ISTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

MONITORING SHIP BASED OIL POLLUTION FOR BLACK SEA

M.Sc Thesis by
A. Tuğsan İŞİAÇIK ÇOLAK

Department : **Maritime Transportation Engineering**

Programme : **Maritime Transportation Engineering**

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512081008

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Supervisor (Chairman) : **Ass. Prof. Dr. Sevilay CAN (ITU)**
Members of the Examining Committee : **Prof. Dr. Hüseyin YILMAZ (YTU)**
Ass. Prof. Dr. Tanzer SATIR (ITU)

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FOREWORD

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May 2011 Cpt. A. Tuğsan İŞİAÇIK ÇOLAK

Maritime Transportation Engineer

TABLE OF CONTENTS

ABBREVIATIONS

AIS	**:** Automatic Identification Sytem
BS	**:** Black Sea
BSC	**:** Black Sea Commision
BSIS	: Black Sea Information System
EMSA	: European Maritime Safety Agency
ESAS	: Environmental Safety Aspects of Shipping
GIS	: Geographic Information System
IMO	**:** International Maritime Organization
MARPOL	**:** International Convention for the Prevention of Pollution from Ships
MONINFO	**:** Environmental Monitoring of the Black Sea Basin: Monitoring and Information Systems for Reducing Oil Pollution Project
OILPOL	**:** Oil pollution Convention
SOLAS	: Safety of Life at Sea
RIP	**:** Regional Information Platform
SAR	**:** Satellite Aperture Radar

LIST OF TABLES

Page

LIST OF FIGURES

Page

MONITORING SHIP BASED OIL POLLUTION WITH SATELLITE FOR BLACK SEA

SUMMARY

After the Bucharest Convention, sea borne transportation especially raw oil and oil products have taken place and it is predicted to continue in the future for Black Sea. Increase of sea borne transportation brings ship based pollution. Also disadvantages of Black Sea environmental and ecological situation. Coastal countries have to take action to reduce the risk of oil spills and its impact in the Black Sea region

Aims are safe navigation, safe ports, monitoring ship traffic, identifying polluter ships, if any accident occurs, to response emergency contingency plan and fight with oil spill as soon as possible.

Ships generate the oil pollution with ship bilge water and sludge or for tankers oil cargo residual and tank washing operations. Remote sensing and monitoring from satellite is used mostly for environmental working program, like forest, ocean, land earthquake movement, etc. monitoring oil spill is one of the branch of remote sensing.,

The Commission on the Protection of the Black Sea Against Pollution is supported by United Nations Support Programme. Also European Commission supports Black Sea countries and give their opportunity to the Black Sea countries.EMSA (European Maritime Safety Agency) shares their satellite services. Black Sea Commission uses EMSA Satellite Services and CleanSea Net (CSN) based on SAR detection. The CleanSea Net service is linked into national/regional response chain. The CleanSea Net service detects oil slicks at sea using satellite surveillance CleanSea Net provides users the satellite resolution pictures, oil spill reports, meteorological wind and wave data, SAR wind and SAR swell data derived from the image and other data when available from external systems like AIS information

Black Sea Commision and their project ‘MONINFO’ uses Clean Sea Net Sytem successfully. Monitoring ship based oil pollution from satellite for Black Sea has already prevented every kind of ship’s bilge water and cargo residual for tankers illegal discharge.

KARADENİZDE GEMİLERDEN KAYNAKLANAN PETROL KİRLİLİĞİNİN TAKİBİ

ÖZET

Son yıllarda Bükreş Konvansiyon'dan sonra , deniz taşımacılığı özellikle ham petrol ve petrol ürünleri Karadeniz'de artış göstermiştir ve tahmin edilen artış devam edecektir. Deniz taşımacılığı beraberinde Karadeniz'e deniz kirliliğini de getirdi. Karadenizin çevresel ve ekolojik özelliği ayrı bir dezavantajdır. Karadenize kıyısı olan ülkeler bu nedenlerden ötürü Karadenize vereceği hasarı göz önünde bulundurarak herhangi bir petrol kirliliğinin önlemek için tedbir almalıdırlar.

Bu projede anlatılmak istenen projenin amacı ,Bir kaza anında acil müdahale planı oluşturma ve kirlilikle en hızlı şekilde mücadele etme, güvenli navigasyonun, güvenli limanın, gemi trafiğinin takibinin sağlanması ve kirletme yapan gemilerin kimlik tespitidir.

Gemide oluşan petrol kirliliğinin kaynağı gemideki sintine suları, slaç ve yük tankerlerinin slop tank'taki yağlı sularıdır. Uzaktan takip ve erken uyarı sistemi çevre çalışmalarında kullanılan en etkin yöntemdir. Denizler de petrol kirliliğinin uydudan takibi de bu yöntemlerden bir tanesidir.

Karadenizin kirlilikten korunması için kurulan Karadeniz Komisyonu Birleşmiş Milletlerin Çevre Programı tarafından desteklenir. Ayrıca Avrupa Komisyonu da bu programı destekler. Karadenize kıyısı olan ülkeler Avrupa Güvenli Denizcilik Ajansı EMSA'nın temin ettiği uydu fotoğraflarından yararlanır. Karadeniz Komisyonu da EMSA'nın Uydu hizmetlerinden ve CleanSea Net servisinden faydalanır. CleanSea Net servisi ulusal/ bölgesel kirlilikle müdahele güçlerine bağlıdır.

CleanSea Net servisi su yüzeyindeki petrolü uydu servisini kullanarak algılar ve kirleticinin kimliliğini tesbit eder. Çözünürlüğü olan uydu resimleri, petrol kirliliği raporu, meteorolojik bilgiler,rüzgar,akıntı hızı, ölü dalgalar ilgili ülkenin sorumlularına gönderilir. AIS bilgileri mevcut olduğunda rapor ile beraber gönderilir.

Karadeniz Komisyonuna ait olan MONINFO Projesi kapsamında CleanSea Net sistemi kullanılmaktadır. Proje çok yeni olmasına rağmen şimdiden bu sistem gemilerden kaynaklanan petrol kirliliğini azaltmaya başlamıştır.

1. INTRODUCTION

The Black Sea region is one of the most important economic areas around world. For Black Sea countries; it is very important route for tanker shipping, oil route, export of gas, and oil products especially for Tuapse and Novorossiysk, and via number of pipelines. Blue Stream connects Russia and Turkey. On March 2007 Black Sea Countries; Bulgaria, Greece, Russia and Turkey, signed the agreement about construction a pipeline Burgas – Alexandroupolis.

How big oil trade pattern is at Black Sea, it brings oil pollution more. Black Sea is nearly closed sea, only two straits connect Turkish Straits and Kerch Strait. Not only this but also Black Sea very low O_2. Main sources of contamination from industrial waters, increasing trade, industrial and shipping make Black Sea worse. Oil density is more than other seas; this is very serious problem for both Black Sea countries and world. This is realized by Black Sea countries, and take an action to prevent more oil pollution A project aimed to monitor oil spill with satellite for Black Sea.is MONINFO; "Environmental Monitoring of the Black Sea Basin: Monitoring and Information Systems for Reducing Oil Pollution" Project.

To provide safer ship and maritime safety more effectively, In 1948 an international conference in Geneva adopted a convention formally establishing IMO (the original name was the Inter-Governmental Maritime Consultative Organization, or IMCO, but the name was changed in 1982 to IMO). The purposes of the Organization, as summarized by Article 1(a) of the Convention, are "to provide machinery for cooperation among Governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade; to encourage and facilitate the general adoption of the highest practicable standards in matters concerning maritime safety, efficiency of navigation and prevention and control of marine pollution from ships IMO's first task was to adopt a new version of the International Convention for the Safety of Life at Sea (SOLAS) [1].

But SOLAS is not enough there must be something to fight and emerge pollution, to prevent ship based pollution. After the disaster Torrey Canyon happened 1967 and 120.000 tonnes oil spilled to the sea, after serious working, the most important convention for preventing ship based oil pollution was adopted 1973 and renewed at 1978 (MARPOL 73/78).

The International Convention for the Prevention of Pollution from Ships (MARPOL) was adopted on 2 November 1973 at IMO and covered pollution by oil, chemicals, and harmful substances in packaged form, sewage and garbage. The Protocol of 1978 relating to the 1973 International Convention for the Prevention of Pollution from Ships (1978 MARPOL Protocol) was adopted at a Conference on Tanker Safety and Pollution Prevention in February 1978 held in response to a spate of tanker accidents in 1976-1977. As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument is referred to as the International Convention for the Prevention of Marine Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78), and it entered into force on 2 October 1983 (Annexes I and II). In 1997 a Protocol was adopted to add a new Annex VI. The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes six technical Annexes. special Areas with strict controls on operational discharges are included in most Annexes[2].

But sometimes international regulations are not enough, like MARPOL Convention.
So as defined Special Area Marpol Annex I, to prevent oil and oil products pollution Special Area countries have to take more action, like Baltic Sea, Black Sea, and Mediterranean Sea.

Under the United Nations Environmental Programme, Bucharest Convention adopted for Black Sea signed 21 April 1992. According to The Bucharest Convention, the Commission shall be established from contracting countries, (Bulgaria, Georgia, Romania, Russian Federation, Turkey and Ukraine) called as Black Sea Commission

Black Sea Commission have a lot of environmental programme to save The Black Sea and fight with marine pollution. One of the taking action step is monitoring ship source oil pollution from satellite and backtracking with AIS and catching the polluters with the shortest time. To understand and realize the system first of all, we need to understand the polluters *Oil, oily products* and *Ships*.

1.1 Marine Pollution

Marine Pollution is great and very troublesome problem, marine pollution can be directly or indirectly by man made source giving energy or substance to the marine environment. marine pollution is created and results hazards to the marine environment, human, marine life…etc.

Marine Pollution Sources:

- <u>Oil Pollution</u>
- Heavy Metals and their products
- Bioaccumulation
- Disposal of Radioactive Materials
- Discharge of Sewage
- Harmful Algal Blooms

Shipping and maritime activities cause a great amount of marine pollution, generally. Of course, oil is one of the most important pollutant resulting from maritime activities.

1.2 Definition Of Oil, Products Of Oil and Oil Pollution

Petroleum means "rock oil", from the Greek *petros*/Latin *petra* (rock), and the Greek *elaion/*Latin *oleum* (oil) [3].

MARPOL defines oil as; petroleum in any form including crude oil, fuel oil, sludge, oil refuse and refined products (other than petrochemicals which are subject to the provisions of Annex II of the present Convention) and, without limiting the generality of the foregoing, includes the substances listed in appendix I to MARPOL Annex [4].

The formation of natural gas and crude oil reserves is a very long term process of millions of years as plants and animals have been broken down and undergone chemical change at high temperature and pressure. Gas and oil found trapped in porous rock-forming large sedimentary basins, which can be called as the reservoir. When pumped out of a well on land or in the seabed, there are thousands of different chemical components in crude oil, mainly organic compounds hydrocarbons which usually make up about 95 per cent of the crude oil [5].

Due to formation and components of oil makes easily pollution on the sea surface. When any simply oil spill occurs to the marine environment called as oil pollution.

2. LEGISLATION ABOUT SHIP BASED OIL POLLUTION

2.1 Terminology and Jurisdiction

To understand how the system is working, it is essential to know the terms mean in this thesis. Some definitions are given as below:

- Internal waters are waters on the landward side of the baseline, usually includes lakes, rivers and bays.
- Territorial Sea is the sea zone not exceeding 12 nautical miles (22.2 kilometres) from the baseline as declared by a Coastal State.
- High Seas is the sea area outside the above-mentioned zones.
- Flag State: The State under whose laws the vessel is registered and under whose nationality the vessel operates. The Flag State issues documentation for the vessel and also has full jurisdiction over the vessel when it is operating in the high seas.
- Port State: The State where the vessel is located at that time, in port or at an offshore terminal.
- Coastal State: The State which has jurisdiction over the waters through which the vessel is transiting or sailing [6] .

2.2 History of Oil Pollution Legislation

Until the late 1960s, it had been almost taken for granted that the oceans were so vast and could be used as waste dumping areas which would be able to cope with whatever pollution. It was recognized that especially oil powered ships, could cause pollution and both the United Kingdom and the United States introduced legislation

in the 1920s to curb discharges of oil resulting from operations such as tank cleaning. But due to the outbreak of World War II, attempts to tackle the problem at an international level failed [7]. The potential for oil to pollute was finally recognised by the International Convention for the Prevention of Pollution of the Sea by Oil, 1954 (OILPOL 1954), which was adopted in London at a conference organized by the

United Kingdom. The Convention provided for certain functions to be undertaken by the International Maritime Organization when it came into being. In fact, the IMO Convention entered into force in 1958 just a few months before the OILPOL convention, so IMO effectively managed OILPOL from the start, initially through its Maritime Safety Committee [8].

As per the OILPOL Convention, most oil pollution resulted from routine shipboard operations such as the cleaning of cargo tanks. In the 1950s, washing the tanks out with water and then pumping the resulting mixture of oil and water into the sea was the normal practice. OILPOL 54 prohibited the dumping of oily wastes within a certain distance from land and in 'special areas' where the danger to the environment was especially acute. In 1962, with an amendment adopted, the limits were extended at a conference organised by IMO [8].

When Torrey Canyon ran aground at English Channel her cargo 120.000 tons of crude oil into the sea. After this incident questions raised about preventing pollution from ships and also exposed deficiencies in the existing system when any ship based accidents occur at sea. This is the great step for the adaptation of the Marpol. First, IMO called an Extraordinary Session of its Council, which drew up a plan of action on technical and legal aspects of the **Torrey Canyon** incident. It was still recognized, however, that although accidental pollution was spectacular, operational pollution was the bigger threat. In 1969, therefore, the 1954 OILPOL Convention was again amended, this time to introduce a procedure known as 'load on top' which had been developed by the oil industry and had the double advantage of saving oil and reducing pollution. Under the system, the washings resulting from tank cleaning are pumped into a special tank. During the voyage back to the loading terminal the oil and water separate. The water at the bottom of the tank is pumped overboard and at the terminal oil is pumped on to the oil left in tank [9].

In 1969,an international conference for adopting a completely new convention was decided to be convened by the IMO Assembly, 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 [9]. IMO adopted amendments to OILPOL 1954, the size of cargo tanks in all tankers ordered after 1972 were limited in 1971.

2.3 1973 International Convention for the Prevention of Pollution from Ships (MARPOL)

Representatives from 71 countries attended to the 1973 conference. Conference resulted in the adoption of the most ambitious international treaty covering marine pollution ever adopted. Much of OILPOL 1954 was incorporated by the convention and its amendments into Annex I, covering oil, while other annexes covered chemicals, harmful substances carried in packaged form, sewage and garbage [8]. The general provision in art.6 of MARPOL 73/78 contains the obligation of Parties acting as Flag State, Port State or Coastal State, to co-operate in the detection of violations and the enforcement of the provisions of the Convention, using all appropriate and practicable measures of detection and environmental monitoring, adequate procedures for reporting and accumulation of evidence. Each Contracting Party to MARPOL 73/78 is obliged to incorporate the regulations in its national legislation, including provisions for prosecution of any discharge above legal limits. The regulations are different depending on whether the sea area has been declared ‘‘Special Area’’ or not. Specific sources of pollution are dealt with within the Annexes [10]:

	Entry into force date
- Annex I Oil	2 October 1983
- Annex II Noxious liquid substances carried in bulk	6 April. 1987
- Annex III Harmful substances carried in packaged form	1 July 1992
- Annex IV Sewage	27 September 2003
- Annex V Garbage produced by ships	31 December 1988
- Annex VI Air pollution from ships	19 May 2005 [4]

Possible sources of ship based pollution both tankers and all ships are shown in the figure below for example for all ships machinery space waste pure products for tankers both machinery space and cargo…..etc;

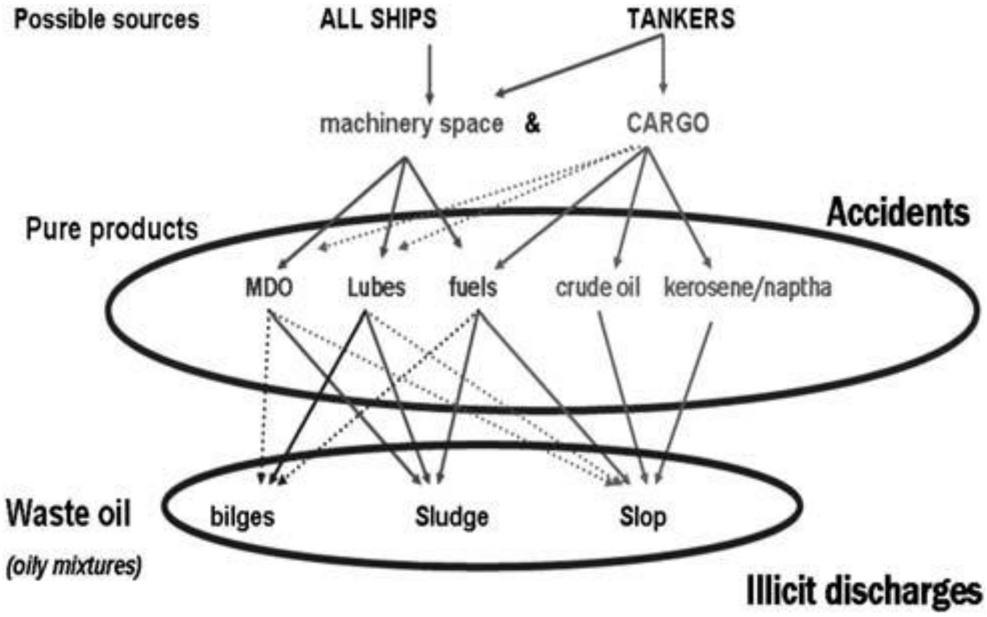


Figure 2.1: Possible sources of oil spills from different ship categories [11].

•MARPOL 73/78 Regulations Dealing With Equipment ,

There are two important Regulations for discharge oil from ships in MARPOL Annex I which detail the required equipment.

Regulation 15 describes the equipment with which oil tankers shall be provided including:

(a) Oil discharge monitoring and control systems fitted with a recording device to provide a continuous record of the discharge in liters per nautical mile and the total quantity discharged, or the oil content and rate of discharge. The system shall be such as to ensure that any discharge of an oily mixture is automatically stopped when the permitted discharge rate is exceeded;

(b) Adequate means for cleaning cargo tanks and transferring dirty ballast residues and tank washings from the cargo tanks to slop tanks; and

(c) Arrangements for slop tanks with a capacity sufficient to retain the slop generated by tank washings, oil residues and dirty ballast residues [4].

Regulation 16 contains similar regulations for the equipment dealing with oil or oily mixtures on board ships which is not carried as cargo but as fuel. These ships must be fitted with oily water separating equipment which will ensure that any oily mixture discharged into the sea after passing through the system has oil content below the limit.

Compliance with the Regulations will avoid discharges above legal limits. It follows that any discharge above legal limits will be the result either of an equipment failure (and as such ‘‘clear grounds’’ for thorough inspection in the next port of call) or a deliberate act. Any discharge or failure of the ‘‘oil discharge monitoring and control system’’ should be entered in the ‘‘Oil Record Book’’, which has to be carried on board ship.

•MARPOL 73/78 Regulations Dealing with Oil Discharge

For the purpose of Annex I, ‘‘Oil’’ is generally defined as petroleum in any form including crude oil, fuel oil, sludge, oil refuse and refined products (other than petrochemicals subject to provisions of Annex II) [4].

The oil discharge regulations in the Convention apply differently depending on whether or not the sea area has been designated a ‘‘special area’’. Oil discharges from cargo tank areas, including pump-rooma – for oil tankers of all sizes [4].

Within special areas DISCHARGES PROHIBITED Except clean or segregated ballast, outside special areas DISCHARGES PROHIBITED Except clean or segregated ballast, Or except when:

1. tanker is more than 50 nautical miles from the nearest land, and
2. tanker is proceeding en route, and
3. instantaneous rate of oil discharge does not exceed 30 litres per NM, and
4. total quantity of oil discharged does not exceed:
   – for existing tankers 1/15 000,
   – for new tankers 1/30 000 of cargo which was last carried, and
5. Tanker has in operation an oil discharge monitoring and control system and slop tank arrangement as per Regulation 15. a Oil discharges from an oil tanker falling under Table I include discharges of cargo oil residue and cargo pump-room bilges. However, the conditions in Table I also apply to discharges from machinery space bilges on oil tankers where mixed with cargo oil residue or when transferred to slop tanks Oil discharges from machinery spaces – regulations for oil tankers of all sizes and other ships bigger than 400 GRT [4]. Within special areas Oil Discharges prohibited, except when:

1. ship is proceeding on a route,
2. oil content does not exceed 15 ppm without any dilution,

3.existence of an operative certified oil filtering equipment complying with Regulation 16(5), which is fitted with an automatic 15 ppm stopping device, and
4. effluent (bilge water) is not originated from cargo pump-room bilges, and is not mixed with cargo oil residues (on oil tankers).

Outside special areas Oil Discharges Prohibited, except when**:**
1. ship is proceeding on a route,
2. oil content does not exceed 15 ppm without any dilution,
3. existence of an operative oil discharge monitoring and control system, oily water separating or filtering equipment, or other installation as required by Regulation 16,
4. effluent (bilge water) is not originated from cargo pump-room bilges, and is not mixed with cargo oil residues (on oil tankers).

Note: unprocessed oily mixtures with an oil content in the effluent not exceeding 15 ppm without dilution, and which (on oil tankers) do not originate from cargo pump-room bilges and are not mixed with cargo oil residue, may be discharged without other restrictions.

Oil discharges from machinery spaces include discharges of machinery space bilges and oil residue resulting from the purification of fuel and lubricating oils [4].

Oil discharges from machinery spaces – regulations for ships < 400 GRT other than oil tankers [4].

Within special areas *Oil Discharges Prohibited* except when oil in effluent without dilution does not exceed 15 ppm (this condition however does not apply for the Antarctic area) [4].

Outside special areas *Oil Discharges Prohibited* except when, at the judgment of the Flag State, all of the following conditions are satisfied as far as practicable and reasonable:

1. ship is proceeding on a route,
2. oil content does not exceed 15 ppm without any dilution,and
3. existence of an operative oil discharge monitoring and control system, oily water separating or filtering equipment, or other installation as required by Regulation 16.

Note: unprocessed oily mixtures with an oil content in the effluent not exceeding 15 ppm without dilution may be discharged without other restrictions [4].

‘‘Special areas’’ for oil (annex I) are:

(i) the Baltic Sea

(ii) the Black Sea

(iii) the Mediterranean Sea

(iv) the Antarctic area

(v) the Red Sea

(vi) the Gulfs area

(vii) the Gulf of Aden

(viii) the North-West European Waters (incl. the North Sea and its approaches, the Irish Sea and its approaches, the Celtic Sea, The English Channel and its approaches and part of the North-East Atlantic immediately to the west of Ireland)

(ix) the Oman Sea.

Oil discharges from machinery spaces regulations for oil tankers of all sizes and other ships bigger than 400 GRT [4]. Oil residues which cannot be discharged into the sea complying with the regulations briefed above, should be retained on board or delivered to reception facilities. Relevant parties such as port authorities have the duty to establish reception facilities as per MARPOL 73/78 requirements. It is however to be noted that, in some areas of the world, such facilities are not available and ships may then have difficulty in delivering their residues. The 15 ppm limit is the key parameter to identify legal discharges of ballast and from machinery spaces in special areas and legal discharges from machinery spaces outside special areas.

3. TECHNICAL INFORMATION ABOUT VESSELS

Ship generates oily waste products due to usage of consuming heavy fuel oil, marine oil and lubricating oil for all types power driven vessels. On the other hand routine tanker operations cause oily waste water.

3.1 How Oily Waste is Generated

Three categories of oily waste generally accumulate onboard large vessels. These are:

●Bilge waste

Machinery spaces on large commercial vessels contain a wide array of complex engineering systems to propel and power the vessel. Supporting systems include those used to manage fuel, lubrication, fuel and lubricating oil purification, saltwater service, bilge and ballast, fire fighting and sewage. Each system contains numerous pumps, fittings, control devices and other components, along with extensive lengths of piping. All components are engineered to prevent and minimize leakages through the use of mechanical seals, gaskets, etc [6].

Waste production occurs everyday. These productions occur because the shipboard machinery spaces are so big, very long piping, thousands of fittings and connections, and leaks from large number of pumps installed. Additionally, condensation from cooling systems of many kinds such as air, water, evaporators, etc. As per the type and size of vessels the names and arrangement of oily waste tanks on board differ.

All vessels over 400 gt are required to have tanks for collecting oily residues (sludge) and they should be of a size that is adequate to the operation of the vessel [6].

Sludge tanks are separate, independent (generally), and/or combined. Bilge water holding tanks are not mandatory but fitted to most vessels. Vessels over 400 gt are also required to be fitted with oil filtering equipment that may include any combination of a separator, filter or coalescer, and also a single unit designed to produce an effluent with oil content not exceeding 15 ppm. Pumps, piping, valves, and other equipment will connect to the different tanks and facilitate the transfer of bilge and other oily wastes throughout the machinery space or engine room [6].

The International Oil Pollution Prevention Certificate (IOPP) and appendix should give information regarding the tanks and equipment onboard for the handling of oily waste. The vessel should have piping and tank diagrams for the various systems. A tank plan with piping diagram should be found with IOPP certificate and Oil Record Book .

●Sludge waste

Nowadays mostly ships burn low quality heavy fuel oil in their engines. Many contaminates exist in this type of fuel. In order to prevent damage to engine systems and improve combustion, the fuel should be purified. After purifying the residues (both the sludge and fluid contaminates) drain to a sludge tank. Purifying method is also used for main and auxiliary engine lubricating oil. The lubricating oil, fuel oil, cylinder oil sludges and oil from dirty oil tanks may be stored in a single waste or sludge tank. Compared with bilge waste, fuel oil sludge is generally less varied and the quantities are more predictable, provided the quality of the fuel oil remains constant. As a general rule of thumb, approximately 1-2% of the heavy fuel oil burned in a vessel's main engine and generators ends up as sludge. The quantity could vary depending on the fuel's quality, its compatibility with previous shipboard fuels and the condition of the equipment used to store, transfer and heat it [6].

•Oil cargo residue waste

Tankers (product, chemical and crude) carry oil in bulk and generate oil cargo waste residues. Tankers have various tanks and may carry many different cargos at the same time. After each change of cargo type, cargo tanks should be cleaned. One of the methods of cleaning tanks is Steam cleaning cargo tanks after carrying petroleum products which produces oily waste. Another method of cleaning process is using a sprinkler-like device, named as "Butterworth" machine that uses sprays pressurized hot water in the cargo tanks which results in a greater amount of oily tank waste than steam cleaning.

●Product tankers

At the end of cargo discharge, the cargo tanks should be completely pumped out ,except a quantity of "unpumpable residue" in each tank. There are several factors affecting the "unpumpable" quantity in each tank as listed below :

– Cargo density
– Temperature
– Trim of the vessel during the stripping operation
– Efficiency of the vessel's cargo equipment/pumps etc
– Efficiency of the vessel's crew
– Design and shape of tank internals.

In a modern product tanker, the "unpumpable" quantities will usually be small, (around 200 litres per tank) but this figure will vary significantly due to the size of the cargo tank/arrangements and the factors noted above [6].

The vessel may also have quantities of cargo in the cargo stripping pipelines and pumps which should be limited to a few cubic metres only. Tankers should carry out cargo tanks washing for the preparation of its next cargo. For the subject operation a quantity of seawater (amount varies as per the requirements) will be taken into a slop tank. By using one of the above mentioned methods, this water is recycled from the slop tank through the cargo tank washing system. At the end of tank washing operation and stripping of the washed tanks and pipelines, contaminated water stored in the slop tank. Quantity of this water will be measured and recorded and calculated as cubic meters.

The vessel may choose to discharge a quantity of the slops (water) through its Oil Discharge Monitoring and Control system after the slops/cargo residues have settled out and the interface-measured quantities have been calculated, in accordance with MARPOL73/78 requirements. The vessel will arrive at the load port terminal with a quantity of slops made up of cargo residues. These slops will usually be discharged for processing in the terminal. The slop tank is cleaned again and the washings discharged ashore in preparation for taking on the next cargo. [6]

●Disposal of wastes

There are three legal options for dealing with sludge and bilge water waste. The sludge should be stored on the vessel for disposal ashore or burnt in the incinerator.

Bilge water is first pumped to a bilge water holding tank. Within new technology new this system may have been automated. Then bilge water is pumped to the Oily Water Seperator by bilge pump. Other method for dealing with bilge water is storing and delivering ashore as disposal. Oil filtering equipment consists of any combination of separator, coalescer or other equipment that separates oil and water, and is commonly referred to as an Oily Water Separator (OWS). This equipment is required to be designed and tested to separate oily water mixtures to a maximum limit of 15 parts oil to one million parts water (15 ppm). The equipment may be fitted with an Oil Content Meter (OCM) and automatic stopping device which prevents the discharge of any effluent above the 15 ppm limit, but this is only required on vessels over 10,000 gt. Such equipment must be approved to international standards under MARPOL73/78. The approval standards are specified in IMO Resolutions [6]. An example of oily water separator is given below:

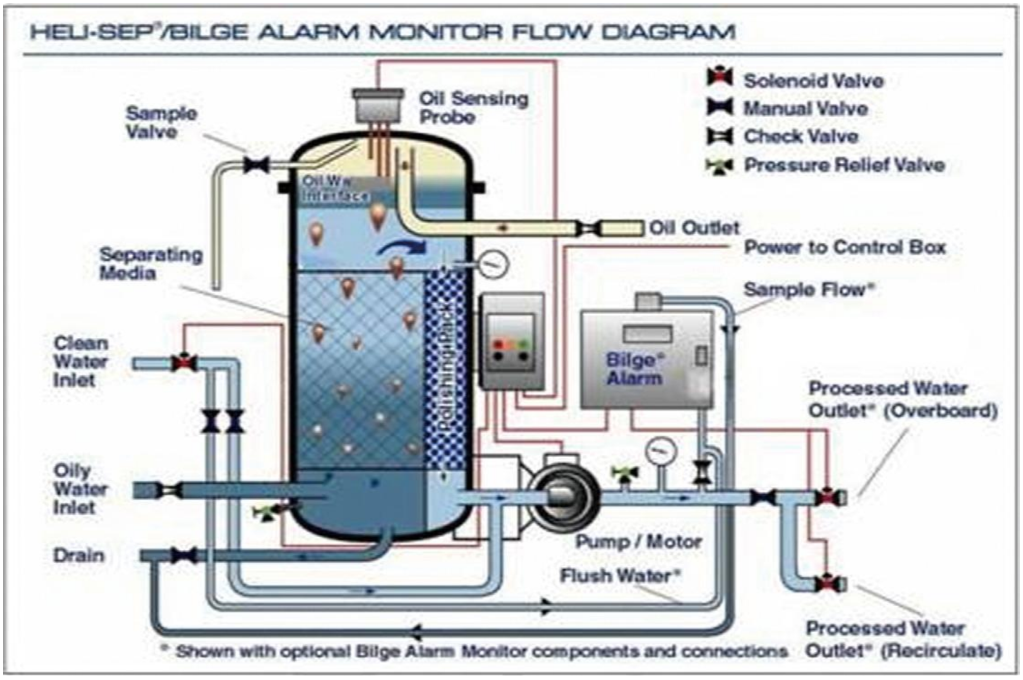


Figure 3.1: Example of oily water separator with bilge alarm [6].

