İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

ENVIRONMENTAL SENSITIVITY INDEX AND A CASE STUDY: BOSPHORUS

M. Sc. Thesis by

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SEPTEMBER 2007

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Date of submission : **14 September 2007**
Date of defence examination: **19 September 2007**

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OCTOBER 2007

İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

ÇEVRESEL DUYARLILIK İNDEKSİ VE BOĞAZİÇİ ÖRNEĞİ

YÜKSEK LİSANS TEZİ

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Tezin Enstitüye Verildiği Tarih : 14 Eylül 2007
Tezin Savunulduğu Tarih: 19 Eylül 2007

Tez Danışmanı : **Prof. Dr. Ayşegül TANIK**
Diğer Jüri Üyeleri **Prof.Dr. Lütfi AKÇA (İ.T.Ü.)**
Prof.Dr. Sedat KABDAŞLI(İ.T.Ü.)

EKİM 2007

FOREWORD

I thank to my dearest teachers Ayşegül Tanık, Ethem Gönenç and Dursun Zafer Şeker for their precious guidance and aid.

I thank to my precious friends Tolga Tezgel, Semih Yüksel, Gülin Arslan, Hande Gürsoy, Tuncay Özkök, Şeyda Dağdeviren, Ayşegül Acar, Emre Erdinç and İlke Pala for their significant support when I am in trouble, or need a hand.

I thank to my mother and father since they have support me through twentyfive long year.

I thank to Semih Yüksel, Tolga Tezgel, Doğa Derneği and Levent Artüz for their kind assistance and guidance in the collection of the ecosystem data and ground observations.

…and if this thesis is a succession it would not be without the help of my friends. I thank you again for "you" are my friend.

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LIST OF ABBREVIATIONS

AMSA	Australian Maritime Safety Authority
BMP	Best Management Practices
CAD	Computer Aided Design
DWT	Dead Weight Tone
EPA	Environmental Protection Agency
ESI	Environmental Sensitivity Index
GIS	Geographical Information System
GPS	Global Positioning System
ICZM	Integrated Coastal Zone Management
IMO	International Maritime Organization
IPIECA	International Petroleum Industry Environmental Conservation Association
MoEF	Ministry of Environment and Forestry
NM	Nautical Mile
NOAA	National Oceanographic and Atmospheric Administration, USA
OPRC	The International Convention on Oil Pollution Preparedness, Response and Cooperation
OSRA	Oil Spill Response Atlas
UfMA	Undersecretariat for Maritime Affairs

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ÖZET

Son yıllarda gemilerden kaynaklanan petrol kirliliği deniz ekosistemleri için büyük bir tehdit oluşturmaya başlamıştır. Bu durum ciddi boyutlarda petrol taşımacılığının yapıldığı Türk Boğazları gibi sularda daha da ciddi gözlenmekte olup, canlı türlerinin değişmeye hatta kaybolmaya başladığı; doğal ortamların bozulmakta olduğu bilinmektedir.

Kıyı alanlarını tehdit eden gemi kazaları ve bunlardan kaynaklanan petrol kirliliği riskini azaltabilmek için, petrol kirliliğine yönelik bir acil eylem planlamasının yapılması böylelikle muhtemel bir kaza halinde kazaya acilen müdahelenin sağlanarak doğal ortamın ve bölgedeki ekosistemin en az zararı görmesi temin edilmelidir. Dünyada da bu amaçla kullanılmakta olan bazı karar destek sistemleri bulunmaktadır. Bunlardan en çok bilineni coğrafi bilgi sistemi üzerinde oluşturulan ve kıyı ekosistemlerinin petrolden etkilenebilirliğini ekosistem tabanlı olarak ortaya koymayı amaçlayan "Çevresel Hassasiyet İndeksi" (Environmental Sensitivity Index) olup yaklaşık 30 yıldır birçok kıyı ekosistemine uygulanmıştır.

Çevresel Hassasiyet İndeksi kıyıların petrol kirliliğinden etkilenebilirliğini ortaya çıkartmak için bir coğrafi bilgi sistemi üzerinde kıyı alanına ait kıyı sınıflandırmasını, ortamda bulunan hassas flora ve faunayı ve kıyı bölgesinde insan kullanımı açısından önem arzeden ve/veya bir petrol kazası sırasında kolayca etkilenebilecek alanları işaretlemek suretiyle oluşturulmaktadır.

Bu çalışmada uygulama alanı olarak seçilen İstanbul Boğazı üzerinde Çevresel Hassasiyet İndeksi uygulanmış ve belirlenen hassas kıyı alanları Coğrafi Bilgi Sistemi üzerinde sayısal olarak haritalanmıştır. Sonuçlar değerlendirilerek İstanbul Boğazı'ndaki hassas alanlar tartışılmıştır. Bunun yanısıra Boğaz'daki üç kritik nokta için kaza senaryoları yaratılmış ve müdahele yapılamaması durumunda etkilenebilecek doğal kaynaklar tartışılmıştır.

Çalışmanın ilk kısmı giriş bölümünü oluşturmakta olup, bu kısımda çalışmanın amaç ve kapsamına değinilmekte, çalışma konusu hakkında genel bir bilgi verilmektedir.

İkinci bölüm, Hassas alan haritalandırma çalışmaları ve Çevresel Hassasiyet İndeksi ile ilgili genel bir literature taraması sunmakta olup, bu indeksin hassas alanların gösteriminde ve planlamasında nasıl kullanılacağı ve bütünleşik kıyı alanları yönetimi ile ne şekilde bir bağlantıya sahip olduğu incelenmiştir. Bunların dışında dünyada Çevresel Hassasiyet İndeksi'nin kullanıldığı çalışmalara ve bunları kullanan ülkelere değinilmiştir. Bu kısımda da görülebileceği gibi bu indeks geçem yaklaşık 30 yılda birçok ülke tarafından kullanılmıştır. Türkiye'ye ait tek indeksleme çalışması da bu bölümde ele alınmıştır.

Üçüncü bölümde Çevresel Hassasiyet İndeksi'nin nasıl uygulandığına değinilmiştir. Fakat bu indekslemede kullanılan verilerin Türkiye şartlarında tedarik edilmesi konusunda bazı sıkıntılar yaşanabilecek olma olasılığına karşın, standart el kitabının dışında önerilere de bu kısımda yer verilmiştir. Burada çalışmanın Türkiye'de gelecekte hazırlanacak hassas alan haritalama çalışmalarında veri bulma konusunda yaşanabilecek sıkıntıların çözümü için yol gösterici olması hedeflenmiştir.

Dördüncü kısım Çevresel Hassasiyet İndeksi'nin İstanbul Boğazı'na uygulanmasına dair detayları içermektedir. Burada hem elde edilen veriler ve bunların öznitelikleri hem de coğrafi veritabanı içerisindeki teknik uygulama bilgileri bulunmaktadır. Özetle tezin bu kısmında hem verilerin toplanması ve işlenmesi hem de bunların coğrafi veritabanı yapısı içerisine yerleştirilmesi konu edilmiştir.

Önceki bölümde Boğaz'ın hassas alan haritası oluşturulmuş olup beşinci bölümde bu harita incelenecektir. Böylelikle Boğaz için petrol kirlenmesi açısından hassas olan noktalar tartışılacak, haritanın nasıl yorumlanacağı ve ne şekilde kullanılabileceği gösterilecektir.

Altıncı bölüm de haritanın nasıl kullanılacağı konusunda örnek olarak konulmuş bir bölümdür ve hassas alan haritasının kullanımını petrol kazası senaryolarını temel alarak göstermektedir. Bu kısımda Boğaz için üç noktada kaza yaratılmış ve bu noktalarda ve çevrelerindeki doğal kaynakların ne ölçüde etkileneceği araştırılmıştır.

Çalışmanın son bölümünde hassas alan haritalandırmanın Türkiye'de ne şekilde kullanılabileceği ve bütünleşik kıyı alanı yönetimi çalışmalarına ne şekilde entegre edilebileceği tartışılmıştır.

ABSTRACT

In recent years, oil pollution originating from ships and tankers has become a threat for marine ecosystems. This is observed in Turkish waters. It is also known that the living species has started to be disturbed and even eliminated; and natural habitat impaired.

In order to reduce the occurance of accidents that threaten the coastal areas and oil spill risk originating from them, an emergency response planning should be prepared. In this way, a probable accident could be responded accurately and immediately for assuring the minimum natural environment damage. There are a few similar decision support systems used in the world. The most-known one is the Environmental Sensitivity Index (ESI) that is built on Geographical Information System (GIS) that aims to describe the vulnerability of a coastal ecosystem regarding oil spills. This system has been applied on numerous coastal ecosystems in the last three decades.

Environmental Sensitivity Index is composed of shoreline classification which is used for indicating oil spill vulnerability of a shoreline; sensitive flora and fauna; and human – use resources that are important for coastal zones.

In this study, Environmental Sensitivity Index is applied on Bosphorus (Istanbul Strait), as the case study of this thesis, and sensitive areas determined through the study is mapped digitally utilizing Geographical Information System. Results are evaluated and discussed. Additionally, accident scenarios are assumed for three critical points along the Bosphorus and natural resources that could be affected in case of an oil spill response is late or ineffective are evaluated.

In the introduction chapter of this study, aim and scope of this thesis is given by giving a fast overview about the study.

Second chapter presents a general literature survey about the sensitivity mapping and Environmental Sensitivity Index (ESI) by showing how this index is used in the determination and planning of the sensitive ecosystems and how it is connected with the Integrated Coastal Zone Management practices (ICZM). Besides, countries which prepared and used the ESI maps and their studies also stated. This literature survey shows that numerous country used sensitivity mapping in the last three decades. The one and only sensitivity mapping application of Turkey is also mentioned in this chapter.

In the third chapter how ESI is applied and its methodology is reviewed. However some problems could be encountered when achieving data needed in an ESI study when conditions in countries like Turkey considered. Hence, some recommendations are given in this section, as different from the original ESI application manual, for tackling data access problem. So this study is designed as a guide for Turkey.

Chapter four contains the details of the application of ESI on the Bosphorus (Istanbul Strait). Chapter both includes information about the data collected and their attributes, and installation of the Geographical Information System structure. To sum

up, this part of the study contains information about data collection, data processing and their application into geodatabase.

As a sensitivity map of the Bosphorus is prepared in the previous chapter, it will be analysed in the fifth chapter. Accordingly, sensitive areas of the Bosphorus will be evaluated and how this map could be used will be shown.

Chapter six is also another chapter that put as an application example and it shows the usage of a sensitivity map based on oil spill scenarios. In this chapter, three accidents in the Bosphorus is assumed and the affection of their surrounding environment and natural resources were evaluated.

Finally, last chapter argues on how sensitivity mapping could be used in Turkey and integrated into ICZM studies.

1. INTRODUCTION

1.1. Aim and Scope of the Study

This study represents a tool that is used in an integrated coastal zone management (ICZM) application, which is a subfield of integrated environmental management studies. ICZM is a concept that allows generating maximum benefit from a coastal zone to all of its components such as the industry located near coastal areas, public living around shorelines, habitats constituting the biosphere, or trading areas forming national economy by minimizing the contradictions they posed on the continuity of each other and maximizing the negotiations between them. Although, by this study, a comprehensive ICZM plan for the Bosphorus Area (which is chosen as case study) will not be established, an ecosystem-based decision support system that will minimize the oil spill risk and support better intervention on emergency.

Geographical Information Systems (GIS) has gained success for storing environmental inventory and reprocessing the environmental data for visualization and presentation recently. Originally, Environmental Sensitivity Index (ESI), as the main topic of this study, grounded on the GIS technology that allows more functionality, as it will be mentioned in detail. Development and implementation of the natural resource management and emergency action plans for the sensitive areas through the definition (or delineation) of the sensitive areas, construction of the inventorial data relating these areas, and storage of the spatial and temporal data is the one of the most important application areas emerged recently.

ESI, which put into practice in 1978 by the US-NOAA (US National Oceanic and Atmospheric Administration), is an GIS-based inventory system that is developed in order to minimize the impacts of oil spill incidents around shorelines and could be used for both defining sensitive habitats/areas and priority areas for the first intervention in an emergency situation. NOAA started "sensitivity mapping" studies for US coasts in the late 70's and then started to transfer its studies into GIS after mid-90. Through the years, a number of country such as Australia, Denmark, Nigeria, Canada or Thailand, has also applied similar sensitivity mapping systems on their coastal areas.

This study aims to develop an ESI map for the Bosphorus Area. Nevertheless, first studies conducted by USA which coined the term –sensitivity mapping– and other countries applied it are reviewed in the literature survey section in order to compare related literature in terms of strong and weak points of different sensitivity mapping applications. Literature survey section also includes the relationship between ICZM and ESI. How ESI should be put into a beneficial ICZM structure is another issue of this thesis.

Since the main point of the thesis is the original application of ESI on Bosphorus , in the materials and methods section a detailed ESI methodology will be given. It should also be noted that since some unique characteristics of the water system, ecosystem data in the map (covered by the area called Bosphorus) could mislead the people who use that system. This probable confusion will also be described in ESI methods to show what kind of weaknesses ESI could have in terms of data used in countries like Turkey. Hence precautions or system offers will be pronounced in order to prevent misuse of the system later in our country, as this thesis could be regarded as a system implementation manual.

Although there are applicational deficiencies within this thesis (when ESI regarded in every respect), ESI, by itself, should be regarded as an essential system revealing the vitality of application of the system for coastal zones of Turkey.

This study shows that Istanbul Strait is an important International waterway built up on a path which so many bird and fish species migrate alongside a great number of hazardous marine vessel. It also houses to endless cultural and historical heritage with its nearly 14 million population. It is obvious that until pollution generated by antropogenic activities controlled effectively, our duty should be aware of what we have and take action to protect them. This study is a step for understanding what we have and showing the threats.

2. LITERATURE SURVEY

2.1 Definition of Coastal Zones as Natural Resources

Coastal areas are important for industrial development, transportation, commercial, tourism and recreational activities, human settlements, and other infrastructure and superstructure systems. These areas produce significant economical values for any kind of human activity when compared to other land types. Rapidly increasing human populations near coastal areas or surface waters has put into risk the integrity of natural resources causing degradation at alarming rates. This fact poses a "contradiction" for humans and necessitates a "negotiation" between development and existence of either nature or human sources (Gönenç, 1997).Unplanned development leads to degradation of an ecosystem. In order to maintain sustainable development of a region, economical, socio-cultural and environmental factors which have an effect on development should be planned in a way to form a balance between utilization and protection. Hence, sustainable development is accepted as an umbrella which covers the economic activity and protection of the environment, development control and prosperity of humans (Mitra, 2003).

In the 20th century, settlements around shorelines and coastal areas have increased due to convenient conditions accomplished for industrial and/or commercial activities. One of the reasons of why the shorelines have been preferred for residential purposes is the alternative of sea transportation (navigation) to highway transportation (Karabey, 1977). Also, other beneficial uses like fishing and recreational activities have an effect on residential sites clustered around coastal areas (Arslan, 1988). Today, approximately half of the total population of the world lives in coastal zones and migratory movement increases from inland zones to the coast (Post and Lundin, 1996).

The coastal zone does not have a rigid definition and the delimitation of its boundaries in a given area (zoning) varies according to political and administrative aspects. The main components of coastal systems, prevailing natural processes and human activities, interact in these spaces in a complex manner, forming an eco-socio-system (Henocques et al., 1997) (Figure 2.1). In the last decades, the combination of increasing human and natural pressures have resulted in endangered coastal areas in terms of their ecological integrity, and regions at risk in terms of socio-economic welfare (Brochier and Giupponi, 2001).

The coast may be considered as the area that forms a link between land and ocean, and a coastal area is defined as the band of dry land and adjacent ocean space (water and submerged land) in which terrestrial processes and land-uses directly affect oceanic processes and uses, and vice versa as explained by Ketchum (1972).

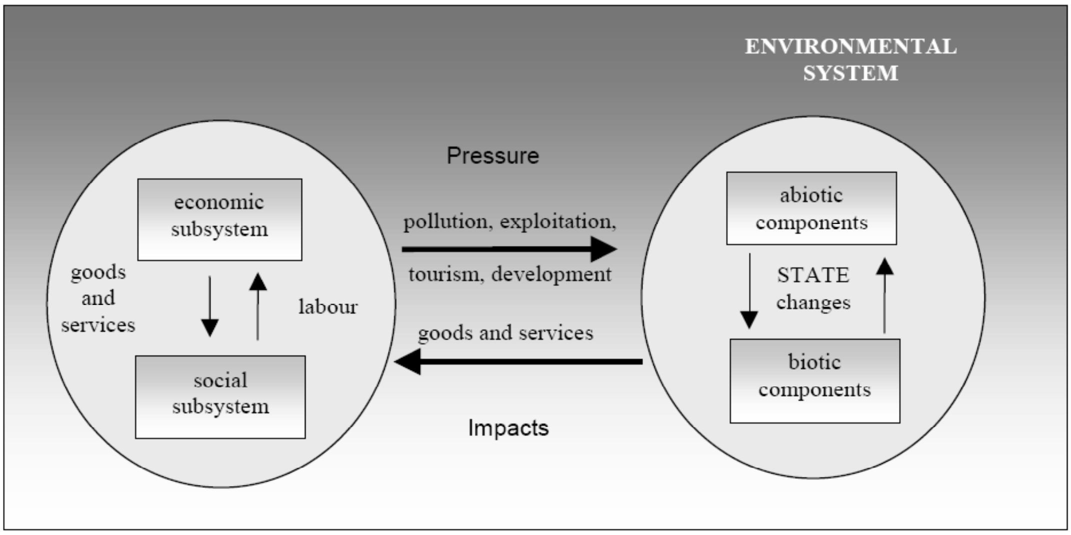


Figure 2.1: Components and interactions of the coastal eco-socio-system (Sawart and Bakkes, 1995).

In practice, the coastal zone may include a defined area on the land-sea interface in the order of a few hundreds of meters to a few kilometers, or extend from the inland reaches of coastal watersheds to the limits of national jurisdiction in the offshore. Its definition will depend on the particular set of issues and geographic factors which are relevant to each stretch of coast (Hildebrand and Norrena, 1992).

As expressed by Scura et al. (1992), the coastal zone has the following characteristics:

- It consists of habitats and ecosystems that provide goods (fish, minerals, etc.) and services (e.g. recreation).
- It serves as the source of the national economy of coastal countries where a substantial proportion of the gross national products (GNPs) relies on some activities such as shipping, gas development, tourism, and so on.

- It is characterized by the competition for land and sea resources, and space by various stakeholders, often concluding in conflicts and destruction of the useful integrity of the resource system, and
- It is a site for urbanization and dense population.

Urbanization around shorelines is widely spread since coastal areas are suitable for establishing harbors, industrial or commercial facilities, ‘discharge’ of domestic and industrial wastes, tourism services and for residential areas resulting in negligence of nature’s needs. Rapid urbanization also leads to rapid degradation in environmental quality and stress on organisms living within the surrounding habitats. Importance of coastal areas and rapid degradation of their (physical, chemical or ecological) qualities obligates management of natural resources. But in a way, coastal zones are multi-user systems which private and public groups use for subsistence (e.g. water and food), economic activities (e.g. living and non-living marine resources) and recreation (e.g. beaches and water areas) (Kaya, 2006). This makes their management harder, and require an integrated philosophy that unifies land-use management, ecological resources management, trading activities management and management of social impacts under one structure. Through such a structure, all of the stakeholders existing in the actual domain (aquatic organisms, humans, and natural compounds such as earth or air) will be defined, with their rights and demands defining the interaction between them.

Environmental protection concept applied in developed countries puts forth the “protection and sustainable use of ecosystems” idea. So a holistic view for the management of both natural resources and anthropogenic inputs (like wastes, modifications, productions, constructions) is vital. This idea developed through an evolutionary process from the control of the pollutant sources one by one into integrated management of pollutant sources such as solid waste management, watershed management, management of industrial wastes or coastal zone management. Integrated management implies a holistic approach, long term view and sustainability.

2.2. What is Integrated Coastal Zone Management?

The term “coastal management” came into common use with the implementation of the United States Coastal Zone Management Act of 1972. The act recognized that a new coastal management approach was needed. Since then, it has been widely recognized that a simple combination of sectoral approaches to management and land-use planning is not appropriate to guarantee the sustainable use of natural resources. Coastal areas require specific management approaches involving a system of relationships among actors who operate directly or indirectly in the coastal zones:

1) People who live, use, or are concerned otherwise (in their beliefs or behaviors) with the coastal environment,

2) Policy makers and managers whose decisions and actions affect the behavior of coastal people, and members of the scientific community: (natural scientists and social scientists) (Figure 2.2).

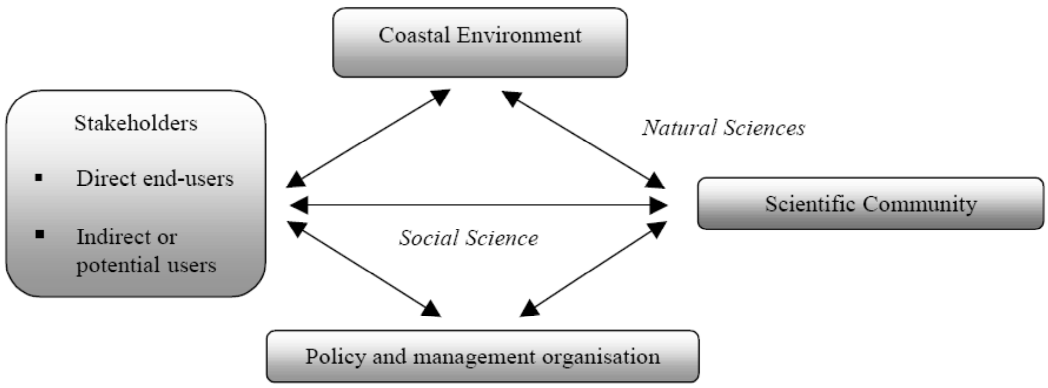


Figure 2.2: Inter-relations within the coastal management system (Orbach, 1995).

“Decision making for coastal area management” implies dealing with uncertain conditions related to variations in socio-economic parameters (demand on coastal resources, demography, technological progress, etc.) and environmental factors (geomorphologic changes, ecological processes, climate change, etc.). Traditional methods of coastal planning have shown limitations in managing this uncertainty and the complexity of choices surrounding an appropriate and rational use of coastal resources. The intrinsic dynamic nature of coastal spaces has been largely ignored by traditional approaches, together with a narrowed vision of problems due to sectoral management practices. The result is decades of uncoordinated management and inappropriate decision-making.

Hence coastal zone/area management involves the continuous management of the use of coastal lands and waters and their resources within some designated area, the boundaries of which are usually politically determined by legislation or by executive order (Jones and Westmacott, 1993).

The 1993 World Coastal Conference defined Integrated Coastal Zone Management (ICZM) to involve a comprehensive assessment, setting of objectives, planning and management of coastal areas and resources, taking into account the traditional culture and historical perspectives, and conflicting interests and uses.

"Integrated Coastal Zone Management" after 30-years of history has emerged as the most appropriate process for dealing with current and long term coastal problems (WCC, 1993; IPCC, 1996; EC, 1999). ICZM is a "process of governance and consists of the legal and institutional framework necessary to ensure that development and management plans are integrated with environmental goals and are made with the participation of all affected (Post and Ludin, 1996).

ICZM is based on the underlying concept of sustainable development. ICZM objectives include:

- maximizing economic and social benefits derived from the use of coastal zone resources;
- minimizing conflicts (provide conflict resolution mechanisms) and the harmful effects of activities on resources, on the environment and upon each other;
- stimulating and guide the sustainable development of coastal regions;
- facilitating integrated decision-making through a continuous decision support process.

Experiences show that overall benefits from addressing and managing sectoral issues simultaneously are greater than pursuing sector-driven development plans (Pernetta and Elder, 1993; Scialabba, 1998). ICZM is not designed to replace specialized sectoral management, but rather to harmonize and complement it (Cicin-Sain and Knecht, 1998). Moreover, ICZM aims at strengthening institutional and legal frameworks and implementing issue-driven action plans through the coordinated application of a series of case-specific elements:

- set of principles;
- set of measures (structural, institutional, economical, legal, financial);

- set of mechanisms (for linking responsible agencies and organizations, for public involvement);
- set of technological tools and instruments (information systems, cost-benefit analyses, scientific models, surveys, environmental impact assessments, etc.).

Davos (1998) contemplates that sustainable coastal-zone policies must be socially constructed, rather than rationally derived by experts, requiring a voluntary cooperation of all stakeholders, and taking into account their competing interests and priorities. The objective in ICZM, according to Davos (1998), should not be to derive “correct” policies but policies that result in the maximum stakeholder support (Schouten et al, 2001). The overall purpose of ICZM is to provide the best long-term sustainable use of coastal natural resources and continuous maintenance of the most beneficial natural environment. ICZM provides a basis for sustainable use of resources, biodiversity preservation, protection against natural hazards, pollution control, enhancement of welfare, development of sustainable economy, and optimum multiple use (Tridech et al., 1999). Integrated Coastal Zone Management (ICZM) is not only a combination of marine and terrestrial issues, but also it is a process that identifies the distinctive characteristic of the coastal area and the joint influence of land and sea (Brochier et al., 2001).

2.3. Development of an Integrated Coastal Zone Management Plan

There are general difficulties in transforming the ICZM objectives into effective actions because of lack of understanding about coastal processes and the connection of interrelations within coastal systems. Moreover, a large range of approaches is available and diverse institutional arrangements can be applied and modified to specific decisional frameworks and types of authority. There is a recognized need for describing methods developed and designed to respond to the barriers of the ICZM issues (Kaya, 2006).

The lack of effective integrated management in coastal areas and particularly the lack of national legislation have been recognized at the European level as one of the main factors responsible for the degradation of coastal and marine environments (EUCC, 1999; EC, 1999a; EC, 1999b). Experience gained during the European Integrated Coastal Zone Management (ICZM) Demonstration Programme (EC, 1999b; EC, 2000) underlines the fact that there is no single correct approach or framework for coastal management and the sustainable allocation of coastal resources. As a consequence, there is a recognized need to define appropriate methodological approaches to implement the general principles of ICZM to any specific location and context.

The formation of the ICZM program needs time and motivation with a good beginning and the achievement of implementation. These processes consist of political considerations to collaborate the initiation of the ICZM program; public participation; legal and administrative capacities to grow and carry out coastal programs; technical abilities and expertise; mechanisms for resources management and data gathering collection; and sufficient funding.

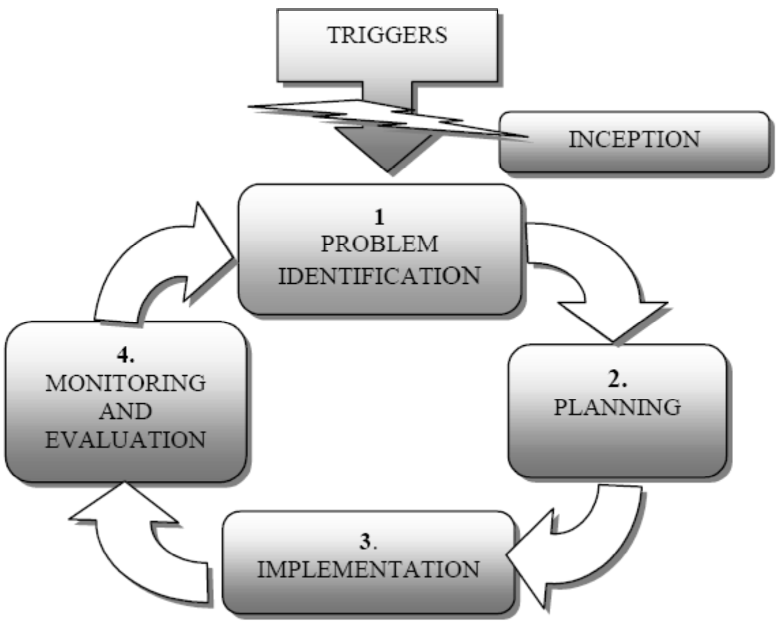


Figure 2.3: Common ICZM Flow Scheme (Brochier and Giupponi, 2001)

In Figure 2.3, a common scheme for the development and implementation for ICZM could be seen showing that these processes are supposed to be non-stop and there is no end position after which the process is concluded. Connection between the stages should include repetitive arrangements and the timely improvement of activities (Brochier and Giupponi, 2001).

It emerged from the literature, that some stages and steps are common to the majority of integrated coastal management procedures. The general structure includes five main stages:

1. Inception,
2. Problem identification,
3. Planning,
4. Implementation, and
5. Monitoring and evaluation.

An iterative cycle of activities, outputs, decisions, and feedback is formed (Figure 2.3).

2.4. Oil Spill as a Threat on the Sustainable Use of the Coastal Areas

Oil pollution and its impacts on the surrounding environment are very hazardous for many living organisms. Since the coastal areas are highly vulnerable to an accidental oil spill, these areas should be planned in a manner that mitigates the oil pollution risk on the habitat. Before passing into the integrated coastal zone management tools for the mitigation of oil pollution risk, it should be practical to give a rough information about the properties of oil, its fate and effects on the environment.

2.4.1. Oil Spill Risk

Oil is a general term used to denote petroleum products which mainly consist of hydrocarbons. Crude oils are made up of a wide spectrum of hydrocarbons ranging from very volatile, light materials such as propane and benzene to more complex heavy compounds such as bitumens, asphaltenes, resins and waxes. Refined products such as petrol or fuel oil are composed of smaller and more specific ranges of these hydrocarbons.

2.4.1.1. Fate of Marine Oil Spills

Oil, when spilled at sea, will normally breaks up and be dissipated or scattered into the marine environment over time. This dissipation is caused by a number of chemical and physical processes by the effect of various environmental conditions such as salinity, wind speed and direction, waves, etc. The processes are collectively known as weathering processes. While some of these processes, like natural dispersion of the oil into the water, cause part of the oil to leave the sea surface, others like evaporation or the formation of water in oil emulsions, cause the oil that remains on the surface to become more persistent.

Depending upon the oil persistency and composition, weathering processes occur. While light products (kerosene etc.) tend to evaporate and dissipate quickly and naturally, persistent oils (such as many crude oils) break up and dissipate more slowly and usually require a clean-up response. Physical properties such as the density, viscosity and pour point of the oil all affect its behavior. Dissipation does not occur immediately. The time this takes depends on a series of factors, including the amount and type of oil spilled, the meteorological conditions and whether the oil stays at sea or is washed ashore. Sometimes, the process is quick and on other occasions it can be slow, especially in sheltered and calm areas of water.

2.4.1.2. Weathering Processes

The eight main weathering processes are listed below, and shown in Figure 2.4.

- Spreading
- Evaporation
- Dispersion
- Emulsification
- Dissolution
- Oxidation
- Sedimentation/Sinking
- Biodegradation

These processes occur depending on different factors and on different stages after accident.

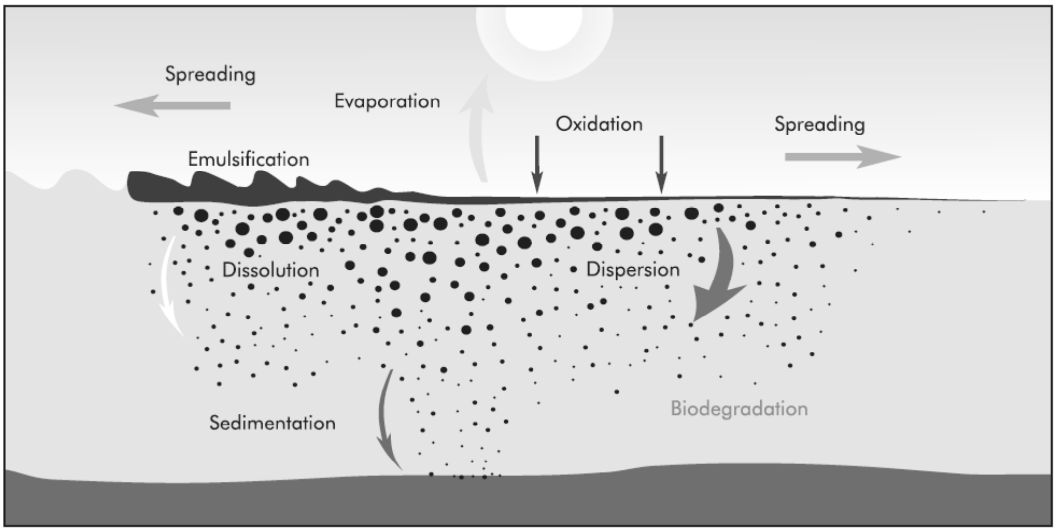


Figure 2.4: Weathering processes after an oil spill incident

In Figure 2.5, a schematic representation of the fate of a crude oil spill showing changes in the relative importance of weathering processes with time is given. The width of each band indicates the importance of the process.

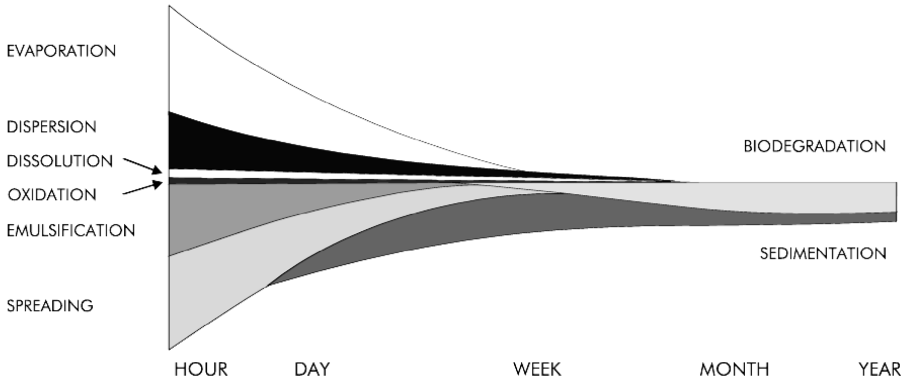


Figure 2.5: Weathering processes through time

2.4.1.3. Combined processes

The processes of spreading, evaporation, dispersion, emulsification and dissolution are most important during the early stages of a spill whilst oxidation, sedimentation and biodegradation are more important later on and determine the ultimate fate of the oil. To understand how different oils change over time whilst at sea, one needs to know how these weathering processes interact. To predict this, some simple models have been developed based on oil type. Oils have been classified into groups roughly according to their density - generally, oils with a lower density will be less persistent. However some apparently light oils can behave more like heavy ones due to the presence of waxes. In Table 2.1, a classification is made in terms of the density of the crude oil products.

Table 2.1: Classification of Crude Oil Products in Terms of Density (ITOPF, 2007)

Group	Density	Examples
Group I	less than 0.8	Gasoline, Kerosene
Group II	0.8 - 0.85	Gas Oil, Abu Dhabi Crude
Group III	0.85-0.95	Arabian Light Crude, North Sea Crude Oils
Group IV	greater than 0.95	Heavy Fuel Oil, Venezuelan Crude Oils

Type of crude oil determines the composition of crude oil and also its fate if it is spilled. Therefore, knowing what type of oil is spilled could help on estimating how oil behave on a given time approximately. Fate of oil in marine environment will determine the response strategy since the composition of the leftover oil products is in a constant change all the time.

2.4.2. Effects of Marine Oil Spills

Oil spills can have a serious economic impact on coastal activities and on those who exploit the resources of the sea. In most cases, such damage is temporary and is caused primarily by the physical properties of oil creating nuisance and hazardous conditions. The impact on marine life is occurs by means of toxicity and tainting effects due to chemical composition of oil, as well as by the diversity and variability of biological systems and their sensitivity to oil pollution.

2.4.2.1. Impact of oil on coastal activities

The effects of a particular oil spill depend upon many factors, not least the properties of the oil. Contamination of coastal amenity areas is a common feature of many spills leading to public disquiet and interference with recreational activities such as bathing, boating, recreational fishing and diving. Hotel and restaurant owners and others who gain their livelihood from the tourist trade can also be affected. The disturbance to coastal areas and to recreational pursuits from a single spill is comparatively short-lived and any effect on tourism is largely a question of restoring public confidence once clean-up is completed. Industries that rely on a clean supply of seawater for their normal operations can be adversely affected by oil spills. If substantial quantities of floating or sub-surface oil are drawn through intakes, contamination of the condenser tubes may result, requiring a reduction in output or total shutdown whilst cleaning is carried out.

2.4.2.2. Biological effects of oil

Simply, the effect of oil on marine life is caused by either the physical nature of the oil or by its chemical components. Marine life may also be affected by clean-up operations or indirectly through physical damage to the habitats in which plants and animals live.

The main threat posed to living resources by the persistent residues of spilled oils and water-in-oil emulsions (mousse) is one of physical smothering processes. The animals and plants most at risk are those that could come into contact with a contaminated sea surface. Examples are marine mammals and reptiles, sea birds, and marine life on shorelines and in mariculture facilities.

The most toxic components in oil tend to be those lost rapidly through evaporation when oil is spilt. Thus, lethal concentrations of toxic components leading to large scale mortalities of marine life are relatively rare, localized and short-lived. Sub-lethal effects that impair the ability of individual marine organisms to reproduce, grow, feed or perform other functions can be caused by prolonged exposure to a concentration of oil or oil components far lower than will cause death. Sedentary animals in shallow waters such as oysters, mussels and clams that routinely filter large volumes of seawater to extract food are especially likely to accumulate oil components. Whilst these components may not cause any immediate harm, their presence may render such animals unpalatable if they are consumed by man, due to the presence of an oily taste or smell. This is a temporary problem since the components causing the taint are lost when normal conditions are restored.

The ability of plants and animals to survive contamination by oil varies. The effects of an oil spill on a population or habitat must be viewed in relation to the stresses caused by other pollutants or by any exploitation of the resource. In view of the natural variability of animal and plant populations, it is usually extremely difficult to assess the effects of an oil spill and to determine when a habitat has recovered to its pre-spill state. In recognition of this problem, detailed pre-spill studies are sometimes undertaken to define the physical, chemical and biological characteristics of a habitat and the pattern of natural variability. A more fruitful approach is to identify which specific resources of value might be affected by an oil spill and to restrict the study to meeting defined and realistic aims, related to such resources.

2.4.2.3. Impact of oil on specific marine habitats

Within each habitat a wide range of environmental conditions prevail and often there is no clear division between one habitat and another.

The impact of oil on shorelines may be particularly great where large areas of rocks, sand and mud are uncovered at low tide. The amenity value of beaches and rocky shores may require the use of rapid and effective clean-up techniques, which may not be compatible with the survival of plants and animals.

Birds which congregate in large numbers on the sea or shorelines to breed, feed or moult are particularly vulnerable to oil pollution. Although oil ingested by birds during preening may be lethal, the most common cause of death is from drowning, starvation and loss of body heat following damage to the plumage by oil.

2.4.2.4. Impact of oil on fisheries and mariculture

An oil spill can directly damage the boats and gear used for catching or cultivating marine species. Floating equipment and fixed traps extending above the sea surface are more likely to become contaminated by floating oil whereas submerged nets, pots, lines and bottom trawls are usually well protected, provided they are not lifted through an oily sea surface. Experience from major spills has shown that the possibility of long-term effects on wild fish stocks is remote because the normal over-production of eggs provides a reservoir to compensate for any localized losses.

Cultivated stocks are more at risk from an oil spill. Natural avoidance mechanisms may be prevented in the case of captive species, and the oiling of cultivation equipment may provide a source for prolonged input of oil components and contamination of the organisms. The use of dispersants very close to mariculture facilities is ill-advised since tainting by the chemical or by the dispersed oil droplets may result.

An oil spill can cause loss of market confidence since the public may be unwilling to purchase marine products from the region irrespective of whether the seafood is actually tainted. Bans on the fishing and harvesting of marine products may be imposed following a spill, both to maintain market confidence and to protect fishing gear and catches from contamination.

2.5. Importance of an ICZM Structure for Turkey and the Straits

Turkish Straits consist of the Strait of Istanbul (Bosphorus), Strait of Çanakkale (Dardanelles) and the Sea of Marmara which is about 322 kilometers and takes about 16 hours to navigate for an average vessel from one strait to the other (Figure 2.6). No part of the Straits lies in high seas which mean less than 12 NM (nautical miles) and they are located in Turkey's internal waters.

