-scene Coordinator (NOSC/ROSC).

Furthermore, the establishment of National and Regional Emergency Centres, which serve as a coordination, operation and response centres, is another important mandatory issue to improve the application of contingency plans. The locations, capabilities, personnel, material and equipment of RECs are determined with taking into consideration the spread of pollution and possible damage, environmental characteristics, closeness to risky areas or being appropriate geographical location to response the oil pollution incidents in risky areas and other relevant factors.

It is obviously ascertained that, Turkey, as a contracted party of OPRC, structures a well-defined and sufficient national regulatory framework to fulfil the requirements of OPRC. In addition, Turkey spends considerable efforts on establishment national administrative authorities to improve the national capabilities.

4. Discussion

With its critical geographical position as a natural bridge between Asia, Africa and Europe, there is a heavy marine vessel traffic in the Turkey's territorial waters. The heavy marine vessel traffic increases the possibility to encounter a major oil spill in Turkish territorial waters. To protect its territorial waters from potential environment pollution risks of heavy marine vessel traffic, Turkey has made significant achievements in ship-sourced oil pollution prevention. The ratification of OPRC Convention in 2003 by Turkey can be accepted as the most critical milestone regarding with ship source oil pollution prevention. Just after ratification of ORPC Convention, OSRL was enacted in 2005 in place to meet international commitment.

Before the enactment of OSRL, the oil spill policy of Turkey is shaped based on the Environmental Law (Law No: 2872). However, the Environmental Law did not include any specific legal framework on oil spill preparedness and response principles. It did not provide any obligation on standardization on emergency response plans, emergency response equipment or organizations. Additionally, only 14 coastal cities in Turkey had their own emergency response plans with the reference of the Environmental Law (Turan, 2009). All these drawbacks in regulatory regime on environmental concerns produce a great necessity to adopt a detailed legal framework to enhance the effectiveness of oil pollution prevention, preparedness and response. In the wake of the enactment of the OSRL, Turkey provide an important progress to meet the international commitment arising from the ratification of the OPRC Convention.

Research and Development (R&D) activities related with the enhancement of oil spill response capabilities, materials and equipment of the administrative authorities in the manner of improvement the application of OPRC Convention are another important issues. At this viewpoint, between the years 2008 and 2010 Ministry of Environment and Forests (with new name Ministry of Environment and Urbanisation) had coordinated research project with the Scientific and Technologic Research Council of Turkey (TUBITAK) on the preparation of the national and regional emergency response plans. In the project one national and six regional emergency response plans was prepared to standardize emergency response plans, emergency response equipment and organizations. On the other hand, Ministry of Transport and Infrastructure (MTI) had contracted national and international R&D institutes to prepare projects on the subjects of establishment of regional emergency response centres, emergency response drills, authorization of emergency response and training companies, control and management of ballast waters, ship source emission control, satellite based oil spill monitoring and radar based oil spill monitoring (MTI, 2013). However, there are still important R&D subjects that need to be focused in coming years. For example, establishment of specialized national test institution on oil spill response is one of the important scopes that is needed to be take into consideration in near future. Additionally, major oil spill environmental impact assessment projects are necessary to figure out impacts of oil spills on socio marine life, socio economy and human health. Besides, R&D projects on oil spill monitoring and tracking will turn into substantial issues to enhance the capabilities and to improve the effectives of oil spill response in forthcoming years (Zhang, 2011).

From the perspective of establishment of systematic training programme, administrative authorities should pay more attention to improve the knowledge and skills of crews in oil-pollution response teams via organizing specialized pollution prevention and response training courses and exercises. Specially, to catch up the technologic development in oil-pollution response equipment, advanced technological equipment training should be regularly organized. Human resource development monitoring system should also be established to monitor the staff qualifications from the perspective of operation ability, to determine potential training necessities and to figure out technical competence and incompetence.

To improve the application of OPRC Convention, it is essential for administrative authorities to take necessary action on development marine oil spill emergency co-operation, improvement emergency response capabilities, increment R&D activities and enhancement crew competencies topics in addition to regulatory issues. Specially, lack of R&D activities on oil spill response can be identified as the most important drawback in the implementation of OPRC Convention. Hence, it is necessary to focus on R&D activities more and comprehensively to improve the capabilities oil-spill response materials, equipment, strategies and methods.

5. Conclusions

Turkey with its critical geographical condition plays a significant role in transportation of oil from producing countries to consumer countries. With the increment of transportation rate of crude oil and oil products through seaway, the risk of oil pollution in Turkey's territorial waters has continuously increased more and more with each day. To protect the marine environment, lives and live hoods, Turkey published OSRL to fulfil the requirements arising from being party to the OPRC Convention. By this means, Turkey constitutes its national legislative framework for oil spills preparedness, response and co-operation. At this insight, Turkey spends comprehensive efforts to meet the implementation requirements of OPRC Convention such as; (i) oil pollution emergency plan requirement of vessels and facilities, (ii) oil pollution reporting requirement, (iii) establishment a national and regional systems for prompt and effective response to oil spill emergencies, (iv) constitution of co-operation between government and industrial stakeholders at national, regional and global level and (v) execution of R&D activities to enhance the state of the art of technologies and techniques for combating oil spills.

To meet the international commitments and requirements of OPRC Convention, Turkey introduce precious efforts. Nowadays, Turkey's regulatory framework is more compatible with the international regulations. Specially, with the enactment of the OSRL, Turkey makes a big stride on protection of the marine environment by ships from operational or accidental discharges. In forth coming years, the effectiveness of combating oil pollution incidents will be enhanced by providing and maintaining impressive implementation of the OSRL and its requirements.

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PROTOCOL ON PREPAREDNESS RESPONSE AND CO-OPERATION TO POLLUTION INCIDENTS BY HAZARDOUS AND NOXIOUS SUBSTANCES 2000 (OPRC-HNS PROTOCOL) AND ITS EFFECTS IN TURKEY

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1. Introduction

In global scale, oil still is the most important source of energy for economic development, which in return leads many countries to enhance their oil trade hence making maritime transportation an important priority. However, as seaborne transportation of oil brings significant profits to those countries, it may also pose danger to human-life, environment and marine ecological life through tanker accidents (Chen et al. 2018). Data has shown that market conditions for tankers have been favorable over the past years. After the crisis in markets in 2008, together with chemicals, transportation of oil both in crude and refined form seems to have experienced best years (Review of Marine Transport, 2016). Owing to the increase in petroleum trade and insufficient tanker numbers in the existing fleet capacities, tanker markets benefited from high freight rates. (Review of Marine Transport, 2016). However, here the term *tanker fleet capacity* does solely refer to an increase in the number of tanker ships operating at seas. While a noticeable decrease in the number of operational tankers at sea may be observed, still the quantity of seaborne transported oil (and other chemicals) increases due to bigger size and carrying capacity of individual tanker. Hence, dangers sourcing from the difficulties in safely maneuvering of bigger ships in narrow and congested waterways will not cease to exist. Moreover, owing to huge amount of cargo being transported, concerns for the catastrophic consequences of a possible tanker accident will be even greater.

Naturally, with the unique geographical location, Turkey has had its share from this significant boost in maritime international tanker transportation traffic.

Turkey, situated in the intersection of Europe, Asia and Africa, is in the midst of intense sea transport lines. Turkey has 8000 km total coastline and it is surrounded by three seas; Northern border of the country is surrounded by Black Sea, while Aegean Sea surrounds the West and Mediterranean Sea lies along the South coast. The Marmara Sea is an inland sea that connects the Black Sea and Aegean Sea through Turkish (İstanbul and Çanakkale) Straits. With a central geography, besides being a peninsula and dealing with every kind of maritime transportation on its extensive coastline, Turkey hosts significant international tanker traffic through İstanbul and Çanakkale Strait as well as the Marmara Sea. The main North-South lanes of transportation from the Black Sea pass first through Turkish Straits and then through the Aegean Sea between Turkey and Greece. As the volume of demand for carbon-based energy (especially oil) increases, the need for moving the oil westward from the Black Sea ports will increasingly continue. Noting this fact and following a clear and co-operative perspective, Turkey has always put emphasis on keeping up with the global requirements as well as observing its national interests. In order to contribute to the common goals of humanity and being well aware of the fact that global problems can only be solved on global scale, Turkey has always been keen on abiding by the international regulations and rules and has been willingly participating all related international conventions. Participating in regional efforts through bilateral and multilateral cooperation has also been one of Turkey's main priorities. Like in other fields of co-operation, Turkey has followed the same pattern in maritime sector, environment protection and valuing human life. "*International Convention on Oil Pollution Preparedness, Response and Co-operation, (OPRC) 1990"* and "*Protocol on Preparedness Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances 2000 (OPRC-HNS PROTOCOL)"* are the two important international conventions in that field both of which were ratified by Turkey in a timely manner.

Rationale behind this timely approach was the fact that international tanker traffic, as an important part of maritime transportation, became too intense especially through the Turkish straits. The maritime sector, while presenting benefits of mass transportation, also poses adverse consequences of possible maritime accidents. In spite of existing national and international rules and regulations for safe navigation, accidents in maritime transportation sector do occur. Especially, accidents in form of grounding, collision, fire on board, explosion and hull breach may pose catastrophic outcomes involving casualties, loss of property and serious and almost irreversible marine environmental pollution. However, accident risks do not source only from international tanker traffic. Considering the length of the coastline of the country, number of heavily operated domestic ports and their approaches as well as tanker loading and discharging operations, risk of tanker accidents and environmental pollution will surely remain as one of the top priorities. Hence having domestic legislation in place is necessary to manage all related issues.

After several serious incidents in the Turkish Straits, in order to ensure safe navigation, Turkey, in cooperation with IMO (International Maritime Organization), has adapted a series of regulations over the last twenty years. In 1994, proposing a Traffic Separation Scheme (TSS) and new regulations in the straits was the first step towards this goal. After revising those rules in 1998, Turkey introduced "*New Instructions*" in 2002 to include one-way traffic and restriction of large vessels carrying hazardous cargo to daylight transit, among other important rules, aimed to contribute to safe navigation. Making Turkish Straits Vessel Traffic Service (TSVTS) system operational in 2003 was the latest step of this goal.

From pollution prevention and response point of view, Turkey as a contracting state for the above-mentioned two conventions, has already taken the primary step by projecting those conventions on domestic legislation. The *Act 5312* (dated 2005) and the respective *Guidelines* (dated 2006) on *"Principles of Intervention in Urgent Cases of Pollution of the Sea Environment by Oil and Other Noxious Items and Compensation* *for Damage"*, are the concrete steps Turkey has taken on projecting international legislation on domestic one. Contracting an international convention and reflecting its rules on domestic legislation surely shows good will and determination. However, all those efforts should be supported by establishing required infrastructure, having clear-cut managerial organization, allocating trained human source and necessary assets. Providing all those should be accompanied by timely and repeating risk assessment, scenario-based simulations and hands-on training as well as updating the overall system when required. If dangers posed by accidents involving hazardous and noxious substances are included in the equation, efforts for intervening, responding and overcoming the pollution problem become even more complicated.

As the significant points of Turkey's approach on safety and the pollution, prevention related issues from both navigation and legislation aspects can be summarized as above, there is still a need to better understand the rationale behind. In the following sections, brief information is presented on the latest tanker traffic data and past maritime accidents in the Turkish Straits. After briefly discussing the link between the convention and the domestic legislation, comparisons of regional and national approaches, in terms of procedures, organizations, allocated assets and managerial aspects are made to assess present capabilities and to find out future needs to have an efficient pollution prevention system.

2. Background / Rationale, recent traffic data and past accidents

As Turkey is general political willingness and tendency for participating in international and regional cooperation is evident, its national concerns must also be recognized. To better understand Turkey's concerns on pollution prevention and intervention, the dynamics of the main international tanker transportation routes and high-risk areas in Turkish waters that pose pollution danger should briefly be reviewed. Looking from this perspective, it can easily be seen that Turkish Straits get the top priority. This is firstly due to population of Istanbul city around the strait, thus the number of people that may be exposed to adverse consequences of a possible accident. Secondly, it is due the fact that Turkish straits are the only waterways subject to the westbound tanker traffic from the Black sea. The sea conditions in the Black Sea are generally calmer than others seas in the North but it may be susceptible to violent storms and heavy seas (EMSA Maritime Accident Review, 2007). Istanbul Strait as the primary exit from the Black Sea is naturally affected by the adverse weather conditions, which in return make it more difficult to maneuver the big size ships, thus increasing risk of accident. Number of ships, human error and technical failures experienced during the transit also contribute to cause of accidents.

As summarized in Table 1, according to the latest official (DGMT, 2018) statistical data, 42.078 vessels passed Istanbul Strait in the year 2017. 8832 of these vessels were tanker ships with various cargos and out of the total number 4005 of the vessels had LOA (Length over All) of longer than 200 meters. Likewise, the same data shows 44.615 vessels passed Çanakkale Strait, 9478 of which were tankers with various cargos and 6197 of the total number had LOAs longer than 200 meters.

Table 1. Statistical summary of vessels passed the Turkish Straits in 2017.

Strait	Total number of vessels	Total number of tankers	LOA Longer than 200 m
İstanbul	42.078	8832	4005
Çanakkale	44.615	9478	6197

These numbers alone show how congested the traffic in the Turkish Straits is. Number of tankers transiting per day corresponds to an average of 10 in Istanbul Strait and 15 in Çanakkale Strait, which cannot be underestimated or disregarded. Although the number in Istanbul strait seems to be declining compared to 15 per day in the year 2013 (Bozkurtoğlu, 2013), still the increase in cargo capacity plays a greater role. Together with total number of transiting tankers, when existing oil refineries, tanker loading and discharging ports and possible oil spills that may source from collision of non-tanker ships are considered, these facts and figures surely require Turkey to have clear-cut regulations, well-established oil spill prevention/intervention organization and necessary assets in place and operational.

With a quick review of the past oil spill accidents, especially in Istanbul Strait, there seems not to be a pleasant picture. Table 2 (Briefed from shows a brief summary of oil spill accidents in Istanbul Strait over the past decades.

Table 2. Major oil pollution quantities in the Istanbul Strait (briefed from Oral and Öztürk, 2006).

Year	Type of accident	Total Oil spilled
1979	Collision	70.000 Tons
1994	Collision	20.000 Tons
1999	Grounding	4.000 Tons
2003	Grounding	480 Tons

From the Turkish perspective, when brief summaries in the tables above are put together, the risk even only in Istanbul Strait proves to be major. Though there seems to be a slight decline in the number of tankers passing the strait, still due to increase in the individual carrying capacity of tankers, statistics show that every two hours a tanker ship transits Istanbul Strait with all the risks posed both to human life and to environmental pollution. This evaluation requires fully equipped and operational response and intervention organization, necessary assets together with proper legislation should be in place both in navigation safety and pollution prevention aspects.

Turkey as the sole state having the power to regulate the passage through the Turkish Straits (Kurumahmut, 2006), through international co-operation and IMO’s support, has succeeded in reducing the accident risk by introducing the new regulations accompanied by the TSVTS system in the straits. However, although Turkey has taken the first steps for legislative side, in the problems concerning pollution prevention and intervention it may still have a way to cover. In the following sections before discussing the domestic and regional efforts to cope with the issue, international researches and studies together with novelties on the issue will briefly be reviewed.

3. Contemporary examples of risk assessment and oil and HNS pollution

As success in any subject requires high level of awareness and mental preparedness, successful operation in any oil spill accident follows the same pattern. While awareness on the issue can be achieved and sustained by making timely risk assessment studies, mental preparedness can be achieved by conducting scenario-based simulations. Allocating all possible assets and conducting real-like exercises complete the process of being prepared for a possible oil spill accident.

Handling and seaborne transportation of hazardous chemical substances has also significantly increased through the past decades (Hakkinen and Posti, 2013). However, being as much prepared for a possible HNS (hazardous noxious substance) pollution seems not to be that easy and standardized as being prepared for oil pollution. Previous studies (EMSA 2010; Bogalecka and Popek 2008; Mullai et al. 2009) coincides with this evaluation. This is due to variety of the pollutant substance. To some level, it is possible to get prepared for oil-based pollutions. However, conducting risk assessment, scenario-based simulation and hands-on exercise for every other kind of HNS does not seem as achievable. This is because the risks posed by each pollutant as well as possible consequences and required intervention/prevention effort will be type-specific, making preparedness harder. Unlike oil spill and pollution, a commonly accepted interpretation of *categorized response procedures* that would define and evaluate the degree of HNS spillages sourcing from the ships, still does not exist. This lack of procedures makes preparing contingency plans for HNS spills difficult to accomplish (Nicolau, 2008). The amount of chemicals transported by sea is relatively smaller than seaborne transported oil products. In spite of this fact, as Häkkinen and Hosti (2013) state, when considering risk posed by probable accidents involving oil, it is much easier to identify the risk that may be caused by oil accidents than that of chemicals.

During the recent decades, in order to contribute to pollution related issues, many studies and researches aimed to provide utilities for coping and dealing with pollution disasters more effectively. Basic tendency of these efforts followed two main goals. Some studies were devoted to risk assessment, accident prevention, foreseeing or analyzing environmental impact of pollution, others mainly concentrated on techniques and methods to intervene and minimize the actual pollution. While some of the recent studies focus on regional risks (Wang et al. 2018), others focus on prevention of accidents leading to pollution (Youssef and Paik 2018; Kollo et al., 2017; Akyüz 2015). From the environmental point of view, some researchers (Harrison 1991; Laffon et al., 2006; Fadigasi, 2017) tried to bring up the environmental, ecological, and economic damage to the neighbouring regions. Studies depicting worldwide situation and effectiveness of pollution response systems (Chen et al 2018; Liu et al 2015; Wang et al 2014) also contributed to the recent efforts. The studies by Can (2007) and Bozkurtoğlu

(2013), on oil-spill trajectory estimation are recent examples of the few domestic studies in national waters.