Above diagram is a good example for an Oil Content Monitor which is used for sampling and measuring the Oily Water Separator effluent during normal discharging. In case of a discharge containing oil in excess of 15 ppm, system raises an alarm and also automatically secures the overboard discharge valve on the processed water outlet. Then by opening the recirculation valve, the discharge fluid returns to the bilge water holding tank or bilges.

In spite of the fact that all Oily Water Separators must be equipped with a system as above, it is mandatory for only vessels greater than 10,000 gt to have a system fitted with an alarm and automatic stopping device. The IOPP certificate should state if it is fitted with such items. In proper operating condition of an Oily Water Separator when the equipment is not attempting to process oil and water emulsions, oil-free water is discharged into the sea, and oily waste is discharged into a sludge tank for incineration or disposal ashore. All kinds of oil transfers, disposal of sludge and bilge water, incineration of oily waste and the overboard discharges via the Oily Water Separator should be recorded in The Oil Record Book Part I3. Also regarding cargo and ballast operations, all loading/unloading of oil cargo, internal transfers, ballasting of cargo tanks, discharge of water from slop tanks and disposal of oil residues should be recorded in the Oil Record Book Part II4.

The formats of the Oil Record Books Parts I and II are contained in Appendix III of Annex I of MARPOL73/78. An example is shown below for the Oil record Book.

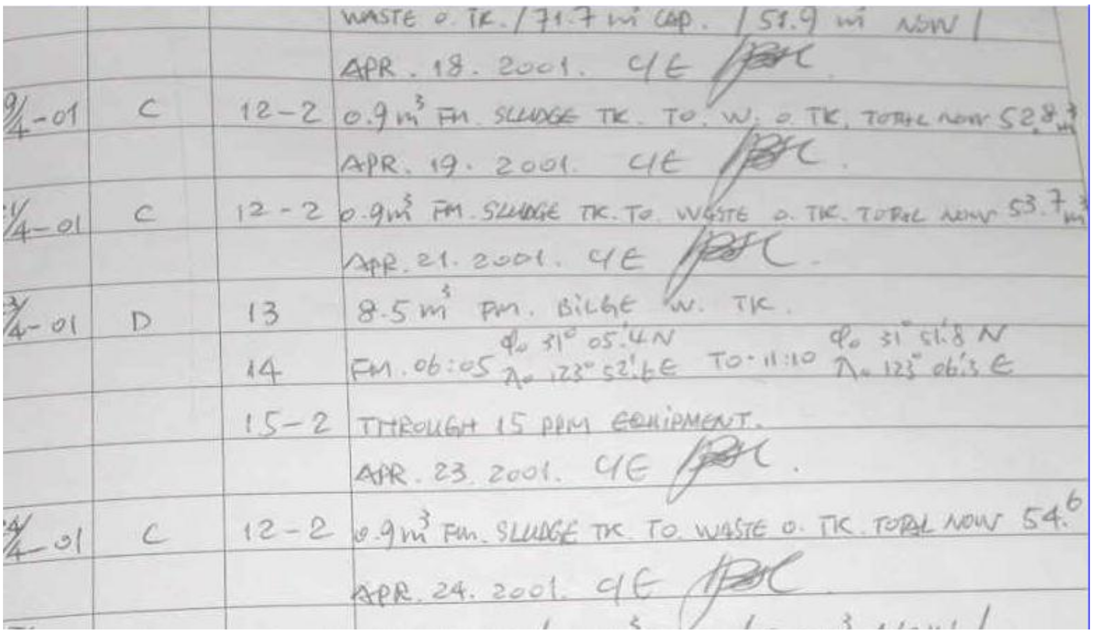


Figure 3.2: Entries in an oil record book part I. [6]

3.2 Elements of Proof for Illegal Discharges

Discharging all kinds of oil or oily mixtures into the sea is prohibited. This rule covers both discharges from the machinery spaces of all vessels of 400 gt and above and discharges from cargo spaces of oil tankers. Only the discharges of effluent with oil content not exceeding 15 ppm which are processed through the use of a certificated oil filtering and monitoring equipment are permitted. Vessels less than 400 gt should store the oil or oily mixtures onboard for discharging to shore facilities or use a system approved by the Flag State as described above not letting the discharges exceeding 15 ppm of oil content. Tankers are permitted to discharge oil cargo residues if the distance from the nearest land is more than 50 nautical miles and in accordance with the specific conditions of Regulation 34 of MARPOL73/78. After these permitted discharges a sheen on the sea surface may be observed. Stricter enforcement of MARPOL73/78 provisions may also be required in Special Areas and Particularly Sensitive Sea Areas. These areas are declared and approved by the International Maritime Organization (IMO). After the adoption of IMO Resolution in 1993, proving illegal discharges at sea has been easier. This resolution endorsed research undertaken by the Netherlands demonstrating that an oily mixture with a concentration of 15 ppm cannot be observed either visually or with remote sensing equipment. The lowest concentration of oil in a discharge where the first traces can be visually observed is 50 ppm. Therefore; any visible traces of oil at sea or in waters near a vessel, indicate a violation and should be investigated.

3.3 Types of Discharge Violation

Some methods which vessels may use to attempt to conceal illegal oil discharges can be mentioned as bypassing pollution prevention equipment, declaring false and corrupted records and tampering with Oily Water Separation equipment.

3.4 Oil Discharges from Tankers Machinery Spaces and All Spaces on Other Type of Vessels

Bearing in mind that there are stricter discharge conditions for “Special Areas” under MARPOL73/78, vessels of 400 gt and above, and all oil tankers, are subject to restrictions with regard to discharging oil and oily mixtures into the sea. If the vessel is underway, the oil content is less than 15 ppm and the oily mixture is processed through approved oil filtering equipment, vessels may discharge oil or oily mixtures from the machinery spaces. An alarm and automatic stopping device in operation should be fitted to the vessels of 10,000 gt and above. System should be activated when the oil content in the discharge from the oil filtering equipment exceeds 15 ppm. To use a bypass equipment to circumvent a vessel’s Oily Water Separator and Oil Content Meter is considered as a violation of MARPOL73/78 regardless of proof of oil content due to not processing the oily mixture through the pollution prevention equipment as required.

•Discharge of oil or oily mixtures from tankers cargo areas

Due to their cargo (which is oil),tankers are treated separately from other vessels as per MARPOL 73/78 rules. The requirements for oil tankers vary depending on the space in the vessel from where the oil is discharged, the flag of the tanker and the distance of the tanker from the nearest land and its location during the discharge.

In case of complying with certain requirements to limit the pollution, seagoing tankers of 150 gt or more may only discharge overboard oily waste mixtures produced as a result of tank cleaning. These vessels should be equipped and use a pollution control system known as the Oil Discharge Monitor and Control system in order to perform such discharges. Discharges should also be recorded in an Oil Record Book (Part II). Vessels should retain the oily mixtures on board for delivering to a reception facility, if the vessel cannot comply with the pollution prevention requirements. Below table shows the diagram of cargo space discharges from tankers.

4. OIL SPILL

4.1 From Crude Oil to Various Oil Products

Viscosity, volatility, and toxicity are the main differences between oil kinds. Viscosity can be described as oil's resistance to flow. Volatility refers to how quickly the oil evaporates. Toxicity refers to how poisonous; the oil is to human nature or other organisms. Spill of the various types of oil may affect the environment differently. The oil spill cleaning operations and methods may also differ. Spill responders categorize oil into four basic types. Here is a list of these four types, along with a general summary of how each type can affect environment.

- Very light oils (jet fuels, gasoline)
- Highly volatile that evaporates within 1-2 days.
- High concentrations of toxic (soluble) compounds.
- Localized, severe impacts to water column and intertidal resources
- Cleanup is not possible.
- Light oils (diesel, no. 2 fuel oil, light crudes)
- Volatile that leaves up to one-third of spill amount as residue after a few days
- Moderate concentrations of toxic (soluble) compounds.
- Has a long term contamination potential for intertidal resources.
- Cleanup can be very effective.
- Medium oils (most of the crude oils)
- About one-third evaporates within 24 hours.
- High potential of severe and long term oil contamination of intertidal areas.
- Oil impacts to waterfowl and fur-bearing mammals can be severe.
- Cleanup most effective if conducted quickly.
- Heavy oils (heavy crude oils, no. 6 fuel oil, bunker)
- Heavy oils with little or no evaporation or dissolution.
- Heavy contamination of intertidal areas.
- Severe impacts to waterfowl and fur-bearing mammals (coating and ingestion).
- Long-term contamination of sediments possible.

- Weathers very slowly.
- Shoreline cleanup difficult under all conditions.

4.2 Effect and Behaviour of Oil

Important physical and chemical properties of oils that will affect the behaviour and effects of oil in water and aquatic environments are its surface tension, specific gravity, and viscosity. The composition and characteristics of an oil, together with a number of circumstances relating to the time and place of the spill, the amounts of oil, weather conditions etc. will determine how persistent the oil will be, how it will spread, whether it will evaporate or sink, etc [12].

4.3 History of Biggest Oil Spill Disasters

Oil spill can be described as the release of liquid petroleum hydrocarbon into the sea or coastal waters, due to some human activities as listed below:

- Leakages due to the collision, agrounding, sinking, etc of oil carrying vessels.
- Vessels, Oil Pipelines and oil platforms/wells.
- Countries at war.
- Illegal dumping by Industries.
- Terrorist activities, sabotages.
- Natural Disasters (Act of Allah)

Results of Oil Spill;

- Thick oil film covers the surface of water. (Darker the Thicker)
- Affects entire marine and natural life.
- Mass fish deaths.
- Nature needs up to 10 years to recover, if oil reaches the sea bed.

The movement of oil slick on the sea surface is showed below with effect of wind and current.

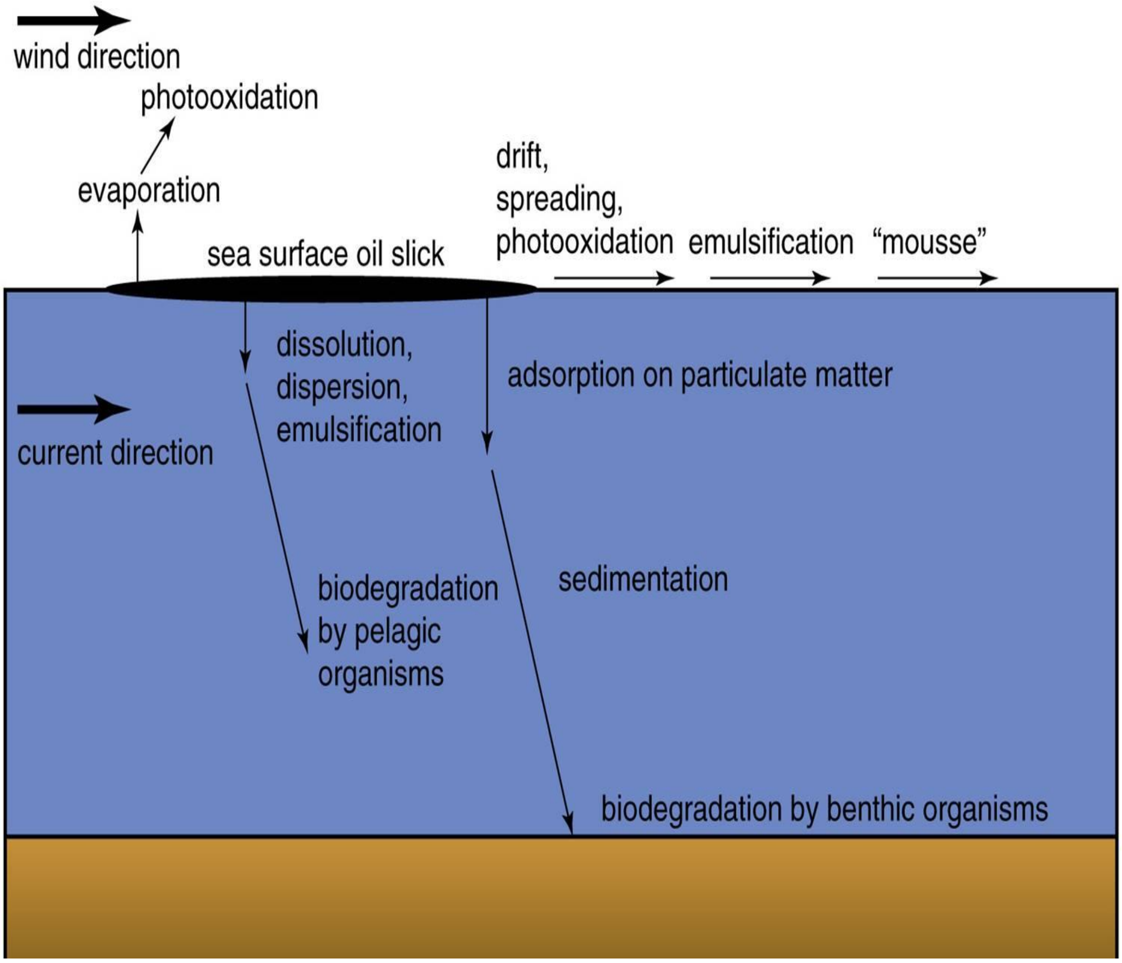


Figure 4.1:.Progress of oil spill on the sea surface. [13]

4.4 Major inputs of Petroleum to the Marine Environment

Major inputs of Petroleum to the Marine Environment as described below:

- 37% comes from Industrial wastes, reach the sea, via storm water drain, creeks, sewage and rivers.
- 33% from oil vessels during transportation.
- 2% during explorations and
- 12% from accidents involving tankers.
- 7% comes from natural sources like fissures from sea bed.
- 9% absorbed from atmosphere [13].

4.5 Major Oil Spills

Fortunately, the number of marine accidents and the volume of oil released is on the decline (see graph, blue line, right scale). The average number of oil accidents of more than 700 tonnes dropped from 25 in the 1970s and nine in the 1980s, to 3.8 between 2000 and 2004 acording to International Tanker Owners Pollutio Federation Limited. [14]

4.5.1 Around world

- *Argo Merchant*, On December 15, 1976, the Liberian tanker Argo Merchant ran aground on Fishing Rip (Nantucket Shoals), 29 nautical miles southeast of Nantucket Island, Massachusetts. Her cargo was approximately 183,000 barrels of No. 6 Fuel Oil (80%) and cutter stock (20%). Attempts to lighter and re-float the vessel were unsuccessful. Two days later the vessel broke in two and sunk spilling approximately 36,000 barrels of cargo. Prevailing currents carried the spilled oil away from the shorelines and beaches of Nantucket.

Figure 4.2: Argo Merchant accidents. [15]

Amoco Cadiz Oil Spill – France, On March 16, 1978, the Amoco Cadiz ran aground on Portsall Rocks, three miles off the coast of Brittany due to steering failure. The vessel had been sailing from the Arabian Gulf to Le Havre, France. The entire cargo of 1,619,048 barrels, spilled into the sea. A slick 18 miles wide and 80 miles long polluted approximately 200 miles of Brittany coastline. Beaches of 76 different Breton communities were oiled. The isolated location of the grounding and rough seas restricted cleanup efforts for two weeks following the incident. Severe weather resulted in the complete break up of the ship before any oil could be pumped out of the wreck.

Ixtoc 1 Oil Well, 1979, in June 1979, an oil well in the Bay of Campeche collapsed after a pressure buildup sparked an accidental explosion. Over the next 10 months about 140 million gallons of crude spouted into the Gulf of Mexico from the damaged oil well.

Atlantic Empress, in July 1979, two full super tankers collided off the coast of Tobago in the Caribbean Sea, precipitating the largest ship-sourced oil spill in history. Both vessels began to leak their crude and caught fire. The Atlantic Empress, stubbornly ablaze, was towed farther out to sea until it exploded 300 nautical miles offshore.26 crew were killed in the disaster and nearly 90 million gallons of crude was dumped into the sea.

Figure 4.3: Atlantic Empress [16].

Burmah Agate, on November 1 1979, the Burmah Agate and the Mimosa collided at the entrance to Galveston Harbor. The Mimosa struck the Burmah Agate on its starboard side, tearing a hole in the hull near Cargo Tank No. 5. An explosion occurred upon impact, and the leaking oil ignited.

Nowruz Oil Field, During the Iran-Iraq War, an oil tanker crashed into the Nowruz Field Platform in the Persian Gulf and knocked it askew, damaging the well underneath. Due to the war the oil well had leaked about 1500 barrels a day for seven months.

Castillo de Bellver, caught fire about 70 miles northwest of Capetown, South Africa, on August 6 1983. The tanker was abandoned and drifted offshore until it eventually broke in half. The stern capsized and sank into the deep ocean, with some 110,000 ton of oil remaining in its tanks. The bow section was towed away and sunk in a controlled explosion. The vessel was carrying nearly 79 million gallons of crude at the time of the accident.

Odyssey Oil Spill, 1988, in November 1988 the Liberian tanker *Odyssey,* fully loaded crude oil, broke in two and sunk in the North Atlantic 700 miles off the coast of Nova Scotia. It also caught fire as it sunk.

Exxon Valdez, the oil slick (blue areas) eventually extended 470 miles southwest from Bligh Reef. The spill area eventually totalled 11,000 square miles.[17]

On March 24 1989, the tanker *Exxon Valdez,* en route from Valdez, Alaska to Los Angeles, California, ran aground on Bligh Reef in Prince William Sound, Alaska. The vessel was traveling outside normal shipping lanes in an attempt to avoid ice. Within six hours of the grounding, the *Exxon Valdez* spilled approximately 10.9 million gallons of its 53 million gallon cargo of Prudhoe Baycrude oil. Eight of the eleven tanks on board were damaged. The oil would eventually impact over 1,100 miles of non-continuous coastline in Alaska.

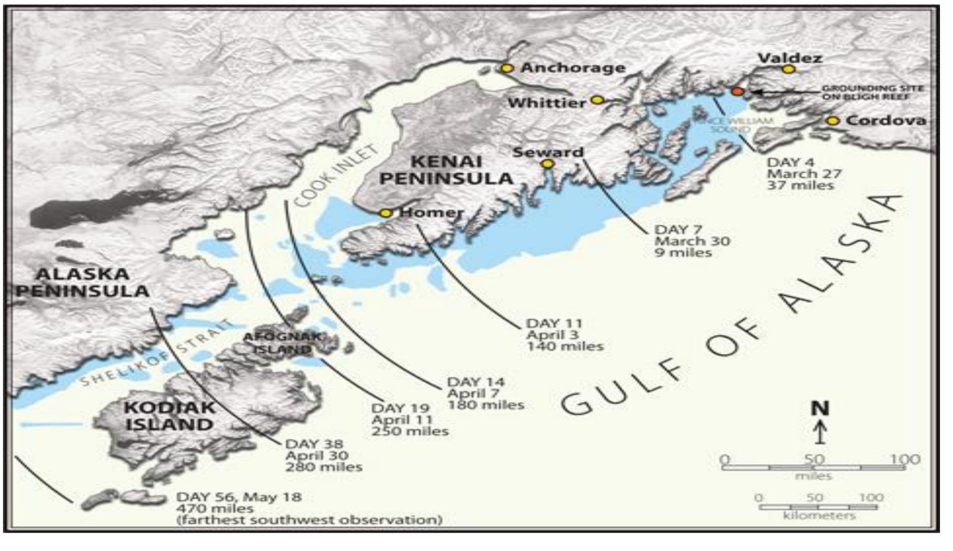


Figure 4.4: Exxon Valdez oil spread [18].

Supertanker Exxon Valdez, 24 Mar 1989, 9:12 p.m. ran aground on Bligh Reef in Prince William Sound, Alaska.

-11 million gallons of crude oil spilled

- Wind & current carried spill to 1,500 miles of shoreline

- Dead: 500,000 birds (90 species)

-4,500 sea otters

- 14 killer whales
- No human life lost, though 4 deaths associated with cleanup
- Immeasurable toll on tourism & fishing industry

After the oil spill, marine lives ruined dramatically as shown below;

Figure 4.5: Exxon Valdez damages.[19]

Barge Cibro Savannah, On March 6 1990 the barge Cibo Savannah exploded as it was being pulled from the dock at Linden, New Jersey. 710,000 gallons of number two fuel oil have been spilled from two tanks. Potential is a total of 4,000,000 gallons in twelve tanks.

Megaborg, in Gulf of Mexico two ship had a collision, as a result of the explosion, a fire started in the pump room and spread to the engine room. It is estimated that 100,000 barrels of crude oil was burned or released into the water.

Arabian Gulf Oil Spills – Gulf WarDuring the 1991 Gulf War, tankers and oil terminals in Kuwait were destroyed, causing oil pollution that estimated 6-8 million barrels of oil into the waters of the Arabian (Persian) Gulf.

Barge Bouchard 155, After the collision Barge Bouchard 155 was holed at the port bow spilling about 8,000 barrels of fuel oil into Tampa Bay. S

M/T Prestige, suffered a fracture in the side shell on 14 November 2002 during a spell of very severe weather outside Spain. The M/T Prestige was a 1976 built Pre-Marpol single hull crude oil tanker. She sank releasing over 20 million gallons of oil into the sea.

Deepwater Horizon, a semi-submersible drilling rig, sank on April 22, after an April 20th explosion on the vessel. Eleven people died in the blast. When the rig sank, the riser—the 5,000-foot-long pipe that connects the wellhead to the rig—became detached and began leaking oil. In addition, U.S. Coast Guard investigators discovered a leak in the wellhead itself. As much as 60,000 barrels of oil per day were leaking into the water, threatening wildlife along the Louisiana Coast. Homeland Security Secretary Janet Napolitano declared it a "spill of national significance." BP (British Petroleum), which leased the *Deepwater Horizon,* is responsible for the cleanup, but the U.S. Navy supplied the company with resources to help contain the slick. Oil reached the Louisiana shore on April 30, affected about 125 miles of coast. By early June, oil had also reached Florida, Alabama, and Mississippi [20]. Some pictures are shown for the effect of oil spill on marine life.

Figure 4.6: Gulf of Mexico oil spill disaster [21].

Figure 4.7: Gulf of Mexico oil spill – Deep Water Horizon [21].

4.5.2 Istanbul Strait / Bosporus Strait

The Bosphorus (Turkish Boğaziçi or İstanbul Boğazı) is the strait separates the European part (Rumeli) of Turkey from its Asian part (Anadolu), connecting the Sea of Marmara (Marmara Denizi) with the Black Sea (Karadeniz). It is an important oil transit chokepoint. It is 30 km long, with a maximum width of 3,700 meters at the northern entrance, and a minimum width of 750 meters between Anadoluhisarı and Rumelihisarı. The depth varies from 36 to 124 meters in midstream. It is a former river valley that was drowned by the sea at the end of the Tertiary period. The city of Istanbul straddles the Strait with a population of more than 11 million people [22].

4.5.2.1 Oil transportation in the Straits

The Bosporus Straits are one of the world's busiest (50,000 vessels annually, including 5,500 oil tankers), and most difficult-to-navigate waterways. Some of the export routes for crude oil production from the Caspian Sea region pass westwards through the Black Sea and the Bosporus Straits en route to the Mediterranean Sea and world markets. The largest expansion of transit volumes would come from the expansion of the CPC oil pipeline. The ports of the Black Sea, along with those in the Baltic Sea, were the primary oil export routes of the former Soviet Union, and the Black Sea remains the largest outlet for Russian oil exports. Exports through the

Bosporus Straits have grown since the breakup of the Soviet Union in 1991, and there is growing concern that projected Caspian Sea export volumes exceed the ability of the Bosporus Straits to accommodate the tanker traffic. Turkey is concerned that the projected increase in large oil tankers would pose a serious navigational safety and environmental threats to the Bosporus Straits. The largest oil tankers that can pass through the Bosporus Straits are the Suezmax class tankers (120,000-200,000 dead weight tons) [22].

4.5.2.2 Marine pollution concerns

İstanbul Strait is very narrow and shipping traffic is very high, it brings too much accident risk seriously both concerned about enviromental and endanger lives of almost 12 hundred million citizen. After the Cold War The Straits had an increase in shipping traffic after the end of Cold War. Vessels are mostly crude oil or liquefied natural gas tankers. This brings number of accidents; from 1988 to 1992, there were 155 collisions in the Straits. In January 2001, VTS (Vessel Traffic Service) began on building a comprehensive radar and vessel control system for Straits. With the high volume of oil being shipped through the Bosporus, oil tanker accidents can release large quantities of oil into the marine environment. This danger was underscored in March 1994, when the Greek Cypriot tanker Nassia collided with another ship, killing 30 seamen and spilling 20,000 tons of oil into the Straits. The resulting oil slick turned the waters of the Bosporus into a raging inferno for five days, but because the accident occurred in the Straits a few miles north of the city, a potential urban disaster was averted. As the number of ships through the Straits grows, the risk of accidents increases, and traffic will likely increase as the six countries surrounding the Black Sea develop economically. With tonnage on the rise as well, the threat of collision is not the only danger: on December 29, 1999, the Volgoneft-248, a 25-year old Russian tanker, ran aground and split in two in close proximity to the southwest shores of Istanbul. More than 800 tons of the 4,300 tons of fuel-oil on board spilled into the Marmara Sea, covering the coast of Marmara with fuel-oil and affecting about 5 square miles of the sea [23].

5. BLACK SEA REGION

5.1. Black Sea

Black Sea is one of the largest inland sea with a surface of 420.000 km ^{2}. It is connected to the World Oceans via the Mediterranean Sea through the Turkish Straits, Gibraltar Strait and with the Sea of Azov through the Kerch Strait. The Black Sea shoreline is 4,340 km long with Bulgaria, Georgia, Romania, Russia, Turkey and Ukraine.

5.1.1 Overview

The Black Sea is the most isolated sea in the World. It is connected to the World Oceans via the Mediterranean Sea through the Bosphorus, Dardanelle and Gibraltar straits and with the Sea of Azov in the northeast through the Kerch Strait. The Black Sea is slowly recovering from a deep environmental crisis it entered during the last few decades, when it has become one of the most environmentally degraded regional seas on our planet [24]. 87% of the Black Sea water is naturally anoxic. Having in mind this fact,Black Sea is highly sensitive to anthropogenic impacts due to the huge catchment area and almost landlocked nature. Rivers pour about 350 cubic kilometres of water into the Black Sea annually. Due to this high amount of water, Black Sea can be considered as an overflowing bowl. This water carries lots of different contaminants originated from the activity of more than 170 million people living in 17 different countries along river banks.

The sea continues to suffer from a long list of ailments:

- pollution by land-based sources;
- losses of biodiversity as a consequence of pollution and the destruction of habitats;
- overexploitation of marine living resources leading to a collapse of fisheries, etc, having a significant impact on the ecosystem health. [25] The figure shows main industrial source of pollution in the Black Sea.

Figure 5.1: Main industrial sources of pollution in the Black Sea basin. [25]

The level of potential operational and accidental risk of oil spills with consequent oil pollution of marine and coastal environment is very high in the Black Sea. Main sources of such oil spills are as follow:

- Oil pipelines:
  - Potential risks due to pipes deterioration;
  - Oil leakage during the illegal incuts to pipelines
- Operational oil spills during reloading and trans-shipment
- Oil transportation by sea/rail:
  - Carriage by rail (tank insecurity) and sea (tankers insecurity; storms, mists)
- Oil refineries

The rising risk of accidental oil spills from oil transport is clearly visible from the number of tankers passing the narrow Bosphorus strait which can have a dramatic consequences for population and for environment in case of major accidents [25].

5.2 Geographic and General Information

Black Sea States are Bulgaria, Georgia, Romania, Russian Federation, Turkey and Ukraine. Coastline length of Black Sea is 4340 km.

5.3 Oceanographic Information

The seabed is divided into the shelf, the continental slope and the deep-sea depression. The shelf occupies a large area in the north-western part of the Black Sea, where it is over 200 km wide and has a depth ranging from 0-160 m. In other parts of the sea it has a depth of less than 100 m and a width of 2.2 to 15 km. The maximum depth of the Black Sea is 2,212 m. The surface area of the Black Sea is 432 000 km2 with a total volume of 547 000 km3 [26].

The Black Sea circulation is characterized by a cyclonic system of currents that is common for the basin. In years with intensive thermodynamic conditions, a distribution of the general dynamic system into sub-basin systems western and eastern cyclonic whirls can occur in the air above the sea. The dynamic system of the Black Sea has a distinct yearly cycle. Maximum circulation intensity takes place in winter and spring when the sea accumulates potential and kinetic energy due to intensive winter thermodynamic interaction within the sea-atmospheric system. [26]
The replenishment of the bottom waters of the Black Sea with new seawater from the Mediterranean takes hundreds of years. This very slow rate of replenishment and the large input of freshwater have led to a stratification of the Black (Black Sea NGO Network 2004). The thin upper layer of marine water (up to 150 m) supports the unique ecosystem. The deeper and more dense water layers are saturated with hydrogen sulfide, that has accumulated from decaying organic matter. [26]
The slow replenishment and the bad mixing of waters does not provide enough oxygen for the process of decomposition and the bacteria in the lower layers use it up entirely. Consequently the Black Sea is virtually dead below a depth of about 180 m and this boundary is being pushed up. Moreover the metabolism of some bacteria generates hydrogen sulphide, a soluble poisonous gas associated with the smell of

rotten eggs. Hydrogen sulphide is present in the entire lower layer of seawater in the Black Sea. [27]

5.4 Coastal Geography and Geology

The Black Sea is the most isolated sea in the World. It is connected to the World Oceans via the Mediterranean Sea through the Bosphorus, Dardanelle and Gibraltar straits and with the Sea of Azov in the northeast through the Kerch Strait. The Bosphorus is essentially a narrow elongated shallow channel approximately 31 km long, with a width varying between 0.7-3.5 km and a depth of 39-100 m [26]. The catchment drainage area of the Black Sea is 2 000 000 km2 with the total river inflow 340.6 km^3 [26]. The sea now suffers from a long list of ailments. Pollution by land-based sources, the loss of biodiversity as a consequence of pollution and the destruction of habitats, over-exploitation of marine living resources leading to a collapse of fisheries; all these have made a significant impact. In addition, there are problems associated with coastal degradation, water borne diseases, the introduction of opportunistic exotic species, and maritime pollution caused by the transportation of oil and other hazardous substances. All these have led to an almost total breakdown of the sea's ecosystems and have hampered the social and economic development of the coastal countries [28].

Therefore Black Sea is very special nearly closed sea and needed to be protected. All above major problem of Black Sea is marine oil pollution. Marine oil pollution sources are ships,oil platforms and oil connections and pipelines. As described below Black Sea is special area according to Marpol Annex –I Regulation. To fight the accidental and operational oil pollution Black Sea Countries have taken action.

Black Sea - it is a region of economical and geo-political sensibility and a connection between East and West and means in bound transport and energy supplies (Fig 5.2); Specific in the Black Sea the oil in water concentration along the main shipping routes is higher then the normal limits (of 15 ppm) [29].

5.5 Fighting with Pollution and Protection of Black Sea

The effort of the coastal states to safeguard the sea is based on the Convention on the Protection of the Black Sea against Pollution (Bucharest Convention) and its three Protocols. The document was signed in 1992 by the six coastal states.