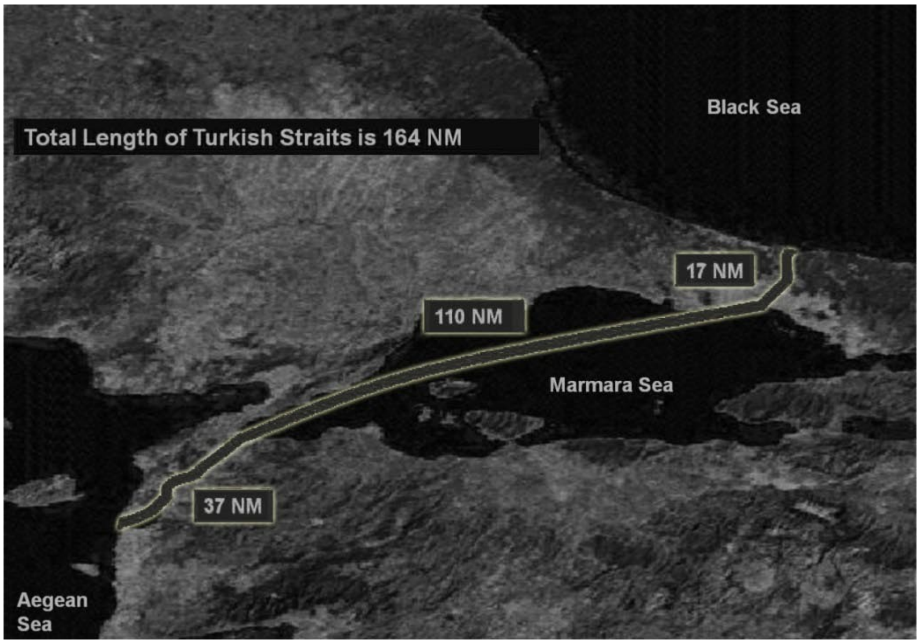


Figure 2.6: Total Length of Turkish Straits
(Coastal Safety General Directorate, 2007)

The length of the Strait of Istanbul is approximately 17 NM (approximately 32 km). Its width varies from 700 meters to 1500 meters and is characterized by a number of sharp turns. The ships must alter route in this Strait at least 12 times with an angle reaching to 80 degrees. Typical and unstable currents prevail at these turns; hence, navigation for a large ship around these sharp turns is quite dangerous. Even medium sized ships encounter difficulties while navigating in these sections of the Strait of Istanbul. Weather conditions causing poor visibility due to thick fog, rain, snow and strong changing currents are further navigational difficulties in these narrow waterways.

The dangers of navigation for a large tanker around these sharp turns are very well known by the whole maritime community. Even medium size ships encounter difficulties while navigating in the dangerous sections of the Strait of Istanbul.

The length of the Strait of Çanakkale is about 37 NM, with a general width ranging from 1300 meters to 2000 meters. Its geographic features are similar to those of the Strait of Istanbul. Satellite photography for Turkish Straits, Strait of Istanbul and Strait of Çanakkale could be seen in the Figure 2.7 (Google Earth, 2007).

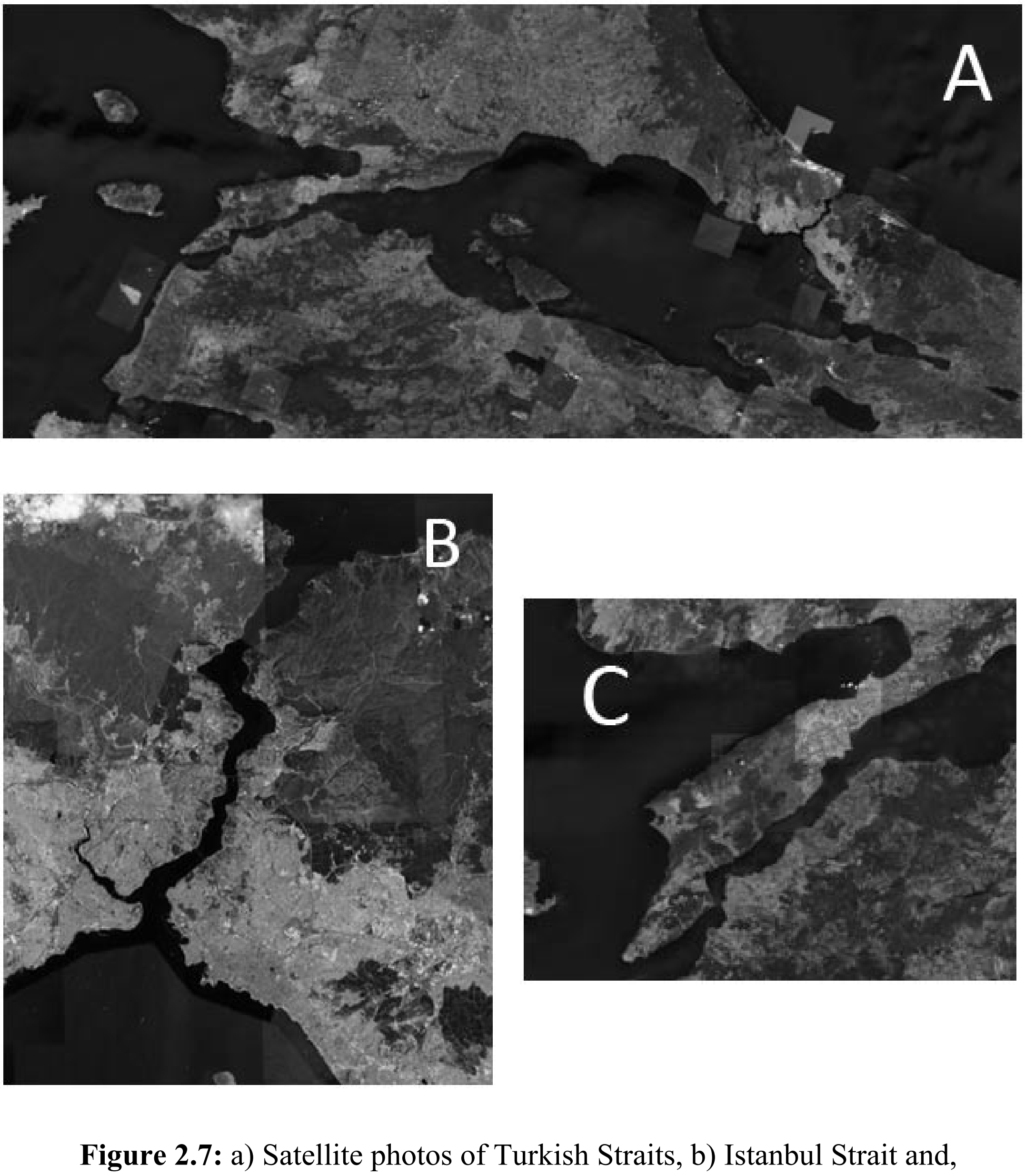


Figure 2.7: a) Satellite photos of Turkish Straits, b) Istanbul Strait and, c) Strait of Çanakkale (Google Earth, 2007)

The Strait of Istanbul is also unique as it runs right through the city of Istanbul, declared as a "World Heritage" by UNESCO, with more than 12 million inhabitants. The shorelines of Istanbul are densely populated. The vessels carrying dangerous cargo regularly approach as close as 50 meters to these inhabited areas. Excluding the vessel traffic and the local traffic such as leisure crafts and fishing vessels, the daily domestic vessel movement alone in the Strait of Istanbul is more than 2500. Over 2.5 million people are daily on the move at sea by intra-city ferries and other shuttle boats, crossing from one side to another in Istanbul.

Existence of great density differences between the Mediterranean and the Black Sea waters is also well-known information and that difference creates a dual layer current system along the Straits flowing in opposite directions (Artüz, 1999). This situation creates an ecological diversity which let different species live together under different hydrological conditions. Because it is also one of the rarest marine biological corridors of the world, Straits also act as a genetic bridge for marine life between the Black Sea and the Mediterranean Sea. Due to the pollution mainly stemming from maritime traffic, this sensitive eco-system is now facing the threat of destabilization. Not only maritime accidents, but also garbage dumping, used oil dumping, ballast water and wastewater discharges contribute to marine pollution. Noise pollution, destruction of natural beauty and damage to cultural heritage are other side effects of the intense maritime traffic.

Table 2.2: Distribution of spilled tar and oil products per sea surface area (Artüz, 1991)

Zones	Surface Area ($10^{12}m^2$)	Waste Crude oil ($mg/m^2/year$)	Tar Formation ($mg/m^2/year$)	Tar Quantity (mg/m^2)
North Atlantic	33	17.45	6.13	5
Mediterranean	2.5	108	38	38
Krasivo Stream	10	33	11.6	3.8
NE Pasific	40	0.74	0.26	0.4
SW Pasific	45	0.05	0.02	0.005

The results of a study conducted on different marine environments are presented in Table 2.2 where oil products were determined for the respective marine environments (Artüz, 1991). As it is seen in Table 2.2, Mediterranean Sea is the most polluted sea by oil products with 38 mg/m^2 tar distribution per sea surface area. Though Marmara Sea is not as polluted as the Mediterranean Sea, it is under threat in terms of both tanker accidents occurring frequently and high traffic density per unit surface area levels.

Bosphorus exposes a high accident risk because of its geography and morphology, as mentioned earlier. The increasingly congested maritime traffic in the Turkish Straits causes serious concern from various aspects. Evolution of the ship characteristics and traffic congestion between 1938 and 1995 is given in Table 2.2. The statistics taken from the Under secretariat for Maritime Affairs shows that in the last decades hazardous materials cargos carried by ships reached to the 10% of the total passings (Çakır, 2002; Otay and Özkan, 2005) (Table 2.4).

Table 2.3: Increase in Traffic in Istanbul Strait (Çakır, 2002)

Years	# of Ship Passed	Heaviest Ship Passed (DWT)
1938	4500	7500
1985	24100	105500
1995	46954	156057

Table 2.4: Total hazardous waste carried through Bosphorus (Çakır, 2002)

Years	# of Total Passing	# of Hazardous Materials Carrying Ship	Percentage in Total Passage	Total Hazardous Materials Amount (M/T)
1997	36543	4303	11,8	63.017.194
1998	49307	5142	13,3	68.573.523
1999	47906	5504	11,5	81.515.453
2000	48079	6093	12,7	91.045.040
2001	42637	6516	15	100.768.977

An accident in the Strait of Istanbul that involves hazardous cargo has the potential of endangering the lives of hundreds of thousands of people, if not millions. Moreover, the effects of an environmental catastrophe resulting from such an accident would leave its scars for many decades. The dense maritime traffic in the Turkish Straits and the consequent marine pollution, have already severely affected the environment.

In a modeling study conducted by the Otay and Ozkan (2003), risk map of the Bosphorus for collisions and ramming / grounding was generated as shown in Figure 2.8. The results of the simulation indicate certain regions in the Strait as

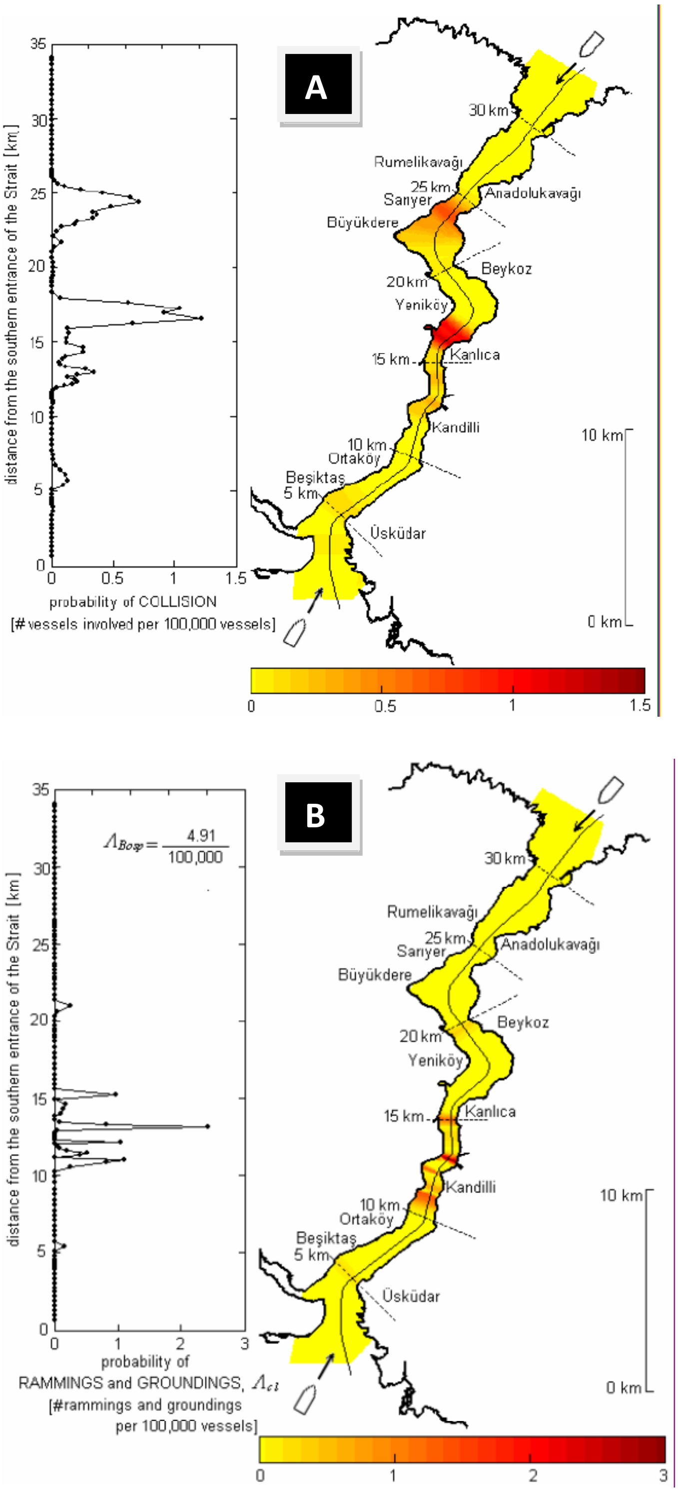


Figure 2.8: a) Risk map for collision, b) Risk map for ramming and grounding (Otay and Özkan, 2003).

high-risk regions. It is also verified in the model that the southbound vessels are at a more disadvantageous condition in terms of ship handling due to the south going surface flow. Therefore, larger southbound vessels are found to be the main cause of the collisions in the Strait of Istanbul. When the collision and ramming/grounding risks are evaluated separately, it is found that the collision risk is higher than ramming/grounding risk in the Strait of Istanbul.

403 main accidents have been recorded in the Strait of Istanbul alone since 1948. The number of collisions has been 292, crashing into buildings in the residential areas along the Strait of Istanbul have been 27, grounding 35 and fire 6.

However, when the rate of accidents are analysed, it is clearly seen that the rate has drastically declined after Turkey started to implement the traffic regulations in the Straits. The number of collisions which was around 50 per year before the enactment of these regulations, this value has dropped to less than 5.

Bosphorus is an important waterway both economically and ecologically though it is under an immense traffic density (which may cause high accident and pollution risk). In order to heal its ecological resources and mitigate accidents, it should be managed under ICZM rules, scientifically. Sensitivity mapping, as a newly – emerged tool for developing oil spill response plans around coastal zones, will be compulsory for such an important area.

2.6. Sensitivity Mapping in an ICZM Framework

The preface of the "Sensitivity Mapping for Oil Spill Response" technical report published by IMO (International Maritime Organization) and IPIECA (The International Petroleum Industry Environmental Conservation Association) partnership starts highlighting "The International Convention on Oil Pollution Preparedness, Response and Cooperation 1990 (OPRC Convention)" which entered into force in May 1995. The Convention provides the framework for international cooperation in combating major oil pollution incidents. An underlying premise of the OPRC Convention is the understanding that prompt and effective action is essential in order to minimize the damage which may result from such an incident. The Convention specifically recognizes and emphasizes the important role which the oil and shipping industries have in this regard (IPIECA, 1994).

Oil pollution has devastating effects on coastal environment and surrounding–affected habitats. A number of different factors will determine the degree of effects that can be expected from an oil spill. Geographical location of the spill, oil dosage and impact area of the accident (distance from the shoreline), oceanographic and meteorological conditions, season and oil composition (or oil type) are the main factors that will determine the impact of oil spill on environment (Hayes et al., 1992).

Oil spill incidents pose a great risk towards the sustainable use of the marine and coastal environments and also threat coastal inhabitants. This is where oil spill response plans (or contingency planning) gain great importance in ICZM schemes.

An Oil Spill Response Plan or a Contingency Plan clearly identifies who, what, when, where, and how oil spill response for a particular marine/coastal environment is to be managed and outlines a set of procedures for correctly responding to such an emergency (Rhode Island Sea Grant - BMPs for Marinas, 2007). The level of action describes how serious the situation is and particularly amount of the spilled oil. Most oil spills can be dealt with locally (Tier 1). Should the incident prove beyond the local capability or affect a larger area, an enhanced but compatible response will be required (Tier 2). The foundation of this tiered response is the local plan for a specific facility such as a port or oil terminal or for the length of coastline at risk from a spill. These local plans may form part of a larger district or national plan (Tier 3) (ITOPF, 2007). This classification (as it is also valid in Turkey) is accepted internationally and points a hierarchical response structure according to the spill tier. After the validation of the spill incident and its tier, sensitivity maps should be used. Their usage ranges from planning practical site-specific shore protection and clean-up, to strategic planning on a regional scale for major accidents in remote areas.

Preparing and updating sensitivity maps are key activities in the oil spill response planning process. These maps convey essential information to spill responders by showing where the different coastal resources are, and by indicating environmentally sensitive areas. The making of a map involves assembling information on resources and deciding on what guidelines for spill response should be included, through consultation with relevant organizations. This can be done regardless of whether or not the benefits of computerized Geographic Information Systems (GIS) and databases are available (IPIECA, 1994).

Reviewing the ICZM procedure [(1) inception, (2) problem identification (3) planning, (4) implementation, and (5) monitoring and evaluation], it is seen that sensitivity mapping covers a few stages of the scheme. Problem identification, planning and monitoring stages are the major stages which sensitivity maps are developed and used. If a community decides to develop an ICZM Plan and determines the oil pollution risk as a trigger for the ICZM Plan, some considerations should be made. Coastal areas that are in the vicinity of oil transportation routes, transfer points or harbors are subject to consistent oil pollution. Oil drill platforms and crude oil exploration activities are another oil pollution sources other than accidental spills or intentional (and also illegal) wash-outs. All these sources having spill risk should be considered. During the proposal procedure of an ICZM Plan, considered risks should be controlled through a mitigation plan for the minimization of its possibility. Oil spill contingency plan will necessitate a sensitivity map eventually, whether it is built on GIS or not. Ecosystem monitoring is also essential for keeping (sensitivity mapping) the system updated. Even if no spill event occurs in the region, habitats could immigrate to elsewhere or invaded by some other organisms.

In conclusion, sensitivity maps have great importance in an ICZM strategy as they provide an opportunity to prioritize the risks posed onto the coastal environment. Determination of the risks dictates action plans for prevention and remediation.

2.7. Oil Spill Preparedness

2.7.1. Strategy Development

The strategy section should cover eight main areas: Introduction; Risk Assessment; Resources at Risk and Priorities for Protection; Response Strategies; Organization and Management; Equipment, Supplies Services and Manpower; Communications & Control; and Training, Exercises and Updating Procedures.

In the introduction, the authority or lead agency responsible for the formulation and implementation of the plan and an explanation of the statutory requirements, if any, should be defined. The geographical coverage of the plan should be outlined and reference made to interfaces with other plans.

The expected frequency and size of spills and the types of oil likely to be encountered should be addressed. Historical spill data, where available, may allow a quantitative assessment. The number of calls made by vessels, particularly tankers, is relevant. A range of possible spill scenarios can be developed from an analysis of oil related activities and the types of oil handled in or transported through the area. The probable movement and fate of slicks should be studied and recorded. Details of oil types and prevailing meteorological and oceanographic conditions should be annexed.

Amenity areas, ecologically sensitive areas, sea water intakes, fisheries, mariculture, seabirds and marine mammals and other resources likely to be threatened by oil spill should be identified. Since it will not be possible to give equal protection to all sensitive resources, priorities need to be determined. Account should be taken of the practical problems as well as the relative economic and environmental values of each resource and their sensitivity to oil pollution. Seasonal variations e.g. of beaches and breeding areas should be noted. Information on the location and sensitivity of resources and priorities for protection is frequently provided in the form of maps annexed to the contingency plan.

Clean-up strategies should be determined in relation to the perceived risk and agreed response priorities. Account should be taken of the limitations of spill control techniques and the most appropriate equipment chosen for the anticipated weather conditions and oil types. Shoreline clean-up strategies should be prepared for the types of coastline likely to be encountered. Predetermined temporary waste storage sites and disposal routes should be detailed. Maps detailing strategies and restrictions, access points and waste sites should be annexed.

The outline of the response organization and the responsibilities of those likely to be involved should be detailed. Central coordination under a single organization which has complete responsibility for handling the operation should be considered in order to minimize confusion. However, procedures for coordination between organizations should be outlined. The size of the response organization will depend on the area covered by the plan, the severity of the threat and the sensitivity of any threatened resources. Relevant government departments, advisors and experts should be annexed.

An inventory of available equipment should be annexed. Provision for food, clothing, shelter, medical facilities and other logistics support should be detailed. The availability of back-up support should be recorded, both nationally and internationally. In the latter case, provision should be made for customs and immigration procedures as well as financial arrangements. The manpower required to respond to a spill should be estimated. Additional manpower may be required in the case of large spills. Contractors and other sources of manpower should be annexed.

The establishment of a fully equipped communications centre should be predetermined to ensure that the correct information is passed to the correct people. The centre should act as a central channel for all information. Where clean-up operations are conducted over extended distances, portable communications centers should be located close to the scene of operations. Supplies of charts, maps, reports, manuals etc. should be provided for. Accurate recording of all actions and maintenance of appropriate documentation related to the use of manpower, equipment and materials as well as expenditure is vital for future reference and the submission of claims for compensation.

Training programs should be developed for all levels of response personnel. Exercises should be held at regular intervals to ensure the plan functions correctly and to familiarize all participants with its contents. Detailed equipment should be mobilized and deployed to test its actual availability and performance. An oil spill provides the best opportunity for improving a plan. Events should be reviewed soon after clean-up has been completed and the plan revised on the basis of lessons learnt.

2.7.2. Implementing the Operational Plan

The operational procedure can be divided into six main parts, generally following the chronological order of occurrence during a spill: Notification, Evaluation, Response, Clean-up, Communication, and Termination.

The information required to allow an accurate evaluation of an incident should be detailed i.e. date, time, position, source, cause, amount and type of oil, slick size etc. and the procedure for the evaluation of the seriousness of the incident should be given. A programme for alerting response personnel and the relevant authorities should be included.

Methods for trajectory modeling, procedures for aerial and terrestrial surveillance, for the identification of threatened resources and for notifying pre-identified parties likely to be affected should be included.

The plan should allow the consideration of various response options according to the situation. Procedures for placing manpower and equipment on standby prior to mobilization should be included.

Procedures should be included for establishing a dedicated response centre, for mobilizing & deploying the necessary equipment and manpower, organizing logistic support, continuing with any aerial surveillance and considering any disposal options. In addition, provision should be made for locating a command post close to the site of the incident. Procedures for opening channels of communication should be detailed.

Guidelines for the level of clean-up required for each location should be given together with procedures for standing down equipment. Guidelines for the restoration of temporary storage sites should be outlined.

Listings of information that will be required to facilitate an efficient and effective response should be included as a series of annexes.

- Contact directory of response personnel - out of office contact details should be included where appropriate.
- Contact directory of third parties - parties likely to have an interest in an incident e.g. police, media, parties of likely impact and other authorities.
- Primary response equipment - government, private contractor and oil industry equipment.
- Auxiliary response equipment - sources of workboats, tugs, helicopters, aircraft, barges, vacuum trucks, tractors, protective clothing, hand tools, radios etc.
- Logistics suppliers - suppliers of catering, housing, transport, sanitation, laundry etc.
- Manpower sources - contractors, local authorities, military, fire brigades, volunteer organizations and other sources.
- Experts and advisors - personnel with detailed knowledge of oil pollution; of the local coastal environment, particularly of flora and fauna; of safety; and of other areas.

- Maps of sensitive areas - showing detailed information on the location of amenity and ecologically sensitive areas; sea water intakes; fisheries; mariculture; seabirds and marine mammals; and other resources likely to be threatened. Seasonal sensitivity should be highlighted.
- Maps of the coastal region - showing priorities for protection; illustrating strategies and restrictions; access points; waste sites; etc.
- Oil types likely to be encountered - detailing their properties; persistence; likely fate and effects; suitable response techniques; etc.

In summary, an effective contingency plan will serve to promote a trained and practiced response when personnel are faced with an emergency situation.

2.7.3. Oil Spill Preparedness in Turkey and Related Institutions

Oil spill response mission is fulfilled with the cooperation of a number of institutions in Turkey. When a denouncement notified to the Undersecretariat for Maritime Affairs (UfMA), it is responsible for reporting it to a few institutions such as Ministry of Environment and Forestry (MoEF), Harbor Directorate, Governor or head official of a district, Coast Guard of the region and authorized institutions.

When an oil spill incident occurs and the situation notified to the UfMA, it is validated first. Then incident reported to the other responsible institutions listed above. After the tier of the incident determined (Tier 1, 2 or 3) response strategy is performed.

In tier 1 incidents, response is fulfilled by the ship or coastal facility that the incident occurred and the operation headed by the operator of the vessel/coastal facility. Results of the operation followed by the Harbor Directorate and MoEF city directorate and conveyed to MoEF and UfMA.

If the tier is determined as tier 2, then response is performed by the contingency response focus point and headed by coordination committee which the governor is the manager of. Operation is conducted by the operation chief assigned by the coordination committee. Loss determination committee constituted by the coordination committee starts the investigations. After all the investigations stopped, damage is indemnified by the UfMA.

In a tier 3 incident which could be considered as a nationwide disaster, commandment of the coordination committee is shifted to MoEF and the operation is conducted from the national contingency response focus point, just like the rest of the procedure.

In an incident, when operation coordinator decide to terminate the operation, he/she report the decision to the upper and lower hierarchical units. Subsequently, coordinator of the incident site stops the activities. Then, operation coordinator evaluates the oil spill response operation in order to improve the future response activities (Baylan, 2007).

2.8. Environmental Sensitivity Index as a Tool for Integrated Coastal Zone Management

Each year approximately 14,000 oil spills are reported worldwide. Even the majority of these spills are not classified as large (producing more than 10000 gallons), they still pose a threat to the environment, ecology, and socio-economic activities of the exposed area. A number of strategies have been employed to aid decision makers in dealing with such disasters. A particular importance has been given to the application of sensitivity mapping with GIS in the management and oversight of oil spill response activities that include determining the trajectory and fate of spilled oil as well as identifying the relative value and sensitivity of natural and man-made resources at risk (Novak, 2006).

A GIS database is not only able to store large volumes of data (such as geophysical, socio-economic, meteorological data or information about natural resources, fisheries, seas or equipments in a spatial or temporal basis), but also the information can be extracted, manipulated, analyzed, and displayed quickly and accurately in this system. In addition, GIS provides a mechanism for maintaining spatial data in dynamic environments and enables the power of spatial relationships to be more fully realized since the system provides graphic output. Although GIS lacks the capability for logical set-based calculations, when used in conjunction with a numerical model, it plays a crucial role in predicting and displaying spill trajectories. For example, oil spill models look to GIS for input on spill location, starting time, depth of the spill, water, wind, and current data, number, type, and amount of particles, boom locations, and actual over flight observations. Once acquired, the model uses the information to determine the range of distances and directions the spill is likely to travel from a particular site as well as its dispersal behavior. Results of the spill simulation can then be displayed in 3-D along with other pertinent spatial information using GIS (Anderson, et al., 1996).

The use of Environmental Sensitivity Index (ESI) is fundamental for oil spill contingency planning and for site definition in early stages of pipeline project design in terrestrial areas. Such environmental sensitivity information may seem too straightforward at first; this simplicity, however, enables rapid, effective decisions to be made in the event of an oil spill. Environmental risk assessment using this methodology is carried out along the Urucu-Coari pipeline in a study conducted by Beisl et al. (2003a) along the planned pipeline between Coari and Manaus and along the Solimões River transportation route and the results of the study demonstrate that pipelines constitute an environmentally saver option for oil transportation in the region (Beisl et al, 2003a).

Environmental Sensitivity Index (ESI) includes spatial data layers depicting the locations 1) shoreline types and coastal habitats, including beaches, wetlands, seagrasses, and coral reefs; 2) biological resources, particularly critical areas such as seabird nesting colonies, juvenile fish nursery areas, and endangered species sites; and 3) human-use resources, such as commercial fishing sites, aquaculture facilities, recreational activities, and protected areas. In addition to spatial data, ESI's also include temporal information on species seasonality and sensitive life-history time-periods.

Beyond the current uses of ESI's for oil spill planning and response, ESI maps and databases could serve as important tools for a variety of coastal zone management tasks, including: coastal planning, permitting, and zoning; environmental assessments; habitat protection and restoration; endangered species management; coastal hazards protection and mitigation; tourism development and management; port development and operations; dredging and dredged-material disposal; and fisheries management.

The ESI map also provides an efficient and convenient inventory of coastal resources. It can be used by land use planners to resolve or compromise conflicts on the multi-utilization of coastal areas. Zoning serves two main purposes in coastal conservation: a) nature reserve (e.g. diving, nature study, fishing, protection of breeding areas), and b) regulatory purposes which is for programs and coastal land use planning, to designate certain areas for particular uses (e.g. hotel, aquaculture, navigation, greenbelt, commercial fishing, nature reserve). Zones are also established to identify the areas for pollution control where certain and appropriate mitigation measures could be implemented for the sustainable use of coastal resources.

In environmental and other planning activities, quantitative measures are often required since the environmental aspect must be balanced against other interests. A very useful feature for the GIS-based ESI map is the capability to combine and overlay different information types. This is a powerful tool that makes it easy for policy planners and decision-makers to analyze the impact of policy decisions and what if scenarios. As it based on up-to-date and large amount of data, ESI is beneficial for policy planning at local, national and regional levels, and could minimize conflicting coastal development in the long-term.

The ESI map contains supporting information for making decision and planning to deal with marine pollution and incidents. The map illustrates the level of impacts from marine pollution point sources on the coastal environment. It is also possible to predict the degree of potential damage on each features arising from future activities.

The updated and complete information of the coastal environments in the ESI database is advantageous in planning for coastal restoration and rehabilitation. It is possible to use GIS options to simulate and demonstrate the different planning alternatives (Tridech et al., 1999).

To illustrate the potential of ESI maps and data products as coastal zone management tools, a few examples of recent and planned applications from USA can be stated. For instance 1) using California ESI data for environmental assessments of California Department of Transportation coastal highway and bridge construction projects; 2) using Massachusetts ESI data to assist in initial screening of potential dredged material disposal sites; 3) using Florida ESI data for planning recreational and spectator water-sports events (jet ski races, etc.) around sensitive species locations and seasons; and, 4) using South Carolina ESI data for identification of geographic areas of particular concern during coastal zoning and permitting are good examples to the ICZM applications of an ESI planning.

In addition to these examples from the U.S.A., the nation of El Salvador in Central America has recently conducted ESI mapping for their entire coastal zone and plans to use ESI information as a foundation for an integrated coastal zone management program. Components of the El Salvador ESI project have been incorporated into the "Law of the Environment", the recently published federal environmental legislation for El Salvador. Under this legislation, government ministers and other authorities are encouraged to consult the ESI maps and databases when reviewing coastal development plans, in order to promote conservation and sustainable development of the coastal and marine environment. Following the lead of the examples outlined above, it is hoped that ESI maps and digital products will soon receive wider application for various coastal zone management applications. Though ESI's primarily support the oil spill planning and response community, coastal zone managers will hopefully find ESI maps and data to be a valuable tool as well (Zengel, 2001).

2.9. Application Examples for Sensitivity Mapping

In this section, examples are given relating to sensitivity indices applied by the different establishments in different states throughout the world. Although the name of that tool which is used for the protection of the natural environment against the chemical / oil spills is varied, main objective remains same: responding quickly against the (chemical / oil) spills in order to prevent the ecosystem from damage. Some of these reviews are taken from sensitivity mapping plans directly, while in some countries these plans are private and the information taken from websites or brochures.

2.9.1. Denmark

That ESI atlas was produced before the oil/gas exploration studies offshore Greenland for pre-assessment of natural shore resources. The main objective of the project is to produce an overview of resources vulnerable to oil spills, for example biological resources (fish, birds etc.), and also create a tool to respond to a possible oil spill. In that project, many items such as coast types, oceanography, ice and climate, biological resources (fish, birds etc.), fishing and hunting, selected areas (e.g. seabird breeding colonies), archaeological sites, logistics and oil spill response methods are included in the sensitivity mapping efforts.

Study team of that project is constituted by a number of professional and representatives of important institutions in Denmark. The National Environmental Research Institute, Department of Arctic Environment (NERI-AE) headed the study team and further provided the biological information in the atlas by also preparing the shoreline and offshore sensitivity maps. NERI also developed a CD presentation solution and an Internet version of the atlas. Coastal morphology maps and basic map layout for the regions within the project area are prepared by GEUS – The Geological Survey of Denmark and Greenland. The Institute of Geography, University of Copenhagen, was responsible for shoreline morphology classification based on air photo interpretation. The Greenland Institute of Natural Resources (GINR) contributed with information regarding living resources (fish, shellfish, birds and whales) and their use in Greenland. The Greenland Ministry of Environment and Nature supplied information and commented on an early draft of the atlas.

The software application used to generate shoreline and offshore sensitivity scores was originally developed for the first atlas in co-operation with AXYS Environmental Consulting Ltd.

As a part of the project, a study of local knowledge was carried out by NERI and GINR. Other institutions that take place in the project are SL Ross Environmental Research Ltd. (sections from the physical environment and logistics maps), The Danish Meteorological Institute (DMI) (data regarding ice, oceanography and climate), and The Greenland National Museum and Archives (GNMA) (archaeological information), briefly.

Environmental Sensitivity Index (or environmental sensitivity ranking system) is used in the Atlas to determine and illustrate the relative sensitivity of shoreline and offshore areas of West Greenland to the effects of an oil spill. This pre-spill ranking allows spill responders and on-scene planners to do a quick evaluation of which areas and environmental components that are most susceptible to an oil spill, and thus provides the information to consensus regarding protection priorities during a spill event.

Through the use of the sensitivity ranking system, each shoreline and offshore area receive a single numeric value, which represents the relative sensitivity of that area to a marine oil spill. This numeric value is ranked as extremely high, high, moderate or low and is illustrated on the summary, regional and operational maps by the use of a color code.

The sensitivity ranking system incorporates the biophysical and social elements of the region that are important from an oil spill perspective. These elements are assigned to and ranked on a relative scale within three major categories: (1) resource (human) use; (2) species occurrence; and (3) oil residence. The third category considers the oil residence periods associated with various coastal types, and the differences in ice and open water zones for the shoreline and offshore areas of West Greenland, respectively. Each of the categories are assigned a weighting factor, which is based on their relative importance within the region. The elements within each of the categories are ranked based on their relative sensitivity to potential effects of oil spills (Mosbech et al., 2000; Mosbech et al., 2004a; Mosbech et al., 2004b).

2.9.2. Alaska

Major reasons targeted by the preparation of an environmental sensitivity index and sensitivity map for Alaska could be regarded as the classification of the Alaskan Beaufort Sea and Chukchi Sea shorelines using the Environmental Sensitivity Index (ESI) classification scheme; creation and incorporation of digital ESI data with the Minerals Management Service (MMS) Coastal and Offshore Resource Information System (CORIS) database (which is also a part of the MMS Corporate Technical Information Management System (TIMS) database) and creation of video products from the aerial video imagery.

The Beaufort Sea was mapped between the Colville River and Point Barrow in the west and between the Canning River and the Canadian border to the east. The middle section of the Beaufort Sea had recently (1994-1996) been mapped and the shoreline data were incorporated into hardcopy ESI maps and digital data produced by the National Oceanic and Atmospheric Administration (NOAA) in 1999. The Chukchi Sea was mapped from Point Barrow to Point Hope (Newman, R., 2002).

The shoreline classification was based on low-altitude (generally less than 100 m) aerial videotape surveys which were collected from a helicopter and direct observations. Besides, latitude and longitude data were simultaneously recorded as voice information. Also, a commercial navigation and data collection software package was used for the storage of flight paths. Recorded video which is nearly 17 hours length in total was used to classify the shoreline types.

ESI and HYDRO datasets, which is acquired digitizing ESRI topographical maps, were passed through the QA / QC (Quality Assurance / Quality Control) procedure as defined in the ESI guidelines. But shoreline classification study conducted in Alaska shorelines does not cover any ecosystem (biological resources) or human-use resources classification (Newman, R., 2002).

2.9.3. Brazil

The Amazon Rainforest is a moist broadleaf forest in the Amazon Basin of South America. The area known as Amazonia or Amazon Basin encompasses 7 million km^2 (1.2 billion acres), though the forest itself occupies some 5.5 million km^2, located within eight nations: Brazil (with 60% of the rainforest), Colombia, Peru, Venezuela, Ecuador, Bolivia, Guyana and Suriname, as well as French Guiana. States or departments in four nations bear the name Amazonas for the Amazon. Amazonian rainforests comprise the largest and most species rich tract of tropical rainforest that exists. Region within the Brazil borders and named as Western Amazonia also houses to an important oil pipeline between Urucu and Coari. In order to get a better understanding of environmental sensitivity to oil spills along the pipeline and in the Western Amazonia region, an environmental risk assessment is carried out along the Urucu-Coari pipeline, along the planned pipeline between Coari and Manaus and along the Solimões River transportation route.

In this risk assessment study, authors points out that more than ten sensitive environments defined by distinguishing their different sensitivity levels in terms of emergency response and clean up (Beisl et al., 2003a). Based on field surveys and previous studies, Petrobras distinguished different habitats in this region, which were used to rank the overall sensitivity of fluvial areas in Western Amazonia to spilled oil as part of the Environmental Sensitivity Index (ESI). The most sensitive fluvial environment for oil spills was given an index of 10b (Flooded vegetation), the least sensitive, an index value of 1 (Manmade structures) (Beisl et al., 2003b). After the extraction of environmental sensitivity information mapped oil-sensitive environments are inserted in a Geographic Information System (GIS) for environmental risk assessment along pipelines and along the Solimões River oil transportation route, Western Amazonia, Brazil.

Through the study, it is find out that the most land cover could be classified as the most sensitive land type, namely flooded vegetation. ESI, developed by US-EPA (Environmental Protection Agency), is chosen as an essential tool for oil spill contingency planning and site definition in early stages of pipeline project design. In pipeline project design process, pipeline mostly situated in areas where oil spill environmental sensitivity is not high throughout the hydrological cycle.

2.9.4. Australia

Australia has a national strategy to respond to marine spills since October 1973 which is dealt only with oil spills in the beginning. But in April 1998 the strategy was extended to deal with the response to maritime chemical spills in Australian waters. Since then the national contingency plan is known as the National Plan to Combat Pollution of the Sea by Oil and other Noxious and Hazardous Substances (National Plan). As the main authority AMSA (The Australian Maritime Safety Authority) manages the National Plan on behalf of the Federal Government, working with State/Northern Territory (NT) governments, the shipping, oil, exploration and chemical industries, emergency services and fire brigades to maximize Australia's marine pollution response capability. On behalf of the National Plan AMSA has been undertaking a number of major projects which covers improved oil spill trajectory model and a GIS based “Oil Spill Response Atlas” (OSRA) nationwide (Gilbert, 2000).

The major outcome of the OSRA project was to produce an integrated and uniform spill response atlas for Australia in a computerized GIS format able to be conveniently accessed and operated by spill response organizations, planning and clean up teams, environmental and wildlife agencies and other emergency organizations.

The use of ESI in oil spill atlases was first recommended by the Dames & Moore in the Review of the National Plan Coastal Resource Atlas program. Coopers and Lybrand, AMSA's internal auditors, have also recommended to AMSA to re-examine the use of ESI in State/NT Coastal Resource Atlases (CRAs) which will be named as OSRA (Oil Spill Response Atlas) later. OSRA datasets include (1) biological, environmental, wildlife and man-made resources present Australia wide, (2) geomorphological mapping and shoreline sensitivity to oil spills, (3) human-use resource considerations, and (4) logistical and infrastructure information to support a spill response which does not included in the NOAA's Environmental Sensitivity Index.

As a priority, only the identified high risk areas of the coastline for oil spills have been covered systematically under OSRA and other regions of Australia to varying degrees which is selected on the basis of the history of oil spills, shipping density, navigational hazard and high environmental sensitivity. An on-going development plan is being developed to support the OSRA project to ensure over the next few years the other regions of the Australian coastline are covered in the GIS. Relating to the usage of the system through the country a national specification was developed for OSRA along with a data dictionary and data management guidelines. All of the process was guided by a multi-agency Steering Committee and followed a series of user workshops in each State and the Northern Territory to determine required data sets and operational functionality. The OSRA GIS includes maps, charts, satellite imagery, point, line and polygon digital data as well as databases and textual information. System covers a wide range of information such as habitats both coastal and near shore marine, coastlines, bathymetry contours, 1:100k scaled topographical charts, marine and national parks, biological resources and conservation status, coastal and marine wildlife resources, aerial photography, landmarks and features, logistic and other infrastructure information.