Other studies mostly deal with technical side of the pollution issue. As simulations are one of the best aids to prepare for a possible post-accident pollution scenario, computer assisted simulations were developed to identify the hazard and to make necessary preparations beforehand. As risk assessment tools, those simulations help anticipating possible hazards and formulating best possible intervention method. This way, correct strategies can be produced; training and communication needs and required intervention assets can be better understood to support the decision-making process.

These aids help completing the risk assessment process. As this process requires risk identification, risk analysis and risk evaluation steps, producing a thorough oil-pollution response plan have become more justifiable with the help of the modern utilities. Amongst many others viable methods, recent calculators are good examples of these computer assisted simulations. For example, ERSP (Estimated Recovery System Potential) is software used for *mechanical recovery*. It calculates recovery-rate both for continuous and batch spills (ERSP Calculator User Manual, 2016). EBPS (Estimated Burn System Potential) calculator on the other hand, is used for, *in-situ burning*. It accounts for the performance of an advancing controlled burn system that burns oil inside of the system's fire boom. Besides evaluating the potential of advancing oil spill burning systems, the EBSP can also be used to explore how to configure a burning system to best encounter and burn oil more efficiently (EBSP Calculator User Manual, 2016). PISCES (Potential Incident Simulation Command and Evaluation System) is a response simulator intended for preparing and conducting command centre exercises and area drills in oil spill response. (PISCES User Manuel Version 2.93, 2008)

This section tried to emphasize the need for proper pollution prevention preparedness and presented examples of recent simulation/calculation aids used for planning and producing oil pollution response plans. Next section will discuss the Turkish oil-pollution response system and compare it with the regional efforts.

4. Efforts to Establish Turkish Emergency Response Organization in Comparison to EU Efforts

4.1. Turkish Efforts

Turkey after adapted Act No 5312 together with its guidelines set to establish an organisation to accomplish the aim. As mentioned above, the best way to deal with pollution problem is to have a well-functioning organisation with adequate assets and to be prepared for possible scenarios. In other words, response action against pollution caused by the spillage of oil or other noxious and harmful substances is possible through the establishment of emergency response centres, equipped with adequate facilities, capabilities and personnel, which are optimally located and easily deployable in the area of responsibility.

Turkey recognising this fact, initiated a project in the year 2006 to create emergency response centres, to determine the most appropriate intervention and training methods, to create a database containing the sensitivity of the sea environment and the effects of substances pollute this environment (DGMIWR, 2018). In parallel to this project, between the years 2006 and 2009, through a separate project supported by The Scientific and Technological Research Council of Turkey (TUBITAK), risk assessment and environmental sensitivity maps were produced. As an output of this study, the locations of emergency response centres and stations were pinpointed in Turkish Emergency Response Liability areas (UBAK, 2013). Figure 1 shows the Turkish Emergency Response Liability areas. This study, besides the location of the centres, helped determining the number of centres and best possible methods to apply in accordance with the area's specialities.

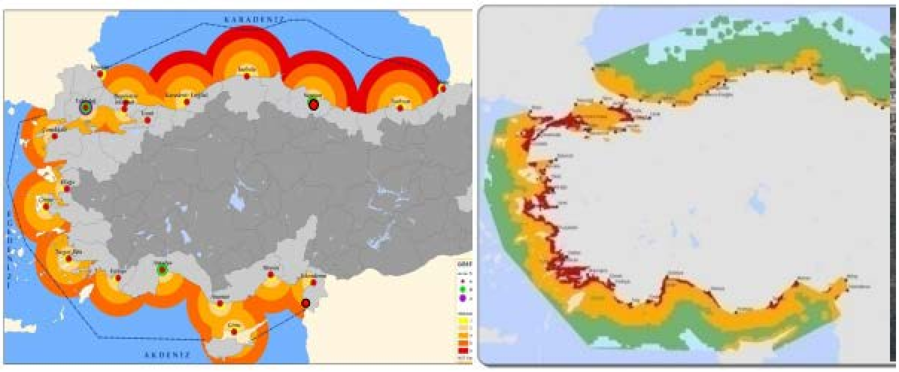

Figure 1. Turkish Emergency Response Liability Areas

Following the sequence of the project, construction of National Marine Safety and Emergency Response Centre (Marmara Ereğlisi) and Regional Emergency Response Centre (Antalya) is already completed. However, 19 Local Emergency Response Stations (equipment storage areas) are still being established. Figure 2 displays the locations of the emergency response stations.

With the established organization, it is envisaged that the emergency response system will timely and effectively intervene any possible pollution caused by oil and other noxious-harmful substances. It is also among the main goals to integrate the other intervening organizations, which are responsible for an oil spill case into the decision support system so that a common situational awareness can be ascertained.

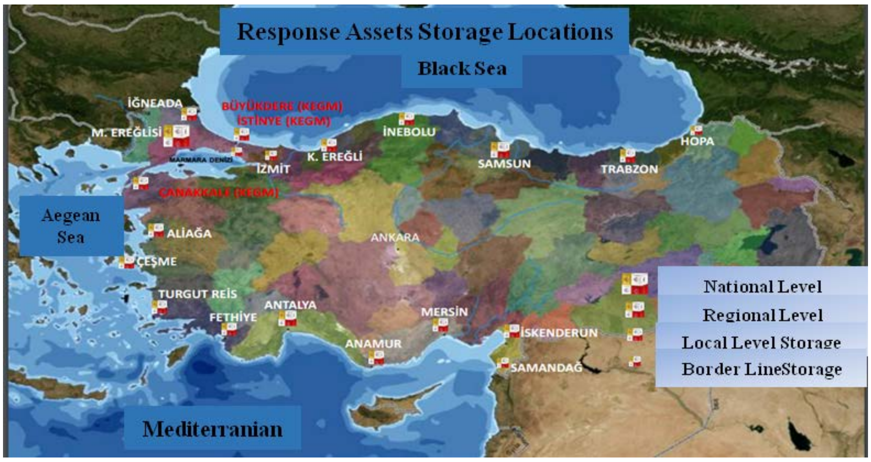

Figure 2. Turkish Emergency Response and Intervention Stations

4.2. EU Civil Protection Mechanism - European Emergency Response Capacity - Barcelona Convention (1976-2004), EMSA HNS Action Plan and Turkey

As explained in European Civil Protection and Humanitarian Aid (ECPHA 2018), the EU Civil Protection Mechanism was established in 2001, encouraging cooperation among national civil protection authorities across Europe. The system was organized to encourage harmonized help from the engaging countries to sufferers of natural and man-made catastrophes within the European Union as well as outside the Union. The operational hub of the Mechanism is the Emergency Response Coordination Centre (ERCC) that monitors emergencies around the globe around the clock, and in case of a crisis, coordinates joint European response operations. The Mechanism assists in marine pollution crises, where it works closely with the Maritime Safety Agency (EMSA). Through the Common Emergency Communication and Information System (CECIS), the mechanism supplies emergency communication tools as well as facilities to monitor the situation. This is done by a web-based warning system, which facilitates real time information flow amongst the countries and the ERCC, which is established in Brussels. The European Community has also strengthened measures for the protection of the marine environment through regional co-operations. In parallel, the Barcelona Convention was signed on 16 February 1976 under the name of "Protecting the Mediterranean against Pollution". Subsequently convention was expanded and renamed as the "Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean" and was put into effect on 9 June 2004. Regional Marine Pollution Emergency Response Centre (REMPEC) of this organization located in Malta. One of the main tasks of the REMPEC has been defined as "*assistance to the coastal States of the Mediterranean region, which in cases of emergency so request, in obtaining assistance of the other Parties to the Prevention and Emergency Protocol or, when the possibilities for assistance do not exist within the region, in obtaining assistance from outside the region*" (REMPEC, 2018).

REMPEC uses some operational tools like The Maritime Integrated Decision Support Information System (MIDSIS-TROCS). This system is designed to provide necessary information to decision makers both in the field and operational headquarters. It basically facilitates the decision making process in order to assess the measures to be taken more accurately in relation to spill event. REMPEC also uses Marine Mediterranean Decision Support System for Marine Safety (MEDESS-4MS). This system is used to enhance maritime safety by reducing the risks and possible effects of spills. It also aims to present an extensive multi-model oil spill estimation approach. In order to achieve this objective, meteorological and oceanographic is collected, integrated and analysed together with ship traffic and operations data and sensitivity mappings. (REMPEC, 2018).

As novelty to support all previous efforts and make things more concrete for the future attempts, European Union, through EMSA introduced *Inventory of EU Member States Oil Pollution Response Vessels* as an official document in 2004. The document has been updated four times; in the years 2006, 2009, 2012 and finally in 2016. In addition, the latest version of the document replaced all previous versions (EMSA 2009; EMSA 2016). The early versions of the document-listed government owned or chartered resources. The information provided was country based and gave detailed lists to include vessel name, vessel type, vessel location, on board equipment, recovered and anti-pollution operation daily rate oil storage capacity. Latest version provides information on:

- Profile of member country
- List of vessels regarding including ownership: Government owned (specialised and non-specialised vessels) and private resources for oil pollution response
- Previous experience with oil pollution response
- Agreements (Regional and bilateral)
- Drills and exercises regarding oil pollution response
- Characteristics of available vessels
- Storage capacity and equipment details
- Anti-pollution response Equipment available on board

Brief evaluation of the above data shows that from oil-pollution response aspect of OPRC-HNS, Europe seems to have a well-established system, sufficient communication and monitoring capabilities together with required assets for responding and intervening possible oil pollution incidents. There is of course always space for further improvement and for increasing capacities.

When Hazardous and Noxious Substances are considered, one of the prevailing guidelines comes from European Maritime Safety Agency (EMSA). HNS Action Plan (2007) is one of the fundamental sources that deal with the pollution issue. With its full title, "*Action Plan for Hazardous and Noxious Substances Pollution Preparedness and Response*", HNS Action Plan covers both oil pollution and HNS pollution preparedness and response issues. The plan defines HNS as "*any substance other than oil which, if introduced into the marine environment, is likely to create hazards to human health, to* *harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the Sea*". In addition, it is stated that the plan should be used in accordance with the "*OPRC-HNS Protocol (2000)"*.

The plan when evaluating the HNS safety, preparedness and response structures of the member states does not present a pleasant picture. According to the insights of the plan, at national level, structures established for response aspect of a possible oil spill, together with contingency plans, are sufficiently developed. However setup and plans for a possible HNS incident are not at the same level. As far as the plan is concerned, main reasons source from the differences in hazards and risks involved in response operations as well as diversity of the techniques utilized in detecting, monitoring and responding such incidents. The action plan also puts forward that "*OPRC-HNS Protocol 2000*" will call for solid cooperation amongst the participating states. Every individual country should have in place procedures for handling a pollution incident. However if individual efforts for handling an incident falls short a close cooperation is required. From the HNS preparedness aspect, the plan states that readiness and preparedness status of individual countries are widely different. Some of the members express that they are not appropriately prepared and operationally ready for responding any large-scale HNS incident should it occur in their area.

When the plan was produced, some member states did not have any capacity in terms of pollution response. This practically meant that they lacked any means and materials to properly respond to any large-scale HNS incident. Thus they would request assistance from other members, either from a neighbouring country or any country in the region possessing the capacity. One other option would be contacting private specialists or specialized institutions. Some other members presented restricted capacity for responding that kind of incidents. In practice this meant that they could interfere if the incident involved recovering undamaged intact packages. One other limitation was that they would be able to respond also HNS discharges only if the substances are similar to oil both chemically and physically. As to handling of complicated HNS incidents, most of the members seem to have very limited experience. When the cargo on board comprises of a variety of substances, dealing with this variety in an emergency requires adequate knowledge on behaviour of individual HNS, which actually is not very easy to attain beforehand. Only few members are able to do hands-on training sessions related to HNS incidents. When marine pollution scenarios due to HNS are played, they are mostly regional or sub-regional scale training. The plan also clarifies that not many member countries have vessels with required assets, specialized rigging and technical capabilities for intervening an HNS release at sea. Those vessels should be capable of operating in dangerous environments (i.e. on board presence of gas detection sensors, special purpose filters, having airproof/over pressurizing systems). They should also be able to be used for lightering of chemicals in bulk and assisting fire fighting as well as for offloading and recovering packaged chemicals. Moreover, those vessels may be rigged with auxiliary equipment that can be used to monitor, detect and recover hazardous substances. They should also have facilities for storage and special protective outfits for intervention (HNS Action Plan 2007).

Turkey with her political willingness to participate in humanitarian and pollution related efforts, being a contracting country both OPRC 1990 and OPRC-HNS 2000, became a party to the revised Barcelona Convention in 2002. While developing her OPRC-HNS capabilities and fulfilling its international liabilities, Turkey made legislative arrangements to reflect the international obligations into domestic legislation. As mentioned above, launching Emergency Response Centres Project can be considered a determined significant step toward the goal. This proves that Turkey wants to enhance its role in protecting the environment against pollution sourced by oil, noxious and harmful substances. On national scale, all of the above-mentioned aspects such as, pollution preparedness and response mechanisms and capabilities, competent authorities, required assets and inventory are regulated by the procedures in the Turkish Act no 5312. The next section will try to assess the correspondence of international and domestic requirements as well as any shortages and critics depicted.

5. OPRC-HNS 2000 and Domestic Legislation: Regulations, Assets and Procedures

In order to provide a more extensive view to the matter, the OPRC-HNS Protocol aims to broaden the perspective of the "*1990 International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC Convention 1990)*". When OPRC 1990 convention came into force on 13 May 1995, it basically targeted to set rules and principles for oil pollution only. However the OPRC-HNS after being adopted by the countries already participants of OPRC in March 2000, is applicable to pollution incidents by hazardous substances other than oil. The OPRC-HNS came into force after 14 June 2007.

The OPRC-HNS Protocol deals with the matter at national, regional and global levels. Besides oil pollution aspects, the Protocol sets a framework of co-operation in case of pollution incident caused by HNS. Cooperation involves training aspects as well as scientific and technological collaboration. This approach also includes establishing systems for enhancing level of preparedness and response for engaging possible threats posed by HNS pollution. Within both OPRC 1990 and OPRC-HNS 2000, a national system for response is required. After designating a national authority, a contact point should be assigned at national operational level together with in place national contingency plans. It is also necessary to support these efforts by proper communication schemes, adequate equipment supply and routine training sessions and hands-on practices within exercises. As long as applicable, required assistance during pollution emergency should be provided to other countries. While this assistance is encouraged, it may also call for payment in return of the help given. As to co-operation practices, The Protocol, in order to enhance preparedness levels and response capabilities, strongly encourages all countries to engage in bilateral or multilateral agreements.

Act No 5312, "*Principles of Emergency Response and Compensation for Damages in Pollution of Marine Environment by Oil and Other Harmful Substances and its application regulation*" (2005) is the prime source regulating Turkish efforts on the issue. As it can be understood from the title of the act, in Turkish legislation, a single act is put in force to cover both response and compensation aspects of a possible pollution incident. The act was supported, and the content was enhanced by the guidelines (2006) and other legislative arrangements such as authorisation of private companies for response tasks.

As OPRC-HNS is adopted to serve to expand OPRC 1990, a basic comparison can be made between OPRC requirements and national legislation (Table 3). The first article of the Convention obliges States Parties to take all-necessary measures to prepare and intervene individually or together in case of oil pollution. This provision also refers to the purpose of the Convention. Countries should act accordingly to ensure that the ships owned or operated by them are in conformity with the Convention (OPRC, 1990, Article 1).

Table 3. A basic comparison between OPRC 90 requirements and Turkish Act 5312

OPRC 90 Requirement	Turkish Act 5312
A national authority for oil pollution preparedness and response	*General coordination authority for implementation is in the **Ministry of Environment and Urbanism.***
The national focal point which will be responsible for the submission and receipt of reports and requesting help or providing the assistance requested and authorized to act on behalf of the State party	*Duties and responsibilities for enforcement of emergency response plans for the prevention of marine pollution caused by ships, preparation, pollution prevention, and compensation of damages and reporting of financial liability guarantees related to enforcement, are in the **Ministry of Transport and Infrastructure***
Authority which will prepare national contingency plan that specifies related duties, powers and responsibilities between relevant public and private organizations in preparedness and response	*The authority, duties and responsibilities related to the preparation of emergency response plans, implementation of emergency response plans in coastal areas, determination of the type and effects of pollution, determination of damages to the environment and rehabilitation of the areas affected by pollution after the incident are in the **Ministry of Environment and Urbanism***

Looking from fulfilling the fundamental aspects, the legislation Turkey introduced seems to meet the requirements of the international convention. When more technical approach is needed, the guidelines to the implementation of the act come into play. As the secondary legislation, Guidelines 5312 (2006) try to sort out details. The regulation is based on the gradual intervention approach in emergency response planning and dictates the implementation of different response levels. According to the articles 10, 11 and 12 of the guidelines, there are three different level of pollution, which require different response actions:

- *Level 1***:** Covers events that may occur because of operational activities on a coastal facility or ship and may cause small-scale pollution. Either a shore based authority or a ship can handle the situation with its own facilities and capacity.

- *Level 2:* This level covers the medium-sized events, which will cause inadequate of coastal facility or a ship's own capabilities to intervene and control and requires regional organization and capabilities.

- *Level 3:* This level deals with large-scale incidents caused by serious accidents at sea or coastal facilities. In a third-level incident, the intervention is carried out within the framework of the National Emergency Response Plan and the Ministry of Environment and Urbanization is responsible for general coordination.