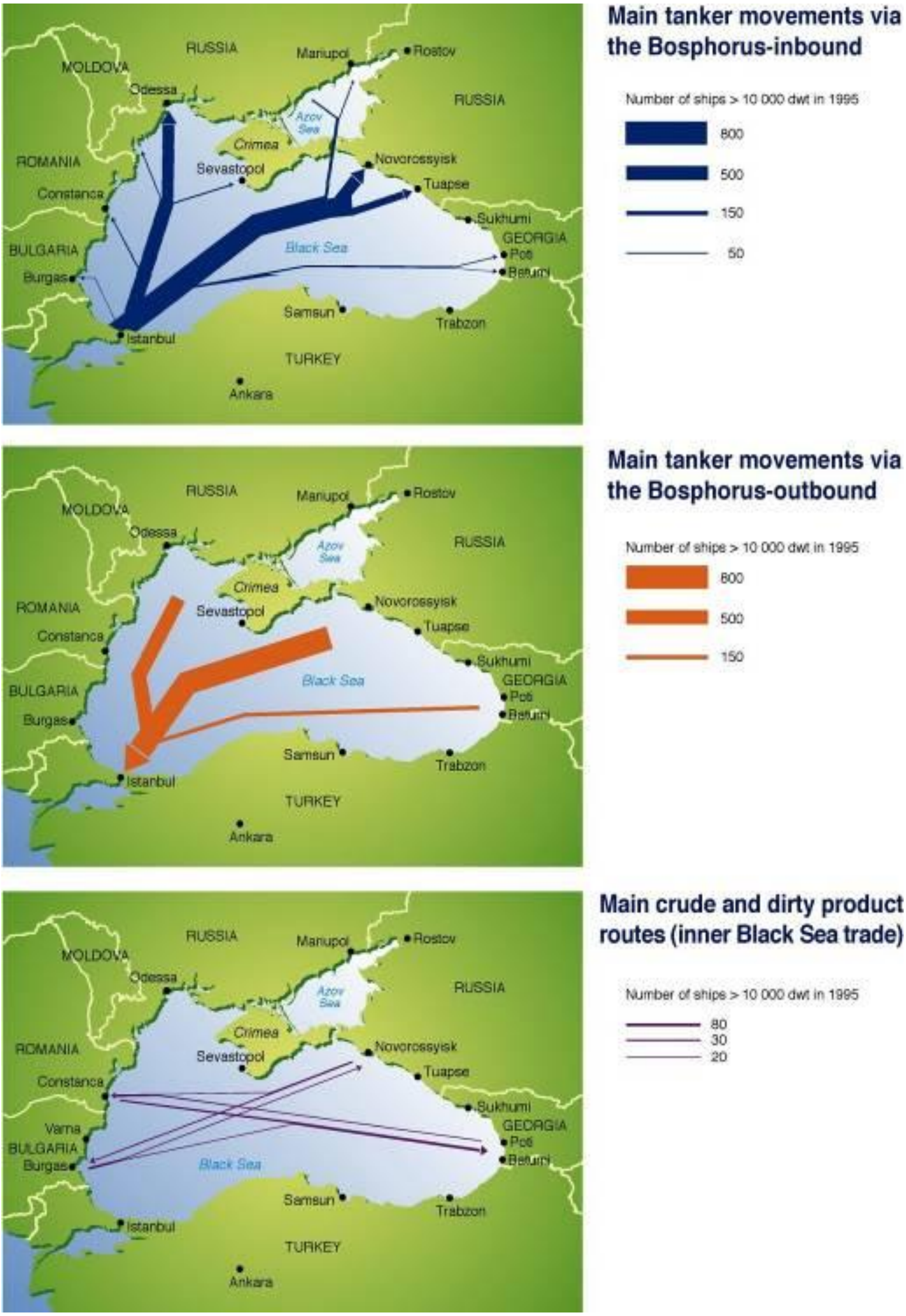


Figure 5.2: Black Sea trade patterns [29].

A Strategic Action Plan on the Rehabilitation and Protection of the Black Sea was adopted in 1996, a comprehensive document which set out the essential policies and measures of implementation in this area.[28] With the establishment of the Commission on the Protection of the Black Sea against Pollution (BSC) and its Permanent Secretariat, for the first time, the efforts of the coastal states to recover the Black Sea were put on sound institutional and financially sustainable ground. Funded by the governments of the contracting parties to the Convention, the new organization is also attracting substantial technical and financial assistance from international donors. It is also bridging the gaps between the programmes and projects funded by the major donors. The BSC co-operates with numerous organizations, which share the objectives of the Convention and/or conduct significant activities on the field of marine and coastal environment [28].

The Black Sea Environmental Programme (BSEP) is the first UNDP/GEF project for technical assistance to the Black Sea countries. Many other partner organizations and multilateral and bilateral donors joined the effort to improve the sea's unique ecosystem [28].

The Convention on the Protection of the Black Sea against Pollution was adopted in 1992 and entered into force 1994. was signed in Bucharest in April 1992, and ratified by all six legislative assemblies of the Black Sea countries in the beginning of 1994. Also referred to as "Bucharest Convention", it is the basic framework of agreement and three specific Protocols, which are [30]:

(1) the control of land-based sources of pollution;
(2) dumping of waste; and
(3) joint action in the case of accidents (such as oil spills).

The implementation of the Convention is managed by the Commission for the Protection of the Black Sea Against Pollution (also sometimes referred to as the Istanbul Commission), and its Permanent Secretariat in Istanbul, Turkey [31].

5.6 Basic Objective of the Convention on the Protection of the Black Sea Against Pollution

To approve the general obligation of the Contracting Parties to prevent, reduce and control the pollution in the Black Sea in order to protect and preserve the marine environment and to provide legal framework for co-operation and concerted actions to fulfil this obligation [31].

In particular:

- To prevent pollution by hazardous substances or matter; Annex to the Convention
- To prevent, reduce and control the pollution from land-based sources; Protocol to the Convention
- To prevent, reduce and control the pollution of the marine environment from vessels in accordance with the generally accepted rules and standards;
- To prevent, reduce and control the pollution of the marine environment resulting from emergency situations; Protocol to the Convention
- To prevent, reduce and control the pollution by dumping; Protocol to the Convention
- To prevent, reduce and control the pollution caused by or connected with activities on the continental shelf, including exploration and exploitation of natural resources;
- To prevent, reduce and control the pollution from or through the atmosphere;
- To protect the biodiversity and the marine living resources; Draft Protocol on the biodiversity
- To prevent the pollution from hazardous wastes in transboundary movement and the illegal traffic thereof; Draft Protocol to the Convention
- To provide framework for scientific and technical co-operation and monitoring activities.

As per the Black Sea Convention article XVII, ‘To perform the aims of this Convention, a Commission on the Protection of the Black Sea Against Pollution shall be established by the Contracting Parties, hereinafter referred to as “the Commission’ The Secretariat of Commission [32]. The Strategic Action Plan for the Rehabilitation and Protection of the Black Sea was adopted 1996 and amended in 2002. Black Sea the Governments of SAP are Bulgaria, Georgia, Romania. The Russian Federation Turkey, and Ukraine. It is recommended that, by January 1997, the Istanbul Commission establish, on the basis of the current structure of BSEP Working Parties, subsidiary bodies which can assist it in the implementation of the Strategic Action Plan [33].

It is recommended that the Istanbul Commission initially establish the following Advisory Groups as its subsidiary bodies, the description and general terms of reference of which are given in Annex I [33]:

a) an Advisory Group on the Environmental and Safety Aspects of Shipping, coordinated by the Activity Centre in Varna, Bulgaria;
b) an Advisory Group on Pollution Monitoring and Assessment, coordinated by the Activity Centre in Odesa, Ukraine;
c) an Advisory Group on Control of Pollution from Land Based Sources, coordinated by the Activity Centre in Istanbul, Turkey;
d) an Advisory Group on the Development of Common Methodologies for Integrated Coastal Zone Management, coordinated by the Activity Centre in Krasnodar, Russia;
e) an Advisory Group on the Conservation of Biological Diversity, coordinated by the Activity Centre in Batumi, Georgia;
f) an Advisory Group on Fisheries and other Marine Living Resources, coordinated by the Activity Centre in Constanta, Romania; and
g) an Advisory Group on Information and Data Exchange, coordinated by the Commission Secretariat [33].

Avoiding Vessel Oil Pollution Policy refers to Vessel source pollution,
- 36. MARPOL 1973/78 shall be more effectively implemented by Black Sea states, especially with a view to giving effect to its provisions on Special Areas, by 2002.

- 37. Due to the rapid increase in traffic to Black Sea ports, the capacity of harbour reception facilities needs to be enlarged in order to comply with MARPOL Special Area requirements. Harbour reception facilities will be installed: for garbage by December 1999; for oil by December 2000; and for chemicals by December 2002.

The use of these facilities shall be made compulsory. In installing harbour reception facilities close cooperation with the private sector will be pursued, the advice of the IMO will be requested, and the results of the study conducted by the BSEP and the European Union will be taken into account.
- 38. A harmonised system of port state control will be established in the Black Sea region through the adoption of a Memorandum of Understanding on Port State Control. It is advised that the Istanbul Commission adopt such a Memorandum, upon

the recommendations of the Advisory Group on Environmental and Safety Aspects of Shipping, by December 1998.

- 39. Black Sea states shall take the necessary steps to enable them to fully exercise their prescriptive and enforcement powers, in accordance with international law, in order to pursue the reduction of illegal discharges by vessels into the Black Sea. 9

- 40. A harmonised system of enforcement, including fines, will be developed for the Black Sea region. It is advised that the Istanbul Commission, upon the recommendations of the Advisory Group on the Environmental and Safety Aspects of Shipping, adopt such a system by December 1998. The primary aim of this system will be to serve as a deterrent for illegal discharges and, where necessary, to exercise enforcement action against illegal dischargers.

- 41. Black Sea states will present a joint proposal to the IMO, in 1997, for conducting an in-depth study on measures to avoid any further introductions of exotic species into the Black Sea through the deballasting of vessels. Given the danger of such species migrating to other seas in the region, the coastal states of the Caspian and Mediterranean Seas will be consulted [34].

5.6.1 Strategic action plan pollution monitoring

Annex – I of SAP is as; Advisory Group on Pollution Monitoring and Assessment coordinated by the Activity Centre in Odessa, Ukraine.

The work of this Group shall focus upon the establishment of a regionally coordinated network of National Status and Trends monitoring programmes and the subsequent development of Environmental Quality Objectives. Specifically, the Group shall provide the following services:

(1) Quality Assurance/Quality Control services for environmental chemical analysis

(2) Coordination of pilot monitoring activities

(3) Coordination of regional training exercises in monitoring

(4) Coordination of regional multi-disciplinary expert consultations to develop common environmental objectives and standards for different water uses in the Black Sea. The Group shall collaborate closely with the Advisory Group on Fisheries and other Living Marine Resources for the development of a region-wide programme for monitoring the biological effects of pollution to be incorporated in the regional monitoring strategy. The Group shall collaborate with National Monitoring Networks

and research institutions in all Black Sea countries, international research programmes and projects and bodies such as IAEA`s Marine Environmental Laboratory, IOC`s Expert Groups, UNEP, WHO and WMO [35] .

The latest amended version of SAP was adopted at Sofia in 2009 and also declerations have been held Odessa Decleration (1993), Bucharet Decleration (2007) and Sofia Decleration (2002, 2009) up to now. One of the Project of Black Sea Commision BSEP (Black Sea Enviromental Programme) is MONINFO Project.

5.7 Moninfo Environmental Monitoring of the Black Sea Basin: Monitoring and Information Systems for Reducing Oil Pollution (Moninfo)

MONINFO is a 2 years (2009 – 2010) project, approved by the European Parliament (EP) and funded by the European Commission (EC). The need for such a project was brought to the attention by EP and EC DG Environment. The project is implemented by the Commission on the Protection of the Black Sea against Pollution (BSC) and beneficiaries are all riparian Black Sea countries. This project is needed because increasing risk calls for the coastal states of the Black Sea to address the issue and urgently consider political, legal and operational initiatives that can improve the existing national and regional capacity on oil spill preparedness, response and co-operation. The BSC works in this project in close cooperation with EC DGs, JRC, EMSA, EEA, IMO, HELCOM, REMPEC, OSPRI etc. All these organization will be invited to be represented in the Advisory Board of the project [36].

In order to reduce the risk of oil spills and its impact in the Black Sea region a regional organisation of joint data and information exchange and relay should be maintained. This organisation should scope and monitor shipping traffic, movement of oil & oil products, ongoing and future activities subject to oil production, storage and transportation. Also up-to-date information on preparedness and response to oil spills is essential for the success of system.In accordance with the principles of prevention and precaution, action should be taken at several stages of the process:

1. Provision of safe oil transport /port operations in the area
2. Monitoring maritime traffic and in particular polluting ships
3. EIA in transboundary aspect for new energy projects
4. Port Reception Facilities

If operational or accidental pollution occurs, the Black Sea states will also need to use the best available information and practices, on the following domains:

1. Response in emergency situation in a general framework for contingency plannig
2. Environmental impact of pollution by oil, [36]

For the success, the participants should also maintain a regular and high level of exercise/training/capacity building which is necessary in the Black Sea region. Also a good co-operation model is needed for linking science, management and industry to develop strategies for safe oil transfer, and in case of needs, assessment preparedness and response regarding oil pollution. No doubt that one of the most important part of such a model is improved monitoring and also overview, availability and accessibility of data & information regarding marine environment, industrial activities and relevant legal and policy frameworks.

5.7.1 Black Sea environmental project - MONINFO

The oil spill pollution is recognized as one of the major threats to the marine environment of the Black Sea in the Strategic Action Plan (SAP) adopted in 1996 as well as in the revised draft SAP. These two documents state that the risk associated with heavy shipping traffic / platforms / offshore installations/ refineries / oil terminals / ports/ pipelines calls for:

(a) development of national emergency preparedness and response systems and their coordination at the regional level,
(b) communication improvement between the private sector, the policy makers and scientists,
(c) improvement/development of the Black Sea Information System (BSIS), (Black Sea Information System - ESAS - Environmental Safety Aspects of Shipping- component) including support data sets within the oil industries, private companies dealing with EIA in this particular field
(d) archiving the assessments, and contributions in data, evaluations and measures of the marine environmental institutes,
e) advancement of surveillance at sea and inspections in ports,
g) enlargement of port reception facilities capacity, and the last but not least
h) further development of legal and policy documents, strengthening enforcement and development of common systems of penalties and claims management for

pollution damages compensation (the common framework for oil tanker spills compensation, through CLC and Fund Conventions and ratifying the Bunker Convention for general shipping related oil spill claims) [36].

The gaps in information about the Black Sea region include the lack of recent assessment of oil pollution coming from Land-Based Sources (LBS), rivers and illegal discharges (last figures refer to 1995-2000) and the lack of real time information on proper operational monitoring and contact responsible institutions for in situ sampling agreed in cases of accidents. Hot spots for oil pollution urgently need to be identified and carefully monitored for their impact on the environment. The region does not have an agreed adequate system for monitoring of accidental pollution [36].

This project will allow to gain the needed experience in working with information systems for improved management, to transfer lessons learned from other regions to the Black Sea, as well as to improve the cooperation of the BSC with the private sector an Objectives [36].

The project should enable the coastal states to better prevent and respond to operational/accidental/illegal oil pollution. Once this project is finished, in the long run and throughout the entire Black Sea region, the competent authorities of coastal states should be in a better position to:

1. improve the safety of oil transfer in a way that diminishes and mitigates the risk of oil spill accidents and emergency situations;
2. collect and access information on the oil pollution and environmental impact by oil and oil derivatives on the Black Sea marine ecosystem during operational and accidental pollution based on in situ sampling, aerial surveillance, and satellite imagery;
3. improve the exchange of oil-related information in the region;
4. update and improve national and regional contingency plans for oil pollution;
5. efficiently respond to any oil spill accident or emergency situation, individually and, in particular, through bilateral cooperation or within the framework of regional actions, allocating responsibilities and competences to relevant institutions and building upon existing structures, such as the OPRC Convention, the BSC and the European Community Civil Protection Mechanism;
6. perform risk and impact assessments;

7. reduce and eventually eliminate illegal discharges of ship-generated wastes in the Black Sea;
8. increase public awareness of environmental concerns and need to protect the Black Sea from oil pollution;
9. achieve good environmental status through reduction/elimination of oil pollution in the Black Sea.
10. within this long term policy approach, and in support of decision making toward reduction/elimination of oil pollution in the Black Sea, the project will pursue the following objectives:Improved information system for combating oil pollution.

- Enhanced monitoring system of operational and accidental pollution
- Enhanced response capabilities, including risk management and emergency preparedness planning to populate the system with quality controlled data **[36]**

To develop and improve the information and monitoring systems for operational, illegal and accidental oil pollution and to enhance the response capabilities, including risk management and emergency preparedness planning can be described as the main objectives of Moninfo Project.

The monitoring and information system of Moninfo could support some of efforts mentioned also in the revised BS strategic Action Plan.

With phases Moninfo is an ambitious project which is funded also by EU. The cost of this project is 2,36 mil Euro for 3 years.(Moninfo Phase 1 commenced on 01.01.2009 and completed at the end of 2010)

Moninfo phase 1 includes 3 work packages (WP), or main objectives :

WP1. Information System development

WP2. Monitoring System development

WP3. Capacity Building

Moninfo phase 2 commenced on 1st of January 2010, will end in 2011, being complementary to MONINFO 1.

As listed below Phase 2 includes 5 work packages to be developed which will help to continue and implement phase 1 by establishing real operational tools to support institutions responsible for monitoring, counteraction and mitigation activities in case of oil spills:

WP 1. R Database and Info platform adopted as RIP and Expert System on oil pollution mitigation and counteraction activities

WP 2. Application of a Web based model for oil pollution forecasting for the Black S

WP 3. Regional Black Sea AIS data server

WP 4. Remote sensing monitoring of oil pollution

WP 5. Capacity building and sustainability

- In order to improve coordination Information should address to improve coordination, level of safety transfer, and monitor the impact of oil pollution on the ecosystem in order to minimize risks and to ensure an adequate level of response.
- Information are fragmented, so it is needed a platform for an integrated monitoring and informed policy-making at all levels of governance.

Control of illegal discharges using satellites, AIS and backtracking as shown below;

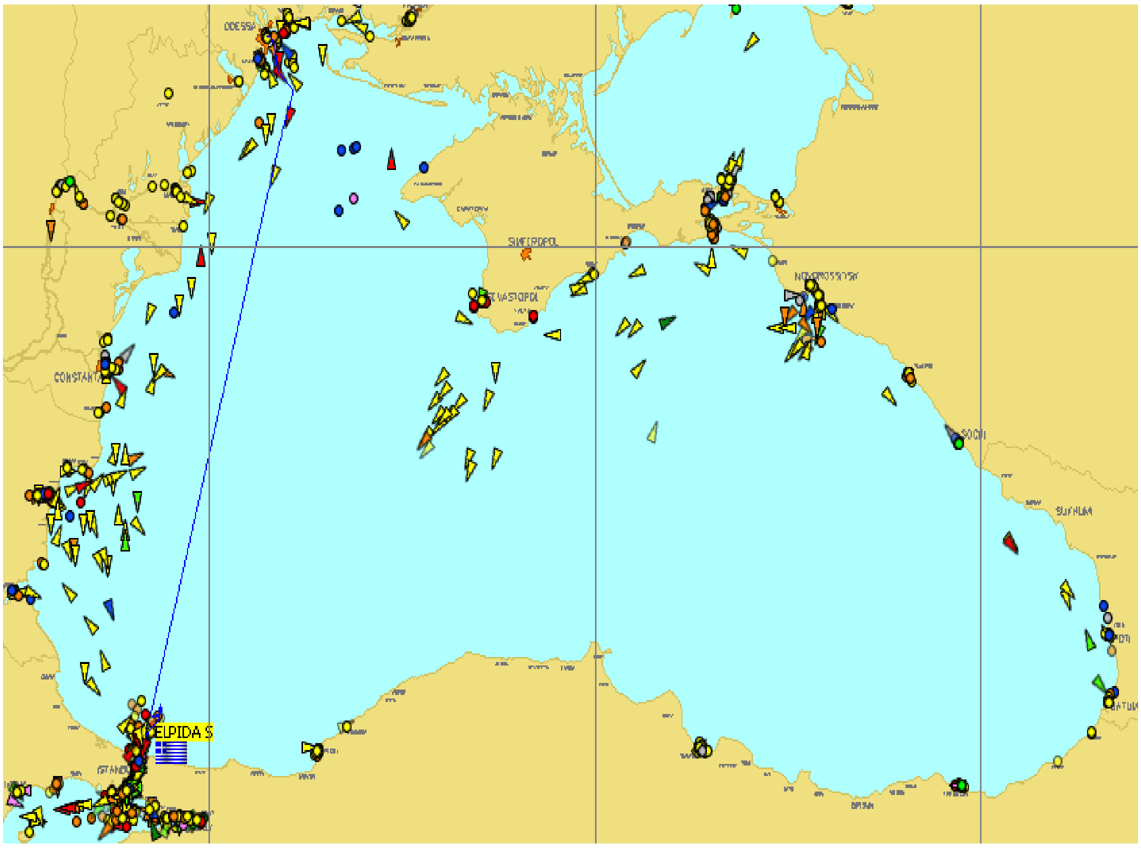


Figure 5.3: Control of illegal discharges using satellites, AIS and backtracking [29].

The Moninfo Information system also includes the AIS data receiving from VTMS providing information of vessel positions, speed, heading, course and other useful information.

Black Sea Countries need AIS Server like other countries as shown; On scene picture of an incident can be fully replayed onto electronic chart with these information. The operational database of information system will be collected from:

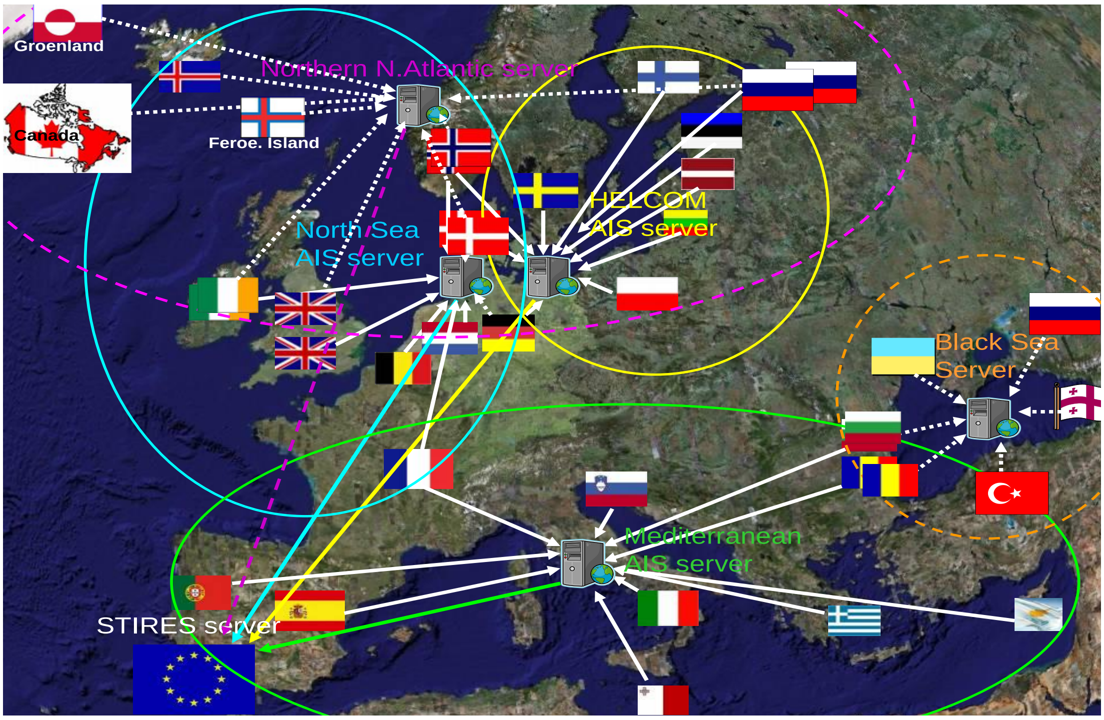


Figure 5.4: AIS Server Moninfo plan for Black Sea [29].

- information on institutions responsible *for counteraction and mitigation activities* in case of oil pollution,
- information on control of operational pollution from ships,
- *up to date* information on amendments of legal instruments related *to marine pollution,*
- information on major oil spills in the Black Sea region (eg. Kerch accident, Moninfo will include in data base this report),
- reports on environmental impact assessment after major oil spills,
- list of institutions responsible for monitoring of consequences in case of oil spills with available “in-situ” data.

5.7.2 Regional information platform

A Regional Information Platform (RIP) as a web portal will be established and implemented by using the information provided by B S countries. Web GIS and database technologies should be used to develop the BS RIP. For accessing the system, no additional software should be required and only a standard web browser should be adequate. In case of incidents necessary and useful information as below could be received from BS RIP:

- Resources for oil spill counteraction activities available for regional support.
- Communications in case of accidents.
- Reports from satellite surveillance and other remote sensing methods for oil pollution in the Black Sea.
- Black Sea AIS system or other sources of AIS data in the region.
- Oil pollution data history including time, place, type and quantity
- Hydrological and meteorological data, etc.

In order to prevent and detect illegal discharges more effectively, monitoring and surveillance through the development of a BS agreement for exchange of AIS data has vital importance.

6. REMOTE SENSING MONITORING OF OIL POLLUTION

The Definition of *Remote Sensing* in the broadest sense, the measurement or acquisition of information of some property of an object or phenomenon, by a recording device that is not in physical or intimate contact with the object or phenomenon under study; e.g., the utilization at a distance (as from aircraft, spacecraft, or ship) of any device and its attendant display for gathering information pertinent to the environment, such as measurements of force fields, electromagnetic radiation, or acoustic energy. The technique employs such devices as the camera, lasers, and radio frequency receivers, radar systems, sonar, seismographs, gravimeters, magnetometers, and scintillation counters. The practice of data collection in the wavelengths from ultraviolet to radio regions. This restricted sense is the practical outgrowth from airborne photography. Sense is preferred and thus includes regions of the EM spectrum as well as techniques traditionally considered as belonging to conventional geophysics [38].

6.1 Remote Sensing Technology

For the environmental viewing, characterizing, and making decisions, remote sensing can be described as one of the most valuable information source. The early use of aerial photography inspired today's remote sensing technologies. In the past 30 years, remote sensing technology has make great achievements on three fronts:

1) starting from military needs and uses to a variety of environmental analysis applications that relate to land, ocean, and atmosphere issues;
2) from (analog) photographic systems to sensors operating with technologies those converting energy from many parts of the electromagnetic spectrum to electronic signals; and
3) from aircraft to satellites.

Today, satellite remote sensing systems use technology of analysing and extracting information by observing, measuring and recording the electromagnetic radiation reflected or emitted by the Earth and its environment.

6.1.1 Comparison to maps, GIS, aerial photography / photogrammetry

The main points of similarity and difference between the field of Remote Sensing (analysis and images) and the fields/products mentioned above are given as below.

➢ Remote Sensing *Vs* GIS

GIS (Geographic Information System) is a kind of software that enables:

- The collection of spatial data from different sources (Remote Sensing being one of them).
- Relating spatial and tabular data.
- Performing tabular and spatial analysis.
- Symbolize and design the layout of a map.

A GIS software can handle both vector and raster data (some handle only one of them). Remote Sensing data belongs to the raster type, and usually requires special data manipulation procedures that regular GIS does not offer. However, after a Remote Sensing analysis has been done, its results are usually combined within a GIS or into database of an area, for further analysis (overlaying with other layers, etc). In the last years, more and more vector capabilities are being added to Remote Sensing softwares, and some Remote Sensing functions are inserted into GIS modules [38].

➢ Remote sensing *Vs* Aerial photography / photogrammetry

Data is collected about the upper surface of Earth in both systems by measuring the Electromagnetic radiation, from airborne systems. The major differences can be listed as below:

- Aerial photos are taken by using analog technology: a film of a (photogrammetric) camera, after scanning ,transformed to digital media. Remote Sensing data is usually collected by a digital CCD camera.
- In spite of the fact that a film has a high resolution (granularity), the CCD measures quantitatively the radiation reaching the sensor (radiance values, instead of a gray-value scale bar) where data can be integrated into physical equations of energy-balance for example.
- Central projection is used for an Aerial photograph where the whole picture taken at one instance. A Remote Sensing image is created line after line; which provides a much more complex geometrical correction .With this method each line (or even pixel) needing to be treated as a central projection.

- Aerial photos can only be effective collecting data only in the visible spectrum , while Remote Sensing sensors can detect and measure radiation all along the Electromagnetic spectrum.
- Aircrafts (planes and helos) are used to take Aerial photos ,while Remote Sensing images also from satellites.
- Atmospheric disturbances affect the accuracy and quality of both systems. While Aerial photos mainly affected from haze (that is, the scattering of light – the process which makes the sky blue),Remote Sensing images affected from processes of absorption. By using some kinds of filters or in post-processing, as it is done in Remote Sensing, atmospheric corrections to Aerial photos can be made. Thermal Remote Sensing sensors can operate also at night time, and Radar data is almost weather independent by the help of some clutter and gain adjustments.
- Most of the achievements in Photogrammetry are the result of efforts for the accurate creation of a 3d model, in order to perform high accuracy plotting the location and boundaries of objects and creating a Digital Elevation Model, by applying sophisticated geometric corrections. In Remote Sensing the main aim is to analyse the incoming Electromagnetic spectrum. In order to perform this analysis atmospheric corrections, sophisticated statistical methods for classification of the pixels to different categories should be used, and analysing the data according to known physical processes that affect the light as it moves in space and interacts with objects should be carried out.
- Satellites can cover a wide area and can monitor continuously if required. This fact makes Remote Sensing images very useful for tracking phenomena on regional, continental and even global scale.
- Remote Sensing is relatively a new technology so the images are available since the early 1970’s. Aerial photos, provide a longer time period for landscape change detection as this technology has been used since World War 1.
- It is very difficult to process Remote Sensing images and requires specialists while aerial photographs can be assessed more easily and simply.

6.2 Applications in General

Each sensor is designed for a specific purpose. Data of the spectral bands to be collected with optical sensors. With radar imaging, the incidence angle and microwave band used plays an important role in defining which applications the sensor is best suited for. There are different type of applications for different type of requirements such as, spectral resolution, spatial resolution, and temporal resolution. There can be many applications for Remote Sensing, in different fields, as described below.

6.2.1 Agriculture

Agriculture plays a dominant role in all country's economies and has a vital importance for the future of human being .Nowadays agricultural mapping is very simple and reasonable by using Satellite and airborne images. Mapping is used to classify crops, examine their health and viability, and monitor farming practices.

6.2.2 Forestry

Forests are a valuable resource providing food, shelter, wildlife habitat, fuel, and daily supplies such as medicinal ingredients and paper. Forests play an important role in balancing the Earth's CO_2 supply and exchange, acting as a key link between the atmosphere, geosphere, and hydrosphere. Forestry applications of remote sensing include the following:

- reconnaissance mapping:
- Commercial forestry:
- Environmental monitoring

6.2.3 Geology

Geology involves the study of landforms, structures, and the subsurface, to understand physical processes creating and modifying the earth's crust. It is most commonly understood as the exploration and exploitation of mineral and hydrocarbon resources, generally to improve the conditions and standard of living in society. Geological applications of remote sensing include the following:

- surficial deposit / bedrock mapping
- lithological mapping
- structural mapping
- sand and gravel (aggregate) exploration/ exploitation

- mineral exploration
- hydrocarbon exploration
- environmental geology
- geobotany
- baseline infrastructure
- sedimentation mapping and monitoring
- event mapping and monitoring
- geo-hazard mapping
- planetary mapping [39]

6.2.4 Hydrology

Hydrology is the study of water on the Earth's surface, whether flowing above ground, frozen in ice or snow, or retained by soil. Examples of hydrological applications include:

- wetlands mapping and monitoring,
- soil moisture estimation,
- snow pack monitoring / delineation of extent,
- measuring snow thickness,
- determining snow-water equivalent,
- river and lake ice monitoring,
- flood mapping and monitoring,
- glacier dynamics monitoring (surges, ablation)
- river /delta change detection
- drainage basin mapping and watershed modelling
- irrigation canal leakage detection
- irrigation scheduling [39]

6.2.5 Sea Ice

Ice covers a substantial part of the Earth's surface and is one of the major factor in commercial shipping and fishing industries, Coast Guard and construction operations, and global climate change studies.