2.9.5. Nigeria

Nigeria, one of the world's largest oil exporters, has a coastline of approximately 853 km facing the Atlantic Ocean. Country's major export product is oil with its 95% share within total export. This situation leads to oil spillage turns to a major problem for their environment destructing flora and fauna of the region. Major geomorphologic units of the Nigerian coast are distinguished as the Barrier-Lagoon complex; the Mud coast; the Arcuate Niger delta; and the Strand coast while the prevailing vegetation of the coastal area composed of characterized by mangrove forests, brackish swamp forests and rain forests.

In Nigeria, the major oil spill reasons are different from the countries mentioned before, mainly spills or accidents occurring during sea transportation. Most of the oil spills in Nigeria occur due to the pipe corrosion (50%). While 28% of spills occur due to the sabotage for illegal oil trading, 21% of them are through oil production operations. Oil spill incidents generally occur around Niger Delta region, where the oil production industry lies, leading substantial environmental damage twinning with the increasing regional industrial population.

After 50's, decreasing environmental quality, by the oil pollution, devastated by the regional oil companies which does not accept or fulfill their responsibilities in accordance with the protection of environment causing to the disappearance of most of the mangroves and a number of organisms living around the shoreline. For their future protection, a consortium was formed by the regional oil companies in 1981 to combat against the oil spills. In the beginning of their research sixty coastal and two hundred riverine/estuarine stations were studied in 1984 and 1985. Data gathered at these stations were used in describing regional and site-specific shoreline types. The outer coastline of Nigeria was divided into five broad categories, and within these categories, the shoreline has been divided into Environmental Sensitive Index (ESI) shoreline types. In addition, an ESI scale was developed and applied for the tidally influenced Bonny/New Calabar mouth and estuary (Badejo et al., 2004).

2.9.6. Malaysia

Thai-Eng (1984) has developed an oil spill vulnerability index for eastern peninsula Malaysia. The Index relates largely to shoreline characteristics, special community types (e.g. mangroves), species (e.g. sea turtles) and habitat utilization (e.g. fish migration routes) strongly influence index values. In this index 10 represents the most vulnerable habitat (Tridech et. al, 1999).

2.9.7. Indonesia

In 1984, Indonesia developed a marine environmental sensitivity index with assistance from the Government of Canada. A national oil spill vulnerability map was produced by Salm and Halim. Classification revealed that the most sensitive habitat in the region is coral reefs and mangroves (ranked as 1) while the least vulnerable habitats are sandy and rocky shores (ranked as 8).

In 1993, the Environmental Management and Development in Indonesia Project (EMDI) proposed a new marine environment sensitivity ranking, which incorporates the existing Indonesian system and the American Petroleum Institute system. The proposed system also incorporates habitat grouping instead of a linear ranking series (Tridech et. al, 1999).

2.9.8. Vietnam

The Coastal Sensitivity Mapping Project (1996), as part of Vietnam National Marine Pollution Control Programme (VNMPCP), developed a coastal ESI ranking system considering sensitivity of coastal environments in term of interaction of the oil with ecological habitats, coastal geology and agricultural practice (Tridech et. al, 1999). Classification covers both coastal resources and shoreline classification.

2.9.9. USA

The Environmental Sensitivity Index (ESI), developed by RPI's senior scientists in 1976, has become an integral component of oil-spill contingency planning and response as well as coastal resource management in the USA and other countries worldwide. In 1979, the IXTOC 1 exploratory oil well blew out, spilling 140 million gallons of crude oil into the Gulf of Mexico. During the two months the U.S. had to prepare for oils slicks from the well to reach the Texas coast, the first Environmental Sensitivity Index (ESI) maps were created by NOAA contractors to prioritize areas for environmental cleanup. Since that time, ESI atlases have been prepared for most of the U.S. shoreline including Alaska; Hawaii; the Great Lakes; and the territories of Guam, Puerto Rico, and the U.S. Virgin Islands (Figure 2.7).

A main objective of oil spill response in the United States, after protecting human life, is to reduce the environmental consequences of both spills and cleanup efforts. To do this, NOAA works with state and federal governments to produce

Environmental Sensitivity Index (ESI) maps, which identify vulnerable coastal locations as well as biological and human-use resources. These valuable maps help to establish protection priorities and identify cleanup strategies.

ESI atlas and database archives include the U.S. territories and many other countries worldwide. Nearly all of the maps of the lower 48 states have been compiled at a scale of 1:24,000, using U.S. Geological Survey (USGS) 7.5-minute quadrangles as the base map. There are a few exceptions where USGS maps were available at different scales or too outdated to be of use. For work in Alaska, 15-minute USGS topographic quadrangles at a scale of 1:63,360 have been used as base maps.

ESI maps were initially hand drawn over U.S. Geological Survey (USGS) maps. Areas along the shore were "ranked" in terms of their vulnerability in the event of a spill. The final product was a set of laminated 13.5" x 17" maps bound into a hard-copy atlas. Since the cost to produce such an atlas made mass production impossible, only three copies would prepared. Although the audience for the maps was small, their utility was unquestionable. Scientists, coastal managers, clean-up contractors, and oil companies used the maps for both oil spill preparedness and response activities.

Technological advances allowed for greater accuracy and distribution of ESI maps. Cost-effective, large-format color copiers quickly made 11" x 17" the preferred page size and improved ESI circulation. Advances in database technology made it practical to collect more information about species vulnerable to oil spills. Also, scientists could now collect more detailed information on seasonality and breeding activities that could affect protection priorities. However, it was the advancement of geographic information system (GIS) technology that had the most profound impact on the production and distribution of the ESI maps.

Figure 2.9: Status of Sensitivity Mapping in USA

The first ESI atlas developed using GIS was produced in 1989. GIS software enabled a more precise presentation of the color-coded, ranked shoreline sensitivity. Biological resources were mapped using lines giving a general idea of the extent of a species and polygons that depicted the area in which a species could be found. Equally significant, the attributes of each polygon and point were now maintained as part of the GIS data structure. Also GIS allows planners and responders to focus on the resources that are relevant at a particular time of year and that occur in a particular area.

Tabular data can be searched to find information about a specific species or a group of species with similar characteristics. For example, it may be imperative to protect any nesting or fledging birds in the event of an oil spill. If a spill were to occur in February, you may find fewer species that meet the specified breeding criteria than if a spill were to occur in June. By highlighting the areas where these species do occur, you are able to quickly visualize the priority areas to protect.

It is also possible to use GIS in the opposite direction. For example, if a spill has already impacted an area, it may be important to figure out what species typically reside there. GIS allows the user to query by location in order to identify potentially impacted resources. GIS also allows the user to estimate how large of an area is impacted by a spill, which may help in calculating the number of response resources that may be needed.

Another advantage of GIS is that it allows the user to play "what if" scenarios and prepare custom maps that are appropriate for the circumstances at a specific time.

ESI maps composed of three types of information: (1) Shoreline Classification that is ranked according to a scale relating to sensitivity, natural persistence of oil, and ease of cleanup; (2) Biological Resources including oil-sensitive animals and rare plants; and habitats, which are used by oil-sensitive species or are themselves sensitive to oil spills, such as submerged aquatic vegetation and coral reefs; and (3) Human-Use Resources which are specific areas that have added sensitivity and value because of their use, such as beaches, parks and marine sanctuaries, water intakes, and archaeological sites. These information groups are collected and composed on a GIS (IPIECA, 1994; US-NOAA, 2002; Gönenç et al, 2007; NOAA Restoration/ Response, 2007).

There are some sensitivity map examples given in the Annex A (OSI, 2007).

2.10. Turkey: BTC ESI Application

The only application of ESI in Turkey was applied on the BTC pipeline project. Environmental Sensitivity Index study was conducted within the scope of the preparation of an oil spill response plan which is applied throughout the pipeline and Ceyhan marine terminal under the Incident Management System.

Incident Management System (IMS) is a database keeping/tracking of the data specific to a spill incident. System is based on the Incident Command System to manage emergency situations and provides the flexibility to undertake and manage all necessary actions to protect the public, the environment, company personnel and assets, for any incident size anywhere along the BTC Pipeline System (BIL, 2005).

Oil Spill Response Plan (OSRP) provides guidance and methods to respond to oil spills generated from activities associated with the pipeline and Ceyhan Marine Terminal of the BTC Pipeline System in Turkey. It is prepared for the pre-planning of the different processes and taking actions in a marine/terrestrial oil spill incident. These processes consist of definition of planning activities and processes, emergency notifications (according to incident tier), response (response decision, method, equipment and mission assignments), regional safety definitions and assignments, incident and risk assesment studies, pollution monitoring, sensitivity analysis of the region, protection methods of wildlife and cultural heritage, mitigation and disposal of collected wastes, and reporting/documentation of incident and it is valid for spills that may occur during the commissioning, operation and de-commissioning. The plan also includes alerting procedures for spills that may originate in Turkey and have the potential for crossing into Georgia and Armenia.

The OSRP determines the response needs which are based on risk assessments carried out for the pipeline, marine terminal and shipping lane. These analyses determine the probability of oil spillage, the distribution and spread of various spill sizes, and the potential impact to sensitive environments and wildlife. The pipeline risk assessment identifies potential spill volume loss by pipeline kilometer. Combined with the analysis of potential spill movement and the environmental sensitivity of potentially exposed areas, the optimum type and location of emergency response resources was determined. This document aims at how BIL as Operator will utilize these resources to protect the terminal and the environment in which it resides.

Sensitivity indexing study has become an important aspect of OSRP of BTC Pipeline project since it presents an inventory of natural resources. ESI map of the region is prepared for terrestrial areas around the pipeline from Baku to Ceyhan and coastal area around the Ceyhan Terminal.

Figure 2.10: ESI map of the Ceyhan Terminal

ESI map of the Ceyhan Terminal (Figure 2.10) have data layers such as shoreline sensitivity categories, wildlife life history / seasonality, important bird areas, spill containment sites, geographical features, water intakes, fish farms. Cliffs, low-lying hills, beaches and swamp areas prevails in the region around the marine terminal. Districts around the Seyhan and Ceyhan Rivers are also covered with sediment beaches and rocky shores. Report says that the swamp areas in the interior region of the İskenderun Bay and shallow waters of the İskenderun Lagoon show the highest vulnerability against oil spills since these areas are marked with ESI 9 and ESI 10. This area is also a nursery ground for fish and provides habitat for thousands of migrating and nesting bird species. Beyond it is a designated International Bird

Area (IBA) and is protected under Turkish law. Marine turtle nesting sites are found on the pocket sand beaches at and to the south of the Terminal and along the outer sand beach of Yumurtalık Lagoon while beaches in the North of the Terminal are not utilized by the turtles due to the high pollution they have. These turtle species are also designated as Critically Endangered (CE) by the International Union for the Conservation of Nature (IUCN) and have Turkish and international protection.

ESI study is also conducted for the areas around the pipeline which has a different categorization adopted for the sensitivity of the terrestrial areas. Through the study a detailed land type (in terms of oil vulnerability) is determined along the environmental impact of the project, ecologically sensitive areas and habitat survey. Determination of the ecologically sensitive areas includes the restoration plans for the contaminated lands and the spills on construction areas.

In the terrestrial classification for oil spill vulnerability, ESI 1 still shows the least vulnerable area while ESI 10 defines that the area most vulnerable and sensitive type of area. Classification developed for the terrestrial area around the pipeline is given in Table 2.5 below.

Table 2.5: Pipeline Sensitivity Index Classification – ESI for land areas

1	Primarily Farm / Grazing Land	6a	Wet Meadow Habitat
2	Forest Habitat	6b	Ecological Sensitive Plant Area
3	Wildlife Protection Area	7	Aquifer Protection Area
4	National Forest	8	Archaeological Area
5a	Special Response Area Fault Zone	9	Special Response Area, Environmental
5b	Karst Zone	10	Rivers and Lakes

3. ENVIRONMENTAL SENSITIVITY INDEX – APPLICATION GUIDELINE

3.1. Development of Environmental Sensitivity Index

Environmental Sensitivity Index that will be applied in this study has been utilized as a major oil spill contingency planning tool for almost 30 years by a number of countries.

In 1979, the *Ixtoc 1* exploratory oil well blew out spilling out 140 million gallons of crude oil into the Gulf of Mexico. After two months the incident occurred, the first Environmental Sensitivity Index (ESI) maps were created by the National Oceanographic and Atmospheric Administration (NOAA) contractors to prioritize areas for environmental cleanup and till today many ESI atlases have been prepared for most of the U.S. shoreline including Alaska; Hawaii; the Great Lakes; and the territories of Guam, Puerto Rico, and the U.S. Virgin Islands (Figure 2.7).

The sensitivity maps were initially hand drawn over U.S. Geological Survey (USGS) topological maps (1:24K topo-maps). Areas along the shore were "ranked" in terms of their vulnerability in a spill event. Scientists used marker pens to color code the maps, making it easy to quickly identify high-risk areas. Icons printed on "sticky dots" were added to the maps to show the location of vulnerable biological species and socioeconomic features such as wastewater discharges, ferries, and managed areas. The final product was a set of paper maps bound into a hard-copy atlas. Since reproduction cost for such an atlas made mass production impossible, generally, only three copies were made: for NOAA's Seattle Office of Hazardous Materials Response Project, NOAA Regional Scientific Support Coordinator, and the Contractor who produced the maps.

Scientists, coastal managers, clean-up contractors, and oil companies used the maps for both oil spill preparedness and response activities.

The *Exxon Valdez* oil spill, occurred in 1989, had a significant impact on the demand for ESI maps. Public concern over the damage oil caused to the coastal environment was heightened. State and federal funds were directed to oil spill prevention and response strategies.

In 1991, California enacted the Oil Spill Prevention and Response Act (SB-2040), which made coastal sensitivity mapping a priority. Alaska also made sensitivity mapping of the entire state coast. Similar legislation in other states increased the funds available for oil spill planning and protection activities, including the creation of ESI maps.

As a result of the increased demand for ESI maps, the Association for Oil Spill Information Management (AOSIM) committee was established and convened in Austin, Texas, in 1993. This committee aimed to define a standard structure and function for ESI maps. It was important to develop a standard ESI format so those who move from spills on different coasts would have maps with the same look, allowing them to easily extract resources at risk. To develop this format, AOSIM identified appropriate resources for inclusion, symbols to be used on hard-copy maps, and database structures for GIS.

From these discussions, NOAA's ESI contractor, Research Planning, Inc. (RPI), prepared the first set of ESI guidelines in June of 1993 and the Marine Spill Response Corporation started to create digital versions of nearly all of NOAA's existing ESI maps. NOAA's Hazardous Materials Response and Assessment Division still use these digital data today for the few remaining states that have yet to be remapped.

In 1994, NOAA and RPI redrafted the ESI guidelines. Since then, the guidelines have been revised twice, the latest version published in 2002. A fourth revision is expected to be published by 2008, based on discussions between some of the original AOSIM members and representatives from additional states and agencies about the future of ESI. The publication of these guidelines allows states and other agencies to develop coastal sensitivity maps that will meet the specified ESI standards (NOAA-Celebrates, 2007; Petersen et al., 2002).

3.2. ESI Today – Towards a GIS Based Mapping System

The first ESI atlas developed using GIS was produced in 1989. GIS software enabled a more precise presentation of the color-coded, ranked shoreline sensitivity.

Biological resources were mapped using lines giving a general idea of the extent of a species and polygons that depicted the area in which a species could be found. Equally significant, the attributes of each polygon and point were now maintained as part of the GIS data structure.

Though the initial intent for implementing ESI mapping on GIS was to produce a high-quality, less-expensive paper product, it quickly became apparent that the GIS data themselves were in high demand. GIS allows planners and responders to focus on the resources that are relevant at a particular time of year and that occur in a particular area.

Tabular data can be searched to find information about a specific species or a group of species with similar characteristics.

In short, GIS allows the user to play "what if" scenarios and prepare custom maps that are appropriate for the circumstances at a specific time.

3.3. ESI Mapping System

US-NOAA published ESI guidelines in order to form a national (and international) standardization. The most updated guideline reached to the third version. In this chapter, reader could find the detailed information about how an ESI map prepared in a GIS. Environmental Sensitivity Index Guidelines version 3.0 (Petersen et al., 2002), will be the core reference book for the future studies.

ESI is composed of layers filled with sensitivity data in a query-capable GIS environment. Data could be seen and queried anytime; manipulated or grouped according to the months or seasons; or sensitive points could be investigated. Data and a truly structured geo database forms the basis of ESI.

3.3.1. ESI database structure

Geo database has a relational data model which defined as a set of relations conforming to the relational database model. Through this structure related data tables could be cross-queried (Wikipedia, 2007). The relational tables are normalized, eliminating the need to enter the same information multiple times, minimizing the likelihood of errors, and easing updates. The tables are also extensible if attributes specific to a geographic area need to be considered. A diagram of the relational database structure will be given in the following sections.

3.3.2. ESI information layers

ESI maps are composed of three general information groups (themes). These are (1) Shoreline Classification (which covers the shorelines ranked according to a scale relating to sensitivity, natural persistence of oil, and ease of cleanup), (2) Biological Resources (including oil-sensitive flora and fauna living around the coastal zone and the water), and (3) Human-Use Resources (which are specific areas that have added sensitivity and value because of their use, e.g. beaches, parks and marine sanctuaries, water intakes, and archaeological sites, etc.). These three information layer piled in a GIS environment under the relational data tables reside in geo-database. Superposition of the three main layers (in a GIS) exhibits overall sensitivity of the any spot on the map screen. A point could be a bird nesting area, and also close to a harbor and a recreational fishing area. Even if an oil spill incident does not occur, it is barely seen that the bird nests would affect from the constant pollution of harbor area, if it is not controlled. The recognition of the bird nests close to that human-use area, guides us to take precautions for that pollution such as oil spill response facilities or skimmers that clean the area periodically.

Moreover, an ESI map could be enriched with extra information types such as bathymetry or wind direction maps in order to provide more information for decision makers or response planners. For example a layer depicting wind direction information could give a rough idea about how oil would be spilled in an incident scenario.

The ESI layers can be grouped into three general categories: base-map layers, biological layers, and human-use layers (Petersen et al., 2002).

1) The base-map layers do not link to any external data tables; rather all their attributes are self-contained. The primary base-map layers are ESI, HYDRO, and INDEX. Additional base map layers may be added for a particular atlas if the local user community has access to the information or has a particular need for a specialized data layer.

2) The biological data layers are generally titled by the actual biological element which is the ESI equivalent of a biological category. Most are mapped with polygons showing the expected geographic extent of an assemblage of species with particular seasonal characteristics and other unique attributes. A typical ESI geodatabase will include the polygonal layers BIRDS, FISH, HABITATS, INVERT (invertebrates, including shellfish and, occasionally, endangered insects), REPTILES (reptiles and amphibians), T_MAMMAL and M_MAMMAL (terrestrial and marine mammals, respectively). Most atlases also include a biological layer, NESTS, where point objects are used to indicate the general vicinity of bird-nesting areas. Since most of the biological layer data covers an area and depicted as polygons in case the need for mapping a point or line data, the layer name indicates the element and data type. For example, FISHPT would be fish locations mapped as points and BIRDL would be bird migration routes mapped as lines.

3) Human-Use Layers residing in the ESI atlases include several human-use features. In the SOCECON layer there are point representations of socioeconomic resources, such as airport, coast guard facility, aquacultures, marinas, boat ramps, and water intakes. In the management (named as MGT in geo-database) layer there are polygonal boundaries for such things as wildlife refuges, marine sanctuaries, and regional and national parks. These points and polygons are linked to the SOC_DAT table in much the same way as the biological layers are linked to the BIORES table.

After this general classification of all data, their collection methodology, and their input into GIS environment will be mentioned.

3.4. Shoreline Classification

Shoreline classification layer is the one that give direct information about how shoreline will be affected if oil reaches to it. Since shoreline habitats are at risk during spills because of the high likelihood of being directly oiled when floating slicks impact the shoreline, information of shoreline type is important. Oil fate and effects vary significantly by shoreline type, and many cleanup methods are shoreline-specific. The complete list of standard ESI shoreline rankings is composed of categories for four environmental settings: estuarine, lacustrine, riverine, and palustrine (Table 3.1). To facilitate data use and exchange, these shoreline types and ranks should be used on all sensitivity mapping projects.

It should be noted that shoreline classification scheme given here is prepared for US coasts. It is a necessity that a shoreline classification assessment in terms of oil spill vulnerability prepared for Turkey.

Table 3.1: ESI Shoreline Classes (Petersen et al., 2002)

ESI TYPE	ESTUARINE	LACUSTRINE	RIVERINE
1A	Exposed rocky shores	Exposed rocky shores	Exposed rocky banks
1B	Exposed, solid man-made structures	Exposed, solid man-made structures	Exposed, solid man-made structures
1C	Exposed rocky cliffs with boulder talus base	Exposed rocky cliffs with boulder talus base	Exposed rocky cliffs with boulder talus base
2A	Exposed wave-cut platforms in bedrock, mud, or clay	Shelving bedrock shores	Rocky shoals; bedrock ledges
2B	Exposed scarps and steep slopes in clay		
3A	Fine- to medium-grained sand beaches		
3B	Scarps and steep slopes in sand	Eroding scarps in unconsolidated sediments	Exposed, eroding banks in unconsolidated sediments
3C	Tundra cliffs		
4	Coarse-grained sand beaches	Sand beaches	Sandy bars and gently sloping banks
5	Mixed sand and gravel beaches	Mixed sand and gravel beaches	Mixed sand and gravel bars and gently sloping banks
6A	Gravel beaches Gravel Beaches (granules and pebbles)*	Gravel beaches	Gravel bars and gently sloping banks
6B	Riprap Gravel Beaches (cobbles and boulders)*	Riprap	Riprap
6C*	Riprap		
7	Exposed tidal flats	Exposed tidal flats	
8A	Sheltered scarps in bedrock, mud, or clay Sheltered rocky shores (impermeable)*	Sheltered scarps in bedrock, mud, or clay	
8B	Sheltered, solid man-made structures Sheltered rocky shores (permeable)*	Sheltered, solid man-made structures	Sheltered, solid man-made structures
8C	Sheltered riprap	Sheltered riprap	Sheltered riprap
8D	Sheltered rocky rubble shores		
8E	Peat shorelines		
8F			Vegetated, steeply-sloping bluffs
9A	Sheltered tidal flats	Sheltered sand/mud flats	
9B	Vegetated low banks	Vegetated low banks	Vegetated low banks
9C	Hyper saline tidal flats		

Table 3.1: ESI Shoreline Classes (continued)

ESI TYPE	**ESTUARINE**	**LACUSTRINE**	**RIVERINE**
10A	Salt- and brackish-water marshes		
10B	Freshwater marshes	Freshwater marshes	Freshwater marshes
10C	Swamps	Swamps	Swamps
10D	Scrub-shrub wetlands; Mangroves	Scrub-shrub wetlands	Scrub-shrub wetlands
10E	Inundated low-lying tundra		

3.4.1. Basis of the Classification Scheme

The classification scheme is based on an understanding of the physical and biological character of the shoreline environment, The concepts relating natural factors to the relative sensitivity of coastline, mostly developed in the estuarine setting, were slightly modified for lakes and rivers. The sensitivity ranking is controlled by the following factors:

- Relative exposure to wave and tidal energy
- Shoreline slope
- Substrate type (grain size, mobility, penetration and/or burial, and traffic ability)
- Biological productivity and sensitivity

Within a mapping region, the degree of energy (total of wave and tidal energy) present on one shoreline segment is assessed relative to the overall energy levels in the region. Table 3.2 shows that shoreline characteristics in terms of energy they are exposed to and Table 3.3 indicates the relation of wave and tidal energy exposure of shoreline.

Table 3.2: Shoreline characteristics in terms of energy they exposed

	Shorelines Exposed to High Energy		Shorelines Exposed to High Energy					Shorelines Exposed to High Energy		
ESI NO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	High-energy shorelines (1A-2B) are regularly exposed to large waves or strong tidal currents during all seasons. They most commonly occur along the outermost coastline of a region or where dominant winds cause waves to strike the shoreline directly or by wave refraction.		Medium-energy shorelines (3A-7) often have seasonal patterns in storm frequency and wave size.					Low-energy shorelines (8A-10E) are sheltered from wave and tidal energy, except during unusual or infrequent events.		

Table 3.3: Relations of wave & tidal energy exposure of shoreline

Increase in	**Increase in**
Wave Height	Wave reflection
	Coastal oil wash off
	Removal of stranded oil
	Habitat adapted to strong tidal currents
Increase in	**Increase in**
ESI Number	Oil vulnerability & sensitivity of shoreline
	Decrease in
	Wave energy
	Wave reflection

Shoreline slope is shows the steepness of the intertidal zone between maximum high and low tides. The intertidal zone is defined as the area between low and high tide marks. Alternately, it is the area of the foreshore and seabed that is exposed to the air at low tide and submerged at high tide (Wikipedia, 2007). And the shoreline is defined as the first 100 m horizontally from the shore to landward in the Turkish legislation (Turkish Law on Coasts, 1990). Table 3.4 shows the effect of shoreline slope.

Table 3.4: Relations of shoreline slope

Increase in	**Decrease in**
Shoreline Slope	Intertidal Zone
	Horizontal wave dissipation
	Oil interaction
	Increase in
	Wave reflection
	Wave breaking

Table 3.5 refers to subtrate relationship of the shore. Substrate types are classified as bedrocks (impermeable and permeable), sediments (mud, pebble, cobbles… etc.),

man – made materials (such as ripraps or seawalls). The most important substrate distinction is between bedrock and unconsolidated sediments. In unconsolidated sediments, there is the potential for penetration and/or burial of the oil by increasing the persistence of oil, leading to potential long-term biological impacts, and making cleanup much more difficult and intrusive.

Table 3.5: Relations of substrate type in a shoreline

Increase in	**Increase in**
Substrate consolidation	Uniform grain distribution
	Decrease in
	Oil penetration into the soil
	Oil burrowing into the soil
	Clean-up efforts (easy clean-up)
	Clean-up cost

The biological productivity of shoreline habitat is an integral component of the ESI ranking. Vegetated habitats, such as marshes and mangroves, have the highest ranking because of the potential for long-term impacts resulting from both exposure to oil and potential damages associated with cleanup activities in these kinds of habitats. Recovery of the ecological services can take decades in these most productive habitats. The ESI ranking reflects the general sensitivity of shoreline habitats.

Table 3.6: Relations of substrate type in a shoreline

Increase in	**Increase in**
Substrate consolidation	Uniform grain distribution
	Decrease in
	Oil penetration into the soil
	Oil burrowing into the soil
	Clean-up efforts (easy clean-up)
	Clean-up cost

Table 3.7: Relations of biological productivity

Increase in	**Increase in**
Bioproductivity	Habitat Sensitivity
	Clean-up efforts (careful clean-up)
	Clean-up cost

All of these factors and first-hand observations from spills were taken into consideration when developing the relative ESI rankings for shoreline types.

ESI shoreline rankings were given in Table 3.1 and a detailed discussion of the ranking system could be found in Annex B.

3.4.2. Shoreline Classification Methodology

ESI scale indicates the susceptibility of a shoreline against oil spills. General considerations of this classification also mentioned.

One and only drawback of using this classification for Turkish shores is the built up based on spill experiences occurred in US coasts. As a consequence, it reveals this experience and fieldwork for each of habitat type take place in the classification. This phenomenon brings about a dilemma for the coastal zones of other regions which does not show the similar characteristics.

Typically, a state's coastline can be field-classified within weeks, weather and tides permitting. The practical application of the ESI scale relies primarily on recognizing shoreline habitats using maps, literature, remote imagery, low-altitude aerial surveys, and ground observations. On the other hand, ESI shoreline classification involves several data sources and a multi-step workflow. The process involved in a typical ESI survey, as described below, is outlined in Figure 3.1.

3.4.2.1. Data Acquisition

In the beginning of shoreline classification stage, the following basic data set must be obtained and processed:

- Base maps
- Shoreline
- Wetland boundaries
- Aerial photos
- Previous shoreline studies

Once the field component of the project is complete, the maps are scanned and the digital shoreline arcs are updated with the ESI attributes noted in the field. The shape and position of the digital shoreline is also changed at this time to reflect field observations. After the information from the field maps has been incorporated into the digital database, the now-ESI color-coded shoreline is re-plotted at the same scale as the original base maps. The classified shoreline plots are then compared by the geologist to the original field-annotated base maps and any errors in shoreline attributes as recorded in the GIS database are corrected. After these revisions and the performance of GIS QA/QC procedures, the ESI shoreline classification is complete.

Base maps. The base maps used for each project are generally the most current topographic maps available. These maps are used during the field surveys and also serve as a background for the final ESI maps. For projects that will be conducted on the Turkish coasts, 1:25000 scaled maps can be used. US institutions use 1:24000 scaled maps (these maps called as "7.5-minute quadrangle maps") but in some regions, such as Alaska, the most detailed maps available are at a scale of 1:63,360 and these are used as the base maps. International atlases used U.S. Defense Mapping Agency and foreign government agency maps that are published at a scale of 1:50,000. According to the most available source, base map choose as either scanned hard-copy map or digital raster graphic (DRG) image (such as digital orthophotography or satellite imageries). After map obtained, it should be modified in the appropriate scale and used.

Shoreline. Since shoreline will be used as a boundary for some features used in the ESI map, it is considered as a key data layer. Shorelines are digitized in-house or are provided by regional or local agencies. Regardless of the shoreline source, any changes in shoreline position (i.e., new man-made features, inlets, etc.) noted during overflights (or land observations) are incorporated into the final shoreline coverage.

Wetland Boundaries. If there are existing wetlands in the region, these features mapped as polygonal features. Commonly, Ministry of Environment and Forestry data are used for domestic projects, but local institutional agencies or nongovernmental organizations have also contributed data for wetland boundary data. In some cases, the only available source for the areal extent of wetlands is their delineation as shown on the topographic base map. When this occurs, the boundaries are verified or modified during the project overflights and used in the final ESI data and atlas.

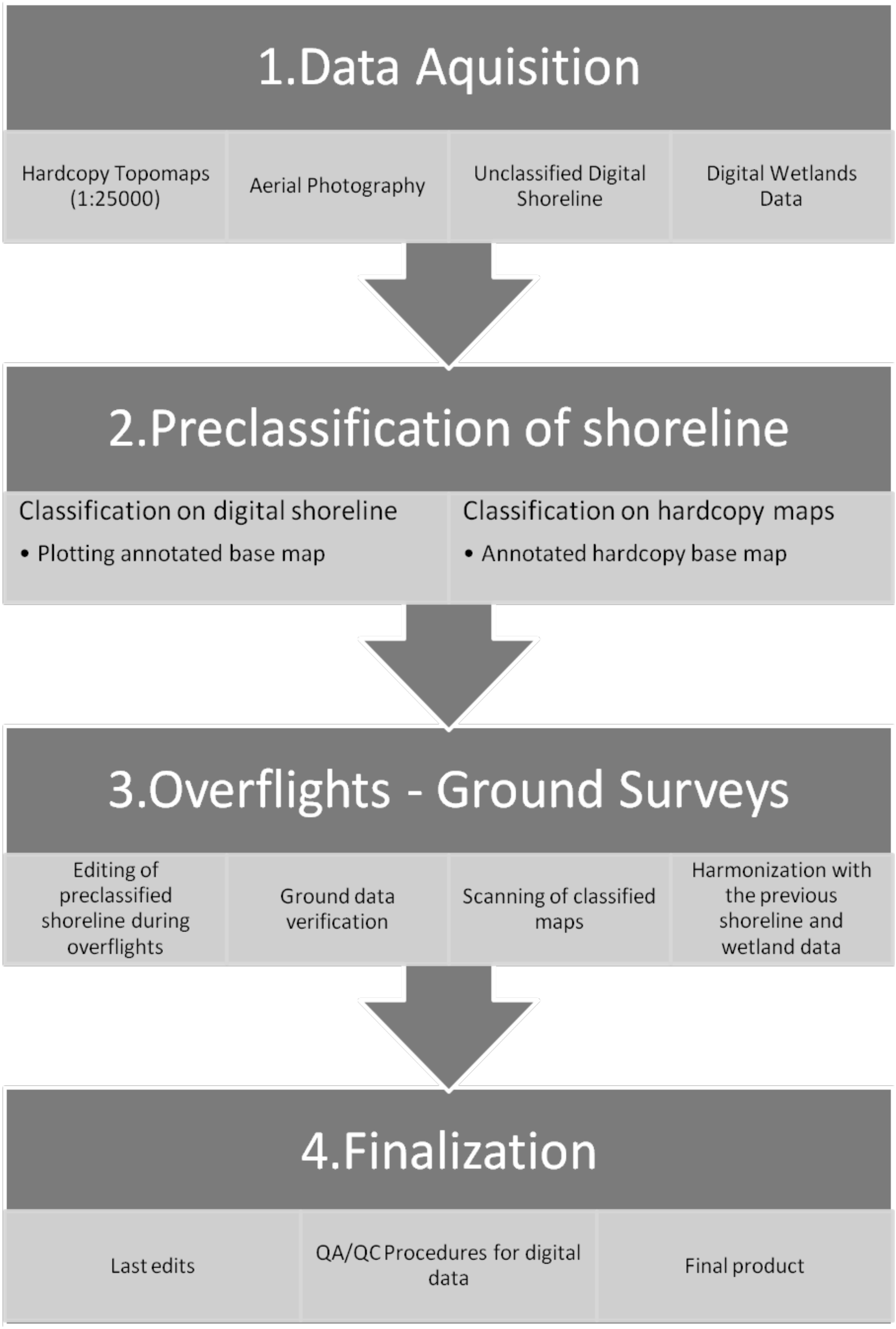


Figure 3.1: Shoreline Classification Flowchart

Aerial Photos. Though the scope and budget of this thesis couldn't afford plane overflights, it is a method for obtaining coastal information. In case aerial photos could be taken for the region or there are available data (from local, regional or national institutions), color, color infrared, and black and white (B/W) photography all provide an overview generating a preliminary ESI classification. DOQQs (digital orthophoto quarter quads) are of particular value since they can be easily geographically registered to match the shoreline to be used in the project and digitally magnified to permit preliminary ESI classification.

Previous Shoreline Studies To become familiar with the field area, the geologist reviews literature (including ESI atlases) pertaining to the mapping area.

3.4.2.2. Preliminary Classification

All data acquired is reviewed for preliminary classification by the geologist. Aerial photography and existing shoreline data generates an initial idea about the region by partially exposing the coastal morphology. If the digital shoreline is available at the time of the preliminary classification, the geologist may update shoreline arcs with the appropriate ESI values and replot them atop the scanned base map for use in the field. If the digital shoreline is not ready to be attributed, the hard-copy base maps are hand-annotated. Once areas with available aerial photos have been preclassified the actual field surveys take place.

3.4.2.3. Field Survey (Overflights – Ground Surveys) Methodology

In an ESI shoreline classification study, fieldwork stage consists of two parts: 1) aerial surveys and 2) ground verification. This stage both provides major data for shoreline classification and helps on the verification and updating of the previous data. Aerial surveys are conducted using fixed, high-wing aircraft and/or helicopters. Because the intertidal zone is being mapped, it is critical that the survey takes place within 2.5 hours of low tide so that the maximum area of intertidal substrate is exposed. Surveys are coordinated with spring low tides when possible and flight plans are always scheduled to maximize time on-site during low tide. During the overflight, altitudes between 90 – 180 m and speeds from 80 to 90 knots should be maintained. The geologist annotates the shoreline with ESI rankings as it appears on the base map, carefully noting transitions in habitats. Shorelines with more than one ESI type in the intertidal zone are annotated on the map in order from landward to seaward ESI classifications (e.g., a seawall fronted by a fine-grained sand beach is noted as 1B/3A and shown with multi-lines on GIS). Because of GIS limitations, a maximum of three ESI classes may be assigned to one segment of coastline. In addition to classifying the shoreline, the observer takes low-altitude, oblique photographs representing each ESI habitat. Field observation provides the most reliable information.

Wetland classification and map detail depends on the complexity of the map region and the availability of polygonal data. When available, polygonal data are incorporated into the final ESI map. It is often not possible to clearly identify freshwater vs. salt- and brackish water marsh from the air. Typically, the only field modification of the wetland data provided is to cross out or sketch tracts of wetlands that no longer exist or have been modified by coastal engineering. In the cases when no digital wetland data exist, the areal extent of wetlands is generally not defined and only their presence and classification along the outer-shoreline is shown. In areas where extensive tracts of wetlands in the coastal zone have no polygonal data, the geologist may verify boundaries during overflights, from existing topographic maps, and by analyzing aerial photographs. Human-use features, such as marinas, boat ramps, and aquaculture sites, are also mapped during the aerial photograph analysis and overflights.

Ground verification takes place daily, depending on the timing of the overflights. Ideally, an example of each habitat should be visited and photographed on the ground. At a minimum, ground verification concentrates on confirming grain-size classifications for sedimentary substrates, since this can be difficult to recognize from the air. If a portion of the coast is identified during the overflights as problematic or difficult to classify, that segment or one like it is ground-checked and the maps are updated according to the ground observations. In regions with complex wetland habitats, field verification is essential for classifications made from the air.

3.4.2.4. Last Edits and Finalization

Once the field component of the project is complete, the maps are scanned and the digital shoreline arcs are updated with the ESI attributes noted in the field. The shape and position of the digital shoreline is also changed at this time to reflect field observations. After the information from the field maps has been incorporated into the digital database, the now-ESI color-coded shoreline is replotted at the same scale as the original base maps. The classified shoreline plots are then compared by the geologist to the original field-annotated base maps and any errors in shoreline attributes as recorded in the GIS database are corrected. After these revisions and the performance of GIS QA/QC procedures, the ESI shoreline classification is complete.

3.5. Biological Resources Data

The biological data is as important as shoreline classes when vulnerability of an ecosystem against oil considered. It is obvious that one data represents the resilience of ecosystem after an oil spill incident while the other represents the resilience of the environment that habitat live in. As far as habitat sensitivity is concerned, both data layer overlapped since they show the total sensitivity.

In biological resources classification animals, plants, and habitats potentially at risk from oil spills are segmented into seven elements based on major taxonomic and functional groupings. Each element is further divided into groups of species or sub-elements with similar taxonomy, morphology, life history, and/or behavior relative to oil spill vulnerability and sensitivity. For example, there are ten sub-elements for birds, including alcids, diving birds, gulls and terns, land fowl, passerine birds, pelagic birds, raptors, shorebirds, wading birds, and waterfowl.

Marine, coastal, and aquatic/wetland species may be present over a very large geographic area. Maps or data indicating the entire distribution of a large number of species potentially located in an area may not be very helpful to responders setting protection priorities. Therefore, it is important to identify the types of species that tend to be vulnerable to spilled oil, the most sensitive life-stages, and in which habitats these life stages occur, as habitat type plays an important role in the persistence of oil and species exposure to oil. Biological resources should be regarded as vulnerable to oil spills when:

- Large numbers of individuals are concentrated in a relatively small area;
- Marine or aquatic species come ashore during special life stages or activities, such as nesting, birthing, resting, or molting;

- Early life stages or important reproductive activities occur in sheltered, nearshore environments where oil tends to accumulate;
- Limited suitable habitat exists within an area for specific life stages or along critical migratory routes;
- Specific areas are known to be vital sources for seed or propagation;
- A species is threatened, endangered, or rare; or
- A significant percentage of the population is likely to be exposed to oil.

Since ecosystem is an entity constantly in a changing situation, biological resources data should be the most updated data. A monitoring system for the mapping region is also advised for being aware of any changes occurring in the ecosystem even if sensitivity map of the region is prepared. As it is clearly seen, ecosystem diversity and abundance of the species changes in monthly or seasonal basis. This also affects the sensitivity of species according to the occurrence time of the oil spill incident. Unfortunately, a static paper (or hard-copy) map shows general habitat information for all year-time or for a specific season. On the other hand, dynamic structure of a GIS gives us the chance of obtaining data for a specific time-span of the year, in case that information is given to the system. In brief, biological data layer should be kept up-to-date and ecosystem of the region should be monitored constantly. This approach help on preparing the most effective and accurate oil spill response plans.

3.5.1. Biological Resources Shown on ESI Maps

Biological resources (flora / fauna and its habitat) shown on ESI maps are listed in Table 3.8. This chapter describes the methodology for compiling biological resources onto maps and data tables for data entry. These guidelines are for biologists or resources managers who compile and edit ESI data.

The first step in the data compilation phase involves making contacts by phone and email with scientists and resource managers who can provide expert knowledge and suggest relevant source materials for biological resources data in the study area. Also regional conservation related NGO's could provide needed data, partially or entirely. Key point here is the confirmed and accurate representation of biological diversity and abundance of species regarding their important life stages such as nesting or laying for birds; or spawning or migration for fishes. Just like previous section, in the classification of coastal ecosystems, species encountered in the coastal habitats of United States is evaluated. Though some species doesn't live in Turkish coastal (or terrestrial) environments, whole classification will take place in these pages.

