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ENVIRONMENTAL IMPACT ASSESSMENT OF OIL AND GAS EXPLORATION AND PRODUCTION IN THE GULF OF MEXICO

By

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Mexico

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this work reflect my own personal views, and are not necessarily endorsed by the University.

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Abstract

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The Gulf of Mexico (GOM) is a semi-enclosed sea that requires a high level of protection from the international community due to its oceanographic and ecologic characteristics. Rapid industrial expansion and the offshore exploration and production (E&P) of oil and gas are damaging the marine environment and endangering its biodiversity. New technologies and the finding of high production wells have remarkably increased these activities and they are expected to continue growing in the foreseeable future. Astonishingly, there are only a few international regulations controlling these potentially polluting operations and their environmental impact. Moreover, the legal status of the nation's sovereign rights to explore and exploit mineral natural resources from the seabed and subsoil in deep waters is still undetermined and confusing. Therefore, offshore E&P activities demand a prompt and cautiously planned solution to face present and future challenges and keep a sustainable development scenario. This paper is focused on the importance of the Environmental Impact Assessment (EIA) into contemporary and future offshore E&P operations in the GOM for ensuring that effects of new projects are fully identified before they are allowed to continue. Hence, it draws attention to various environmental problems in the region and makes recommendations to international organizations and institutions that can contribute to improving the actual situation.

Keywords: GOM, EIA, E&P, OCS, FPSO, deep waters, special area.

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List of Abbreviations

CCOMJHC	USA Centre for Coastal & Ocean Mapping Joint Hydrographic Centre
CIB	Centro de Investigaciones Biológicas del Noreste
CITMA	Ministerio de Ciencia, Tecnología y Medio Ambiente
CLCS	Commission of the Limits of the Outer Continental Shelf
DETR	Department of the Environment, Transport and the Regions
E&P	Exploration and Production
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIS/MIA	Environmental Impact Statement/Manifestación de Impacto Ambiental
EMS	Environmental Management System
EPA	Environmental Protection Agency
ERA	Environmental Risk Assessment
FPSO	Floating Production Storage and Offloading System
G&G	Geological and geophysical
GESAMP	Group of Experts on the Scientific Aspects of Marine Environmental Protection
GIS	Geographic Information Systems
GOM	Gulf of Mexico
GRN	Gulf Restoration Network
HSE	Health & Safety Executive
IADC	International Association of Drilling Contractors
ICM	Integrated Coastal Management
ILA	International Law Association

IMO	International Maritime Organization
INEGI	Instituto Nacional de Estadística Geografía e Informática
ISO	International Organization for Standardization
IUCN	The World Conservation Union
LGEEPA	Ley General de Equilibrio Ecológico y Protección Ambiental
LME	Large Marine Ecosystem
MARAD	Maritime Administration
MARPOL 73/78	International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto
MMS	United States Minerals Management Service
NDBC	National Data Buoy Center
NEPA	National Environmental Policy Act
NOAA	National Oceanographic and Atmospheric Administration
NOIA	National Ocean Industries Association
NOPP	National Oceanographic Partnership Programme
OCS	Outer Limit of the Continental Shelf
OBM	Oil-based muds
OPL	Oil Field Publications Limited
OPRC	International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990
OSMA	Office of Safety and Missions Assurance
PEMEX	Petróleos Mexicanos (Mexican oil and gas company)
PNUMA	Programa de las Naciones Unidas Para el Medio Ambiente
PPS	Precision Planning and Simulation Corporation
R&M	Refining and Marketing
SCT	Secretaría de Comunicaciones y Transportes
SEMARNAP	Secretaria del Medio Ambiente, Recursos Naturales y Pesca
TDS	Total dissolved solids
UK	United Kingdom

UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea, 1982
UNEP	United Nations Environmental Programme
USA	United States of America
USBC	United States Bureau of the Census
USCG	United States Coast Guard
USDE	United States Department of Energy
USGS	United States Geological Survey
WCR	Wider Caribbean Region
WMU	World Maritime University

Chapter 1

Introduction

1.1 Background of the study

The Gulf of Mexico (GOM) is bounded by five USA states, six Mexican states and Cuba. It is a deep marginal sea and the 9th largest body of water in the world (Eugene, 1999). Due to its oceanographic and ecologic conditions, it is considered a "special area" by the IMO and requires a higher level of protection than other areas of the sea (IMO, 2002a). A prominent feature in this area is the Loop Current, which plays an important role in shelf nutrient balance and becomes the Gulf stream that is responsible for moving excess heat gained in the tropics to the poles, thus maintaining the Earth's thermal equilibrium (Boesch, 1987). In addition, the use of natural resources in the GOM is a major portion of the Gulf coast economy and its waters are a focal point for impacts and consequences of many offshore oil and gas activities.

Oil and gas represent more than 60% of the world's primary energy supply and will continue playing an important role in the foreseeable future. This will be of particular importance in developing economies with some 60% of annual growth in energy demand. At present, the principal crude oil fields of the western hemisphere and more than 65% of the offshore oil and gas installations operating worldwide are located in the GOM (UNEP, 2003). With rapid industrial expansion, the exploration and production (E&P) of oil and gas in the GOM has contributed to environmental degradation, endangered its biodiversity and sustainable development (UNEP, 1997).

According to the former deputy US Secretary of Energy Bill White: “In the Gulf of Mexico, the industry is in a race between technology and depletion” (NOIA, 1996, ¶1). Similarly, the president of Mexico, Vicente Fox, has announced, “Mexico is on an “environmental crusade”. He has promised to enact legislation to combat pollution and to bring US and Mexican environmental and labour standards closer together” (EIA, 2001, ¶3). Therefore, there is a need to emphasize the importance of the EIA and its implementation into contemporary E&P projects in waters of the GOM.

1.2 Scope and aims of the study

The oil and gas industry consists of two parts: “upstream” or the E&P area of the industry; and “downstream”, that is the sector which deals with refining and processing of crude oil and gas products and their distribution and marketing (R&M) (UNEP, 1997). This study is focused exclusively on the upstream part of the offshore oil and gas industry, the environmental impacts of its activities and the importance of its assessment.

Excessive exploration and exploitation of offshore oil and gas development are damaging waters of the GOM. Drilling activities have become unbearable for the coastal regions. Similarly, development of new technologies and the finding of reservoirs with high production wells in the deepwater portion of the GOM have resulted in a remarkable increase in oil and gas exploration, development and production. Therefore, E&P activities call for a carefully planned solution that can go into effect as soon as possible. Implementation of stringent measures through an Environmental Impact Assessment (EIA) as well as cooperation among the affected coastal states is a matter of priority in this region and highlight its importance is the main objective of this work. This paper also identifies the potential environmental impacts of E&P activities in the GOM and considers measures to avoid, minimize or mitigate these effects.

The motivation of this dissertation is the newly increased interest in the environmental problems of the offshore oil and gas E&P activities in the GOM. It is not attempting to reflect the broad and extremely complex problem of developing oil and gas resources. The content of it is limited to analyzing the present and foreseeable problems regarding impacts to the environment within the context of an EIA. The final objective of this work is to draw attention to some major environmental problems surging on the coastal and deepwater activities of the GOM and to examine their substance.

1.3 Methodology design

The methodology adopted in this dissertation to investigate, analyse, compare and find results is based on literature review on a five months base period. It mainly includes periodicals, magazines, reports and books from the IMO and WMU libraries, the USA Department of Interior (Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region), and the USA Northeast Fisheries Science Centre. It also incorporates review of previous studies made by Mexican scientists and gathering of data from the Mexican Navy Oceanography Department and the National Oceanographic and Atmospheric Administration (NOAA). Similarly, it considers personal interviews with experts in the subject in different places of Europe (Austria, Finland, and Russian Federation).

Likewise, up to date and reliable software[1], CD ROMs and Internet sources were employed for the development of this work. The structure of the dissertation is based on the World Maritime University (WMU) guidelines for written assignments and dissertations 2003 and it is referenced in accordance with the Publication Manual of the American Psychological Association (APA System).

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[1] The software employed in the development of this dissertation are: PISCES 1 version 1.5, SURFER 8 (Contouring and 3D surface mapping) and ESRI Arc Explorer (The Gulf of Mexico GIS map viewer).

The content of it has a regional and international approach and it is divided in six chapters organized as follows: Chapter two is a description of the GOM considering its geography and general characteristics. It is intended to illustrate that the region is a large marine ecosystem of paramount importance and deserves more attention from the international community. Therefore, it highlights its oceanographic and ecologic conditions as well as its economic significance for their coastal states in order to analyze the actual position of the region as a special area.

Chapter three defines and stresses the significance of an EIA in E&P activities in the GOM. It describes its process and analyses its regulatory status and problematic issues among their coastal states. It also discusses the actual and the future situation of the EIA in the region and the threat that E&P activities represents if it is not put into practice in a proper, coordinated and standard way.

Chapter four addresses the environmental impacts of the offshore upstream industry. It demonstrates that, in spite of the widespread use of offshore structures and speedy industrial growth of E&P activities in the Gulf region, there are still no international regulations controlling discharges from its operations and the impacts that they represent to the marine environment. A complementary side issue examines the controversial legal status of the outer limit of the continental shelf in view of its increasing importance in recent deep-water activities and development of new technologies.

Chapter five concentrates on the Environmental Risk Assessment (ERA) within the context of an EIA in new E&P activities. It simulates and develops a hypothetical scenario of an oil spill to analyze the acute environmental impacts from the possible installation of a Floating Production Storage and Offloading System (FPSO) in a new real USA oil and gas field. It eventually discusses the results and makes a comparison of the GOM with the Baltic Sea in this regard.

Finally, chapter six presents the conclusions drawn directly from the analysis of every chapter. It also puts forward some recommendations addressed to several areas such as the International Maritime Organization, the United Nations Commission on the Limits of the Continental Shelf (CLCS), the Gulf of Mexico coastal states, the Secretariat of the Mexican Navy and the World Maritime University (WMU). The conclusions and recommendations are by no means final or indisputable.

Chapter 2

Description of the Environment

It is practically impossible to address impacts and consequences coming from offshore E&P activities and mitigate their effects if there is no knowledge of the environment where they take place. For that reason, this chapter contains a description of it considering its geography and general characteristics. It is intended to illustrate that the GOM is a large marine ecosystem of utmost importance and deserves more attention from the international community. In consequence, it highlights the oceanographic and ecologic conditions as well as the economic significance for their coastal states in order to analyze the actual position of the region as a special area.

2.1 Geography and general characteristics

The GOM is a marginal sea with unique oceanographic characteristics owing to the restriction with the Atlantic Ocean. It is the ninth largest body of water in the world, fifth in average depth and ninth in volume among oceans and semi-enclosed[1] seas (see Table 2.1). It is bordered by the USA to the North, six Mexican States to the West, and to the Southeast with the island of Cuba. It is located between 18^0 and 31^0 Latitude North and 97.5^0 and 81^0 Longitude West (see Figure 2.1). The Gulf region covers more than 4,000 Km (2,600 miles) of littoral from the Florida Bay to the Yucatan Peninsula with outlets from 38 major river systems (Toledo Ocampo, 1999).

[1] According to Part IX of UNCLOS (Article 122), semi- enclosed sea is "a gulf, basin or sea surrounded by two or more States and connected to another sea or the ocean by a narrow outlet or consisting entirely or primarily of the territorial seas and exclusive economic zones of two or more coastal States" (UNCLOS, 1982).

Table 2.1 Area, average depth, and volume of the largest oceans and enclosed water bodies of the world

Water body	Area (Km^2)	Average depth (m)	Volume (1,000 Km^3)
Pacific Ocean	166,242,517	3,940	654,921
Atlantic Ocean	86,557,800	3,575	309,471
Indian Ocean	73,427,795	3,840	281,954
Arctic Ocean	13,223,763	1,039	13,740
South China Sea	2,974,615	1,464	4,354
Caribbean Sea	2,515,926	2,575	6,478
Mediterranean Sea	2,509,969	1,501	3,769
Bering Sea	2,261,070	1,491	3,372
Gulf of Mexico	1,507,639	1,615	2,434
Sea Okhotsk	1,392,125	973	1,354
Sea of Japan	1,012,949	1,667	1,688
Hudson Bay	730,121	93	68
East China Sea	664,594	189	126
Andaman Sea	564,879	1,026	580
Black Sea	507,899	1,191	605
Red Sea	452,991	538	244
North Sea	427,091	94	40
Baltic Sea	382,025	55	21
Yellow Sea	293,965	37	11
Persian Gulf	229,992	99	23
Gulf of California	153,069	724	111

(Source: Eugene, 1999, p.65)

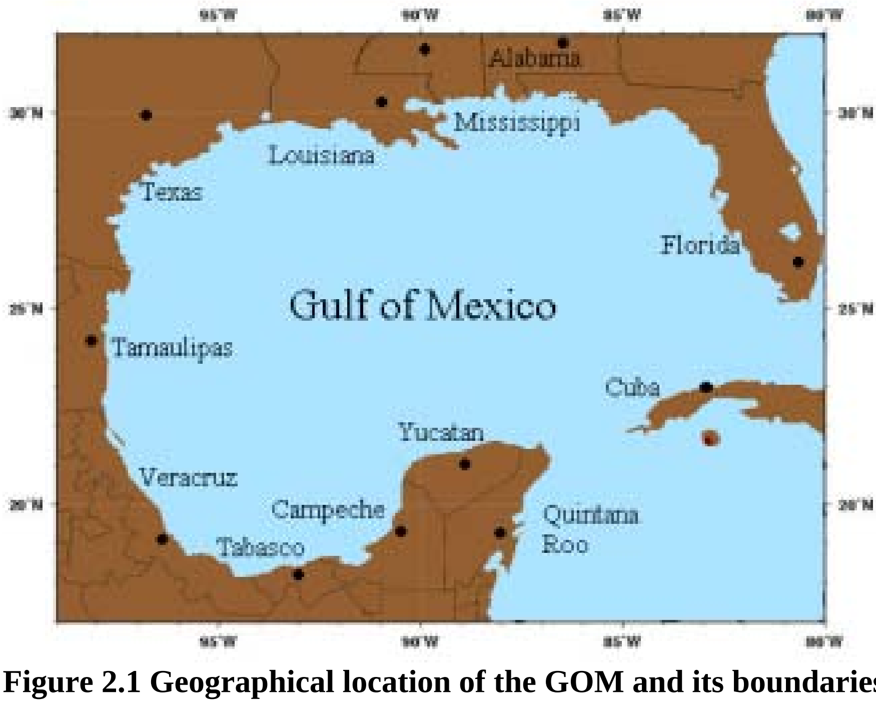

Figure 2.1 Geographical location of the GOM and its boundaries

The two major fluvial systems are the Mississippi-Atchafalaya River in the USA and the Grijalva-Usumacinta in Mexico. Altogether, they discharge more than 31.6 x 10^6 kg/s of fresh water (Giattina & Altsman, 1999). It is one of the most diverse and rich environmental systems of the planet and the international community shares its bountiful resources for a variety of purposes including transportation, fisheries, natural resources and recreation.

2.2 Oceanographic conditions

2.2.1 Currents

The circulation of currents in the GOM is influenced by winds as well as by warm and salt waters. They enter the Gulf through the Yucatan Straits, circulate as the Loop Current (see Figure 2.2), and exit through the Florida Straits forming the Gulf Stream, that is responsible for moving excess heat gained in the tropics to the poles, thus maintaining the Earth's thermal equilibrium (Boesch, 1987). These important motions are accountable for the distribution of nutrients and plankton within the GOM on a variety of space and time scales.

As the Loop current penetrates northward into the GOM, its course becomes unstable and large cyclonic and anticyclonic rings are detached. These rings are the most impressive features of the Gulf flow field. They are as big as 400 km in diameter and propagate slowly westward and southwestwards at speeds of approximately 5 cm/s before dispersing on the Mexican and Texas shelves (Wiseman et al., 1999). The process of Loop current penetration into the northern and western part of Mexico (the Mexican anticyclone) and the large ring separation occurs at an average rate of approximately once every year (Vazquez de la Cerda, 1975). Although the motion of the rings has been tracked by satellite infrared imagery and altimetry, their circulation patterns are still obscure and the details are in general not well understood (Wiseman et al, 1999).

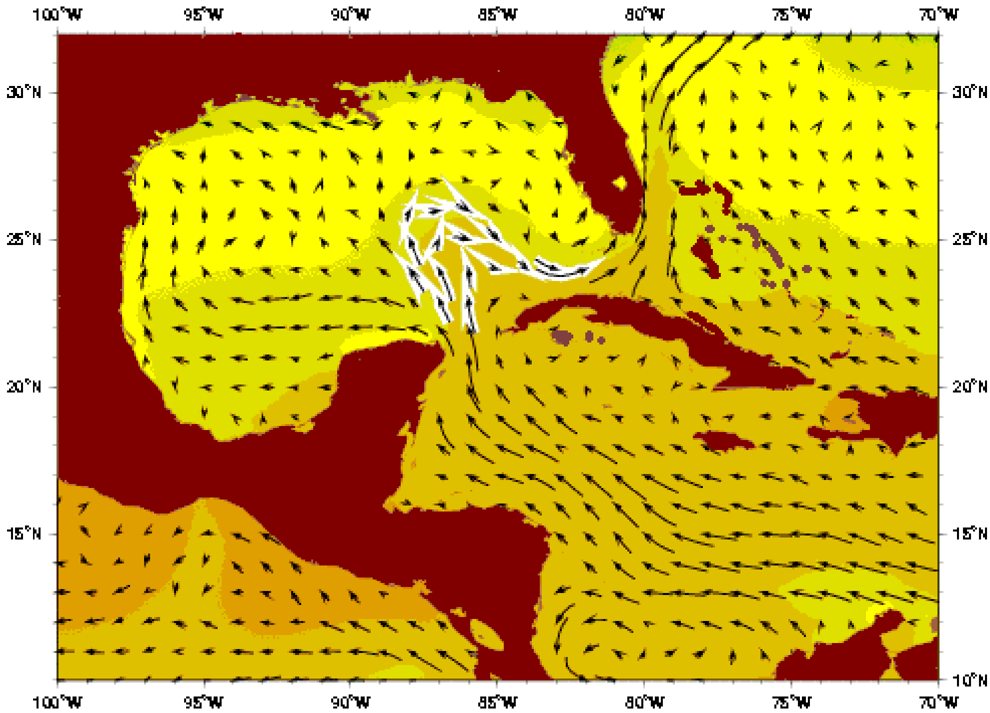

Figure 2.2 The Loop Current, February 19-20, 1996
(Source: NOPP, 2003)

2.2.2 Tidal streams and waves

Tide is the periodic rise and fall of the ocean waters resulting from the gravitational attraction of the moon and the sun upon the water and the earth surface. The various horizontal movements resulting from the tide are known as tidal currents or tidal streams. Tidal streams play a decisive role along the GOM coastline effecting critical littoral environments where there are a number of bays and estuaries that do not have a direct connection to the sea. These movements make possible the migration of massive amounts of animals and plants towards an alimentation and shelter area. As a consequence, the complex ecosystem of the GOM can perform its function (Toledo Ocampo, 1996).