In addition to the Guidelines (2006), Turkish authority issued a special Communiqué, which states that only certain public institutions and private companies are authorized within the framework of the relevant legislation for response and intervention of marine pollution that may occur in the surrounding seas of Turkey (Communiqué 2009/4). These authorized companies sign a contract and perform the urgent response task on behalf of coastal facilities. The Communiqué, as an integral part of the rules and regulation, gives an exhaustive list of sea vessels, rigging and equipment, which the authorised units are, expected to possess. However, later inspections performed by the governmental bodies proved that some of the companies who received the authorization failed to obtain/possess the required equipment. Hence, in 2017 the national authority suspended the authorizations keeping them on standby.

Here we can conclude that Turkey, having taken all necessary legal steps to ascertain a fully functional pollution response system, still have shortages to completely achieve the goal. Besides the fact that Emergency Response Stations are still being established, the response assets and human power to deal with possible pollutions are not yet in place. Moreover, a detailed inventory of ready-to-use assets has not yet been produced as it is done in the EU. From HNS point of view, like many other countries, Turkey has a long way in order to fully be capable of dealing with this kind of pollution.

From liability and compensation aspect of the issue, there are some critics on the Act 5312. Demir (2011) states in his study that, the act has not constructed a noteworthy civil liability regime. According to Demir, besides being inconsistent with the International law, the focus and core of the act is wrongly placed. Instead of civil liability, the act deals with preparedness and intervention. The critic states that the act has many unclear terms and the body of the text is not organized well. The same critic recommends that the main content of the act should be revised to focus on urgent intervention only, the items and parts involving civil liability and compensation should be separated from the act.

6. Conclusion

Owing to its geographical location, oil and HNS sourced maritime pollution incidents, together with prevention, intervention and response to accidents causing the pollution will always be at the top priority for Turkey. Having dense tanker traffic in Turkish Straits and a vast coastline, not only encourages, but also dictates this approach. Besides its political willingness, Turkey become one of the contracting countries to both OPRC 1990 and OPRC-HNS 2000 in a timely manner in order to participate in efforts to protect human life and environment. When domestic legislation is concerned, Turkey by introducing Act 5312 and its sub-legislations have been trying to do its best to establish its own response system, set, and conform to the required standards. However, this cannot yet be classified as job-well-done yet. There obviously is more to be done to reach the standard Turkey is aiming for. In HNS response area, there seems to be a gap to be filled. Although this mainly sources from type-specific nature of response measures and this is the case with many other countries, still especially heavily populated areas like Istanbul Strait, promptly requires this issue to be taken care of.

As explained above with the international examples of researches and studies, first of all, Turkey must have its scholars to work more on the subject and encourage them to produce alternative area-specific approaches that would facilitate any possible solution. This attempt should include area-specific simulations for the authorities to clearly see what could happen if things go wrong in terms of pollution causing incidents. These risks could get more measurable thus more manageable. As in western examples, creating an inventory of assets for response and intervention to oil and HNS pollution will standardize any attempt to deal with the incidents. This should also be supported by well-trained human power and periodic exercises to be fully prepared for a possible incident. These exercises should be conducted for not only responding but also intervening purposes, hence making Turkey's efforts more concrete and dependable. A dependable national system for preparedness and response, together with organisation, trained personnel, basic equipment and especially contingency plans against marine pollution incidents are the key indicators to mark the performance and achievement of response to pollution incidents.

While establishing the emergency response system, like in western example, among all responsible stakeholder institutions, information network infrastructure should be created within the decision support system and especially real time meteorological and oceanographic data should be integrated into this network. In this context, this information network should be integrated into organization, which includes CECIS and REMPEC.

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THE INTERNATIONAL CONVENTION ON SALVAGE (SALVAGE) 1989 RELATED WITH OIL SPILL IN TURKEY

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1. Introduction

The most significant reason of oil pollution in the seas is the marine accidents that caused or involved by the operation of ships. Those accidents cause harmful effects on the environment irreversibly. Additionally, in most of these accidents, the oil, which is carried as cargo and fuel on ships, is seeped into the sea. Besides, it can be observed that a plenty of states, private entities and the individual ships, which hoists different countries' flags, are responsible for many marine pollution incidents. Oil pollution incident is particularly damaging to more than one coastal state's territorial waters, exclusive economic zone and the interests involved.

Thus, salvage is emerging as a solution, which is caused by shipping accidents in the maritime industry, especially for the prevention of oil pollution in the sea. Even the pollution prevention function of salvage has become a vital mission of salvage services. Over the years, salvages activities have also improved and developed by international protocols. The most important one out of these protocols is The International Convention on Salvage (SALVAGE) 1989. The Convention provides compensation for the marine corporations which taking their role to prevent marine accidents (IMO, 2018). It is also an incentive to them in a sense. SALVAGE 1989 become meaningful in an association especially with CLC 69 Conventions (International Convention on Civil Liability for Oil Pollution Damage) and FUND 92 Conventions (International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage) (Bozabalı, 2011). Because there is a relationship between the salvage operations and the compensation of the damages caused by oil pollution. The "no cure no pay" principle in the 1910 Brussels Convention led to the failure of the parties to perform the salvage action to prevent or reduce environmental pollution properly (Bozabalı, 2011). This situation, especially in the case of oil tankers, increased the pollution of the sea and therefore the responsibility of the ship-owner for this pollution. SALVAGE 1989 has fundamentally changed the principle of "no cure no pay". It has been issued that the saver will entitle for a fee under the name of special compensation which eliminates or minimizes the damage caused by marine pollution, although nothing could have been rescued after the salvage action (IMO, 2018). Although Turkey attended the conference, at which the convention has signed, Turkey did not accept the agreement at the beginning.

Turkey needs to take the necessary precautions to protect the coastline from the busy maritime traffic with a potential risk leading to maritime disaster. Salvage has a particular importance in Turkey, which is located on a significant maritime geography and is sensitive to environmental oil spill especially on the straits, with the increase in maritime traffic. For this reason, SALVAGE 89 is one of the most important international regulations in the Turkish Straits in addition to local practices in environmental protection. Turkey's SALVAGE 1989 laws that enact with reservations was published in the Official Gazette dated May 29, 2013 and entered into force (Official Gazette 28661, 2013).

2. The Role of SALVAGE 89 to Preventing Oil Spills

SALVAGE 89 came into force on 14 July 1996 by the IMO (International Maritime Organization) and replaced the 1910 Brussels Convention. The most important development for the prevention of marine pollution in 1910 Brussels Convention as the basis "no cure, no pay" is the change in principle. According to the new SALVAGE Convention, the definition of damage to inland and marine environment is as follows; "substantial physical damage to human health or to marine life or resources in coastal or inland waters or areas adjacent thereto, caused by pollution, contamination, fire, explosion or similar major incidents" (IMO, 1996). Based on this inclusive definition, the most important feature of the SALVAGE 89, the work done for the prevention of pollution is encouraging in that direction. In particular, Article 14 encourages efforts to minimize or prevent marine pollution without consider the outcome of the salvage operation. In particular, first two clause of Final Act of SALVAGE article 14 Special Compensation (1996) heading on this subject;

- *“If the salvor has carried out salvage operations in respect of a vessel which by itself or its cargo threatened damage to the environment and has failed to earn a reward under article 13 at least equivalent to the special compensation assessable in accordance with this article, he shall be entitled to special compensation from the owner of that vessel equivalent to his expenses as herein defined.*
- *If, in the circumstances set out in paragraph 1, the salvor by his salvage operations has prevented or minimized damage to the environment, the special compensation payable by the owner to the salvor under paragraph 1 may be increased up to a maximum of 30 per cent of the expenses incurred by the salvor. However, the tribunal, if it deems it fair and just to do so and bearing in mind the relevant criteria set out in article 13, paragraph 1, may increase such special compensation further, but in no event shall the total increase be more than 100 per cent of the expenses incurred by the salvor”* (p.6).

The concept of salvage operations includes to assisting a vessel or coastal structures in danger and to prevention function of environmental damage. However this international convention cannot affect regulations of national law and the responsibility of coastal state. According to this, the coastal state has the right to intervene in potential salvage operations in order not to threaten its own shores against the factors that cause environmental pollution such as oil spill. According to Final Act of SALVAGE (1996), for all parties involved in the salvage action, the reward must be sufficient to encourage salvage activities and the following criteria without regard to the order must be as:

“*(a) the salved value of the vessel and other property;*

(b) the skill and efforts of the salvors in preventing or minimizing damage to the environment;

(c) the measure of success obtained by the salvor;

(d) the nature and degree of the danger;

(e) the skill and efforts of the salvors in salving the vessel, other property and life;

(f) the time used and expenses and losses incurred by the salvors;

(g) the risk of liability and other risks run by the salvors or their equipment;

(h) the promptness of the services rendered;

(i) the availability and use of vessels or other equipment intended for salvage operations;

(j) the state of readiness and efficiency of the salvor's equipment and the value thereof ” (p.6).

For this reason, it can be said that SALVAGE 89 encouraged salvage in cases of marine accidents, such as oil spill, which would endanger interests other than the interests of the owner. Savers are rewarded in terms of the risks and current legal circumstances that are experienced in environmental events. This situation has increased the sensitivity of the environment by creating a significant sensitivity to the serious marine accidents.

The negative consequences of releasing large amounts of hazardous or toxic cargo into the environment have now become easier to assess with environmental concerns for marine accidents, that have caused oil spills such as Torrey Canyon (1967) and Exxon Valdez (1989) (Shaw, 1996). These incidents demonstrated the importance of the timely and effective salvage intervention, the role of the salvage action in the oil spill and the protection of the marine environment. In many cases, the prevention of environmental pollution is more important than saving the ship or its cargo. Today, the prevention of environmental pollution in many such incidents is more important than the salvage of the ships or its goods.

3. SALVAGE 89 and Turkey

The first legal responsibility for salvage and aid in Turkey was adopted in Brussels Convention 1910. Turkey became a party to this convention, however, today's heavy marine traffic, increasing oil and hazardous cargo, growing and managing hampered vessels, has led to the emergence of new needs and necessities in the field of salvage (Oğuz and Cerit, 2008). In Turkey experienced serious maritime accidents in recent years on top in terms of how Turkish territorial waters and straits of all these needs has revealed that it is necessary. In order to respond to these new requirement and events, Turkey was adopted The International Convention on Salvage 89 in 2013.

Turkey's environmental sensitivity is increasing with each passing day intensive in the Turkish Straits. In addition, it is obliged to ensure the safe navigation of the vessels by keeping the environment in the foreground. Therefore, the complementary aspects of the convention are also adopted together with the provisions in accordance with the proposal. Among the innovations brought by the accepted system is the abandonment of the distinction between the concepts “salvage” and “aid” arising from the 1910 Convention in the new TCC (Turkish Commercial Code) (Official Gazette 27846, 2011). According to the first article of the SALVAGE 1989 Convention, any assistance to the endangered ship and goods is a “salvage action” 1989 which leads to the implementation of the convention. Therefore, these two concepts are now gathered within the concept of “salvage” (Official Gazette 28661, 2013).

The convention entered into force, coastline pollution that may occur after the incident against Turkey's measures will not prevent proper international law. The accession of Turkey to the Salvage 89 and the reproduction of its articles under the Turkish domestic law, gave significant contributions to this Convention (Bugra, 2015).

The small differences between the TCC and Convention provisions on prohibited services and other contracts may initially appear to be appropriate to the problem. Therefore, these differences lead to theoretical discussions about whether the salvage operation is based on meeting the criteria set out in the Convention. For the purpose of qualifying for a reward, the application of the provisions of both the Convention and the TCC shall give the same result (Bugra, 2015). About this subject, salvage operations controlled by public authorities by Final Act of SALVAGE (1996) are detailed below;

- *“This Convention shall not affect any provisions of national law or any international convention relating to salvage operations by or under the control of public authorities.*
- *Nevertheless, salvors carrying out such salvage operations shall be entitled to avail themselves of the rights and remedies provided for in this Convention in respect of salvage operations.*
- *The extent to which a public authority under a duty to perform salvage operations may avail itself of the rights and remedies provided for in this Convention shall be determined by the law of the State where such authority is situated”* (p.4).

On the other critical point of SALVAGE 89 in Turkey, the most important feature of the contract is that it encourages the work done to prevent pollution. Based on inclusive damage to the environment definition in SALVAGE 89: a serious maritime accident in the law that has been on top of recent years in Turkey, the Turkish territorial waters in terms of how all of these needs have that it is important. In Turkish territorial waters such as “Independenta” (1979), “Nassia” (1994) and “Volganeft 247” (1999) (Kubilay, 2014) have revealed the importance of qualified salvage services and the oil spill as well as the salvage of ships and cargo and prevention of environmental pollution has also become an important necessity. To prevent pollution, salvage or aid that could in Marmara, Aegean and Mediterranean coasts and Turkish Straits against potential disaster, Turkey's participation in SALVAGE 89 it is clear that the benefit to making salvors encouraged. This intervention will show itself especially in the Turkish Strait and possible accident will be prevented further. In addition, it conduces to taking private aid about salvage operation for DGCS (Directorate General of Coastal Safety) as the main responsible enterprise.

The DGCS is responsible for salvage services in the Turkish Straits. The Head of Salvage and Rescue Services Department of DGCS provides salvage services as the main authority in the Turkish Straits with emergency response teams and salvage tugs (DGCS, 2018). DGSC is also responsible for providing the necessary equipment and facilities for pollution prevention and disposal procedures. In order to interfere with possible environmental pollution in ship salvage operations, DGSC has equipment as open sea and port barriers, fire barriers, skimmer, sea slug and barge. However, there are no rescue stations or major rescue facilities for the emergency intervention in the Turkish coastline outside the Straits region.

Figure 1. Area of responsible on Straits of DGCS (EIA, 2018)

According to the area of responsible on Straits of DGCS (Figure 1), DGCS is in charge of the Turkish territorial waters; between the Şile Lighthouse and the Karaburun Lighthouse in the Black Sea, and Turkish territorial waters in the Aegean Sea between Bozcaada and Gökçeada coasts between Bababurnu and Gulf of Saros and between the two borders the Black Sea and the Dardanelles Straits and the Sea of Marmara (DGCS, 2018).

Figure 2. Oil spill response and internal skimmer system (DGCS, 2018)

Ship's Name	*NENE HATUN*
Owner: *DIRECTORATE GENERAL OF COASTAL SAFETY*	
Flag	*TURKEY*
Port Of Registry	*ISTANBUL - 8523*
Call sign	*TCA3371*
Class Notation	*+I +HULL +MACH Fire Fighting Ship 3-water spraying Oil Recovery Ship; Special Service Diving Support Vessel Surface; Standby Rescue Vessel; Unrestricted navigation HEL, AUT-UMS, MON-SHAFT, INWATERSURVEY, DYNAPOS AM/AT R, SDS*
Year Of Built/ Place	*2015 / Yalova*
LOA/ Breadth	*87,8 m / 18 m*

Figure 3. The tug named Nene Hatun of DGCS (DGCS, 2018)

Figure 3 shows that the tug named Nene Hatun of DGCS is one of the most developed salvage tools, to carry out the salvage and relief operations of the ships and cargoes, except for war and auxiliary vessels, and to carry out rescue, relief and rescue operations in all these seas. Figure 2 shows Oil Spill Response and Internal Skimmer System are also inventory of DGCS to prevent environmental pollution (DGCS, 2018).

4. Conclusions

Salvage is emerging as a solution, which is caused by shipping accidents in the maritime industry, especially for the prevention of oil pollution in the sea. SALVAGE 1989 provides compensation for the salvors which taking their role to prevent marine accidents. It is also an incentive to them in a sense. Salvage has a particular importance in Turkey, which is located on a significant maritime geography and is sensitive to environmental oil spill especially on the straits, with the increase in maritime traffic. For this reason, SALVAGE 89 is one of the most important international regulations in the Turkish Straits in addition to local practices in environmental protection. In this sense, it is important that the DGCS, which is responsible for salvage services in the Turkish Straits, has broad authority

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CHAPTER 7

CONVENTIONS COVERING LIABILITY AND COMPENSATION RELATED WITH OIL SPILL

This chapter describes the conventions covering liability and compensation related with oil spill. Oil spill is one of the main concerns of maritime sector globally due to environmental damages, injured or death human and socio-economic effects. This international problem is solved by the IMO with the preparation, adoption, ratification and implementation of the relevant conventions. The mission of IMO has performed safely and effectively in all oceans and seas. The fundamental of IMO's philosophy is clean sea and oceans. IMO is an organization that plays a key role in the protection of clean sea and marine environment- as summarized in the IMO's Mission Statement: Safe, Secure and Efficient Shipping on Clean Oceans". The international maritime industry and trade depend on the safer, cleaner and effective implementation of IMO Conventions to operate efficiently. With these Conventions concerning the sea trade, it is aimed to increase the security of the ships, cargoes and the lives of the people on the ship. The occasional huge spills cause the growth of public expectations for effective spill response and increased spiller liability. Considering this, it becomes an obligation to have complex contingency planning for increasingly rare high-impact events. The tiered system of compensation includes the International Convention on Civil Liability for Oil Pollution Damage (CLC) and the International Oil Pollution Compensation (IOPC) Funds, which collectively provide more coverage than ever before to those affected by oil spills".
The main scopes to create CLC are "to ensure the adequate compensation available for oil pollution damage and establish liability of ship owners that their ships release or discharge oil".

Serap İNCAZ
Özlem ATEŞ DURU

INTERNATIONAL CONVENTION ON CIVIL LIABILITY FOR OIL POLLUTION DAMAGE (CLC), 1969 AND ITS APPLICATIONS

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1. Introduction

The CLC Convention contributes not only to the responsibility of oil pollution, but also to the development of maritime trade. Like other agreements, the CLC convention is a considerable stage in the inhibition of pollution.