Six major life forms are classified by NOAA's experts: Marine and terrestrial mammals, birds, fishes, invertebrates, reptiles and amphibians. Classification is slightly different from common biological taxonomy.

Table 3.8: Biological resources shown on ESI maps (Petersen et al., 2002)

Category	Sub-Category	Locations Shown on Maps
Marine Mammal	Dolphin	Concentration areas
	Manatee	Concentration areas, cold weather refugia
	Pinniped	Haulouts, concentration areas
	Polar Bear	Concentration areas
	Sea Otter	Concentration areas
	Whale	Migratory or other concentration areas
Terrestrial Mammal	Bear	Intertidal feeding or aquatic/wetland concentration areas, areas hazardous to spill responders
	Canine	Locations of threatened, endangered, or rare species
	Deer	Intertidal feeding or aquatic/wetland concentration areas
	Feline	Locations of threatened, endangered, or rare species
	Pig	Areas hazardous to spill responders
	Small Mammal	Aquatic fur-bearer concentration areas, locations of threatened, endangered, or rare species
Bird	Alcid	Rookeries; winter concentration areas
	Diving Bird	Rookeries; forage/wintering areas; roosting concentration areas
	Gull/Tern	Nesting sites; other concentration areas
	Passerine	Locations of threatened, endangered, or rare species, especially nesting areas
	Pelagic	Rookeries, roosting, and other concentration areas
	Raptor	Nesting sites; migratory/feeding concentration areas
	Shorebird	Nesting sites; migratory, wintering, and roosting concentration areas
	Wading Bird	Rookeries; feeding and roosting concentration areas
	Waterfowl	Wintering and migration concentration areas, nesting sites
Reptile/Amphibian	Alligator/Crocodile	Concentration areas, especially nesting locations
	Other Reptiles/ Amphibians	Locations of threatened, endangered, or rare species, especially aquatic/wetland concentration areas
	Turtle	Nesting beaches; concentration areas

Table 3.8: Biological resources shown on ESI maps (continued)

Category	Sub-Category	Locations Shown on Maps
Fish	Diadromous	Spawning and nursery areas; locations of threatened, endangered, or rare species
	Estuarine Nursery Fish	Spawning, nursery, and other concentration areas
	Estuarine Resident Fish	Spawning or other concentration areas; locations of threatened, endangered, or rare species
	Freshwater Fish	Spawning and nursery areas; locations of threatened, endangered, or rare species
	Marine Benthic Fish	Spawning and nursery areas; reefs, kelp beds, or other concentration areas
	Marine Pelagic Fish	Spawning or other concentration areas
Shellfish/Insect	Bivalve	Harvest areas; abundant beds; locations of threatened, endangered, or rare species
	Cephalopod	Harvest areas; areas of high concentrations
	Crab	Nursery areas; areas of high concentrations
	Echinoderm	Harvest areas
	Gastropod	Harvest areas; high concentrations, locations of threatened, endangered, or rare species
	Lobster/Crayfish	Nursery, spawning, and harvest areas; locations of threatened, endangered, or rare species
	Shrimp	Nursery areas; locations of high concentrations
	Insect	Locations of threatened, endangered, or rare species
Habitat/Rare Plant	Coral Reef	
	Floating Aquatic Vegetation	Areas of floating aquatic vegetation
	Hardbottom Reef	
	Kelp Bed	
	Rare Plant	Locations of threatened, endangered, or rare species or communities
	Submerged Aquatic Vegetation	Areas of submerged aquatic vegetation; seagrass beds
	Worm Bed	

Marine mammals cover (1) dolphins and whales, (2) manatees, (3) pinnipeds (seals, sea lions and walruses), (4) polar bears, and (5) sea otters. These sub-elements and their descriptions are given in Table 3.9 in detail.

Terrestrial mammal dataset shows intensive life areas of organisms which could be classified as (1) small, semi-aquatic furbearing, (2) bears, and (3) other mammals. Table 3.10 shows the information relating terrestrial mammals. Terrestrial and marine mammals groups both represented as brown features (points, lines or polygons) on ESI maps.

Table 3.9: Marine Mammals dataset (Petersen et al., 2002)

SUB-ELEMENT	DESCRIPTION
Dolphins and whales	Restricted to water. There are no restrictions to offshore or inshore extent.
Manatees	Restricted to water. Manatees are generally shown in estuarine waters and often associated with cold-weather refuge areas such as springs, river mouths, power plant cooling water outfalls, etc. They may also concentrate in inlet mouths.
Pinnipeds (seals and sea Lions, Walruses)	Can be displayed on water and land. On land, pinniped haulout and pupping sites may be shown as points or polygons occurring on beaches, rocky headlands, and across small islands.
Polar bears	Can be displayed on land or water as polygons, or as points to identify denning sites. They are often associated with pack ice, but do not range far inland. They are described as marine mammals because they are classified as such in the Marine Mammal Protection Act.
Sea otters	Occur in nearshore waters. They may also be associated with kelp beds and invertebrate concentration areas.

Table 3.10: Terrestrial Mammals dataset (Petersen et al., 2002)

SUB-ELEMENT	DESCRIPTION
Small, semi-aquatic furbearing	Typically shown throughout salt, brackish, and freshwater wetlands, and occasionally in other shoreline habitats.
Bears	In Alaska, they are shown along streams with salmon runs, or where they present a hazard to spill responders. Threatened and endangered species and other special aquatic or wetland concentrations may also be shown.
Other mammals	Mostly threatened, endangered, or other important species are mapped case-by-case.

Bird layer covers bird types such as (1) alcids, (2) diving birds, (3) gulls and terns, (4) passerine birds, (5) pelagic birds, (6) raptors, (7) shorebirds, (8) wading birds, and (9) waterfowls. Occurrences of these birds groups are listed in Table 3.11 below and shown as green features on map.

Unlike other habitats, fish data layer do not have sub-elements. They are always restricted to water. General distributions are usually defined by bathymetric contours, distance from the shoreline, habitat type (such as reefs), or salinity zone. Anadromous fish are usually mapped as polygons and arcs in streams and rivers, but occasionally a point representing the stream mouth is used instead. Some important concentration areas and spawning areas are also mapped in addition to more general distributions. Occasionally rare species occurrences are mapped as points or polygons and represented with blue color.

Table 3.11: Bird dataset (Petersen et al., 2002)

SUB-ELEMENT	DESCRIPTION
Alcids	Occur in offshore waters and on islands or cliffs where they nest.
Diving birds	Typically shown in nearshore areas along shorelines, and on tidal flats, islands, and in sheltered bays, estuaries, lagoons, etc.
Gulls and terns	Usually shown as buffers along shorelines, and on tidal flats, islands, and in sheltered bays, estuaries, lagoons, etc.
Landfowl	Occur in terrestrial areas, sometimes in and around wetland areas.
Passerine birds	Endangered, threatened, or rare passerines that rely on coastal or wetland habitats are included when appropriate, especially if nesting occurs in the
Pelagic birds	Occur in offshore waters and on islands or cliffs where they nest.
Raptors	Occur along rivers, coastal shorelines, in wetlands, and in sheltered waters.
Shorebirds	Typically mapped using a 75-100m buffer (onshore and offshore) along sand and gravel beaches. They are also mapped on tidal flats and in wetland habitats.
Wading birds	Usually restricted to wetlands, tidal flats, tidal creeks, and the margins of sheltered waters (bays, estuaries, lagoons, sloughs)..
Waterfowl	Waterfowl (ducks and geese) are usually mapped in nearshore areas, such as bays, estuaries, and lagoons, and are also commonly shown extending through salt, brackish, and fresh wetlands, and into rivers. Some species groups, such as sea ducks, may be mapped further offshore

Reptiles and amphibians group covers (1) turtles, (2) alligators and crocodiles, and (3) lizards, snakes, amphibians and other reptiles and listed in the Table 3.12 below and shown with red color on ESI maps.

Table 3.12: Reptiles and amphibians dataset (Petersen et al., 2002)

SUB-ELEMENT	DESCRIPTION
Turtles	May include sea turtles and diamondback terrapins. Sea turtle nesting and haul-out areas are usually mapped as points or as 75-100m onshore/offshore buffers along sand beaches. Important marine foraging and nursery concentration areas may also be shown. Diamondback terrapins are usually mapped as polygons in wetlands.
Alligators and Crocodiles	Often restricted to sheltered waters (estuaries, bays, etc.), streams, wetlands, and nesting along sand or vegetated shorelines.
Lizards, snakes, amphibians and other reptiles	In some cases other threatened, endangered, or rare species may be included, such as salt marsh snakes.

Under invertebrates data layer (1) abalones, (2) cephalopods, (3) clams, (4) crabs, (5) echinoderms, (6) gastropods, (7) lobsters, (8) mussels, (9) oysters, (10) scallops,

(11) shrimps, and (12) insects and their description is given in Table 3.13 below. Invertebrates layer use orange color as their standard symbolization.

Table 3.13: Invertebrates dataset (Petersen et al., 2002)

SUB-ELEMENT	DESCRIPTION
Abalones, cephalopods, clams, crabs, echinoderms, gastropods, lobsters, mussels, oysters, scallops, and shrimp	Almost always restricted to water and tidal flats. General distributions are usually defined by bathymetric contours or distance from the shore. There may also be special concentration areas defined by habitat type or fishing concentrations.
Insects	Typically only depicted if they are threatened, endangered, or rare and associated with coastal, wetland, or aquatic habitats.

Habitats and rare plants layer consist of (1) algae, (2) coral beds, (3) floating aquatic vegetation, (4) hardbottom reefs, (5) kelp beds, (6) submersed aquatic vegetation, and (7) terrestrial rare plants data sets. Mapped habitats are tabulated in Table 3.14 and these data sets are shown with purple features in GIS.

The types of species that are typically mapped are those that are vulnerable and sensitive to oil spills and disturbance-related response activities; species that are threatened, endangered, or rare; and species that are of commercial/recreational importance. In general, coastal, marine, aquatic, wetland, and riparian species and habitats are emphasized. In some cases, the sensitivity of a habitat type may be low, but the sensitivity of species that use or rely on the habitat may be high.

Table 3.14: Habitats and plants dataset (Petersen et al., 2002)

SUB-ELEMENT	DESCRIPTION
Algae	Algal beds, important species
Coral Reefs	Living, reef-building coral areas; rare species
FAV	Floating aquatic vegetation
Hardbottom Reefs	Other hard substrates that provide structural habitats or cover
Kelp	Beds or forests of kelp
SAV	Submersed aquatic vegetation
Upland Plants	Special/rare upland (terrestrial) plants, habitats, or communities

Depicted biological resources does not only represented with their geographical (or spatial) information but also their attributes used for further information. This is actually realized by the use of GIS. Attribute data used for the mapped habitat includes: species names (common and scientific); the legal status of each species (threatened, endangered, and special concern listings); concentration/abundance; seasonal presence by month; and special life-history time-periods (e.g. spawning, nesting). In addition to legal status, the global conservation status ranks for certain species, as defined by The Nature Conservancy and the Natural Heritage Programs, could be included in atlases, as it is applied in USA since 1997.

The concentration of a species in a given location may include qualitatively or quantitatively defined descriptions of species such as their abundance (e.g., high, medium, or low); the number of individuals, nesting or breeding pairs; or nests which occur at a site or within a polygon. The data collection tables, atlas introductory pages, and metadata identify the types of numbers included in the concentration field. When concentration is not known, the concentration field could be left blank.

The monthly seasonality data (inputted in data tables) contain "X" signs or abundance values in months when the species are present in the site or polygon location. The "X"s indicate presence, while the numbers correspond to abundance categories. Monthly abundance is only used for fish and invertebrates data, and this information could be provided by related academic institutions, local or regional non-governmental organizations and state (or governmental) agencies. For denoting numbers of species numbering method could be used in the way each number represents the abundance of species such as 1 = no information; 2 = rare; 3 = common; 4 = abundant; and 5 = highly abundant. When indicating the salinity information of fisheries (as this parameter could change according to the season), use of a notation based on letters could be proposed as in H = high (which stands for high salinity low rainfall, stream flow, or runoff), T = transitional, and L = low (for low-salinity) time-periods.

Associated with each species location and monthly presence are the time-periods when various life-history stages or activities occur. The life-history time periods are different for each biological element. The life-history time periods listed are those that have resulted in the concentration of the species at the particular location (e.g., a nesting colony, spawning site, or nursery area has been mapped) and often are related to sensitive time-periods associated with reproductive activities or early life-history stages.

Finally, the databases include source documentation at the feature/species level. For every species associated with each feature (a site or location indicated by a point, line, polygon, etc.) there can be a unique source or sources. Two source fields are used for biological resources, a geographic and a seasonality source. Typically, one source will provide the geographic location, species name or list, concentration, and type of resource occurrence (nesting site, migratory stop-over), while another source will be used to determine seasonality and life-history information. The same source may provide all of the information and would be listed as both the geographic and seasonality source.

3.5.2. Biological Resources Data Collection

As mentioned before, sensitive species living in the surrounding habitat will be used for biological resources layer. This information is collected through a comprehensive literature survey in the management of a biologist group. Collected information, when added to the latest surveys is used for filling data tables in order to generate the related tables of the ESI spatial geo database. An example form is given in the Table 3.14 with the descriptions of the columns of form. This form also related with the one given in Table 3.15 and Table 3.17. Thus, these three forms should be considered together. Column descriptions of the data tables are given below them. To avoid space losses, only a few rows of the data tables are given. These table structures are proposed for use during biological data collection studies by printing or filling them by spreadsheet software.

Table 3.15: Biological Resources form example (Petersen et al., 2002)

1. Site (map# –	2. Species name	3. Conc. (high/medium/low or #)	4. Season	5. Geog. source	6. Seas. source

Site (map # - polygon #) is the unique id for the indication of biological resource location. It identifies each polygon by map number and polygon number. The map number is entered in the bottom right corner of the map. Multiple polygons with the same combination of species, concentration, seasonality, and source can be assigned the same wildhab# (wild habitat number).

Common name of the species that is used in public. When a polygon contains an assemblage of species, each species associated with the wildhab# should be listed separately. Species name, in combination with Season ID#, is linked to the Seasonality/Life-history data tables (Table 3.15).

Descriptive concentration of the species (in terms of abundance) or numbers of individuals (if it is known) in the actual polygon. Concentration can be given as "high", "medium", or "low", or as "another appropriate descriptive term", or as "the number of individuals" or "the nests within the polygon". The definition or range of values represented by each descriptive category or numerical value must be described in the introductory pages of the atlas and in the metadata report. If numerical concentrations are used, indicate whether the numbers represent individuals, nests, breeding pairs, etc. If abundance categories are listed by month in the seasonality tables, the concentration field is left blank.

Season ID is the number code (e.g., 1, 2, 3, etc.) that is used to differentiate polygons in which the same species has different seasonal distributions. It represents the seasonal distribution of a species within a polygon or group of polygons. The code number, in combination with species name, is linked to the seasonal information given in the Seasonality/Life-history data tables (Table 3.15). When the same species is present in different seasons, different season ID#s are used. For instance, least terns may be present in several different polygons at two different times of the year. They may be listed for wildhab# 1-05 (and other maps and polygons) as being present in spring only, while least terns listed for wildhab# 1-12 are present year round. In this case, the first listings for least terns would have season ID# "1" and the second listing would have Season ID# "2". Follow this convention for all maps and data tables.

Geographical source ID is simply a number that corresponds to the source which provided the locational and concentration information on a species included in a polygon, line, or point feature.

Seasonality source ID is a number that corresponds to the source that provided the seasonality information on a species included in a polygon, line, or point feature. The seasonality source may be the same as the geographic source. Table 3.16 presents the life history for each species in the biological resources layer.

Table 3.16: Seasonality / Life History data table example (Petersen et al., 2002)

ELEMENT: Bird		3. Seasonal Presence												Life-history Stage and Reproductive Timespans			
1. Season ID	2. Species Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	4. Nesting	5. Laying	6. Hatching	7. Fledging
1	Brown Pelican	X	X	X	X	X	X	X	X	X	X	X	X	–	–	–	–
2	Brown Pelican						X	X	X	X				JUN – SEP	JUN – JUL	JUL – AUG	AUG – SEP

1. Season ID column gives the same information mentioned in the fourth column of the previous table.

2. Common name of the species.

3. Seasonal presence columns consist of the months and could be used in two notations as stated before. Checking off the months indicates the months a species is present. If relative abundance is known for the monthly presence, the following number codes may be used despite of it is optional:

1: No information

2: Rare

3: Common

4: Abundant

5: Highly abundant

Last four columns show the information about life-history stage and reproductive time spans. Sensitive life-history stages and activities differ by elements (such as birds or fish) and these different sensitive life stages are defined below in Table 3.16. Life-history time-periods are listed as a range in months (i.e., APR-JUL). Five fields are available for listing sensitive time periods, and these fields remain consistent by element for all atlases. Reference the atlas-specific metadata for the definition of life activities listed in older atlases.

4. Shows the entire time-span in which eggs/young are present (includes laying, hatching, and fledging)

5. Shows time period when eggs are being laid and incubated

6. Covers the months when young are hatching

7. Shows time period when young are being reared (until they leave the nest)

The Atlas Species List (Table 3.17) is linked to the Biological Resources Table using the SPECIES NAME and ELEMENT fields. The geodatabase developed by US-NOAA for ESI consist of fields such as species common name; scientific name (genus/species), state T/E/C (threatened/endangered/species of special concern) listings, element and sub-element classifications, and Natural Heritage Program (NHP) global conservation status ranking. This list is particularly useful where there are multiple common names used for the same or different species, when species have different state or federal T/E listings in different geographic locations, and when a new species needs to be added to the nationwide species list. This database structure designed in the framework of national environmental applications of USA state institutions. This structure will be modified for Turkish environmental law and applications.

Table 3.17: Life history time periods for each element in biological resources layer (Petersen et al., 2002)

DATA COLUMN	DESCRIPTION
Marine Mammals	The life-history activities for marine mammals are *mating, calving, pupping*, and *molting*. Mating refers to the time periods when adults concentrate to mate. Calving (dolphins, whales, and manatees) and pupping (seals, sea lions, and sea otters) refer to when females are giving birth to young. Molting refers to the time when seals and sea lions haul out to shed fur and skin.
Terrestrial Mammals / Habitats	Life-history categories are not typically listed for terrestrial mammals and habitats/rare plants. In certain instances (e.g., coral spawning and juvenile periods), they could be indicated, but must be defined in the atlas introductory text and metadata report.
Birds	The life-history activities for birds are *nesting, laying, hatching*, and *fledging*. Nesting refers to the entire period when birds are laying eggs, hatching eggs, and fledging young. Laying, hatching, and fledging are subsets of nesting.
Reptiles	The life-history activities for reptiles are nesting, hatching, inter-nesting, and juvenile. Nesting refers to the deposition of eggs by turtles and the time period when turtle eggs are present. Nesting also refers to the laying and tending of eggs and nests by crocodilians. Hatching refers to the time period when young are hatching and emerging from the nests. Inter-nesting is a special category for sea turtles, defined as the period prior to and during nesting when adult males and females concentrate in nearshore waters. Mating often takes place during this time. Juvenile refers to the period when juveniles are present.

Table 3.17: Life history time periods for each element in biological resources layer (continued)

DATA COLUMN	DESCRIPTION
Fish	The life-history activities for fish are spawning, eggs, larvae, juvenile, and adult. Spawning includes the actual spawning act and any spawning-related migration or concentration periods, especially those associated with diadromous or estuarine fishes. Eggs refers to the period when eggs are present. Larvae refers to the period when larval stages are present. Juvenile refers to the time when juveniles are present, and is especially emphasized in nursery areas. Adult indicates the seasons when adult (mature) fish are present.
Invertebrates	The special life-history activities for invertebrates are spawn/mate, eggs, larvae, juveniles, and adults. The descriptions of these activities and life stages are generally the same as for the fish (see above). Mating refers to reproductive activities performed by species with internal fertilization (e.g., blue crab), and can include migratory or other concentrations associated with mating. Spawning typically refers to the release of gametes to the water column, but in species that mate, it can also refer to the mass release of fertilized eggs or larvae to the water column.

Column descriptions for Table 3.18 are given below.

1. **Species ID:** A number code used to identify and track species during GIS data processing. There is an ESI Master Species List that contains number codes for all species that have been included in previous ESI atlases. The person compiling biological data for an ESI map must have the most recent copy of the Master List (Appendix A) to enter the species code. New species can be added to the Master Species List as needed.

Table 3.18: Atlas Species List (Petersen et al., 2002)

1. SPEC. ID	2. SPEC. NAME	3. SCINT. NAME	4. STATE	5. S/F	6. T/E	7. DATE_PUB	8. ELMNT	9. SUBELM	10. NHP
118	Brown Pelican	Pelecanus occidentalis	DE	S	E	51994	BIRDS	DIVING	G4
118	Brown Pelican	Pelecanus occidentalis	NJ	-	-	21994	BIRDS	DIVING	G4

2. Species Name: The common name of the species listed in the biology tables. The common name can vary geographically and a '*new species ID #*' can be added when the common name does not match the existing master species list.

3. Scientific Name: The Latin genus and species name of the species. This field is extremely important when there are several common names used for the same species.

4. State: The two-letter state abbreviation code. For a single-state atlas, enter this code only once for all threatened or endangered species. If an atlas spans more than one state, list each state in which the species is threatened or endangered on a separate line.

5. S/F: Federal and/or State protection status. Indicate both using S/F or just one using either "F" or "S."

6. T/E: Threatened (T)/endangered (E) /species of special concern (C) status. Indicate status in the same order as the jurisdictional designation.

7. Date_Pub: Date of reference used to determine T/E listing or status.

8. Element: Biological element.

9. Subelement: Biological subelement.

10. Natural Heritage Program (NHP): Natural Heritage Program global conservation status rankings (e.g., G1, G2) compiled by The Nature Conservancy and the state Natural Heritage Programs. Contact the appropriate state NHP office for a list of rankings by species. If a species is not tracked by the NHP, place a"–"in this field.

3.5.3. Relations of Data Forms

Relations of three data forms are summarized in Figure 3.2. All forms have related columns that constituting relational geodatabase structure. In biological resources form, species and their concentrations take place. Species name in this table comes from Atlas Species List form which holding detailed information about the species encountered in the region. Species residing in the Seasonality – Life History form is also connected to Atlas Species List data form from Species Name field. Biological Resources Form and Seasonality Life History Form shares Season ID field. Life History Stage field from Seasonality Life History Form shows differentiation according to the element type. For instance subfields under the life history stage column are different for birds and fishes.

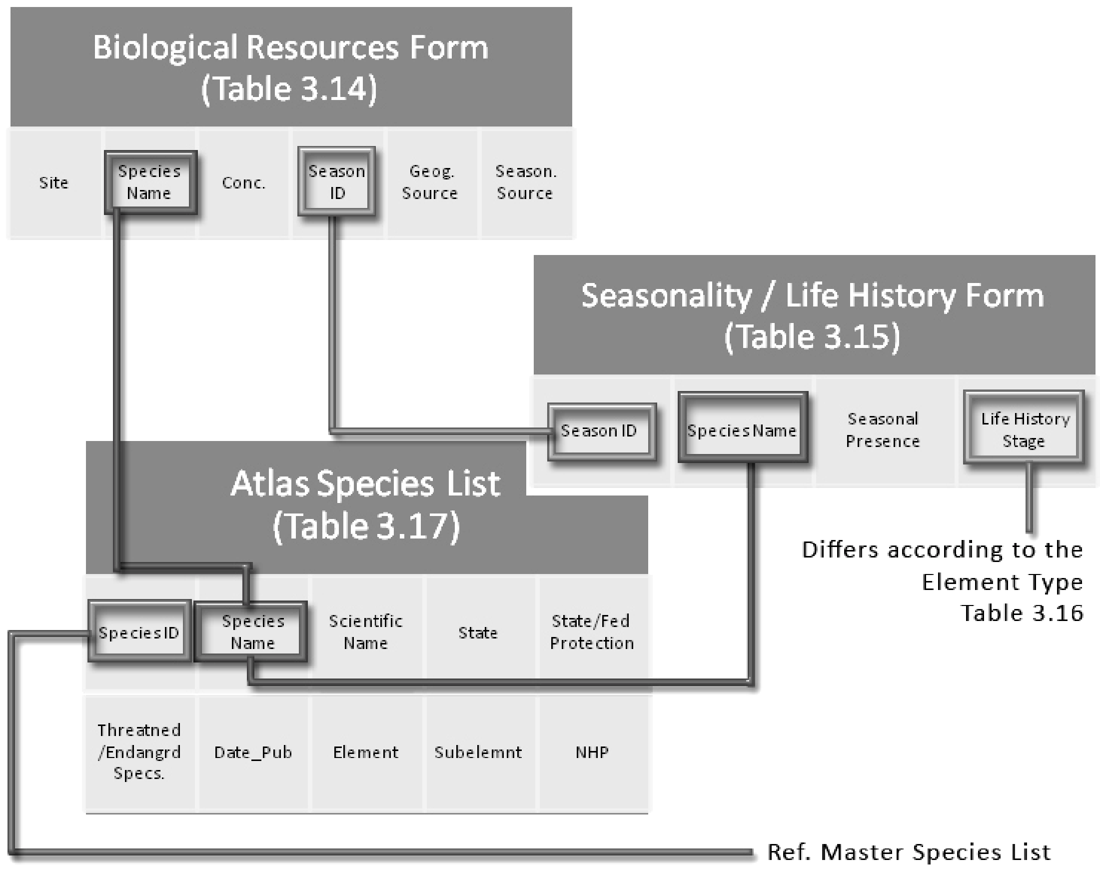


Figure 3.2: Relations between biology layer tables

3.6. Human – Use Resources Data

Human use resources data depicts the areas that is important for human use and could be harmed by any oil spill incident, vessel accident, fires, etc such as historical, substantial r recreational areas. It is also important to map the areas that could be used for oil spill response such as harbors, boat ramps or coast guard facilities. Human-use resources can be divided into four major components (Table 3.19):

- High-use recreational and shoreline access locations;
- Management areas;
- Resource extraction locations; and
- Archaeological and historical cultural resource locations.

Recreational areas shown on sensitivity maps include high-use recreational beaches, sport-fishing, diving sites, surfing areas, and artificial reefs (used for both fishing and diving). Boat ramps and marinas are shown, both as recreational sites and access points for response activities. Airports, ferries, and helipads are shown as access points.

Officially designated management areas include designated critical habitats, national and regional parks, Indian reservations (included for mapping studies in USA), marine sanctuaries, nature conservancy lands, wildlife refuges, and preserves and reserves set aside by various agencies and organizations. Other ecological sites that have special resource management status can be included as Special Management Areas.

Resource extraction locations include aquaculture, commercial and subsistence fisheries, log-storage areas, mining-lease sites, and water intakes. Log-storage sites and intertidal and subtidal mining leases are included so that appropriate protection and cleanup strategies can be developed. Log-storage sites can contain large numbers of valuable wood products that, when oiled, must be cleaned at great expense before sale. Owners of intertidal mining leases must be contacted before removal of oiled sediment. For aquaculture, water intakes, and other economic resources, an owner and emergency contact name and telephone number may be listed. High-value commercial fishing areas are also a critical component to ESI mapping, particularly leased shellfish beds and nearshore, shallow-water fisheries such as crabbing, shrimp harvest, lobster harvest, and estuarine fisheries. Often, the concern is to minimize impacts to the catch and fishing equipment as gear is pulled from the water through surface slicks. Non-commercial seafood harvest areas, including subsistence use areas, identify fishing sites and invertebrate collection areas that are often of great cultural and economic importance to local populations.

Cultural resources include archaeological, historical, and other sites of religious or cultural importance. The most sensitive types of cultural resources are those that are located in the intertidal zone, or sites located very close to the shoreline where they may be directly oiled or disturbed by response or cleanup activities. If there are multiple sites close to one another than the general area is often indicated by one point or a series of points along the shoreline. However, many archaeological, historical, and cultural sites are location-sensitive, so the exact location of the site often cannot be disclosed. In such cases, the resources are often described in general in the introductory pages of the atlas and not shown at all; or a symbol in the general, but not the actual location of the site, is shown on the ESI map instead. It is important to note that users of ESI products must go the original source to obtain location-sensitive data.

Each human-use resource is assigned by a feature type and feature code. Color codes are not used as in biological resources. Human-use features such as recreational areas, access locations, resource extraction sites, and cultural resources as typically drawn as points, while management areas are drawn as polygons. A leader line is attached to each feature and the map and feature number (socval#) are clearly indicated (e.g., 1-H1 would indicate the first human-use resource on map #1). Where a resource, such as an archaeological site or fishing area, appears multiple times on the same map, the same site number can be given to each point symbol. If a resource extends across multiple topographic maps, different socval numbers will be given for the different maps (e.g., 2-H1, 3-H2.). The Human-Use Resources form (Table 3.19) attributes the mapped human-use features. The headings are described below the table.

Table 3.19: Human use Resources data collection form

1. Site No	**2. ResType**	**3. ResName**	**4. Geog Source**	**5. Attribute Source**
05 - H01 A	AS	Bizans Kalıntıları	3	3
05 - H02 A	F	Piri Reis Kültür Limanı	4	4

1. Site No is unique to all location given in the geodatabase. It is composed of a map number and a site number with 'H' letter indicating that it is a human-use resource input.

2. ResType column gives information about the type of point. Types that could be encountered in an ESI map is given in Table 3.20 with their notations.

3. ResName is the common name of the given place. It should be better descriptive.

4. GeogSource column filled with unique ID's identifying the source that provided locational information

5. AttribSource column filled with unique ID's identifying the source that provided attribute information

Table 3.20: Human – use resources and their notations (Petersen et al., 2002)

Data Element	Sub-Element (Notation)	Mapped Areas
Recreation/ Access	Access (A2)	Vehicular access to the shoreline
	Airport (A)	Includes airports, landingstrips, etc.
	Artificial reef (AR)	Attracts high concentrations of fish and divers
	Beach (B)	High-use recreational beaches
	Boat Ramp (BR)	High-use marine/estuarine facilities
	Diving Site (DV)	High-use recreational areas
	Ferry (F)	High-use ferry routes
	Helipad (HP)	Designated helicopter landing sites
	Marina (M)	High-use marine/estuarinefacilities
	Recreational Fishing (RF)	High-use recreational areas
	Surfing (S2)	High-use recreational areas
Management Areas	Designated Critical Habitat (CH)	Officially designated by Fisheries Management Authorities
	Indian Reservation (IR)	Indian Reservations and Tribal Lands
	Marine Sanctuary (MS)	Waters managed by Fisheries Management Authorities
	National Park (NP)	Land managed by National Parks Management Authorities
	Nature Conservancy (NC)	Protected lands
	Park (P)	State and regional parks
	Special Management Areas (MA)	Usually water-associated special management areas
	Wildlife Refuge, Preserve, Reserve (WR)	Federally and state managed reserve areas
Resource Extraction	Aquaculture Site (AQ)	Hatcheries, ponds, pens, etc
	Commercial Fishing (CF)	Important, high-use areas
	Log Storage Sites (LS)	Areas of high economic importance for logging activities
	Mining (M2)	Intertidal/subtidal mining leases
	Subsistence (S)	Designated harvest sites
	Water Intake (WI)	Industrial; drinking water; cooling water
Cultural Resources	Archaeological Site (AS)	Water, coastal, or wetland-associated
	Historical Site (HS)	Water, coastal, or wetland-associated

3.7. Geodatabase

The database structure is shown in Figure 3.3.

Geodatabase is composed of three geographic theme groups for listing sensitive habitats; data tables for storing detailed information about these habitats; and look-up tables for improving the connectivity between database tables.

In Figure 3.3, boxes represent the geographic themes. Each box contains table names and their fields as indented. For instance, ESI (arcs), ESI (polys), HYDRO (arcs), HYDRO (polys), INDEX (polys) are all data tables constituting BASE MAP layer theme. ESI (arcs) table comprised of ESI, LINE, SOURCE and ENVIR fields (or columns). Arrows between tables shows the relationships between different tables. Relations established between related tables provide extensive advantages for databases.

3.8. Map Legend Standards

Through the revisions of ESI mapping system, the need for a standardized ESI notation and legend system could be helpful when comparing different ESI maps. The reason for developing a standard legend is lean on fast-reading and comparability of the maps in an oil spill response activity. In this section map legend standards will be given for visual interface of an ESI map.

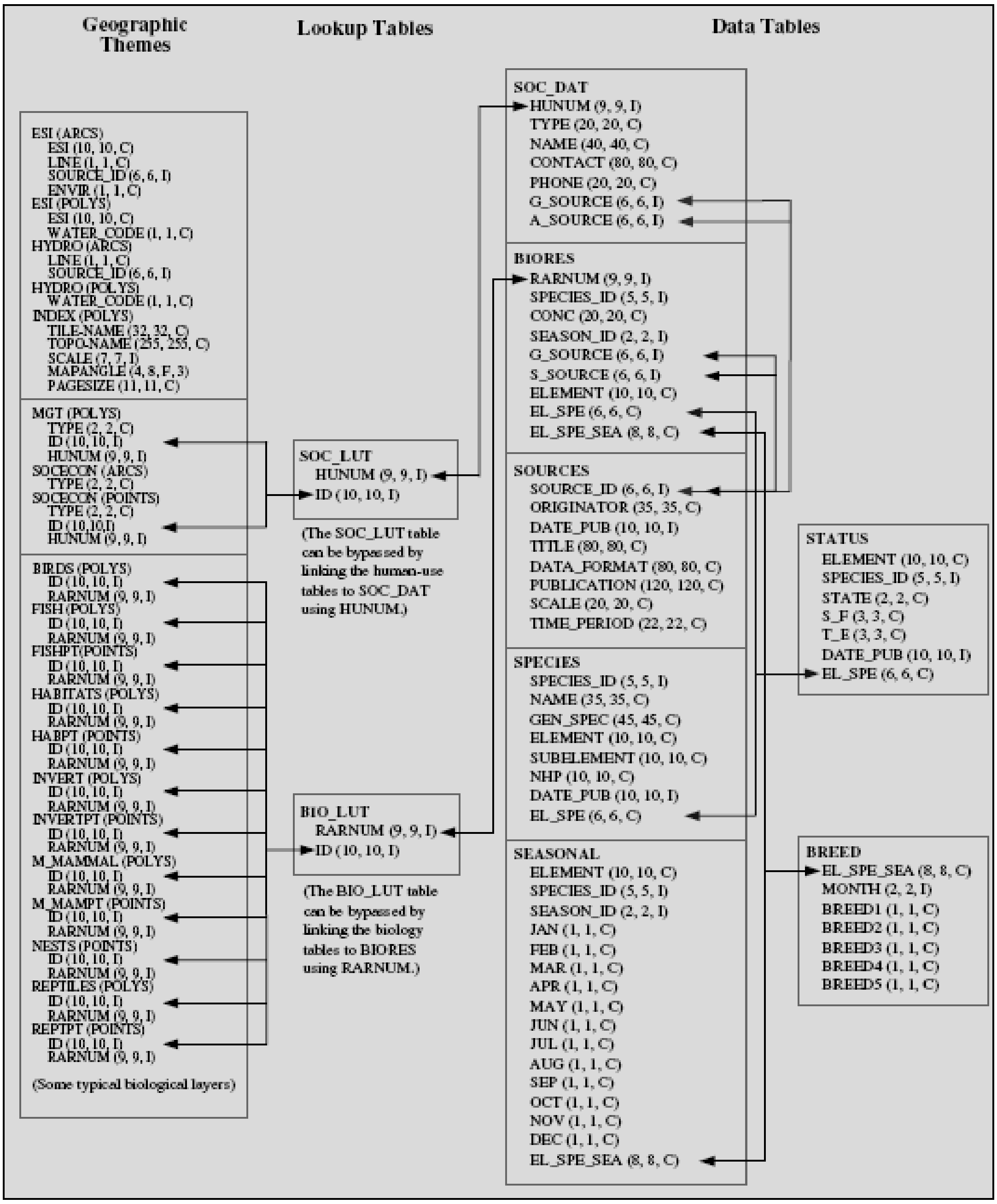


Figure 3.3: Relational geodatabase structure of an ESI (Petersen et al., 2002)

3.8.1. Shoreline Classification Legend

Representation of shoreline classes is color-coded and for ESI classes 15 color is chosen. These colors used for corresponding ESI shoreline class in an ESI map. Standard colors are given in Table 3.21 as RGB (Red – Green – Blue) and CMYK (Cyan – Magenta – Yellow – Key (or Black)) color books. While marking classified shorelines in GIS or CAD environment corresponding color formulas should be used.

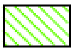
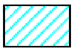
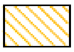
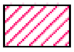
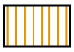
Table 3.21: Color scheme used for representing the shoreline habitat rankings on maps (Petersen et al., 2002)

ESI RANK	COLOR	CMYK	RGB
1A/1B	DarkPurple	56/94/0/13	119/38/105
2A/2B	LightPurple	38/44/0/0	174/153/191
3A/3B	Blue	88/19/0/0	0/151/212
3C/4	LightBlue	50/0/0/0	146/209/241
5	Light Blue Green	50/0/25/0	152/206/201
6A	Green	100/0/100/0	0/149/32
6B	LightGreen	22/0/100/0	221/214/0
7	Olive	0/0/100/25	214/186/0
8A	Yellow	0/0/100/0	255/232/0
8B	Peach	0/34/28/0	254/189/170
8C/8D/8E/8F	LightOrange	0/17/81/0	247/205/75
9A/9B/9C	Orange	1/42/99/0	248/163/0
10A	Red	0/100/100/0	214/0/24
10B/10E	LightMagenta	0/50/0/0	245/162/188
10C	DarkRed	0/81/56/13	209/77/80
10D	Brown	0/56/69/25	197/114/70

3.8.2. Biological Resources Legend

Biological resource polygons in an ESI map are also marked as color-coded and hatched. Table 3.22 shows the accepted color codes for biological resources data. Polygonal data should be hatched with appropriate pattern angle and color and icons are placed in or connected to the boundary of the polygon. When more than one biological element (e.g., fish and birds) is included in the same polygon, a black-hatch polygon is used.

Table 3.22: Symbolization for the biological features shown on ESI maps (Petersen et al., 2002)

ELEMENT	COLOR	HATCH PATTERN ANGLE	SYMBOL	CMYK	RGB
Birds	Green	45		56/0/100/0	136/185/0
Habitats	Violet	90		18/73/5/0	168/0/102
Fish	Cyan	135		100/0/0/0	0/159/230
Invertebrates	Light orange	45		0/31/100/0	255/184/0
Marine mammals	Light brown	0		19/44/88/0	215/153/52
Reptiles and amphibians	Red	135		0/100/56/0	216/0/67
Terrestrial mammals	Light brown	90		19/44/88/0	215/153/52

3.8.3. Human – use Resources Legend

Nearly all human-use features are represented as points on the map. The only exceptions are managed lands (i.e., parks, preserves, reserves, and refuges), which are shown as polygons, and bridges, international boundaries, and other unclosed polygons which are shown as lines. The symbol for the human-use feature is offset from the feature with a leader line drawn from the symbol to the feature. For polygon and line features, the boundary of the feature is drawn using a dashed line, and the symbol for the feature is placed somewhere inside the boundary. When revealing the exact location may endanger resources (such as historical and archaeological sites), the maps have icons that typically obscure the location. If there are many points clustered in the same area, either only a few icons are placed on the map products or they are moved in order to display all of the features. In the GIS database, the data provider uses discretion when disclosing location sensitive resources. In some instances, the data may be displayed on the map products only, with the resources removed from the digital database. Users should consult the ESI atlas introductory pages and GIS metadata to determine the availability of human-use resource information that may be location-sensitive.

Figure 3.4: ESI symbols that represent biological and human-use resources (Petersen et al., 2002)

4. APPLICATION OF ESI ON ISTANBUL STRAIT- BOSPHORUS

4.1. Application Area

There are more than 260 straits in the world which none of them even remotely resembles the Turkish Straits in terms of the geography and other factors. The Turkish Straits are considered as one of the most strategic waterways of the world. Figure 4.1 shows the nearshore districts of Istanbul Strait and Golden Horn.