2.2.3 Winds

The GOM is one of the hurricane generation zones of the tropical Atlantic. Strong winds over 120 km/h begin from the Caribbean region and the Campeche sound at the end of May or beginning of June (see Figure 2.3) and come to the end in November each year (NOAA, 2003). Another important factor for the circulation of the superficial waters in the Gulf is the presence of strong polar winds. Meanwhile, the prevailing southeast trade winds are blowing from the Southeast, frontal strong winds called "nortes"[2] blow from the North and northwest influenced by continental masses of polar air. These characteristics make the GOM a region of high risk for navigation and human activities.

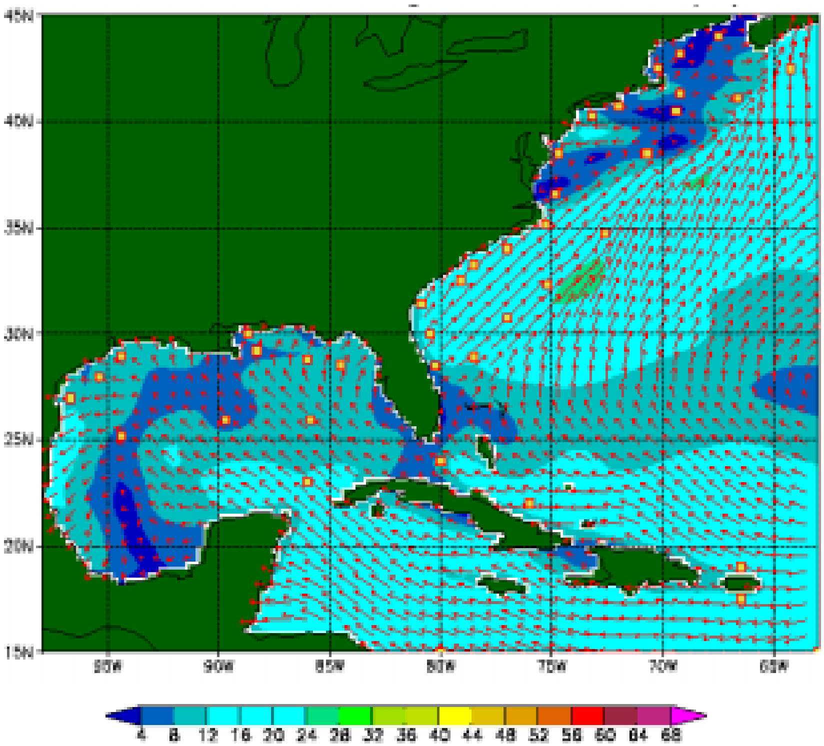

Figure 2.3 Winds speed (knots) and direction (vector) June 20, 2003 **(Source NOAA, 2003)**

[2] Polar winds are called "nortes" in Mexico. From 20 to 30 "nortes" are present during autumn and winter and some of them reach speeds over 140 Km/h (Toledo Ocampo, 1996).

2.2.4 Deep waters

According to Shiller, (1999): “Deep waters of the Gulf have the characteristics of upper North Atlantic deep water as modified during the passage through the Caribbean” (p.135). The Minerals Management Service (MMS) is currently making an exploratory study of deepwater currents in the GOM. Recent data have shown unknown processes of strong currents and high activity of the Loop Current in the deep Gulf. However, these developments are still not understood. The final report of this ongoing study is expected to conclude on September 2006 (MMS, 2003). Therefore, what could be said about the physical oceanography of deep waters in the GOM (see Figure 2.4) is, at this stage, pure speculation.

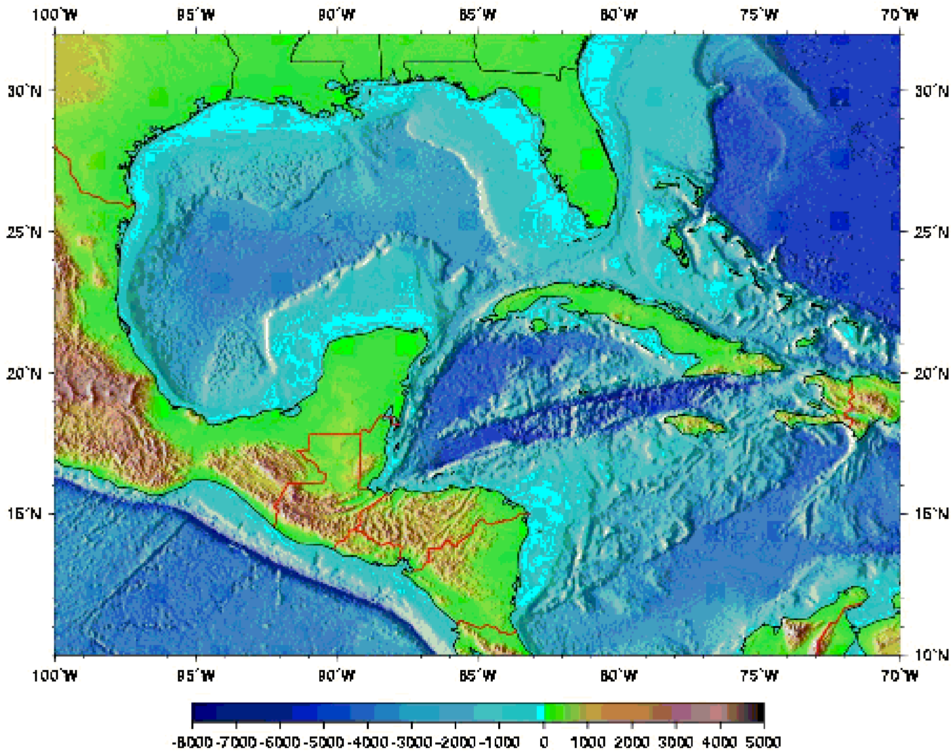

Figure 2.4 Bathymetry of the GOM
(Source: NOPP, 2003)

2.3 Ecologic conditions

2.3.1 Wetlands

The global sea level has increased between 10 to 25 cm over the last 100 years due to the global warming effect that melts polar ice caps and glaciers. As a result, increased flooding, saltwater intrusion and erosion of the coastline are affecting numerous Gulf coast wetlands (USGS, 1997). Wetland loss around the Gulf coast (see Figure 2.5) is also reaching tremendously severe levels due to human activities. Between the periods 1945 (before the major effects of oil and gas exploration) to date, the annual rate of wetlands and marsh loss increased from 0.36% to more than 2% in the coast of Louisiana (Birkett & Rapport, 1999).

Figure 2.5 Wetlands in the GOM
(Sources: EPA, 2003; Mugica, 2001& Toledo Ocampo, 1996)

Similarly, on the coast of Mexico more than 35% of the wetlands have suffered some degree of deterioration due to industrial development, over fishing and oil drilling facilities that represent a problem because of the large variety of toxic products that are thrown into the water (IUCN, 1999). Among the principal and high economic value ecosystems, wetlands include estuaries and lagoons, mangroves, sea grasses and coral reefs that are also natural habitats of lots of species, many of them at extinction risk.

2.3.2 Estuaries and lagoons

A complex combination of geological processes, high concentration of nutrients, mixture of sea and freshwater, tides and currents makes the GOM one of the most important estuarine zones of the earth. These estuaries serve not only as a source of nutrients for the shelf but also as a garden center grounds for plenty of species that spawn on it. For that reason, in the USA and Mexico, the estuarine system is considered as an area of critical importance. On the other hand, the lacunars systems are vigorously open and highly subsided by adjacent terrestrials, marine and atmospheric environments with a high productivity potential and a great deal of human uses. Two huge systems deserve, to some extent, particular mention: Terminos lagoon on the Northwest shore of the Yucatan Peninsula (Campeche) and Florida Bay in the Northeast part of the USA. Both of them are considered a marine protected area for the flora and the fauna (Wiseman et al., 1999).

Estuaries and lagoons are the root of the region’s output, high biodiversity, and much of its food supply (Yañez Arancibia et al., 1999). Similarly, they are also shelters against natural disasters and are indispensable to key economic sectors such as sea transportation, oil exploitation, and fishery development. For this reason, a source as valuable as the GOM must be prudently used and activities on it carefully planned.

2.3.3 Mangroves and Sea grasses

Among the tropical coastal ecosystems of high biodiversity are the mangrove forests, which surround huge areas of littoral in the GOM. In the USA coasts, mangroves communities are mainly concentrated in Florida. Besides Brazil, Mexico and Cuba are the Latin-American countries with more abundance of mangroves with more than half a million of hectares respectively. This amount covers approximately 60 to 75% of the GOM ecosystem (CIB, 2001). Mangroves delimit the transition between land and sea. They are the natural protection against strong winds and hurricanes that prevail in the GOM. Moreover, they are the fortification against flooding and the principal source of the fisheries of the region providing food and refuge to many terrestrial and marine species. Besides their essential role in the equilibrium of the terrestrial and marine life, these ecosystems are very limited and are in extinction process (Cintron & Schaeffer, 1992). Therefore, minor alteration puts them in great danger.

Seagrasses are no less important. They are also extremely significant for the biological economy in the GOM because they stabilize sediments and provide habitats and forage for a great variety of fish and invertebrates. Unfortunately, according to the USGS National Wetlands Research Centre, seagrassess also constitute an ecosystem in trouble. Moreover, scientists have discovered that declining seagrass range from 12% to 66% in bays and estuaries of the GOM (USGS, 2000). The reasons are not completely understood because of the lack of monitoring and consequently data from this ecosystem. However, studies are being carried out to determine the causes and mitigate its effects.

2.3.4 Coral Reefs

Coral reefs are one of the tropical systems in the GOM with diversity and aesthetic value. That is why they are known as natural treasures. This ecosystem keeps a high productivity of biomass and the greatest number of species than any other marine or terrestrial ecosystem.

They also play a crucial role in the chemical equilibrium of the oceanic waters because of the huge production of calcium carbonate. These reefs form a discontinuous ring that bounds the Gulf basin. The most extensive areas of this geologic process are found on northern Cuba as well as in the banks and islands coast of south Florida and the Yucatan Peninsula. In the northwestern and central parts of the Gulf such as Louisiana, Texas and Veracruz they are found in isolated formations (Moreno Casasola, 1999). Their structure build barriers which control the erosion of the coast line and dissipate energy from the currents, developing low energy environments suitable for the reproduction of almost 25% of all marine species (Toledo Ocampo, 1996). Coral reef habitats contribute hundreds of millions of dollars annually to the region fishing industry and help generate billions of dollars a year for the tourist industry (USGS, 2002). In recent decades coral reefs have been catastrophically damaged mostly due to anthropogenic activities. The USGS scientists are working hard to understand the biological and geological issues that affect coral reefs in the GOM.

2.3.5 Species at risk: Marine mammals and sea turtles

Habitat destruction, deliberate killing and declining food are the most important and recognized threats to marine mammals and sea turtles (UNEP, 2003a). Although, it is a global problem, the Gulf region host particular species currently under threat (see Table 2.2). One of the activities that destroy the natural habitats and kill these animals are the way the removal and decommissioning of platforms are carried out so far. At present 30 % of almost 4,000 oil and gas platforms in the GOM are reaching the end of its useful life and will be removed. Historically, 67% of these platforms have been removed by explosive means (GRN, 2003); therefore, in the very near future there will be a significant increase in the number of explosive platform removals. This impact, as well as other possible effects of oil and gas developments on marine mammals (see Appendix A), needs to be assessed and protective measures should be taken into account.

Table 2.2 Endangered marine mammals and sea turtles of the GOM

Marine Mammals	
Order Cetacea	Order Carnivora
Eubalaena glacialis, northern right whale *Balaenoptera musculus*, blue whale *Balaenoptera physalus*, fin whale *Balaenoptera borealis*, sei whale *Megaptera novaengliae*, humpback whale *Physeter macrocephalus*, sperm whale	*Monachus tropicalis*, Caribbean monk seal (already extinct) Order Sirenia *Trichechus manatus*, West Indian manatee
Sea Turtles	
Caretta caretta, loggerhead *Lepidochelys kempi*, Kemp's ridley *Dermochelys coriacea*, leatherback *Chelonia mydas*, green *Eretmochelys imbricate*, hawksbill	

(Source: Adapted from Lang & Fertl, 2001, p. 2)

2.4 Economic significance of the GOM

2.4.1 Population

Coastal areas in the GOM have been and will continue to be the most rapidly growing area at a rate of more than 20 % in the next 20 years (Cato & Adams, 1999). The total population in five US states around the GOM has increased from 18.3 million in 1950 to 49.5 million in 2003. It means from 12% to 17% of the total population of this country[3].

[3] According to the US Bureau of the Census, the population in the USA has grown from 152,271,417 in 1950 to 291, 216, 106 in 2003 (Source: USBC, 2003).

Among these states Florida and Texas have the highest rate of population at 27% and 22% respectively. In the six Gulf coastal states of Mexico the population has increased from 3.8 million in 1950 to 14.6 million in 2000. It represents 15% of the total population of the country[4]. Veracruz is the highest populated state on the coast and the third one in Mexico with almost 7 million of inhabitants (INEGI, 2003).

2.4.2 Fisheries

An important component of the total economic value of the GOM is represented by the commercial fishing industry[5]. The commercial fishing industry in the USA Gulf was valued at 630 million dollars in 1993, which represented 21% of the total value for fishery in USA, 20% less than the total obtained in 1984 (Cato & Adams, 1999). This steady decline may be due to over fishing, economic competition from cheaper imported fish, destruction of wetlands and the growing dead zone[6] at the mouth of the Mississippi river, which has already changed fisheries considerably (Rabalais et al., 1999). In Mexico, fisheries are considered the most important Gulf coastal resource of the region with more than 26% of the national production and with an approximate value of 240 million dollars annually. Roughly 90,000 people are involved in fishing activities in twenty fishing ports located in the region. The most important fisheries are oyster with 90% of the national production and shrimp (mostly brown shrimp) with more than 50% of the national production (Zarate Lomeli, et al., 1998).

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[4] In accordance with the last census made by the INEGI (2000) the total population of Mexico is 97, 483 412. On the other hand the population in Cuba is approximately 11.5 million (Cato & Adams, 1999)

[5] The reorganization of the fisheries sector in Cuba doesn't allow data to be readily available. However, it is considered to be significant (Fernandez Mayo & Ross, 1998).

[6] A hypoxic (oxygen-starved) area covers almost 8,000 square miles during the summer and autumn in the Northern part of the GOM due mainly to nutrients enrichment. (For further information refer to the EPA web site: http://www.epa.gov/msbasin/actionplan.htm)

However, uncontrolled growth of artisanal fishing has diminished the main commercial species of Mexican waters. This situation does not allow the assessment of its magnitude. Therefore, it is difficult to differentiate the fishery impact related to environmental factors or to deterioration of nursery habitats (Gracia & Vázquez-Bader, 1999).

2.4.3 Oil and Gas

The GOM has the most developed infrastructure for oil and gas production of the world and it is considered one of the major oil provinces in production of the western hemisphere. This infrastructure is highly concentrated in coastal areas (see Figure 2.6). According to the MMS, offshore operations in the Gulf produce one-eighth of its oil and a quarter of the USA domestic natural gas (MMS, 2002). Although the USA is still the third largest producer of oil in the world, domestic oil production cannot supply all of USA's needs and it should import more than 60% of its oil from foreign and often unstable nations (MMS, 2000).