6.2.6 Land Cover & Land Use

Although the terms land cover and land use are often used interchangeably, their actual meanings are quite distinct. Land cover refers to the surface cover on the ground, while Land use refers to the purpose the land serves. The properties measured with remote sensing techniques relate to land cover, from which land use can be inferred, particularly with ancillary data or a priori knowledge. Land use applications of remote sensing include the following:

- natural resource management
- wildlife habitat protection
- baseline mapping for GIS input
- urban expansion / encroachment
- routing and logistics planning for seismic / exploration / resource extraction activities
- damage delineation (tornadoes, flooding, volcanic, seismic, fire)
- legal boundaries for tax and property evaluation
- target detection - identification of landing strips, roads, clearings, bridges,
- land/water interface [39]

6.2.7 Mapping

Managing land resources can not be performed without mapping and of course, mapped information is the product of analysis of remotely sensed data. Mapping applications of remote sensing include the following:

- Planimetry:
- digital elevation models (DEM's)
- Baseline thematic mapping / topographic mapping

6.2.8 Oceans & coastal monitoring

The oceans are the vast and valuable food, row material and biophysical resource which are vitally important in CO2 storage, and are an important link in the earth's hydrological balance. They are also the main element of world transportation. Due to the economic and technical developments triggering changes in land-use patterns, coastlines become environmentally sensitive .Often coastlines are also biologically diverse inter-tidal zones, and can also be highly urbanized.

Ocean applications of remote sensing include the following:

- Ocean pattern identification:
- currents, regional circulation patterns, shears
- frontal zones, internal waves, gravity waves, eddies, upwelling zones, shallow, water bathymetry
- Storm forecasting
- wind and wave retrieval
- Fish stock and marine mammal assessment
- water temperature monitoring
- water quality
- ocean productivity, phytoplankton concentration and drift
- aquaculture inventory and monitoring
- *oil spill*
- mapping and predicting oil spill extent and drift
- strategic support for oil spill emergency response decisions
- identification of natural oil seepage areas for exploration
- Shipping
- navigation routing
- traffic density studies
- operational fisheries surveillance
- near-shore bathymetry mapping
- Intertidal zone
- tidal and storm effects
- delineation of the land /water interface
- mapping shoreline features / beach dynamics
- coastal vegetation mapping [39]

For collecting and recording energy which is reflected or emitted from a target or surface, a sensor should be placed on a stable platform away from the target or surface being monitored. Platforms for remote sensors can be placed on the ground, on an aircraft or balloon (or some other platform within the Earth's atmosphere), or on a spacecraft or satellite outside of the Earth's atmosphere. The information recorded by Ground-based sensors are more detailed about the surface which is compared with information collected from aircraft or satellite sensors. This can be used to better characterize the target which is being imaged, making it possible to better understand the information in the imagery. Sensors can be placed on a ladder, tall building, cherry-picker, crane, etc.

Aerial platforms are placed on wing of aircrafts and sometimes on helicopters. Aircrafts are often used to collect very detailed images and make it more easier to collect data over virtually any portion of the Earth's surface at any time. In space, remote sensors are sometimes controlled from the space craft or, more commonly, from satellites. Satellites are objects which revolve around another object.

In this case, manmade satellites include those platforms launched for remote sensing, communication, location and navigation purposes. Because of their orbits, satellites can provide repetitive coverage of the Earth's surface on a continuing basis. Of course cost of such a satellite sensor system much more than other sensing systems.

6.3 Satellite Characteristics: Orbits and Swaths

There are plenty of different platforms suitable for placing remote sensing devices to monitor, view and image targets. In spite of the fact that ground-based and aircraft platforms are used widely, satellites provide a great deal of the remote sensing imagery commonly used today. There are several special characteristics making satellites particularly useful for remote sensing of the Earth's surface. The movement of a satellite around Earth takes place on a path called as satellite’s orbit. Satellite orbits are selected as per the features of the sensors and task of the satellites. Also orbit selection is decided by taking into account the altitude (their height above the Earth's surface) and their orientation and rotation relative to the Earth. If a satellite which is at very high altitudes (approximately 36,000 kilometres), view the same portion of the Earth at all times, this type of orbits are called geostationary orbits. These geostationary satellites revolve at speeds equal to the rotation of the Earth so they seem relatively stationary. This feature allows the satellites to observe and collect information continuously over specific areas. Many remote sensing platforms are designed to follow an orbit (basically north-south) which, in conjunction with the Earth's rotation (west-east), allows them to cover most of the Earth's surface over a certain period of time.

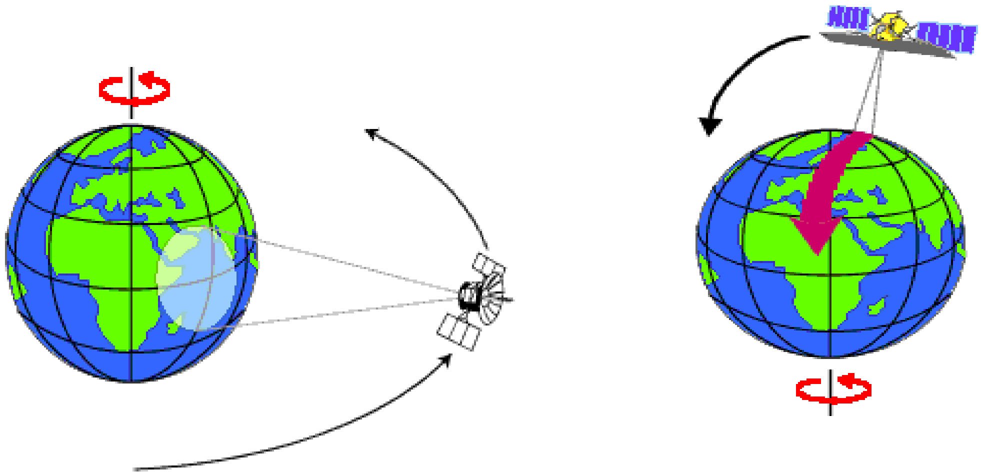


Figure 6.1: Remote Sensing platforms rotations [40].

These are near-polar orbits, so named for the inclination of the orbit relative to a line running between the North and South poles. Many of these satellite orbits are also *sun-synchronous* such that they cover each area of the world at a constant local time of day called *local sun time.* At any given latitude, the position of the sun in the sky as the satellite passes overhead will be the same within the same season [41].

Today's remote sensing satellites have near polar orbits. On such kind of an orbit satellites make two kinds of movement called ascending and descending passes. Ascending pass is the movement of satellite towards northern pole on one side of the Earth and descending pass is the movement of satellite towards the southern pole on the second half of its orbit. If the orbit is also sun-synchronous, the ascending pass takes place on dark side of the Earth and descending pass takes place on the sunlit side. Sensors only have the capability of recording reflected solar energy on a descending pass, which is a result of solar illumination need. With the progress and development of technology, active sensors which provide their own illumination or passive sensors that record emitted (e.g. thermal) radiation can also image the surface on ascending passes.

During the satellite's revolution, the sensor "sees" a certain portion of the Earth's surface. The area imaged on the surface, is referred to as the swath. Imaging swaths for space borne sensors generally vary between tens and hundreds of kilometres wide. As the satellite orbits the Earth from pole to pole, its east-west position wouldn't change if the Earth didn't rotate. However, as seen from the Earth, it seems that the satellite is shifting westward because the Earth is rotating (from west to east) beneath it. This apparent movement allows the satellite swath to cover a new area with each consecutive pass. The satellite's orbit and the rotation of the Earth work together to allow complete coverage of the Earth's surface, after it has completed one complete cycle of orbits [41].

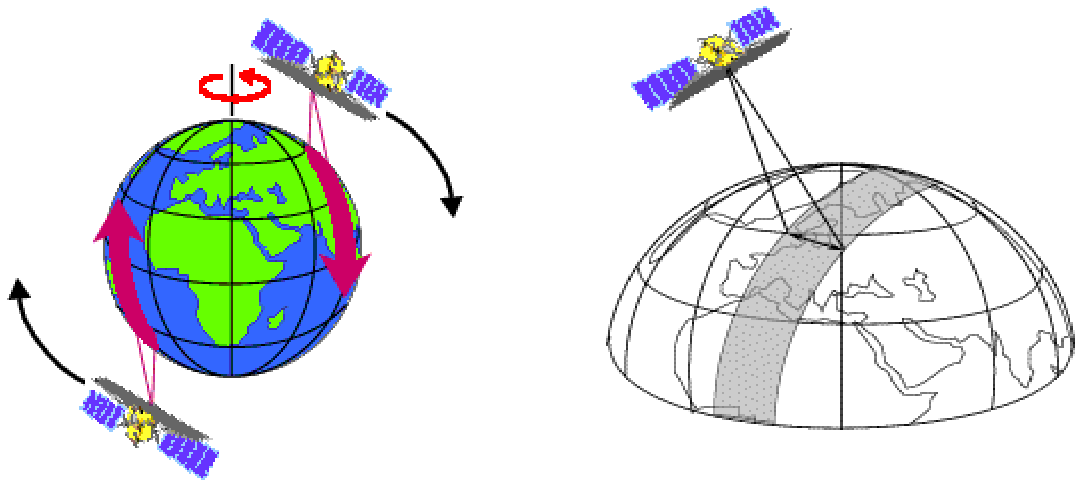


Figure 6.2: Ascending – Swath [41]**.**

If we start with any random point in a satellite's orbit an orbit cycle will be completed when the satellite passes over the same point. The point on the earth's surface directly below the satellite is called nadir point. The exact length of time of the orbital cycle may change for each satellite. The time required for the satellite to complete its orbit cycle is not the same for each time and it is called "revisit period". The revisit period is an important factor for monitoring applications, especially when a sudden image is required.

6.4 Scanner Sensor Systems

Electro-optical and spectral imaging scanners produce digital images with the use of detectors that measure the brightness of reflected electromagnetic energy. Scanners consist of one or more sensor detectors depending on type of sensor system used[42].

6.4.1 Synthetic aperture radar sensors

Synthetic Aperture Radar (SAR) image data provide information different from that of optical sensors operating in the visible and infrared regions of the electromagnetic spectrum. SAR data consist of high-resolution reflected returns of radar-frequency energy from terrain that has been illuminated by a directed beam of pulses generated by the sensor. The radar returns from the terrain are mainly determined by the physical characteristics of the surface features (such as surface roughness, geometric structure, and orientation), the electrical characteristics (dielectric constant, moisture content, and conductivity), and the radar frequency of the sensor. By supplying its own source of illumination, the SAR sensor can acquire data day or night without regard to cloud cover.

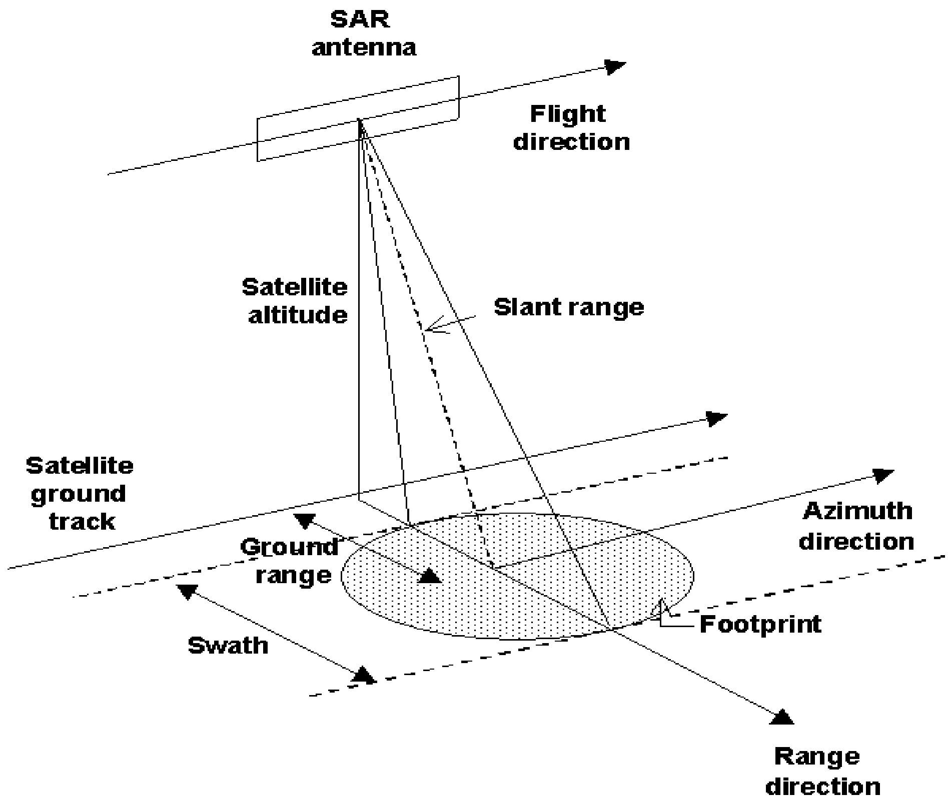


Figure 6.3: The side-looking SAR moving in azimuth direction [40].

Synthetic aperture radar (SAR) satellite systems are currently used for European Space Agency's (ESA) European Remote Sensing Satellite 1 (ERS-1), launched July 1991, and the Japanese Earth Resources satellite (JERS-1), launched February 1992. Contacts are provided for ERS-1 data and JERS-1 data. The ERS-1 sensor operates in the C-band frequency (approx. 5.6 cm wavelength) and JERS-1 operates in the L-band frequency (approx. 23 cm wavelength).Both sensors have a nominal spatial resolution of approximately 30 m. The Canadian Space Agency plans to launch its RADARSAT in 1995.The current level of experience in operational use of SAR data is very limited compared to the use of visible and infrared data acquired by the multispectral satellite sensors. Several main characteristics of SAR data taken together, however, may improve more extensive evaluation and use of SAR data for land-use and land-cover information. promote more extensive evaluation and use of

SAR data for land-use and land-cover information. These characteristics consist of;
1) the unique information of surface roughness, physical structure, and electrical conduction properties;
2) the high spatial resolution;
3) the 24-hour, all-weather data-acquisition capability; and
4) the now realizable long-term continuity of the data that enables repetitive (seasonal) coverage of major global land regions.

6.4.2 Scattering Mechanisms

The strength of reflection from a target in SAR imaging is affected by several important factors. These factors can be divided into 2 main group as satellite system factors and ground surface factors.

1. Satellite system factors:
• the radar beam incidence angle
• wavelength of the radar
• the polarization of the radar
2. Ground surface factors:
• the roughness of the surface
• the geometrical structure of the surface
• the dielectric properties of the surface
• the wind speed
• the angle between the radar beam and the wind
• the geometrical structure of the surface
• the dielectric properties of the surface
• the wind speed
• the angle between the radar beam and the wind [40]

6.4.3 Surface scattering

For flat terrain, the local reflection angle is the same as the incidence angle as shown in figure a). Most of the incident energy will be reflected away from the sensor, resulting in a very low return signal. Rough surfaces will scatter incidence energy in all directions and return a significant portion of the incident energy back to the antenna. This is illustrated in figure b) [43] .

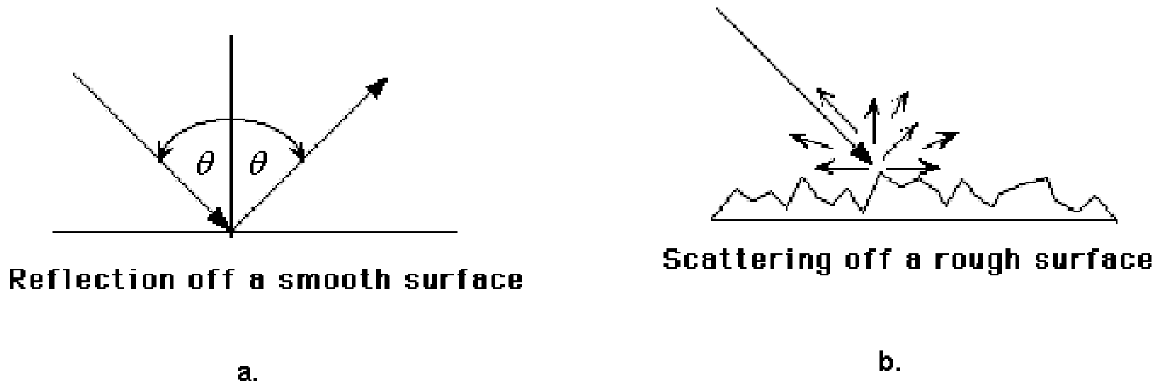


Figure 6.4 : Scattering mechanisms. a) Reflection off a smooth surface. b) Scattering off a rough surface [43] .

6.5 Oil spill Imaging With Synthetic Aperture Radar

A wide range of ocean surface phenomena have been imaged with SAR. In addition to oil spills, several phenomena may dampen out the Bragg waves sensed by the SAR. When these waves are dampened, very little of the emitted signal will return to the SAR. A dark area will therefore appear in the SAR image [44].

6.5.1 Imaging of low-backscattering ocean features

Both atmospheric processes that affect surface wind conditions (and thus the generation and modulation of Bragg waves and oceanic processes that directly modulate the Bragg wave spectrum, produce signatures imaged by SAR [44]. Generally, lower wind speeds generate fewer Bragg waves. This results a smoother sea surface and in the SAR imagery it appears as a dark area. Below a low wind speed, Bragg waves will be invisible in the image due to inadequate back scattering radar energy toward the SAR .Image visibility also depends on the modulation of Bragg waves. The sea surface backscatter decreases rapidly with increasing radar incidence angle. Success in detecting low-backscatter ocean features may well depend on where the features lie within a swath. As a result the wider the swath, the larger the contrast between near and far range.

Wind direction is also an important factor affecting the level of backscattering. A crosswind (wind blowing perpendicular to the range direction) produces lower backscattering than an upwind or downwind (wind blowing along the range direction)

6.6 Oil Spill Detection

Oil spills no doubt destroy marine life, give fatal damage to habitat for animals and humans. To isolate the affected areas and organise cleanup efforts properly, a number of factors should be identified:

- Spill location
- Size and extent of the spill
- Direction and magnitude of oil movement
- Wind, current and wave information for predicting future oil movement

Remote sensing gives the advantage of observing events remotely and often inaccessible areas. Remote sensing can be used to both detect and monitor spills.
Remote sensing data gives rate and direction of oil movement for ocean spills through multi temporal imaging. By entering these data to drift prediction modelling which makes further control and clean up efforts more effective and easier. Remote sensing devices which are used can be listed as infrared video and photography from airborne platforms, thermal infrared imaging, airborne laser fluourosensors, airborne and space-borne optical sensors, as well as airborne and space borne SAR.

SAR sensors can operate even in poor weather conditions and during darkness which is an advantage over optical sensors [45].

The key operational data requirements are fast turnaround time and frequent imaging of the site to monitor the dynamics of the spill. For the identification of oil spills high resolution is one of the key elements. High resolution sensors give always better results. On the other hand wide area coverage is very important for initial monitoring and detection. Airborne sensors are expensive but have more efficiency and the advantage of frequent site specific coverage if required. It can be accepted or assumed that spills often occur in bad weather conditions which makes airborne surveillance difficult. For very accurate detections even detecting oil films as thin as 15 mm, Laser Fluorosensors are the best choices. It is possible to identify oil on shores, ice and snow, and determining what type of oil has been spilled. However, they require relatively cloud free conditions to detect the oil spill.

SAR sensors can image oil spills through the localized suppression of Bragg scale waves. Oil spills are visible on a radar image as circular or curvilinear features with a darker tone than the surrounding ocean (the small waves that cause backscatter on radar images of the sea are dampened by a thin film of oil). Wind speeds greater than 10 m/s break up and disperse the oil slick which makes detection difficult. Also a natural surfactant may cause a false detection. By using of secondary means of information sources and multi-temporal data, it may be possible to discriminate between the false and true detections.

6.6.1 Look-alikes: dark structures resembling oil spills

The following are examples of natural phenomena that can create oil spill look-alikes (causing false detections) appearing in SAR imagery. Natural biogenic surfactants/natural film: Natural biogenic slicks are produced by plankton and fish substances normally released into the environment [46]. Examples of oil slick;

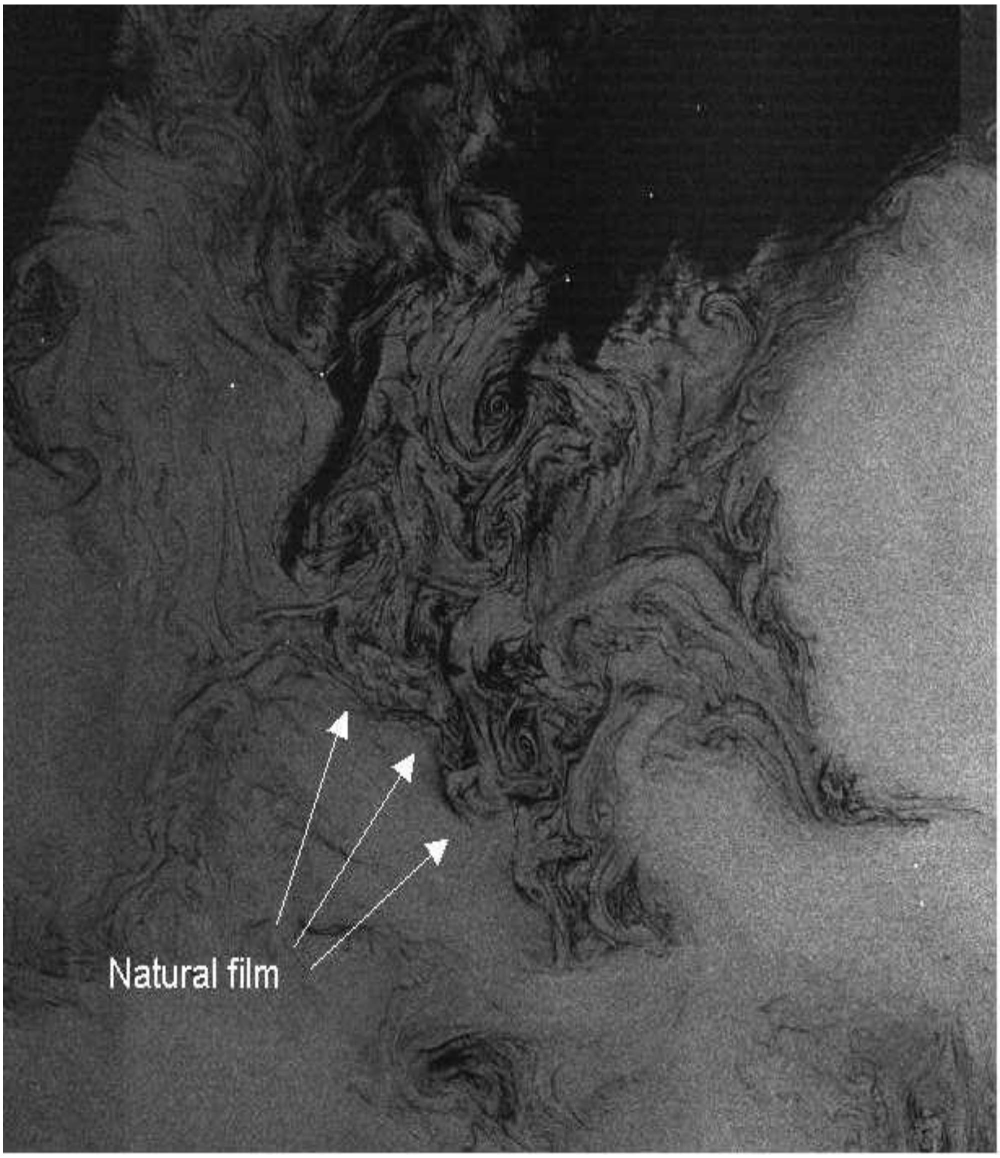


Figure 6.5: Natural film [46].

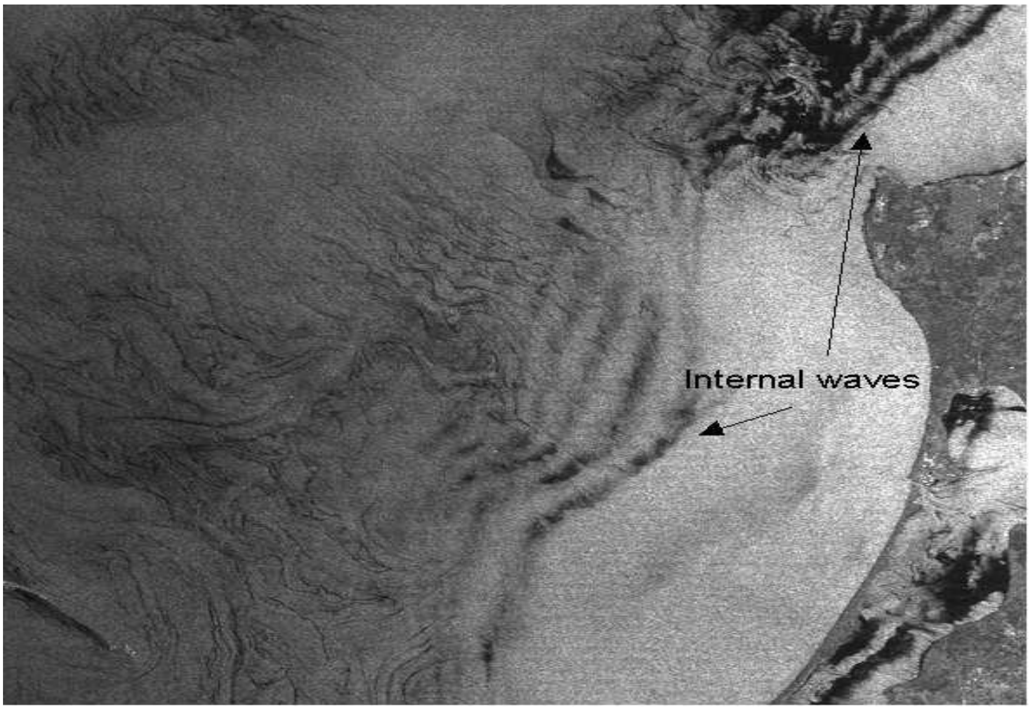


Figure 6.6: Parts of an Figure: ENVISAT WSM Image from 22.10 2005 [46].

- Natural mineral surfactants: Natural mineral slicks are the result of ocean-bottom oil seeps.
- Grease ice: Sea ice can also dampen ocean surface waves. In particular, grease ice (composed of small crystals that form when seawater begins to freeze) dampens Bragg waves and produces areas of extremely low backscattering [46].

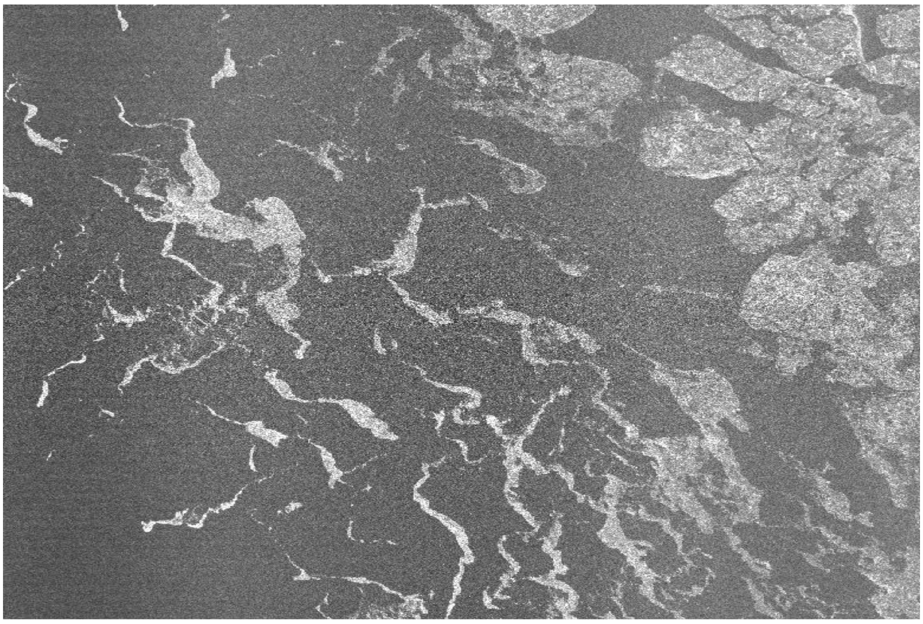


Figure 6.7: ENVISAT Alt Pol Mode Precision Image. 9.11.2004 [46].

- Low surface winds: As a fact the sea surface roughness is directly related with the wind condition which affects the quality and accuracy of image sensed by SAR. Dark areas appear with wind speeds below the threshold wind speed of about 3 m/s.
- Rain cells, Shear zones, Internal waves also generate dark areas in sar image.

6.6.2 Summary of SAR

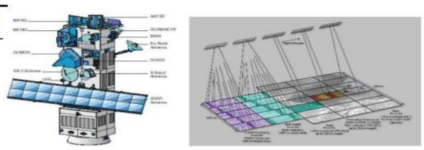
Briefly; SAR has the capability of operating in all weather conditions and covers wide area which makes SAR one of the most important techniques to monitor oil pollutions.

Advantages
– Day & night observation.
– All-weather capability.
– High spatial resolution.
-- Wide area coverage

SAR parameters
– Frequency band.
– Polarization.
– Incidence angle
– Swath width
– Resolution

Choosing large swath widths gives better results in oil spill detection while reducing the image resolution. It means there is a trade-off between the image resolution and the swath coverage. The Satellites carrying SAR and their parameter as shown;

Satellite (sensor)	Operative	Owner	Band
SEASAT	1978 – 1978	NASA	L
ALMAZ	1991 – 1992	RSA	S
ERS-1	1991 – 1996	ESA	C
ERS-2	1995 – operating	ESA	C
RADARSAT-1	1995 – operating	CSA	C
RADARSAR-2	2007– operating	CSA	C
ENVISAT (ASAR)	2002 – operating	ESA	C
ALOS (PALSAR)	2006 – operating	JAXA	L
TerraSAR-X	2007 – operating	DLR	X
Cosmos Skymed-1/2	2007 – operating	ASI	X



SAR sensor	Resolution (m)	Swath width (Km)
ERS-2	30 x 26.3	100
ENVISAT	30 x 30	100
RADARSAT-1	50 x 50	300
RADARSAT-1	100 x 100	450 – 500
ENVISAT	150 x 150	400

Samples of satellite SAR parameters

Figure 6.8: Satellites carrying SAR instruments focusing in ocean observation SAR Satelitte and Parameter.[47].

6.7.The Principle of Oil Spill SAR Imaging

The presence of oil on the surface of sea causes damping effect on the short wind waves (Bragg Waves) and reduce the radar back scattering. In such cases the oil spilled areas can be seen as dark patches in SAR images. An oil spill is physically a low backscatter area and appears as a dark area in SAR images.