Figure 4.1: Nearshore Districts of Istanbul Strait and Goldenhorn

According to Montreux Convention of 1936, the number of vessels passing through the Straits has increased 11 times while their total tonnage has increased more than

25 times. In recent years, not only the frequency of vessel traffic has increased, but also the size of vessels and the nature of cargoes have drastically changed.. The ratio of oil, oil products and other dangerous and hazardous materials transported by large tankers has been rapidly increasing. Indeed, the number of oil tankers and other dangerous cargo vessels passing through the Strait of Istanbul increased by 90% from 4248 in 1996 to 8097 in 2003. Similarly, the amount of hazardous cargo increased from 60.1 million tons in 1996 to 134.6 million tons in 2003, with an increase by 125 % . The vast increase in the number of vessels and the amount of hazardous cargo in recent years has caused considerable growth of the risk of maritime disasters in the Turkish Straits which will cause severe consequences on the surrounding human and marine environment at remarkable proportions. Numerous tragic accidents that have occurred in the Straits in the past are evidential in this regard. Among the accidents occurred in the Bosphorus, Independenta (1979), Stawanda (1980), Unirea (1982), Nassia (1994), Volgoneft (1999) are considered as destructive accidents with the great amount of oil spilled. Beyond these, Rubi Unyon-18 sink with sheep in its cargo; and Petersburg discharged gas ammonia. All these incidents created impairments on the Bosphorus ecosystem and the number of ships and the characteristics of the cargo carried maintain the magnitude of risk posed on Bosphorus ecosystem.

Istanbul Strait is the most established part of Istanbul for residential purposes. Shoreline also houses for manors and similar historical heritages built waterside. Nearly 60% of shoreline is (highly) modified and used for residential purposes, while the remaining 40% is the natural (unmodified) coastal area towards the north part of the city.

After describing the methodology for preparing the ESI sensitivity map, system has been applied to the study area which is the Bosphorus (or Istanbul Strait). In this study, the highly populated residential zones of Istanbul are chosen corresponding to the shorelines starting from Kadıköy to Beykoz in the Asian side and from Eminönü to Sarıyer in the European side.

4.2. Acquired and Used Data

ESI mapping system requires a huge amount data beyond its diversity. While producing a sensitivity map nearly a dozen of experts from different disciplines have to work together by collecting data relating their specialty area, since the system is composed of different data layers.

This study is only conducted by the author himself by collecting the required information and aggregating them under well-known ESI methodology. In this section, acquired data for ESI mapping is referred.

Shoreline classification stage requiring field data collection is conducted by means of 4 consecutive field trips. This stage also required digital area maps which is obtained from different institutions which will be described below.

Biological resources layer is composed of spatial data relating to different sensitive animal and plant habitats. Not only their coordinates is given but also their attribute information (such as abundance/concentration or seasonal existence… etc.) is presented and displayed. Although every endeavor is made, up-dated aquatic habitats information could not be reached. The ESI mapping of the Bosphorus stores fish and bird habitat information.

Human use resources data is also collected through the ground observations and other data that are previously gathered. All data is brought together and reprocessed for filling of ESI geodatabase. At this stage, some features and data tables of the geodatabase are imported from 1:100K scaled Environmental Master Plan geodatabase file prepared for Istanbul (IMPUDC, 2006).

The data used in the study will be mentioned in the application methodology section with their detailed features and utilities in the flow scheme.

4.3. Application Methodology

ESI application methodology given in the previous chapter is applied in this study. In this chapter, instead of repeating this methodology again, differences and modifications in the application will be summarized.

4.3.1. Shoreline Classification

Shoreline classification study consists of; (1) initial data collection, (2) pre-classification of the shoreline, (3) field observations, and (4) final data processing and classified digital shoreline production (Figure 3.1).

In this study, besides some difficulties and practical complications faced, original application methods were mostly obeyed.

4.3.1.1. Equipments used for shoreline classification

.For the entire work, required equipments are listed below.

- Google Earth 4 Pro, 1-week limited shareware edition
- Garmin E-Trex Legend GPS
- Kodak Digital Camera

Google Earth is a software that is used for viewing satellite imagery. Although program could be benefited as freeware, shareware version of the program is used for getting high– resolution imagery which helped on image processing and digitizing stages.

GPS device and digital camera is used for field observations. Ground observations are conducted for collecting data to be used in both shoreline classification and human-use resources.

4.3.1.2. Initial Data Acquisition

Google Earth is a free software that lets user to reach satellite imagery, maps, terrain and 3D buildings. Beyond searching and viewing any location from atmosphere, it also lets saving images in jpeg image format (Google Earth, 2007). Unfortunately, this software does not allow saving images in geocoded formats such as geotiff. Geocoded formats enables the user to find out the exact coordinate of a point as latitude and longitude on a world image when it is viewed with appropriate software (Wikipedia, 2007). On the other hand, Google Earth shows the coordinates information of mouse pointer which allows to save them in order to geocode a photograph by further processing.

Two groups of image is saved from the Google Earth. The first group covers the images of the coastal zone and this image group is used for pre-classification and ground observations; whereas the second image group covers the image of the strait, and is used for digitization and digital shoreline production.

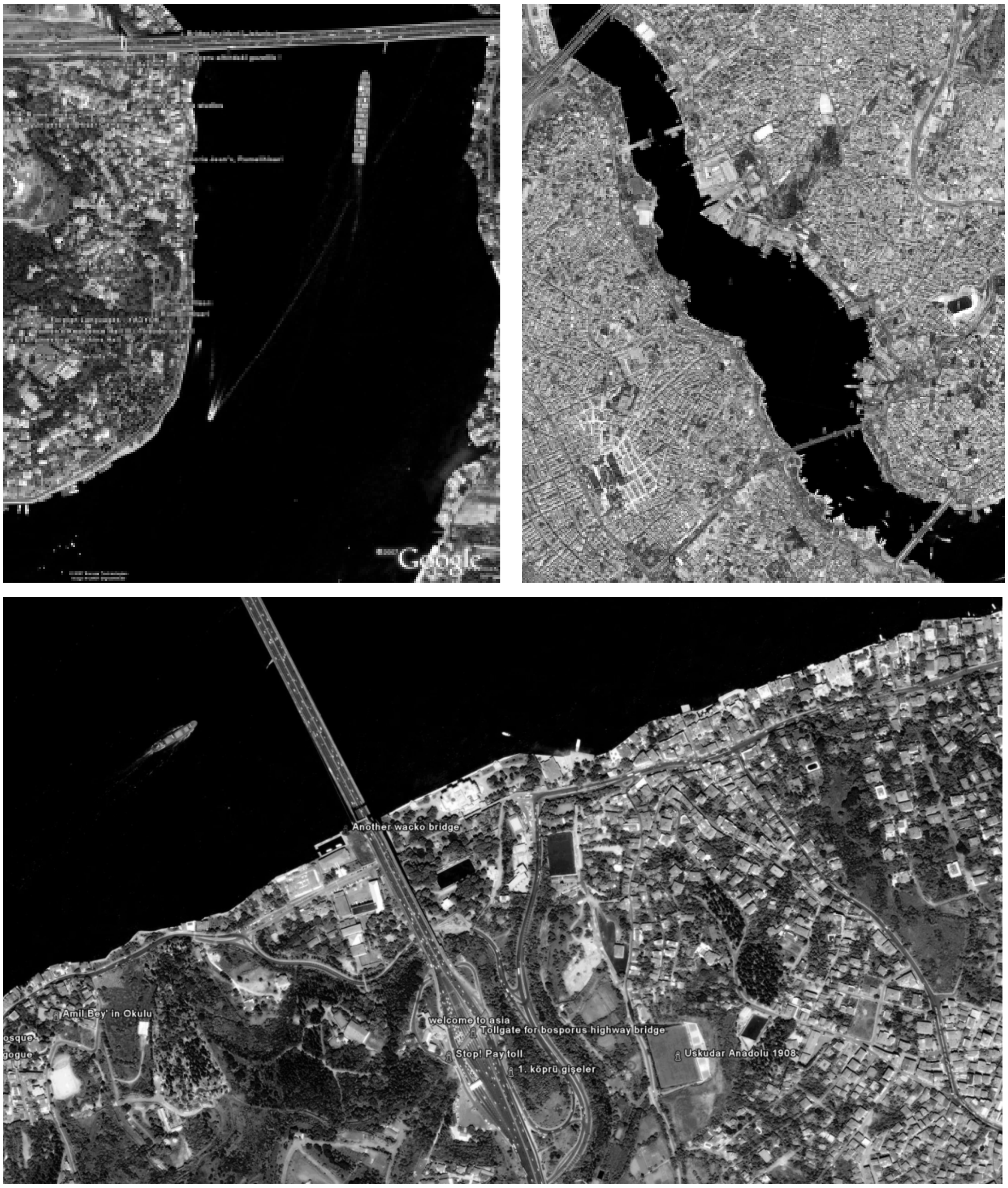


Figure 4.2: Google Earth imageries for the Strait of Istanbul and Goldenhorn (Google Earth, 2007)

Emphasis is given to the ability for observing the shoreline and the surrounding environment in full detail for classification and later studies. Thus, high resolution photos taken (2400x1821 px) by using Google Earth 4 Pro version which lets saving hi-res satellite photo. 16 hi-res photos for European shorelines starting from Karaköy, 3 photo for Goldenhorn and Eminönü district, and 18 photos for Anatolian side are taken via Google Earth (Figure 4.2). Photos are taken in color (RGB) format and after digitizing, they are converted to black and white (B/W) for using as a base map.

Another digital unclassified shoreline of the Bosphorus was taken from Istanbul Technical University (ITU) Geodesy and Photogrammetry Engineering Department. However, in order to obtain more detailed and updated shoreline, Google Earth imagery and AutoCAD (Raster Design 2007 Educational Edition) is used. 8 satellite images are connected properly in CAD environment and are merged in order to obtain one image. Digitization is implemented by drawing a polyline over the shoreline as seen on the satellite imagery (Figure 4.3). Since study area does not have a wetland, digital wetland information is not examined.

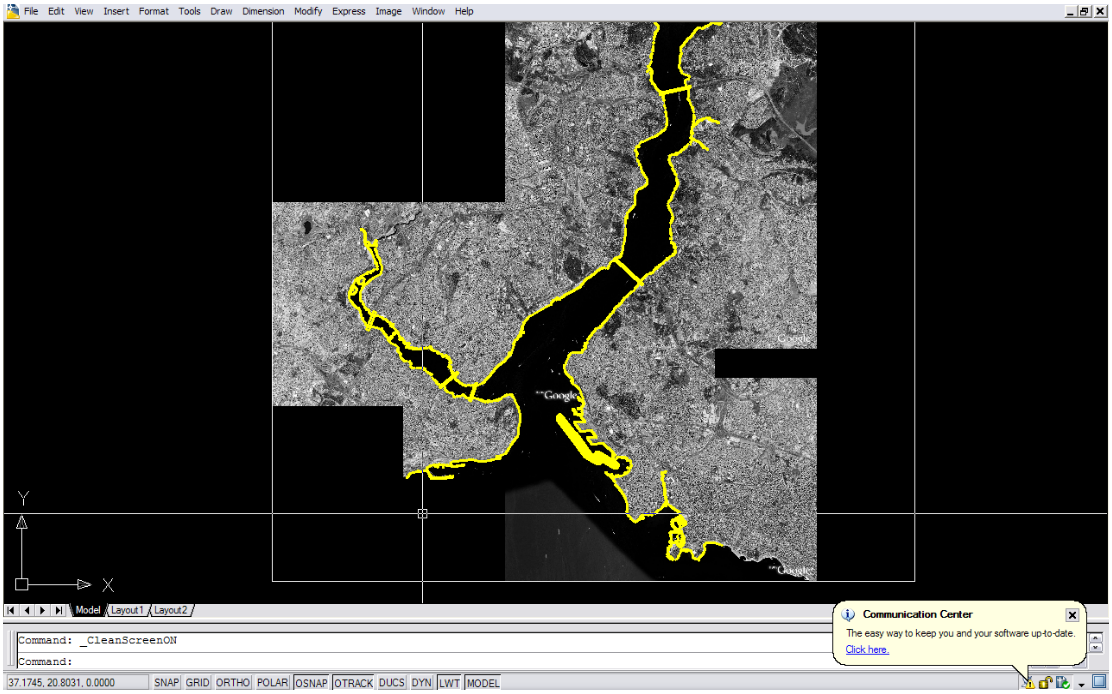


Figure 4.3: Digitized shoreline over the Google Earth Imagery

Using Google Earth photos is a convenient method for low-budget shoreline classification project. Software and images provide the display of the distribution of the green areas and urban zones, rivers and lakes, superstructure such as roads, railways or bridges by partially exposing the topography of the study area. Acquisition of digital shoreline from ITU, when combined with free imagery (which also provides topographical information) hacked the need for topographic maps since their acquisition requires a tough bureaucracy in Turkey.

Also a remote sensing orthophoto is taken from Igem Consulting for use in this study. Orthophoto of the region reflects the regional topography sufficiently. It is used as a base map for the ESI (Figure 4.4).

Figure 4.4: Orthophoto map of the Strait of Istanbul

4.3.1.3. Pre-classification of Shoreline

Pre-classification of the shoreline could be made both on digital shoreline data in a CAD or GIS environment and on hardcopy maps. Both ways are acceptable.

In this study, pre–classification is made on hardcopy print-outs obtained via Google Earth. With the help of previous shoreline knowledge, Istanbul shorelines are classified beforehand for saving time in the ground surveys stage.

Same imagery is also used for planning of survey routes. 4 ground observations are planned and realized. Field observation routes are determined as listed;

(1) Moda – Kadıköy – Harem – Üsküdar – Beylerbeyi – Çengelköy – Kandilli – Küçüksu – Anadoluhisarı – Kanlıca.

(2) İstinye – Emirgan – Rumelihisarı – Bebek – Arnavutköy – Ortaköy – Beşiktaş – Kabataş – Karaköy.

(3) Üsküdar – Eminönü – Karaköy – Kasımpaşa – Hasköy – Fener – Balat – Ayvansaray – Sütlüce – Eyüp (and backward by ship), and

(4) İstinye – Yeniköy – Tarabya – Büyükdere – Sarıyer – Rumelikavağı – Garipçe – Rumelifeneri – Sarıyer – Anadolukavağı – Ortaçeşme – Beykoz – Paşabahçe – Kanlıca.

4.3.1.4. Field Observations

Observations are made only via terrestrial trips not by the aircraft observations since this method is, in a way, unfeasible within the scope of this study. Utilization of Google Earth imagery is also another reason for omitting air observations. For more extensive sensitivity mapping studies, this option could be appraisable. It is also possible to use overflight observation option in territories which is hard to move along from land. Taking photos from a few hundred meters could be more helpful (Figure 4.5).

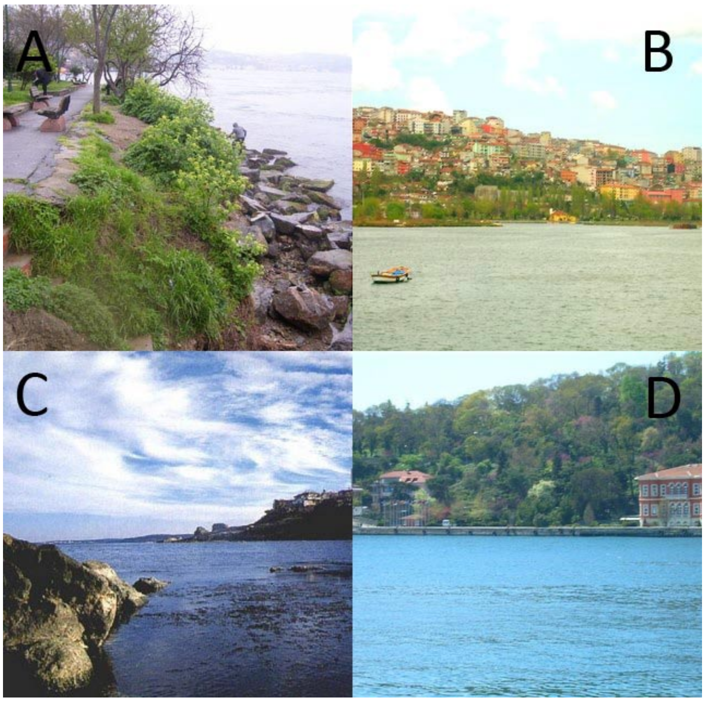


Figure 4.5: Photos from different shoreline types of Istanbul (a) Kuleli, ESI 1B, (b) two little sediment islands in Goldenhorn, ESI 9B, (c) Rumelifeneri, ESI 1B in the outer facet of the marine sanctuary while inner walls are classified as ESI 6B, (d) Istinye shorelines, ESI 1B.

Field observations are helpful both for collection of the shoreline data and registering the human-use resources on the observation route. In this study, shoreline type is recorded as it is observed. Photos (taken during ground observations) are also used for final processing. Although meteorological conditions were not suitable for taking photos from the Asian side towards the European side in the first site observation, meteorological conditions of later observations allowed for far distance photographing in order to use in final data processing.

Shorelines observed are noted with their descriptions and shoreline class (if it is classified in-situ) during the observations.

4.3.1.5. Final Data Processing

For final data processing, photography (taken during ground observations), site descriptions and previous satellite imagery, and remote sensing photos are used collectively. Results and assessments of the Bosphorus shorelines are given in the, Results and Discussions section.

All shoreline types are digitally redrawn in AutoCAD environment for GIS import stage. All recorded shoreline types are given in Figure 4.6.

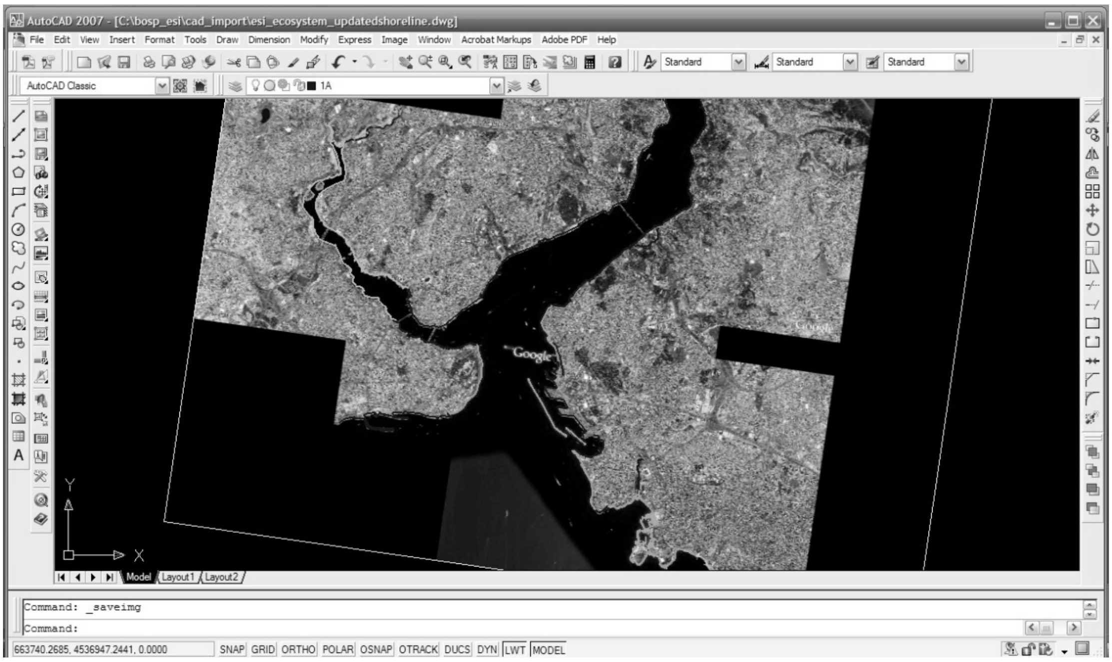


Figure 4.6: Sample of shoreline classification view of Istanbul Strait

4.3.2. Biological Resources

Biological Resources stage of the study is managed via literature survey and personal meeting. In a meeting held by a hydrobiologist, Artüz (2007) informed that aquatic animal habitat (or namely fish) in Bosphorus is declined drastically in the last decade and habitats of existing species cannot be announced as intensive living area. Regarding the increasing vessel traffic and marine pollution in the Bosphorus, the aquatic species left the area or are being eliminated from the Strait. It is also mentioned that few species visits the area for their sensitive life-time (such as spawning or nursing, etc.). Consequently, it should be emphasized that there is left just a few aquatic species in the Bosphorus. Although it is technically possible, instead of inserting a few species in the map, it is considered more feasible to put nearly 140 species of the previous decade from a practical point of view. For better comprehension of the sensitivity mapping study, it is determined to use the earlier data (Artüz, 1999).

4.3.2.1. Fish Layer

Placing fish polygons on an ESI map is mentioned in detail in the previous sections. However, the data acquired in Turkey is not polygonal. In general, two types of data exist in the ecosystem measurements conducted in Turkey. In the first group, aquatic organisms are sampled from points. In these sampling points, fish samples are taken and their concentration (or abundance) is measured. However, this method does not inform the sensitive living areas of fish (although this method is also used in some countries such as Denmark) but just highlights which species live in the actual sampling point. Another method is used in this study in a slightly different way.

On the other hand, Bosphorus is on the fish migration route to Black Sea or to Mediterranean Sea in certain periods of the year. Thus, most of the species that could be found in Bosphorus are pelagic species that are species living far from the coastal zone. Since the majority of the fish species are pelagic, most of them observed on their migration periods throughout the year. Remaining species which live around the coastal zone and that do not frequently change their living area are called demersal species. Abundance of demersal species is declining in recent years and thus, constant oil pollution is becoming a threat to them. An insignificant portion of them are demersal in their egg period, and when they reach their larvae period they become pelagic species. As a consequence of these phenomena, a great majority of fish species encountered in the Bosphorus do not settle around throughout their lifetime. Low population of demersal species in the region or the pelagic species which use the Bosphorus as a nursery area cut down the number of these sensitive areas for aquatic organisms.

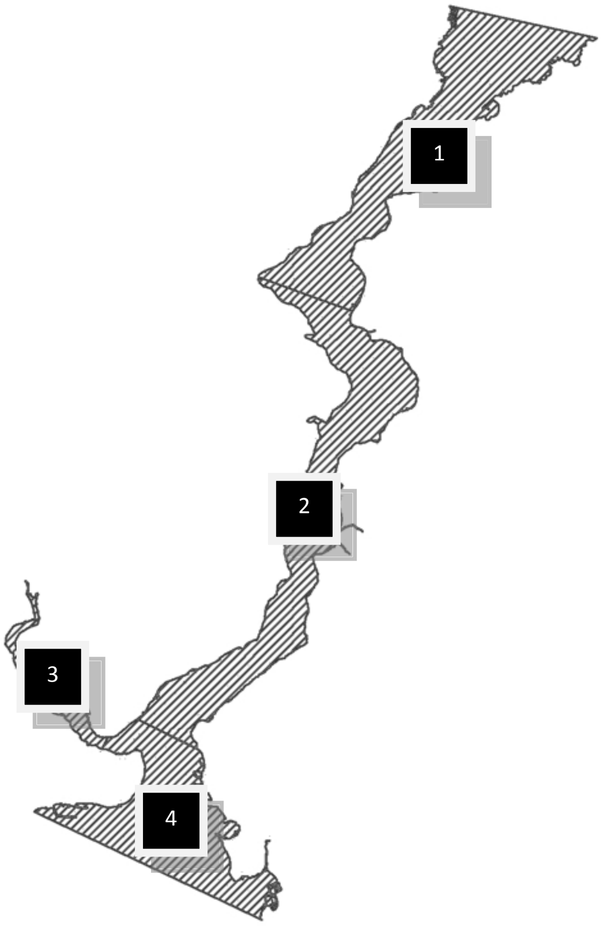


Figure 4.7: Regional boundaries of fish species in the Bosphorus

Existing living environments of fish data in Turkey is recorded as regions. Fish data in this study is grouped under four regions of the Bosphorus;

1. Black Sea species placed around the Northern part of the Bosphorus, 2. Bosphorus species placed in the area around bridges, 3. Goldenhorn species, and 4. Marmara species placed near to the south end of Bosphorus (Figure 4.7).

In Annex C, fish species in Bosphorus for the year 1999 are given. This table gives the scientific and common name of the species and abundance of the species in the intensive living region. Common name column is filled with Turkish names of the fishes as much as found (Artüz, 1999; Artüz, 2004).

4.3.2.2. Bird Layer

For bird data layer, birding observations of the last two decades obtained from Nature Foundation (Doğa Derneği) (DD, 2007). Irrelevant data are extracted and the remaining ones are processed conforming to the bird layer standards. Remaining data columns for bird layer is the name of the species, observation date and place, number of individuals and observation coordinates.

Observed birding species that will be used in ESI geodatabase is given in Annex D. Furthermore, in Annex E, abundant bird species are listed as grouped by polygon which they are observed.

Seasonality – Life History Tables for both fish and bird layers is given in Annex F and Annex G, respectively.

4.3.2.3. Other Layers

Bosphorus and Istanbul shorelines do not house any marine and terrestrial mammals. Although sometimes dolphins could be seen in the Strait, they do not spent time. Similar situation is also acceptable for turtles and reptiles such as crocodile. In summary, only fish and birds living around the shorelines will be placed in the ESI database prepared for the Bosphorus. ESI map of Bosphorus covering all biological resources could be found in Annex H.

4.3.2.4. Data Forms

Data forms mentioned are used in order to collect biological resources data and for GIS geodatabase creation. For getting detailed information about how to use and fill out these forms, Chapter 3 can be referred.

Biological resources forms (Table 3.14) and seasonality- life history forms (Table 3.15) filled during the compilation of biological resources data layer are uploaded into to geodatabase. These tables could be queried under the ESI map given in the ESRI ArcGIS format (Annex I) or through the Access file (*.mdb) reside with ArcGIS *.mxd file.

4.3.3. Human-use Resources

In human-use resources layer, buildings, areas, plants, or other structures (which is important for human use, life, subsistence, could be used as a recreational facility or could be harmed after an oil spill incident directly or indirectly, e.g. through fire after a collision and spill incident) residing near or around the shoreline are marked. These structures are either important for human-use or they gain importance in an oil spill incident. This stage was conducted during shoreline classification surveys.

Environmental Master Plan of Istanbul (IMPUDC, 2006) is also used for populating Human – Use layer data.

4.3.3.1. Ground Surveys and Data Collection

In ground surveys, stage two data group were investigated and collected, namely shoreline classes and human-use resources. An example for data collection forms that comply with the geodatabase tables were given in the previous chapter. Accordingly, data forms are filled out conforming standard method as expressed in ESI Guidelines v3.0 (Petersen, 2002).

Data representing high–use recreational and access areas depends on remote sensing photos, Google Earth imagery, literature information, and ground surveys. 1:100K scaled Environmental Master Plan (EMP) are also used as a resource for access facilities (roads, railways) and recreational areas (IMPUDC, 2006). Management areas such as parks, national / regional parks or marine sanctuaries were recorded during the ground surveys. Also, Google Earth imagery and municipal maps were used for validation. Resource Extraction Sites are not very common in the coastal zone of Istanbul. Cultural Resources covers the archeological and historical areas, and this information is provided from EMP (IMPUDC, 2006) beside the surveys.

4.3.4. Geodatabase Build-up

Data that is used to build up geodatabase are partially imported from already existing geodatabases prepared for EMP of Istanbul by importing and manipulating data; and partially converted and loaded from ground surveys. In the latter, ground survey data are first drawn in the CAD environment and then imported into ArcGIS. Geodatabase procedure, followed in this study is given below.

4.3.4.1. Geodatabase Creation and Schema Import

First step in preparing an ESI map on a geodatabase is the creation of database and definition of the required tables and relations under it. For shortening this procedure, geodatabase was created and the remaining database units were imported from another ESI application sample.

Geodatabase creation and import were managed under ArcCatalog of ArcGIS 9.1. Geodatabase limits were given as below. These values could be used for further updating or editing of this database or used in similar geodatabase projects for the Istanbul region.

Projected Coordinate System	: WGS_1984_UTM_Zone_35N
Projection	: Transverse Mercator
False Easting	: 500000.00000000
False Northing	: 0.00000000
Central Meridian	: 30.00000000
Scale	: 1.00000000
Latitude of Origin	: 0.00000000
Linear Unit	: Meter
Geographic Coordinate System	: GCS_WGS_1984
Datum	: D_European_1954
Prime Meridian	: 0
Angular Unit	: Degree

In conclusion, geodatabase is copied with its all entities excluding data, allowing directly loading or putting new data into it. After geodatabase creation, its tables and relations between tables (which are alternatively named as "database schema") are imported (or simply copied) from another geodatabase sample prepared for California, USA. This procedure was managed by using "extract data" option under disconnected editing tool of ArcGIS (Perencsik et al., 2005).

Geodatabase structure is similar to the one given in Figure 3.3.

Instead of using geodatabase schema copy method, database, tables and relations could be created one by one as an alternative. This method seems time-consuming though.

4.3.4.2. Geodatabase Data Filling (Import – Input)

Data populated in the geodatabase are as listed:

1. Geodatabase base maps: Orthophoto satellite image of Istanbul is directly used. Otherwise, Google Earth imagery was used after merging 8 images conveniently under Autodesk Raster Design integrated AutoCAD 2007.
2. Shoreline classification data: These data group are first drawn in AutoCAD 2007, and then imported into ArcGIS. During import session shoreline class polygons are projected as WGS_UTM_Zone_35N.
3. Biological and human-use resources data: Data processes filled into convenient data forms previously given. For putting polygonal fish data into GIS, first polygons were drawn and then fish types living under the polygon drawn entered the geodatabase. Same procedure was re-conducted for each of the polygonal living region. Bird data were tabulated as polygonal data as the observation regions where their concentration is high. Thus, observation regions (polygons) are entered into ArcGIS as polygonal feature class and related with biofile which contains the information of all species covered by the study (Figure 4.8). Human–use resources are recorded as point features except for management areas such as mining areas which is recorded as polygonal zones.

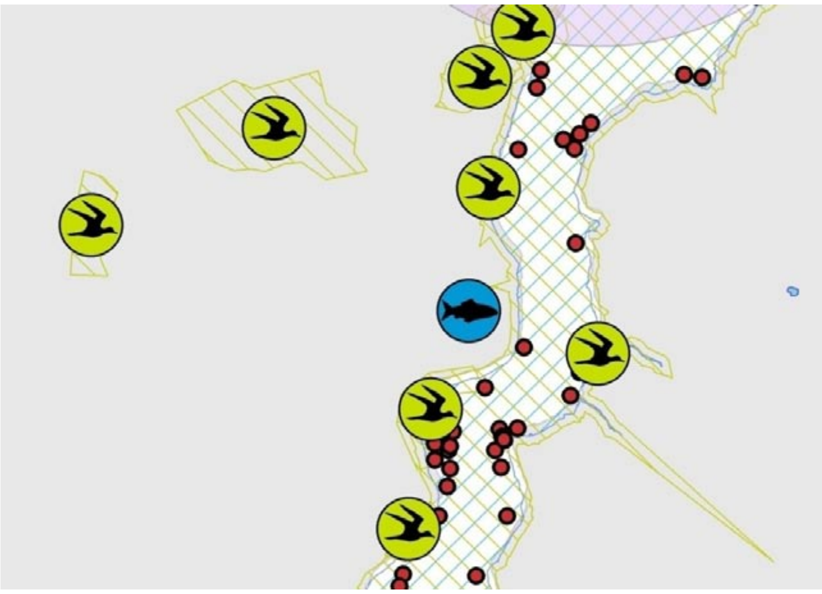


Figure 4.8: A Sample view from bird and fish living areas around Küçüksu – Rumelihisarı

4.3.4.3. Geodatabase Packing

After all these information layers are stored in GIS form and incompatibilities removed, geodatabase file were saved and published in portable document format (extension .pdf) (Annex 5).

5. RESULTS AND DISCUSSION

The steps of the sensitivity mapping, data collection and processing stages and development of the Geographic Information System were the key points of the study. In this section, the results of this study will be given and discussed, focusing mainly on the coastal zone of Istanbul.

5.1. Introduction

This study is applied in the highly residential shoreline of the Istanbul Strait, Bosphorus. Shoreline is accepted as 100 m according to the Turkish Law on Coasts (1990).

In this section, evaluation of the data collected will be done. For better comprehension of the region in terms of oil spill vulnerability, a regional classification is made. Since the centre of the Bosphorus and the far zones of the Goldenhorn indicate different oceanographic, physicochemical and ecological characteristics, evaluation will prove that in different parts of the Bosphorus, different vulnerability patterns are seen. In this chapter, evaluation of the biological aquatic community has not been done since the data collected is not updated and there are certain known differences in the region. Sensitivity maps are given in the Annex H.

5.2. Evaluation of the Black Sea Region

Rumelifeneri, Sarıyer, Büyükdere, Anadolufeneri, Ortaçeşme and Beykoz districts are grouped in the North Bosphorus (or alternatively Black Sea Region). In the Northern region, shoreline is rarely modified and remained as beaches or rocky shores as compared to the southern regions of the Bosphorus. There are limited residential areas in the region and the existing areas are not densely populated. Especially the great majority of settlements around the north exit of the Bosphorus are in the form of small villages with low populations. Natural environment in the region is generally unmodified which has a great effect on the biological diversity.

In the settlements located in the North edge of Istanbul Strait (Rumelifeneri and Anadolufeneri), shoreline is under the impact of high tidal and wave effect generated by the strong currents of the Black Sea. With the effect of the strong currents, rocky shores formed in the region. This shoreline group was mentioned in the previous chapters as the least vulnerable type against oil spills. Rocky cliffs dominating in the region form a wall (buffer) effect towards the strong currents. In case of an oil spill incident, oil will reach to the shoreline immediately related to the meteorological (wind direction, precipitation, etc) and hydrological conditions. Offered response activity for this kind of shorelines is circumscribing the spilled oil in the sea, and then leave the oil portion that reached to the shoreline. Stranded oil will be removed with the energy of the wave reflected in the shoreline.

There are lighthouses built on rocky cliffs in the region (Figure 5.1). Also, the region houses a number of boat ramps and marine sanctuary for fishing activities. Since substantial fishing is an important economical resource in the region, integrity of ecosystem is important. Coast guard facility is an important location for oil spill response activities and response strategies for surrounding districts could be formed based on Rumelifeneri region.

Figure 5.1: A scene from Rumelifeneri

In the villages between Sarıyer and Rumelifeneri, there are a few beaches belonging to ESI 3 shoreline type. These beaches are generally natural coarse sand or gravel beaches which are classified under middle energy ESI group (between ESI 3A and ESI 7). These beaches remain under the protection of the shore extent or structures such as rams (Figure 5.2). However, they should be considered as more vulnerable in terms of oil spill. If this kind of substrate are covered with oil after a spill incident, clean-up efforts for these areas are both difficult and expensive. There is also a risk of damaging the natural environment. A waterbreak is seen on Figure

5.2.b classified its north edge as 6B. 6B stands for riprap structures which is a kind of broken stone material. This material, somewhat abundant in the south shoreline of Istanbul, is out of the scope in this study. Since this material is useful for recreational purposes and shoreline stability, cavities between broken stones is easily filled with oil reaching to the riprap shores. Thus, clean-up efforts on riprap structures are somewhat harder. Sometimes the only solution to clean a riprap shoreline is to replace all the stones in the polluted coast.

From Garipçe village to Rumelikavağı in the European side of the Bosphorus, there is no settlement in the shoreline except the beaches. This area is classified as ESI 3A which is coarse sand beaches or ESI 1A (exposed rocky shores). In the Altınkum / Elmaskum beach region, there are recreational facilities near the beach and a boat ramp for the local boats and yachts. This area could be regarded as a touristic area with low density, but in a marine accident, it could be used for response activities since it has a wide shoreline access area. Rumelikavağı and Sarıyer are also close settlements and thus supplementary response forces for a possible incident could be located between these two regions.

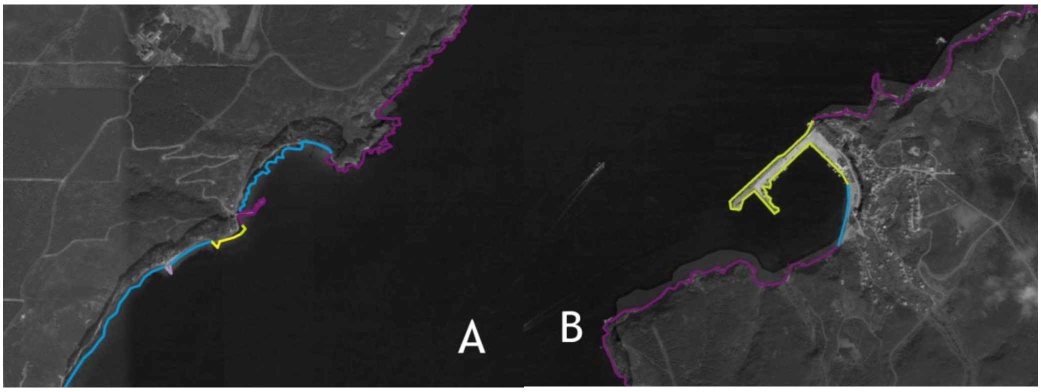


Figure 5.2: Beach shorelines in Black Sea region of the Bosphorus; a) Garipçe Village, b) Anadolufeneri.

Asian side of this Middle North Bosphorus region is formed with solid cliffs which could be classified as ESI 1 type. After the Anadolukavağı Centrum, the coast near the military zone is occupied with coarse grained sand beach next to an access road. This bay ends with another military zone by ending in the north part of the Bosphorus, Beykoz. In the battery, there are a few piers and ram, and these could be used as effective oil spill response points.

Finally, Sarıyer and Büyükdere bays are in the European side. The shoreline in the European side is constructed and modified. General shoreline substrate is cement grouting materials which allows no oil penetration. Cement grouting behaves like rocky shores; it has low penetration, it reflects the waves by raising the wave energy and thus stranded oil wash out in short durations. A coast guard facility in this bay is still used for oil spill response operations. In the region, one-way road is built on a pier because the access area is quite narrow. This situation causes sediment accumulation just behind the pier. This kind of structure also attracts shellfish and although it constitutes a modified area creating its own habitat in time.

5.3. Evaluation of the Bosphorus Region

Starting from Büyükdere, Tarabya, Yeniköy, İstinye, Emirgan, Rumelihisarı, Bebek, Arnavutköy, Ortaköy, Beşiktaş, Kabataş in the European side and Üsküdar, Beylerbeyi, Çengelköy, Vaniköy, Küçüksu, Anadoluhisarı, Kanlıca, Paşabahçe in the Asian side of Istanbul constitute the Central Bosphorus Region. After this region of the Strait, shoreline substrate becomes completely solid, cement grouting. Since currents in the entire Bosphorus have high wave energy and most of the shoreline is covered with man-made structures, whole region is classified as 1B which is exposed, solid, man-made structures (Figure 5.3).

Figure 5.3: Central Bosphorus Region is formed with solid, man-made shorelines

In the sensitivity map, there are also shallow areas such as the mouth of the Küçüksu River near Anadoluhisarı district. The river banks are partially riprapped and coarse beach. Throughout the entire Bosphorus, there are numerous piers and boat ramps. Since this shoreline is used for residential purposes, coastal zone is generally occupied by waterside mansions or historical houses which have personal boat ramps. Since these boat ramps belong to the local residents and as they are not observed from the road (which also means they are not commonly used by anyone) these features are not recorded into geodatabase. Rather, ignoring personal boat ramps, marine sanctuaries and the coast guard facilities are recorded for evaluating them in an oil spill response scenario.

Near to the mouth of Küçüksu River, Küçüksu Beach is recorded during the surveys; however, this beach was not in use. The point is, using this area, which is also entered into geodatabase as beach, could be dangerous from an environmental engineering point of view as there is a wastewater treatment plant located in the upriver (Figure 5.4).

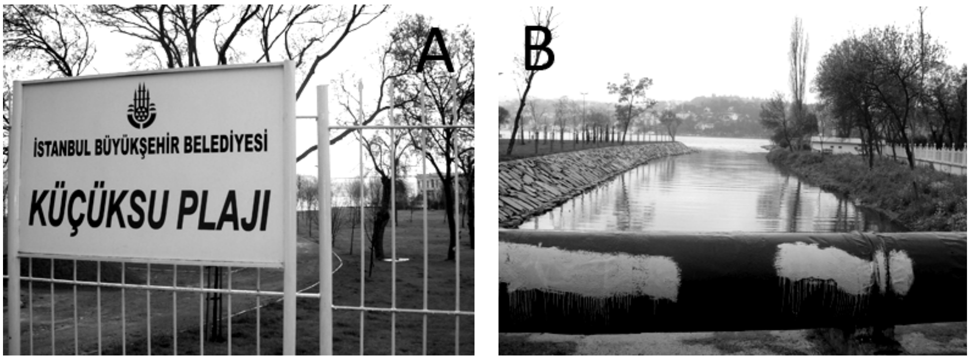


Figure 5.4: Küçüksu Beach (a) which is located near to the mouth of Küçüksu River (b)

In general, the first 50 meters of Asian coastal zone is occupied with residential manors which are historical. Thus, the shoreline of the Asian side is generally regarded as a historical belt with its spectacular waterside manors. This situation must also be taken into account during planning an oil spill response strategy for this region and protection of this gentle, fragile structure should be considered. The fires from the two collided vessels reaching to the residential areas are evidently terrible for both the owners of these houses and the inhabitants of the Metropolis..