Due to sea trade, the seas are contaminated with oil and petroleum products. The responsibility for the harm resulted from oil pollution is determined according to the conditions of the regulation.

The Civil Liability Convention compensates the spill-oil pollution harm, which is caused by the main tankers and is suffered by a state, which signed the Convention with the inclusion of territorial sea.

The cause-effect relationship between the event and the behaviour that causes the responsibility in the law is called liability. This concept is based on the logic of claiming that the damage is incurred. Compensation must be paid for pollution of the sea or the environment. Liability is realized by international conventions on marine pollution. The CLC 1969 convention was the first liability contract for pollution caused by oil. For this reason, in this study, we tried to emphasize proper pollution prevention preparedness and we will discuss "*International Convention on Civil Liability for Oil Pollution Damage (CLC), 1969 and applications of (CLC)*", 1969 related with oil spill in Turkey.

2. Revising the Convention System

Under the protection of the International Maritime Organization (IMO), several regulations have been taken on to address the legal responsibility for damage occurred by oil pollution (Gurumo and Han, 2012). These regulations can be given as follows at Table 1.

Table 1. History of Liability Conventions (Gurumo and Han, 2012).

Name of convention	Explanation of convention
CLC 1969	International Convention on Civil Liability for Oil Pollution Damage of 29 November 1969
CLC 1992	International Maritime Organization Protocol of 1992 to amend the International Convention on Civil Liability for Oil Pollution Damage of 29 November 1969
Fund Convention 1971	International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage of 18 December 1971 (ceased to be in force in 2002)
Fund Convention 1992	International Maritime Organization Protocol of 1992 to amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage of 18 December 1971
Supplementary Fund Convention 2003	Protocol of 2003 to amend the International Convention on the Establishment of an International Fund Compensation for Oil Pollution Damage 1992.
Bunker Convention 2001	International Convention on Civil Liability for Bunker Oil Pollution Damage of 21 March 2001.

3. The Context of CLC 92 Applications

The Torrey Canyon catastrophic accident reasoned the scattering of 120,000 tonnes of crude oil in southern England and northern France and caused great damage to coastal and wildlife.

The main reason for the occurrence of the CLC contract is the Torrey Canyon accident (Figure 1) which is providing solid liability and mandatory insurance for pollution caused by oil. Even though the 1992 CLC-IOPC convention is a coverage regime for oil, the 1992 CLC-IOPC funds are limited only to damage caused by pollution due to persistent oil spill from the tankers. This convention does not include any compensation for non-persistent oil such as seawater, oil-free, non-carbonated or other chemicals (other chemicals, liquefied gases or harmful substances).

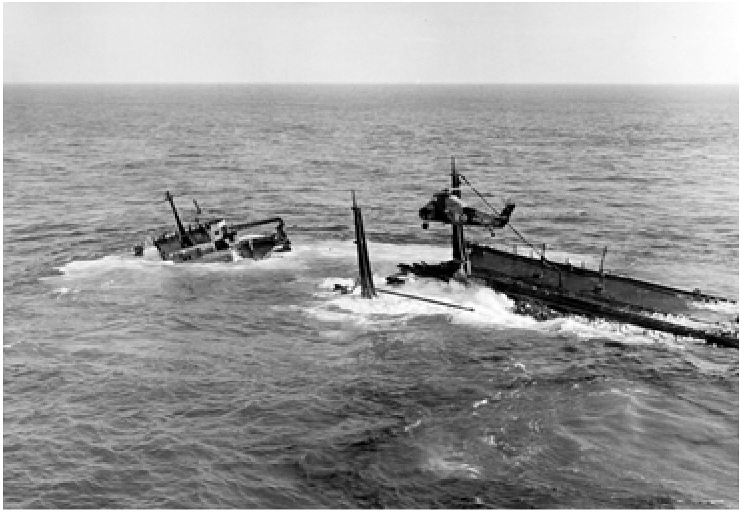

Figure 1. Torrey Canyon accident (www.axfordsabode.org.uk/torreyc11.htm).

1969 CLC Convention was replaced by two protocols in 1992 and the amended conventions are known as the 1992 Convention on Civil Liability and the 1992 Fund Convention. In other words, the 1969 International Convention of Civil accessibility for oil pollution damage, 1969 ('1969 CLC') and the 1971 International Convention on the establishment of an International Fund for oil pollution damage 1971 (1971 Fund convention') have been revised and the 1992 accessibility Conventions (1992 CLC). were put into force.

The 1992 CLC Protocol was put into effect on the 30th of May 1996, with the participation of the nine states, which are Denmark, France, Germany, Japan, Mexico, Norway, Oman, Sweden and the United Kingdom. It also includes the instruments of ratification, approval or acceptance of both protocols (Osuga, 1996).

4. The 2003 Supplementary Fund Protocol

After the 2002 Prestige accident, compensation amounts were demanded to be renewed to make the claims for compensation admissible. Because, this case would be more than the highest amount available under the 1992 CLC and the 1992 Fund Convention (Figure 2). Therefore, the 2003 Supplementary Fund Protocol was taken up to introduce a nonobligatory third level of indemnity to the 1992 CLC and 1992 Fund Convention (UNCTAD, 2012).

Figure 2. Prestige accident (titan.uio.no, 2016 from Wikimedia)

"On the 13th of November 2002, the oil tanker Prestige loaded with 77.000 tons of heavy fuel oil suffered damage in its hull off the coast of Finisterre, Spain, known as the Coast of Death" (titan.uio.no, 2016).

5. The Meaning of Pollution Damage

The parties responsible for the damage are the ship owner, the charterer or the owner of the oil causing the damage. 1969 CLC *also* assumes responsibility for the ship owner that caused the accident at the time of the accident. Subject to some special exceptions, pollution is strictly dependent on the ship owner, where the polluting oil is spilled or emitted (Kiran, 2010).

Damage caused by pollution can be defined under Article 2 of the CLC 1992 as follows:

- *"Loss or damage caused outside the ship by contamination resulting from the escape or discharge of oil from the ship, wherever such escape or discharge may occur, provided that compensation for impairment of the environment other than loss of profit from such impairment shall be limited to costs of reasonable measures of reinstatement actually undertaken or to be undertaken";*
- "*the costs of preventive measures and further loss or damage caused by preventive measures*".

6. Liability

Parties responsible for damage are the ship owner or the charterer or owner of oil and the ship that caused the damage.

7. Limitation of Liability

The responsibility of the ship owner is normally limited under 1992 the Civil Liability Convention. There was an increase in the limits by about 50.37% as of 1st of November 2003. These limits are given as follows Table 2 (IOPC Funds, 2018):

Table 2. Limitation of liability

Ship Tonnage	Limitation of Liability
for a ship not exceeding 5 000 units of gross tonnage	Special Drawing Rights (SDR) 4 510 000 (USD 6.29 million),
for a ship with a tonnage between 5 000 and 140 000 units of tonnage	SDR 4 510 000 (USD 6.29 million) plus SDR 631 (USD 881) for each additional unit of tonnage
for a ship of 140 000 units of tonnage or over	SDR 89 770 000 (USD 125.3 million)

If the damage caused by pollution is proven to be the result of the intentional conduct and negligence of the ship owner, the right to limit the responsibility of the ship owner is eliminated.

8. Geographical Scope

On the basis of geographical terms, the Article II of convention CLC 92 should be applied exclusively as below; (CLC 92, Article II):

> "*To pollution damage caused": "in the territory, including the territorial sea, of a Contracting State; and in the exclusive economic zone of a Contracting State, established in accordance with international law, or, if a Contracting State has not established such a zone, in an area beyond and adjacent to the territorial sea of that State determined by that State in accordance with international law and extending not more than 200 nautical miles from the baselines from which the breadth of its territorial sea is measured*".

> "*To preventive measures, wherever taken, to prevent or minimize such damage*".

Convention's implementation criteria are based on the territory regardless of the claimant's nationality or place of residence. Additionally, pollution which does not occur inside the territorial waters of a contracting state or which occurs in a non-contracting state is not covered by the convention (Farahani, 2011).

9. 2003 Protocol for Supplementary Fund

Main features of the Protocol for Supplementary Fund are given below (Liebert, 21 June 2017):

> "*Pay compensation when damage exceeds, or there is a risk that it will exceed, the applicable limit under 1992 Fund. Maximum compensation 750 million SDR, including amounts payable under 1992 Convention. Contributions from oil receivers in State Parties to Supplementary Fund Protocol. Minimum contribution: 1 million tons of contributing oil are deemed to be received in each State Party Supplementary Fund Protocol"*

10. Member States Regarding the Kind of Conventions

Member states of Liability Conventions are given in Figure 3. According to this, 1992 Fund Convention has 114 member states, 1992 Civil Liability Convention has 136 member states, 2003 Supplementary Fund has 31 member states and 1969 Civil Liability Convention has 34 member states.

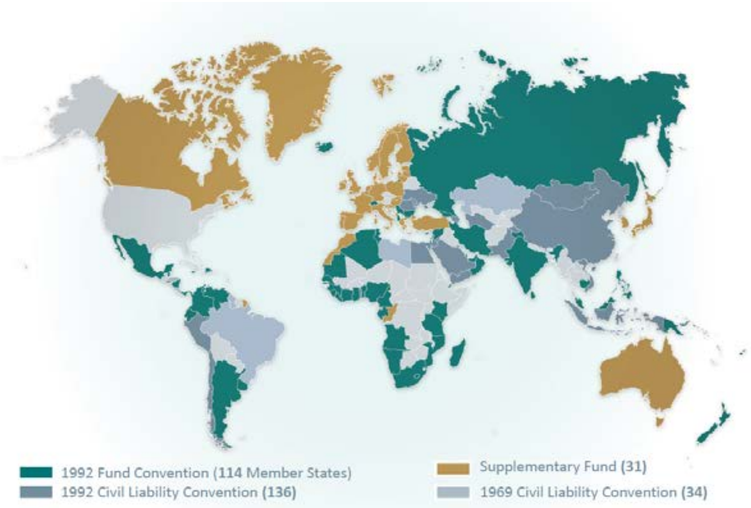

Figure 3. Member States to the kind of Conventions (Liebert, 2017).

11. Compensation of Damage Caused by Oil Spill

Table 3 shows the highest legal limits in force for relevant compensations as well as contracting states.

Table 3. Maximum amounts of compensation available with respect to any one pollution incident (values expressed in million SDR) under different international legal instruments in force and number of Contracting States. Information on Contracting States based on IMO (www.imo.org); SDR exchange rate based on (www.imf.org) from UNCTAD, 2012).

Tanker size **(gt)**	1969 CLC as amended	1992 CLC **(post 2003)**	1992 Fund Conv. (post 2003)	2003 Supp. Fund Protocol
5,000	0, 665	4,510	203	750
10,000	1,33	7,665	203	750
50,000	6,65	32,905	203	750
100,000	13,3	64,455	203	750
140,000	14	89,695	203	750
150,000	14	89,770	203	750
200,000	14	89,770	203	750
Contracting States	37	124	105	27

12. Liability and Compensation for Ship-Source Oil Pollution

A great amount of damage has been made by the oil spills, which were caused by ships. Because of this, international conventions for handling and supervising pollution caused by oil have been put into effect and developed. These are very much to the point and aim to handle each case differently depending on the where the oil spill comes from and what type it is (Table 4). The aim of these conventions is the creation of a combined responsibility system and structures for pollution caused by oil for affected parties.

Table 4. International liability and compensation regime for oil pollution in shipping activities (Yang, 2017).

Year	Convention	Type of Pollution
1969 / 1992	International Convention on Civil Liability for Oil Pollution Damage	Persistent oil pollution
1971	International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage	Persistent oil pollution
1996	International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea	Hazardous and noxious substances
2001	International Convention on Civil Liability for Bunker Oil Pollution Damage	Bunker oil pollution

13. Conclusion

Once the Torrey Canyon incident took place, the necessity for certain conventions for the responsibility and damages for oil spill pollution has been appreciated. The first convention for liability on oil pollution caused by persistent hydrocarbons was CLC 1969 (Gurumo and Han, 2012).

The contract was signed by the IMO on 29th November 1969 to meet the financial responsibility arising from marine pollution caused by oil pollution. According to the convention, in cases of natural disasters (Act of God), war (act of war), and sabotage of third parties, the fund covers the costs incurred after oil spill.

In case of any accidents and the other situations, if the territorial waters are spilled oil by a ship, the damage is compensated by the fund where the insurance is collected. While a large-scale amendment of "the CLC 1969" was in effect until 1992, "the CLC 1992" and the "Fund Convention 1992" were put into practise after this date. The founding of "the CLC 1992" has demonstrated the gravity of maintaining international oil pollution responsibility and the applicability of the compensation system. "Fund Convention 1992" meets damages in cases where the owner of the ship is not responsible for CLC 1992, if the ship owner fails to fully fulfil his financial obligation or exceeds the amount of compensation covered by the damage contract.

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1992 PROTOCOL TO THE INTERNATIONAL CONVENTION ON THE ESTABLISHMENT OF AN INTERNATIONAL FUND FOR COMPENSATION FOR OIL POLLUTION DAMAGE (FUND 1992) AND ITS APPLICATIONS RELATED WITH OIL SPILL IN TURKEY

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1. Introduction

The Torrey Canyon collusion at 1967 was a great source of the law and legal regime of liability related to petroleum chemical pollution in the international arena. CLC, which is stands for Civil Liability Convention, provided a very eligible mechanism for ensuring the payment of compensation for oil and chemical pollution damage at 1969. In addition, it neither deal satisfactorily with all the legal nor financial and other questions raised during the Conference adopting the CLC Convention. At 1971, very important conference held in Brussels that recommended that IMO should prepare such a scheme and the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage was adopted. According to IMO records; "*Fund purposes are consist of to provide compensation for pollution damage to the extent that the protection afforded by the 1969 Civil Liability Convention is inadequate, give relief to shipowners in respect of the additional financial burden imposed on them by the 1969 Civil Liability Convention, such relief being subject to conditions designed to ensure compliance with safety at sea and other conventions, give effect to the related purposes set out in the convention*". The Fund's also obligation to pay compensation is confined to pollution damage suffered in the territories including the territorial sea of all contracting States. Moreover, the Fund is also obliged to pay compensation in respect of measures taken by a Contracting State outside its territory. However, the Fund is not obliged to indemnify the owner if damage is caused by his wilful misconduct or if the accident was caused, even partially, because the ship did not comply with certain international conventions. The Convention contains provisions on the procedure for claims, rights and obligations, and jurisdiction. The main point that, contributions to the Fund should be made by all persons who receive oil by sea in Contracting States. The International Convention on the establishment of FUND, was adoption at December 18th, 1971. In addition, entry into force was at October 16th, 1978. Besides this information, it was superseded by 1992 Protocol. This protocol was adoption November 27th, 1992 and entry force were at May 30th, 1996.

2. Legal Responsibility and Related International Convention on the Petroleum Pollution Date of 1992

Nowadays, the Torrey Canyon collusion is great source of the legal status about chemical contamination related to petroleum pollution in the international arena (Ling Zhu, 2007).

Any legal arrangements and enforcements to compensate for the pollution brought by the oilrig's accidents until the time it took shape in 1967 by the Torrey Canyon. Before 1967, all the companies and persons were responsible, if any collusion or oil spill were happened coastline of any countries or territorial water of any countries. The greater impact happened due to the larger oil spills. The responsible of the spilled who was not only damaged but also charged of the cleaning operations. All situations had changed after Torrey Canyon disaster. The new developments have emerged in terms of pollution resulting from the oil accident and legal liability and fund conventions after Torrey Canyon disaster. By the Torrey Canyon which was the famous disaster known by worldwide, more attention has been paid to oil accidents and concrete steps have been taken to account for the subsequent environmental disasters. If the checked all international legal regulations, there was no agreement in this matter to compensate the damage of the parties. In this case, a great injustice and unlawful circumstances arise.

3. The Importance of M/T Torrey Canyon disaster and Convention 92

The Torrey Canyon, a tanker of Liberian flagged, 123,000 gross tonnes, hit the Seven Stones rocks near the Land Off coast as it headed towards England with about 119,000 tons of oils, which loaded from the Kuwait at the 18 March 1967. Torrey Canyon had sunk from the stern and spilled oil slowly (Figure 1). Pollution had been reaching England's Cornwall coastline and Sicily islands, pollution was noticed after 2 days the other coastline. Nearly 100000 tons of oil spilled and it was great disaster of this coastline and world marine pollution history. More than 20000 sea birds have been died.

Figure 1. Torrey Canyon disaster at 1967.

After the accident, the number of sea creatures could not be determined. Tried to dilute the petroleum by intervening with 1000 tons detergent. Due to this operation, nearly 20.000 tons petroleum under control. At the end, Torrey Canyon split into two parts and contamination could not control. Then, the British Navy decided to destroy the tanker. Some spilled oil had been removed, but significant amount of them had reached the British coastline. Some of the British and France coastline especially touristic areas were affected from pollution.

Torrey Canyon, which was considered as the biggest accident that ever happened, had been exposed to oil pollution about 180 kilometres of coastline. End of disaster, it has been disarrayed for both Britain and France. In addition, a large part of the marine population, sea creatures have also disappeared. (Lee, 2010).

Many legal problems have arisen both public and private law regarding damage of petroleum pollution after disaster. Since the damage is large, this process has been brought various challenges to the agenda. After disaster many plaintiffs of disaster, demanded that the damage be resolved.

Liberian flagged tanker M/T Torrey and the Barracuda Tanker Company located at the Bermuda Islands. The tanker has been assigned to the American petroleum company by the time charter contract. However, during the disaster, Torrey Canyon has been assigned Voyage charter with British Oil Company.