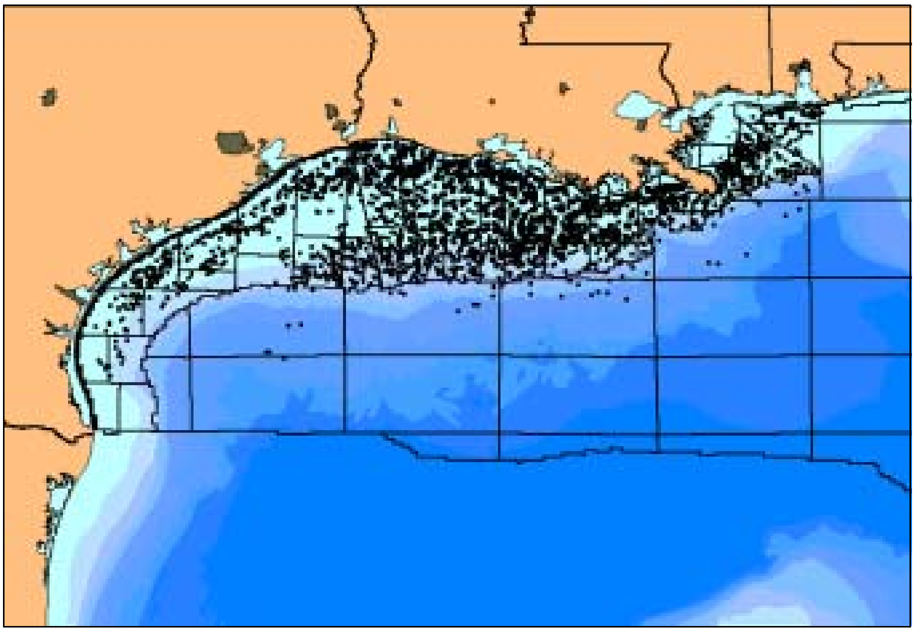

Figure 2.6 USA Gulf areas and offshore oil and gas infrastructure to date (Source: OPL, 2003)

This is one of the reasons why exploration and development activities in the USA have accelerated rapidly in deep waters during recent years. In Mexico, more than 80% of crude oil and 90% of the national production of natural gas is derived from the Gulf, mostly from the Campeche bay, which also has the biggest infrastructure of the nation (Zarate Lomeli, et al., 1998). The Cantarell Field is PEMEX[7] E&P's (PEP) large, heavy oilfield, located 100km off the coast of the Yucatan Peninsula. It is the largest offshore development project in the world to date, with a total installed cost of more than $5 billion. However, although a giant natural gas bubble has maintained pressure over the Cantarell's field for the last 20 years, reservoir pressure has decreased and injection of nitrogen is made through the world's largest nitrogen production and injection infrastructure to increase production (EIA, 1999). What can be forecast for this situation is that Mexico will be also looking for oil and gas in deep waters in a very near future as Cuba is doing now after the discovery of a big oil and gas reservoir in its EEZ (see Section 3.5.1).

2.4.4 Maritime transport

The USA is the world's leading maritime and trading nation accounting for 1 million metric tonnes or approximately 20% of the annual borne overseas trade. In other words, although maritime transport represents less than 50% of the integral part of the total transportation, more than 95% overseas trade is moved by ship. The major US Gulf coast ports are involved in tankers and dry bulk trade. Similarly, the largest cruise ship port of call not only for the USA but also the world over is Miami, Florida. These facts represent a huge amount of maritime traffic in US Gulf waters (MARAD, 1999). On the other hand, in spite of the huge coastal areas, vast resources and the potential to growth, the Cuban and Mexican merchant marines are not competitive at global level and they are quite far from being so. However, the maritime traffic has been increasingly growing during the last years particularly in Mexico and this trend is expected to develop in the next years.

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[7] Petroleos Mexicanos (PEMEX) is the Mexico's oil company. In Cuba the Oil state company is Cubapetroleo.

For instance, from 1994 to 2000 maritime transport including hydrocarbons increased from 186 to 245 million tonnes, which means an increment of 31.8%. Similarly, in the same period of time, the transportation of passengers on cruises and ferries augmented from 5.3 to 7.4 millions of passengers which represented an increment of almost 40%. Most of this increment accounted from the GOM itself (SCT, 2003). Marine transportation is a key element of economic competitiveness. In order to remain competitive, infrastructure should continue increasing and those nations, which are not developed enough, must improve as soon as possible. The GOM is the gate of most of the maritime traffic for its surrounding nations. Therefore, it is clearly seen that it represents and will increasingly stand for a huge amount of traffic to its countries.

2.5 Special Area

The Wider Caribbean Region (WCR), which includes the GOM, has been designated by IMO as a special area under Annex V of MARPOL 73/78. However, neither the WCR nor the GOM are considered as special areas under Annex I, Annex II and Annex VI of the Convention (see Table 2.3).

MARPOL 73/78 defines this area as "a sea area where for recognized technical reasons in relation to its oceanographic and ecological conditions and to the particular character of its traffic the adoption of special mandatory methods for the prevention of sea pollution by oil is required" (IMO, 2002a, pp. 47, 244 & 385). As it can be seen, the GOM is a large marine ecosystem with oceanographic and ecological conditions of uppermost importance. The character of its maritime traffic is now of major significance and it is continuously growing. The reason why it has not been designated as a special area under Annexes I, II and VI requires further analysis and it should be undertaken by the coastal states of the region[8]. One of the reasons could be the lack of reception facilities in the region as a whole.

[8] The MARPOL 73/78 Convention has been ratified by the three coastal states in the GOM.

Table 2.3 Special areas under MARPOL 73/78 as amended

Annex I (Oil)	Annex II (Chemicals carried in bulk)	Annex V (Garbage)	Annex VI (Air pollution from ship)
Mediterranean Sea Black sea Baltic sea Red Sea* Gulfs Area* Gulf of Aden* Antarctic Area North-West European Waters	Baltic Sea Black sea* Antarctic Area	Mediterranean Sea* Black Sea* Baltic sea Red Sea* Gulfs Area* North Sea Wider Caribbean Region* Antarctic Area	Baltic sea§ North-West European Waters§

(Source: IMO, 2002, p. 6)

MARPOL 73/78 requires the use of reception facilities and all parties to the convention are bound to provide adequate reception facilities for ships calling at their ports. The requirements for such facilities are especially necessary in special areas (IMO, 2002b). Deficiency of this infrastructure is nowadays a worldwide problem mainly in developing countries and in the GOM is not an exception. It involves many sectors of the industry to invest a lot of money; thus, it is a situation for which a satisfactory solution is difficult.

* The "special area" requirements for these areas have not taken effect because of lack of adequate reception facilities, and lack of ratification of the Convention by the coastal states concerned (IMO, 2002)

§ These areas become SO_x Emissions Control Areas after entry into force of the air pollution annex.

However, lack of reception facilities in developing countries such as Cuba and Mexico should not be a limitation or excuse for the preservation of the environment and conservation of its natural resources[9]. Therefore, the initiative to have the GOM as an international sea recognized as a special area in the whole sphere of action should be addressed as soon as possible in the context of integrated management and sustainable development.

In conclusion, the criteria that IMO requires for the designation of a special area is based on the ecologic, oceanographic and vessel traffic characteristics of it. This chapter showed that the Gulf region is a semi-enclosed sea that possesses the necessary features to be considered as a special area. However, it is not deemed so in the whole spectrum of the MARPOL 73/78 Convention. Although lack of reception facilities could be one of the reasons of this hindrance, the GOM is an essential ecological unit that deserves more attention from the international community especially from its coastal states. No assessment of anthropogenic activities such as offshore operations could properly take place if the environment is not fully known. Therefore, biological and physical processes of the area should be fully understood to suitably address the possible impacts of activities and the assessment of their effects. The extent of these impacts can only be judged through an effective EIA.

[9] In accordance with IMO Resolution A. 927 (22) adopted in November 2001 (Guidelines for the designation of special areas under MARPOL 73/78) "The requirements of a special area designation can only become effective when adequate reception facilities are provided for ships in accordance with the provisions of MARPOL73/78" (IMO, 2002b, p.4)

Chapter 3

Environmental Impact Assessment

The GOM represents one of the world's major oil and gas producing areas and now is facing an exhaustive activity where the environmental effects are not completely understood and must be addressed. Current activities in deep waters cannot be regarded only as an extension of previous ones and their impacts can only be judged through a new effective EIA. The purpose of this chapter is to define and stress the importance of it in E&P activities in the Gulf region. It describes its process and analyzes its regulatory status and problematic issues among their coastal states. It also discusses the actual and the future situation in the region and forewarns the threat that these activities represent if the EIA is not managed in a proper, coordinated and standard way.

3.1 Definition and importance

EIA is an essential process for ensuring that the likely impacts of new projects on the environment are completely identified and considered before the project is allowed to continue. Then, it is considered as one of the main instruments of environmental planning to preserve and protect the environment (Glasson, et al., 2001). An EIA is important because it develops anticipatory policies, plans and programs to prevent and mitigate significant adverse environmental impact. As a result, it gives explicit considerations to environmental factors at an early stage in the decision making process. Similarly, it makes clear the interrelationship between economic activities and their environmental consequences.

Thus, it ensures a sustainable development and minimizes major harmful impacts and it also helps to alleviate fears created by lack of information (DETR, 2000). The result of an EIA is an Environmental Impact Statement (EIS) or "Manifestación de Impacto Ambiental (MIA)." This document looks at all positive and negative effects of a particular project on the environment and it is one component of the information required to assist decision makers in making their final choices about a project.

3.2 Purpose and need

The development of the oil and gas industry in the GOM has been astonishing for its rapid progress and wide geography of E&P activities not only in coastal but also in deep waters. This fast expansion has contributed to environmental degradation, endangered its biodiversity and sustainable development (UNEP, 1997). In accordance with the former deputy US Secretary of Energy Bill White, "In the GOM, the industry is in a race between technology and depletion" (NOIA, 1996, ¶1). These tendencies are expected to be even more pressing in Mexico and Cuba, where, because population growth is larger and present living standards lower, there will be more pressure on environmental resources (Glasson, et al., 2001).

The president of Mexico, Vicente Fox, has announced, "Mexico is on an "environmental crusade". He has promised to enact legislation to combat pollution and to bring US and Mexican environmental and labour standards closer together" (EIA, 2001, ¶3). As a general rule, environmental policy is moving away from the narrow concept of the protection of environmental resources towards a broader concept of development and sustainability. Concern about wider distribution impacts that could affect interests of third parties is evolving in different forms such as public participation and political negotiations.

The present situation has determined the necessity to incorporate ecological criteria within the environmental policies with the goal of maintaining and preserving the marine environment and its natural resources. One of the first and most important measures and strategies with a preventive character that has been applied to protect the environment is the EIA. However, in the particular case of E&P activities, the EIA is rapidly changing. Therefore, there is a need to implement an EIA into all the contemporary E&P projects in waters of the GOM to preserve and protect the environment in a permanent and sustainable manner. The EIA should be carried out for specific environmental components and it should be done within a process.

3.3 EIA Process

Apparently, planners have conventionally assessed the impacts of developments on the environment, but definitely not in the way required by the EIA (see Section 3.5). The EIA process is a management-intensive process. Even though there is no exclusive approach to develop it and it could vary from country to country; several publications consider basic key stages. In general terms, the process should be cyclical and should consider the interaction among various steps. Figure 3.1 shows the basic steps in the EIA process and their interrelation.

3.3.1 Screening, scoping and baseline studies

Project screening narrows the application of an EIA to those projects that may have significant impacts to the environment considering their type, development and location. Scoping, on the other hand, seeks to identify from a number of alternatives those environmental impacts that are significant. The way an EIA addresses these alternatives will determine the subsequent decision-making process and provide rapid and cost effective solutions.

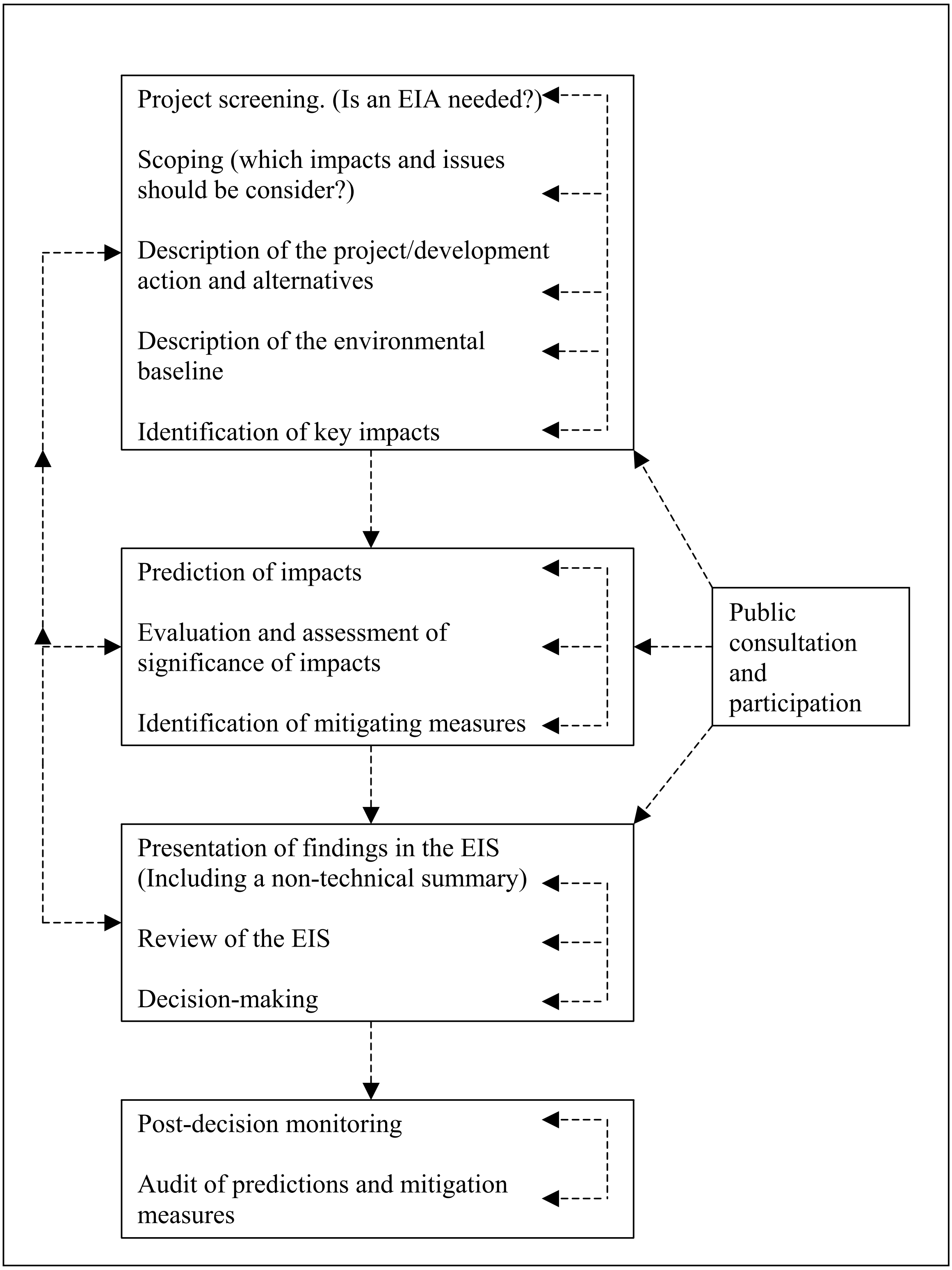

Figure 3.1 The EIA Process
(Source: Glasson, et al., 2001, p.5)

In assessing the potential environmental impacts of the offshore E&P activities the first issue to be considered is the environmental baseline. It includes the description of the environment taking into account its geographical characteristics as well as the oceanographic, ecologic and socio-economic environment (Spouge & Robinson, 1992). Similarly, it considers the present and future state of the environment taking into account changes resulting from anthropogenic and natural events. Figure 3.2 illustrates the dimensions that should be considered in the establishment of an environmental baseline.

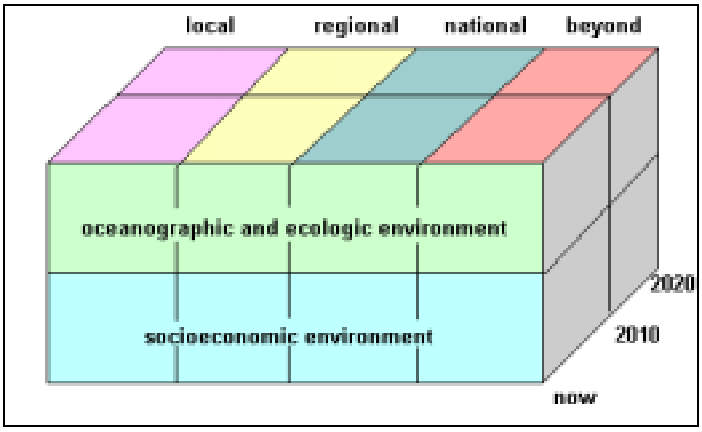

Figure 3.2 Environment: Components, scale and time dimensions
(Source: Adapted from Glasson, et al, 2001, p. 19)

In E&P projects the consideration of an EIA is compulsory under any law of any country in the GOM. Basically the developer does and is responsible for this assessment. However, it should be revised and approved by the national environmental agency concerned. When several countries are involved in the project, or when they could be affected by other countries' activities the EIA should be evaluated for all the concerned agencies (Jernelöv, 2003)[1].

[1] Interview by the author (May, 2003). *Environmental Impact Assessment of oil and gas Exploration and Production in the Gulf of Mexico*. Austria, Vienna.

3.3.2 Impact prediction

Impact identification and prediction bring together E&P projects and baseline environmental characteristics. Thus, potentially significant environmental impacts are identified and considered in order to recognize the magnitude of the project and predict what would happen. All predictions have an element of uncertainty; however, the focus in an EIA study is normally on uncertainty about the environment and the means by which the uncertainty might be reduced.

3.3.3 Mitigation

Evaluation follows from prediction and involves an assessment of the relative significance of the impacts. Once these are identified, mitigation measures should be taken into account with the purpose of avoiding, minimizing, remedying and compensating the predicted adverse impacts of the project. According to Therivel and Morris (2001) "Best practice dictates that the *precautionary principle* should be applied, i.e. that mitigation should be based on the possibility of a significant impact before there is conclusive evidence that it will occur" (p. 9).

3.3.4 Presentation of findings and proposals in the EIS/MIA

It is the responsibility of the developer to prepare and present the findings of the EIA in the EIS/MIA document submitted with the planning application. It should ensure that potential conflicts of interest have been addressed. In addition, this information should be written in a non-technical summary and in a form that can be understood even by non-specialists without undermining its content. The use of maps, graphs, charts tables and photographs are common presentation methods in order to make the EIS as transparent and clear as possible (DETR, 2000).

3.3.5 Implementation and Monitoring

Implementation responsibility rests with line managers of relevant environmental protection agencies in each country. They should fully understand the legal and statutory regulations as well as other corporate obligations to responsible environmental management. On the other hand, monitoring will confirm that commitments are being met. Thus, it is a dynamic instrument that should auto-fit with the whole life process of the project (Zarate Lomelí, et al., 1996).