The figure shows how SAR catch spills from sea surface;

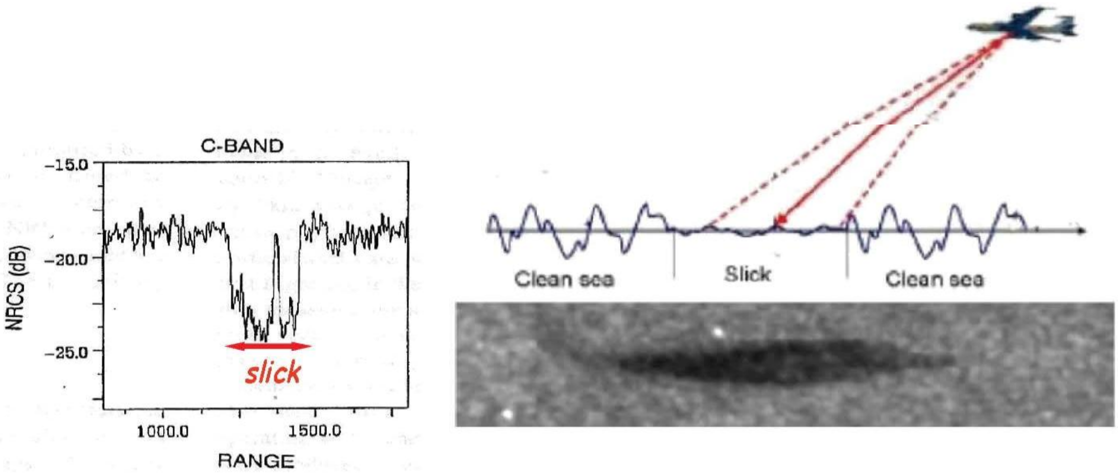


Figure 6.9: Oil slick detection [48].

Dampening is not only caused by low wind speed area, there are other physical natural phenomena also dampen the Bragg waves and generate dark areas (look-alikes). So, the major difficulty is to differentiate between oil spills and look-alikes of natural origin.

Look-alikes include:

- Low wind speed areas
- Biogenic slick (Natural surface films)
- Rain cells
- Cold upwelling
- Current shear zones
- Ship wakes
- Others

6.7.1 Limitations in detection

Neither very calm sea nor very rough sea surface is favourable conditions for oil slick detection. The figure shows optimum sea and wind condition;

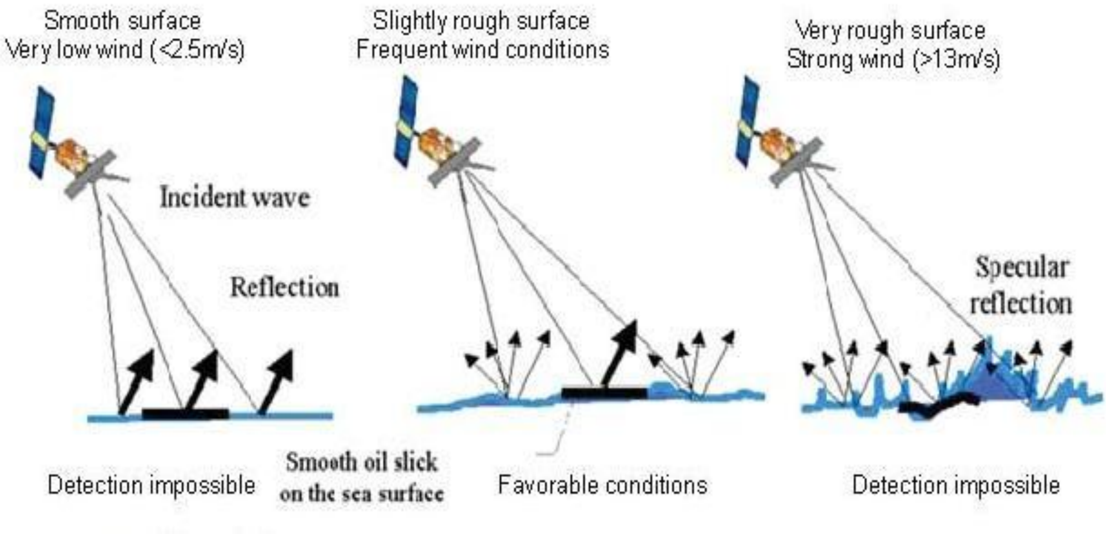


Figure 6.10: Slick detection condition [48].

6.7.2 Criteria for oil spill

The criteria for oil spill as below:

- Dark and homogeneous spots in a uniform windy area;
- Linear dark areas, not too large, with unexpected and sudden turns due to change of wind directions or surface current. Under these circumstances natural slicks tend to disappear.
- Near ship or rig; or locations of ship lane;

6.7.3 Criteria for look-alike

- Low wind areas;
- Coastal zones due to wind sheltering;
- Elongated dark areas with no abrupt turns (smooth turnings) often in the shape of a spiral;
- Natural film aligned parallel with a bright current shear or convergence zone;
- Cluster of rain cells, the cell centres have a very low backscatter value and are surrounded by squall lines with a higher backscatter.
- Some pictures for real oil slick detection, one of the example is M/T Prestige accident;

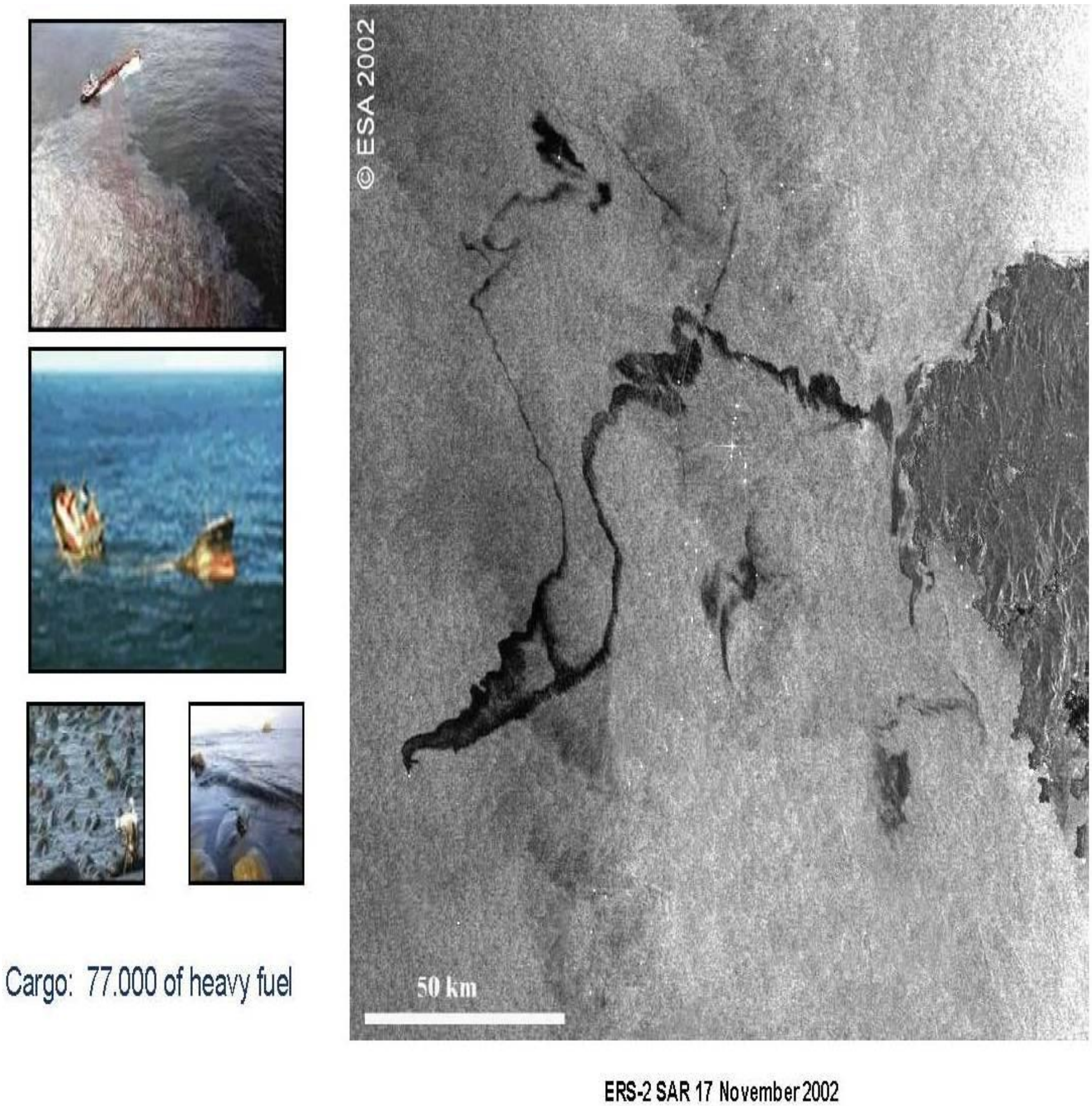


Figure 6.11: Prestige satelitte oil slick pictures [48].

6.8 SAR Image Processing

In order to be fast and accurate in detecting, identifying and clarifying the dark formations as oil spills, there should be semi or fully automatic methodologies for assessing and processing the rapidly increasing SAR data.

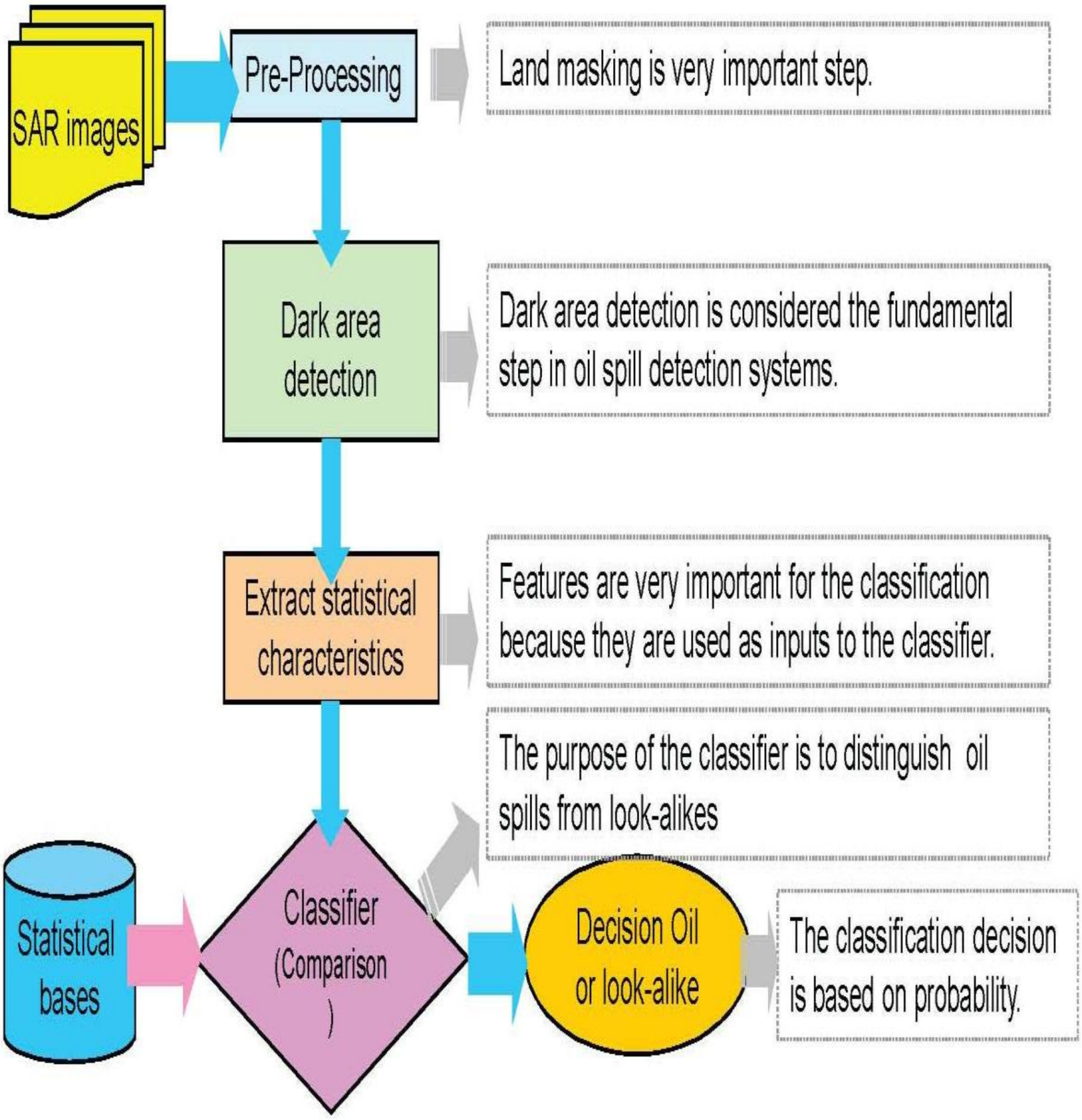
6.9 Oil Spill SAR Monitoring Service

- Service description
  - – Geo-location
  - – Parameters: area, size, orientation, complexity, contrast
  - – Reliability

– Source (Ship, platform, …)

– Metocean conditions

Table 6.1: Basic Function for oil spill detecting methodology [48].



- Early warning system:

  – Semi-automatic detection scheme

  – Validation by a trained operator

- Required evolution

  – Extra auxilary information to reduce FAR (false detection of slicks)

  – Combined operation with AIS (Fig 6.12)

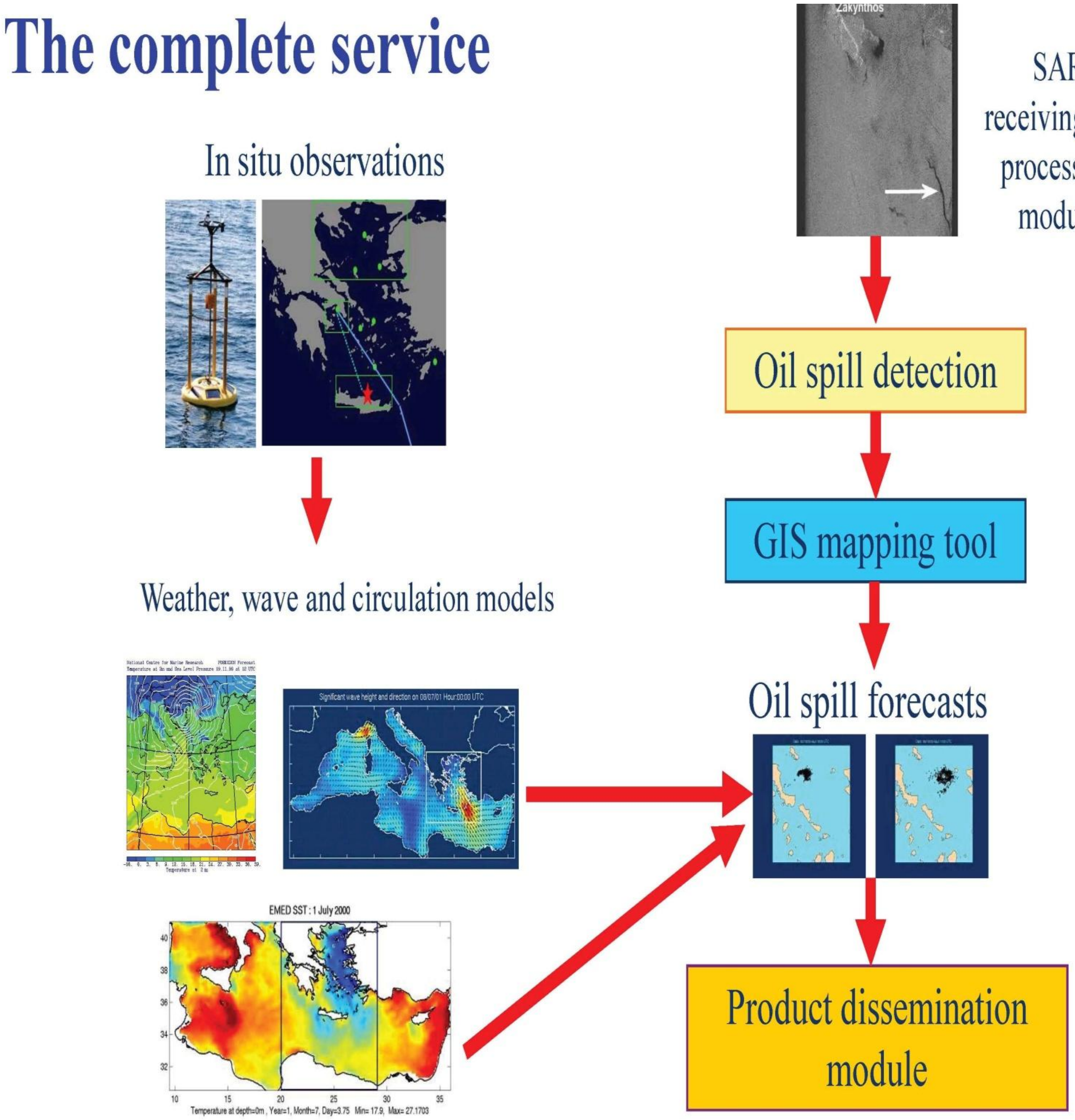


Figure 6.12: Complete service of SAR [48].

7. SATELITTE BASED MONITORING - SURVEILANCE SERVICE EMSA

After the "ERIKA" sinks off the Coast of Brittany at December 12, 1999;Eurpoean Commision decided to establish EMSA for maritime safety.

7.1 Objectives of EMSA

Within the fields of maritime safety, pollution prevention from ships and ship security, EMSA has the following main operational objectives:

• To ensure the proper implementation of EU maritime legislation

• To foster technical cooperation and development and disseminate best practice

• To provide technical advice to the Commission and MS

• To provide operational capabilities, in particular to top up Member State's capabilities for oil pollution response [47].

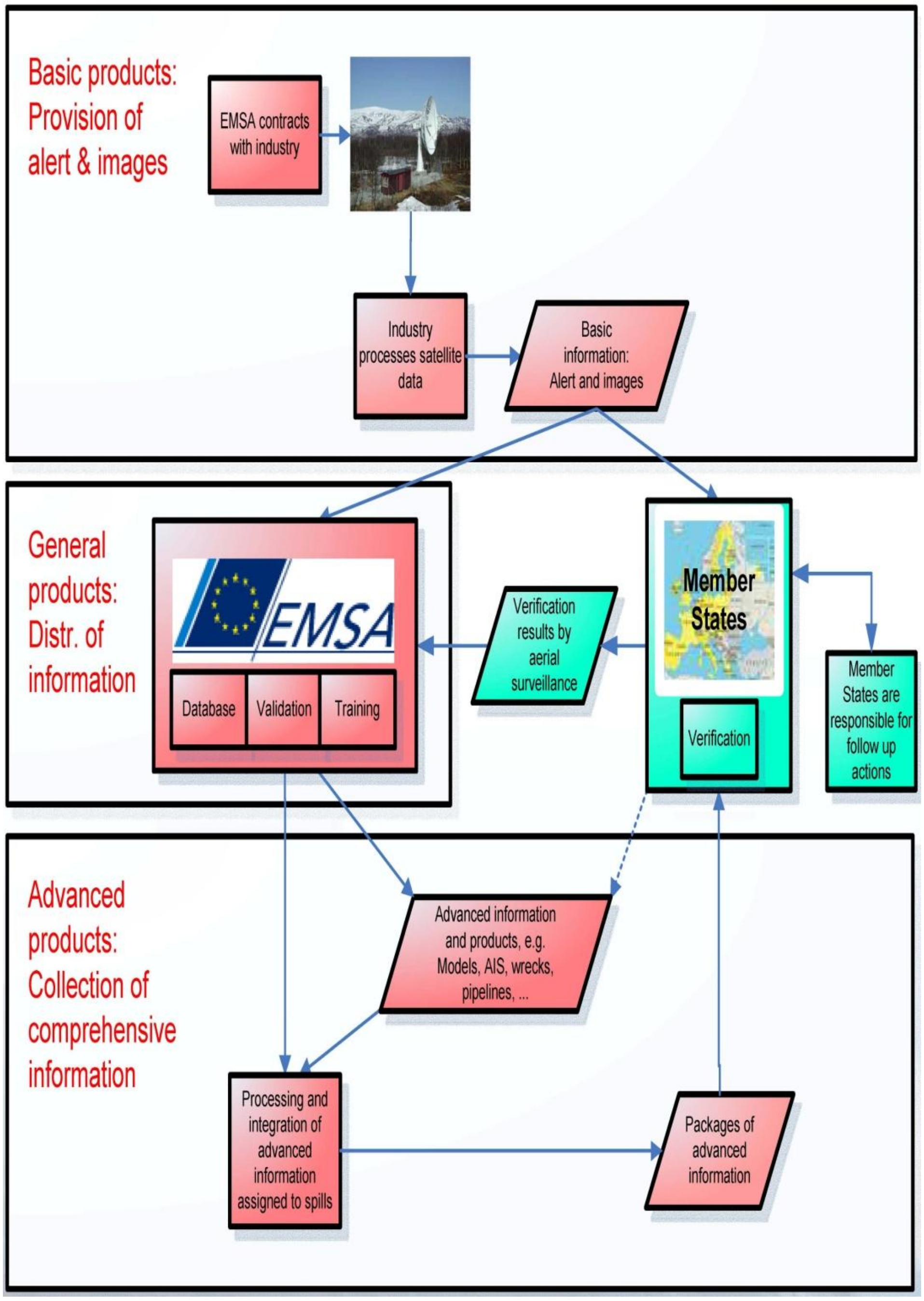
7.1.1 Scope of EMSA satellite service

A system that integrates into the national / regional response chain and strengthens operational pollution surveillance and response for accidental spills and deliberate discharges from ships

• To assist CS to locate and identify polluters in areas under their jurisdiction. Routine monitoring of European seas for illegal discharges in cooperation with Coastal States [47].

Monitoring of large scale accidental oil spills (under activated Charter**)** Investigation of pollution 'hot spots', development of statistics Provide satellite images and information 'free of charge' to Coastal States [47] Information flowchart of EMSA Diagram as shown;

Table 7.1: Information flowchart of EMSA [47]



7.2 Spatial Distribution of European Waters

Emsa Spatial Distribution is

- Baltic Sea
- North Sea and waters around UK, Norway and Iceland
- West European water from English Channel to Gibraltar
- Canary Islands
- Western Part of Mediterranean Sea

- Eastern Part of Mediterranean Sea
- *Black Sea*

The Coverage of EMSA Satellite with Latitude and Longitude as shown in the figure;

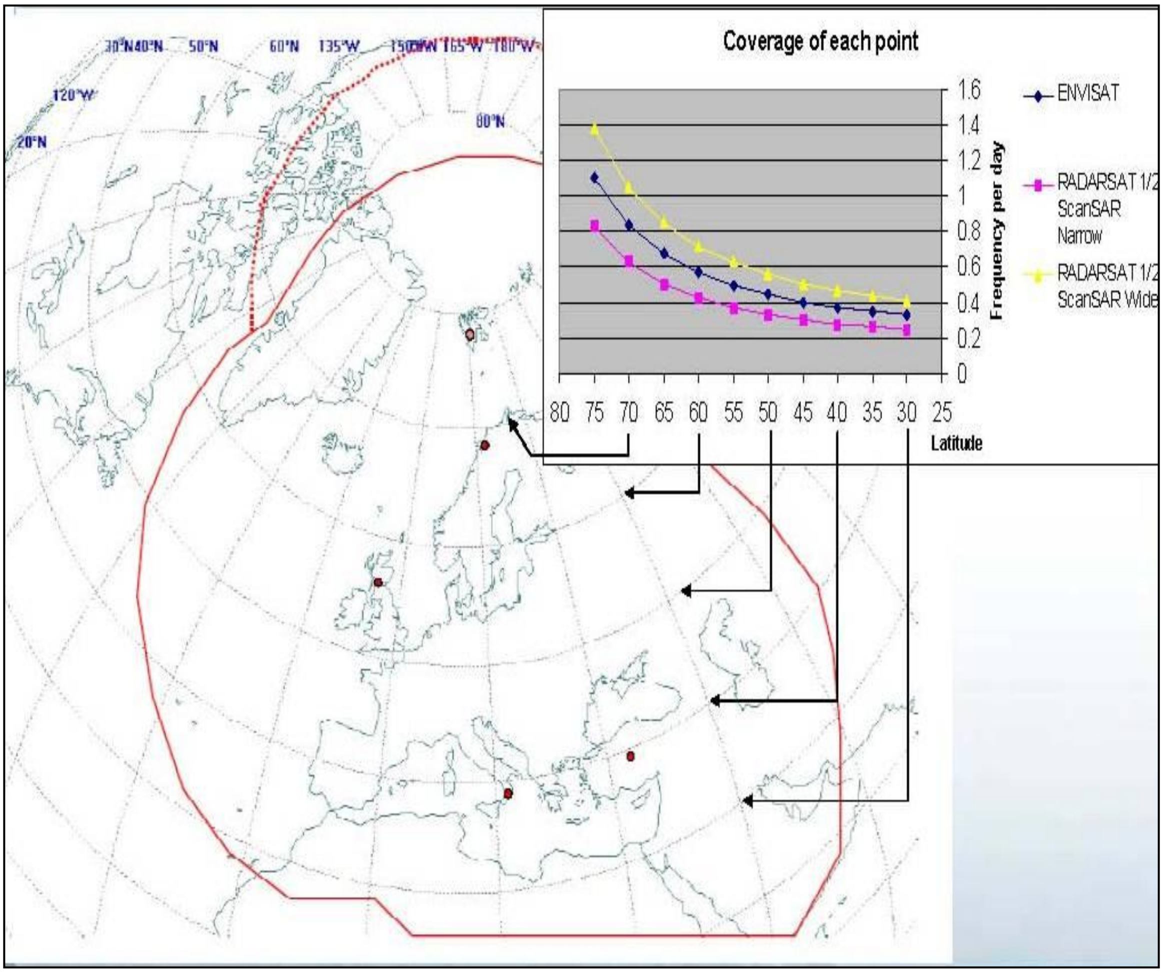


Figure 7.1: Coverage Of Satelittes [47].

7.3 Process of Catching Ship Based Oil Polluters by EMSA

- *with alert information*

Notification**:** by Email, FAX, SMS, or phone or a combination of them to the responsible Member State and neighbouring countries

-Alert time: Nom. 30 min after satellite overpass (max. 45 min) (even CLEAN AREA shall be reported)

Delivery of Images: Full (original) and reduced resolution images available at the time of alert

- *provided oil spill information*

-Oil spill occurrence notification, time

-Oil slick position, extent

-Slick characteristics (e.g. pattern), confidence level

-Meteo wind and wave (Wind speed and direction for each area surveyed at time of image acquisition - assimilated meteo data)

-Possible oil spill source identification/ potential polluters (e.g. vessel, offshore platforms, pipelines, etc.)

-If provided by Member States: wreck and pipeline information (seperate information layers)

-If available: AIS information (Identification of vessels from appropriate AIS/VTS at time of image acquisition)

-Border Lines (EEZ, PSSA, territorial borders) Alert mechanism **[47]**

The Alert Mechanism of EMSA is as shown below when monitoring and detecting oil spill.

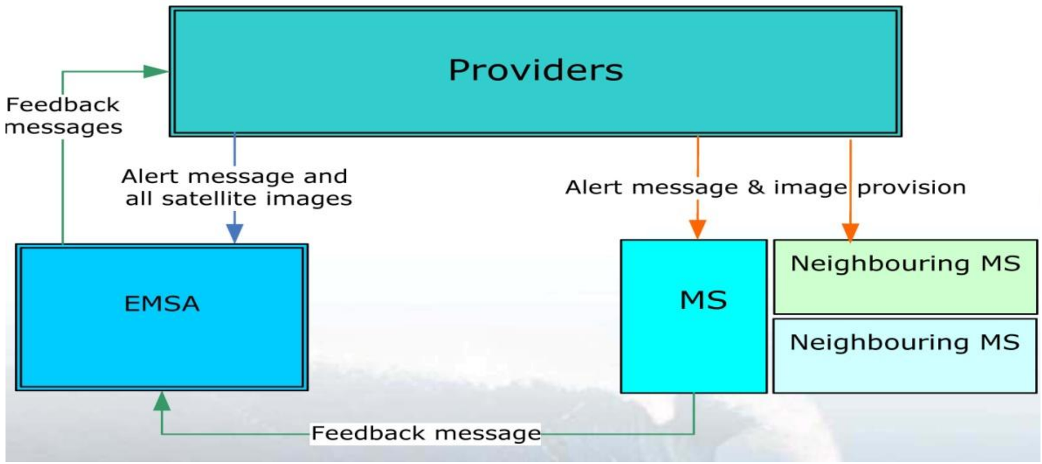
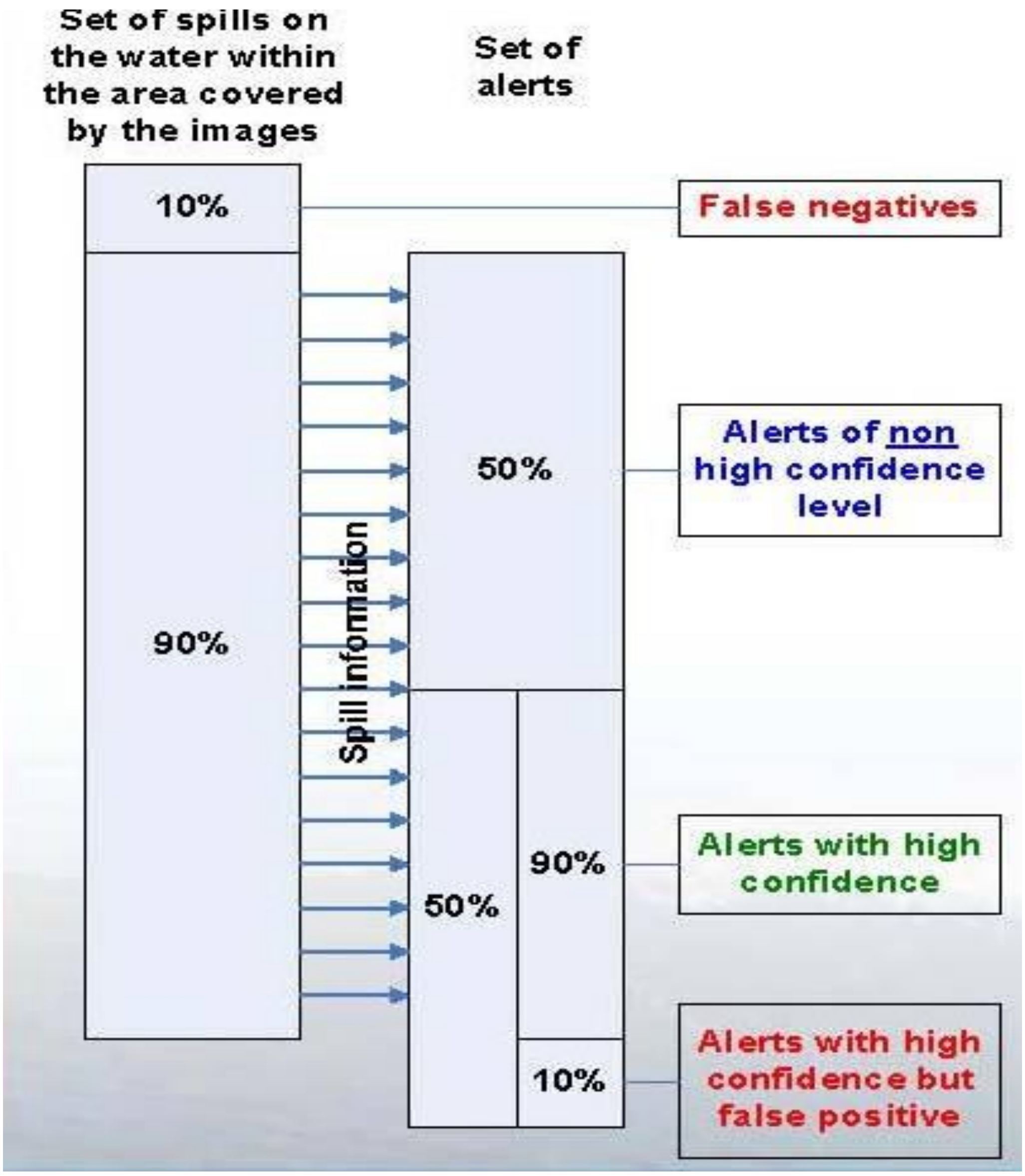


Figure 7.2: Alert mechanism [47].