Generally driveway is located next to the shoreline in European side on the contrary of the Asian side. On the other hand, it is sometimes splitted into two one-way road constructed with cement grouting as in Sarıyer Bay and one of these divided roads is generally built on the posts stuck in the sea. Around these divided roads sediment accumulation is observed. Thus, these sections (placed in the Bebek and Arnavutköy) are recorded with a second ESI line as ESI 5 other than its original shoreline type.

Also districts such as Kuruçeşme, Beylerbeyi and Baltalimanı show different coastal characteristics within the first 100 meters (which is the legal definition of coastal zone) (Turkish Law on Coasts, 1990). These areas are recorded with double ESI line. Although ESI database allow using sequential three ESI lines, in Istanbul Strait, maximum two sequential ESI lines were used.

European side has satisfactory number of marinas and piers throughout the Bosphorus coasts, especially in the bays which have more stagnant water. These shores are expected to come across with oil pollution problem since the wash-off is low. But, on the other hand, these areas have good potential for responding oil spills with their constructed facilities.

As a cultural / recreational facility Galatasaray Island constitutes a human-made obstacle for vessels (Figure 5.5a) just like Maiden's Tower (Kızkulesi). Because of the Marmaray- Bosphorus Tube Tunnel Crossing construction, for a few years more, there will be a construction site near the Üsküdar – Harem shoreline (Figure 5.5b).

Figure 5.5: Human–made obstacles in Bosphorus a) Galatasaray Island b) Maiden's Tower

Bosphorus region is also rich in recreational and cultural facilities. Most of the open shorelines in Asian and European site are used for recreational fishing. On the edge of some public structures on the Asian side, there are additional recreational fishing sites as well. Coastal zone houses local parks, and big regional parks. Some bays are used as diving areas. There is no local public beach in the Central Bosphorus region even though some of them exist on the Northern Bosphorus and Marmara coasts (Figure 5.6a).

Areas to be used as oil spill response were classified under recreational / access facilities. In European side, driveway is located next to the shore. But on the contrary, Asian side is occupied with residential areas, as mentioned previously. In this area, there are access streets in nearly every half kilometer. Sometimes, one can find boat ramps beside these streets.

In some areas, there are marine sanctuaries since subsistence fishing is an important economical resource (Figure 5.6b). These areas are evaluated under resource extraction areas. In Bosphorus, the local habitat is critically disturbed with the local traffic, sewage discharges, tanker wastes and other impacts. The reason of why this study is conducted with former ecosystem data is the abundance of aquatic species in the region that critically diminished. As a result, the entire Bosphorus region could be regarded as a Critical Habitat Region.

Figure 5.6: Recreational / Access Facilities on the route (a) Recreational fishing, (b) Marine sanctuaries

Beşiktaş is an important area with its historical importance such as Dolmabahçe Palace nearshore. Kabataş and Karaköy districts house harbors thus there are a number of hoist areas. These wide areas are also used for oil spill response activities.

5.4. Evaluation of the Goldenhorn Region

Karaköy, Kasımpaşa, Fener, Hasköy, Balat, Ayvansaray, Eyüp are the main landing piers of the Goldenhorn Ship Line. After Eyüp, ship traffic is hardly seen because of the bathymetry. Goldenhorn (Haliç) is a river estuary and has a flat surrounding environment in general. Water is generally stagnant and has slow currents relating to the meteorological conditions after the Unkapanı Bridge near Şişhane.

Figure 5.7: Shoreline classification of Goldenhorn region

Banks of Haliç is low and inundated in place with its wide intertidal zone in the Eminönü side (Figure 5.7 and 5.8). In Karaköy side, sometimes land gains height, but this side is almost flat and medium to wide intertidal zone. Oil pollution originating from comparatively low marine traffic of this region, could lead to a threat when slow currents in the region are considered too.

As a consequence of the slow currents, creeks carrying water to the Goldenhorn also formed two small alluvial islands in time. These islands were classified as ESI 9B (namely, vegetated low banks), since they are mostly composed of sediment.

Shores of the Haliç from Unkapanı Bridge upto the division near Eyüp are classified as ESI 8B since the shoreline is a man-made (modified) structure but the prevailing current conditions are still or slow (sheltered shoreline zone). Another reason for choosing ESI 8B is the substrate and habitat relationship in the region. Substrate also covers attached organisms.

Haliç shorelines are generally used as recreational facilities. Miniaturk and Feshane Cultural Facility are the major recreational facilities. In the recent years, with the increasing water quality, Goldenhorn and the surrounding areas have become more tourist-attractive districts. Especially, international events and historical / cultural centers in the region, make this area more important.

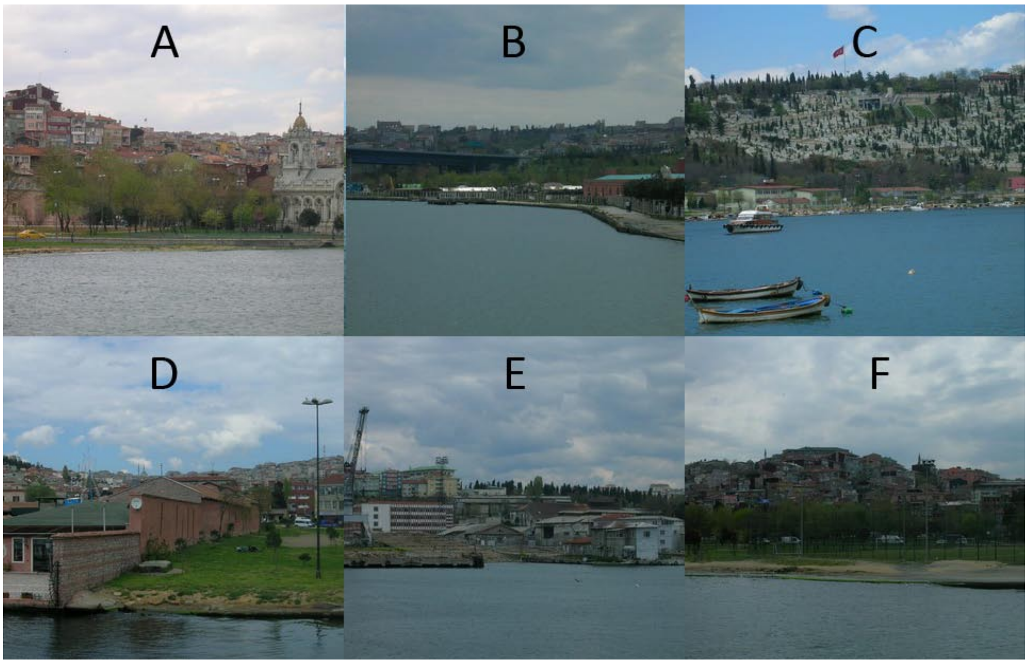


Figure 5.8: Different views from Goldenhorn, (a) Fener banks, (b) Eyüp, towards Feshane Cultural Center, (c) Eyüp, fishing boats, (d) Sütlüce banks, (e) Kasımpaşa, old dockyard, (f) Balat banks

Ecosystem of this region is not so diverse with the ongoing effect of the bottom sediment, though a great portion of it is eliminated. During the migration of some fish species, fish confusing its way may turn to Goldenhorn. But this situation should not be considered as diversity.

5.5. Evaluation of the Marmara Region

Eminönü, Sarayburnu, Üsküdar, Harem, Kadıköy and Moda banks were classified as Marmara region of the Bosphorus. All of these areas constitute one of the oldest parts of the city and hold numerous historical and cultural sites, structure and region. On the other hand, on both side of the Strait, there are piers, docks, customs and harbors. These areas are used for both tourism and transportation purposes. In the south exit of the Bosphorus, shorelines are generally protected by breakwaters and rams. This situation makes these shorelines more protected against strong tidal interaction and wave energy. As a result, shorelines are built as riprap or modified cement medium and generally have a flat topography.

Üsküdar has a number of historical structure nearshore. In fact, the historical pattern of the Üsküdar district has been explored. Nowadays, ancient Byzantium remains were excavated during the Marmaray studies (Figure 5.9). Maiden's tower was also another cultural and historical heritage for the region; but in contrast, it is a man-made obstacle for marine traffic, as mentioned before. Starting from Harem region shoreline is filled with broken stones named as riprap. The advantages and drawback of these structures were described previously in terms of oil spill vulnerability.

Harem district is the heart of transportation since the custom and harbor are established. Custom and harbor area are connected with the railway network and services both via railway and marine transportation. It is built between Harem and Haydarpaşa districts. This zone has hoist facilities for loading/unloading ship cargos. Near the custom, ferry piers and coast guard corps are located. This situation should be considered important for oil spill response. Heavy oil pollution originating from the ships anchored on these shorelines is also inevitable and understandable.

Starting from the customs until Haydarpaşa and Kadıköy, breakwaters are constructed for the protection of the shoreline. On the edge of breakwaters, there is a lighthouse. Breakwater shores are riprap and there is a crowded seagull population within Haydarpaşa – Kadıköy the region. This region also houses the local ship lines piers and constitutes an important quantity of the Bosphorus traffic.

Eminönü and Karaköy districts are also used for transportation purposes, beyond their historical beauties. Another custom is established. These sides of the Bosphorus are classified as ESI 1B type. Shoreline has a mild slope and under the effect of currents come from Marmara Sea.

With two lighthouses established on both sides of this region, the Bosphorus ends. The lowest latitude of the Bosphorus encounters the lighthouse in the Kadıköy, which is in front of the piers, wastewater treatment plant and its discharge points. After this point, the Marmara Sea starts geographically. This shoreline is also covered with riprap structures and classified as ESI 6B. Up to the mouth of the

Kurbağalıdere, riprap structure continues and the shoreline changes to the cement material again. This stream is heavily polluted and could even be observed from the Göztepe Intersection on E5 motorway. Although dredging studies are still ongoing, stream has muddy water which does not allow any habitat settle in.

Figure 5.9: Byzantium Remains near Üsküdar nearshore.

Figure 5.10. Marmara Region of Bosphorus

6. OIL SPILL SCENARIOS FOR BOSPHORUS

In this chapter, three oil spill incident scenarios have been assumed and evaluated in order to apply sensitivity map of the Bosphorus in real life situations. As it is mentioned in the previous chapters, ESI mapping gives a quick idea about the sensitivity level of the given area in the mapped region against oil spills. The map also presents an inventory of the sensitive natural resources that could be affected in an oil spill incident for taking precautionary measures. The three sample sites will be evaluated for an imaginary spill incident. As a result of the evaluation the shoreline and habitat under risk will be pointed out. While selecting the incident sites, considered selection criteria is also given in the following sections.

6.1. Development of the Oil Spill Scenarios and Site Selection

Incident sites were chosen based on the modification level of the shoreline and statistics of the accidents happened previously. In Figure 6.1, the selected locations for the scenario analysis can be seen together with the plot of major accidents that have occurred till year 2007.

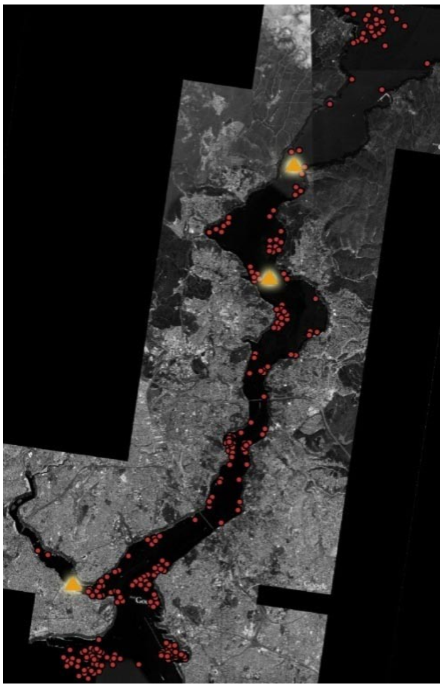


Figure 6.1: Accident sites until 2007 (Undersecreteriat for Maritime Affairs, 2007).

Briefly, three accidents were assumed for the man-made and natural zones of Bosphorus and Goldenhorn regions (Figure 6.1). Each accident is assumed as if it occured by a collision of two vessels navigating in the counter courses and the effect of the spill on the natural resources assessed after the collision by using the ESI map. Estimation of the natural resources affected is based on the buffer zone analysis made around the accident points. Damage of each accident is assessed within the surrounding area in regions of 1 km and 3 km around the spill site. This differentiation can be assumed as late response or response to the incident in bad weather conditions and thus less effective protection around the incident zones.

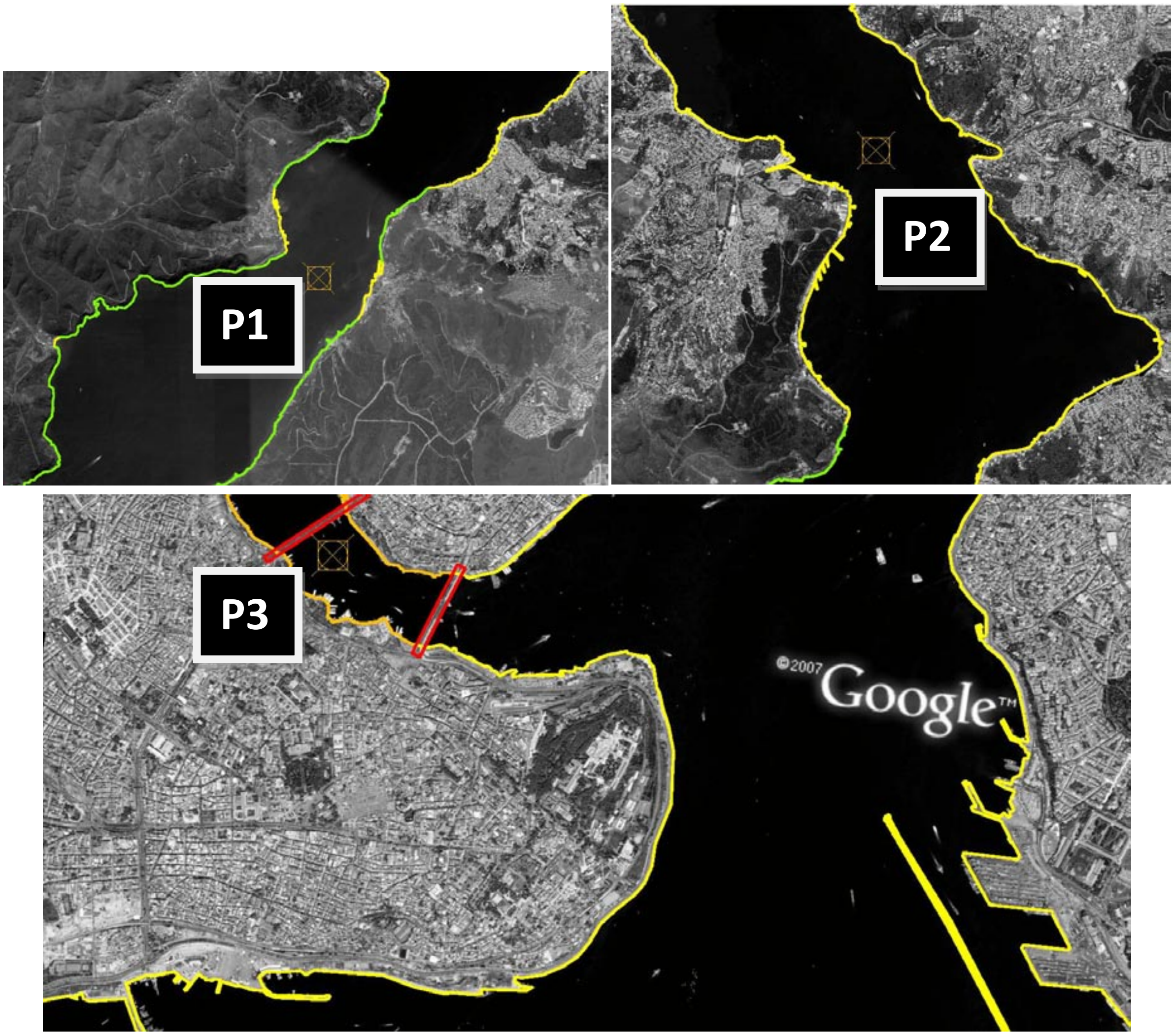


Figure 6.2: Selected accident locations

Figure 6.2 show the site of accidents for each scenario. Shorelines are color-coded in three different colors which are different from standard ESI color-coding legend. Green shorelines show that zone is natural, while yellow and orange shorelines mean that the shoreline is modified. Differentiation between yellow and orange shorelines (beyond that these are man-made) is that the orange zones are exposed to low wave energy which indicates a low natural attenuation potential in case of a spill incident. On the other hand, yellow shorelines are under the effect of high wave interaction facing the Bosphorus currents. Red bars in the figure show the two strategic bridges connecting European and Asian parts of Istanbul.

6.2. Accident Scenarios and Evaluation of the Natural Resources Affected by a Spill

6.2.1. Scenario #1: Natural – Manmade Shoreline Zone

This area is located at a place where natural coastal zones end (green shorelines) and more developed, modified (yellow shorelines) coastal zones start (Figure 6.3). Although some accidents have occurred before the selected region, however, its importance comes from its unmodified nature. Starting from Rumelikavağı and Anadolukavağı, North region of Bosphorus remained natural, and these regions seem more vacant than the south of the city. It can be seen from the map of accidents that have occurred previously (Figure 6.1) that a number of accidents happened in the past around the Rumelifeneri coast.

General shoreline structures prevailing in the region are beaches in the European side and rocky shores in the Asian side. These shorelines are classified as ESI 1 and ESI 3, which indicates that the shoreline is affected by high wave energy. ESI 1 shorelines constitute rocky shoreline structures, which has low oil penetration and high natural attenuation capacity due to the high wave interaction. On the other hand, ESI 3 indicates the sandy beaches that do not show the same stability against any spill incident. Sand substratum could allow faster oil penetration. Hence, oil response teams should be careful around that habitat. A few recommended response methods for these types of coasts will be described in the following sections.

The region also houses a few bird and fish species. Native bird and fish species that could be affected by the spill are given in Table 6.1 and Table 6.2. Although, the species encountered in the region could change according to the time of the spill, these lists give the species that should be considered. Fish species that are listed will be the same in both 1 and 3 km damage zone. For the birds, Sarıyer and Koç University polygons are covered (for 3 km damage zone) in addition to the Bosphorus and Anadolukavağı polygons (within 1 km damage zone). Annex 3 gives all bird polygons within the GIS, sorted according to their observation sites.

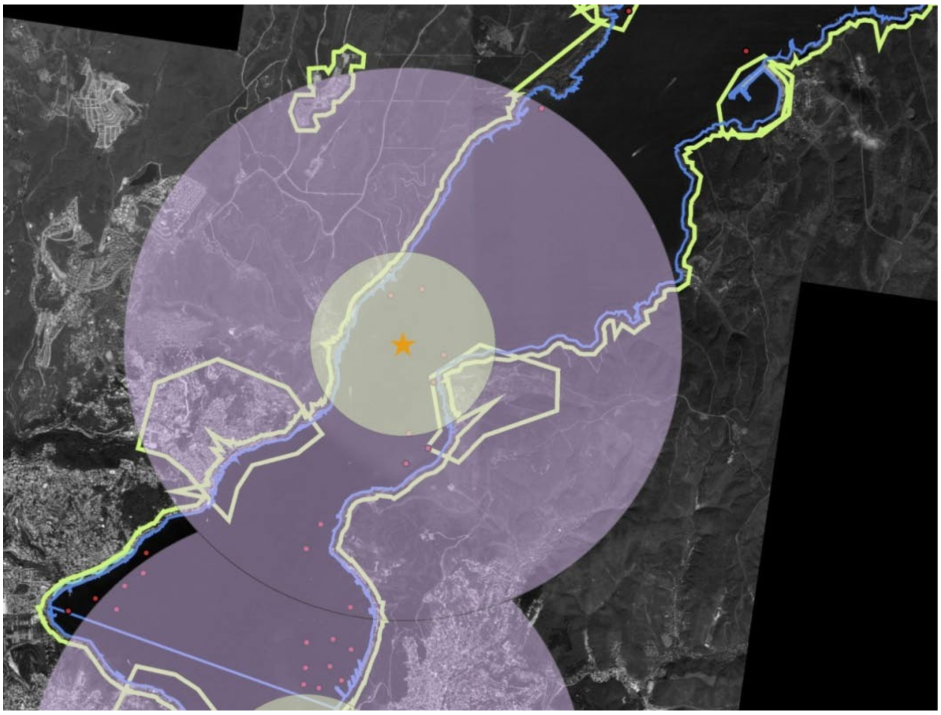


Figure 6.3: 1 – km and 3 – km damage zones around the P1 incident location

Table 6.1: 1 km and 3 km damage zones around the P1 incident location

1	Atherina mochon	Thin-lipped grey mullet	12	Mullus surmuletus	Striped mullet
2	Belone belone	Garfish	13	Sarda sarda	Atlantic Bonito
3	Engraulis encrasicolus	Anchovy	14	Scophtalmus maeoticus	
4	Gadus euxinus		15	Smaris alcedo	
5	Maena chrysalis	Low-body picarel	16	Smaris vulgaris	
6	Maena vulgaris		17	Spratella spratus	
7	Mugil auratus	Golden – grey mullet	18	Temnodon saltator	
8	Mugil capito	Thin-lipped grey mullet	19	Trachinus draco	Greater Weever
9	Mugil cephalus	Topbaş / Topan	20	Trachurus mediterraneus	Atlantic Horse
10	Mugil chelo		21	Trachurus trachurus	Horse Macarel
11	Mullus barbatus	Striped mullet	22	Trigla gurnardus	Grey Gurnard

So the species that could be harmed in an oil spill incident could be seen from Annex 3 through the bird polygons covered by damage zones.

6.2.2. Scenario #2: Manmade Shoreline Zone

Second spill site (Figure 6.4) is surrounded by the residential and recreational areas. Coastal zone is completely covered by man-made structures such as seawalls and groins. A major drawback of the region is that the Strait of Istanbul is the narrowest in this region and becomes threatening with its sharp turns. Both sides of the Bosphorus in the region are classified as 1B because of their modified structures. Area is rich in fish while there have been few bird observations made. Fish species that could be affected by an oil spill incident in the region are given in Table 6.2. In case spill response delays and oil reaches to the 3 – km damage zone, some fish species listed in the first scenario (Table 6.1) could be affected. Birds under threat could be seen from the Bosphorus and Tarabya regions in first damage zone and İstinye in second (3 – km) damage zone (Annex E).

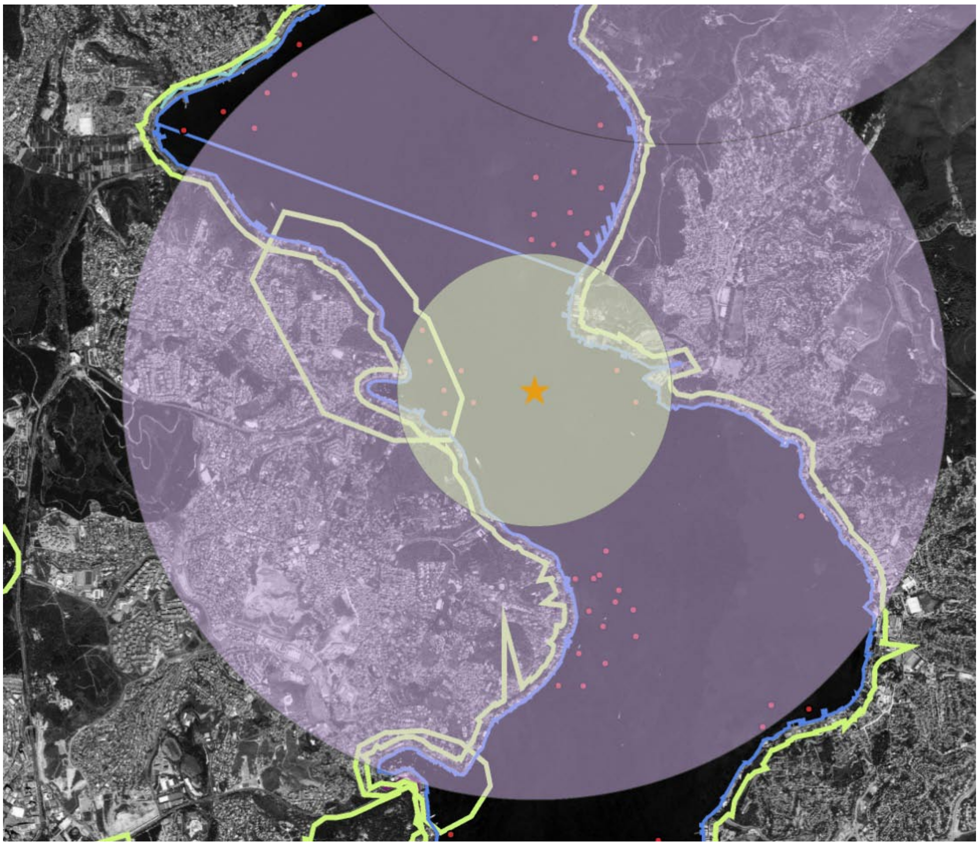


Figure 6.4: Second scenario location – P2

Table 6.2: Abundant fish species encountered around the P2 region.

1	Atherina mochon	Thin-lipped grey mullet
2	Belone belone	Garfish
3	Maena chrysalis	Low-body picarel
4	Maena vulgaris	
5	Mullus barbatus	Striped mullet
6	Mullus surmuletus	Striped mullet
7	Sarda sarda	Atlantic Bonito
8	Smaris alcedo	
9	Smaris vulgaris	
10	Temnodon saltator	
11	Trachinus draco	Greater Weever
12	Trachurus mediterraneus	Atlantic Horse Macarel
13	Trachurus trachurus	Horse Macarel
14	Trigla gurnardus	Grey Gurnard
15	Trigla lyra	Piper Gurnard

6.2.3. Scenario #3: Modified – Low Wave/Tidal Energy Shoreline Zone

This scenario has been chosen since the region is under low wave energy (Figure 6.5). But at the entrance of Golden Horn region (between Unkapanı and Galata Bridges) there is a high traffic due to the boats, ships and intra-city ferries while inner regions have lower traffic. Low wave speed makes oil proceed slower in the region thus giving time for the oil spill response. Region is classified as 8B, sheltered solid man-made structures. Since Golden Horn has been highly polluted in the last decades, its habitat has lost its diversity. However, some bird polygons are observed and mapped in the region. The only abundant fish species in the region is *Trachurus Trachurus* (İstavrit) but probably this species too comes from Bosphorus. Karaköy, Eminönü, Bosphorus and Balat regions cover observed bird species.

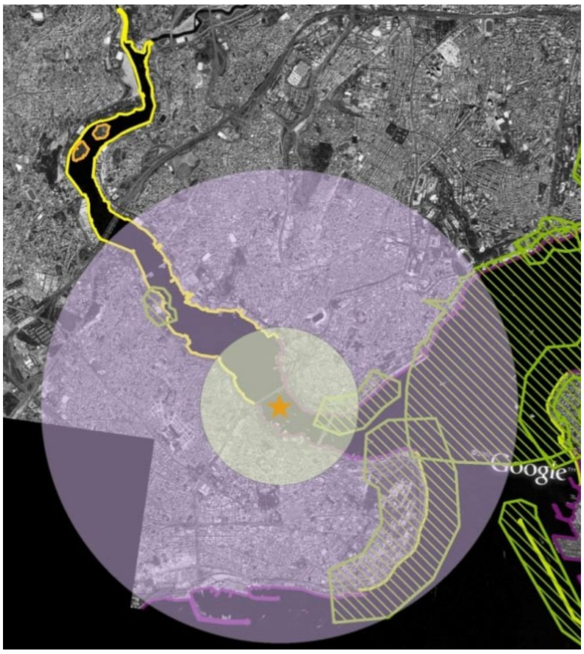


Figure 6.5: Last scenario location – P3

6.3. General Classification of the Coastal Zone of the Istanbul in Terms of Oil Spill Vulnerability

Two types of shorelines prevail in Istanbul. Man-made shoreline structures (such as jetty structures, ripraps, groins, piers and cement seawalls) cover great majority of the whole Istanbul shoreline. These structures generally form solid and invulnerable bodies against any oil spill incident. Shorelines of Golden Horn region are also highly modified although these shores are exposed to very low wave energy (generated by small boats). Second shoreline type generally lies in the less developed/urbanized northern districts of the city. This type is constituted by less modified (or mostly natural) shorelines.

Development level of the shoreline is important since it has a direct effect on the coastal habitats. Modified and natural coastal zones show different habitat characteristics even in the same environmental conditions. When a region is dominated by man-made structures, regional habitats generally are inclined to change in the way to harmonize with the new environment. On the other hand, when it is considered together with the atmospheric and hydraulic conditions, man-made shorelines are less vulnerable to oil spill incidents and generally oil pollution on the shoreline is removed by the wave action.

When these two kinds of shorelines are considered, the oil spill response strategy will differ in an oil spill incident in Bosphorus according to its occurrence site besides wind and wave direction and atmospheric conditions. Though a comprehensive oil spill response operation changes for different timeframes of the spill episode (since as the time passes oil products will change and proceed through sea (or even air) and cover multiple response techniques for different stages; environmental setting will be determining for rational response methods set.

In this section, sound response methods will be stated for these two coast types of Istanbul although other applicable techniques will be referred as well.

6.3.1. Modified Coastal Zones

6.3.1.1. Habitat Description and Sensitivity of Modified Coastal Zones

Man-made structures include vertical shore protection structures such as seawalls, piers, and bulkheads, as well as riprap revetments and groins, breakwaters, and jetties. Vertical structures can be constructed of concrete, wood, and corrugated metal. Concrete is the mostly used material for groin shores or seawalls (residential structures) while metal, wood and stone is used in piers, breakwaters (structures around harbors). Riprap revetments are constructed of boulder-sized pieces of rock, rubble, or formed concrete pieces placed parallel to the shoreline for shore protection. Riprap groins are oriented perpendicular to shore to trap sediment; jetties are designed to protect and maintain channels; and breakwaters are offshore structures constructed to protect an area from wave attack. Riprap structures have very large void spaces and are permeable, while seawalls and bulkheads have impermeable, solid substrates. These structures are very common along developed shores, particularly in harbors, marinas, and residential areas. The range in degree of exposure to waves and currents vary widely, from very low in dead-end canals, to very high on offshore breakwaters. Boat wakes can generate wave energy in otherwise sheltered areas as in Golden Horn district.

Man-made structures have a range of sensitivity to oil spills, depending on the degree of exposure to natural removal processes. These type of coastal zones have sparse biological communities and use, and there are often sources of pollutants or habitat degradation nearby, such as urban runoff, deep discharge systems, chronic small oil spills in marinas, poor water quality, and limited water circulation. More intrusive cleanup techniques are often conducted due to their lower biological use, higher public demand for oil removal for aesthetic reasons, and need to minimize human exposure to oil in populated areas. It is acknowledged that man-made structures can vary in permeability, cohesion, and mobility and, in turn, how they are affected by oiling. Though vertical structures are generally impermeable to oil penetration, oil can heavily coat rough surfaces, forming a band at the water line. Oil band on the Florya coasts still remains after the Volgoneft accident in 1999. During storms, oil can splash over the top and contaminate terrestrial habitats. There are such occurrences in Golden Horn region also. Riprap poses significant cleanup problems because of large void spaces between the riprap and heavy accumulations of debris. Large amounts of oil can become trapped in the riprap, where it is difficult to remove and a potential source of sheening and this kind of pollution could be encountered through Harem coasts, near harbor.

6.3.1.2. Oil spill response methods for modified coastal zones

Most appropriate response methods for modified coastal zones are listed below.

1. Manual Oil Removal/Cleaning and Debris Removal: This method is effective for removing debris and small, persistent pockets of oil.

2. High-Pressure, Cold-Water Flushing: This method is effective for removing sticky oils from solid surfaces and flushing pooled oil from riprap crevices, even for gasoline in populated areas. Its one major drawback is that pressured water may flush oiled sediments (if present) into near shore bottom habitats, and if it is used on gasoline spills it may transport the oil to more sensitive habitats.

3. Sorbents: This method should be used along riprap structures to recover residual sheening oil after other cleanup methods have been conducted. Its overuse results in excess waste generation.

4. Vacuum: Early use of vacuum on pooled oil in crevices can increase the oil recovery rate and minimize oil losses during flushing but it can only remove thick oil from accessible areas.

5. Natural Recovery: this method is the most effective for lighter oils and more exposed settings thus heavier oils may necessitate removing persistent residues.

Table 6.3: Relative environmental impact from response methods for manmade structures (ESI = 1B, 6B, 8B) (NOAA and API, 1994).

Oil Type / Response Method	Gasoline Products	Diesel-Like Oils	Medium Oils	Heavy Oils
Manual Oil Removal/Cleaning	–	A	A	A
Debris Removal	–	A	A	A
High-Pressure, Cold-Water Flushing	B	A	A	B
Sorbents	B	A	A	B
Vacuum	–	B	A	A
Natural Recovery	A	A	B	B
Flooding	B	A	A	C
Low-Pressure, Cold-Water Flushing	B	A	A	C
Low-Pressure, Hot-Water Flushing	–	B	B	B
High-Pressure, Hot-Water Flushing	–	B	B	B
Shoreline Cleaning Agents	–	B	B	B
Solidifiers	B	B	B	–
In-Situ Burning	–	B	B	B
Nutrient Enrichment	–	C	C	D
Steam Cleaning	–	C	C	C
Sand Blasting	–	C	C	C
Chemical Shoreline Pretreatment	–	I	I	I
Natural Microbe Seeding	–	I	I	I

Moreover, flooding, low-pressure hot/cold-water flushing, high pressure hot water flushing, using shoreline cleaning agents or solidifiers and in-situ burning are other methods that can be used on modified shorelines by generating low adverse effect on habitat. A matrix showing the most used oil spill response method and relative effect of each on manmade shorelines is given below in Table 6.3. In the table, habitat impact level of the response method is notified by the letters. Relative environmental impact of each response method for the specific environment or habitat for each oil type, using the following definitions:

A = May cause the least adverse habitat impact.

B = May cause some adverse habitat impact.

C = May cause significant adverse habitat impact.

D = May cause the most adverse habitat impact.

I = Insufficient Information - impact or effectiveness of the method could not be evaluated at this time.

"-" = Not applicable for this oil type.

This notification is also used in the matrix given for bedrock habitats. Further information about response methods and their adverse effects on the each habitat classified by ESI could be found in the NOAA and API (1994).

6.3.2. Natural Coastal Zones

6.3.2.1. Habitat Description and Sensitivity of Natural Coastal Zones

This shoreline type is characterized by an impermeable rocky substrate. The rock surface can be highly irregular, with numerous cracks and crevices. The slope of the shoreline varies from vertical rocky cliffs (such as Garipçe, Anadolukavağı regions) to shelving bedrock shores (e.g. North facet of the rocky platforms at Rumelifeneri) where flat or gently dipping rock layers have been cut by waves into wide platforms. Bedrock habitats are exposed to wide ranges in wave energy but there can be a thin veneer of sand and gravel sediments on

the rock platforms, although storm waves will strip these sediments off exposed shorelines. Boulder-sized debris can accumulate at the base of exposed rocky cliffs and exposed rocky platforms (e.g. Rumelifeneri).

Sensitivities shown by the bedrock shoreline habitats depend upon their degree of exposure to natural removal processes. They have hardly any attached organisms and plants which mean that rocky shore productivity is typically low. However, they may provide shelter to fish and nesting sites for birds which can be present in large numbers in near shore waters. Any oil that is deposited in the exposed settings will be rapidly removed from its faces, although oil persistence on any specific shoreline segment is related to the incoming wave energy during (and shortly after) a spill. The most resistant oil (mostly heavy fraction of the spilled oil) would occur as a patchy band at or above the high water line, or deposited in any surface sediments.

In sheltered settings, oil will readily adhere to the rough rocky surface, forming a distinct band along the water line. Cracks and crevices will be sites of oil pooling and persistence. Oil will also penetrate and persist in any surface sediment. Medium to heavy oils can be very sticky and form thick black bands, while lighter oils are more readily removed by wave action, evaporation, and response efforts.

Table 6.4: Relative environmental impact from response methods for bedrock shores (ESI = 1A, 2, 8A) (NOAA and API, 1994).

Oil Type **Response Method**	**Gasoline Products**	**Diesel-Like Oils**	**Medium Oils**	**Heavy Oils**
Response Method	Gasoline Products	Diesel-Like Oils	Medium Oils	Heavy Oils
Natural Recovery	A	A	A	B
Debris Removal	–	A	A	A
Sorbents	B	A	A	B
Flooding	B	A	B	C
Low-Pressure, Cold-Water Flushing	B	A	A	C
High-Pressure, Cold-Water Flushing	B	B	B	B
Manual Oil Removal/Cleaning	–	B	B	A
Vacuum	–	B	B	B
In-Situ Burning	–	B	B	B
Shoreline Cleaning Agents	–	–	B	B
Solidifiers	–	B	B	–
Low-Pressure, Hot-Water Flushing	–	C	B	B
Nutrient Enrichment	–	C	C	D
High-Pressure, Hot-Water Flushing	–	D	C	C
Steam Cleaning	–	D	D	D
Sand Blasting	–	D	D	D
Natural Microbe Seeding	–	I	I	I
Chemical Shoreline Pretreatment	–	I	I	I

Another matrix showing the most used oil spill response method and relative effect of each on bedrock shorelines is given below in Table 6.4.

6.3.2.2. Oil spill response methods for bedrock coasts

Methods listed below have the least adverse effects on the bedrock shores so these are offered to be performed primarily.

1. Natural Recovery: Sheltered bedrock may need cleanup because of slow natural removal rates if wave interaction with the rocky shore is low. Cleanup of larger spills may be needed because of the amount of oil present.
2. Debris Removal: Degree of oiling that warrants debris removal and disposal depends on human and sensitive resource use of the site.

3. Sorbents: Overuse of this method generates excess waste. Physical removal rates of heavy oils will be slow, so less oil will be mobilized for recovery by sorbents

7. CONCLUSIONS AND RECOMMENDATIONS

7.1. Impact Area of This Study

The study is applied in the highly populated residential shoreline of the Bosphorus. Shoreline is accepted as 100 m according to the related legislation. Ground surveys and data collection is conducted from Yenikapı up to the Sarıyer district in the European side and from Moda up to the Kanlıca in the Asian side. Beyond these areas, Goldenhorn estuary is also covered. However, with the help of the Google Earth imagery, the entire coastal zone of the Bosphorus area is classified with appropriate ESI rankings although these areas were not visited yet.

The aim of this study is to prepare a guideline to those interested parties that desire to prepare a sensitivity map for Turkey on GIS environment. Chapter 3 is written to explain the methodology as it has not been applied in Turkey yet. Alternately, for achieving this target, the ESI methodology is applied on the Bosphorus. With its high marine traffic (both transit passing ships and local traffic) and a past with disastrous tanker accidents, authorities controlling Strait of Istanbul area should seriously consider wise management of vessel traffic for protecting natural and built environment. A system like the one recommended in this chapter (which also covers the ESI sensitivity mapping system) could be used for environmental planning and policy making purposes. However, it should be revised and updated periodically.

This study will have a positive effect on the improvement of ecological status, when it is used rationally. By using this sensitivity map, authorized institutions may prepare oil spill response plans and required response facilities. Protecting the shoreline, ecosystem and the sea will bring both economical and ecological advantages.

It should be noted that either all stages of a sensitivity mapping project or any item within ESI (such as shoreline classification only) could be mapped for a coastal zone. Developing sensitivity maps is a must for countries like Turkey, which has long shoreline and utilize the sea by various activities. Fortunately, the Ministry of Environment and Forestry of Turkish Republic decided to apply a risk assessment for all shorelines. In the first step, it is determined to give competancy licences for private companies who develop risk assessment studies for coastal zones. ESI is a good indexing system with its easily–understandable structure. This gives the opportunity that ESI could be used by non-technical managers besides the oil–spill responders and contingency planners. Accordingly, application of ESI for all Turkish shorelines, prior to a risk assessment is recommended.

Importance of this sensitivity mapping study is obvious for Turkey and Turkish Straits due to the (1) increase in the number of ships passed through the Straits (Bosphorus and Dardanelles) and (2) increase in the oil (and hazardous chemical) transportation. This phenomenon poses a risk for Bosphorus and Istanbul people since the shorelines houses to concentrated coastal residential use, priceless historical and cultural heritage, and seasonal migration path for economically important fishes.

In view of the fact that ESI mapping system helps to,

- Develope a preparedness mechanism for a fast response,
- Mitigate the effects of oil spill incidents,
- Develop land use plans,
- Develop regional environmental policies,
- Implement EIA studies, ESI mapping system should be applied by the government in order to generate sustainable coastal zone policies. This study will be an example step for achieving this aim.