3.3.6 Public participation

The participation of the public in environmental policy and regulation has boosted noticeably in recent years. Public involvement and comments help to ensure the quality, clarity and usefulness of the EIA. Their views are also important in the decision making process and allow applications, negotiations and consultation. Participation from the public is useful at most stages of the process in determining the extent of an EIA. It also provides expert information in assessing the significance of the possible impacts and proposing mitigation measures. Eventually, it ensures that the EIS is objective, honest and complete and monitors the development of it.

3.4 Regulatory framework

In order to develop an EIA, developers and decision makers must be aware of the respective international, regional and national regulations and are advised to consult the relevant planning authority well in advance of a planning application. Regulatory control and enforcement is rigorously the responsibility of competent national authorities.

3.4.1 International and Regional regulations

The environmental assessment of potential effects of activities is considered in the Art. 206 of the United Nations Convention on the Law of the Sea (UNCLOS, 1982), which is in force since 1994. Mexico and Cuba are member parties to the Convention but the USA is not. In the GOM, the regional legislation that should be followed regarding EIA is the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena de Indias, 1983). Article 12 of the Convention states that as part of their environmental management policies "The contracting parties shall undertake an EIA to assist the planning of their major development projects to prevent or minimize potential impacts." The USA, Mexico and Cuba are contracting parties to the Convention and therefore are bounded to follow its provisions. Standard methodologies and procedures to assess environmental impact of the offshore oil and gas industry vary widely in these countries. Hence, scientific and technical cooperation among them, as also stated by the Convention (Article 13), are necessary.

3.4.2 National Regulations

The Minerals Management Service (MMS) and the Department of the Interior regulate oil and gas E&P development in the USA. In Mexico, this function belongs to the Secretariat of Environment, Natural Resources and Fisheries "Secretaria del Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP)." In Cuba, these activities are regulated by the Ministry of Science, Technology and Environment "Ministerio de Ciencia, Tecnología y Medio Ambiente (CITMA)." The EIA was introduced for the first time in the USA decision-making process in 1969 when the National Environmental Policy Act (NEPA) was promulgated. Since then a number of international agencies and governments have incorporated it in their management policies (UNEP, 1990).

In Mexico, the EIA had not been done in a formal way until 1988 with the promulgation of the General Law of Ecological Equilibrium and Environmental Protection "Ley General de Equilibrio Ecológico y Protección Ambiental (LGEEPA)" (PNUMA, 1989). Similarly, in Cuba the framework legislation regarding EIA was just implemented in 1995 under the Law of EIA Process, Ministry of Science, Technology and Environment "Reglamento del Proceso de Evaluación de Impacto Ambiental, (NOAA, 2003a). This Law was recently amended under the Resolution 77/99 and entered into force in July 1999.

3.5 Actual situation

Despite the importance and widespread use of the EIA in E&P activities, criteria or specific strategies have not been developed or have been developed on an incomplete basis. Table 3.1 shows the actual situation of the EIA in the GOM region.

Table 3.1 Actual Situation of the EIA in the GOM Region

Problematic issue	USA	Mexico	Cuba	∑
Administrative and legal framework of the EIA	2	2	1	5
Human Resources and Institutional Infrastructure	3	2	1	6
Regulations and Technical norms	3	2	2	7
Formats and Guidelines for the EIA	3	2	1	6
Consultants opinion poll	0	2	0	2
Public participation	2	1	1	4
Environmental monitoring	2	1	1	4
Conventions with other countries of the region regarding EIA	3	2	1	6
Level of environmental information	3	2	2	7
Methods and techniques in EIA	3	2	1	6
Social and Economic value of the environmental impact	2	0	1	3
∑	26	18	12	
0 Not existent; 2 Regular	1 Deficient or in implementation; 3 Very Good			

(Source: Yanez-Arancibia y Zárate, 1995[2]; NOAA, 2003a)

[2] As retrieved by Zarate Lomelí et al., 1996

As it can be seen, the EIA that is being carried out so far has not been as efficient as it should be. There are still many limitations in the actual implementation of the EIA in the GOM region. Even so, the increasing necessity of oil and gas as a main resource of energy has enlarged the development of technology to explore in deep waters.

3.5.1 Cuba: A dangerous reality

In spite of the potential impact of the Torricelli and Helms-Burton laws[3] from the USA to Cuba (US embargo) and although several Companies have been penalized as a result of them (Perez Jimenez, 1996), the E&P activities in Cuban waters are attracting big oil and gas companies the world over (Viloria, 1998). The most outstanding scientists of the world, (USA, Mexico, Canada, UK, France, Spain and Cuba), considered the GOM as the biggest and finest oil and gas reservoir and perhaps the last virgin area ever exploited on the globe (Carrandi, 2002, & Oramas, 2003). As a result, oil giants companies such as, Sheritt International (Canada), Repsol-YPF (Spain), and Petrobras (Brazil), among others, have undertaken prospecting and are expected to start drilling at the end of this year (2003) in deep waters of the GOM (Reuters, 2003).

However, Cuba is a new boundary, banned for some, highly risky for others and unknown for many**.** The EIA is a relatively new issue in this country and they do not have the expertise even to deal with offshore installations in shallow waters. How much impact a deep-water Cuban oil and gas strike might make is completely unclear.

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[3] These laws are a severe restriction from the USA against any foreign investment in Cuba with the purpose of bringing down the Castro government by exerting economic pressure. They have become a point of dispute between the USA and the rest of the world because they are perceived as detrimental to human rights and are against many international laws (See Titles III and IV of the Helms-Burton Law "The extraterritoriality of US sanctions") (Hoffmann, 1998).

What can be expected of this trend? The more the expansion of E&P activities takes place, the more is the probability of risk and so the evaluation of impacts on the marine environment becomes crucial. Therefore, there is a high potential probability of risk present.

The traditional picture of exploring and producing oil and gas is changing. The EIA that have been carried out so far will not be of importance within a few years. New techniques and gathering of knowledge will be needed. Technology will help to solve many of the problems that the E&P activities are facing regarding EIA. However, as it has been seen, new solutions will certainly bring new problems. For instance, the economic and technical challenges and failure probabilities of the Floating Production Storage and Offloading Systems (FPSO). Items such as hull structure, bending moments, bow impacts and motions may need to be addressed. Similarly, the use of Geographic Information Systems (GIS) also represents a problem when constantly having to monitor the variability of the structure situation due to the variety of weather conditions. Although this structure may be designed to remain on station during 100-year hurricane event, (Haug & Millan 2001) the "real world" has shown that accidents do happen and with higher frequency than the forecasts. In addition, such kind of accidents would result in catastrophic and irreversible events and so far there is no complete assessment of what would be the real consequences of the FPSO's use in deep waters of the GOM.

The evaluation of risk and the forecast of events cannot be properly made if an adequate environmental management is not in place. It provides a structured procedure to achieve a continual improvement and to face the new problems and challenges of E&P activities. Moreover, it is the cornerstone of any activity related with sustainable development such as the production of oil and gas.

3.6 Environmental management

When things go well it is because they conform to standards. However, according to Patin, 1999 “At present, no standardized or commonly accepted methodologies exist for the integral quantitative assessment of the environmental impact of the offshore oil and gas industry’s activities. Different countries use different procedures and methods for this purpose” (p. 58). What can be seen so far is that there is no standardization in the procedure to carry out EIA among the GOM coastal states (see Table 3.1). In order to properly carry out an EIA, it is necessary to have an appropriate Environmental Management System (EMS) within the environmental policy of the developer, international agencies and governments.

The EMS is an instrument, which helps organizations to take more responsibility for their actions, put in practice their objectives and monitor their developments. The international standards, which the International Organization for Standardization (ISO) develops, are very practical. They offer governments with a technical base for environmental legislation. Moreover, they also give developing countries a basis for making the right decisions when investing their scarce resources and thus avoid squandering them. ISO 9000 and ISO 14000 families and their standards have a worldwide reputation and can be applied to any organization and to E&P activities, either large or small. ISO 9000 is concerned with quality management. On the other hand, ISO 14000 is primarily concerned with environmental management. This means what the organization does to reduce damaging impacts on the environment caused by its activities, improving its environmental performance. In order to keep pace with this rapid change and technological progress, the EIA becomes an integral and essential element that is obliged to be carried out in all stages during the planning process of oil and gas E&P. The implementation and standardization of the EMS such as the series 14000 of the ISO is a powerful instrument to help managers and decision makers make the right decisions in a suitable, uniform and economic way.

To conclude, the EIA is an essential part in the decision making process to properly assess the development of new projects and their possible effects on the environment. This chapter has revealed that in spite of its importance, it is a relatively recent issue that has been skipped, underestimated or has not been properly carried out among the GOM coastal states. This condition has brought problematic issues that do not allow for effective assessment in actual offshore E&P operations. Moreover, new rapid and pervasive developments of these activities in deepwaters have complicated more the situation and they demand a completely new EIA. Environmental matters in deep waters cannot be regarded only as an extension of previous E&P activities. In countries such as Cuba and Mexico it is imperative to face these new issues before any new E&P development either in coastal or deep waters is authorized to continue. The consideration of a uniform and common EMS between the environmental agencies of the coastal states is essential to reach this goal and preserve the environment.

Chapter 4

Environmental impacts of the offshore E&P industry

Crude oil and natural gas play a key role in the world's fuel energy balance. In the GOM alone, there are more than 3,900 offshore drilling platforms to date and new offshore E&P operations are happening. This chapter addresses the environmental impacts of the offshore upstream industry. It demonstrates that despite the widespread use of offshore structures and speedy industrial growth of E&P activities in the Gulf region, there are still no international regulations controlling discharges from its operations and the impacts that they represent to the marine environment. In addition, it examines the controversial legal status of the outer limit of the continental shelf in view of its increasing importance in recent deep-water activities and development of new technologies.

4.1 Offshore E&P regulatory regime

The real potential environmental impacts of the offshore oil and gas E&P industry (see Appendix B) and the correspondent environmental protection measures (see Appendix C) cannot be fully understood if there is no comprehensive appreciation of how the entire structure of environmental protection functions. Therefore, the first item that is considered is the regulatory environment of E&P activities.

The general principles and requirements for environmental protection actions related with the exploration and exploitation of the oceans are considered in the United Nations Convention on the Law of the Sea, 1982 (UNCLOS).

It serves as an umbrella for the concrete guidelines and rules developed by the International Maritime Organization (IMO). Activities coming from oil and gas E&P are major sources of marine contaminants. However, international regulations for the control of pollution caused by activities from the offshore oil and gas industry are rather limited[1] (see Appendix D). In general terms, discharges from offshore installations can be divided into two main parts: accidental (acute impacts) and operational (chronic impacts). To certain extent, accidental discharges are covered by the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78). Article 2 (4) of the Convention defines fixed or floating platforms as "vessels", therefore, it includes them into the regulations for discharges of oil and other hazardous substances into the sea.

Similarly, the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC), 1990 deals with these matters in respect to the development of oil pollution emergency plans. Similar to accidental discharges, operational discharges can also be split into two main categories: machinery space discharges and discharges directly arising from E&P activities. Machinery space discharges are covered by regulation 21 in the Annex I of the MARPOL 73/78 Convention. However, there are not mandatory regulations at global level regarding discharges coming from E&P activities (see Table 4.1). According to IMO, 2002 "The release of harmful substances "directly" arising from the exploration, exploitation and associated offshore processing of sea-bed mineral resources is not covered by MARPOL 73/78 Article 2 (3)(b)(ii)[2] or any other international instrument"[3] (p.22).

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[1] Currently, more than 70 international conventions and agreements are directly concerned with protecting the marine environment. Nevertheless, none of them is exclusively regulating offshore oil and gas development (Patin, 1999).

[2] The content of this article states: Discharge does not include release of harmful substances directly arising from the exploration, exploitation and associated offshore processing of seabed mineral resources.

Table 4.1 Typical discharges during oil and gas E&P activities

Source, Activity	Discharge
Exploratory drilling	Drilling muds (mostly water-based), drilling cuttings
Developmental drilling	Drilling muds (oil and water-based); drilling cuttings, well-treatment fluids
Well completion	Well completion fluids
Well workover	Workover fluids
Production operations	Produced water (including formation water and injection water); ballast water; displacement water; deck drainage; drilling muds; drilling cuttings; produced sand; cement residues; blowout-preventer fluid; sanitary and domestic wastes; gas and oil processing wastes; slop oil; cooling water; desalination brine; test water from the fire control system; atmospheric emissions
Accidental discharges	Oil spills; gas blowouts; chemical spills

(Source: Patin, 1999, p. 69)

4.2 E&P Operations

Several phases are involved in the finding and extraction of oil and gas resources. The exploration phase comprises aerial surveys, seismic surveys and exploratory drilling. Exploratory wells (also known as appraisal or 'out step' wells) are the last step in the exploration activity and are drilled to verify the findings of geologists and geophysicists. Development or production wells are usually drilled after a suitable amount of oil and gas has been found in any region (IADC, 1999).

[3] The International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (Dumping Convention), also exclude the dumping of wastes derived from the exploration and exploitation of seabed mineral resources.

4.2.1 Geological and Geophysical Surveys

The impact on aquatic creatures begins with the geological and geophysical (G&G) surveys. The exploration includes, among others, methods of seismic and electrical surveys. The use of explosives was employed in the past to generate sound waves and thus, obtain the profile of the subsurface rock layers[4]. Nowadays, modern technologies such as 3D seismic surveys are used. However, insufficient information does not give the quantitative assessment of its effects on marine organisms. Similarly, the incomplete data indicates the possibility of lethal effects of seismosignals on most water fauna species. Early stages of fish development are especially vulnerable.

4.2.2 Exploratory and appraisal drilling

When a potential geological configuration has been identified, the next step is the drilling of exploratory boreholes. If this operation is successful more wells are drilled to determine the size of the field. These wells are called "out step" or appraisal wells. While drilling, drilling fluid, also called mud, is pumped through the drilling pipe and back to the surface equipment. This mud helps to balance underground hydrostatic pressure, keep the bit cool and lubricated and flush out rock cuttings (UNEP, 1997). However, the discharge of drilling muds and cuttings into the sea represents one of the major environmental impacts and threats during offshore E&P activities. Another major danger is associated with unexpected blowouts from the well as a result of encountering zones with abnormally high pressure.

[4] This practice was prohibited because it was associated with high environmental risk (In the 1960s, it led to a catastrophic situation in the Caspian sea including the mortality of more than 200,000 large sturgeons) (Patin, 1999).

4.2.2.1 Drilling muds

The environmental impact of drilling fluids is related with the presence of lubricating materials in their composition. These substances normally have a hydrocarbon base. Several types of drilling fluids are used at present in offshore drilling (see Appendix E). Even though the development of new drilling fluids includes lots of less toxic compounds, it does not ensure complete and rapid degradation of the content of oil. Most of the studies on the toxicity on drilling fluids are based on acute experiments where most common species of marine organisms are used as test objects.[5] These studies show the impact of drilling muds in biochemical and hematological levels and significant increase in sensitivity of fish and marine crustaceans at the larval stage. They also revealed accumulation of hydrocarbons in the organs and tissues of fish and invertebrates and change in the settling range of plankton. Alterations in community structure and development of anaerobic conditions were also found. Nevertheless, according to Patin, 1999 "these data are not sufficient for comprehensive evaluation of the environmental hazard of drilling fluids… and its effects are unable to predict" (p.261).

4.2.2.2 Drilling cuttings

Hundreds of tons of drilling cuttings and chemicals go overboard each offshore oil platform in the GOM without any control. This situation raises various and serious concerns about the possible ecotoxicological disturbances in areas of offshore production. Among others, the main toxic agents in drilling cuttings are oil and oil products. In accordance with some national and international standards, the permissible oil content in drilling cuttings should not exceed 100 g/kg (GESAMP, 1993). However, during actual industrial operations this concentration exceeds for much the permissible limits (from 100 to 1,000 times).

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5 The results are often represented in LC_{50} ("Lethal Concentrations" causing the death of 50% of test organisms during a certain exposure time usually from 48 to 96 hours.)

These levels can cause noticeable disturbances in the constitution and functions of benthic communities up to 10 km away from the place of discharge (Patin, 1999). Moreover, studies made in the GOM revealed that the presence of increased toxicity of sediments containing drilling cuttings was connected with the presence of not only oil residuals but also heavy metals (Vazquez, et al., 2001). Some of them are biologically important and dangerous (often radioactive) to living organisms even at low concentrations.

4.2.2.3 Drilling accidents: Mexico, a sad experience

In December 1978, without any previous EIA (Jernelöv, 2003)[6], the Mexican Company Petroleos Mexicanos (PEMEX) began drilling the IXTOC-I well, located in the central portion of the continental shelf of the Campeche Bay (see Figure 2.1). Unfortunately, on June 3, 1979, the well blew out when the drilling pipe was taken away (Botello, et al., 1996). As a result, one of the world's most spectacular and largest oil spills in history happened (see Table 4.2).

Table 4.2 Summary of past spills involving blowouts and offshore platform casualties in the GOM

Spill name	Spill volume	Duration	Spill Rate	Oil recovered
Chevron Main Pass 41 2/10/70	65,000 bbl	48 days	1,000 bbl/day	15,600 bbl
IXTOC-1 6/3/1979	3,522,400 bbl	9 months	10,000/ 30,000 bbl/day	Negligible
Shell Platform 26 12/01/70	58,640 bbl	5 months	Approx. 1000 bbl/day	Dispersants used
1 barrel (bbl) (oil, US) = 42 gallons (liquid, US) = 159 liters = .136 tons				

(Source: MMS, 1998, p.7)

6 Interview by the author (May, 2003). *Environmental Impact Assessment of oil and gas Exploration and Production in the Gulf of Mexico*. Austria, Vienna.