7.4 Rate of True False Detection

Detection Probability (for wind speeds between 2m/s and 12m/s) is better 80% for minor spills and better 90% for major spills. False negative rate: Min. 90% of all oil spills within the areas covered by the images have to be reported. False positive rate: Max. 10% of all alerts which are marked as highest level of confidence may be no oil Confidence: Min. 50% of all actual spills have to be alerted with highest level of confidence. Diagram of true false detection is as shown below.

Table 7.2: Alerts diagram [47].



8. PREVENTING OIL POLLUTION AROUND EU WATERS AND BLACKSEA

The European Maritime Safety Agency (EMSA) has extended the directives regarding marine pollution prevention and response, after facing the very bad results of the *Prestige* accident. By adopting a directive in 2005, the European parliament and the Council aimed at incorporating international standards for ship originated pollution into Community law and at couraging governments to punish responsible of illegal discharges with adequate penalties.

This Directive gives the responsibility to EMSA to "work with the Member States in developing technical solutions and providing technical assistance in actions such as tracing discharges by satellite monitoring and surveillance.

As a result of this directive, European wide operational system for oil slick detection based on satellite sourced synthetic aperture radar (SAR) images, which is called CleanSeaNet has been set up and provided by the Agency. This European service widens existing surveillance systems at national or regional level, strengthens Member States response to illegal discharges and supports response operations to accidental spills.

Support to Member States affected by accidental spills is an important and interesting aspect of the service but this article will focus mainly on the use of CleanSea Net in illegal discharge response chains [49].

In order to increase the efficiency of preventing illegal discharges, deliberate spills must be detected and located across wide areas during day and night and in all weather conditions.

In the 1980's, many European coastal states had airborne based surveillance systems by using low flying aircrafts on which Side-Looking Airborne Radar (SLAR) used. This type of radar is able to detect a large variety of pollutants (such as oil spills) and other phenomena on the sea surface. By using SLAR combined with other sensors such as Infrared/Ultraviolet Scanners (IR/ UV), Microwave Radiometers (MWR) and Laser-Fluorescence Sensors (LFS), adds system the capability of determining the spectral Signature of detected substances. In this way, distinction of mineral oil from other substances and determining the oil types can be possible. Also it can be possible to estimate the oil spill thickness and the volume of the spill. It should be bearded in mind that, remote sensing technology is inadequate for the success without the combination of visual detection by experienced operators which can be considered as the key element.

The Bonn Agreement Oil Appearance Code, which correlates apparent oil colour and slick thickness, is used by many European countries. Today courts in some Member States accept visual observation and relevant visual evidence recordings enough and satisfactory for sentencing. Also for the authoroties of such states such evidences are sufficient to bring a suspected vessel into port for further investigation and detention. Satellite SAR imagery became available in the 1990's.

SAR sensors detect the dampening effect of oil on the sea surface. A smooth surface will appear as a black pattern on the SAR image, while a rough surface will be much brighter. Even very thin oil films can be detected from space, independent of weather and visual conditions for instance in the presence of a thick cloud formation.

The development of satellite oil detection and monitoring techniques with their reasonable costs give the advantage of monitoring wide areas at regular time intervals. In the mid 2000's, only a few European countries were using such satellite systems in their national response organisations integrated with aerial surveillance systems. With CleanSea Net. EMSA set up the first European wide satellite oil detection and monitoring service. There are three satellites in CleanSea Net which are polar orbiting SAR satellites. The name of these satellites are ENVISAT, RADARSATI and RADARSAT2.E VISAT has the swath coverage capability of 405 km while RADARSAT has 300 km, with the swath being the width of the land strip covered by the radar at each overpass. At the equator the frequency of observations for polar orbiting satellites is significantly smaller than at higher latitudes. CleanSea Net has a high flexibility for surveillance operations which are supporting illegal discharge response organisations by using three wide swath capable satellites which minimizes affects of orbit constraints. European waters can be scanned several times per day as per the needs of each individual Member State. Aerial surveillance is the only way to identify the type and thickness of pollution. On the other hand, satellite observations give support by relaying slick positions to air units for further investigation which optimise the use of air assets.

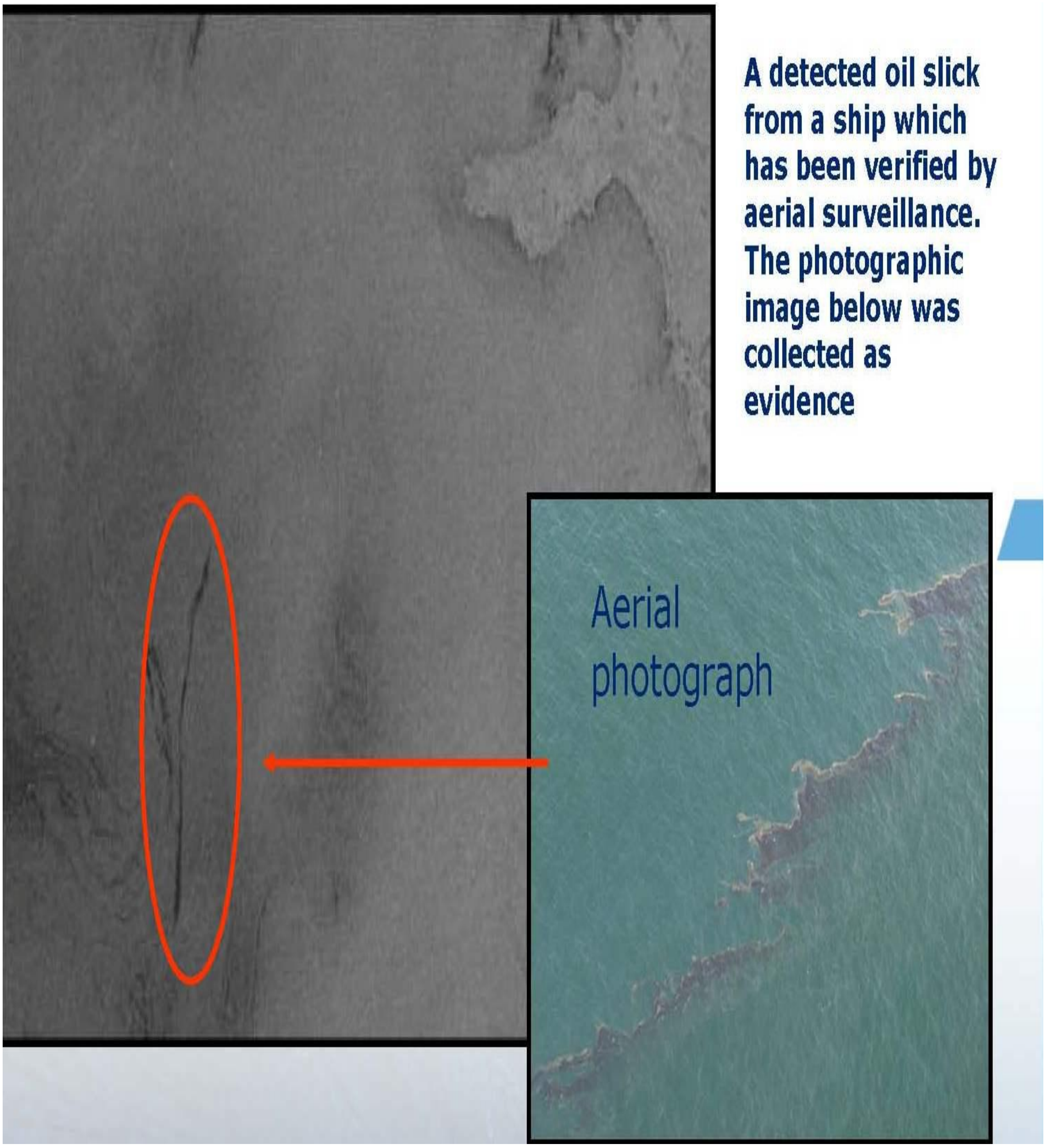


Figure 8.1: Examples of detected oil slick verified by aerial surveillance [47].

Therefore, CleanSeaNet, like any satellite based oil pollution monitoring service, is not a separate and independent system. CleanSea Net can be considered as an auxiliary complement system that strengthens national operational response organisations.

8.1 Catching polluters / CleanSea Net

Most critical thing to catch polluters while committing pollution is time. So, for a rapid engagement of polluters, delay between satellite detection and alert should be minimum. CleanSea Net is a near real time service. When E 'VISAT or RADARSAT satellite passes Over European waters, it is always within range of the ground stations in the CleanSea Net network. As a result, receiving station can acquire data regularly and this data can be simultaneously downloaded.

There is a need of complex processing of SAR data before using for oil detection. The capability of relaying processed and analysed SAR images with a little time delay is a great achievment. Also it is a real challenge to inform Member States of the location of potential spills in near real time. The CleanSea Net service is contracted to a group of European companies (KSAT, Telespazio and Edisoft).As per the contract, system has the obligation to deliver data in less than 30 minutes. Like any radar, SAR sensors are able to detect ships and quite often their wakes (trails). A ship appears as a bright dot on the surface. When a long and linear spill is detected trailing in ship’s wake, there is little doubt about the nature of the ongoing discharge. After detection of discharge, it is necessary to identify the vessel and to determine the legality of the observed discharge as per MARPOL. Traffic monitoring and information systems are the most important elements providing the essential information for the identification of vessels suspected of pollution. Integrated surveillance systems including vessel traffic information systems such as AIS coastal stations are being developed by most of the European countries. AIS coastal stations in Member States cover most of European waters and most of them are now connected to regional servers.

Since the end of 2008, by direct accessing to AIS based vessel traffic information via above mentioned regional servers, CleanSea Net has had the capability to positively identify the source of possible pollution when a vessel is still connected to the slick. It is also possible to prove the responsible of a recent spill if the vessel's track matches the pattern of the spill where there is no possible confusion between the different vessels observed in vicinity of the reported slick.

The use of hind~casting oil drift modelling tools combined with vessel traffic information further enhances the capabilities of the authorities in the Member States to identify polluters. Backtracking of spills and intersecting the trajectory with vessel tracking data limits the number of potential polluters and allows authorities to carry out more in-depth checking of suspicious vessels. This is an important element in the chain of evidence and provide a significant deterrent effect which should lead to a decrease in illegal discharges [49]. Follow up on CleanSeaNet detections is the responsibility of each coastal state, but the response may vary a lot from one country to the other. In some countries, each time a satellite acquisition is planned, an aircraft is either in flight or on stand by, thus increasing the chances of catching a polluter in the act. Some European Member States are now inflicting fines of many hundreds of thousands Euros for deliberate pollution in violation of MARPOL regulations [49].

As an example, on 18 March 2009, a French court handed the Russian- flagged general cargo ship Skulptor Anikushin a EUR 350,000 fine for deliberate pollution in the English Channel during its voyage to Saint Petersburg in July 2008. The ship had been brought into Dunkirk and detained for one week until a EUR 400,000 bail was paid by the ship operator. A possible spill detected on a SAR satellite image may constitute a suspicion that a ship has been engaged in a discharge. More and more Member States use CleanSeaNet detections to trigger Port State Control inspections when vessel traffic monitoring systems, AIS information, and soon LRIT information allow the clear identification of the source. A number of polluters have been fined on the basis of evidence collected during such inspections [49].

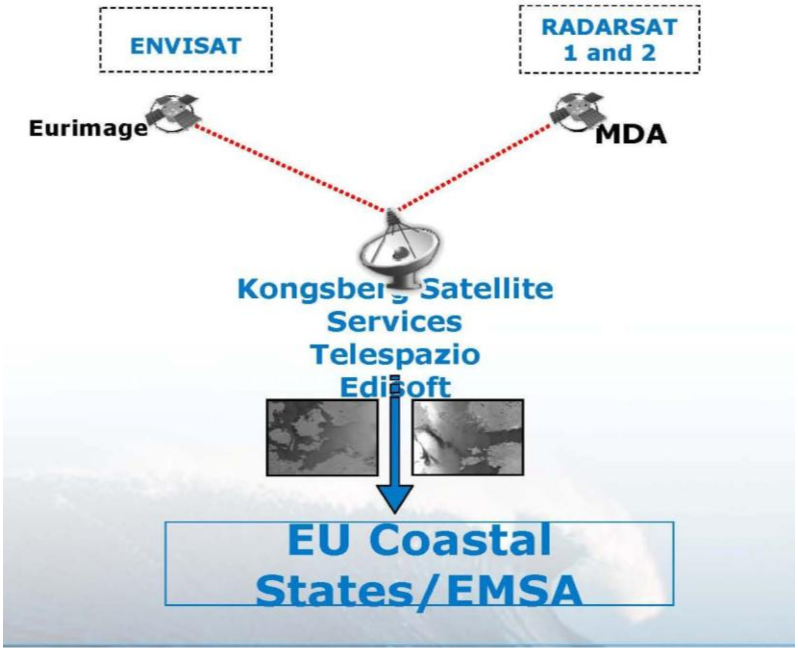


Figure 8.2: The Satelittes used by EMSA [49].

8.1.1 C1eanSeaNet figures

CleanSeaNet commenced operation in April 2007 providing service access to 24 coastal states. From 16 April 2007 until 31 December 2008 total 3679 satellite scenes (2031 ENVISAT and 1648 RADARSAT) have been acquired and analysed.Satellite based European oil pollution monitoring service monitored more than 400,000,000 km2 of sea. For covering the same area with aerial surveillance ,it would have taken more than 25,000 flight hours.

In most cases, each satellite scene covers more than one country's waters. The scenes ordered by CleanSeaNet have fulfilled more than 7.000 national requests by Member States and this quantity indicates the economies of scale generated by having a European level service.

Although not all of detections were oil,during this period 4,027 possible oil slicks were detected and reported to the authorities of the relevant countries.After 18 months,study of operations prooved that the percentage of CleanSeaNet detections checked on site by aircraft or vessels confirmed as being mineral oil.In spite of the fact that the values may vary from one region to the other but can reach values as high as 80% like in the Western Mediterranean Sea.

CleanSea Net detected most of the spills along the main maritime traffic routes. This indicates and proves that ship originated illegal discharges are still an important reason of pollution which results significant damage to marine and coastal environment. With CleanSeaNet such pollutions will not be unnoticed and hided. It is mandatory for ship masters to report any observed pollution at sea. They should be conscious that it is becoming more and more risky not to report accidental spills that they may have caused. Not only the seafarers but everybody should always bear in mind the vital importance of preservation of marine resources and pay utmost attention to take necessary precautions to reduce marine pollution fort he future of human being.. Taking action of Emsa is as shown against pollution.

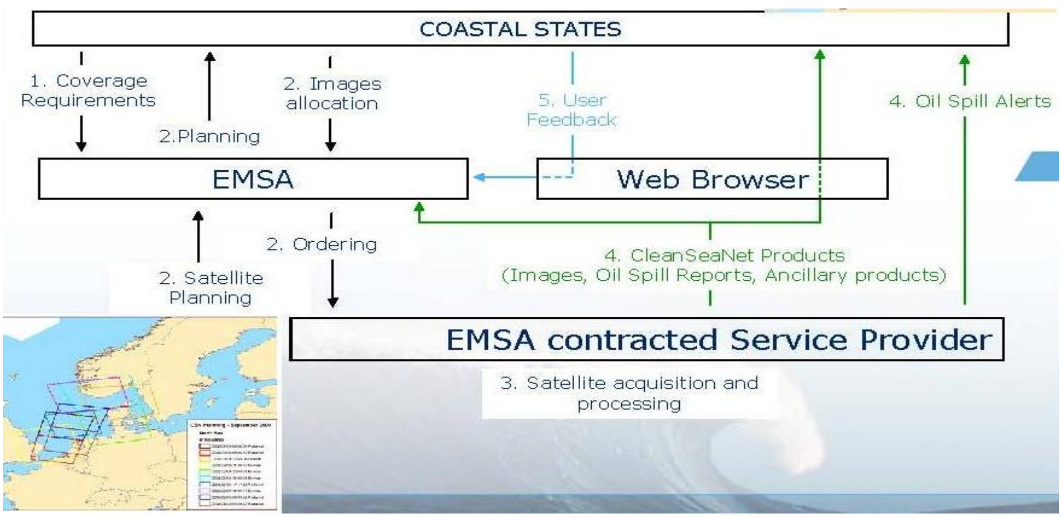


Figure 8.3: CleanSea net flow chart [47].

The Cleansea Net web page as shown below, the scanned ships and the required map view are listed.

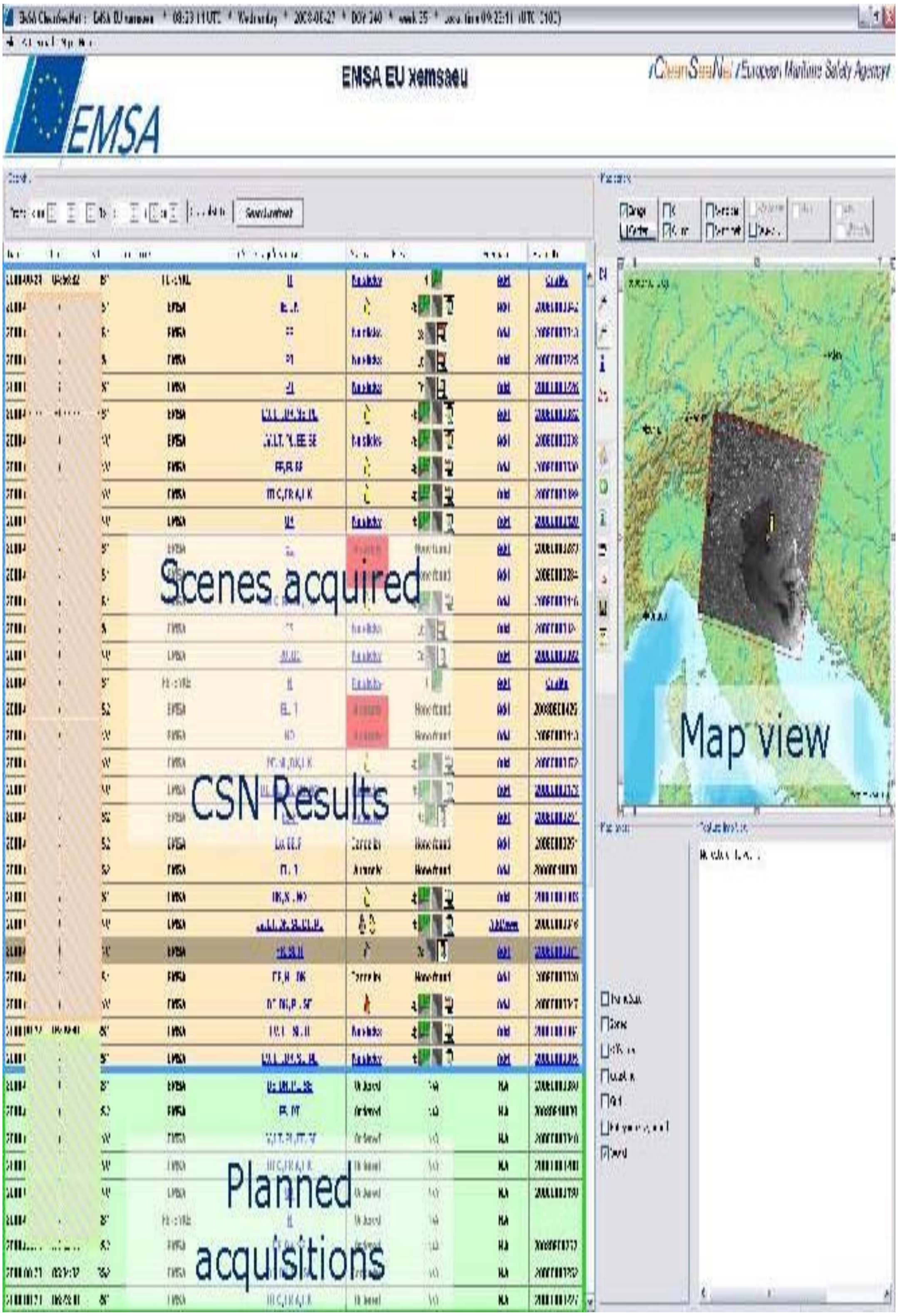


Figure 8.4: CleanSea net results [47].

9. APPLICATION AND EXAMPLES OF MONITORING SHIP SOURCE OIL POLLUTION AROUND EU WATERS, MEDITERENAN AND BLACK SEA

Accidental pollution at sea can be reduced but never completely eliminated; however, deliberate illegal discharges from ships can indeed be reduced by the strict enforcement of existing regulations and the control, monitoring and surveillance of maritime traffic. Despite this, operational oil discharges are common and represent the main source of marine pollution from ships. To analyse this problem, the Joint Research Centre (JRC) of the European Commission has focused its attention on the need to monitor in the long term sea-based oil pollution. This research aims, in particular, to map the oil spills, to identify the hot spots and to define the trends in all European seas. For this reason, Joint Research Center has collected all relevant data concerning sea-based oil pollution from different actors and archives. For the North and Baltic seas, data from aerial surveillance were used and, for this reason, all oil spills are real and confirmed. Conversely, the data for the Mediterranean and the Black Sea derive from oil spills detected by JRC in low resolution SAR (Synthertic Aperture Radar) satellite images from archives. For the Mediterranean and the Black Sea, these data represent only source to draw some preliminary conclusions on [50].

9.1 Comparasion Of EU Waters

In the North Sea, regular aerial surveillance to detect oil spills and to catch the polluters began in the 1980s. The eight countries bordering the North Sea work together under the Bonn Agreement and undertake aerial surveillance using aircraft equipped with remote sensors (RS). Data of observed oil spills are available from 1986. It should be stressed that in the North Sea there are many off-shore installations which are sources of sea-based pollution. Deliberate illegal oil discharges from ships have also regularly been observed within the Baltic Sea since 1988. A complex set of measures known as a Baltic Strategy has been implemented by the nine contracting parties to the Helsinki Convention. These measures include surveillance flights and improved usage of remote sensing equipment. As a result, a decrease in the number of observed illegal discharges has been identified over recent years in the North Sea and in the Baltic Sea, despite the rapidly growing density of shipping. Although the number of observations of illegal oil discharges has been decreasing it should be kept in mind that, for some areas, aerial surveillance is not evenly and regularly carried out and therefore there are no entirely reliable figures for all areas [50].

For the North-East Atlantic, there are no data available on a regular basi concerning deliberate oil discharges from vessels. Moreover, this area is not defined 'Special Area' according to Annex I of the MARPOL Convention. Outside 'Special Areas', it is difficult to assess if visible oil discharges from ships are illegal. However, in this area there was, for the first time, operational use of satellite imagery during the Prestige accident in 2002. For the Mediterranean Sea and the Black Sea there are no data derived from regular aerial surveillance, so the only possible way to monitor these seas is the use of SAR satellite images from archives. The reliability of the satellite image analysis is not yet fully satisfactory and further investigations and validation activities are necessary. However, the use of archive satellite imagery is the only way to extract information for these seas. The Joint Research Centre (JRC) is carrying out a systematic mapping of the oil spills using satellite imagery in these two seas. This action helps to reveal the scale of the oil pollution problem, thus stressing the need for more concerted international action. Vessels, airplanes and satellites are used to detect and monitor oil spills. The vessels, especially if equipped with specialized radars, can detect oil at sea, but they can cover a very limited area. Aircraft are the most frequently used tool to detect and monitor oil pollution at sea. Observations by experienced aircrew are fully reliable in detection, classification and quantification of observed pollution. Aerial surveillance can be based on simple visual analysis of the aircrew, using for example the Bonn Agreement Oil Appearance Code, or can be executed with auxiliary RS tools. Airborne observations can be carried out using Side Looking Airborne Radar (SLAR) to locate the oil spill, infrared/ultraviolet sensors (IR/UV) to quantify the extent of the film, microwave radiometer (MWR) to measure the spill thickness, and laser-fluorosensor (LFS) to classify the oil type Among these methods, SLAR is the most used. Satellites equipped with Synthetic Aperture Radar (SAR) can provide information on the presence of oil at sea. Brekke and Solberg (2005) presented a detailed description of oil spill detection by satellite remote sensing in the world's oceans. It should be remembered that satellite-borne SAR images do not allow the detection of oil spills if the sea surface is too rough or too smooth, i.e. in the case of winds approximately below 2ms and above 10ms, finally satellite SAR images are unable to identify the pollution culprit (i.e. the name of the ship which polluted); whereas satellites can at best detect the position of the possible pollution culprit [50].

The data used for the Mediterranean and the Black Sea are derived from analysis of SAR satellite imagery. The datatype used in this study was mainly SAR uncalibrated low-resolution images, since these are the most targeted and cheap product for the application. A spatial resolution (pixel) of about 200m appeared to be sufficient for statistical investigations of marine oil pollution Data were provided by the European Space Agency (ESA) [50].

In order to be certain to the maximum possible degree that the detected spills were due to man-made activities rather than look-alike manifestations of natural phenomena, all the images were carefully analysed using a dedicated semi-automatic detection scheme, which includes, as final step, a decision by a skilled operator. Each identified spill was then registered in a database, together with information concerning its geographic position, the date and time of detection, the spilled area, its average contrast strength, and a vector describing its shape. It is important to underline that oil spills in the period 1999–2004 have been identified in archive images and the presence of oil at sea has not been confirmed by aerial or vessel surveillance. For this reason, even though only high confidence features have been taken into consideration, we prefer to term them ‘possible oil spills’. Potential oil spills are reported with 3 Confidence levels (low, medium and high) [50].

9.2 Advantages of Using Clean Sea Net

CleanSea Net European Satellite Oil Spill Monitoring and Vessel Detection Service since 2007 is making routine monitoring of all European waters and emergency services in case of accidents/incidents, Analysis of SAR (Synthetic Aperture Radar) satellite images to detect oil on the sea surface:

- ENVISAT, RADARSAT-1/2, 2.100 analysed satellite images per year, Distributed Service-Network approach via regional service providers (acquiring and processing satellite data).

- Nearly Remote Timing: 30 minutes end product delivery, Emergency portfolio under the GMES/Data Access
- Grant providing access to third party mission data, 69 authorised users: Pollution response authorities (Coast Guard, Customs, Navy, ...) of 26 EU coastal states, Norway and Croatia
- SAR satellite and SAR products used in CSN sunsynconous satellites with fixed overpass timing. Active sensors needs no sunlight. And also not impaired by clouds or winds [51].

9.2.1 The EMSA CleanSeaNet web browser

Web browser example of Clean Sea net and detected ships as shown below;

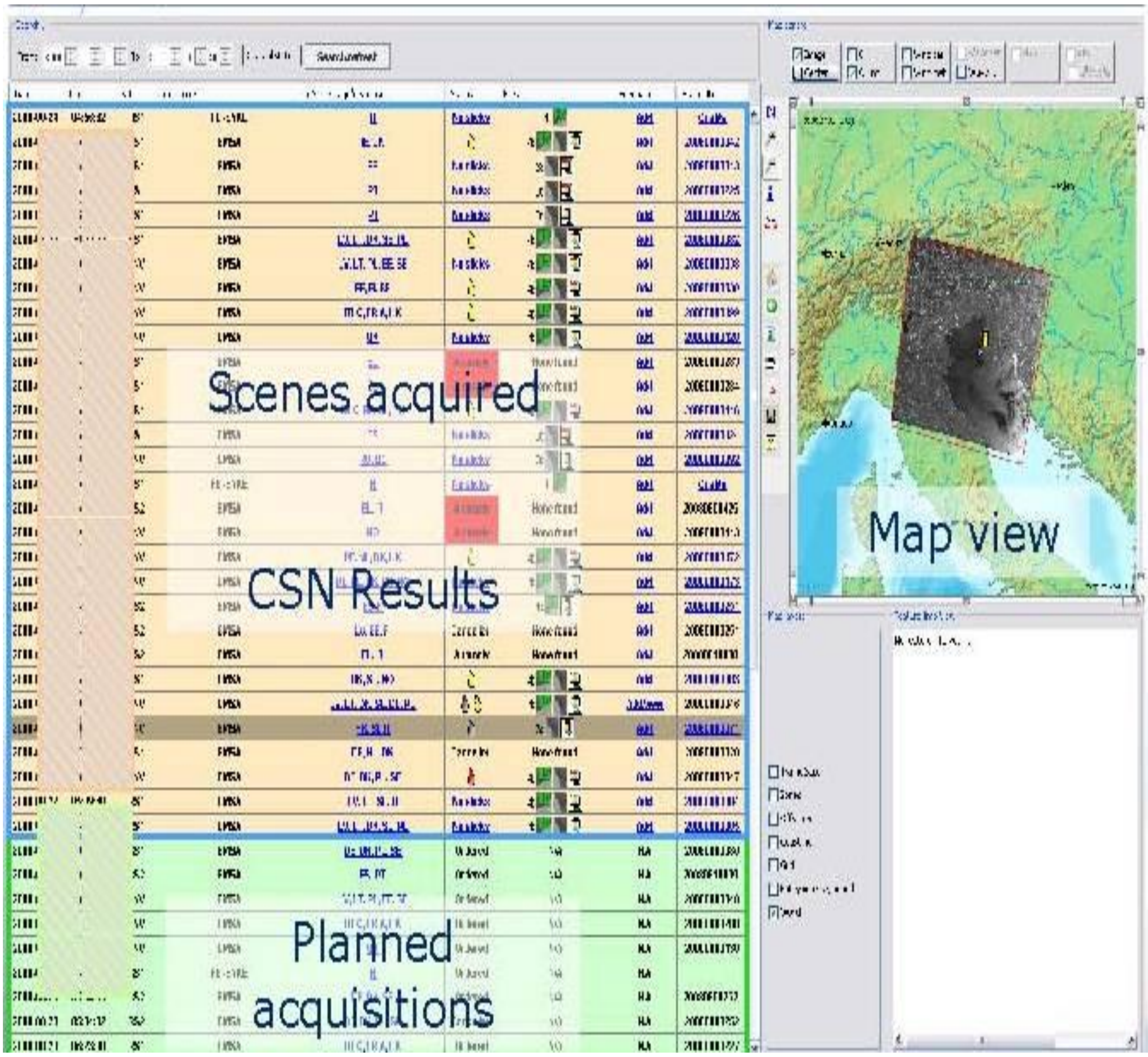


Figure 9.1: CleanSea Net Web browser [51].

9.2.2 CleanSeaNet Results – All European areas

The below picture shows around EU Clean Sea Net verification at 2009.