As mentioned above, most of the pollution damage has come to the British coastline, but France also suffered considerable damage.

The company was seen in the Barracuda Islands. This situation possess kind a problem for the company's foreclosures. On the other hand, there was another question in the proceedings; the company executives were in USA. There was a detail was a ship flag. The ship was Liberian flagged and this situation was great problem for arresting and taking under control. Liberia was in easy flag implementation. In addition, this flag was not involved in many international agreements. In addition, Torrey Canyon Company was leased on time charter to another company. With this agreement, the technical and commercial responsibilities were shared between charterer and owner. Same time, the tanker was rented to another company by voyage charter while it was still under during the time charter agreement. In this case, all responsibilities transferred to the new charterer. By this situation, it was difficult to determine the extent to which responsible for pollution. Because of this accident, studies have been initiated for the abolition of deficiencies in international law.

Torrey Canyon accident was a milestone in responsibility for oil pollution as it increases the environmental awareness and thus creation of the current international regime through IMCO. By the Torrey Canyon, the British government called for duty on the IIMCO to regulate of responsibility for oil pollution (Healy, 2010).

The IMCO council had agreed to work on this issue and two working groups have been formed accordingly. First working group has been tasked with addressing similar public law issues which including the right to intervene in the offshore events, particularly in the open sea where the costal state was at risk of pollution. The other working group has been tasked with assessing matters of private law, such as liability for pollution damage and compensation.

4. Preparation of the Convention 92 and Transition to Action

After Torrey Canyon accident, a conference about oil pollution was held in the city of Brussels in 1969. In the conference, all the problems of the both public and private law were discussed in order to meet the damage that occurred in accident. Results of the conference, International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (INTERVENTION) and International Convention on Civil Liability for Oil Pollution Damage (CLC) conventions were prepared.

CLC was adoption at 29 November 1969. In addition, it was entry into legal force at 19 June 1975. With time and technological development effects, it needed a replacement by the 1992 Protocol. It was adoption at 27 November 1992. In addition, it was entry into legal force at 30 May 1996(6). CLC is also backbone of oil pollution liability regime accepted by most of the countries (Soyer, 2012).

At the Brussels conference in 1969, the most debated issue was who belonged to oil pollution. While some of the delegates participating in the conference supported the responsibility of fault, which replaced the burden of proof, the other delegates wanted to accept flawless responsibility. According to this situation, the first group was supposed to be liable if the ship-owner was defective. This was in favour of the ship-owner when the ship-owners took every precaution and were not responsible for the accident. On the other hand, the ship-owner still would be responsible for the ship-owner in the event of an accident, even if he took all kinds of precautions. Although both sides are right at their own right, the compensation of the petroleum pollution and the meeting of the expenditures made were the most important questions.

Consequently, it was considered a strict liability regime, which made possible the escape responsibility in some exceptional cases (Abecassis et al., 1985).

In accordance with this regime, even if the charterers of the ship do not have any fault, like an example that collusion between a tanker and a ship are in collusion and cause of the pollution, the ship could be responsible.

Nowadays, it is considered normal for responsibility for pollution damage to be subject to perfect responsibility, but in 1969, the adoption of the principle of perfect responsibility was perceived as a great innovation. Over the years, thanks to the impeccable liability regime, the costs of determining the defects of the lawsuits applied by the Convention and the resolution of the proceedings have been resolved without delay (Soyer and Tettenborn, 2012).

Basically, CLC is based on strict liability, liability only directing the ship to the registered owner, limitation of liability and compulsory insurance elements (Soyer, Tettenborn, 2012).

The international regime that regulates the responsibility for the chemical pollution's equipment consists of the International Covenants on the Legal Responsibility of the Oil Pollution Dam of 1969 and 1992. This regime has been adopted globally and has been made part of domestic law by some States (Soyer, 2012).

Both in 1971 and 1992, The Fund became an international organization, and centred London, UK.

These Funds were financed by fees collected in the form of taxes or drawings from petroleum buyers located in the States Parties. These funds are to provide additional compensation in respect of damages, which could not be completely remedied under the main purpose of the legal liability agreements (Jacobsson, 2007).

Protocol to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND 1992) provide a two-stage compensation system (Soyer, 2012).

Accordingly, the ship-owner is held responsible for the extent of the damage of oil pollution up to the limits determined in accordance with FUND 1992. If the damage exceeds these limits, the oil industry is responsible for the rest. This system ensures that adequate compensation can be provided to the harmed part of petroleum pollution at a reasonable speed, without delay and dispute (Soyer, Tettenborn, 2012).

CLC has two goals, first one was adequate compensation for those who are injured in these cases, and the second was to prescribe uniform rules of accountability and procedures (Wu, 1996).

After convention, March 16th 1978 M/T Amoco Cadiz which Liberia flagged, spilled 223000 tons petroleum to the French coastline. Short after, March 7th 198, M/T Tanio splitted into two pieces due to weather condition. Spilled more than 13500 tons petroleum to the French coastline. After these accidents, it is once again seen that the limits of responsibility stated by international agreements are inadequate in terms of accidents leading to significant damage.

The 1992 Convention has been widely accepted and enforced by many contracting states government in the field of international law, due to its compensation rights. With this convention, the contracting states were taking measures against a major oil pollution that could happen on their own shores.

From the IMO achieve, as of July 10th 2014, there are 133 State Parties to the CLC of 1992; and the filings in these States constitute 96.7% of the entire world trade fleet. The Fund Convention in 1992 has already become a party to 114 States, and the filings in these States constitute 94.16% of the entire world trade fleet.

5. Scope of the Convention 92 and Applied Field

By implement the convention under the CLC, cause of the pollution is petroleum source and this oil source must come from a tanker. This convention will not be valid if oil spillage or disintegration occurs on a ship outside the oil tanker. When the convention is considered, it is necessary for a state party to the Petroleum Pollution Legal Liability Convention to enter the coastal zone or within the borders of the exclusive economic zone. In this case, if the government has not accepted convention, rules could not be applied. In addition, government are leading the party to be in favour of this convention so that the damage can be covered in the event of any possible oil and chemical pollution.

The Convention shall enter into force in each nation's territorial waters of the contracting governments. Therefore, each country territorial waters should be determined. There is no definite written rule for the determination of the territorial waters limitation of countries. It was expressed with UNCLOS (United Nations Convention on the Law of the Sea) at 10 December 1982. It was generally mentioned as 12 NM (nautical miles) from the territorial waters of all the countries. Many countries have been entered this convention into their national legislation.

On the other hand, it should be emphasized that even if a maritime accident causing pollution damage occurs in the open sea, the Convention will be applicable. However, this will arise since the pollution damage because of the incident in the open sea occurs in the territorial waters of countries or its exclusive economic zone. The Torrey Canyon accident has also begun in the open sea, but oil pollution has emerged in the territorial waters of France and England and in its exclusive economic zones (Lee, 2010).

The definition contained in the agreement refers to ships and marine vessels. Therefore, inland waterway vessels operating in lakes and rivers, located offshore installations, fixed and floating oil platforms and oil pipelines. Therefore, CLC was outside of the scope of application. In this respect, it would not be wrong to say that CLC is essentially a tanker agreement (Ünan, 1987).

According to IMO definition; this does not apply to warships or other vessels owned or operated by a State and used for the time being for Government non-commercial service. The Convention, however, applies in respect of the liability and jurisdiction provisions, to ships owned by a State and used for commercial purposes. The only exception as regards such ships is that they are not required to carry insurance. Instead, they must carry a certificate issued by the appropriate authority of the State of their registry stating that the ship's liability under the Convention is covered. In the convention, at article 11 determined which vessels were excluded from the application. Accordingly, Naval Forces ships and other non-commercial ships dedicated exclusively to public service are excluded from the scope of international agreements. However, public administration's vessels allocated for commercial purposes were in the field of application. In fact, the vessels that were engaged in commercial activities of the government could not benefit from the judicial immunity (Lee, 2010).

Definition from IMO that; the Convention covers pollution damage resulting from spills of persistent oils suffered in the territory (including the territorial sea) of a State Party to the Convention. It is applicable to ships carrying oil in bulk as cargo, i.e. generally laden tankers. Spills from tankers in ballast neither bunker spills from ships other than tankers are not covered, nor is it possible to recover costs when preventive measures are so successful that no actual spill occurs. The ship-owner cannot limit liability if the incident occurred because of the owner's personal fault.

The Protocol also extended the Convention and with its legal status to cover spills from sea-going vessels constructed or adapted to carry oil in bulk as cargo so that it applies apply to both laden and unladen tankers, including spills of bunker oil from such ships. To be compensated some conditions have to be fulfilled caused from damages. Primarily, it should come to the fore because of oil pollution except for the ship. It is also necessary for the pollution to occur when the oil is leaked or released from the ship (Kender, 1983).

The right to claim damages under the convention was not recognized by the loading part concerned. Likewise, the measures for cleaning the oil pollution should be taken except ship. The costs of cleaning were not included if the body of the ship is exposed to pollution (Lee, 2010).

The event referred from CLC was an unusual situation or an accident that happened to the ship during the voyage. For example, the collusion or landing were usual conditions. In addition, usual conditions of the vessels were not in considered (Kender, 1983).

As a result, arguably the measures taken after the oil spill occurred would be compensated from the convention. However, the situation would be different if there was a danger of such pollution occurring before oil pollution occurs. From convention of 1969, if a tanker landed on the ground, the measures taken to prevent the danger of pollution in the territorial waters of the government were excluded if petroleum pollution occurs. From the 1992 Agreement, if the danger of an imminent and serious danger of such reasonable measures taken to prevent such a threat would be compensated accepts the scope of pollution damage. (Lee, 2010)

The damage caused by the preventive measures in accordance with the convention was also compensated by the pollution damage (Abecassis, 1978).

In addition, any restriction order to compensate the losses caused by contamination from another fire prevention is not provided, the damage caused by explosions or diluents and the like which are used for other reasons can be compensated under the convention (Lee, 2010).

CLC was applied to pollution cases arising from petroleum carried as cargo or fuel. CLC were intended to be issued only when preparing the oil carried as a load of pollution. However, this distinction has been abandoned, considering the difficulty of practically detecting whether oil leaking into the sea is transported as petroleum, or as using by ship (Lee, 2010).

Article 3/f.1 of CLC, it was necessary to cause the pollution damage of permanent petroleum leaked or released from a vessel entering within the application of the convention because of the incident (Kender, 2004).

The owner of the property (who was the control operation either owner or charterer) on the date when the incident causing the pollution damage becomes the case is held responsible (Çetingil, 1983).

However, it has been adopted that the responsibility of oil and chemical contamination would be complemented by fund, which would be funded by chemical companies, since it would be contrary to the right of the ship owner to bear all this responsibility (Lee, 2010).

Even if there was a malfunction of the seafarers or captain of a pollution damage to which the convention might be applicable, the liability should be determined only in accordance with the convention and might be directed only to the property and its insurer or financial guarantors (Abecassis, 1985).

6. Compulsory Responsibility Insurance or Financial from 92 Convention

Petroleum-derived marine contamination is predominantly caused by the accident of ships carrying oil. If the ship or transportation operated by the charterer, then it is even more difficult to get compensation for the parties who have suffered due to the accident.

The company that operates the ship may not have enough financial power to meet the loss of the company alone. In this case, it can cause the victimization of those who have been wounded due to the accident to continue. 92 Convention obligates oil tanker owners and operators to take out compulsory liability insurance or to provide a similar financial guarantee. Thus, arises the right to sue the personnel who has suffered damage in the event of damage.

The ship-owner registered in a Contracting State and carrying more than 2,000 tons of oil in bulk as cargo shall be required to maintain insurance or other financial security, such as the guarantee of a bank or a certificate delivered by an international compensation fund, in the sums fixed by applying the limits of liability prescribed in Article V, paragraph 1 to cover his liability for pollution damage under this Convention.

Nevertheless, in practice, it is observed that the owners of the ship often insure and insure their responsibilities (Kender, 2004).

The international liability and compensation regime, created by the 1992 Civil Liability and Fund Conventions, was intended to ensure an appropriate proportion of the economic consequences of marine oil spills from tankers between the shipping and oil industries. In order to address the imbalance created by the establishment of the

Supplementary Fund, which will be financed by the oil industry, the International Group of P&I Clubs.

The reasonable measures costs taken to minimize or avoid such danger, and the liability arising from any kind of accident or damage caused by these measures, shall be borne by club guarantee. In addition, if oil is leaked from the tanker registered in the club, or if the member of the club is wounded in the same way, this damage is also compensated within the scope of insurance coverage (20).

While the Convention applies to financial guarantees such as certificates issued by any bank guarantee or international compensation fund, very few of the ship-owners apply to these options, usually under club insurance, to ensure this responsibility. (Anderson, 1998)

Subject to the provisions of this Article, each Contracting State shall ensure, under its national legislation, that insurance or other security to the extent specified in paragraph 1 of this Article is in force in respect of any ship, wherever registered, entering or leaving a port in its territory, or arriving at or leaving an off-shore terminal in its territorial sea, if the ship actually carries more than 2,000 tons of oil in bulk as cargo. Subjects to the provisions of this Article 7 and part 11, each Contracting State shall ensure, under its national legislation, that insurance or other security to the extent specified in paragraph 1 of this Article is in force in respect of any ship, wherever registered, entering or leaving a port in its territory, or arriving at or leaving an off-shore terminal in its territorial sea, if the ship actually carries more than 2,000 tons of oil in bulk as cargo (Soyer and Tettenborn, 2012).

Any sums provided by insurance or by other financial security maintained in accordance with paragraph 1 of this Article shall be available exclusively for the satisfaction of claims under this Convention (Kender, 2004).

The obligation to keep the certificate relating to the assurance in respect of the vessels falling within the scopes of all applications of the legal status and the content of the said certificate shall be in accordance with CLC article 7 / f. 2 provision (Jacobsson, 2007).

This certificate must be approved by the State where the register is registered, or if it is understood that the conditions have been fulfilled (Kender, 1983).

Any claim for compensation for pollution damage may be brought directly against the insurer or other person providing financial security for the owner’s liability for pollution damage. In such case, even if the owner is not entitled to limit his liability according to Article V, Paragraph 2, the defendant may avail himself of the limits of liability prescribed in Article V, paragraph 1. He may further avail himself of the defences (other than the bankruptcy or winding up of the owner) which the owner himself would have been entitled to invoke. Furthermore, the defendant may avail himself of the defence that the pollution damage resulted from the wilful misconduct of the owner himself, but the defendant shall not avail himself of any other defence, which he might have been entitled to invoke in proceedings brought by the owner against him. The defendant shall in any event have the right to require the owner to be joined in the proceedings (Kender, 1983).

7. Implementation of CLC in Accordance with Turkish National Law

There were two basics amenities' for preparing legislation number of 5312. The first objective is that current environmental legislation is insufficient in preventing and compensating for petroleum pollution from ships. Therefore, in 2000 the Ministry of Environment and the Coastal Maritime Affairs has prepared a new legislation by the Police General Directorate. Due to political developments, legal regulation was completed on 21/07/2004 and enacted on 03/05/2005.

The second main objective was the preparation of the application of Law No. 5312 European Union standards in the context of harmonization with the European Union.

By law number of 5312, is to determine the safety of marine origin and rights arising from international and national law for the prevention of environmental contamination and responsibility. It is also aimed to prevent the pollution caused by the vessels, to determine and compensate damages after the accident, to determine the powers and responsibilities of the parties involved in the accident.

Law 5312 encompasses ships carrying petroleum vessels and other hazardous materials at capacity of 500 gross tons and over. There is no exact definition about the tank, and the oil tanker statement is used. According to the law warships, auxiliary warships with ship operated for non-commercial activities, which are excluded from state-owned or operated by the application.

Limitations area in the law of the sea area consist of Turkey's internal and territorial waters, country's continental shelf and exclusive economic zone are valid.

In addition, open seas beyond the territorial waters can be covered by taking the opinions of the relevant public institutions and establishments in order to prevent them from intervening in case of emergency and compensating the existing damages. According to the 1992 Convention, the scope of intervention in open seas beyond the territorial waters, which are not specified in addition to the scope of Law no. 5312, has been limited to 200 nautical miles.

According to the law, the precautions taken prior to the incident are out of scope. In this regard, the vessels need to take adequate measures. What should be the intervention and protective measures is defined after the incident has occurred. According to the 92 convention, the measures and measures to be taken are to prevent the occurrence of accidents or to reduce the effect of the harm to the minimum level if an accident occurs.

There is oil, fuel, sludge, refined petroleum products and liquid hydrocarbons extracted from underground, including the loads specified in the MARPOL 73/78 convention for cargo carried in its cargo. The 92 convention includes permanent hydrocarbon minerals such as petroleum, cargo or crude oil, fuel oil, heavy oils and grease in fuel tanks. When the 92 convention is compared with the law, differences are observed.

There is a definition of ships carrying petroleum and other harmful substances while defining the vessels in the law. The vessels carrying other harmful substances are not included in the definition of the 92 convention. There is no requirement that a ship in the 92 convention will carry petroleum and its derivatives that cause permanent pollution if the accident occurs.

Parties responsible for accidents within the scope of the Law are those who are responsible for accidents occurring after the event or for damages caused by accidental deaths and injuries from the damages caused by pollution caused by the incident or from the expense of the protective measures, the damages caused by marine life, the correction of the polluted area, income losses and other public damages.