Every day, for 9 months, more than 2,500 tons of oil were released into the sea (MMS, 1998). The oil spilled polluted a great amount of the GOM littoral due to the tides and currents. Mostly sand beaches and barrier islands, which protect high productive and ecological important ecosystems such as coastal lagoons and mangroves, were affected. The total release was approximately 480,000 tons (Botello, et al., 1996); more than 13 times the Exxon Valdez spill volume. Reports and studies showed that the oil spill affected in an important way the species and ecosystems of the bay due to the amount and the chemical toxicity of it (Birkett & Rapport 1999; Botello, et al., 1996, Gavouneli, 1995).

4.2.3 Development and production

Once the size of the oil field is determined, the subsequent wells drilled are called development or production wells. The drilling process involves analogous methods than exploration activities, nonetheless, with a larger number of wells being drilled, the degree of activities evidently increase in proportion and consequently the impacts on the marine environment.

4.2.3.1 Produced waters

Produced waters are waters created along with oil during petroleum extraction. A single platform can reach volumes up to 7,000m^3 every day (see Table 4.3) and hundreds of thousands of tons a year (Patin, 1999). The elevated toxicity of some produced waters is explained by the existence of the most toxic substances in their composition such as biocides and heavy metals. Concentrations of heavy metals in produced water from the GOM are rather variable with a common trend of higher metal levels in fluids with higher content of total dissolved solids (TDS) (Trefry, et al., 1995).

Table 4.3 Volumes of treated produced water discharged to the ocean in different parts of the world

Location	Discharge rate (m^3/day)
U.S. GOM	549,000
Offshore California	14,650
Cook Inlet, Alaska	22,065
North Sea	512,000
Australia	100,000
West Java	192,000

(Source: Neff, 1998[7])

The prompt dilution of produced waters has been used as an argument to demonstrate the limited and irrelevant environmental impacts of these discharges. Nonetheless, oceanographic conditions vary from place to place and in different periods of time and they should be taken into consideration. Moreover, the long-term biological effect of produced waters in low concentrations has not been studied yet.

4.2.3.2 Natural gas

Unlike oil hydrocarbons, the toxicity of natural gas and its elements have been left outside the area of environmental investigation, control and regulation. This in consequence, limits the possibility of an adequate assessment and, thus, prevention of environmental impacts. However, despite the lack of research, laboratory experiments have shown that the primary fish response to the gas presence develops much faster than fish response to most other toxicants in the water[8]. Similarly, the activity of the offshore industry along with routine and accidental releases of gas hydrocarbons can cause environmental and biological effects such as changes in benthic and plankton communities and disturbances in fish migration.

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[7] As retrieved by Patin, 1999. p. 70

[8] The acute toxicity of dissolved methane begins to manifest itself at about 1ml/l. Primary behavioral responses are observed at levels as low as 0.02-0.1 mg/l (Patin, 1999).

Moreover, it contributes, together with other anthropogenic activities, to a noticeable increase in methane concentration in the atmosphere, intensifying the greenhouse effect and increasing the likelihood of global climatic changes in the near future (USGS, 1997 & Patin, 1999). These situations are increasingly a subject of concern worldwide. Therefore, the study of the toxicological characteristics of natural gas in the marine environment deserves more attention.

4.3 Decommissioning and abandonment of offshore installations

Decommissioning is the practice in which the operator of an offshore oil and gas installation get approval for and implement the removal, abandonment or reuse of an offshore facility when it is no longer needed for its contemporary use (HSE, 2001). Planning for decommissioning as well as its environmental impacts should be considered at the beginning of the development as part of the overall management process.

Although several techniques have been proposed for the removal of offshore installations[9], to date, the removal of them is quite impossible without using explosive materials. For instance, about 51,000 specimens were found dead floating after one explosive activity near the shore of Louisiana and Texas in 1992 (Gitschlag & Herczeg, 1994). The impacts on these specimens were, however, not as hazardous as for example, in fish larvae, juveniles and marine plants. Moreover, the quantitative assessment of marine biota and its environmental effects are rather complicated because of the lack of related data and methods (Kevin & Hempen, 1997). Still, enough evidence exists to enforce strict regulations of explosive activities in the removal of offshore platforms in the GOM.

[9] According to the MMS, the three decommissioning alternatives, still under study, are: leave the platform in place, complete removal of the offshore platform from the ocean, and partial removal of the platform with disposal of the material either onshore or offshore (MMS, 2001).

4.4 Present state and trends

Even though most of the known oil and gas fields are located in shallow waters of the continental shelf[10] of the GOM (see Figure 4.1), the present trend and future E&P projects are the operation of drilling units in deep waters (water depths beyond 1,000 ft [305m]) (see Figure 4.2) due to the discovery of major hydrocarbon fields with very high flow rate (Wingrove, 2003). Figures 4.1 and 4.2 illustrate the clear trend to look for hydrocarbons towards deep waters. This trend makes the assessment of E&P activities of priority importance in view of the influence that they could bring to neighbouring states and the international community itself. This issue raises the international obligation of delimiting the outer continental shelf and to solve the problems that it represents to avoid possible conflicts among the coastal states.

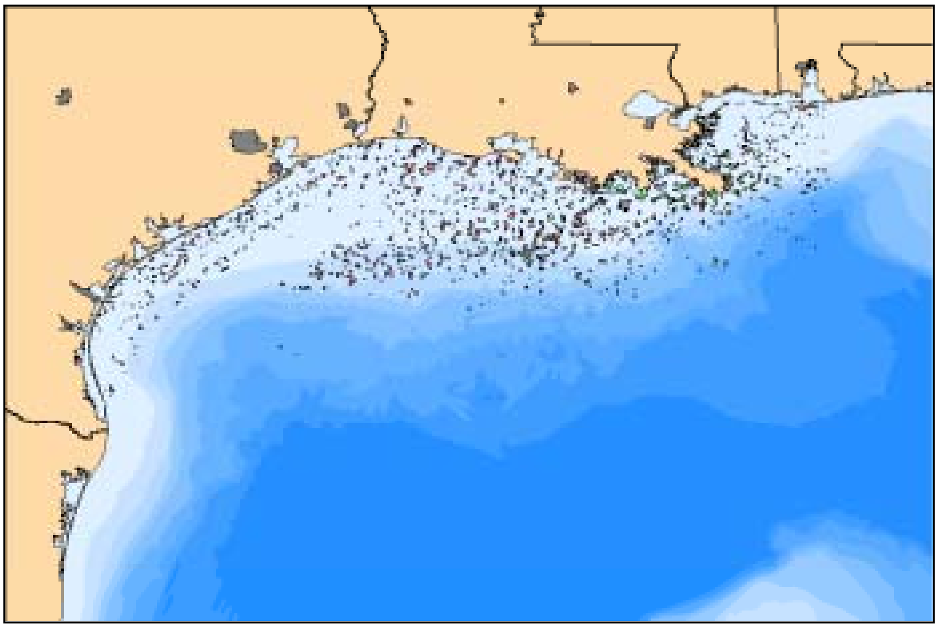

Figure 4.1 Actual oil and gas production fields in the USA GOM
(Source: OPL, 2003)

[10] About 18% of the known oil reserves lie under the continental shelf of several states and it is estimated that 70% of the yet undiscovered resources will be found under the sea (Gavouneli, 1995; Churchill, 1999).

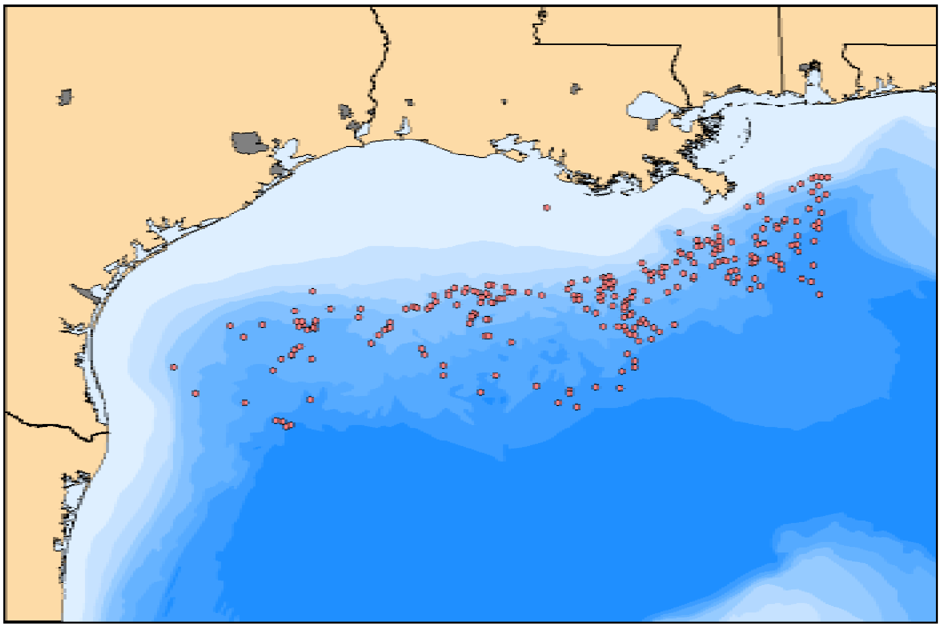

Figure 4.2 New potential oil and gas fields in the USA GOM OCS
(Source: OPL, 2003)

4.4.1 "Outer limit" of the continental shelf (OCS)

The huge diversity and richness of the continental shelf makes its legal status quite controversial and difficult to interpret (see Figure 4.3). The rules to establish its limits are contained in three different sources. These are UNCLOS, the Convention on the Continental Shelf, and customary International Law. The recent concept of the Exclusive Economic Zone (EEZ) makes it even more complicated to understand, raising a number of questions in the international community that still today cannot be accurately answered (ILA, 2002). As if this were not enough, the USA has yet another definition of the "outer continental shelf" in its national legislation[11] despite the fact that the term, as it is, does not appear in any part of UNCLOS. This convention requires, in its article 76(8), the intervention of an international body, the Commission of the Limits of the Outer Continental Shelf (CLCS).

[11] Outer Continental Shelf Lands Act. Section 3, (43 U.S.C. 1331).

Coastal states are requested to submit the limits of their continental shelves when they extend more than 200 nautical miles from the normal baseline[12]. The recommendations, which the CLCS make, are then final and binding. Unlike Mexico and Cuba, the USA lacks accession to UNCLOS. However, none of them have fulfilled the broad application of international law (either conventional or customary law) regarding limiting the outer continental shelf.

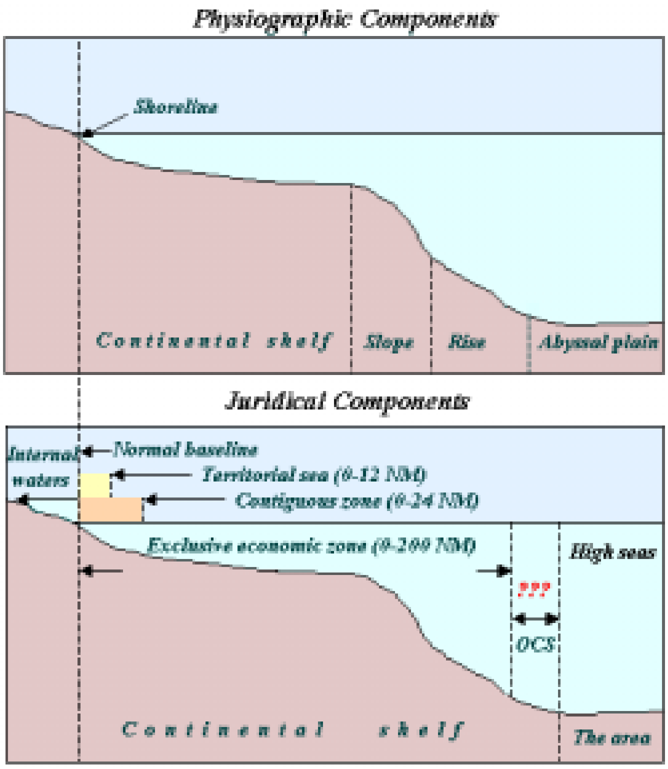

Figure 4.3 The OCS: An area that should be established with care[13] (Source: UNCLOS, 1982)

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[12] To date only the Russian Federation has fulfilled with this requirement (UN, 2003).

[13] The juridical nomenclature of UNCLOS defines components that pertain to the seabed and to the super adjacent waters**:** the territorial sea, the EEZ, and high seas. UNCLOS also defines juridical components that pertain only to the seabed**:** the continental shelf and the area. Note that the juridical continental shelf and the physiographic continental shelf are not the same. (Macnab & Haworth, 2001 as retrieved by CCOMJHC, 2003, ¶ 2.2.2).

On the other hand, new technology is pushing more and more the limit farther from shore. This situation makes the exploration and exploitation of oil and gas in deep waters of the GOM rather complex. It also complicates the cooperation that should occur among their coastal states because none of them know the limits of the others. What would happen if an accident occurred on the OCS and the deep sea beyond it? According to ILA, 2002 so far "States generally have not provided for the possibility of state responsibility and even liability from pollution damage in the high seas from any activities undertaken in the outer continental shelf area" (p.16). How is it possible to assess the environmental impacts of an unknown area? As it can be seen, much needs still to be done to better assess the ecological impacts of the oil and gas E&P not only in the GOM but also all over the world.

4.4.2 Deepwater activities

Deepwater operations have the potential to result in substantially larger oil spills than those that occur closer to or directly in coastal habitats. Although an occurrence of a spill associated with deepwater drilling activities is a very low probability event (MMS, 2000), the behavior and transport dynamics of accidental sub sea release of oil in deep waters are not completely understood. Likewise, at these water depths where the temperature is cold enough and the pressure is high enough, elevated asphaltene concentrations can be found in the oil. As a result, it will be very heavy and it will sink, the oil then will spread over the bottom and it will have a totally different distribution. Consequently, it will last for hundred or thousands years because the weathering process practically does not exist there. The environmental impacts include, among others, depositing an impenetrable and non-dispersing asphaltic concrete over benthic environments and chemosynthetic communities making them non productive. This means that an EIA considering new technology should seriously take into account previous E&P activities in deep waters in the GOM.

4.4.3 New E&P technologies

There is no other way to test new technology but operating it. Therefore, the environmental risk of an accident is potential and always present. The MMS undertook a comparative risk analysis of FPSO, which has never been used in the GOM to date, with other deepwater production systems such as the spar and tension leg platform (TLP) (see Appendix F). The purpose of the study was to assess risks covering all aspects of offshore oil and gas production. The main result showed that there are no significant differences in the oil spills among these systems and the risk associated with the FPSO (Gilbert, et al., 2001). However, the environmental effects of possible oil spilled were not taken into account. Similarly, the total volume of oil spilled and the maximum volume of oil spill in a single accident were not considered. As it can be seen there is a tremendously narrow understanding of the types of production system that are being used so far in deep waters of the GOM. Besides the three dimensional seismic survey, another recent successful and economic system that has been used in exploratory activities is the directional drilling (see Figure 4.4).

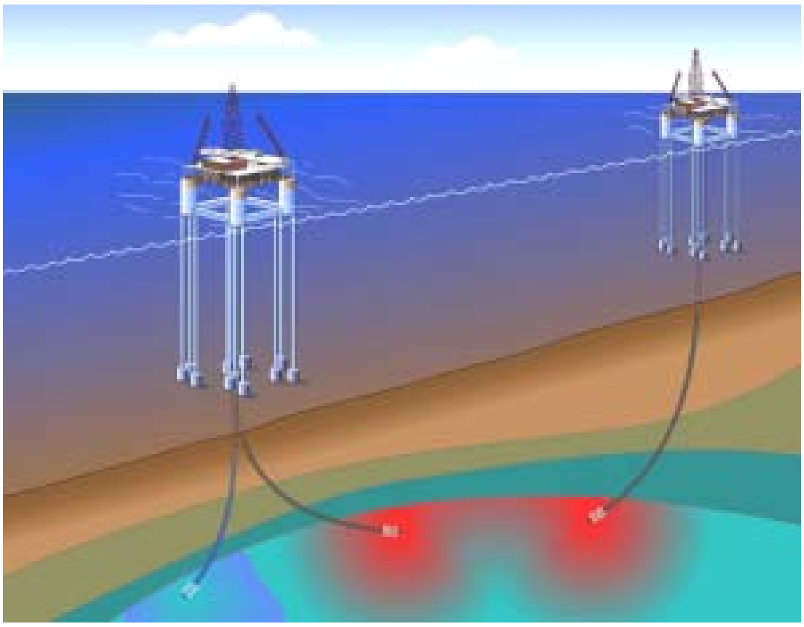

Figure 4.4 Directional drilling
(Source: Mical, 2003)

This system has the power to move three dimensionally through the earth minimizing surface disruption and is leaving behind the traditional vertical drilling. This new kind of technology is practically doubling the amount of oil and gas supply per well since 1985 (USDE, 1999). Nevertheless, according to Dr. Jernelöv[14] “If you make an unintentional error while drilling or if you drill into an area between two oil wells in which geological characteristics does not allow the retention of oil, it would bring a seepage situation.” He also added, “Once this situation starts, it is very difficult to stop and the impacts that it would bring would be totally different.” The point here is that with the use of new technologies, whichever they are, certainly many of the traditional problems will be avoided. However, they may create new problems and the environmental assessment needs to be different because the traditional ones definitely do not include these new situations.

4.4.4 The future of E&P

In the GOM to date, there are no offshore E&P platforms in Cuba. In Mexico, there are roughly 55 structures, most of them located in the marine zone of Campeche (Zarate Lomeli et al., 1998). In contrast, in the USA there are almost 4,000 fixed offshore structures operating on its OCS. Most of these structures are operating in shallow waters (see Table 4.4). However, exploration and plans for development of oil and gas in the OCS water depths more than 300m is currently experiencing a dramatic increase in the GOM (Wingrove, 2003). In these water depths, the use of conventional fixed platforms is quickly becoming technologically inconvenient and unprofitable.