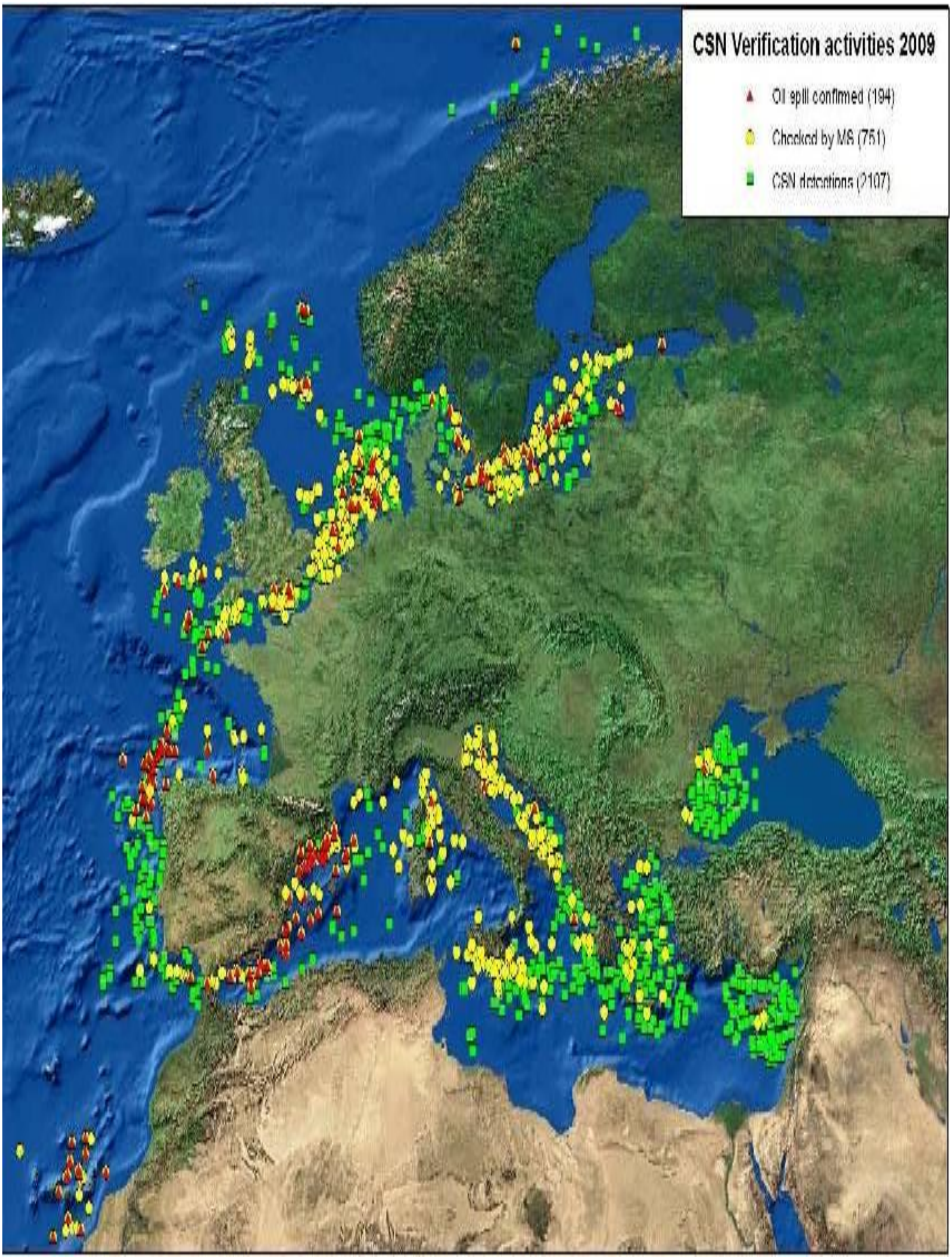


Figure 9.2: CSN verification 2009 [51].

9.2.3 CleanSea Net results – identifying polluters

Possible spill reported by CSN and confirmed by aircraft as being mineral oil - 42 km long polluter identified using AIS information, as shown below;

Figure 9.3: Envisat image [51].

ENVISAT image acquired over the Canary Islands on 15 September 2009 by the Azores ground station. confirmed by aircraft as being mineral oil - 42 km long ships identified using AIS information. Ship back tracking over laying the spill track provide strong evidence for identification of the polluter

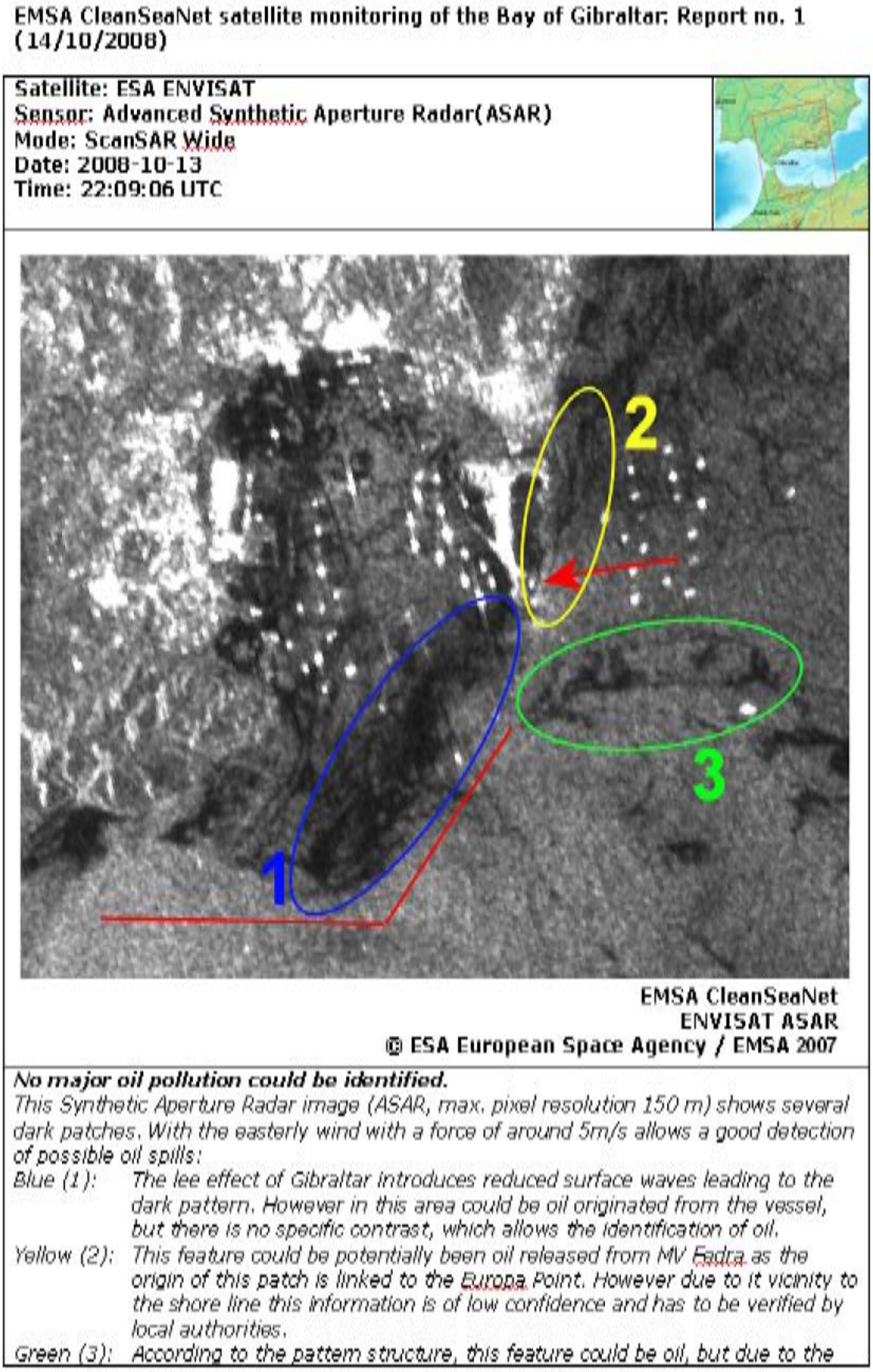
9.2.4 Support in case of accidental spills

In case of accidental spills, EMSA has the capacity to support the affected Coastal State with additional satellite coverage:

- Envisat and Radarsat 1 and 2 images: emergency planning and ordering via CleanSeaNet.
- Other SAR or optical data: in case of major disasters via the activation of the "International Charter for Space and Major Disasters".

A close cooperation between the CleanSeaNet team and the affected Coastal State allows optimising satellite planning and ordering. The figure shows;

- Grounding of the MS Fedra off Gibraltar in October 2008


EMSA CleanSeaNet satellite monitoring of the Bay of Gibraltar: Report no. 1 (14/10/2008)

Satellite: ESA ENVISAT
Sensor: Advanced Synthetic Aperture Radar(ASAR)
Mode: ScanSAR Wide
Date: 2008-10-13
Time: 22:09:06 UTC

EMSA CleanSeaNet
ENVISAT ASAR
© ESA European Space Agency / EMSA 2007

No major oil pollution could be identified.

This Synthetic Aperture Radar image (ASAR, max. pixel resolution 150 m) shows several dark patches. With the easterly wind with a force of around 5m/s allows a good detection of possible oil spills:

Blue (1): The lee effect of Gibraltar introduces reduced surface waves leading to the dark pattern. However in this area could be oil originated from the vessel, but there is no specific contrast, which allows the identification of oil.

Yellow (2): This feature could be potentially been oil released from MV Fedra as the origin of this patch is linked to the Europa Point. However due to it vicinity to the shore line this information is of low confidence and has to be verified by local authorities.

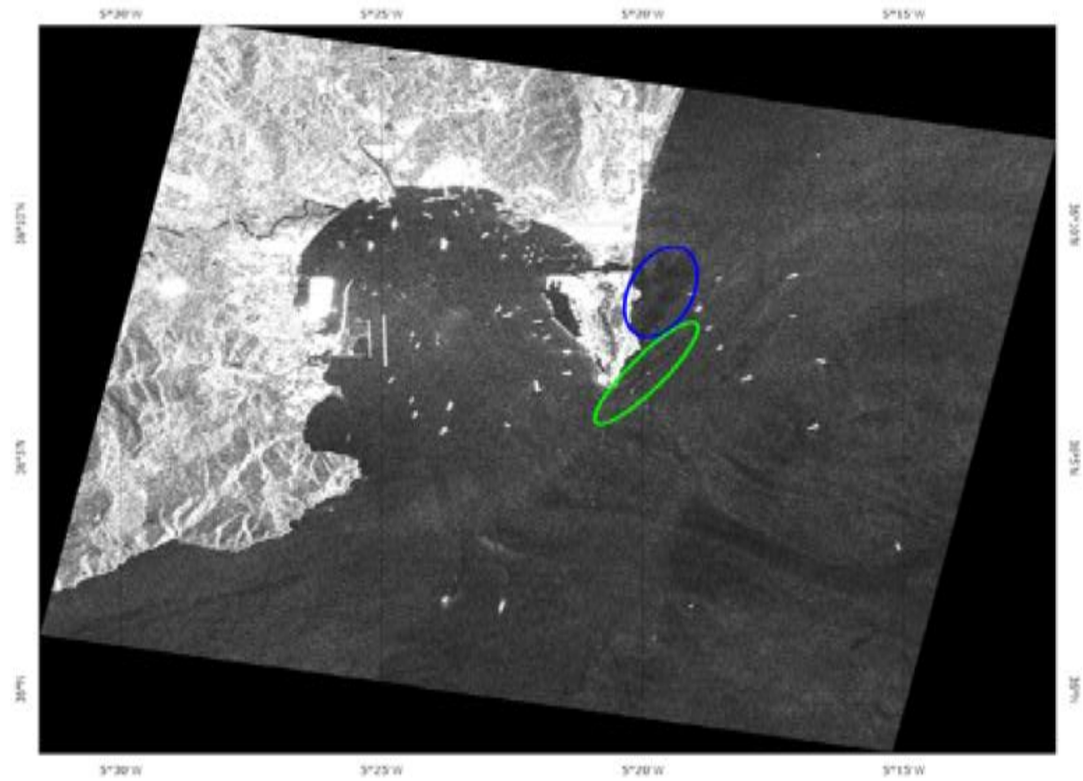
Green (3): According to the pattern structure, this feature could be oil, but due to the

Figure 9.4: An oil spill accident [51].

- Another satellite accident report of Grounding of the MS Fedra off Gibraltar in October 2008 as shown below; picture taken from Radarsat 1- SAR . CleanSea Net Service- EMSA.

EMSA CleanSeaNet satellite monitoring of the Bay of Gibraltar: Report no. 6 (22/10/2008)

Satellite: RADARSAT 1
Sensor : Synthetic Aperture radar
Mode: Standard Image S3
Date: 2008-10-22
Time: 06:23:17 UTC



EMSA CleanSeaNet
Radarsat 1 Standard Image Mode
2008-10-22 06:23:17 UTC
© CSA/MDA/EMSA

No major oil pollution could be identified.

No major potential oil slicks are identified in this Synthetic Aperture Radar image (RADARSAT-1, max. pixel resolution 50 m). Wind conditions permit detection of possible oil slicks.

Blue: *This dark patch could be due to the window shadow originated by the elevation of the Europa Point.*

Green: *According to the pattern structure, these features could be oil. However due to its vicinity to the shore line this information is of low confidence and has to be verified by local authorities.*

Figure 9.5 : An oil spill accident. **[51]**

For each accidental situation, EMSA issues tailor-made products, briefings, reports, etc. to better fulfil Coastal States authorities expectations.

9.2.5 CSN 2nd Generation: a Complete Approach

An integrated maritime surveillance platform: comprehensive, flexible and advanced system; providing meteorological and sea state information, SST, algae, ... vessel traffic information (AIS)

Oil drift modelling: links to forecast and backtracking models tailored for specific sea areas Static information (Nautical charts, bathymetry, borders, ...) Optical and multispectral images Satellite vessel detection Fusion of data Vessel tracking with backtracking data for polluter identification wind and wave for improving the confidence; an example:

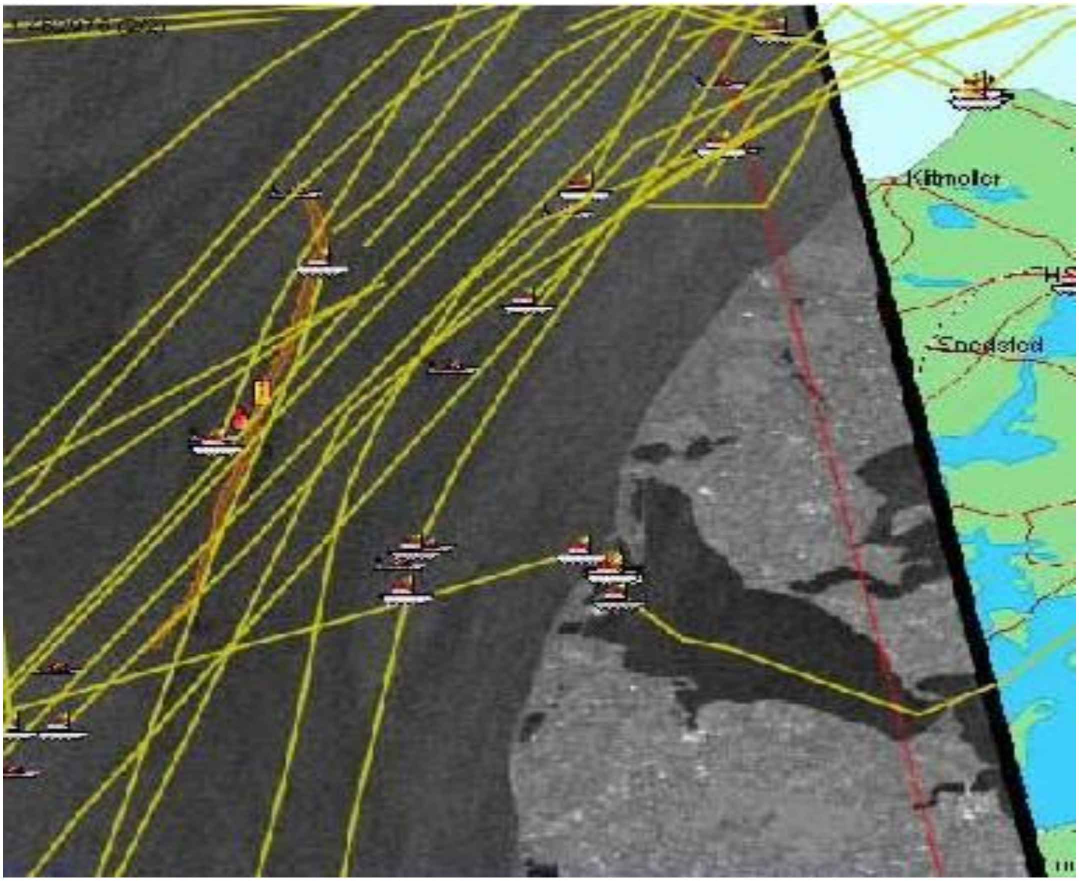


Figure 9.6: Vision for the CSN integrated system [51].

Integrated system to strengthen the national/ regional response chain for accidental spills and deliberate discharges from ships.as shown as;

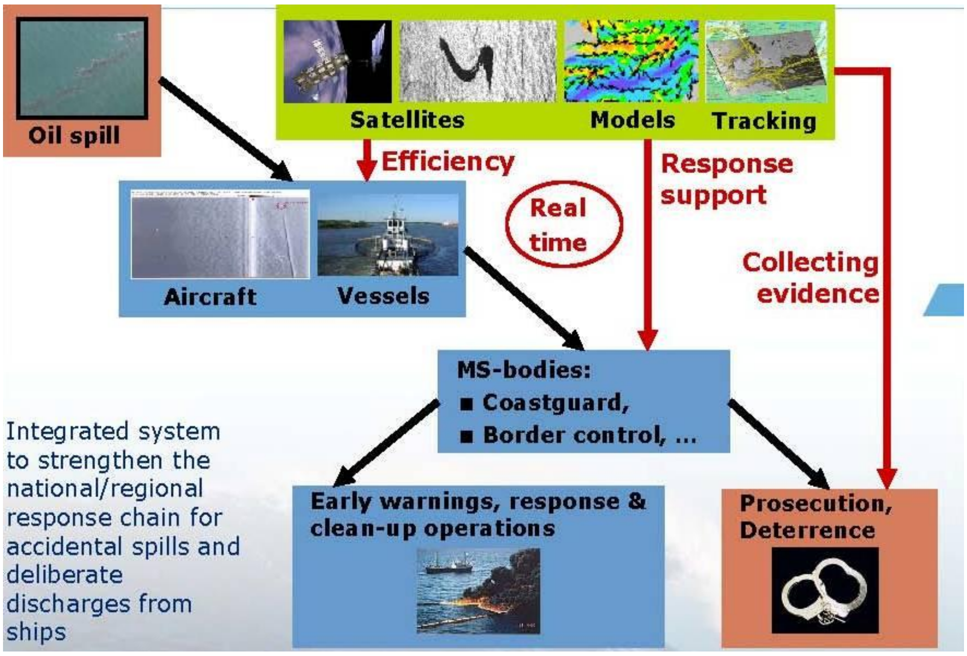


Figure 9.7: Integrated System for avoding pollution [51].

9.2.5 Spill drift modelling

Forward oil spill modelling is to support response operations and backward modelling is to identity of polluters. An example is shown;

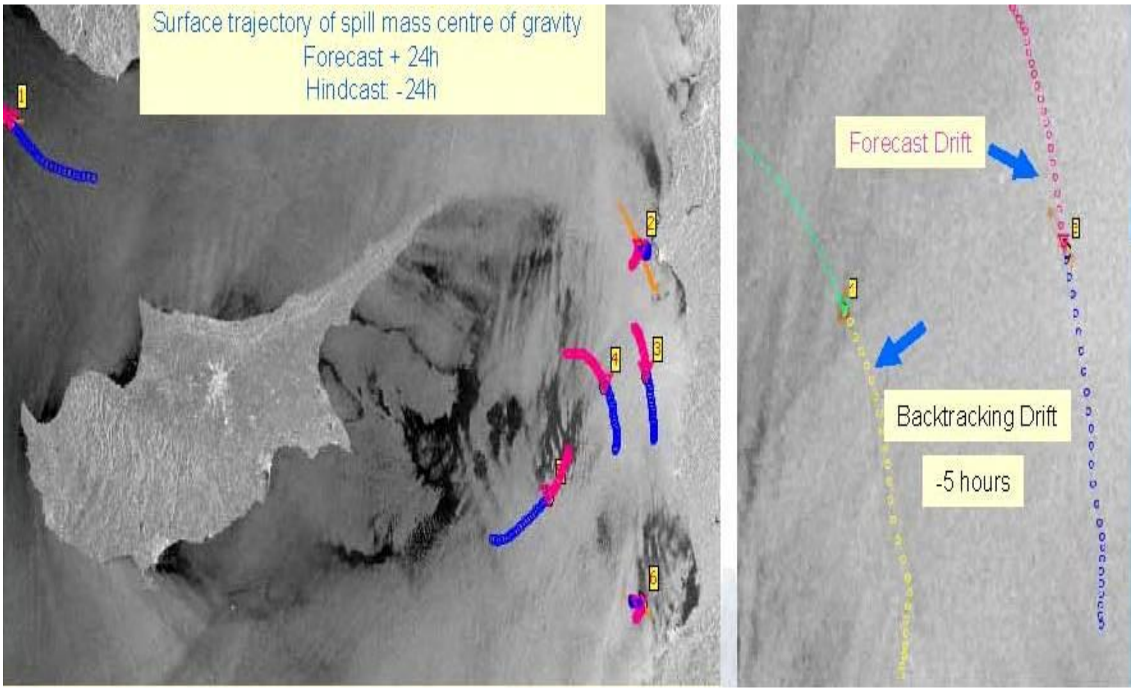


Figure 9.8: An example of oil spill forward and backward modelling [51].

While catching polluters as figure shown below; using Safe Sea Net which provides AIS information makes easy to catch.

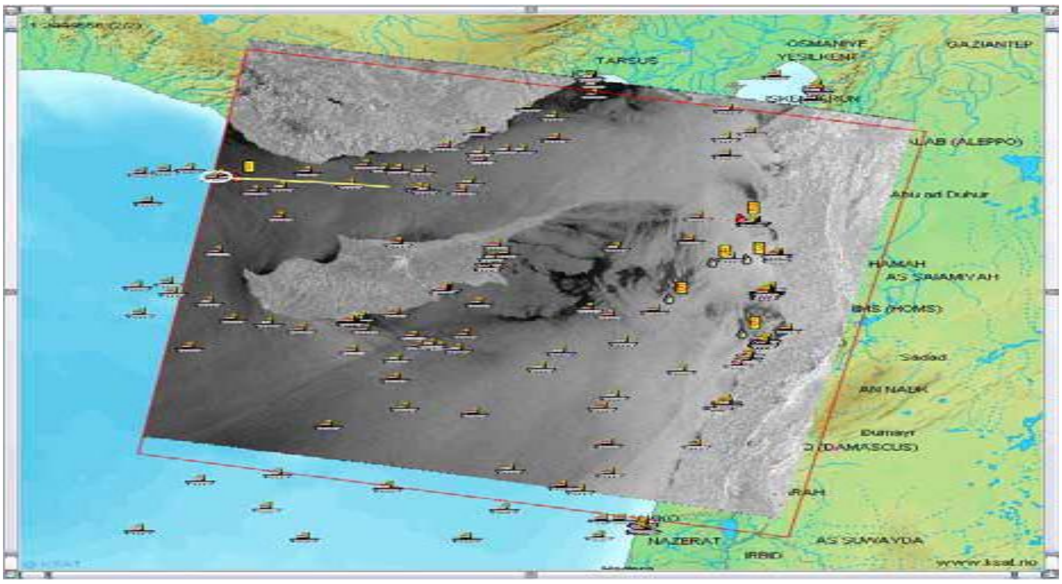


Figure 9.9: Detection of oil spill 12.03.2010 CleanSeaNet ENVISAT image [51].

9.3 Case Studies

First example as shown below; Monitoring the spill in Irish waters –February 2009 CSN alert on four possible oil slicks sent to Irish Coast Guard and to MCA on 14/02/09, mineral oil spill (at least 300m³of heavy fuel oil) confirmed by aerial surveillance, Spill was due to failure during refuelling at sea operation involving Russian Navy vessels 7 satellite images acquired over the area. Oil still visible on 27 /02/ 2009.

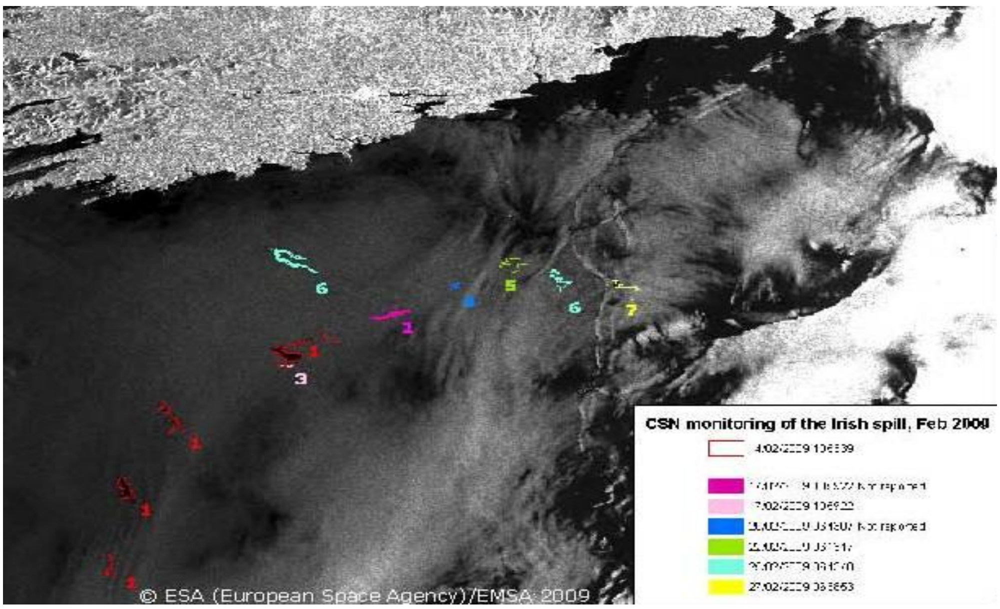


Figure 9.10: Irish spill monitoring [51].

These examples are from Italian Coast Guard. According to their legislation policy, their legal framework chain about catching illegal discharge; Validation in situ and collecting sample when means available

1.Cross-check of satellite images with all ships reporting systems (ARES, LRIT, AIS, VTS, VMS)

2. Request to neighbour countries to carry out PSC/MARPOL inspection, Carrying out PSC/MARPOL Flag State inspection and collecting samples to correlate with "in situ ones",when the case

3. Imposing fine for infringement and sending to the court for serious one

4. Issuing POLREP (use of both system CSN and SSN).**[52]**

- *CASE OF INTEREST OF ITALIAN COAST GUARD*

  - Case n 1: M/V Humboldt Bay II at 18 August 2010

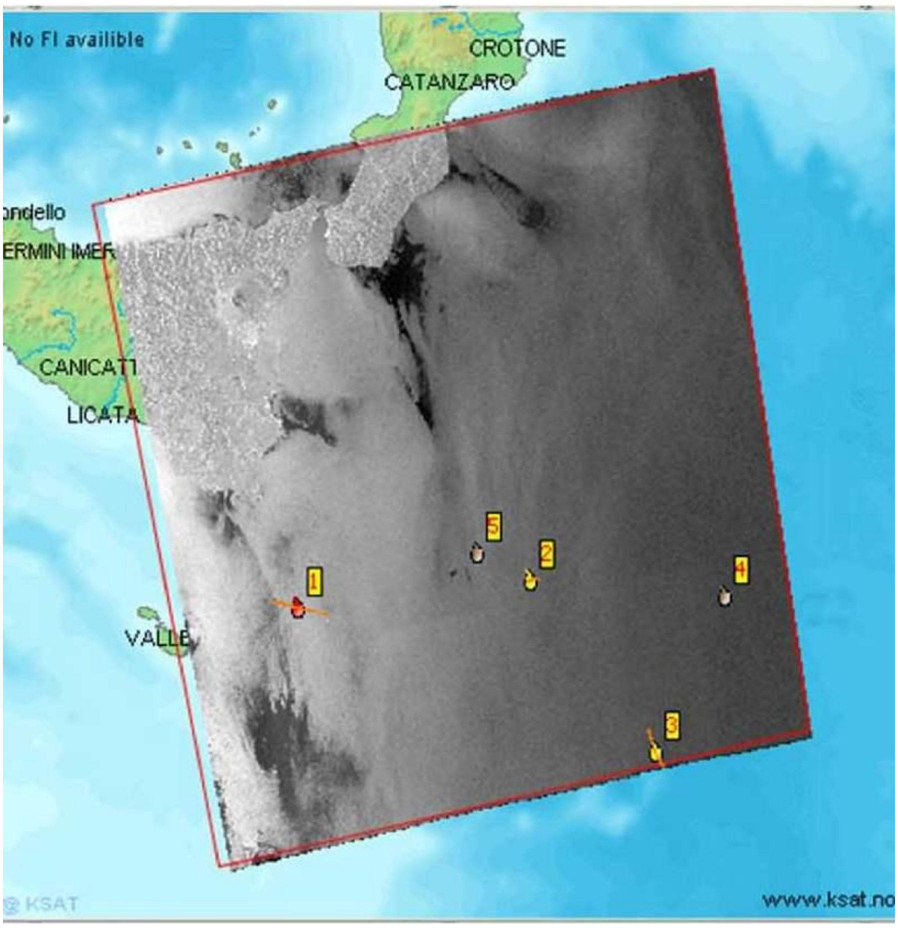


Figure 9.11: M/V Humboldt Bay oil slick detection [52].

M/V Humboldt Bay was detained, AIS information showed that the vessel port of call was Turkish ports, Italian Coast Guard asked for port state control with pollution reporting system.

When the ship was detected PSC Officers found;

- Oil record Book is not true
- Lack of IOPP Certificate
- Illegal connections between sludge and water tanks
- Oily Water Separator has directly overboard discharge connection

M/V Humboldt Bay, correlation of data of AIS information, vessel information as ship type, ship ID information, next port of call, type of cargo and destination time, etc.