7.2. System Recommendations for Better Protection of Coastal Waters

Bosphorus is one of the most important and unique marine pathways throughout the world. Beyond the advantages as a natural gateway between the Black Sea and Mediterranean Sea, it also conceals some dangers. Its morphology is the most obvious threat for its visitors when united with the meteorological conditions. Due to these facts, the only solution for reaching sustainable use of coastal zone is to establish an integrated structure. In this section, an overall system recommendation is mentioned, ESI sensitivity mapping studies are just a part of it.

System is reflected as an overall system which has a number of sub-elements. These sub-elements interact with each other via their each output. Sub-elements of the system could be named as (1) navigational safety, (2) coastal identification, (3) emergency definition, (4) emergency planning & response, and (5) integrated coastal zone management (Figure 7.1).

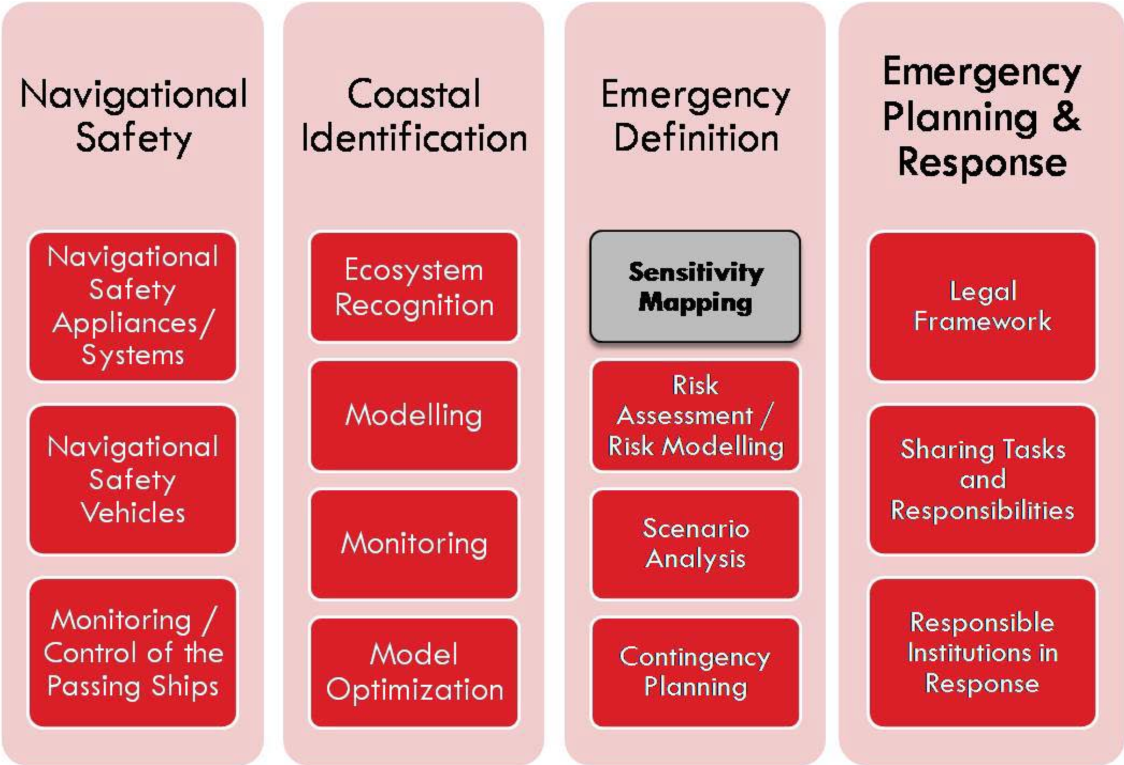


Figure 7.1: Components of the offered Coastal Management System

For navigational safety, some precautions have been taken in the recent years and all of the services and structures gathered under this structure named as VTS (Vehicle Traffic Services). These services cover radar towers, CCTV cameras, Doppler current sensors, meteorological and physicochemical parameter profilers, dGPS reference stations, etc. Most of these equipments are used within 13 unmanned marine traffic observation towers (Figure 7.2).

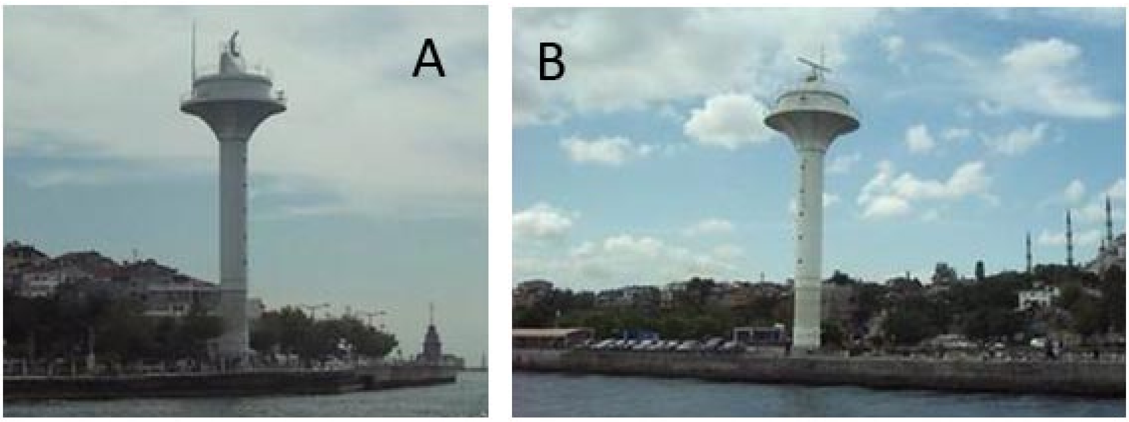


Figure 7.2: Unmanned Marine Traffic Observation Towers. a) Üsküdar, b) Ahırkapı

Coastal identification component should be used for getting a detailed x-ray photograph of the coastal zone. Modeling of the ecosystem and shoreline processes makes future estimations possible for the area. If the area is under detailed monitoring, all the changes and extreme conditions will also be distinguished by sending an updated message to the total management system.

With the help of the definition data of the shoreline generated by the coastal identification procedures, emergency definition stage allow to make estimations about the threats that could harm the ecosystem. ESI assist on the definition of the sensitive habitats and coastal zones. By using a sensitivity map, different scenarios could be developed for different disaster tiers and to get prepared by using these scenarios.

The last element is the emergency planning and response, work connected with emergency definition element for determining required institutions and legal framework to eliminate the threats. This stage is more likely to be established by the national government.

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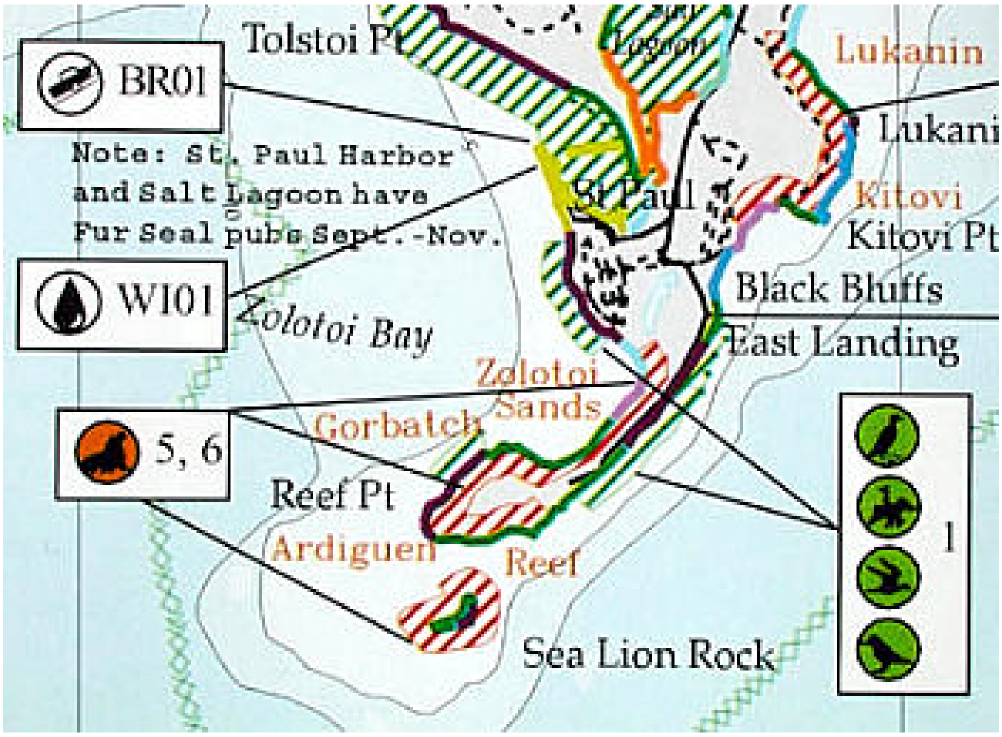
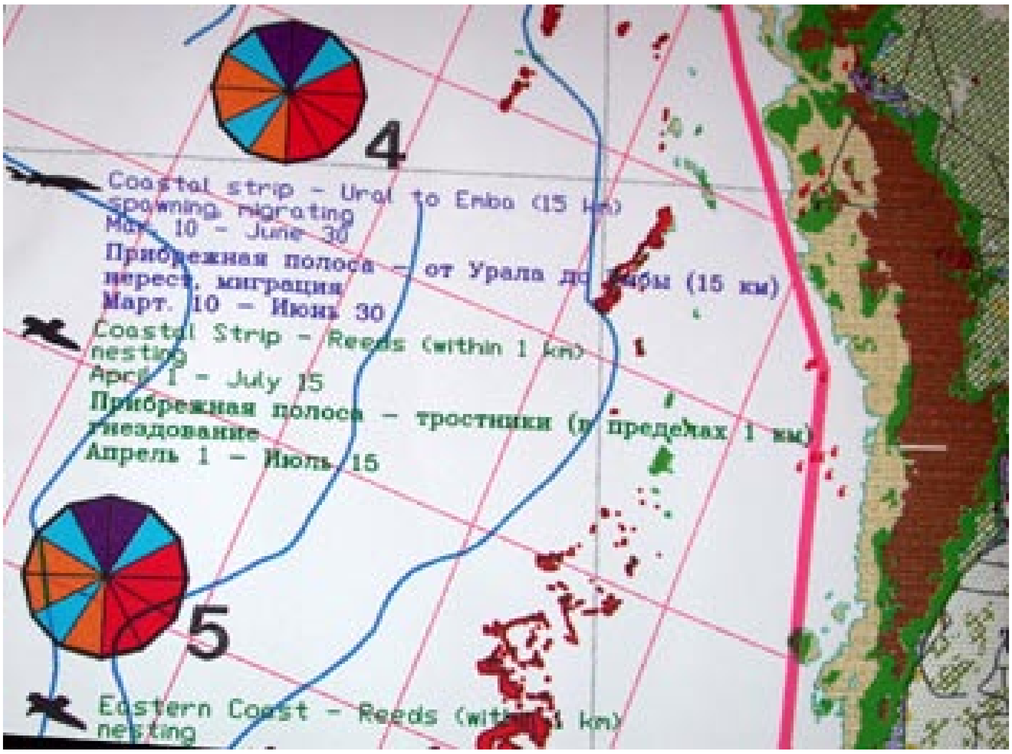
ANNEXES

ANNEX A. Sensitivity Map Examples From Different Countries (OSI, 2007)

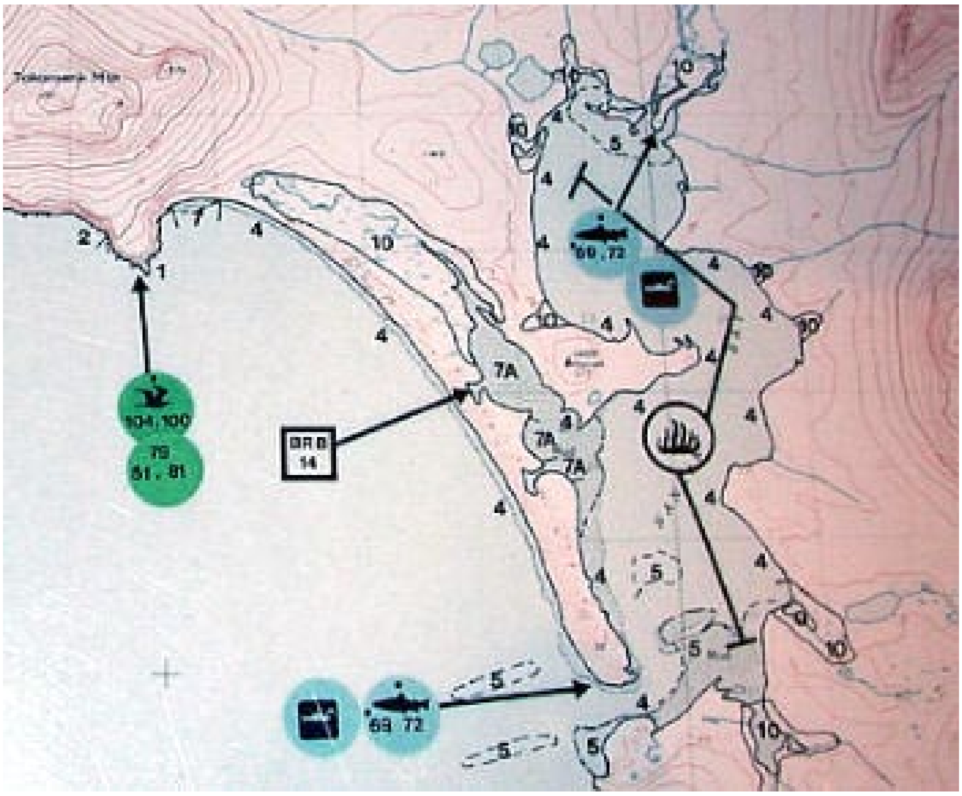


Alaska



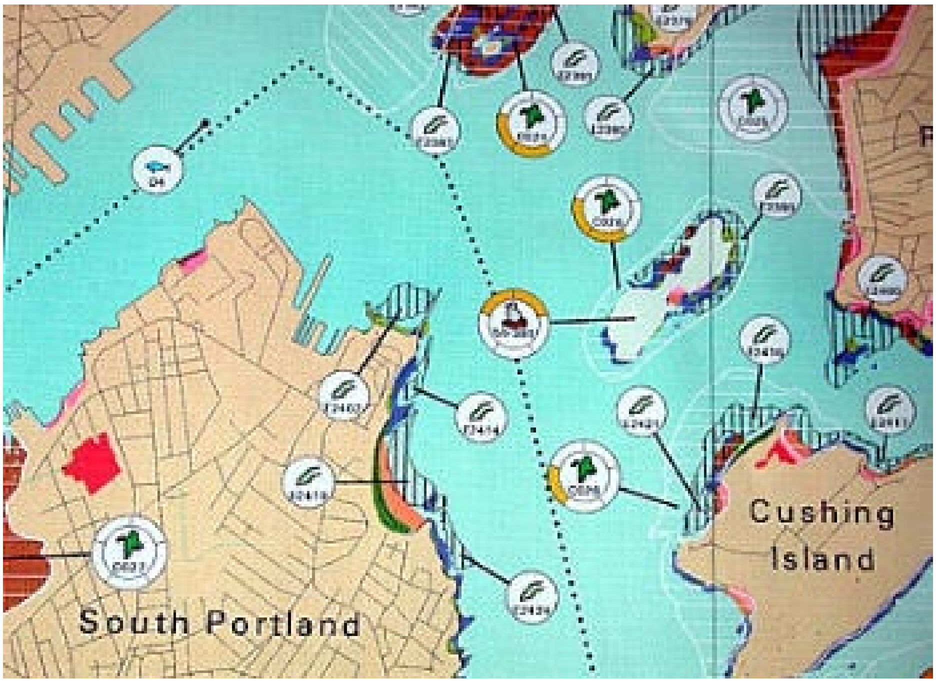
Caspian Sea

Kuwait



Alaska, Bristol Bay

Hamburg, Germany

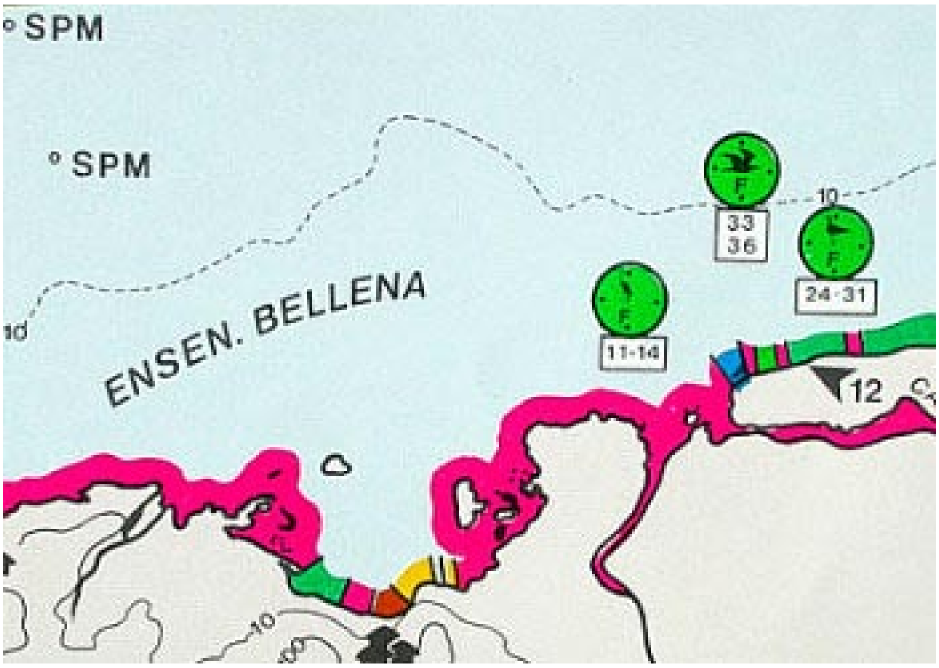


Maine, USA

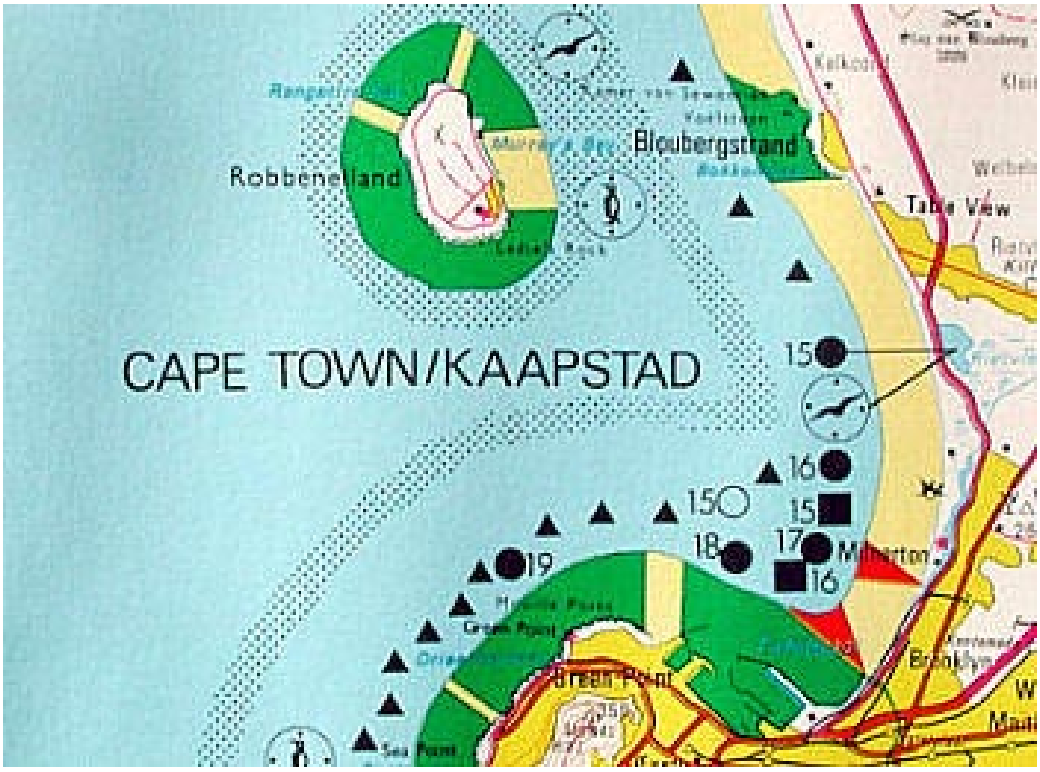
Massachusetts, USA

St. Lawrance, Canada

Nigeria



Panama



South Africa

ANNEX B. Definition of ESI Rankings (Petersen et al., 2002).

In this section ten main shoreline groupings will be given with their main characteristics in terms of oil spill vulnerability, natural (oil) attenuation ability, clean-up easiness (and cost). Classification is made according to the criteria listed in the Chapter 3.4 though it was developed for the US shorelines. Necessity of development of such a classification for Turkish shorelines will be highlighted again since it barely shows the sensitive coastal areas.

Shoreline classification is based on these criteria:

- Wave exposure degree
- Wave reflection patterns
- Slope of the intertidal zone
- Substrate / Grain size – type
- Sediment accumulation pattern
- How flora / fauna behave against spilled oil

Rank 1: Exposed, Impermeable Vertical Substrates

The essential elements are:

- Regular exposure to high wave energy or tidal currents.
- Strong wave-reflection patterns are common.
- Substrate is impermeable (usually bedrock or cement) with no potential for subsurface penetration.
- Slope of the intertidal zone is 30 degrees or greater, resulting in a narrow intertidal zone.

Rank 2: Exposed, Non-Vertical, Impermeable Substrates

The essential elements are:

- Regular exposure to high wave energy or tidal currents.
- Regular strong wave-reflection patterns.
- Slope of the intertidal zone is usually less than 30 degrees, resulting in a wider intertidal zone; it can be less than five degrees and the intertidal zone can be up to hundreds of meters wide.
- Substrate is impermeable with no potential for subsurface penetration over much of the intertidal zone, although there can be a thin, mobile veneer of sediment in patches on the surface.
- Sediments can accumulate at the base of bedrock cliffs, but are regularly mobilized by storm waves.
- By the nature of the setting, attached organisms are hardy and used to high hydraulic impacts and pressures.

Rank 3: Semi-Permeable Substrate, Low Potential for Oil Penetration and Burial; infauna present but not usually abundant

The essential elements are:

- The substrate is semi-permeable (fine- to medium-grained sand), with oil penetration usually less than ten cm.
- Sediments are well-sorted and compacted (hard).
- On beaches, the slope is very low, less than five degrees.
- The rate of sediment mobility is low, so the potential for rapid burial is low.
- Surface sediments are subject to regular reworking by waves and currents.
- There are relatively low densities of infauna.

Rank 4: Medium Permeability, Moderate Potential for Oil Penetration and Burial; infauna present but not usually abundant

The essential elements are:

- The substrate is permeable (coarse-grained sand), with oil penetration up to 25 cm possible.
- The slope is intermediate, between 5 and 15 degrees.
- Rate of sediment mobility is relatively high, with accumulation of up to 20 cm of sediments within a single tidal cycle possible; there is a potential for rapid burial and erosion of oil.
- Sediments are soft, with low trafficability.
- There are relatively low densities of infauna.

Rank 5: Medium-to-High Permeability, High Potential for Oil Penetration and Burial; infauna present but not usually abundant

The essential elements are:

- Medium-to-high permeability of the substrate (mixed sand and gravel) allows oil penetration up to 50 cm.
- Spatial variations in the distribution of grain sizes are significant, with finer-grained sediments (sand to pebbles) at the high-tide line and coarser sediments (cobbles to boulders) in the storm berm and at the toe of the beach.
- The gravel component should comprise at least 20 percent of the sediments.
- The slope is intermediate, between eight and 15 degrees.
- Sediment mobility is very high only during storms, thus there is a potential for rapid burial and erosion of oil during storms.
- Sediments are soft, with low trafficability.
- Infauna and epifauna populations are low, except at the lowest intertidal levels.

Rank 6: High Permeability, High Potential for Oil Penetration and Burial

The essential elements are:

- The substrate is highly permeable (gravel-sized sediments), with penetration up to 100 cm.
- The slope is intermediate to steep, between ten and 20 degrees.
- Rapid burial and erosion of shallow oil can occur during storms.
- There is high annual variability in degree of exposure, and thus in the frequency of mobilization by waves.
- Penetration can extend to depths below those of annual reworking.
- Sediments have lowest traffic ability of all beaches.
- Natural replenishment rate of sediments is the slowest of all beaches.
- Infauna and epifauna populations are low, except at the lowest intertidal levels.

Rank 7: Exposed, Flat, Permeable Substrate; infauna usually abundant

The essential elements are:

- They are flat (less than three degrees) accumulations of sediment.
- The highly permeable substrate is dominated by sand, although there may be silt and gravel components.
- Sediments are water-saturated so oil penetration is very limited.
- Exposure to wave or tidal-current energy is evidenced by ripples in sand, scour marks around gravel, or presence of sand ridges or bars.
- Width can vary from a few meters to nearly one kilometer.
- Sediments are soft, with low trafficability.
- Infaunal densities are usually very high.

Rank 8: Sheltered Impermeable Substrate, Hard; epibiota usually abundant

The essential elements are:

- They are sheltered from wave energy or strong tidal currents.
- Substrate is hard, composed of bedrock, man-made materials, or stiff clay.
- The type of bedrock can be highly variable, from smooth, vertical bedrock, to rubble slopes, which vary in permeability to oil.
- Slope is generally steep (greater than 15 degrees), resulting in a narrow intertidal zone.
- There is usually a very high coverage of attached algae and organisms.

Rank 9: Sheltered, Flat, Semi-Permeable Substrate, Soft; infauna usually abundant

The essential elements are:

- They are sheltered from exposure to wave energy or strong tidal currents.
- The substrate is flat (less than three degrees) and dominated by mud.
- The sediments are water-saturated, so permeability is very low, except where animal burrows are present.
- Width can vary from a few meters to nearly one kilometer.

- Sediments are soft, with low trafficability.
- Infaunal densities are usually very high.

Rank 10: Vegetated Emergent Wetlands

The essential elements are:

- The substrate is flat and can vary from mud to sand, though high organic, muddy soils are most common.
- Various types of wetland vegetation, including herbaceous grasses and woody vegetation cover the substrate. Floating aquatic vegetation (FAV) and submersed aquatic vegetation (SAV) are treated separately from the ESI classification as biological resources under the habitat/rare plant coverage.

ANNEX C. Common fish species in Bosphorus (Artüz, 1999)

NAME (Lat.)	NAME (Tur.)	ABUNDANCY					MONTHS											
							Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Alosa fallax nilotica	Tirsi	++	+	-	+													
Ammodytes cicerellus		+	-	-	+													
Anguilla anguilla	Yılan Balığı	+	-	-	+													
Argentina sphyraena	Derinsu Gümüş Balığı	-	-	-	+		-	+	+	+	+	-	-	-	-	-	-	-
Arnoglossus grohmanni	Dil Balığı	+	+	-	+													
Arnoglossus kessleri		+	+	-	+													
Arnoglossus laterna	Dil Balığı	+	+	-	+													
Atherina hepastus	Çamuka	+	+	-	+		-	-	-	+	+	+	-	-	-	-	-	-
Blennius galerita		+	+	-	+													
Blennius gattorugine	Bantlı Horozbina	+	+	-	+													
Blennius ocellaris	Kelebek Horozbina	+	+	-	+													
Blennius pavo	İbikli Horozbina	+	+	-	+													
Blennius sanguinolentus	Horozbina	+	+	-	+													
Blennius sphinx		+	+	-	+													
Blennius tentacularis	Kahküllü Horozbina	+	+	-	+													
Boops boops	Altınkuşak / Kupez	+	-	-	+		-	-	-	-	-	-	-	-	+	+	-	-
Boops salpa	Sarpa	+	-	-	+													
Callionymus lyra	Üzgün	-	-	-	+													
Capros aper		-	-	-	+													
Chromis chromis	Papaz Balığı	+	+	-	+													
Citharus linguatula	Pisi Balığı	-	-	-	+													
Conger conger	Mığrı	+	+	-	+													
Ctenolabrus rupestris	Taraklı Çırçır	+	+	-	+													

ANNEX C. Common fish species in Bosphorus (Artüz, 1999) (continued)

Engraulis encrasicolus	Hamsi	+++	+	-	+		-	-	-	+	+	+	+	+	+	+	-	-
Flessus vulgaris	Dere Pisisi	+	+	-	+													
Gadus euxinus		+++	+	+	+		+	+	+	+	+	-	-	-	-	-	-	-
Gasterosteus aculeatus		+	+	-	+													
Gobius cobitus	Taş Kayası	+	+	-	+													
Gobius cruentatus	Tekir Kayası	+	+	-	+													
Gobius kessleri		+	+	-	+													
Gobius melanostomus		+	+	+	+													
Gobius niger	Kömürcün Kayası	+	++	+	+		-	-	-	-	-	+	+	+	-	-	-	-
Gobius paganellus	Hortum Kayası	+	+	-	+													
Gobius platyrostris		+	+	-	+													
Gobius rattan		+	+	-	+													
Gobius syrman		+	+	-	+													
Hippocampus brevirostris	Denizatı	+	++	-	+													
Julis vulgaris		+	+	-	+													
Labrus bergylta	Kikla	+	+	+	+													
Labrus mixtus		+	+	+	+													
Labrus merula		+	+	+	+													
Labrus turdus		+	+	+	+													
Labrus viridis	Yeşil Lapin	+	+	+	+													
Lepadogaster bimaculatus		+	+	-	+													
Lepadogaster candollii		+	+	+	+													
Lepadogaster gouannii	Yapışan	+	+	+	+													

ANNEX C. Common fish species in Bosphorus (Artüz, 1999) (continued)

Mugil so-iuy	Rus Kefali	+	+	+	+													
Naucrates ductor	Kılavuz Balığı	+	+	-	+													
Nerophis teres	Deniz İğnesi	+	+	-	+													
Ophidium barbatus	Kayış Balığı	+	+	-	+													
Pegusa natus	Dil Balığı	+	-	-	+													
Scophtalmus maximus		-	-	-	+													
Scorpaena ustulata		+	-	-	+													
Sebastes dactylopterus		-	-	-	+													
Solea kleinii		-	+	-	+													
Solea lutea		-	+	-	+													
Solea melanochira		-	+	-	+													
Solea monochir		-	+	-	+													
Solea ocellata		-	+	-	+													
Solea variegata		+	+	-	+													
Solea vulgaris	Dil Balığı	-	+	-	+		-	-	-	+	+	+	-	-	-	-	-	-
Spyraena spyraena	Iskarmoz	+	-	-	+													
Spratella spratus		+++	-	-	+		-	-	-	-	+	+	-	-	-	-	-	-
Symphodus scina		+	+	-	+													
Syngnatus acus	Deniz İğnesi	+	+	+	+													
Syngnatus schmidti		+	+	+	+													
Syngnathus taeniotus		+	+	-	+													
Syngnathus typhle		+	+	-	+													
Zeus faber	Dülger Balığı	+	-	-	+													
Zostericola ophiocephala		+	-	-	+													

ANNEX D - Observed bird species in and around İstanbul (Kuşbank, 2007)

SPECIES NAME	COMMON NAME	SPECIES TYPE	OBS #	TOT. INDIV. #
Ardea cinerea	Gray Heron	Wading	192	3275
Bucephala clangula	Common goldeneye	Waterfowl		170
Calonectris diomedea	Cory's shearwater	Pelagic	3	14
Chlidonias hybrida		Gull_Turn	4	206
Chlidonias leucopterus	White-winged black tern	Gull_Turn	5	334
Cygnus columbianus	Tundra (whistling) swan	Waterfowl	3	36
Cygnus cygnus		Waterfowl	8	235
Cygnus olor	Mute swan	Waterfowl	22	204
Fulica atra	Eurasian coot	Waterfowl	204	31748
Gavia arctica	Arctic loon	Diving	19	634
Gavia stellata	Red-throated loon	Diving	1	5
Larus cachinnans	Yellow-legged herring gull	Gull_Turn	332	32569
Larus canus	Mew gull	Gull_Turn	32	318
Larus fuscus	Lesser black-backed gull	Gull_Turn	24	825
Larus genei	Slender-billed gull	Gull_Turn	29	430
Larus ichthyaetus	Great black-headed gull	Gull_Turn	4	36
Larus marinus	Great black-backed gull	Gull_Turn	7	205
Larus melanocephalus	Mediterranean gull	Gull_Turn	57	2261
Larus minutus	Little gull	Gull_Turn	20	342
Larus ridibundus	Black-headed gull	Gull_Turn	221	12393
Mergellus albellus			30	2611
Mergus merganser	Common merganser	Waterfowl	2	23
Mergus serrator	Red-breasted merganser	Waterfowl	13	1565
Pandion haliaetus	Osprey	Raptor	11	1068
Pelecanus onocrotalus	Pelican	Diving	9	248
Phalacrocorax aristotelis	Cormorant	Diving	57	5186
Phalacrocorax carbo	Great cormorant	Diving	226	106884
Phalacrocorax pygmeus		Diving	96	56157
Podiceps auritus	Horned grebe	Diving	3	1600
Podiceps cristatus	Great-crested grebe	Diving	166	211347
Podiceps grisegena	Red-necked grebe	Diving	2	102
Podiceps nigricollis	Eared grebe	Diving	78	11850
Puffinus yelkouan	Shearwater	Pelagic	118	25028
Rissa tridactyla	Black-legged kittiwake	Pelagic	3	871
Somateria mollissima	Common eider	Waterfowl	5	2511
Sterna bengalensis	Lesser crested tern	Gull_Turn	1	5
Sterna hirundo	Common tern	Gull_Turn	24	3899
Sterna sandvicensis	Sandwich tern	Gull_Turn	29	8876
Tachybaptus ruficollis	Little grebe	Diving	136	23133
Tadorna ferruginea	Ruddy shelduck	Waterfowl	4	3104
Tadorna tadorna	Common shelduck	Waterfowl	27	226

ANNEX E – Bird species sorted with their observation polygons

Anadolu Feneri
Gavia arctica
Larus canus
Podiceps cristatus
Podiceps grisegena
Podiceps nigricollis
Puffinus yelkouan

Anadolu Hisarı
Larus fuscus
Puffinus yelkouan

Anadolu Kavağı
Chlidonias leucopterus
Larus cachinnans
Larus melanocephalus
Larus ridibundus
Phalacrocorax carbo
Puffinus yelkouan

Arnavutköy
Puffinus yelkouan

Balat
Podiceps cristatus

Baltalimanı
Larus fuscus
Larus ridibundus
Puffinus yelkouan

Bebek
Fulica atra
Phalacrocorax aristotelis
Tachybaptus ruficollis

Beşiktaş
Larus cachinnans
Larus minutus
Puffinus yelkouan

Boğaziçi
Ardea cinerea
Gavia arctica
Larus cachinnans
Larus canus
Larus fuscus
Larus melanocephalus
Larus ridibundus
Pandion haliaetus
Phalacrocorax aristotelis
Phalacrocorax carbo
Podiceps cristatus
Podiceps nigricollis
Puffinus yelkouan
Sterna bengalensis
Sterna sandvicensis
Tachybaptus ruficollis

Eminönü
Ardea cinerea
Fulica atra
Gavia arctica
Larus cachinnans
Larus canus
Larus fuscus
Larus ridibundus
Phalacrocorax aristotelis
Phalacrocorax carbo
Podiceps cristatus
Podiceps nigricollis
Puffinus yelkouan
Puffinus yelkouan

Emirgan Korusu
Larus cachinnans

İstinye
Larus cachinnans
Phalacrocorax aristotelis
Phalacrocorax carbo

Fenerbahçe Burnu
Larus cachinnans
Larus fuscus
Larus ridibundus
Phalacrocorax aristotelis
Phalacrocorax carbo
Phalacrocorax pygmeus
Podiceps cristatus
Podiceps nigricollis

Garipçe Köyü
Larus cachinnans
Larus ridibundus
Puffinus yelkouan

Haydarpaşa / Dalgakıran
Ardea cinerea
Fulica atra
Larus cachinnans
Larus fuscus
Larus marinus
Larus melanocephalus
Larus ridibundus
Phalacrocorax aristotelis
Phalacrocorax carbo
Puffinus yelkouan
Sterna hirundo

Kadıköy
Ardea cinerea
Fulica atra
Larus cachinnans
Larus canus
Larus melanocephalus
Larus ridibundus
Pelecanus onocrotalus
Phalacrocorax aristotelis
Phalacrocorax carbo
Podiceps cristatus
Podiceps nigricollis
Sterna sandvicensis

Karaköy
Larus cachinnans
Larus ridibundus
Phalacrocorax aristotelis
Phalacrocorax carbo
Podiceps cristatus
Puffinus yelkouan

Koç Üniversitesi
Larus cachinnans
Larus fuscus
Larus melanocephalus
Larus ridibundus
Pandion haliaetus
Phalacrocorax carbo
Puffinus yelkouan

Maslak - İTÜ Kampüs
Fulica atra
Larus cachinnans
Larus ridibundus
Phalacrocorax carbo
Podiceps cristatus
Tachybaptus ruficollis

Ortaköy
Calonectris diomedea

Parkorman
Larus cachinnans

Rumeli Feneri
Fulica atra
Gavia arctica
Gavia stellata
Larus cachinnans
Larus canus
Larus fuscus
Larus ichthyaetus
Larus melanocephalus
Larus ridibundus
Mergus serrator
Phalacrocorax aristotelis
Phalacrocorax carbo
Podiceps cristatus
Podiceps nigricollis
Puffinus yelkouan
Rissa tridactyla
Tachybaptus ruficollis

Sarıyer
Larus cachinnans
Larus melanocephalus
Phalacrocorax carbo
Puffinus yelkouan
Sterna sandvicensis

Seyrantepe
Larus cachinnans
Larus ridibundus

Suadiye
Mergus serrator
Phalacrocorax aristotelis
Phalacrocorax carbo
Podiceps cristatus

Tarabya
Larus cachinnans
Larus fuscus
Larus ridibundus
Phalacrocorax aristotelis
Phalacrocorax carbo
Podiceps cristatus
Puffinus yelkouan
Sterna sandvicensis

Üsküdar
Ardea cinerea
Gavia arctica
Larus cachinnans
Larus ridibundus
Pandion haliaetus
Pelecanus onocrotalus
Phalacrocorax aristotelis
Phalacrocorax carbo
Podiceps cristatus
Podiceps nigricollis
Puffinus yelkouan
Sterna sandvicensis

Yıldız Parkı
Ardea cinerea
Larus cachinnans

ANNEX F - Seasonality - Life History Forms - Bird

ELEMENT: Bird		3. Seasonal Presence												Life-history Stage and Reproductive Timespans			
1. Season ID	2. Species Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	4. Nesting	5. Laying	6. Hatching	7. Fledging
1	*Ardea cinerea*	X	X	X		X				X	X			-	-	-	-
2	*Bucephala clangula*	X											X	-	-	-	-
3	*Calonectris diomedea*		X											-	-	-	-
4	*Chlidonias hybrida*	X	X											-	-	-	-
5	*Chlidonias leucopterus*			X						X	X			-	-	-	-
6	*Cygnus columbianus*								X					-	-	-	-
7	*Cygnus cygnus*	X												-	-	-	-
8	*Cygnus olor*							X	X	X				-	-	-	-
9	*Fulica atra*	X	X	X				X			X		X	-	-	-	-
10	*Gavia arctica*				X			X		X	X	X		-	-	-	-
11	*Gavia stellata*	X												-	-	-	-
12	*Larus cachinnans*	X	X	X	X	X	X	X		X	X	X	X	-	-	-	-
13	*Larus canus*	X	X	X						X		X	X	-	-	-	-
14	*Larus fuscus*	X	X	X	X			X						-	-	-	-
15	*Larus genei*									X	X	X		-	-	-	-
16	*Larus ichthyaetus*	X	X											-	-	-	-
17	*Larus marinus*												X	-	-	-	-
18	*Larus melanocephalus*					X			X	X	X	X	X	-	-	-	-
19	*Larus minutus*	X		X										-	-	-	-
20	*Larus ridibundus*	X	X	X	X	X	X	X			X		X	-	-	-	-
21	*Mergellus albellus*						X							-	-	-	-
22	*Mergus merganser*					X								-	-	-	-
23	*Mergus serrator*				X									-	-	-	-

ANNEX F - Seasonality - Life History Forms – Bird (continued)