The law is held jointly responsible for the damages of two or more gates from accidents involving all the ships, and the parties responsible for all the vessels. In the case of the 92 convention, only the owners of the ship are liable for the damage resulting from the pollution. Under the law, ship-owners, owners, captains, administrators, tenants, accountants and guarantors are jointly held liable. Under the 92 convention, the compensation fund is established to limit the responsibility of the owners of the ship. When this fund is created, insurance, financial guarantee, guarantor will be determined. In any case, it will not be able to open a claim for damages to any party other than the insurer and the owner.

Turkey is a party that determined they do not have to guarantee financial obligations stipulated in international conventions, foreign-flagged ships in the scope of 5312, rescue services except Turkish territorial waters in order to stop the Turkish iron points or ports other than the internal waters or inland waters and not allowed to enter the inland waters. They will be removed within 30 days if they are detected. Turkish flagged vessels, which do not comply with the conditions according to the law, are tied up to the conditions and removed from the flights.

The loading of in this case, is transferred to another ship with the owner of the ship or the cargo, or the cargoes are removed according to the legislation.

The ships entering the application area, which are according to law, conventions to which Turkey is a party in the warning, should have the financial responsibility documents required from them, and they must be reported to the relevant authorities. Vessels without the necessary documents are not allowed to enter Turkish territorial waters. It is checked whether the vessels to enter or operate the port and the innocent passage vessels are valid CLC certificates.

According to the law, a commission is established for the determination of damages of a pollution coming to the all scene. This commission is formed by representatives of the relevant institutions.

If it is necessary, may invite the representatives and experts of other institutions to the commission. The commission may carry out the damage to the Turkish or foreign institutions to determine the damage after the accident. The amount of damage determined is valid for approval by the commission. This situation is incompatible with the 92 convention. In 92 conventions, the amount requested for damages is decided by the authorized institutions. In this case, the incompatibility between the international indemnification system and the national indemnification system arises. At the same time, this may lead to non-compliance in the legal area.

In accordance with the law, the ministry responsible for maritime has been authorized to pay damages determined by the commission of losses incurred. According to the 92 conventions, this task is performed by the fund institutions.

The law assesses sea pollution at three levels because of sea accidents. When the accident occurred, according to law, of which Turkey is a party in the convention reference is made to award damages to compensate conditions. It is emphasized that the subject conventions will be valid in the payment of fees and assessments and indemnity payments. Thus, in case of an accident occurring in the territorial waters of Turkey in the international arena shows that under the protection of the rights of foreign-flagged vessels.

8. Conclusions

Hundreds of ships pass every day in to Turkish territorial sea and Turkish Strait sea area. A significant part of these vessels is carrying crude oil and petroleum products. In this case, it carries big risks for Turkey's territorial waters and shores. Therefore, Turkey is to bring the requirements of the Law No. 5312 side that agreement and replacing it with great seriousness. Another important issue is that Turkey is a party supply convention with legal regulations and necessary controls. Eliminating any risk of an accident with possible serious and strict inspection be made by Turkey should reduce the number of accidents. Accident risks will be eliminated from the very beginning, leading to costly cleaning operations and advanced economic losses. To ensure this, the international treaties that are part of the Law no. 5312 should be treated more seriously and more strict regulations should be adopted.

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INTERNATIONAL CONVENTION ON LIABILITY AND COMPENSATION FOR DAMAGE IN CONNECTION WITH THE CARRIAGE OF HAZARDOUS AND NOXIOUS SUBSTANCES BY SEA (HNS), 1996 (AND ITS 2010 PROTOCOL) AND ITS APPLICATIONS RELATED WITH OIL SPILL IN TURKEY

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1. Introduction

In general, water has no boundaries and seas are beyond state desires of absolute sovereignty. Oil spill is one such area that exceeds the State capability of an individual state. This creates the international conventions and several protocols in order to make a mutual protection system and compensation regime worldwide.

Besides oil, hazardous and noxious substances ("HNS") are also dangerous substances for the environment and due to the reason of the international carriage of these goods by vessels, it becomes more and more important to deal with and to protect the environment. The protection dated back quite old times, there were several attempts to make a mutual and well-working protection system.

In order to add the liability and protection system of the hazardous and noxious substances to the international conventions, in 1996 "The International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea 1996 and its 2010 Protocol" (the consolidated version, all together the ("HNS Convention") has been adopted during the international conference and then an additional protocol has been prepared in 2010. These two conventions are known as HNS Convention and are also referred as HNS Convention in this chapter. Although the convention is not come into force yet, the importance is very well known and the attemps of having it ratified by relevant number of states are ongoing.

2. Historical Background

"The United Nations Convention of Law of the Sea dated 1982" ("UNCLOS") is a basic convention which includes some clauses referring to the pollution and compensation regime. The most important about UNCLOS was the negotiation period that brought the attention of International Maritime Organization ("IMO") to start preparation of "Civil Liability Convention, the 1992 Protocol" ("CLC") and "Fund Convention". These two important conventions then came into force and accepted broadly by this attempt of IMO.

As regards to the pollution, protection and compensation, the first convention is "The International Convention for the Prevention of Pollution from Ships 73/78" ("MARPOL") but before that, the first attempt was in 1954 during the International Conference held in England and "International Convention for the Prevention of Pollution of the Sea by Oil" ("OILPOL") which is the ancestor of MARPOL 73/78, came into force. OILPOL was then amended in 1962 and 1969.

Then in 1990, "The International Convention on Oil Pollution, Preparedness, Response and Co-operation" ("OPRC"), has been ratified by many countries. As per Article 10[i] of OPRC, IMO has been invited to work on to include hazardous and noxious substances to the convention. After 10 years, "The Protocol of Preparedness, Response and Operation to Pollution Incidents by Hazardous and Noxious Substances" has been signed in 2000. ("OPRC HNS")

Apart from the several conventions that are mentioned above, regarding the compensation because of oil pollution, "The International Oil Pollution Compensation Funds" ("IOPC Funds") include three organisations between states ("1976 Fund, the 1992 Fund and the 2003 Supplementary Fund") which cover the compensation regime for "*oil pollution damage resulting from spills of persistent oil from tankers*".

Compensation is payable in accordance with two international conventions. "The International Convention on Civil Liability for Oil Pollution Damage, 1969" and being replaced by 1992 Protocol, entered into force 30th May 1996 (Civil Liability Convention "CLC") and "The International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage" dated 1971 and then its Protocols dated 1992 and 2003 ("Fund Convention") known as the new regime.

The CLC provides; "*A first part of compensation, which is paid by the owner of a ship that causes the pollution damage. It puts down the principle of strict liability for ship owners and provides a system of compulsory liability insurance. The Fund Convention provides a second part of compensation, which is financed by oil importers in Member States who have imported, by sea, more than 150,000 tonnes of oil in the previous calendar year. The size of annual additives varies according to the amount of oil and the number and size of claims settled in any one year. Claims arising out of a cost effective incident can raise the contribution required in any given year*" (Kuyucu, 2017, s.318)

The International Conventions and related supplementary measures are taken on international level, mostly and mainly after the disasters had happened such as the Erika Incident (Erika West of France, 1999) was effective on the adoption of the Supplementary Fund by the International Maritime Organisation in May 2003. This provides an extra layer of protection and compensation.

In one hand, the above conventions and fund conventions, together with all attempts to have a mutual and strong protection worldwide, are all about oil and oil pollution. On the other hand, the transport of hazardous and noxious substances by sea is an important trade that there is a need for a specific convention and compensation regime, which was missing until the establishment of HNS Convention. Chemicals and other products support many manufacturing processes and IMO regulations ensure their safe transport so far. However, incidents do happen and "*The International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea 1996 and its 2010 Protocol is the last piece in the puzzle needed to ensure that those, who have suffered damage, have access to a comprehensive and international liability and compensation regime*" (Güneyli, 2012, s.210).

3. HNS Convention

The HNS Convention covers the liability for damage related to the carriage of hazardous and noxious substances by sea. These substances are defined as per the references to existing list of hazardous substances in IMO conventions and codes.

The geographical application within the scope of the HNS Convention is explained in Art. 3.2 including territorial waters, continental shelf and exclusive economic zone**.** Damage is defined in Art. 1.6. The HNS Convention defines damage, in difference from the other conventions which makes it specific in this way by including "loss of life or personal injury, loss of or damage to property outside the ship carrying HNS substances, loss or damage by contamination of the environment, and the costs of preventive measures as well as further loss or damage caused by them". (The HNS Convention and its 2010 Protocol, Loss of life, 2018)

The HNS Convention is based on a very successful model of the CLC and Fund Conventions, which both cover pollution damage caused by spills of persistent oil from tankers. The model and specific need of the Convention was first brought into discussion and then incorporated by an international conference in 1996. As with the original oil-pollution compensation regime, "*the HNS Convention will establish a system for compensation in two separate parts to be paid in the event of accidents at sea, in this case, involving hazardous and noxious substances such as chemicals*".

The most important fact about the convention is that *"it covers pollution damage but also the risks such as fire and explosion, including loss of life or personal injury as well as loss of or damage to property"*, which makes the convention to differ in that way as well from the previous conventions.

The explanation of the two-part system for compensation is as following;

- *"Part one will be covered by compulsory insurance taken out by shipowners, who would be able to limit their liability".*
- *"Part two will be paid from a fund, made up of contributions from the receivers of HNS Convention. Contributions will be calculated according to the amount of HNS Convention received in each party in the preceding calendar year.* (The HNS Convention and the 2010 Protocol, The explanation of, 2018)*"*.

The Convention brings strict liability for the shipowner and a system of compulsory insurance and insurance certificates.

The Convention does not apply to claims that are related to the claims which may occur within the scope of a contract for the carriage of goods and/or passangers and damages related to the pollution which are outlined in the CLC or to damage caused by radioactive materials of class 7 defined on Art. 4/3 (b) of the HNS Convention. The HNS Convention in one hand strengthens the protection regime of the claimants in several important ways. On the other hand, it also introduces "*strict liability for the shipowner, provides higher limits of liability than the present regimes, and a system of compulsory insurance or other financial security and insurance certificates. If the damage more than the limits of the shipowner's, than it brings the result of financial incapability of the shipowner of meeting the obligations under the HNS Convention, or there is no liability regarding damage arises for the shipowner, the claimant may get the compensation from* *the International Hazardous and Noxious Substances Fund (HNS Fund)."* Compensation will be paid from the HNS Fund up to a maximum amount which is stated pursuant to the Convention including compensation paid by the shipowner/insurer.

As stated above, the HNS Convention approaches the international oil pollution conventions, which is a consistent and competent international regime for compensating injured parties for oil pollution damage which a system that has functioned very well so far. Therefore, the success of the HNS Fund system will very much depend upon administrative simplicity, as well as the need of compensation paid although its complex issues regarding the definition of the hazardous and noxious substances.

Although all attempts of the international bodies, by 2018, the 1996 HNS convention and its 2010 Protocol had still not entered into force, due to an insufficient number of ratifications. Another international conference in 2010 was adopted a Protocol to the HNS convention (HNS Protocol 2010) that was addressing practical problems that had prevented many States from ratifying the original Convention.

When the 2010 HNS Protocol enters into force, the 1996 Convention, as amended by the 2010 Protocol, will be called "The International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea, 2010".

The HNS Convention establishes the principle that "*the payment will be made by the polluting party and ensures that the shipping and HNS industries provide compensation for those who have suffered loss or damage resulting from a HNS incident. The shipping, oil, gas, chemical, petrochemical and other HNS industries are committed to pay such compensation through an international system which is covered and provided by the HNS Convention and also benefits all State Parties by establishing a system of strict liability and clear claims criteria.*"

The reason that the 2010 HNS Convention has still not entered into force yet is the requirement of at least 12 states must ratify the convention including "*four States each with not less than 2 million units of gross tonnage and having received during the preceding calendar year a total quantity of at least 40 million tonnes of cargo that would be contributing to the general account* (The HNS Convention and its 2010 Protocol, Four States each, 2018)".

Turkey has ratified the HNS Convention on 23rd.April 2018 together with Canada, and then recently Denmark has ratified the HNS Convention. Currently, four states have ratified the HNS Convention; Norway, Canada, Turkey and Denmark.

4. Hazardous and Noxious Substances ("HNS")

"*Hazardous and noxious substances*" within the context of HNS Convention and other conventions and Codes mean, "*Any substances, materials and articles carried on board a ship as cargo, referred to oils, carried in bulk, as defined in regulation 1 of Annex I to the MARPOL 1973, as modified by the Protocol of 1978 relating thereto, then as amended, noxious liquid substances, carried in bulk, as defined in regulation 1.10 of Annex II to the MARPOL 73/78, as amended*" (HNS Convention Implementation, Any substances, materials, 2018)

"*Those substances and mixtures provisionally categorized as falling in pollution category X, Y or Z in accordance with regulation 6.3 of the said Annex II, which are,* *dangerous liquid substances carried in bulk listed in chapter 17 of the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk, as amended, and the dangerous products for which the preliminary suitable conditions for the carriage have been prescribed by the Administration and port administrations, dangerous, hazardous and harmful substances, materials and articles in packaged form covered by the International Maritime Dangerous Goods Code, as defined, liquefied gases as listed in chapter 19 of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk and the products for which preliminary suitable conditions for the carriage have been prescribed by the Administration and port administrations involved in accordance with paragraph 1.1.6 of the Code, liquid substances carried in bulk with a flashpoint not exceeding 60°C, solid bulk materials possessing chemical hazards covered by the International Maritime Solid Bulk Cargoes Code, as amended, to the extent that these substances are also subject to the provisions of the International Maritime Dangerous Goods Code in effect in 1996, when carried in packaged form and residues from the previous carriage in bulk of substances*" (Guide on Hazardous and Noxious Sunstances by Sea, Those substances and mixtures, 2016).

As stated above, hazardous and noxious substances are defined in several international conventions and codes but until the implementation of HNS Convention, there was no specific convention covering the carriage of these substances and the protection and damage regime.

In general meaning, the definition of hazardous and noxious substances are said to be *"any substance other than oil, introduced into the marine environment, to cause hazards to human health, harm living resources and other marine life, damage amenities, and/or interfere with other legitimate uses of the sea. Transport by sea provides the lower cost solution for the carriage of large quantities over long distances. HNS transported by sea represent 11% of the chemicals traded worldwide"* (Cunha, et al., 2014). Apart from that, the increase of international trade constitutes major zones, often in narrow straits, rivers and channels, where the risk of spillage is further increased such as the situation of Turkish Straits.

HNS spills are different from oil spills because of the characteristics of wide variety of products that may be involved or mixed with different results such as different weather situations. For instance, most oils initially float on the sea and are not mixed easily with water, HNS chemicals exhibit a wider range of behaviors and noxious to marine organisms. Therefore, HNS have a broad range of potential characteristics that may cause wider effects once released into the marine environment.

The categorization of the goods according to these characteristics is fundamental for preparedness and response to spill incidents within the framework of the conventions. Information on a short-term action and the information of the product spilled in seawater makes it possible *"to define an action plan, for instance, detection, monitoring and containment that is well adapted to the geographical location, particular meteorological conditions, hydrodynamics, and characteristics of the water column and sea bottom compartments"* (Cunha et al., 2014).

5. Damage, Liability and Compensation within the Context of HNS Convention

As stated, the HNS Convention covers the definition of "damage" which makes it clear that claims for damage to the environment are acceptable. Although environment is not defined in the HNS Convention, the aim should be understood to cover damage to the environment, for example, damage to species of flora and fauna, to food chains in the environment, to aesthetic and cultural values.

The context of HNS Convention states clearly that "*the shipowner has strict liability for damage caused by HNS substances on board the ship. Strict liability is in conformity with the solutions in the oil pollution conventions and also the exceptions under the HNS Convention correspond to the rules in the oil pollution field. In general meaning, there will be no liability to be attached to the shipowner if he/she proves that the damage resulted from an act of war or a natural phenomenon of an exceptional, inevitable and irresistible character. Concerning natural extraordinary situations, it should be noted that the HNS Fund is not accepted from liability. However, there is a special rule limiting amounts for damage resulting from natural extraordinary situations*" (Dockray, 2004).

In summary, the scope of application in CLC is the oil pollution damage resulting from spills of persistent oil from tankers and covers pollution damage suffered in the territory, territorial sea or exclusive economic zone or equivalent area of the State. The pollution damage is defined as loss or damage caused by contamination.

The advantages for the States of being a signatory to the CLC and Fund Convention are mainly the protection regime come into force when a pollution incident occurs. Compensation is available to governments, which have incurred costs for clean-up operations or precautinary measures and to private bodies or individuals who have suffered damage because of the pollution in a tanker oil pollution incident for example.

Both of the above conventions CLC and Fund provide a wider scope of application than the previous conventions. The main reason is that the environmental disasters and the missing part of these conventions regarding the hazardous and noxious substances. That was why the attempt of IMO has been welcomed.

Both the coverage and geographical application of the HNS Convention is comprehensive and it covers about 6000 types of hazardous and noxious substances as defined in several Codes. Strict liability of the shipowner, together with the complementary HNS Fund, is another point that strengthen the position of claimants. The HNS Convention both contains advantages for the shipowner and quick process of the claims procedure and at the same time minimize the possibilities of arrest or other security measures. The HNS Convention could form an acceptable and well functioned international compensation system.

6. The Legislation in Turkey as Regards to International Conventions for Oil Pollution and HNS

Regarding to domestic legislation, Law No.2872, TheEnvironmental Code, covers the all type of pollution and the liabilities in general. The compensation and liability regime are also covered by this Code for the polluter.

Law No.6102, The New Turkish Commercial Code regulates the liability of the shipowner for oil pollution.

Law No.5312, The Code of Indemnification of Pollution with Oil and Harmful Substances in Emergency Situations regulates mainly the emergency situations and the pollution other than oil.