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[14] Interview by the author (May, 2003). *Environmental Impact Assessment of oil and gas Exploration and Production in the Gulf of Mexico*. Austria, Vienna.

Consequently, as new discoveries are being made, the technology continues to evolve to meet the needs of deepwater challenges. This means that, although economic activity associated with offshore oil and gas E&P is expected to increase in the future, a slow and steady decreasing of platforms will take place.

Table 4.4 Water depth of fixed offshore structures operating on the GOM OCS as of December 31, 1997

Depth ranges (m)	**Non-major structures**	**Major structures**	**All structures**
0-20	272	78	350
21-50	914	399	1,313
51-100	500	524	1,024
101-150	124	306	430
151-200	78	245	323
201-300	44	298	342
301-400	6	71	77
401-500	0	22	22
501-900	2	18	20
> 900	2	13	15
Total	1,942	1,974	**3,916**

(Source: Pulsipher et al., 2001, p. 13)

The growing population, the high demand of energy and the accelerated development of technology are making the whole E&P picture change. In a recent study, the MMS forecasted[15] that the number of offshore structures on the GOM shows a decline of nearly 30% over the period 1997 to 2023 (see Figure 4.5).

[15] The forecast was made on base of econometric modeling techniques on historical data from 1947 to 1996 (Even considering two standard errors, they did not reverse these trend).

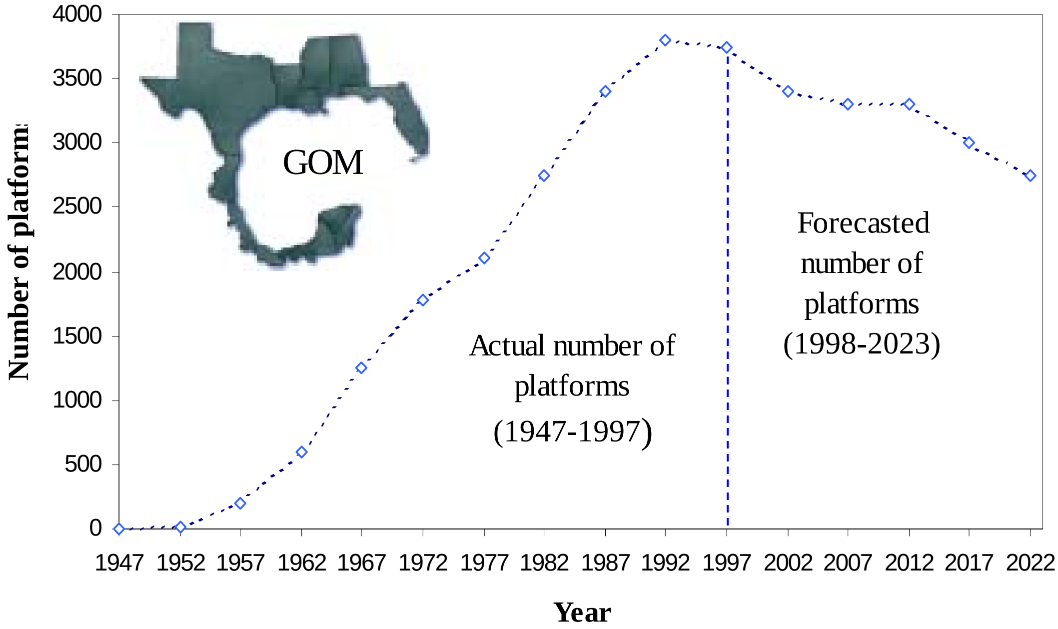

Figure 4.5 Platforms operating on the GOM OCS
(Source: Pulsipher et al., 2001, p.2)

Meanwhile the average rate of new installations will not even reach 140 per year (approx. 3,500 platforms installed over this period), the removal rate over this period will reach almost 190 per year (approx. 4,600 structures removed over that period) (Pulsipher et al., 2001). The reason for this tendency is that many of the new platforms are expected to be larger and located in deep waters further from shore and the old ones are smaller and located in shallow waters. Similarly, as the E&P is moving to deeper waters, with larger and complex structures and the use of advanced seismic imaging and directional drilling, more wells can be installed from a single platform in a more economic way.

Moreover, the very probable use of FPSO in the GOM will improve even more the E&P in this region. This trend is opening a big gate to the economic development of the oil and gas industry on the one hand. On the other hand, it is also bringing a lot of new environmental challenges that should be faced and considered since the very beginning of the planning process.

In summary, areas that in a recent past were beyond human reach are at this moment the cores of extensive industrialized activity. This chapter has exemplified that the offshore E&P industry has been and is taking advantage of the unregulated situation thereby damaging the environment immeasurably. The level and environmental effects of E&P operations are not fully known yet but are progressively more evident. Additionally, the legal situation to limit the extent of the outer continental shelf to carry out these activities is also misleading and coastal states have not been able to solve yet this puzzle. This in turn is a problematic topic that could raise international conflicts between neighbouring coastal states.

In addition, the incomplete knowledge of new technology and the unknown processes of deepwaters in the GOM make its assessment rather difficult. Therefore, in order to keep away from latent accidents, a number of studies and the gathering of expertise in several science fields are required before the implementation of newer technologies in the GOM such as the FPSO. As a result, the environmental impacts of the offshore E&P industry urgently call for a properly regulated and studied management in order to effectively carry out an EIA.

Chapter 5

Environmental Risk Assessment within the context of EIA

Commitment from the top and political will are the necessary elements to manage environmental risk adequately. Therefore, the well-known credo for addressing environmental issues “Think globally…act locally” should be understood among the GOM coastal states and EIA specialists. It is not necessary to be a risk assessor or an expert in mathematics and modelling in order to understand the basic concept of risk and its application in environmental risk-based decision-making. EIA practitioners should be familiar with Environmental Risk Assessment (ERA) as a complementary and powerful tool for analysis. Hence, this chapter seeks to explore its role from an EIA perspective analysing the acute impacts of E&P activities. It simulates and develops a hypothetical worst-case scenario of an oil spill from the possible installation of a FPSO, in a new real US oil and gas field. It eventually discusses the results and makes a comparison of the GOM with the Baltic Sea in this regard.

5.1 Consideration of the risk

In order to understand risk (Brookes, 2001), it is necessary to answer three key questions:

1) What can go wrong?
2) How likely is it? and
3) What are the impacts?

Chapter 6

Conclusions and Recommendations

The objective of this dissertation is to emphasize the importance of the EIA in contemporary and future offshore oil and gas E&P operations in one of the most important ecosystems of the world, the GOM. It also identifies the environmental impacts resulting from these activities and considers measures to mitigate the effects. In addition, it draws the attention to various environmental problems taking place in the coastal and deep waters of the region and examines their content. It does not consider the broad and complex problem of developing oil and gas resources. For that reason, the conclusions and recommendations are by no means final or indisputable.

6.1 Conclusions

The GOM is an outstanding Mediterranean type sea and very important ecosystem not only for the surrounding coastal states but also the entire world. Because of its geography and general characteristics, it is one of the ten largest oceans and semi enclosed water bodies in the world. Although many of the biological and physical processes of the Gulf are yet unknown and currently being studied, its oceanographic and ecologic conditions as well as the character of its traffic fulfils the IMO requirements to be considered as a special area. As a result, it deserves particular attention from the international community. However, despite its importance, it only enjoys this status under one of the four annexes that the MARPOL 73/78 considers.

The Gulf region also represents one of the world's most important oil and gas producing areas and it is a focal point for impacts and consequences of many offshore E&P operations. Presently, it is confronting extensive activity in deep waters where the environmental consequences are not actually understood. The assessment of impacts of these new activities should be different than the former ones. Therefore, the proposed projects and their probable impact should be well known through the process of an EIA. It ensures a sustainable development and assists decision makers to preserve and protect the environment. Thus, the EIA becomes a fundamental part that should be performed within the planning process of E&P operations in a general and standard way among the coastal states. Unfortunately, the EIA is a relatively recent practice, particularly in Mexico and Cuba, and it is not properly carried out into contemporary E&P projects.

With the aim of ensuring an effective EIA, the environmental impacts from the offshore E&P industry should be completely identified in order to control its activities. However, in spite of a number of regulations and international conventions dealing with the protection of the marine environment, there are no worldwide mandatory provisions regarding discharges resulting directly from E&P activities (chronic impacts). These discharges represent one of the main environmental impacts and threats for the marine biota and still today there are not enough data to assess their hazard and to predict their effects. Similarly, drilling accidents (acute impacts) in deep-waters are another problem because of the unknown behaviour and transport of oil in sub-sea release incidents.

Another issue that complicates the assessment of impacts from E&P activities in deep waters is the unclear legal status of the OCS. It causes difficulties in the use of new technology and limits the extent of exploration and exploitation of the seabed.

Similarly, it undermines the cooperation among the coastal states because none of them knows the extent of their sovereign rights for exploring and exploiting their natural resources. Moreover, narrow understanding of deep water processes and new technology that is already being employed in the GOM, as well as the plan to implement the use of FPSO, calls for a very careful assessment to avoid potential accidents. Therefore, the actual EIA of new deep-waters in E&P operations cannot be properly done because of the following reasons:

1) There are no international regulations controlling E&P discharges resulting directly from the exploitation of seabed mineral resources.
2) The legal status of the OCS is still obscure and controversial and;
3) Lack of information from deep-water processes and the employment of new technology does not enable the assessment of its environmental effects.

Finally, the consideration of a hypothetical exercise shows the imperative necessity of EIA specialists to be familiar with ERA as an important instrument for analysis. It also highlights the importance of having a proactive instead of a reactive approach in environmental issues and promotes the coordination and cooperation of the coastal states to face the challenges of new developments in E&P activities. The approach that the Baltic countries are taking serves as an example for the GOM coastal states.

6.2 Recommendations

Recommendations are directly derived from the analysis of the conclusions and are addressed to different organizations and institutions that can solve or improve some of the problems that were found in the GOM region. These recommendations anticipate problems and are in line with the foreseeable future.

6.2.1 To the International Maritime Organization (IMO)

Due to its oceanographic and ecologic characteristics as well as the character of its traffic, the GOM requires special mandatory measures for the prevention of marine pollution not only from ships but also from E&P activities. Therefore, its status as a special area should be addressed by the international community and their coastal states not only in Annex V but also in Annexes I, II and VI of MARPOL 73/78.

On the other hand, the lack of international regulations controlling discharges directly arising from the exploration and exploitation from the seabed mineral resources should also be tackled immediately. Although it has been argued that this is a problem that requires the direct control from the coastal states because the platforms are normally fixed and they only pose a threat of local pollution, this is not entirely true anymore. New technology is rapidly pushing E&P activities towards the sea and near the OCS of other countries. Thus, fixed platforms are not economically feasible any longer and the trend shows a steady decline in the use of them in the near future. Moreover, developing countries such as Cuba and to certain extent Mexico do not have the capacity to develop their own national standards or fulfil requirements of international regulations to protect the environment.

As a result, special mandatory measures to consider the GOM as a special area in all the context of MARPOL 73/78 as well as international regulations controlling discharges from offshore E&P activities are issues that should be deemed now by the IMO. Considering the time that the adoption and entry into force of new regulations takes, and taken into account that in the GOM, the industry is in a race between technology and depletion, it is recommended that actions be taken as soon as possible in this delicate area for the sake of environmental protection and sustainable development.

6.2.2 To the United Nations Commission on the Limits of the Continental Shelf (CLCS).

Article 76 provisions from UNCLOS convention are far from clear and must be clarified as soon as possible in order for the member states to establish their limits of the outer continental shelf (OCS) and legally exploit their natural resources. The convention requires the permanent establishment of the limits of the OCS when it exceeds 200 NM from the normal baseline. The problem is that it also takes the foot of the continental slope as a reference and even worse: it has to be determined as the point of maximum change in the gradient at its base. How can this point be used as a fixed point of reference if it is subject to permanent oceanographic changes? How can the countries determine such limits if still today, physical processes in deep waters are not known in most areas of the world? How can the CLCS guarantee that the approved limits of the OCS of the countries today will not overlap tomorrow? These unanswered questions as well as the lack of precision in the content of article 76 of the Convention confuse coastal states and delay the submission of their OCS documentation. Perhaps developed countries can deal with this situation because they have the resources to contemplate, fully study and permanently monitor their maritime zones. However, most of the developing countries do not. Therefore, it is strongly recommended that, in one way or another, the provisions of the convention be standardized in order for the state parties to fulfill their international obligations. This situation, for the reasons that have already been mentioned, should be addressed at once to avoid potential problems and possible international conflicts.

6.2.3 To the GOM Coastal states

In order to implement measures to properly carry out an EIA, international, regional and national regulations should be known and enforced in a uniform and standard way by the competent national authorities of the coastal states.

Hence, scientific and technical cooperation among them is essential to get rid of the problematic issues that these countries are currently facing. It includes scientific research, monitoring and the exchange of data and other scientific information. Article 123 of UNCLOS states: “States bordering an enclosed or semi-enclosed sea should co-operate with each other in the exercise of their rights and in the performance of their duties under this Convention”. The future situation of the region depends on the mutual aid between the USA, Mexico and Cuba in the same way that the Baltic countries do. Differences and misunderstandings must be solved as soon as possible for the sake of the environment and the protection of its natural resources.

Consequently, it is recommended that a common data base be set up where all the environmental agencies of the coastal states can be properly and timely informed not only of the environmental effects of new technology but also of geologic, biologic, chemical, meteorological and oceanographic data of the region. This in turn will save time, money and will enhance the cooperation of the coastal states and the proper implementation of the EIA in E&P activities of the region. Additionally, it will improve the decision making process within their environmental management systems and the protection of one of the most important ecosystems in the world.

6.2.4 To the Secretariat of the Mexican Navy

“Think globally…act locally” is the key to success. Regarding marine environmental protection in Mexico, the Secretariat of the Mexican Navy, in coordination with other national secretariats, is responsible for enforcing, among others, the international provisions of UNCLOS and MARPOL 73/78. In this regard, its main maritime environmental responsibilities are: The prevention and control of marine pollution considering technical and scientific cooperation with national agencies and foreign countries and topographical studies of the Mexican maritime zones.

Thus, in order to properly carry out EIA activities taking place in national waters and the particular protection of the GOM, the following recommendations have been made:

1) MARPOL 73/78 sets out requirements of port reception facilities that are an essential requisite for the establishment of special areas. Hence, a satisfactory economic and technical solution to the shortage of reception facilities in ports of the GOM should be found. Coordination and cooperation with national secretariats as well as environmental agencies of the USA and Cuba should be considered in order to find an appropriate solution to this problem.

2) In order to better assess the environmental impacts of polluting E&P activities in the Gulf region, it is recommended that permanent oceanographic stations be installed providing up-to-date and reliable data of the oceanographic and meteorological conditions of the area. Additionally, a close coordination should exist with the Mexican oil company PEMEX in order to develop software programmes for modelling oil spills that properly fit key risk areas on the GOM, such as the mathematical model that the Russian Professor, Sergey Ovsienko, developed for the Baltic Sea region.

3) Regardless of the unclearness of the Article 76 of UNCLOS, it is also recommended that topographical studies be carried out with the purpose of delimiting the Mexican Outer limit of the Continental Shelf and fulfilling in a coordinated way international obligations under the Convention. In addition, scientific studies of Mexican deep waters should also be performed with the aim of better assessing the E&P activities that PEMEX will do at these depths in the near future.

4) As part of sustainable development and continuity in maritime environmental activities in Mexico, it is recommended that Navy officers be sent on a regular basis to World Maritime University (WMU) in order to gain international maritime knowledge with practical application. Similarly, it is necessary that a liaison, having access to the highest level of management, be designated; thus, providing a genuine link between the Mexican Navy and IMO. Therefore, the regulations and amendments, which constantly are taking place, can be directly managed to properly fulfil the Navy's maritime environmental responsibilities. These are important and necessary steps to advise and support the decision takers at high levels and overcome the environmental problems that the nation itself is suffering now.

Although, in general terms, these suggestions can be considered as long-term and costly recommendations, steps towards the achievement of them should be taken into account in the budget of the nation. Thus, the Secretariat of the Mexican Navy must put them into its agenda as a priority in order to keep harmony with the speedy international development of maritime regulations as well as the policy of the actual Mexican President Vicente Fox: "Mexico is on an environmental crusade". There is no other way to get rid of the status of developing country but by facing these real challenges.

6.2.5 To World Maritime University

Most government and funding agencies that sponsor major engineering projects, such as offshore E&P activities, require that an assessment of the potential environmental impacts of the project be carried out. The increasing necessity to evaluate environmental impacts due to the pressure and development of new technology makes this issue really essential and important.

The realization of an EIA is mandatory in many of the maritime projects in many nations. Moreover, it is a recent environmental issue that is growing with accelerated impetus. Therefore, as a center of excellence for high-level maritime education and to better serve the global maritime community, it is recommended that a simulation system be implemented for real world exercises to provide the practical knowledge of an ERA as a powerful tool for analysis to properly carry out an EIA. Through a mathematical modeling, it will be possible to simulate an oil or chemical spill interacting with a variety of clean up measures. Thus, it will prepare students to conduct a response exercise and finally to perform an appropriate and complete maritime EIA. This software will also help to enhance the aims of the actual subjects that the university imparts such as:

MSEP 207	Prevention and combating marine pollution
MAD 303	Maritime environmental principles
MSEP 303	Maritime accidents and emergencies
MAD 306	Maritime casualty investigations
METN 306	Maritime casualties
METN 405	Marine traffic control systems

The software does not necessarily need to be expensive. The crisis management system to simulate oil spills from ©Transas Marine (PISCES2) does not require a sophisticated hardware. In fact, it uses a single PC compatible computer under windows 2000. It has been designed to be in compliance with international requirements and the control procedures are carried out in line with the ISO 9001 standard. The exercise illustrated in Chapter 5 of this dissertation shows only a small example of the software versatility. As a result, it can be considered as a short-term goal and can be implemented whenever WMU decides.