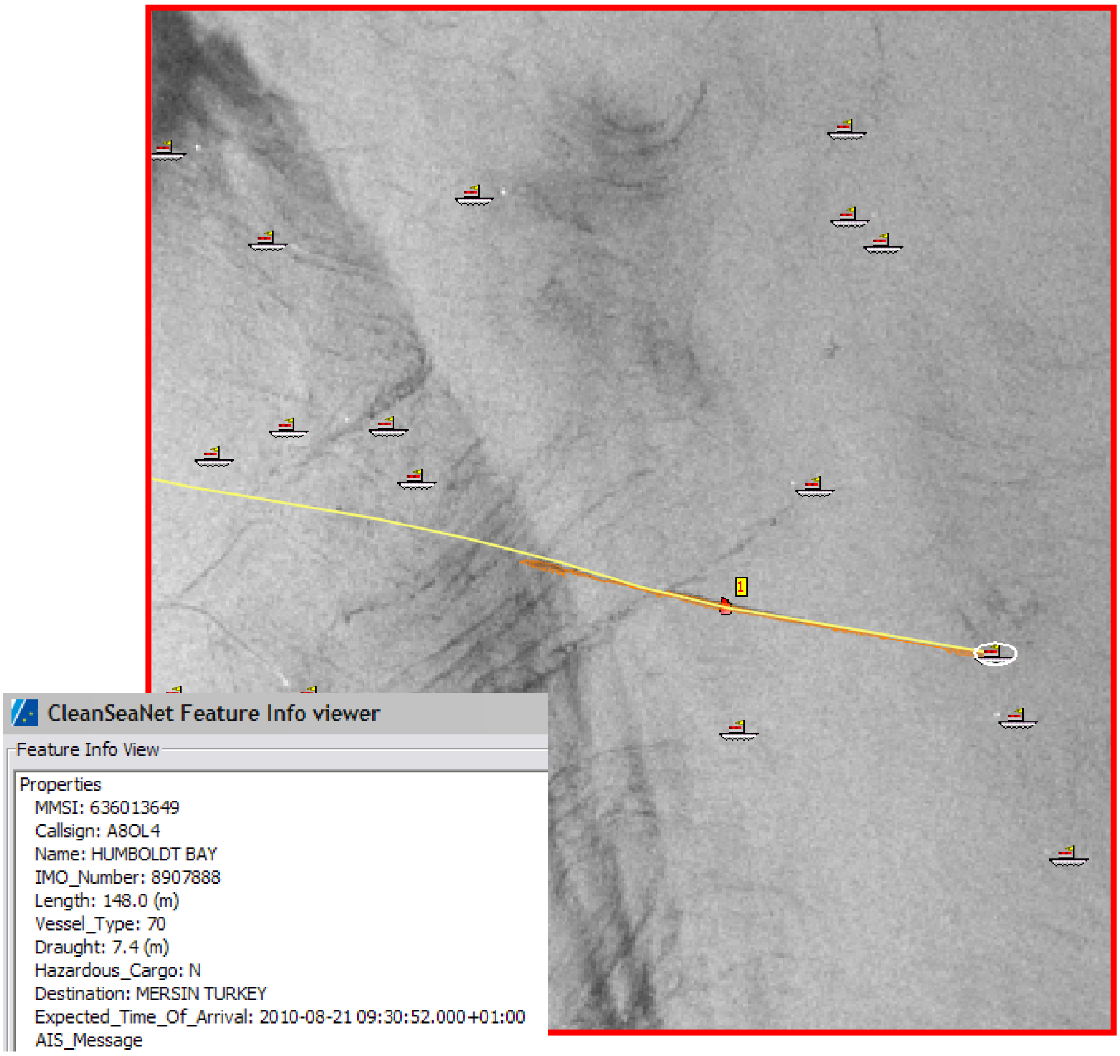


Figure 9.12: Correlation data with AIS information [53].

9.4 Monitoring Black Sea - Moninfo Project

Four Black Sea Countries uses Clean Sea Net System, within Moninfo Project. Bulgaria, Georgia, Romania and Turkey. Last Year 21 Images have taken 59 Detections and 6 Feedback Reports have been carried out with 0 Anomalies; 0 Cancellations. As figure showhs the diagram;

An example for the Area of satellite coverage of Black Sea, last year during three months Agust, September and October, totally 21 pictures were taken and 59 detections made.

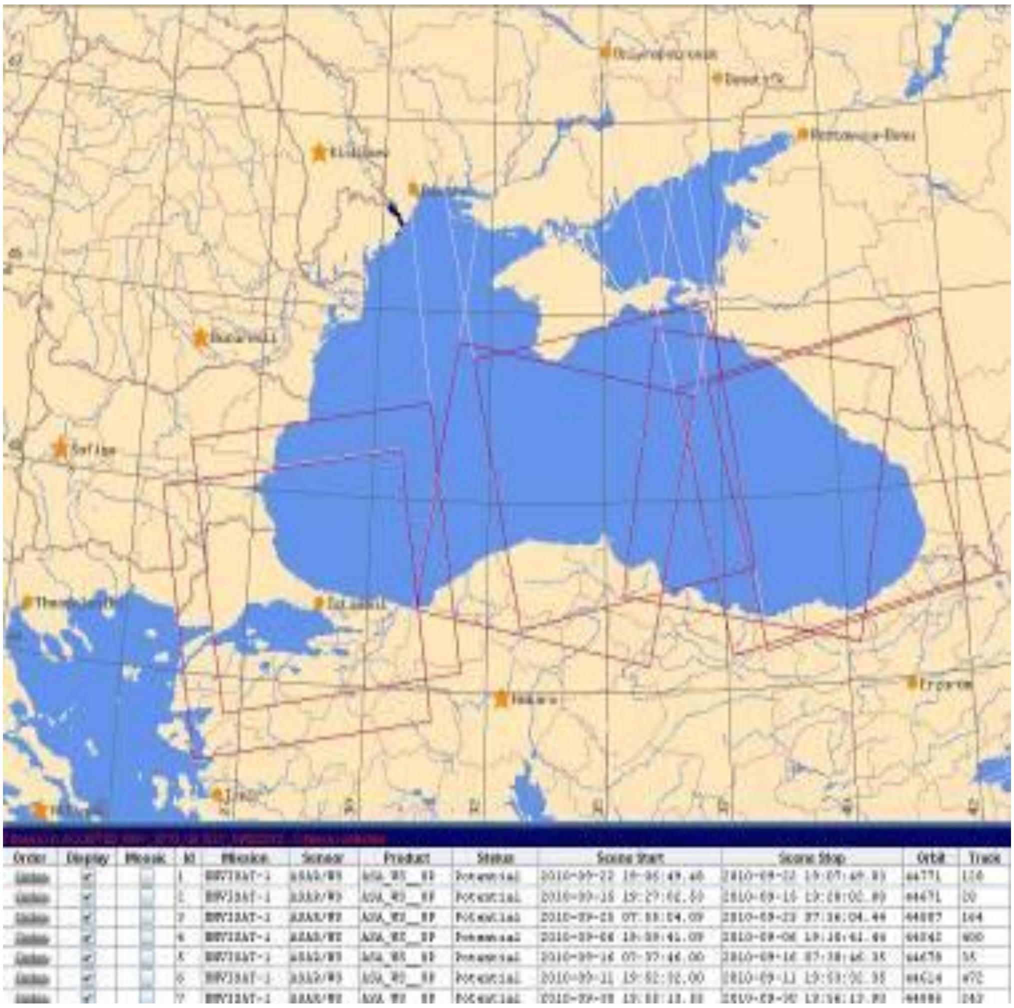
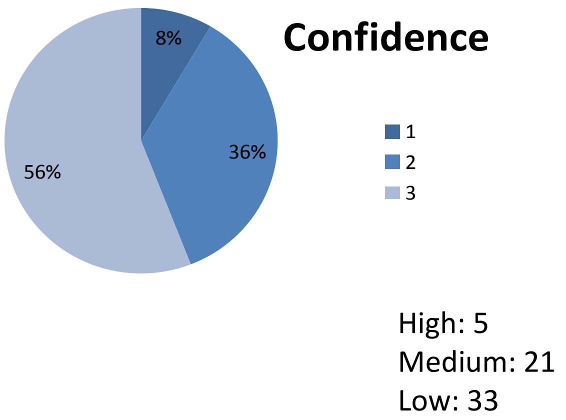


Figure 9.13: Area of satellite coverage for Black Sea [53].

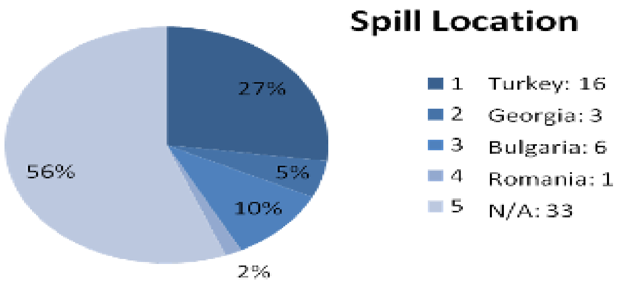
The below tables shows with high, medium and low Moninfo confidence of level of oil spill and spill location for Black Sea last year during three months Agust, September and October.

Table 9.1: Moninfo confidence of level of oil spill - a [53].



..

Table 9.2: Moninfo confidence of level of oil spill - b [53].



During Moninfo Project the below figure shows that most of the detection of oil spill could not be resulted. Green symbols show not checked oil spill, in the figure red and yellow do not exist, their means, yellow symbol shows CSN detection checked and red shows CSN detection confirmed.

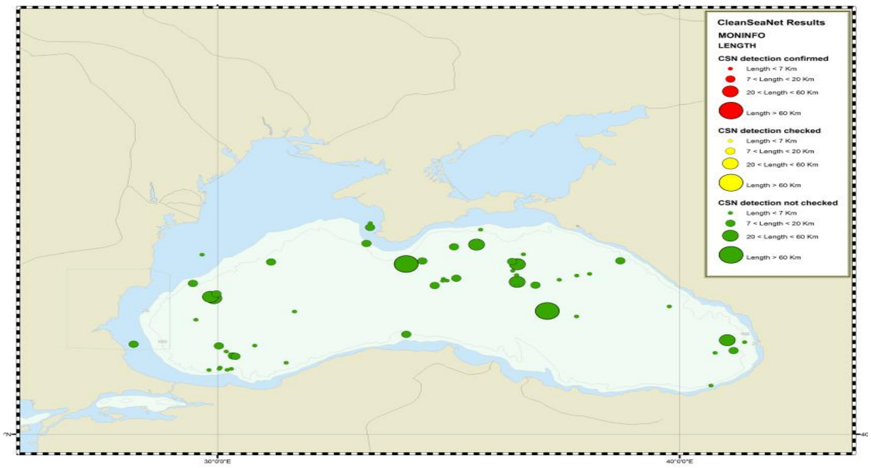


Figure 9.14: Black Sea detection possibility [53].

9.4.1 Some Examples for Black Sea Area

Case A: Image from 26/08/2010 at 19:55:15 UTC

- Correlation with AIS data for a detection in Bulgaria:
- High confidence spill

Remote sensing provides a unique technology to identify potential (illicit) pollutions and polluters as shown in the example.

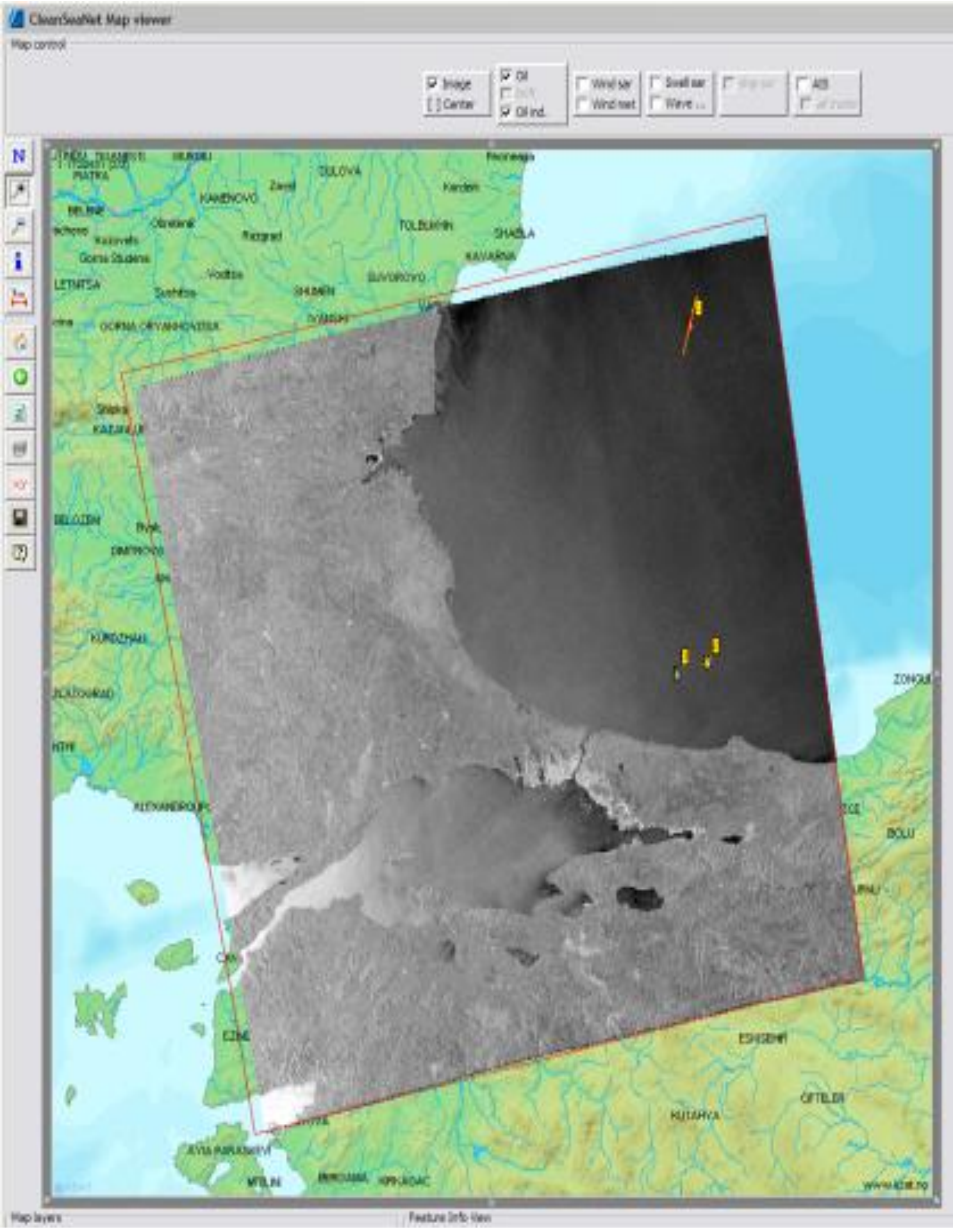


Figure 9.15: A case study for Black Sea [53].

Correlation with AIS data for a detection in Bulgaria: High confidence spill, easily vessel, destination time and next port of call information can be accessed. Yellow line shows backtracking. Red line shows oil slick.

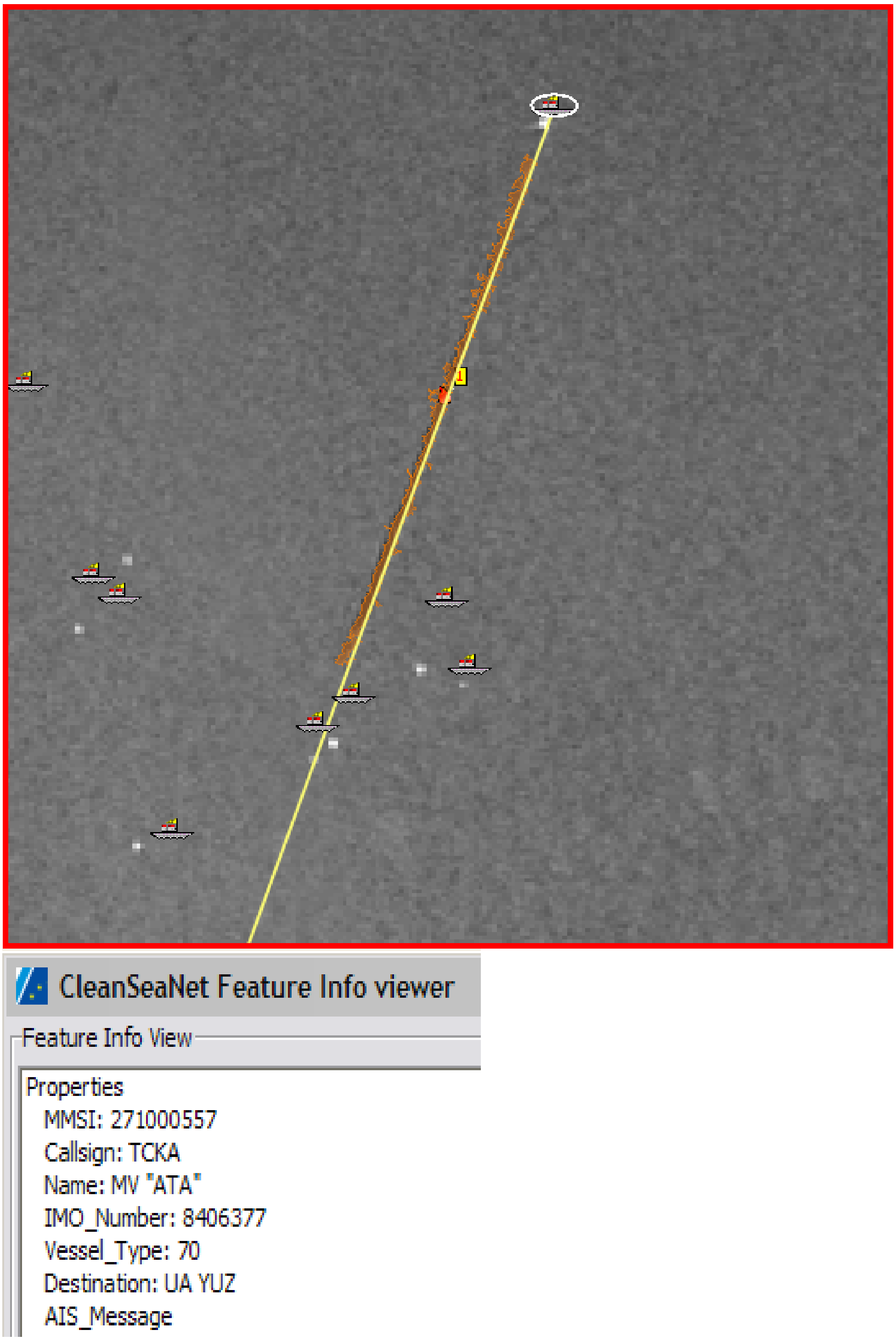


Figure 9.16: A case study for Black Sea [53] .

- Case B: Image from 30/09/2010 at 19:55:03 UTC

M/V Vessel Volgo Balt 248

– near Bulgarian water,

– detected with CleanSea Net System with medium confidence oil spill.

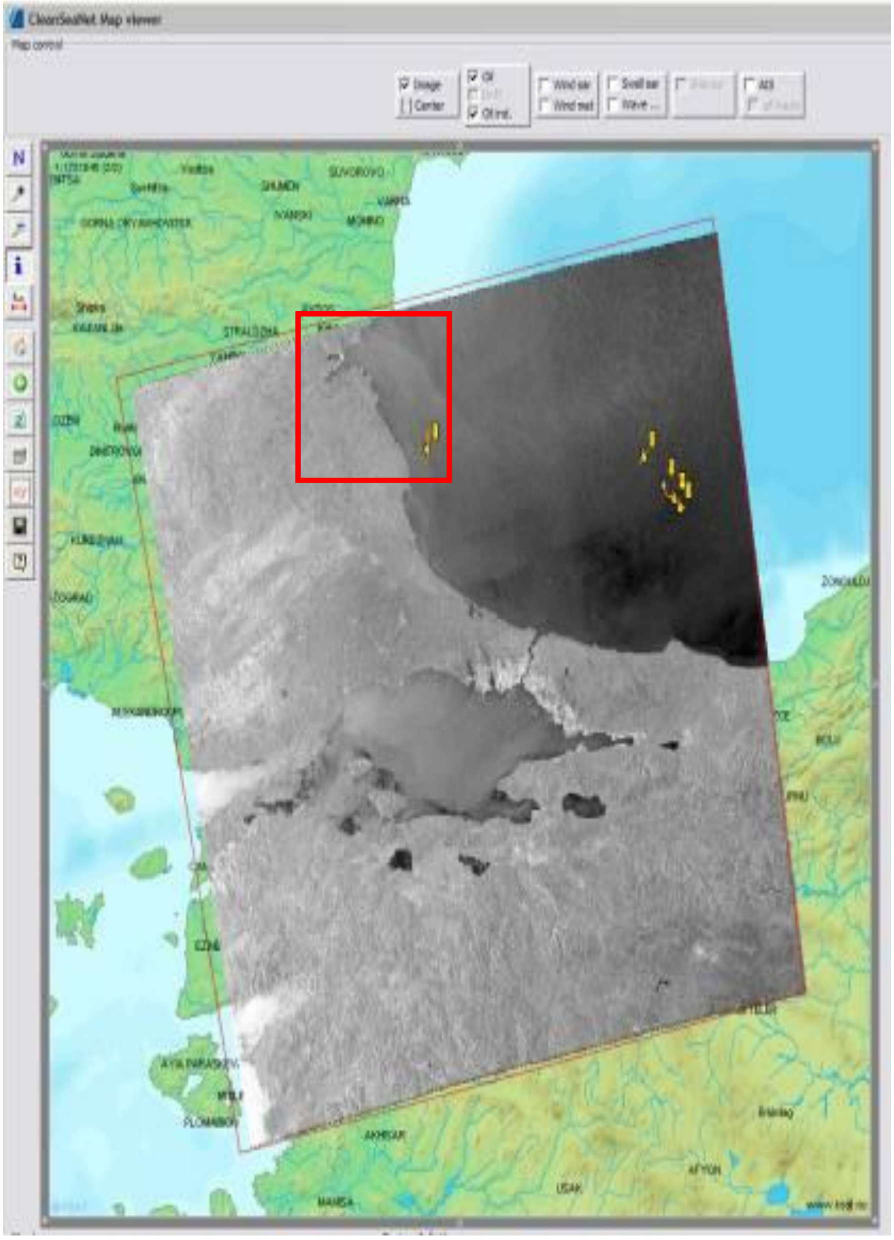


Figure 9.17: A case study for Black Sea [53].

Correlation with AIS data for a detection in Bulgaria:Medium confidence spill. AIS backtracking system is very essential for catching the polluters. Bulgaria is one of the CleanSea Net user.

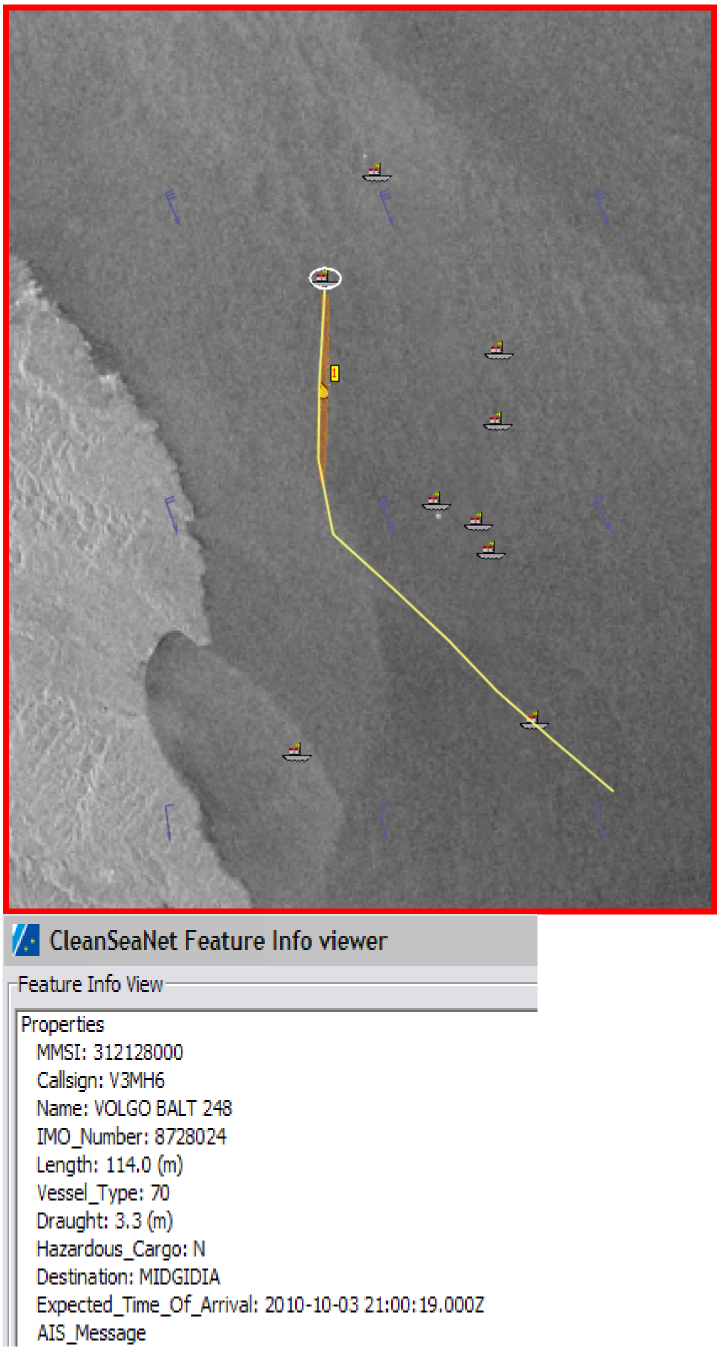


Figure 9.18: A case study for Black Sea [53].

Prosecution Information of the Black Sea Cases listed below:

– M/V MATRIX

– M/V ELENA KUDRYANT SEA

– M/T HUMBOLDT BAY

– M/V SKYLARK

– M/V OLGA 1

Table 9.3: Prosecution information of the detected ships [53].

CSN Image	Notification	Ship Name/Flag	Inspection Date	Inspection Place	Results
16.06.2010	16.06.2010 Italy	M/V MATRIX	19.06.2010	Akçansa port	oil-water separator was not working, leakage from the oil-water separator's filter, closing valve of separator was not working. The ship was **detained** because of these deficiencies.
21/06/2010 08:11:56 UTC	21.06.2010 Bulgaria	M/V ELENA KUDRYAVTSEA	23.06.2010	Efesan port	There were no deficiencies detected
18/08/2010 20:45:00 UTC	20.08.2010 EMSA	HUMBOLDT BAY	23.08.2010	Mersin Port	wrong records on the oil record book, illegal by pass lines on the bilge and sludge pumps, sludge between bilge separators and overboard valve. It was determined that the ship made **illegal discharge** and **detained**.
22/09/2010 19:06:39 UTC	Georgia	SKYLARK	29.09.2010	Unye port	There were no deficiencies detected
22/09/2010 19:06:39 UTC	Georgia	OLGA-1	30.09.2010	Kroman Port	illegal pipeline discovered from bilge water tank to overboard, number of tanks don't match IOPP certificate , vessel was **detained** on 30.09.2010 and released on 02.10.2010.

10. CONCLUSION

Petroleum means "rock oil", from the Greek *petros*/Latin *petra* (rock), and the Greek*elaion/*Latin *oleum* (oil). The term petroleum is nowadays used as a common denotation for crude oil (mineral oil) and natural gas, i.e., the hydrocarbons from which various oil and gas products are made. Petroleum, then, is a collective term for hydrocarbons, whether solid, liquid or gaseous [54].

With the increasing capacity of sea borne transportation, marine pollution especially ship based oil pollution has become one of the most important issue around world.

The great achievement and challenge in satellite technology has opened a new horizon in remote sensing and monitoring technologies. For the existence of human being, the future of mother earth and its nature especially seas have great importance. Therefore, technologies in all branches have been used to protect and preserve world seas. Especially the civilized and EU countries are widely using such technologies.

After the Bucharest Convention, SAP, Sofia and Odessa Declarations. The developing Black Sea countries also have proved their awareness level of pollution of Black Sea and started to take action. Many project and systems are being put in progress by Black Sea Commision like Moninfo.

Moninfo Project has annexes about fighting kind of pollutions for Black Sea. One of the Moninfo Annex is monitoring ship source oil pollution for Black sea. To monitor oil pollution from satellite. Black Sea countries uses EMSA CleanSea Net services, nowadays The Russian capacity under SCANEX- and the Turkish capacity by Istanbul Technical University, Center for Satellite Communications and Remote Sensing (ITU CSCRS) are also available.

The EMSA CLEANSEANET (CSN) satellite service offers all EU Coastal Member States, Iceland and Norway a near-real time marine oil-spill detection service by using radar satellite imagery acquired by the ENVISAT, RADARSAT-1 and -2 SAR satellites. The service covers all European sea areas and is integrated within the national and regional oil pollution surveillance and response chains. The complete process, from the image acquisition to the oil-spill detection takes 30 min maximum.

CSN is based on three regional service providers (KSAT – Northern Europe, Telespazio – Southern Europe, EDISOFT – Atlantic coast) that acquire and process satellite data. Then they proceed with the oil spill analysis and deliver the results to the Coastal States and to EMSA. Such results identify potential oil spills by a three-stage confidence level (low, medium and high) or a "clean sea" notification [55].

For *Turkey*, CleanSea Net system has been activated since January 2011 after successful compilation of 6 monthly pilot project . And also being a candidate Member of EU and member of Black Sea Commission, Turkey has been given the right of using CleanSea Net facilities.

In order to take information regarding the operation of the system I made a visit to the relevant office in Ankara which is responsible to use the system on behalf of Turkish Maritime Affairs.

During my visit to Turkish Maritime Affairs, my observations about the application are as below:

- EMSA sends the satellites pictures without AIS information so it takes time and makes diffucult to make backtracking.
- Up to now due to lack of aerial surveillance service, the alerts of spill have never been detected with real time remote monitoring so the alerts of slicks are always possible oil slicks.
- In near future aerial surveillance will be mandatory at least for the high level alert in 20 nm around Turkish waters with the facilities of Coast Guard aerial units. Due to lack of aerial surveillance, I can not present any particular case or a document taken from Turkish Maritime Affairs in my thesis
- It is realized that responsible Turkish Maritime Affairs workers are only beginner levels about usage of CleanSea Net sytem.

Despite the fact that the system is new, in near future the system will able to be used more effectively with the improvement of staff experiences and with a better mutual data exchanges between Emsa and States.

When Bulgaria and Romania use the CleanSea Net system, due to the candidate of European Commision, Black Sea Commision makes press to EC and EMSA to use CleanSea Net System. Before this, CleanSea Net was used just for Black Sea area with fee. When EMSA accepted Turkey to use CleanSea Net without fee, all Turkish Waters have been detected by EMSA Satelittes. Black Sea Commision has great effective press to EMSA and successful six monthly pilot project period provides allowance to use without fee.

Georgia also accepted to use this safe system but Russian and Ukranian did not accept this project because they do not want the EC as a Black Sea Commision Member so Black Sea Commision Permanenet Secreteriat tries to find another system for Russian and Ukranie, they have intention to use Russian capacity under SCANEX- and the Turkish capacity by Istanbul Technical University, Center for Satellite Communications and Remote Sensing (ITU CSCRS).

I would like to give some information about ITU-CSCRS; ITU-CSCRS is the first center established in Turkey to conduct application oriented projects in remote sensing and satellite communications technologies. ITU-CSCRS has the capabilities of acquiring images from remote sensing satellites, processing data, and sending the products via satellite links to resident and foreign users. The station can receive images of the Earth's surface within a radius of 3000 km. In the center the data acquired from SPOT-2, SPOT-4, RADARSAT-1, ERS-2, NOAA-11, NOAA-14, METEOSAT satellites is archived, formatted and processed with the state-of-the-art technology [56].

Russian and Ukranian do not want to set Regional Black Sea AIS Server for the Black Sea. Even Commision pays all the fees, Russian and Ukraine do not want to AIS Server in Black Sea because Turkey was chosen as hosting country, it,means server will be at Turkey if AIS BSC Server sets.

Turkey uses CleanSea Net system but can not use Safe Sea Net so in CleanSea Net Web browser, when we try to find the polluters, We can not intercept the polluter ship shown in the Cleansea net system with AIS information, but EU countries can easily reach the vessel information with all detail in the Safe Sea Net.Black Sea Commision makes press to be member of Safe Sea Net.

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CURRICULUM VITAE

Candidate's full name:	A. Tuğsan İŞİAÇIK ÇOLAK
Place and date of birth:	Tarsus / 30.01.1982
University attended:	Nearest University, Maritime Faculty, Deck Department, 2004