Apart from the domestic legislation not limited with the above, there are several international conventions, which Turkey has ratified and became a party. These are as following; International Convention on Civil Liability for Oil Pollution Damageand its 1992 Protocol together with Fund Convention has been ratified by Turkey in 2001 and came into force on 17.08.2002.

By the New Turkish Commercial Code Law No.6102, it is accepted that the said conventions are incorporated directly into domestic law.

Turkey has ratified MARPOL 73/78 and its Annexes I, II and V, on 24.06.1990 and these came into force on 10.01.1991. The attempts to ratify Annexes III, IV and VI, which are known as 1997 Protocol, are still ongoing.

Turkey has ratified HNS Convention in April 2018 and Turkey is one of the first of three countries, which had ratified the convention. The reason is mainly based on the previous several disasters that had happened in the Turkish Straits Sea Area (TSSA). In those disasters, Turkey was not a party to the CLC, Fund and Supplementary Fund Conventions, therefore could not benefit from those international conventions'protection systems (Atamer, 2013).

7. The Examples of Environmental Disasters Related with Oil and Hazardous and Noxious Substances in Turkey

The M/T Independenta accident was one of the most terrible accidents which had happened in 1979, which about 95,000 tons of crude oil was spilt and burnt. That was occurred at the İstanbul Strait to the Sea of Marmara by the Romanian motor tanker collided with the Greek cargo ship off the Haydarpasa Port. A part of the cargo of crude oil spilled and caught fire.

Because of the explosion and fire on board, many crewmembers had died in that incident. Buildings were reportedly damaged up to long distances. The attempts to put off the fire by Navy was not successful. The casualty grounded close to the port with the fire eventually burning itself. This caused the closure of the İstanbul Strait to traffic for a number of weeks.

Later in 1994, The M/T Nassia Accident occurred at the northern exit of the İstanbul Strait. The motor tanker namely Nassia was travelling from Italy to Russia when she was hit by a Cargo Ship in the İstanbul Strait. A crack immediately appeared in the vessel, causing the release of crude oil. The oil quickly spread and caused five successive explosions. The fire spread to the other vessel namely Shipbroker, sparing only the skeleton of the vessel. The incident had a severe impact not only on environment but also on human lives. Due to the collision between the two ships, 24 crew members were killed, 29 injured and 10 reported missing.

After these incidents, it was reported that between 1982 and 1994, over half of the accidents occurred in the İstanbul Strait were collisions. During the first half of 1994, over ten accidents occurred. Just after the Nassia incident, it was decided by the government to change the navigation rules in Istanbul strait and many measures entered into force. The use of automatic pilot was banned, the need for special permission for certain vessels was required and obtaining assistance at the entrance to the strait became possible. Furthermore, the Turkish authorities, supported by the IMO, decided to impose assistance by professional pilots on the largest vessels entering the strait. But all these preventive measures did not work very well and did not provide the complete level of compensation. There was still a need for international level attempt. (Wetterstein, 1997)

Another grounding accident had occurred 1999. The tanker vessel namely The M/T Volgoneft-248 broke into two pieces in the Sea of Marmara. Coastal structures were heavily affected by the oil pollution (Otay, 2000). Once again, there was no protection at an international level at that time for Turkey.

The Straits of İstanbul and Çanakkale are narrow navigational waterways. In addition, the navigation routes in the Sea of Marmara are rather close to its northern coastline, especially at the southern exit of the İstanbul Strait and at the entrance to the Çanakkale Strait. Therefore, Turkey has a very big risk as regards to the carriage of oil and hazardous and noxious substances. A tremendous area affected by the oil spill during the Volgoneft 248 accident (Figure 1).

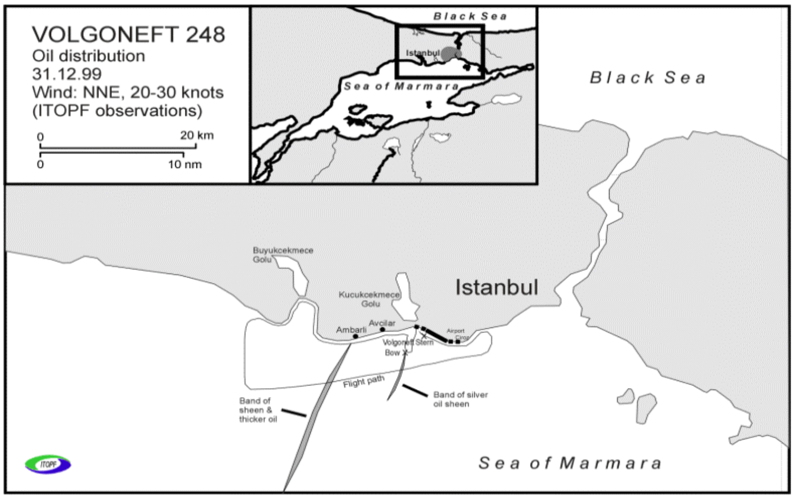

Figure 1. Spill Area (ITOPF, 2000)

After Volgoneft incident, the water circulations were analysed and compared with the previous oil spill accidents, in the Sea of Marmara and consequently, the dynamic distribution of oil concentrations in the Marmara Sea were found. The findings showed that the most critical point in terms of pollution is the southern entrance of the İstanbul Strait.

At the date of those above-mentioned accidents had happened, Turkey was not a party to both CLC and Fund Conventions and Turkey could not benefit the protection and compensation regime of the said conventions.

Therefore, the importance of being a party to International conventions are well learned by the severe accidents that had happened within Turkey's territorial sea, especially along the İstanbul Strait that affected both the sea life, flora and the people who are living in the city at all. That was one of the main reasons why Turkey ratified HNS Convention as a third country.

In respect of Turkey's position referring to the geographical position of the Çanakkale and İstanbul Straits, it has high importance of being a party to the international conventions and utilizes the international protection of the fund conventions.

8. Recent Accidents in the Sea of Marmara

Recently, two different accidents occurred in the Sea of Marmara. One is the chemical tanker that exploded along Marmara Sea close to Istanbul on 20th January 2014 (Figure 2). The chemical tanker explosion might not be counted as an environmental disaster at first instance such as the Independenta since there was no big amount of chemical leakage, but one crewmember was dead, and due to the explosion, the chemical residues has been spread along the area.

Figure 2. Chemical tanker explosion killed one and injured four (photo: MAREX).

Another recent incident that had occured in June 2015 along Çanakkale Strait, that was the tanker vessel namely "Scorpio" and cruise ship "Celestyal Crytal" collided during the transit of the Strait. The tanker was badly damaged causing some of her flammable naphtha cargo to spill into the water. No injures were reported among the tanker crew or the passengers on board the cruise ship. The spill along this region could have more effectively grow up and needed the most significant consideration for the protection of the environment and human lives.

9. Conclusion

In many respects Turkey, especially Turkish Straits, are having a unique geographical and economical importance for the international carriage of goods by vessels. Athough several attempts and precautionary measures by the states were taken so far, accidents do happen and cause environmental damage, death or injured people and huge economical effects.

The international legislation regarding oil pollution, the regime for protection and compensation were widely implemented but still there is an incomplete part of this legislation as regards to hazardous and noxious substances.

In respect of all attempts to make the HNS Convention ratified by relevant number of countries and bearing in mind that the number of vessels carrying HNS cargo is growing, it is urgently needed to bring the HNS Convention into force. Therefore, in this chapter, the importance of being a part of these international conventions and the ratification of the HNS Convention is construed.

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BUNKERING INCIDENTS AND SAFETY PRACTICES IN TURKEY

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1. Introduction

In today's globalized world, raw material and manufactured goods constantly are being transported from one point to another. Maritime transportation undertakes the great majority of these transportation operations. As of 2017, the merchant fleet of the world comprises of approximately 93 thousand vessels of different ship types (UNCTAD, 2017). The merchant fleet of Turkey has 1,505 vessels of 1000GT and over as of 2016, according to the UNCTAD Review of Maritime Transport report. In addition, the great majority of the maritime traffic in Turkish waters is focused in the Straits of Çanakkale and İstanbul. The Strait of İstanbul is among the largest seaways with intense vessel traffic in the world, that connects the Black Sea to the Sea of Marmara (Akten, 2006). The İstanbul Strait is the third busiest shipping channel in the world with an annual 50,000 ships, including 8,000 tankers, following the straits of Dover and Malacca, as presented in Figure 1.

Figure 1. Busiest Shipping Channels; Dover, Malacca and the İstanbul Strait(www.marinetraffic.com/)

This high traffic, and even higher volume of goods carried, brings along great risks of marine accidents and incidents such as contact, collision, capsizing/listing, grounding/stranding, fire/explosion, damage to ship equipment, etc. These incidents are threats to the lives of the personnel on board the ship, as well as to the environment and the marine wildlife. These marine incidents may cause injury or death of the seamen on the ship and environmental pollution via spillage of cargo or oil. Among the effects to the environment, the most hazardous is most probably the oil spillage. In these incidents, oil spills to the sea, either from the cargo bays, as the cargo carried by the tankers, or from the bunkers, as the fuel used for the machines of vessels, used to lubricate ship's parts, or the sludge remaining after the operation of the ship. The majority of cases of environmental pollution are caused not by accidents but by operational hazard, by discharging ship bunkers and various pollutants (e.g. residues in the cargo bay, oils used for lubrication and hydraulic power) (EMSA, 2017). These marine incidents have sparked new international regulatory frameworks. For instance, the disastrous grounding of *Torrey Canyon* in 1967, which was the first major event of extensive oil pollution, in which 120,000 tonnes of oil spilled, contributed to the motivation for the MARPOL convention (Akten 2006: 282-3). Akten categorises oil pollution incidents into two, either resulting from the "*ship operations* such as loading or discharging of oil, bunkering, oil transfer etc. as *operational pollution* or resulting from *ship accidents* such as collision, grounding, hull failures, fire and explosion as *accidental pollution* (Akten, 2006: 284).

In the literature, there are many studies on the oil pollution caused by marine accidents (Alves et al., 2015; Lan et al., 2015; etc.). However, the studies focusing on oil pollution due to bunkering are limited in number when compared to other causes of oil pollution, but there are some recents studies on the topic (Prokopiou and Tselentis, 2002; O'Brien, 2006; Talley et al., 2012). In this respect, this study aims at discussing the bunkering practices in Turkey with regard to the 2001 *"International Convention on Civil Liability for Bunker Oil Pollution Damage*", known also as the "*Bunkers Convention"*. To attain this objective, the study is structured as follows. The first section will provide a brief introduction what bunkering is and what the possible dangers of the operation are. The second section will scrutinize the Bunkers Convention, relating it to the everyday practices of bunkering operations in Turkey. The third and the last section will present a conclusion and make recommendations, taking the recent developments in the maritime sector, and especially in bunkering practices.

2. Bunkering Operations

Bunkering can be defined as the operation of transferring of fuel, lubricant oils and oils for hydraulics for the use of the ship itself, and the residues of these oils as sludge, from a land facility at the port or through barges in the port. Bunkering operations are situated at the ports and they incorporate the storage of "bunker" fuels and the provision of the fuels to the vessels (http://www.abshipping.co.za/what-is-bunkering/). In the case of boats and small vessels, bunkering is performed from shore, using equipment similar to gas stations; on the other hand, ships are bunkered from one or more dedicated barges, as in shown in Figure 2 (Ronza, 2007).

Figure 2. Bunkering operation (from marineinfobox.blogspot.com).

According to the international statistics about accidental pollution, bunkering is acknowledged as a process that poses a high environmental risk. Bunkering comprises several partners and multifarious procedures and protocols that complicate the process (Prokopious and Tselentis, 2002).

In order to reduce the human errors to prevent accidents various steps should be followed from even before starting the bunkering operation. First, the quantity of bunker to be received on the ship should be decided by the chief engineer considering the ensuing voyage and calculating the reserve oil in consultation with the master. Secondly, the sequence of the bunkers to be filled should be determined, discussing with the chief officer to guarantee the proper draft and trim of the vessel. All crew should be informed about the bunkering process, about their duties, and the measures to be taken to prevent any incidents, especially overflow of bunker oil that would cause an oil spill.

When the bunkering operation starts, the first thing to do is to ensure that the bunker barge is taken alongside safely, as presented in Figure 1. Then, a safe access should be provided between the ship and the barge. Later the bunker man should go to the Engine Control Room to meet the Chief Engineer and his/her assistant to discuss the specifications of the bunkering process, such as the filling rate (Tonnes/h), the pressure on the bunker line (maximum 3 bars), the sampling procedure, the order of the oil types to be taken (if there are more than one grade of oil), and determining the emergency stop signal to ensure mutual understandability. The crew should ensure that all scuppers are stopped to prevent oil coming out of these holes. The overflow tank should be checked and be verified that it is empty.

After these procedures are completed, the bunkering team should receive the bunker line to the deck and connect the line to the flange of the ship. All bolts on the flange should be placed and tightened to prevent dislocation of the line from the flange. After this procedure, the line and the bunker valve on the ship should be checked again, since a closed valve would damage the bunker line and cause oil to spill. The bunkering process should start with two tanks at the port and starboard to ensure proper draft. During the bunkering process, ullage should be checked to have an idea about the quantity of oil in each tank. When the tanks reach at 85% ullage the valve for the third tank should be opened and only after this, the valve of the almost filled tank should be closed. After closing the valves, they should be checked against leaks.

As it can be understood from the procedures explained above, bunkering process is very open to human error and equipment malfunction. There are other procedures to be completed in bunkering process, such as sample collection and recording, but these are not discussed here since they are not directly related to bunkering incidents.

After providing brief information about what bunkering is and what its procedures are, the study will continue with the international regulations about bunkering and their applications in the maritime sector.

3. Regulatory Frameworks about Bunkering and Their Implementations

International conventions for the prevention of oil pollution in shipping have concentrated on on oil-cargo spills rather than bunker oil (fuel) spills; e.g. the 1969 International Convention on Civil Liability for Oil Pollution Damage, its enhancement with the 1992 Protocol; the 1971 International Convention on the Establishment of an International Fund for Oil Pollution Damage, its enhancement with the 1992 Protocol; and International Convention for the Prevention of Pollution from Ships 1973 (Talley et al. , 2012). These regulations do not focus on bunkering incidents; instead, they only address the oil-cargo spills (Talley et al., 2012). However, the 2001 International Convention on Civil Liability for Bunker Oil Pollution Damage was adopted by the representatives from 70 states at a conference organised by IMO in London. The convention entered into force in 2008.

Noting the success of the 1992 *International Convention on Civil Liability for Oil Pollution Damage*, the convention "considers that complementary measures are necessary to ensure the payment of adequate, prompt and effective compensation for damage caused by pollution resulting from the escape or discharge of bunker oil from ships", and it aims "to adopt uniform international rules and procedures for determining questions of liability and providing adequate compensation in such cases."

The convention comprises of 19 articles, 7 of which are about the signature, ratification, acceptance, approval and accession. Article 1 of the convention defines incident as "any occurrence or series of occurrences having the same origin, which causes pollution damage or creates a grave and imminent threat of causing such damage" (Bunkers, 2001) In the same article, pollution damage is defined as follows:

> *"(a) loss or damage caused outside the ship by contamination resulting from the escape or discharge of bunker oil from the ship, wherever such escape or discharge may occur, provided that compensation for impairment of the environment other than loss of profit from such impairment shall be limited to costs of reasonable measures of reinstatement actually undertaken or to be undertaken; and*
>
> *(b) the costs of preventive measures and further loss or damage caused by preventive measures."*
>
> *(Bunkers, 2001)*

In addition to this international law, the Turkish regulation "Law Pertaining to Principles of Emergency Response and Compensation for Damages in Pollution of Marine Environment by Oil and Other Harmful Substances", which has been enacted in 2005 with the law number 5312 makes mention of pollution caused by bunker oil, regulating the emergency response actions and the liabilities of the ship owners.

Following this convention and the Law no 5312, the maritime companies devised bunkering procedures and safety protocols to avoid any incident and thus liability. These protocols include steps (excluding safety measures not related to oil spill) to be followed before the bunkering process such as:

- the grade of oils to be bunkered: their amount, volume, loading temperature, initial loading rate, maximum loading rate, the maximum line pressure;
- properties of the tanks to be bunkered: their volume as %, volume of oil prior to loading, available volume, volume to be bunkered and total volumes;
- checks to be performed by the barge before berthing: obtaining necessary permissions to go alongside the receiving ship; ensuring all hoses are in good shape and are appropriate for the service intended.
- checks before bunkering: mooring securely; providing means of access between the ship and the barge following safety procedures; providing competent communications between responsible officers; ensuring an effective watch on board; ensuring effective plugging of all scuppers and monitoring of temporarily removed scupper plugs; ensuring that the drip trays are in position on decks around connections and bunker tank vents; checking the initial line up and blanking of unused bunker connections by fully bolting; ensuring that the transfer hose is properly rigged and fully bolted on the ship and the barge; ensuring that the overboard valves linked to the cargo system, engine room bilges and bunker lines are closed and sealed; ensuring that all hatch lids are closed; providing regular monitoring for bunker tank contents; getting ready the oil spill clean-up material.