The USCG is currently using this simulation system for training purposes under the requirements of the US oil pollution Act 90.

Similarly, the Precision Planning and Simulation Corporation (PPS) (http://www.ppscorp.com/) is also employing it for training and development of oil contingency plans in response to numerous types of emergency situations. Hence, in order to forecast and anticipate problems and adapt them to future situations, it is advisable that WMU consider this recommendation to be in line with the future and to continue helping maritime administrations to fulfil the aims of IMO “Safer ships and cleaner oceans”.

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Appendix A

Possible effects of offshore oil and gas development on marine mammals

I. - Disturbance/noise from ship and aircraft operations, seismic profiling, platform construction, drilling, etc., may:

a. Interfere with or disrupt vocal communications, feeding, breeding or other vital functions.
b. Cause animals to avoid or abandon important feeding areas, breeding areas, resting areas, or migratory routes.
c. Cause animals to use marginal habitat or to concentrate in undisturbed areas, which in turn may result in crowding, overexploited food resources, increased mortality, and decreased reproduction.
d. Stress animals and make them more vulnerable to parasites, disease, and/or predation.
e. Attract animals, making them more vulnerable to oil spills hunting, harassment and;
f. Alter the distribution, density, movements, or behaviour of important prey species.

II. - Dumping, dredging, drilling, pipelines, support facility and storage facility construction may:

a. Damage or destroy haul-out sites, feeding areas, or other areas of similar importance; and
b. Adversely affect the distribution, abundance, behaviour or productivity of important prey species.

III. - Oil from well blowouts, pipelines breaks, tanker accidents, and chronic discharges associated with routine operations may:

a. Kill or debilitate marine mammals by matting and reducing the insulating quality of fur; cause acute or chronic poisoning due to inhalation or ingestion of toxic hydrocarbon components or ingestion of contaminated food; cause irritation of skin, eyes, or mucous membrane, or fouling of baleen;
b. Kill, debilitate, or otherwise reduce the abundance or productivity of important prey species and/or species lower in the marine food web, resulting in acute or chronic nutritional deficiencies, including starvation;
c. Stress animals, making them more vulnerable to disease, parasitism, and/or predation;
d. Interfere with the formation of mother-pup bonds and cause mothers (particularly colonial breeding pinnipeds) to abandon pups;
e. Cause animals to abandon or avoid contaminated breeding areas, feeding areas, etc., and/or to concentrate in unaffected areas; and;
f. Attract animals to debilitated prey, making them more vulnerable to contact with oil and the ingestion of contaminated prey.

IV. - Contaminants in drilling muds, waste discharge, etc. may:

a. Kill or debilitate animals that are exposed to contaminants; and
b. Contaminate, accumulate in, and kill or debilitate important prey species or species lower in the marine food web.

V. - Increased ship traffic may increase the probability of collisions between ships and marine mammals.

Source: Lang & Fertl, 2001, p.4

Appendix B

Summary of potential environmental impacts of offshore E&P activities

(This table should be cross-referenced with the table in Appendix C "Environmental protection measures")

Activity	Source	Potential Impact	Component Affected	Comments
Exploratory and appraisal drilling	Site selection	Interactions	H/B/Aq	Consider sensitivities in relation to biota, resource use, cultural importance, and seasonality. Potential impact on local ports and infrastructure.
	Operations	Discharges Emissions Wastes	H/At/B/Aq/T	Discharges to ocean – muds, cuttings, wash water, drainage, sewage, sanitary and kitchen wastes, spillages and leakages. Emissions from plant equipment; noise and light; solid waste disposal onshore and impact on local infrastructure. Disturbance to benthic and pelagic organisms and other marine resources. Changes in sediment, water and air quality. Emissions and discharges from well test operations, produced water discharges, burning and flare, additional noise and light impact. Effects of vessel and helicopter movements on human and wildlife.

Continued…

(Continued): Summary of potential environmental impacts of offshore E&P activities

Activity	**Source**	**Potential Impact**	**Component Affected**	**Comments**
Exploratory and appraisal drilling *(Continued)*	Decommissioning	Foot print	H/Aq	Proper controls during operations and careful decommissioning should effectively remove risk of long-term impact. Improper controls can result in sediment and water contamination, damage to benthic and pelagic habitats, organisms, biodiversity. Onshore in terms of solid waste disposal, infrastructure and resource conflicts.
Development and production	Site selection	Interactions	H/B/Aq	Long-term site selection based upon biological and socio-economic sensitivities and minimum disturbance. Risk of impact to sensitive species, resource conflict, access. Long term support and supply base requirement and impact on local port infrastructure.

Continued…

(Continued): Summary of potential environmental impacts of offshore E&P activities

Activity	Source	Potential Impact	Component Affected	Comments
Development and production *(Continued)*	Operations	Discharges Emissions Wastes	H/At/B/Aq/T	Long-term, chronic effects of discharges on benthic and pelagic biota; sediment and water quality, impact of drill cuttings and mud discharges, produced water, drainage, sewage, sanitary and kitchen wastes, spillage and leakage. Emissions from power and process plant and impact on air quality. Noise and light impact from facilities and flaring. Solid waste disposal and impact on onshore infrastructure. Increased vessel and helicopter movements.
		Socio-economic cultural	H	Loss of access and resource use interaction. Local port, harbour and community interactions related to supply and support functions.
Nomenclature: H= Human, socioeconomic and cultural; T= Terrestrial; Aq= Aquatic; At= Atmospheric; B= Biosphere.				

Source: Adapted from the UNEP, 1997, pp. 17-20

Appendix C

Environmental protection measures

Activity	Source of potential impact	Environmental protection measures
Aerial Survey	Aircraft	• Use environmental assessment to identify protected areas/sensitivities. Schedule operations during least sensitive periods.
Seismic operations	Seismic equipment Vessel operations	• Use environmental assessment to identify protected areas and local sensitivities. Schedule operations during least sensitive period. • Consult local authorities and other stakeholders regarding survey programme. • Dispose all waste materials properly to meet local, national and international regulations. • Apply proper procedures for handling and maintenance of equipment. • All towed equipment must be labelled and highly visible. • Make adequate allowance for deviation of towed equipment when turning. • Prepare contingency plans for lost equipment and oil spillage. • Attach active acoustic location devices to auxiliary equipment to aid location and recovery. • Store and handle explosives according to operator's procedures and local regulations • Consider using guard boat in busy areas. • Report all unplanned interactions with other resource users or marine life to the authorities. • Use local expertise to support operations e.g. spotting marine mammals, wildlife, etc.

Continued…

(Continued): Environmental protection measures

Activity	Source of potential impact	Environmental protection measures
Exploration and appraisal drilling	Site selection	• Use environmental assessment to identify protected areas/sensitivities. Schedule operations during least sensitive periods. • Consult with local authorities regarding site selection and support infrastructure- ports, vessel, and air traffic. • Select least sensitivity location within confines of bottom target/drilling envelope. Consider directional drilling to access targets beneath sensitive areas. Consider cluster well drilling. • Local conditions must be fully assessed- wave, wind and currents. • In coastal areas, select site and equipment to minimize disturbance, noise, light and visual intrusion.
	Access	• Exercise strict control on access and all vessel and rig activity. • In coastal areas where sensitivities dictate use vessels in preference helicopters.
	Operations	• Consult with local authorities regarding emissions, discharges and solid waste disposal/notifications in regard to other resource users. • Requirements specified in planning process must be met including supply vessel operations. • **Aqueous discharges**. Oily water from deck washing, drainage systems, bilges, etc. should be treated prior to discharge to meet local, national and international consents. • Sewage must be properly treated prior to discharge to meet local and international standards. Treatment must be adequate to prevent discolouration and visible floating matters.

Continued…

(Continued): Environmental protection measures

Activity	**Source of potential impact**	**Environmental protection measures**
Exploration and appraisal drilling *(Continued)*	Operations *(Continued)*	• Biodegradable kitchen wastes require grinding prior to discharge, if permitted under local regulations. • Most spills and leakage occur during transfer operations (ensure adequate preventive measures are taken and that spill contingency plan requirements are in place). • Store oils and chemicals properly in contained, drained areas. Limit quantities stored to a minimum level required for operational purposes. Ensure proper control documentation and manifesting disposal. Do not dispose of waste chemicals overboard. • Produced water from well tests must meet local regulations or company specified standards prior to discharge. • Preferentially separate and store oil from well test operations. If burnt, ensure burner efficiency is adequate to prevent oil fall out onto sea surface. • **Solid wastes.** Ensure requirements specified in the planning process are met with regard to waste treatment and disposal. • Collect all domestic waste and compact for onshore disposal. Ensure proper documentation and manifesting. Ensure onshore receiving and disposal meet local requirements. • Consider waste segregation at source for different waste types – organic, inorganic industrial wastes etc.

Continued…

(Continued): Environmental protection measures

Activity	Source of potential impact	Environmental protection measures
Exploration and appraisal drilling *(Continued)*	Operations *(Continued)*	• No debris or waste to be discarded overboard from rig or supply vessels. • Waste container must be closed to prevent loss overboard. • Spent oils and lubes should be containerized and returned to shore. • Considering bulk supply of materials to minimize packing wastes. • **Muds and cuttings**. Preferentially use low toxicity water based drilling muds. Minimized the use of oil-based muds (OBM). • Mud make-up and mud and cuttings disposal requirements addressed in the planning process must be met.' • Do not dispose of whole OBM to sea. Any oil cuttings discharged must meet local regulations or company specified standards. • Continue down hole disposal of OBM wastes. • Atmospheric emission/noise/light. Ensure requirements addressed in the planning phase are met with regard to emissions noise and light. • Well test burners must be efficient, maintained and effectively burn gas and oil. • H_2S emissions must be effectively controlled.
	Decommissioning and restoration.	• All debris must be removed from seabed • Decommissioning of onshore support facilities must meet planning requirements.

Continued…

(Continued): Environmental protection measures

Activity	Source of potential impact	Environmental protection measures
Development and Production	Site selection and access	• Long term occupation of sites, including supply and support base, will require detailed assessment of environmental implications, particularly where resource of conflicts arise and commercially important species may be affected. • All aspects identified for exploration drilling should be applied to permanent sites. • Consult with local authorities. • Consider site and route selection for flow lines and pipelines.
	Operations	• Evaluate construction and drilling activities and impacts separately from operational activities. • Maximize use of central processing facility and use of satellite and cluster wells to minimize footprint. • All aspects identified for exploration drilling should be applied to permanent sites. • Consult with local authorities. • Evaluate implications of development on local infrastructure, in particular, infrastructure related to onshore service functions- port and harbour operations, resource use conflicts, waste treatment and disposal, socio-economic implications, employment, local services and supply.

Continued…

(Continued): Environmental protection measures

Activity	Source of potential impact	Environmental protection measures
Development and Production *(Continued)*	Operations *(Continued)*	• Assess full implications of well treatment and work-over, process, storage; power generation and other support and accommodation facilities in terms of long-term disturbance and impact. • Incorporate oily water treatment system for both produced water and contaminated water treatment to meet local, national and international discharge limits. • Include sewage treatment system, particularly if close to shore, to meet local requirements. • Assess treatment of waste gases and emission limits, particularly where gas is flared. Avoid gas venting. • Treatment and disposal of solid, toxic and hazardous wastes onshore will require proper planning, particularly if local infrastructure is limited in capacity and capability. A detailed waste management plan will be required. • Prepare detailed contingency plans, personnel training and regular exercise of response, taking into consideration storage and export systems. • Establish consultation and local liaison activities. • Monitor waste streams in order to meet compliance requirements.
	Decommissioning and rehabilitation	• Any facilities and infrastructure handed over to local authorities must include proper instruction for use, maintenance and include proper training procedures.

Continued…

(Continued): Environmental protection measures

Activity	**Source of potential impact**	**Environmental protection measures**
Development and Production *(Continued*	Decommissioning and rehabilitation *(Continued)*	• Develop a full decommissioning and rehabilitation plan in consultation with local authorities. • Decommissioning of offshore structures is subject to international and national laws, and should be dealt with on a case-by-case basis with local authorities. • Record and monitoring site as required after appropriate decommissioning activities.

Source: Adapted from the UNEP, 1997, p. 39-49

Appendix D

Regional and international conventions regulating environmental impact of the offshore oil and gas industry in the Gulf of Mexico

Regional

- Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, Cartagena de Indias, 1983

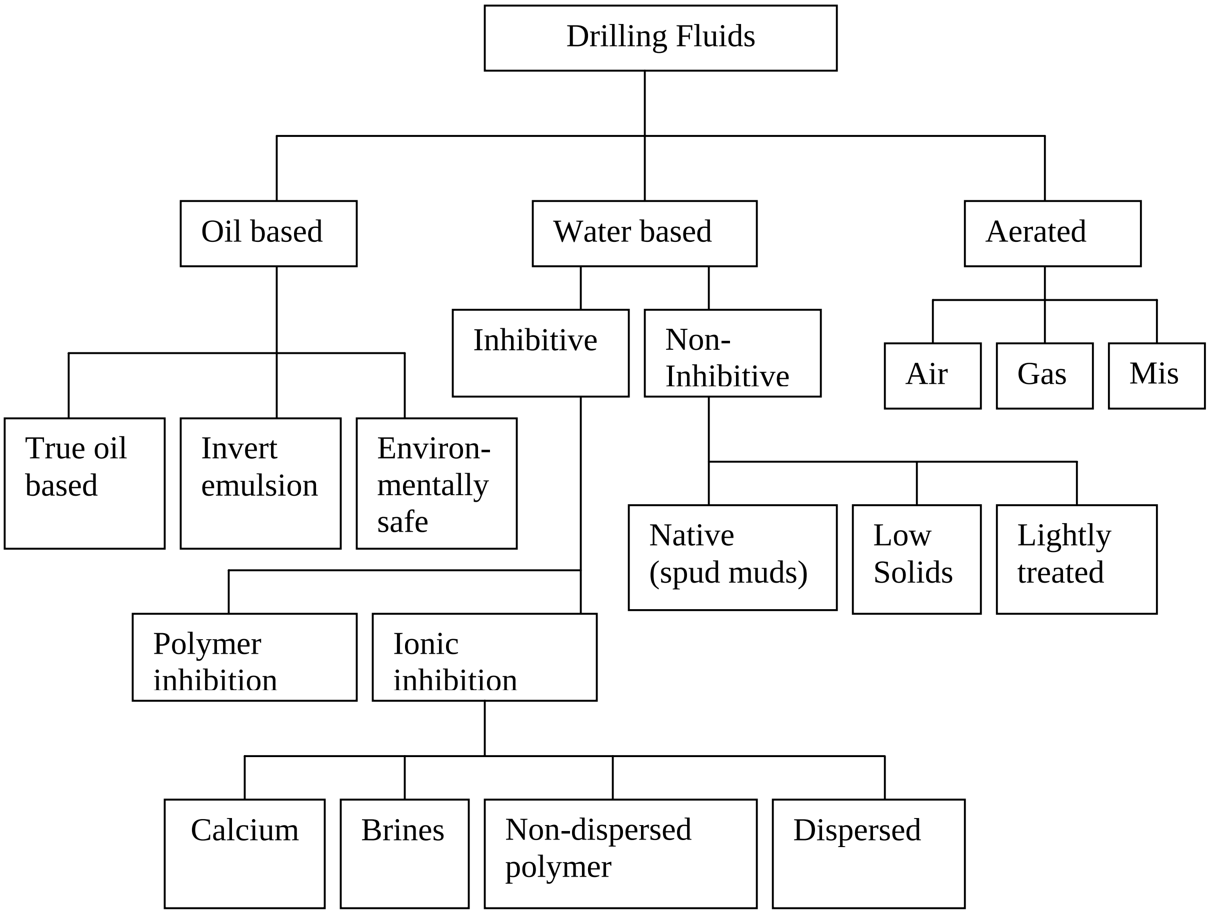
International

- United Nations Convention on the Law of the Sea (UNCLOS), Montego Bay, 1982
- International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78), London, 1973 and 1978
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (Dumping Convention), London, 1972
- International Convention on Oil Pollution Preparedness, Response, and Co-operation (OPRC), London, 1990
- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (Intervention Convention), Brussels, 1969
- Convention on the Control of Trans- boundary Movements of Hazardous Wastes and their Disposal (Basel Convention), Basel, 1989

- Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS), London, 1996
- International Convention on Civil Liability for Oil Pollution Damage 1969 (1969 CLC), Brussels, 1969, 1976, and 1984
- International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage 1971 (1971 Fund Convention), Brussels, 1971

Appendix E

Drilling fluids



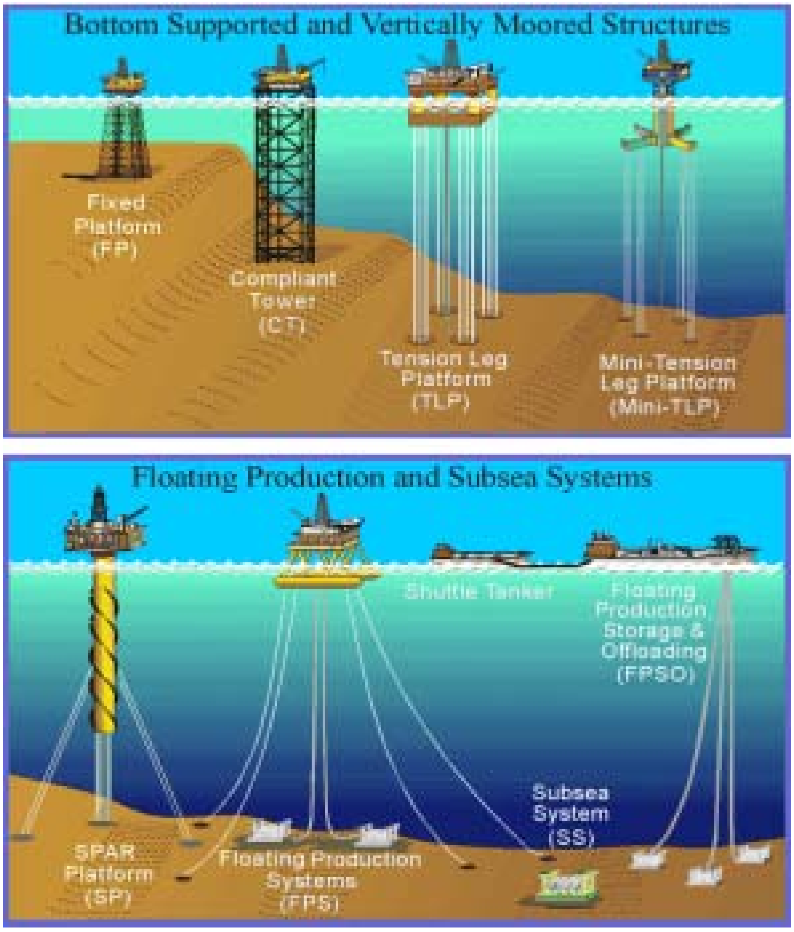
All drilling muds consist of liquid phase and solid phase. Based on the liquid phase, drilling mud is classified into three types:

1. *Water based*
2. *Oil based*
3. *Emulsions*

The solid phase consist of weighting materials like barites and viscosifiers like clays and polymers. In addition to the above a drilling mud contained other additives like *fluid loss, control agents, dispersants, lubricants, detergents, emulsifiers, flocculants, defoamers, bactericides* and *lost circulation material.* (Source: IADC, 1999).