ELEMENT: Bird		3. Seasonal Presence												Life-history Stage and Reproductive Timespans			
1. Season ID	2. Species Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	4. Nesting	5. Laying	6. Hatching	7. Fledging
24	*Pandion haliaetus*		X	X										-	-	-	-
25	*Pelecanus onocrotalus*					X	X							-	-	-	-
26	*Phalacrocorax aristotelis*		X	X	X	X								-	-	-	-
27	*Phalacrocorax carbo*	X	X	X	X	X				X	X	X	X	-	-	-	-
28	*Phalacrocorax pygmeus*	X	X								X	X		-	-	-	-
29	*Podiceps auritus*	X												-	-	-	-
30	*Podiceps cristatus*	X		X	X	X		X		X		X	X	-	-	-	-
31	*Podiceps grisegena*								X					-	-	-	-
32	*Podiceps nigricollis*			X	X	X		X		X	X		X	-	-	-	-
33	*Puffinus yelkouan*	X	X									X	X	-	-	-	-
34	*Rissa tridactyla*											X		-	-	-	-
35	*Somateria mollissima*											X		-	-	-	-
36	*Sterna bengalensis*										X			-	-	-	-
37	*Sterna hirundo*	X	X	X		X			X		X			-	-	-	-
38	*Sterna sandvicensis*		X	X	X		X				X	X		-	-	-	-
39	*Tachybaptus ruficollis*	X		X	X	X	X			X			X	-	-	-	-
40	*Tadorna ferruginea*								X			X		-	-	-	-
41	*Tadorna tadorna*	X				X							X	-	-	-	-

ANNEX G - Seasonality - Life History Forms – Fish

ELEMENT: Fish		3. Seasonal Presence												Life history Stage and Reproductive Timespans				
1. Season ID	2. Species Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	4. Spawning	5. Egg	6. Larvae	7. Juvenile	8. Adults
101	*Achantias vulgaris*	X	X	X	X	X	X	X	X	X	X	X	X					
102	*Alosa fallax nilotica*																	
103	*Ammodytes cicerellus*																	
104	*Anguilla anguilla*																	
105	*Aphya minuta*																	
106	*Argentina sphyraena*		X	X	X	X												
107	*Arnoglossus grohmanni*																	
108	*Arnoglossus kessleri*																	
109	*Arnoglossus laterna*																	
110	*Atherina hepastus*				X	X	X											
111	*Atherina mochon*					X	X	X	X									
112	*Belone belone*			X	X	X	X	X	X									
113	*Blennius galerita*																	
114	*Blennius gattorugine*																	
115	*Blennius ocellaris*																	
116	*Blennius pavo*																	
117	*Blennius sanguinolentus*																	
118	*Blennius sphinx*																	
119	*Blennius tentacularis*																	
120	*Boops boops*									X	X							
121	*Boops salpa*																	
122	*Callionymus belenus*																	
123	*Callionymus festivus*																	
124	*Callionymus lyra*																	

ANNEX G - Seasonality - Life History Forms – Fish (continued)

ELEMENT: Fish		3. Seasonal Presence												Life history Stage and Reproductive Timespans				
1. Season ID	2. Species Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	4. Spawning	5. Egg	6. Larvae	7. Juvenile	8. Adults
125	*Capros aper*																	
126	*Cepola rubescens*																	
127	*Charax puntazzo*																	
128	*Chromis chromis*																	
129	*Citharus linguatula*																	
130	*Conger conger*																	
131	*Corvina nigra*					X	X	X	X									
132	*Crenilabrus griseus*																	
133	*Crenilabrus mediterraneus*																	
134	*Crenilabrus ocellatus*																	
135	*Crenilabrus tinca*																	
136	*Crenilabrus tigrinus*																	
137	*Ctenolabrus rupestris*																	
138	*Dentex dentex*																	
139	*Dicentrarchus labrax*																	
140	*Diplodus annularis*				X	X	X	X	X									
141	*Diplodus sargus*				X	X	X											
142	*Diplodus vulgaris*										X	X						
143	*Engraulis encrasicolus*				X	X	X	X	X	X	X							
144	*Euthynus alletteratus*							X	X									
145	*Flessus vulgaris*																	
146	*Gadus euxinus*	X	X	X	X	X												
147	*Gadus merlangus*																	

ANNEX G - Seasonality - Life History Forms – Fish (continued)

ELEMENT: Fish		3. Seasonal Presence												Life history Stage and Reproductive Timespans				
1. Season ID	2. Species Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	4. Spawning	5. Egg	6. Larvae	7. Juvenile	8. Adults
148	*Gaidropsaurus mediterraneus*																	
149	*Gasterosteus aculeatus*																	
150	*Gobius cobitus*																	
151	*Gobius cruentatus*																	
152	*Gobius kessleri*																	
153	*Gobius melanostomus*																	
154	*Gobius niger*						X	X	X									
155	*Gobius paganellus*																	
156	*Gobius platyrostris*																	
157	*Gobius rattan*																	
158	*Gobius syrman*																	
159	*Hippocampus brevirostris*																	
160	*Julis vulgaris*																	
161	*Labrus bergylta*																	
162	*Labrus mixtus*																	
163	*Labrus merula*																	
164	*Labrus turdus*																	
165	*Labrus viridis*																	
166	*Lepadogaster bimaculatus*																	
167	*Lepadogaster candollii*																	
168	*Lepadogaster gouannii*																	
169	*Lepidotriglia aspera*																	
170	*Lichia amia*																	

ANNEX G - Seasonality - Life History Forms – Fish (continued)

ELEMENT: Fish		3. Seasonal Presence												Life history Stage and Reproductive Timespans				
1. Season ID	2. Species Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	4. Spawning	5. Egg	6. Larvae	7. Juvenile	8. Adults
171	*Lithognathus mormyrus*					X	X	X										
172	*Lophius piscatorius*																	
173	*Maena chrysalis*																	
174	*Maena vulgaris*																	
175	*Merlucius merlucius*	X	X	X	X	X												
176	*Morone labrax*							X	X									
177	*Molva elongata*																	
178	*Mugil auratus*								X	X								
179	*Mugil capito*							X	X	X								
180	*Mugil cephalus*				X	X	X	X	X									
181	*Mugil chelo*								X	X								
182	*Mugil saliens*								X	X								
183	*Mugil so iuy*																	
184	*Mullus barbatus*					X	X	X										
185	*Mullus surmuletus*																	
186	*Naucrates ductor*																	
187	*Nerophis teres*																	
188	*Oblada melanura*				X	X	X											
189	*Ophidium barbatus*																	
190	*Pagellus erythrinus*				X	X	X											
191	*Pagrus ehrenbergii*			X	X	X												
192	*Paracentropristis hepatus*																	
193	*Pegusa natus*																	

ANNEX G - Seasonality - Life History Forms – Fish (continued)

ELEMENT: Fish		3. Seasonal Presence												Life history Stage and Reproductive Timespans				
1. Season ID	2. Species Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	4. Spawning	5. Egg	6. Larvae	7. Juvenile	8. Adults
194	*Pleuronectes flesus*	X	X	X														
195	*Sarda sarda*					X	X	X	X									
196	*Sardina pilchardus*							X	X	X	X							
197	*Sciaena cirrosa*						X	X										
198	*Scomber colias*						X	X	X									
199	*Scomber japonicus*																	
200	*Scomber scomber*			X	X	X	X											
201	*Scophtalmus maeoticus*				X	X	X											
202	*Scophtalmus maximus*																	
203	*Scophtalmus rhombus*				X	X												
204	*Scorpaena porcus*						X	X	X	X								
205	*Scorpaena scrofa*																	
206	*Scorpaena ustulata*																	
207	*Sebastes dactylopterus*																	
208	*Serranus cabrilla*							X	X									
209	*Serranus scriba*							X	X	X								
210	*Smaris alcedo*					X	X	X	X									
211	*Smaris vulgaris*																	
212	*Solea kleinii*																	
213	*Solea lutea*																	
214	*Solea melanochira*																	
215	*Solea monochir*																	
216	*Solea ocellata*																	

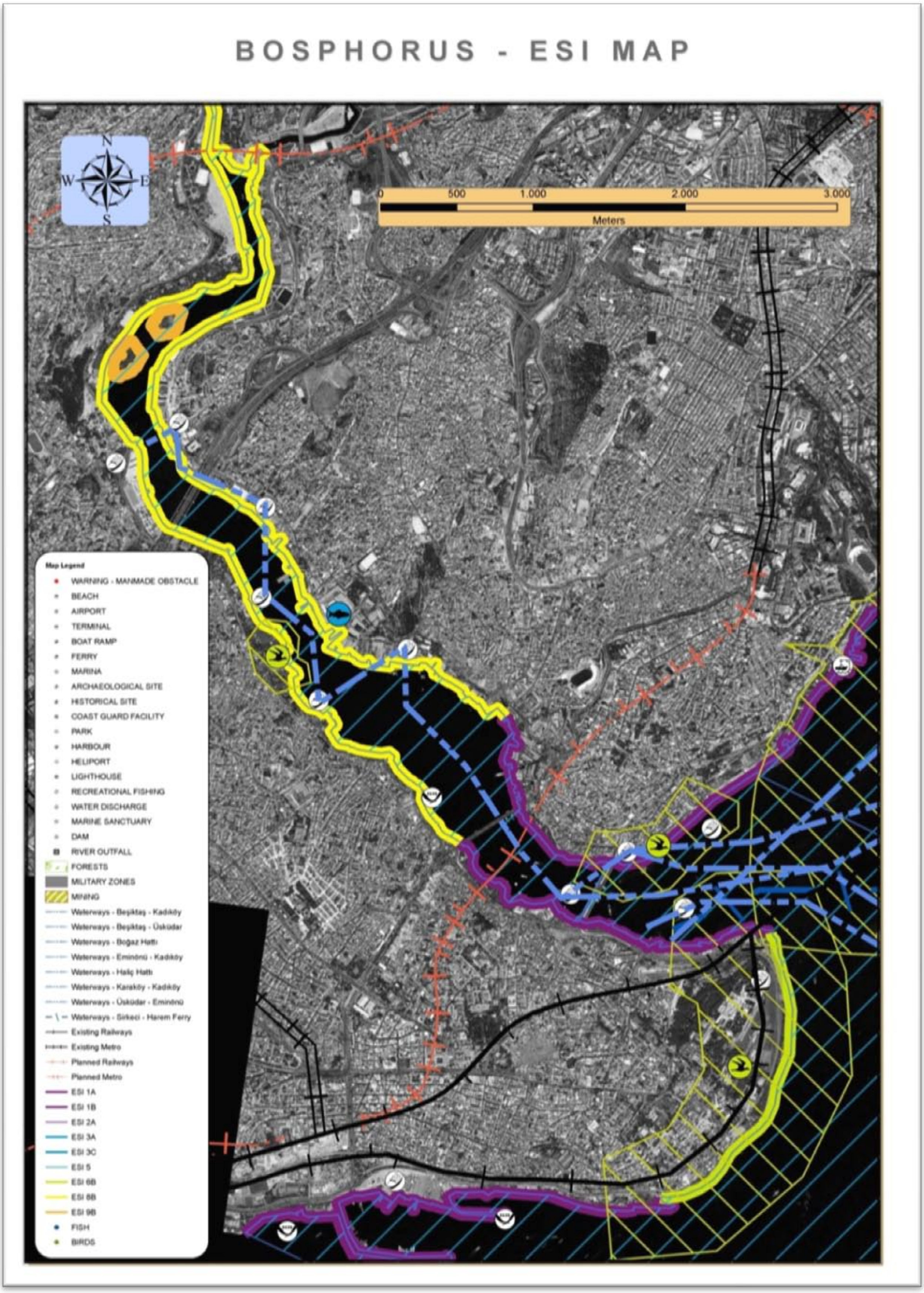
ANNEX G - Seasonality - Life History Forms – Fish (continued)

ELEMENT: Fish		3. Seasonal Presence												Life history Stage and Reproductive Timespans				
1. Season ID	2. Species Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	4. Spawning	5. Egg	6. Larvae	7. Juvenile	8. Adults
217	*Solea variegata*																	
218	*Solea vulgaris*				X	X	X											
219	*Spyraena spyraena*																	
220	*Spratella spratus*					X	X											
221	*Symphodus scina*																	
222	*Syngnatus acus*																	
223	*Syngnatus schmidti*																	
224	*Syngnathus taeniotus*																	
225	*Syngnathus typhle*																	
226	*Temnodon saltator*				X	X												
227	*Thunnus thynnus*							X	X									
228	*Trachinus draco*																	
229	*Trachinus radiatus*																	
230	*Trachurus mediterraneus*				X	X	X	X	X									
231	*Trachurus trachurus*					X	X	X										
232	*Trachipterus cristatus*																	
233	*Trigla gurnardus*						X	X										
234	*Trigla lineata*																	
235	*Trigla lucerna*						X	X										
236	*Trigla lyra*																	
237	*Trigla pini*																	
238	*Uranoscopus scaber*																	
239	*Xiphias gladius*						X	X										

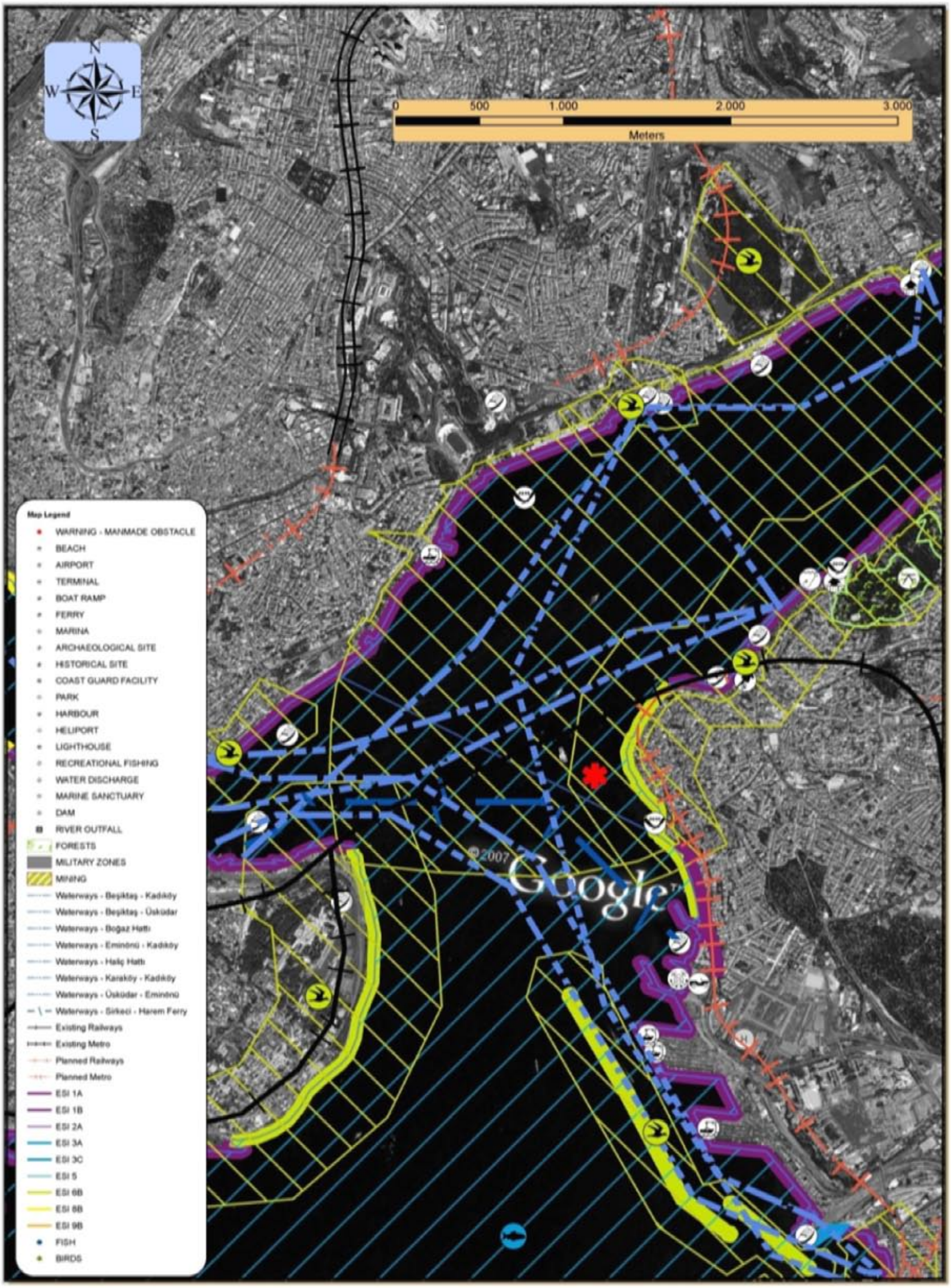
ANNEX G - Seasonality - Life History Forms – Fish (continued)

ELEMENT: Fish		3. Seasonal Presence												Life history Stage and Reproductive Timespans				
1. Season ID	2. Species Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	4. Spawning	5. Egg	6. Larvae	7. Juvenile	8. Adults
240	*Zeus faber*																	
241	*Zostericola ophiocephala*																	

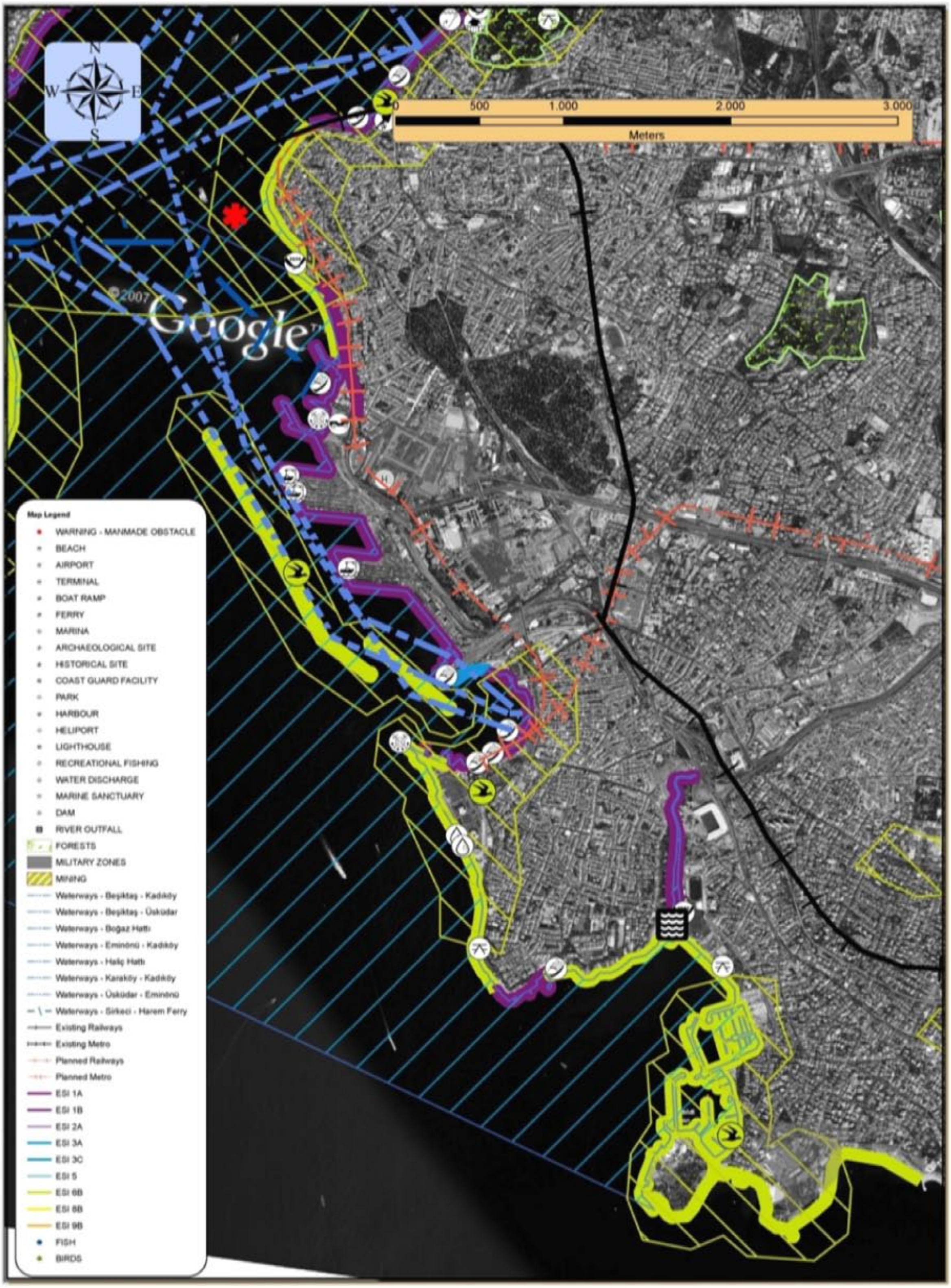
ANNEX H – Sensitivity Maps of Bosphorus

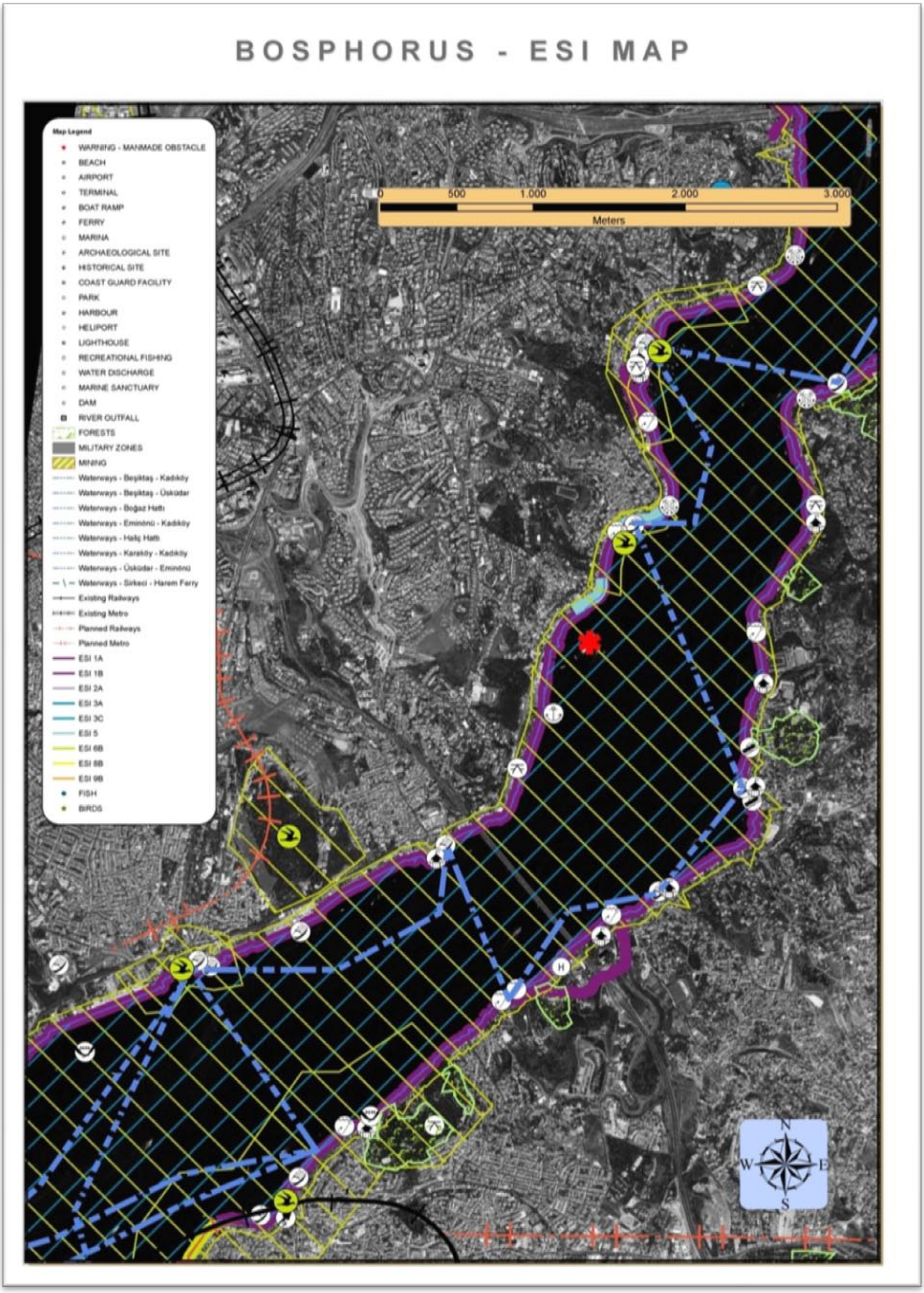


BOSPHORUS - ESI MAP

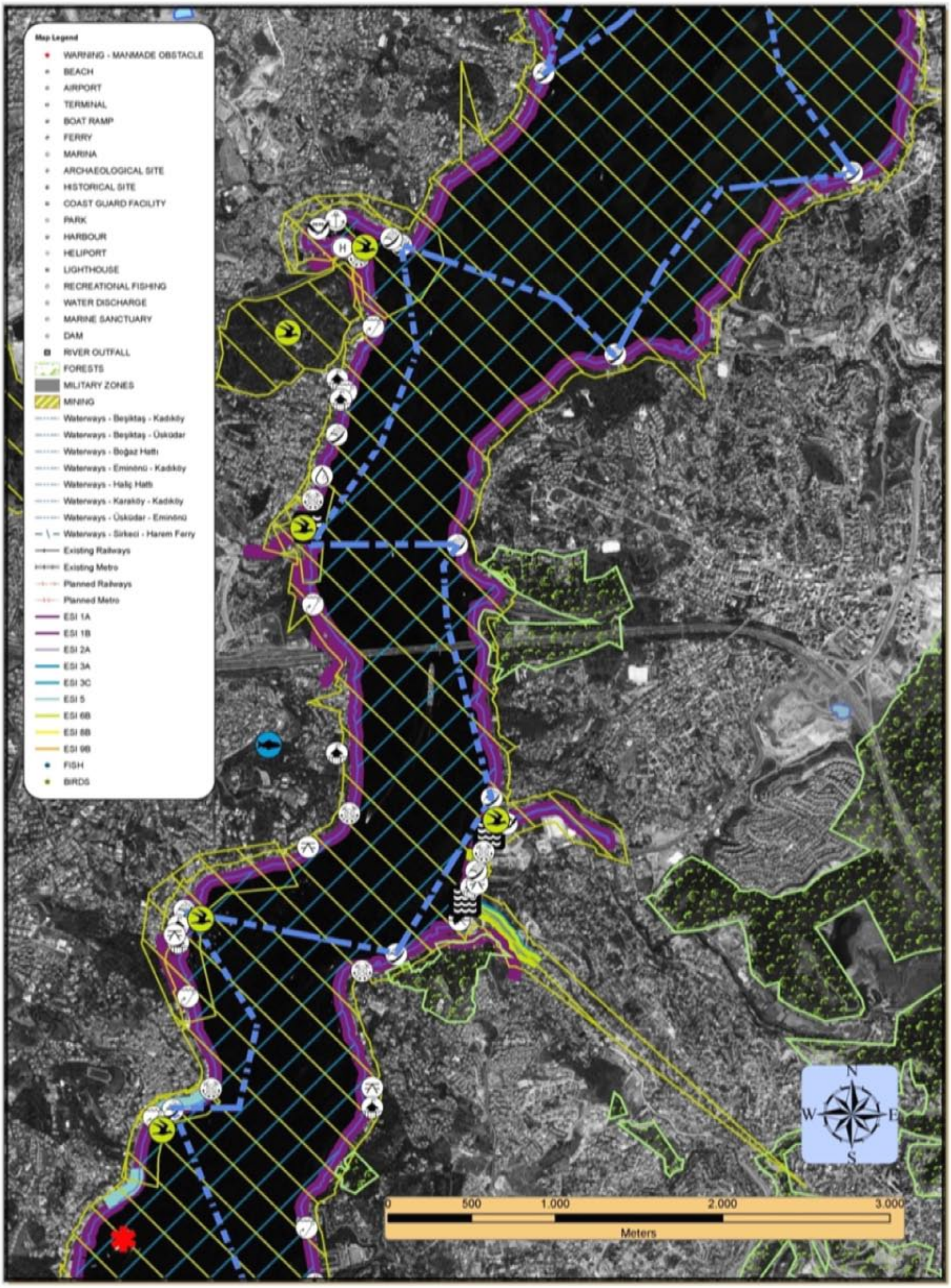


BOSPHORUS - ESI MAP

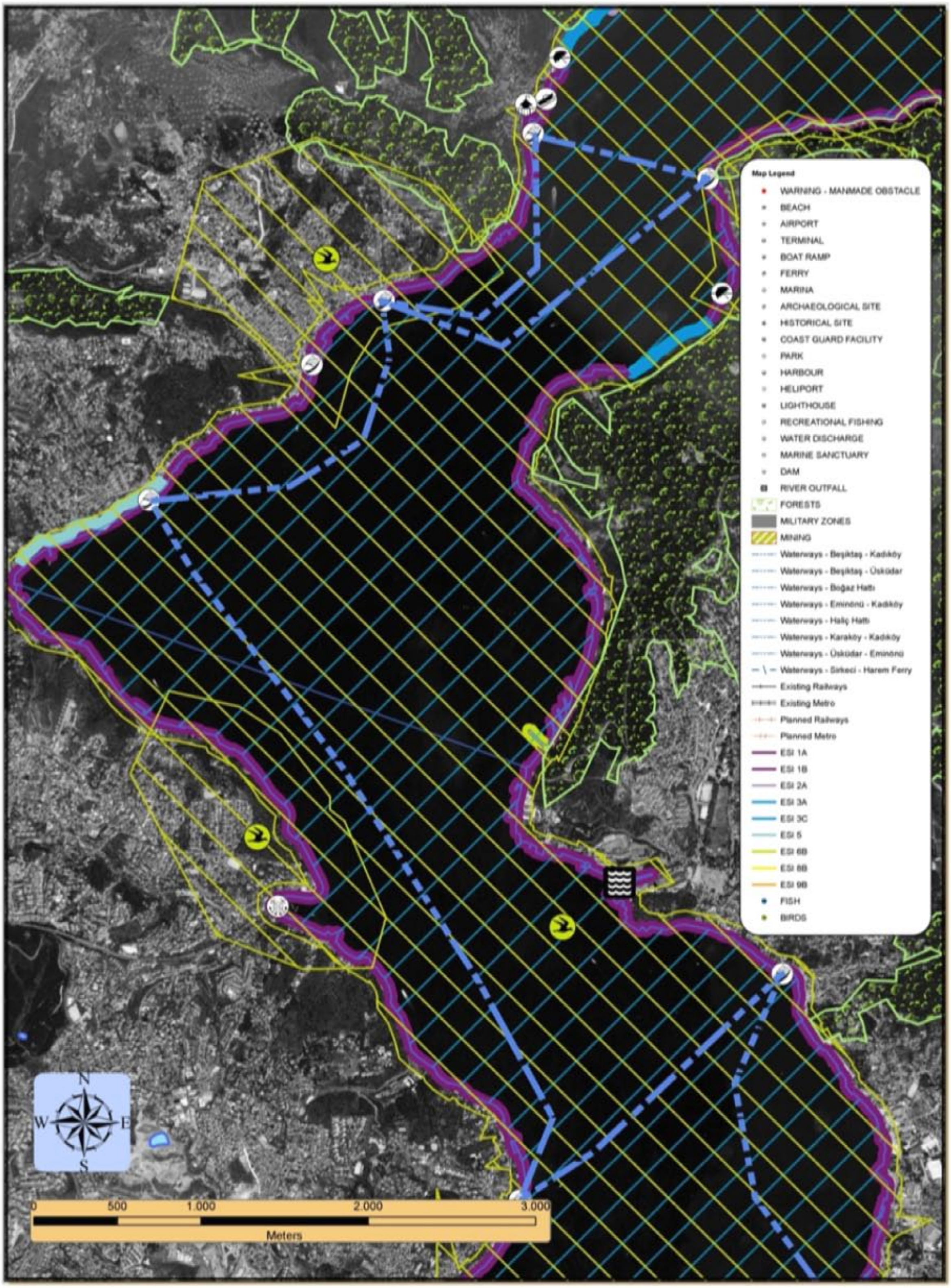



BOSPHORUS - ESI MAP
Map Legend
WARNING - MANMADE OBSTACLE
BEACH
AIRPORT
TERMINAL
BOAT RAMP
FERRY
MARINA
ARCHAEOLOGICAL SITE
HISTORICAL SITE
COAST GUARD FACILITY
PARK
HARBOUR
HELIPORT
LIGHTHOUSE
RECREATIONAL FISHING
WATER DISCHARGE
MARINE SANCTUARY
DAM
RIVER OUTFALL
FORESTS
MILITARY ZONES
MINING
Waterways - Beşiktaş - Kadıköy
Waterways - Beşiktaş - Üsküdar
Waterways - Boğaz Hattı
Waterways - Eminönü - Kadıköy
Waterways - Haliç Hattı
Waterways - Karaköy - Kadıköy
Waterways - Üsküdar - Eminönü
Waterways - Sirkeci - Harem Ferry
Existing Railways
Existing Metro
Planned Railways
Planned Metro
ESI 1A
ESI 1B
ESI 2A
ESI 3A
ESI 3C
ESI 5
ESI 6B
ESI 8B
ESI 9B
FISH
BIRDS
0
500
1.000
2.000
3.000
Meters
N
W
E
S

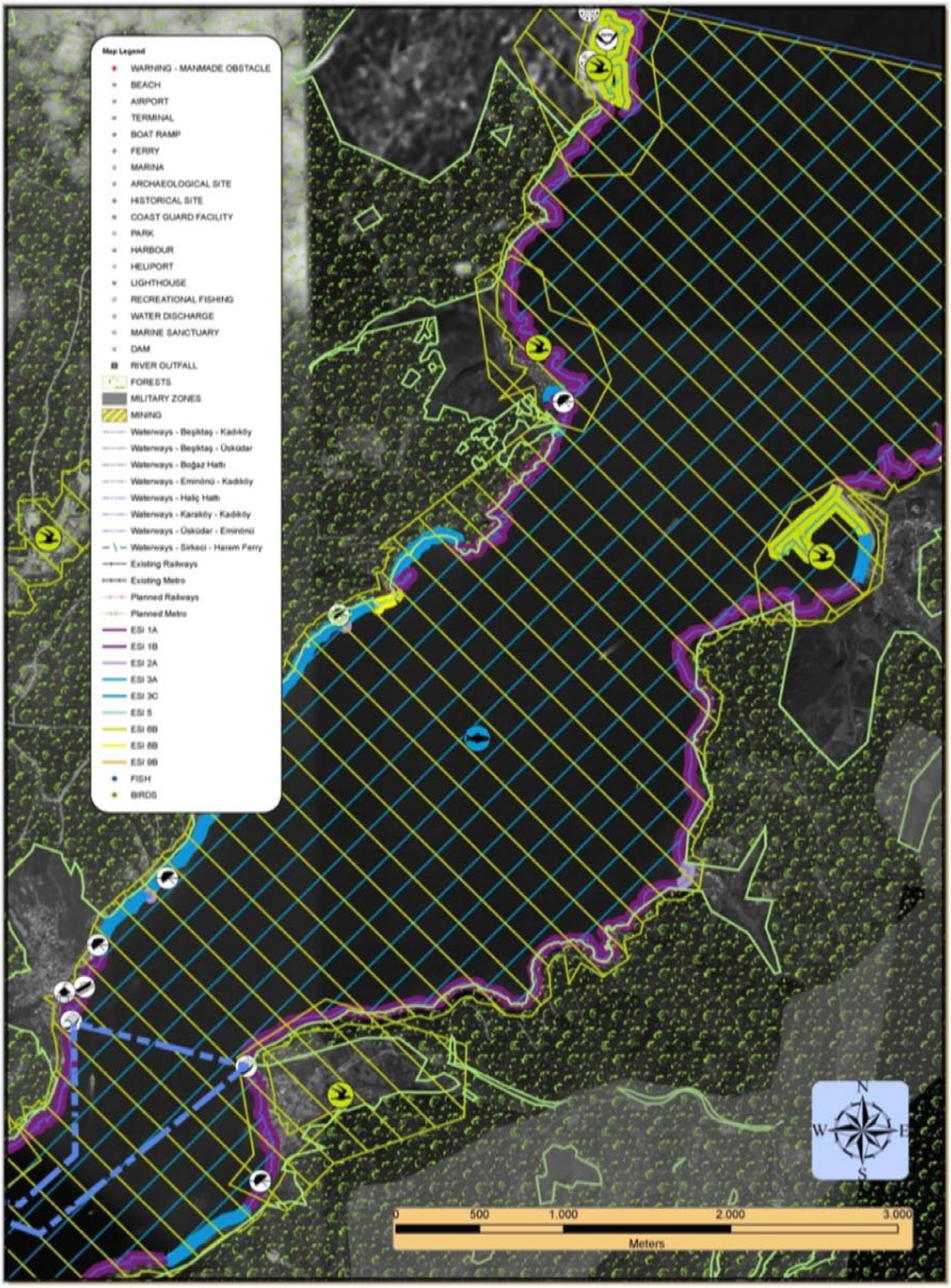
BOSPHORUS - ESI MAP



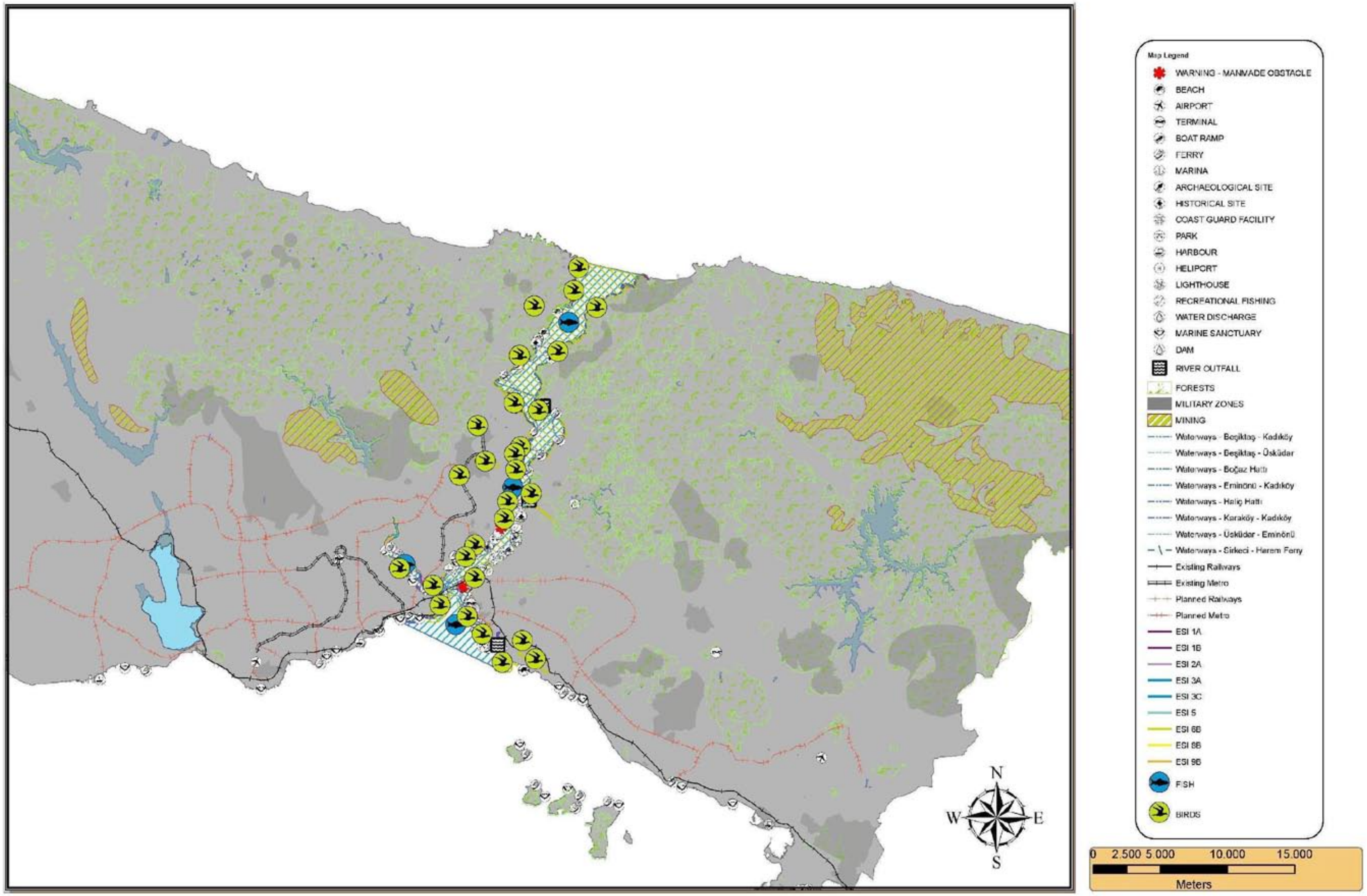
BOSPHORUS - ESI MAP



BOSPHORUS - ESI MAP



BOSPHORUS - ESI MAP



ANNEX I – Digital ESI Map and Geodatabase

Digital ESI map could be found in the thesis CD in ESRI ArcGIS *.mxd format. As the geodatabase of the system, MS Access is used. Database file could also be found in the ESI map directory.