The maritime companies have also prepared safety protocols to follow during the bunkering process. These protocols include steps such as:

- checking the oil entering the correct tank,
- reducing the pumping rate before topping of a tank or changing bunker tank,
- closing valves as each tank is completed,
- ensure sufficient ullage in the final bunker tank for hose draining,
- notifying the barge when the final bunker tank is reached,
- giving the barge ample warning to reduce the pumping rate,
- closing all filling valves upon completion,
- ensuring that all hoses are fully drained,
- closing and blanking off the manifold connections,
- blanking of the disconnected hose couplings,
- reconfirming all bunker line and tank filling valves are secured,

4. Bunker oil spills in Turkey

When big amount of oil spills, resulted from shipping accident, have been analysed it is seen that most of them emerged in or near ports. ITOPF oil spill statistics reports that 80% of all tanker spills are less than 7 tonnes and that 80% of these arise from operational events such as those that might occur during loading, discharging and bunkering (O'Brien, 2006). Similarly, there are many studies on the ship accidents in Turkey (Bolat, 2016; Yılmaz and İlhan, 2018). However, not all of these accidents are related to oil spills. Akten (2006) gives a list of oil spill incidents in Turkish straits, presented in Table 1, without mentioning if they were oil-cargo spills or bunker oil spills.

When newer data on marine accidents are addressed via the Accident Investigation Board's website (www.kaik.gov.tr), it is seen that there are some incidents related to bunker oil spills. One such incident confirms the claims that most of the oil spills occur at ports during bunkering and this operation is prone to human error.

On 29 March 2011 the Georgia registered dry cargo vessel AMAL was unloading her cargo at the Rota Port in the Gulf of İzmit. On the same day, the bunker barge URLA 1 went alongside AMAL for bunkering at 13:40. The connection of the transfer line was completed in 25 minutes and the bunkering procedure was started. At 15:00, when transfer 47 metric tonnes of the planned 50 metric tonnes was completed, an oil spill of 1 metric tonnes occurred when the oil leaked through the air vents of the bunker tanks to the deck and from the deck to the sea via the scupper holes, which are shown in Figure 3 as unplugged. The port authorities were informed about the incident at 16:15 and the emergency action personnel reverted to the area. The 200 meters long barrier was placed into the sea surrounding the vessel AMAL and the barge URLA 1. The cleaning procedure started after authorising the Mavi Deniz Çevre Hizmetleri Inc.

Table 1. Important oil spill incidents in Turkish Straits (Akten, 2006).

Date	Area	Ships	Spilled quantity
1960	Istanbul Strait	MV World Harmony and MV Peter Zoranic	18,000 mts oil
1964	Istanbul Strait	MV Norborn and wreck of Peter Zoranic	
1966	Istanbul Strait	MV Lutsk and MV Kransky Oktiabr	1,850 mts oil
1979	South entrance of Istanbul Strait	MV Independentia and MV Evriali	20,000 mts oil
1980		MV Nordic Faith and MV Stavanda	
1982		MV Unirea	66,400 mts oil
1988		MV Bluestar and MV Gaziantep	1,000 mts ammonia
1990	Istanbul Strait	MV Jampur and MV Da Tung Shan	2,600 mts oil
1994	Istanbul Strait	MV Nassia and MV Shipbroker	22 mts oil
1999	Istanbul Strait	MV Semele and MV Sipka	10 mts oil
1999	Istanbul Strait	MV Volganef 248	1,500 mts oil
2002	Istanbul Strait	MV Gotia	20 mts oil
2003	Istanbul Strait	MV Svyatoy Panteleymon	230 mts oil

Figure 3. Unplugged scuppers on the vessel AMAL (AMAL and URLA 1, KAİK Ship Accident Report).

The Chief Engineer of AMAL stated that, before the spill, they recognised a powerful airflow from the air vent and they requested the barge to reduce the line pressure. However, the spill started as dropping and then it turned into bursting. The chief officer and the chief engineer of the barge stated that they did not exceed the agreed maximum line pressure (4 bars) and they continued bunkering at 2.5 bars. They understood something was wrong from the gestures and shouting of the Chief Engineer of AMAL, and they pressed the emergency stop button and closed the manifold valve.

The accident report reveals the reasons for this incident to occur. For instance AMAL had a considerable amount of trim that would mislead the bunkering calculations. The ship crew were not provided with adequate means of communication. The bunkering line of AMAL did not have any pressure gauges to monitor the line pressure. The scuppers were not plugged before bunkering. The crew of AMAL were not familiar with the safety protocols for bunkering and pollution response procedures after the incident. The port authorities were not aware that a bunkering operation would be made until the barge had arrived to the port, and they did not have the adequate equipment to provide emergency response.

All these factors combined, the pollution response was late and inadequate. The pollution spread over the barrier placed around the vessel and the barge as in shown in Figure 4.

Figure 4. Polluting spreading outside the barrier (AMAL and URLA 1, KAİK Ship Accident Report)

In a more recent incident occurred on 22 July 2015, two sand coasters AKEL and ŞENGÜL K collided at the sand area off Şile, İstanbul at 02:30. The vessel AKEL received a blow from the starboard and sank in a short time. After the accident, bunker oil spill occurred from AKEL, and pollution response was given by the Directorate General of Coastal Safety vessels as in shown in Figure 5.

On 18 December 2016, the Panama registered vessel Lady Tuna went aground on the sandbank to the west of the Ufuk isle lighthouse after loading her cargo from the fishing farms and while proceeding her anchoring position for the customs operations. Because of the accident, material damage occurred at the bunker tank area of the vessel and oil spill occurred. At the end of the pollution response activities, it was understood that 75 cubic meters of oil spilled from Lady Tuna.

Figure 5. Shore pollution after the accident and pollution response activities (LADY TUNA, KAİK Ship Accident Report)

4. Conclusion

Oil spills are one of the major concerns of the maritime sector. While disastrous oil spills attract the attention of media, minor oil spills and especially bunkering related oil spills remain at the background. However, it is a fact that 80% of oil spills occur at the ports while loading, unloading and bunkering. Considering that non-oil-cargo vessels are becoming larger and thus their bunker tanks are getting larger in volume, it is possible to state that bunkering incidents would become more hazardous. In addition, there are 400 major bunkering ports around the world (World Oil Outlook 2015) serving to a great number of vessels each day. Ports have more personnel than the vessels and human error becomes a great concern considering the heavy load of these ports/hubs.

Another point that is yet to be discussed in this respect is the new types of fuels used in newly built vessels, such as LNG, LPG or CNG. Studies on the alternative fuelled vessels and their bunkering operations has already started in the world. However, the international conventions and the safety protocols linked to these conventions do not make any mention of these new fuels. The safety protocols are still based on fuel oil, diesel oil and lubricant oils. However, as states and unions of states, i.e. EU, force the companies to comply with certain emission rates, and carbon footprint restrictions, they would seek for alternative fuels such as LNG, LPG or CNG. It can be argued that the international regulations and safety protocols should be reviewed and updated considering these new alternative fuels, without waiting an incident, like Torrey Canyon, to occur to take action.

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"NAIROBI INTERNATIONAL CONVENTION ON THE REMOVAL OF WRECKS, 2007" AND ITS EFFECTS ON TURKEY

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1. Introduction

"The Nairobi International Convention on the Removal of Wrecks (WRC)" was accepted during a conference organized in Kenya on 18/5/2007 and entered into force on 14/4/2015. Turkey has not been yet between 39 State Parties. The Convention aims to ensure that ship wrecks (Figure 1) outside the territorial waters are removed quickly and efficiently and that States have some decisive rights to dispose of wrecks in their territorial waters. The convention also covers the provisions of the shipowners' responsibility for wrecks' detection and removal.

This chapter includes explanations on the application details of "The Nairobi International Convention on the Removal of Wrecks" and its effects on Turkey.

Figure 1. Ship wreck (from DTO, 2015)

2. The Area of Application of the Convention

The shipwrecks can be dangerous for navigation or sea area. For the effective disposal of debris and the payment of compensation for the related costs, uniform international rules and procedures must be applied. It is a convention which states that many wrecks, including the regional sea, may be in the territory of the state. Within uniformity in legitimate regimes which govern responsibility and liability for disposal of dangerous debris, the benefits can be identified. On December 10, 1982, the importance of the convention in the Gulf of Montego and the conventional international law of the seas and the application of this Convention in accordance with these provisions were forced.

3. The Area and the Purposes of This Convention

Convention area and ship defined as follows:

> "Convention area means the exclusive economic zone of a State Party, established in accordance with international law or, if a State Party has not established such a zone, an area beyond and adjacent to the territorial sea of that State determined by that State in accordance with international law and extending not more than 200 nautical miles from the baselines from which the breadth of its territorial sea is measured" (International Maritime Organization [IMO], 2007, p. 2).

> "Ship means a seagoing vessel of any type whatsoever and includes hydrofoil boats, air-cushion vehicles, submersibles, floating craft and floating platforms, except when such platforms are on location engaged in the exploration, exploitation or production of seabed mineral resources" (IMO, 2007, p. 2).

A marine casualty shall mean a collision of a ship or another incident occurring on the inside of ship or outside the ship; this may result in property harm to a ship or its cargo. The wreck occurred after a marine accident can be given as Table 1.

Table 1. The wreck occurred after a marine accident (IMO, 2007).

The wreck
1. a sunken or stranded ship
2. any part of a sunken or stranded ship, including any object that is or has been on board such a ship
3. any object that is lost at sea from a ship and that is stranded, sunken or adrift at sea
4. a ship that is about, or may reasonably be expected, to sink or to strand

Related interests mean the interests of a coastal State directly affected or threatened by a wreck, such as: according to convention can be following at Table 2.

Table 2. Related Interests of a Coastal State (IMO, 2007).

Interests	Explanations
maritime coastal, port and estuarine activities	fisheries activities, constituting an essential means of livelihood of the persons concerned
tourist attractions and other economic interests	the area concerned
the health of the coastal population and the wellbeing of the area	including conservation of marine living resources and of wildlife
offshore and underwater infrastructure	-

4. Objectives and General Principles of Convention

Objectives and general principles of convention can be listed as follows:

> "*A State Party may take measures in accordance with this Convention in relation to the removal of a wreck, which poses a hazard in the Convention area.*
> *Measures taken by the Affected State in accordance with paragraph 1 shall be proportionate to the hazard.*
> *Such measures shall not go beyond what is reasonably necessary to remove a wreck, which poses a hazard and shall cease as soon as the wreck has been removed; they shall not unnecessarily interfere with the rights and interests of other States including the State of the ship's registry, and of any person, physical or corporate, concerned.*
> *The application of this Convention within the Convention area shall not entitle a State Party to claim or exercise sovereignty or sovereign rights over any part of the high seas.*
> *States Parties shall endeavour to co-operate when the effects of a maritime casualty resulting in a wreck involve a State other than the Affected State*" (IMO, 2007, p. 3).

5. The Scope of Application

The application scope is specified in article 3. Unless otherwise specified in this Agreement, this Agreement will apply to the debris in the Convention area (IMO, 2007).

6. Exceptions to the Convention

"*This Convention shall not apply to measures taken under the International Convention relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969, as amended, or the Protocol relating to Intervention on the High Seas in Cases of Pollution by Substances other than Oil, 1973, as amended*" (IMO, 2007, p. 4). This exception is especially important for oil pollution.

"*A State Party shall require the master and the operator of a ship flying its flag to report to the Affected State without delay when that ship has been involved in a maritime casualty resulting in a wreck*" (IMO, 2007, p. 5).

The cases that can be listed in the report are shown in Table 3.

Table 3. Situations of the affected state in the report (IMO, 2007)

Cases
1. the precise location of the wreck
2. the type, size and construction of the wreck
3. the nature of the damage to, and the condition of, the wreck
4. the nature and quantity of the cargo, any hazardous and noxious substances
5. the amount and types of oil, including bunker oil and lubricating oil, on board

"*This Convention shall not apply to any warship or other ship owned or operated by a State and used, for the time being, only on Government non-commercial service, unless that State decides otherwise. Where a State Party decides to apply this Convention to its warships or other ships as described in paragraph 2, it shall notify the Secretary-General, thereof, specifying the terms and conditions of such application*" (IMO, 2007, p. 4).

7. Determination of hazard

The hazard is determined in the contract is shown in Table 4 according to the following criteria.

Table 4. Criteria of hazard depending on Convention (IMO, 2007).

Criteria
1. the type, size and construction of the wreck
2. depth of the water in the area
3. tidal range and currents in the area
4. according to United Nations Convention on the Law of the Sea, 1982 particularly sensitive sea areas identified
5. proximity of shipping routes or established traffic lanes
6. traffic density and frequency
7. type of traffic
8. nature and quantity of the wreck's cargo, amount and types of bunker oil and lubricating oil, the oil on board the wreck and, the damage likely to effect should the cargo or oil be leave of into the marine environment
9. vulnerability of port facilities
10. prevailing meteorological and hydrographical conditions
11. submarine topography of the area
12. height of the wreck above or below the surface of the water at lowest astronomical tide
13. acoustic and magnetic profiles of the wreck
14. proximity of offshore installations, pipelines, telecommunications cables and similar structures
15. any other circumstances that might necessitate the removal of the wreck

8. Locating wrecks

Upon recognition of a wreck, the Affected State, the State and organizations, including good offices, boats and the nature of the debris and government-related positions will use all feasible means to alert an emergency.

When the Affected State has strong evidence that a wreck will pose a danger, it should use all available means to ensure that all efforts are made to determine the exact location of the wreck.

9. Marking of wrecks

> "*If the Affected State determines that a wreck constitutes a hazard, that State shall ensure that all reasonable steps are taken to mark the wreck. In marking the wreck, all practicable steps shall be taken to ensure that the markings conform to the internationally accepted system of buoyage in use in the area where the wreck is located. The Affected State shall promulgate the particulars of the marking of the wreck by use of all appropriate means, including the appropriate nautical publications*" (IMO, 2007, p. 7).

10. Reporting wrecks

Information about which cargo is carried is also important. It should contain information on different oils, including bunker oil and lubricating oil, as well as hazardous and hazardous substances.

In case the affected State determines that it brings about a danger under the convention, it can be stated that it is related to the criteria to be taken into consideration according to Article 6 (Kern, 25 February 2016).

11. Insurance requirements related with oil spill

> "*The Wreck Removal Convention closely follows the strict liability and insurance provisions which currently apply to oil tankers under the Civil Liability Convention (CLC) and ships of 1,000 gross tonnage and over under the Bunker Convention*" (The Shipowners' Club, 5 November 2014).

12. Ship owners' responsibilities

> "*The owner and any manager or demise charterer which operates a ship flagged in a State Party have an obligation to report any wreck without delay to the State Party (in whose waters the incident has occurred). If the State Party determines that a wreck is a hazard to navigation or the environment, that State Party should ensure it is marked. It can also require the registered owner to mitigate the hazard by removing the wreck. If the registered owner does not remove it, the State Party can. The registered owner is responsible for the costs of locating, marking and removing the wreck except under very limited circumstances*" (Allen and Overy, 2015).

13. The Most Famous Shipwreck in the World

It is possible to list some of the famous wrecks around the world. However, the most famous shipwreck in the World is Titanic (Figure 2). She unfortunately sank after colliding against an iceberg in her first voyage on April 14, 1912. About 1517 passengers and crew have lost their lives in the World's biggest marine tragedy (Marine Insight, October 2017).

Figure 2. Titanic wreck (from CNN Travel, 2018).

14. The International Nairobi Convention on the Removal of Wrecks, Effects on Turkey

"*The International Nairobi Convention on the Removal of Wrecks*", referred to in Article 5 of Law No. 7061, was adopted on 18/5/2007. The effective date of the convention is 14/4/2015. Turkey has not yet entered in the 39 States Parties.

In terms of wrecked ships, the 2007 International Nairobi Convention on Wrecks, based on the sovereignty of the state, introduced provisions to the wreckers of this wreck to lift the ship from its location and, if not, to be lifted by the state.

Today, many coastal states can demand the removal of any wrecks, even if it is not considered as a problem, or if it is considered as an obstacle or danger. This demand is generally a legally binding lifting order.

With the regulation, the competence in international legislation is intended to be included in Law No. 618.

With the Article, the port authority may ask for the removal of the vessel if it is shipwreck or semi-submerged, which carries life, property and environmental risks, or which may be impeded on the ship and in such a way as to impede the salvation of the voyage.

In other cases, the port authority may provide up to forty-five days to the ship's owner or captain for lifting the ship to a safe location. If the instruction is not fulfilled within this period, the port authority shall be authorized to remove, dispose and sell these ships or their goods.

15. Conclusion

> "*The latest international convention in the field of maritime law adopted in Nairobi in May 2007 titled the International Convention on the Removal of Wrecks is an addition to the existing maritime law and international system of safe navigation and protection of the marine environment*" (Petrinović et al., 2013).

"*The Nairobi WRC 2007*" includes international rules on wrecks and drifting or sunken cargoes. In addition, it includes detailed information on their rights and obligations of the states and owners. The Convention explains rights and liabilities related to all kinds of processes in wreck removal.

The Convention, adopted because of the Diplomatic Conference held in Kenya's capital Nairobi, fills an important legal gap in matters such as legal liability, indemnity and compulsory insurance, especially in terms of the detection and abolition of wreck and wreck that pose a risk to maritime environment and beyond the territorial waters. The convention will shed light on the arrangements that countries will adopt to remove the wreckage in their territorial waters. The Convention covers the responsibility for ship-owners to detect and remove wrecks.

The Nairobi Convention recognizes the possibility of wreck being exposed to safe navigation in the sea and in marine environments and intends to provide a legal basis for the immediate and effective elimination of such wreck from the exclusive economic zones of the member states.

"*The Nairobi WRC 2007*" specifically states in which occasion Article 4 of the Convention will not be applicable.

> "*The Convention shall not apply to measures taken under the International Convention relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969, as amended, or the Protocol relating to Intervention on the High Seas in Cases of Pollution by Substances other than Oil, 1973, as amended*" (Luttenberger et al., 2011).

The Contracting States were given the opportunity of extending convention to the debris within territorial waters. It is likely that this would be an appealing opportunity and that more and more States will be able to reach more agreement because of the provisions on compulsory insurance and the direct action against the insurer.

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