Appendix F

Deepwater Development Systems



Basic options used in constructing the Gulf's deepwater permanent production platforms **(Source: MMS, 2000a)**

Fixed Platform (FP)

An FP consists of a jacket (a tall vertical section made of tubular steel members supported by piles driven into the seabed) with a deck placed on top, providing space for crew quarters, a drilling rig, and production facilities. The fixed platform is economically feasible for installation in water depths up to 1,500 feet.

Compliant Tower (CT)

A CT consists of a narrow, flexible tower and a piled foundation that can support a conventional deck for drilling and production operations. Unlike the fixed platform, the compliant tower withstands large lateral forces by sustaining significant lateral deflections, and is usually used in water depths between 1,000 and 2,000 feet.

Tension Leg Platform (TLP)

The TLP consists of a floating structure held in place by vertical, tensioned tendons connected to the sea floor by pile-secured templates. Tensioned tendons provide for the use of a TLP in a broad water depth range with limited vertical motion. The largest TLP's have been successfully deployed in water depths approaching 4,000 feet.

Mini-Tension Leg Platform (Mini-TLP)

The Mini-TLP is a floating mini-tension leg platform of relatively low cost developed for production of smaller deepwater reserves, which would be uneconomic to produce using more conventional deepwater production systems. It can also be used as a utility, satellite, or early production platform for larger deepwater discoveries. The world's first Mini-TLP was installed in the Gulf of Mexico in 1998.

SPAR Plattform (SPAR)

The SPAR consists of a large diameter single vertical cylinder supporting a deck. It has a typical fixed platform topside (surface deck with drilling and production equipment), three types of risers (production, drilling, and export), and a hull, which is moored into the seafloor. SPARs are presently used in water depths up to 3,000 feet, although existing technology can extend its use to water depths as great as 7,500 feet.

Floating Production System (FPS)

An FPS consists of a semi-submersible unit, which is equipped with drilling and production equipment. It is anchored in place with wire rope and chain, or can be dynamically positioned using rotating thrusters. Production from sub sea wells is transported to the surface deck through production risers designed to accommodate platform motion. The FPS can be used in a range of water depths from 600 to 7,500 feet.

Sub Sea System (SS)

The SS ranges from single sub sea wells producing to a nearby platform, FPS, or TLP to multiple wells producing through a manifold and pipeline system to a distant production facility. These systems are presently used in water depths greater than 5,000 feet.

Floating Production, Storage & Offloading System (FPSO)

An FPSO consists of a large tanker type vessel moored to the seafloor. An FPSO is designed to process and stow production from nearby sub sea wells and to periodically offload the stored oil to a smaller shuttle tanker. The shuttle tanker then transports the oil to an onshore facility for further processing. An FPSO may be suited for marginally economic fields located in remote deepwater areas where a pipeline infrastructure does not exist. Currently, there are no FPSO's approved for use in the Gulf of Mexico.

Source: MMS, 2000a

Appendix G

Classification of hazard identification for possible causes of oil spill

According to Spouge (1992), the hazards which might give rise to an oil spill are classified as:

Drilling events

1. Drilling blowouts, ie uncontrolled flows from the well being drilled;
2. Drilling spills, ie limited hydrocarbon spills from the drilling or testing equipment;
3. Mud spills, ie spills during loading, storage, or use of oil based mud.

Production events

1. Production blowouts, ie uncontrolled flows from the well in production or during a workover;
2. Wellhead leaks, ie limited spills from the wellhead equipment;
3. Process leaks, ie spills from the separation, metering or pumping equipment on the platform;
4. Diesel spills, ie spills during loading, storage or use of diesel fuel.

Export events

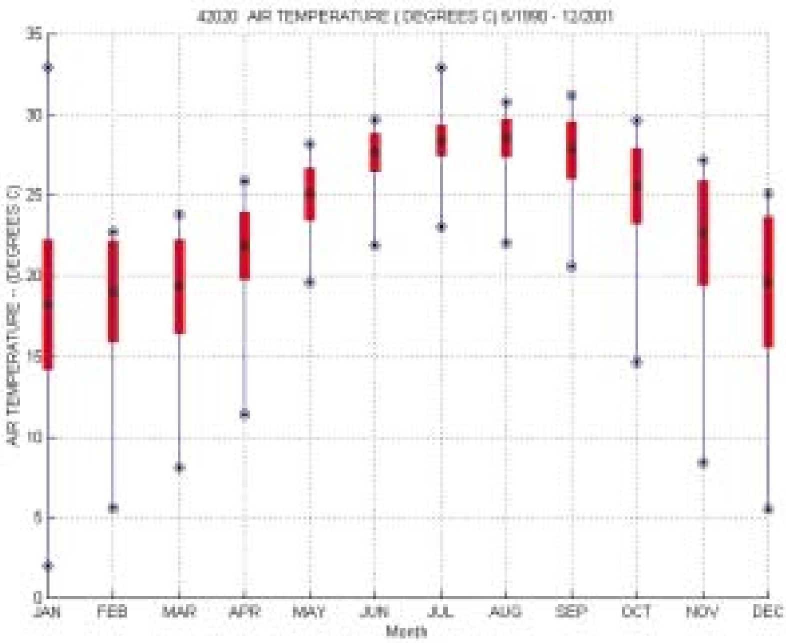
1. Pipeline and riser failures, associated with pipeline export of oil;
2. Crude storage spills, associated with bulk storage of oil in gravity tanks, loading buoys or storage tankers;
3. Crude loading spills, associated with the loading of tankers offshore.

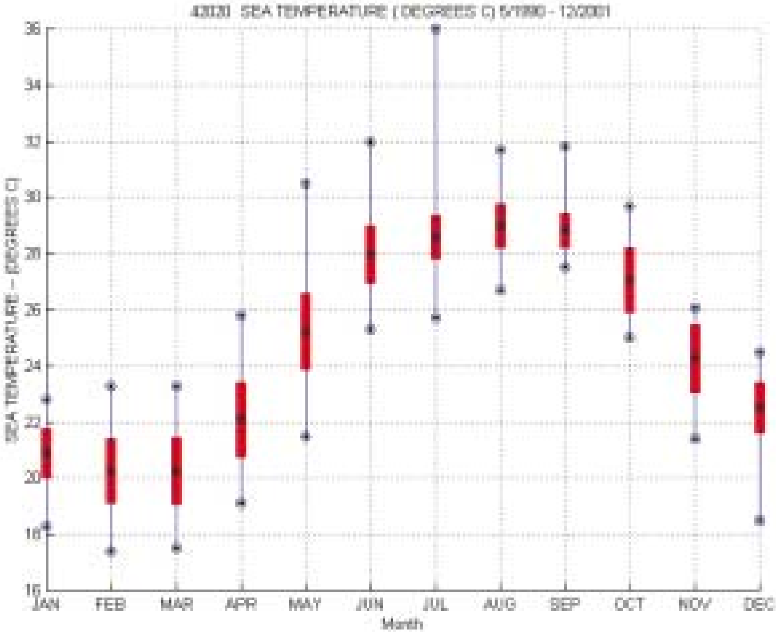
Escalation events

1. Fires and explosions, where the initial leak is ignited and leads to a greater spill;
2. Collisions, where damage from a ship collision causes a spill;
3. Structural failure, where this leads to a spill.

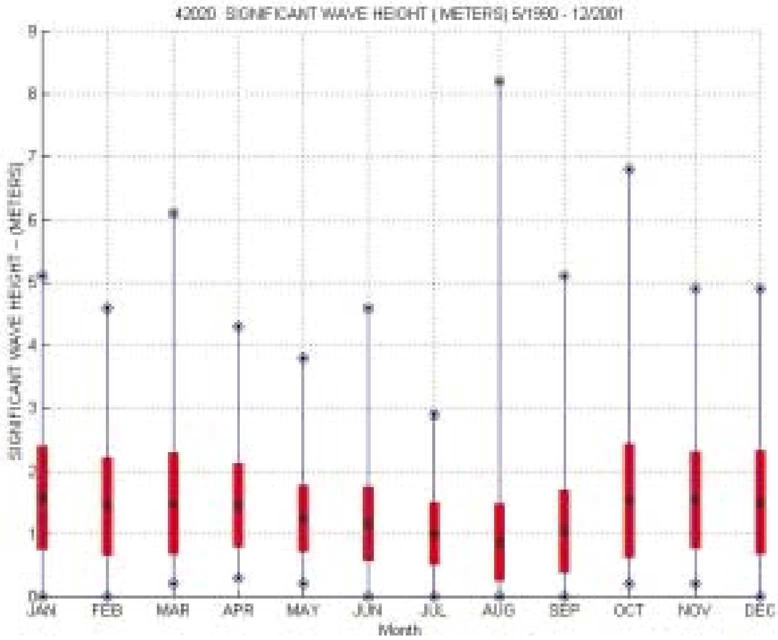
Appendix H

Recent historical data (1990-2001): Station 42020 - Corpus Christi, TX. 50NM Southeast of Corpus Christi, TX.26.95 N 96.70 W (26°57'00"N 96°42'00"W)

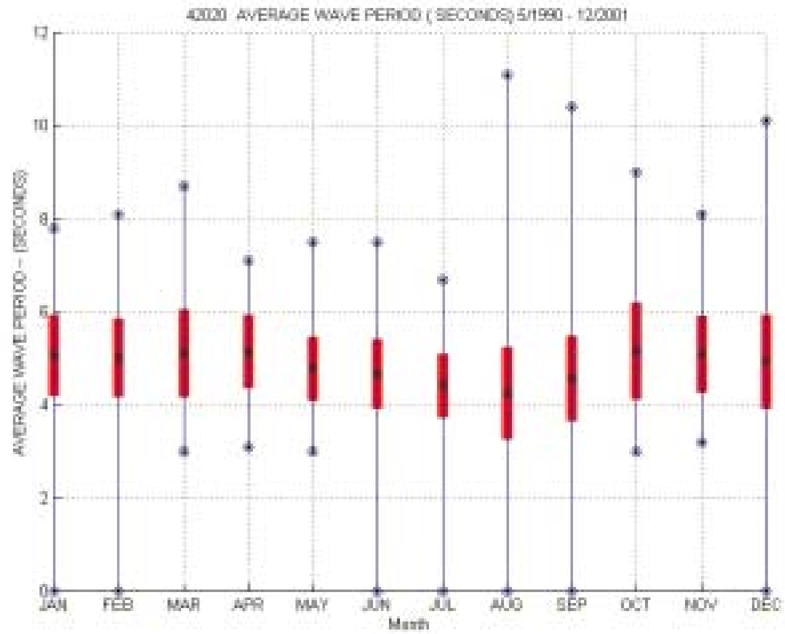




42020 SEA TEMPERATURE (DEGREES C) 5/1990 - 12/2001
SEA TEMPERATURE -- (DEGREES C)
Month
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC



42020 SIGNIFICANT WAVE HEIGHT (METERS) 5/1990 - 12/2001
SIGNIFICANT WAVE HEIGHT -- (METERS)
Month
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC


42020 AVERAGE WAVE PERIOD (SECONDS) 5/1990 - 12/2001
AVERAGE WAVE PERIOD -- (SECONDS)
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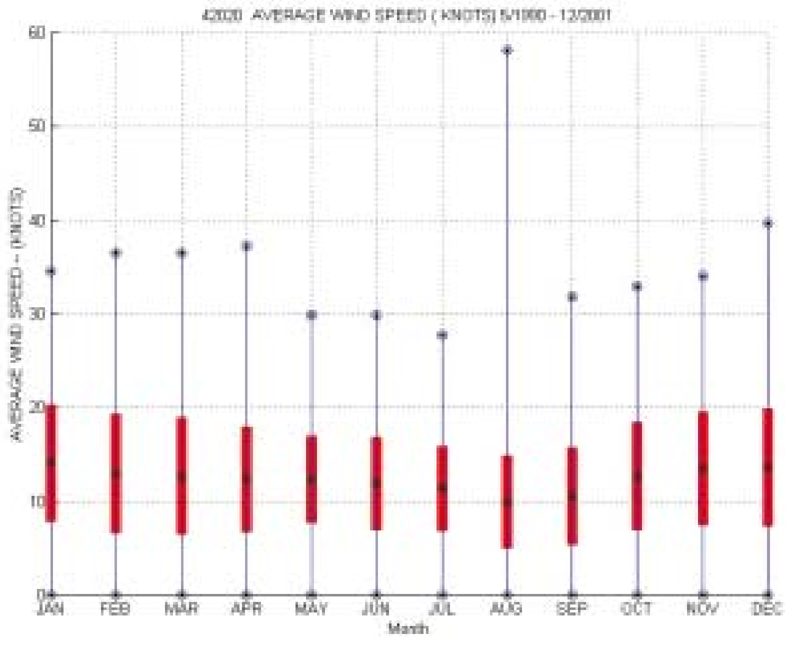
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC


42020 AVERAGE WIND SPEED (KNOTS) 5/1990 - 12/2001
AVERAGE WIND SPEED -- (KNOTS)
Month
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APR
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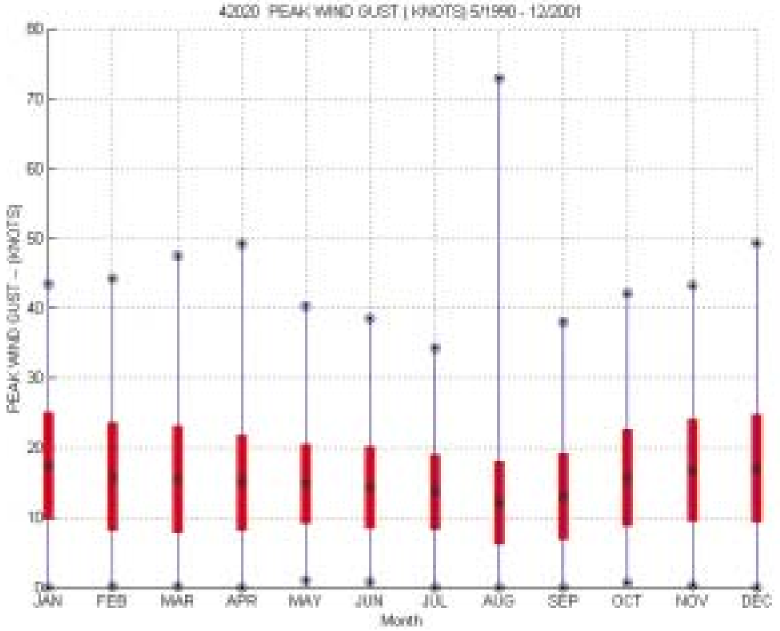
SEP
OCT
NOV
DEC



Source: NDBC, 2003

Appendix I

Oil Types

Oil is commonly considered to be a single substance, but there are actually many different kinds of oil. The kinds of oil differ from each other in their viscosity, volatility, and toxicity. Viscosity refers to the resistance of the oil to flow. Volatility refers to how quickly the oil evaporates into the air. Toxicity refers to how toxic, or poisonous, the oil is either to people or other organisms.

When spilled, the various types of oil can affect the environment differently. They also differ in how hard they are to clean up. Spill responders group oil into four basic types (NOAA, 2003b). Following is a list of those four types, along with a general summary of how each type can affect shorelines.

Type 1: Very Light Oils (Jet Fuels, Gasoline)

- Highly volatile (should evaporate within 1-2 days).
- High concentrations of toxic (soluble) compounds.
- Localized, severe impacts to water column and intertidal resources.
- No cleanup possible.

Type 2: Light Oils (Diesel, No. 2 Fuel Oil, Light Crudes)

- Moderately volatile; will leave residue (up to one-third of spill amount) after a few days.
- Moderate concentrations of toxic (soluble) compounds.
- Will "oil" intertidal resources with long-term contamination potential.
- Cleanup can be very effective.

Type 3: Medium Oils (Most Crude Oils)

- About one-third will evaporate within 24 hours.
- Oil contamination of intertidal areas can be severe and long-term.
- Oil impacts to waterfowl and fur-bearing mammals can be severe.
- Cleanup most effective if conducted quickly.

Type 4: Heavy Oils (Heavy Crude Oils, No. 6 Fuel Oil, Bunker C)

- Heavy oils with little or no evaporation or dissolution.
- Heavy contamination of intertidal areas likely.
- Severe impacts to waterfowl and fur-bearing mammals (coating and ingestion).
- Long-term contamination of sediments possible.
- Weathers very slowly.
- Shoreline cleanup difficult under all conditions.