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Moving to zero : the potential for improving environmental protection under the discharge regime of Annex I of MARPOL 73/78

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MOVING TO ZERO: THE POTENTIAL FOR IMPROVING ENVIRONMENTAL PROTECTION UNDER THE DISCHARGE REGIME OF ANNEX I OF MARPOL 73/78

By

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DECLARATION

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

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

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DEDICATION

Dedicated to my father,

who passed away during my research work for this dissertation.

May Allah let him rest in peace.

ABSTRACT

Title of Dissertation: **Moving to zero: The potential for improving environmental protection under the discharge regime of Annex I of MARPOL 73/78**

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Scientific research reveals that a 15-ppm regulatory limit of oil discharge from shipboard operations has a long-term harmful effect on the marine environment, its biodiversity and eco-system. Statistics on marine pollution shows a substantial reduction in operational discharge of oil from tanker operations, whereas a negligible change has been observed in operational discharges from machinery spaces. As a result, operational discharges from machinery spaces remain the largest oil polluting source of the oceans from shipping activities.

Discharges from machinery spaces also have a problem of complying with the regulatory limit of 15-ppm due to the presence of detergents and emulsion causing substances in the bilge water and oil. However, technological developments in oily water separators and other oil filtering techniques, in some parts of the world, show a remarkable improvement in the maintenance of the regulatory limit. Use of these technologies can reduce the oil content of the operational discharges from machinery spaces much below the regulatory limit and even almost to zero-ppm, and hence eliminate the harmful effects of operational discharges into the marine environment.

This study provides the possibility to reduce the present regulatory limit of 15-ppm to zero ppm in the near future through a thorough discussion of the development of the legal, technical and enforcement regimes under MARPOL 73/78.

Key words: Oil pollution, Marine environment, Engine room discharges, Discharge standards, Reduction, MARPOL.

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LIST OF ABBREVIATION

BIMCO	The Baltic and International Maritime Council
BLG	Sub-committee on Bulk, Liquids and Gasses
CBT	Clean Ballast Tank
COW	Crude Oil Washing
DE	Sub-committee on Ship Design and Equipment
DNA	Deoxyribo Nucleic Acid
DWT	Deadweight tons
GRT	Gross Registered Tonnage
HSSC	Harmonized System of Survey and Certification
ICONS	International Commission on Shipping
IMCO	Intergovernmental Maritime Consultative Organization
IMO	International Maritime Organization
IOPP	International Oil Pollution Prevention
ISM	International Safety Management
LOT	Load On Top
MARPOL	The International Convention on the Prevention of Pollution from Ships
MEPC	Marine Environment Protection Committee
MER	Marine Engineers Review
OILPOL	The International Convention for the Prevention of Pollution of the Sea by Oil
ORB	Oil Record Book
ppm	parts per million

PSCO	Port State Control Officer
SBT	Segregated Ballast Tank
SOLAS	The International Convention for the Safety of Life at Sea
STCW	The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
UNCLOS	The United Nations Convention on the Law of the Sea
wsf	water soluble fraction

INTRODUCTION

A bird, oil soaked and dead, or a beach, soiled with black oil; are the first few images that cross our minds whenever we think about ships and pollution. Besides accidental spills from ships, which are occasional, but dramatic and sensational, there is another kind of oil pollution carried out everyday, called operational discharge. Statistics on marine pollution reveals that the operational discharge from ships is the largest source of ship source oil pollution of seas.

Operational discharge is carried out due to ballasting and tank washing of the cargo tanks of a tanker, known as discharge due to tanker operations, and pumping out of oily bilge water from machinery spaces of all ships. Due to the development of technology and application of stricter rules concerning tanker discharge, pollution from tankers has been reduced substantially. The discharge from machinery space, however, remains the largest source of marine pollution at present.

The International Convention for the Prevention of Pollution from Ships, (MARPOL 73/78), in particular Annex I of this Convention, deals with oil pollution from ships. Although, current scientific evidence suggests that even a small amount of oil can be harmful to the marine environment, the MARPOL 73/78 Regulations 9, 10, and 16 of Annex I allow a 15-ppm (parts per million) oil discharge from the machinery spaces of ships. However, this regulatory limit of 15-ppm discharge is often exceeded for various reasons, hence causing more pollution and more harm to the marine environment, its biodiversity and eco-system.

Considering the fact that the technology to reach a close to zero-ppm discharge is available now, the intention of this paper is to explore the possibilities of improving the regulatory standard by reducing the present discharge limit of engine room discharge from 15-ppm to zero-ppm within coastal areas, since most marine organisms live within such areas. This improvement will help to save the marine eco-system and its biodiversity. Moreover, this will help to preserve our supply of the food chain. Another intention is to increase the reader's general understanding about oil pollution and oil pollution prevention regimes related to marine transportation, thus creating a greater awareness among them and through them to those who can bring about changes to improve the present standard of engine room operational discharge to zero-ppm.

The scope of discussion, however, will be limited to the development of the legal regime, development of the technical regime and enforcement regime under MARPOL 73/78. The methodology that has been adopted to write this dissertation is mainly research of reference materials, books, journals, periodicals available at the World Maritime University library and study materials from Professors and visiting lecturers. Also, interaction with many surveyors and maritime officials during field studies in the Scandinavian countries and in the U.K. In addition, intensive correspondence with many scholars and scholarly persons and different manufacturers of oily water separators and their responses have made it possible to complete this dissertation.

This dissertation consists of five chapters. Chapter 1 will provide a general view of oil pollution, its sources and in particular the operational discharges from shipping sources. The effect of oil on the marine environment and why we need to improve the regulatory limit is also described in this Chapter. In Chapter 2, a historical development of operational oil discharge control is discussed to find out if there is any provision or scope left for the improvement of the present regulatory limit.

In Chapter 3, technical developments in respect of pollution prevention equipment are discussed to see if the equipment is available to comply with the proposed regulatory limit of zero-ppm discharge. In Chapter 4, the enforcement regime under MARPOL 73/78 is discussed to see whether the proposed change in the regulatory limit will have any implications on the present enforcement regime and if any, how to overcome them. In Chapter 5, a conclusion is drawn on the basis of the overall discussion made in the previous chapters.

CHAPTER 1

SOURCES OF MARINE POLLUTION BY OIL AND THEIR IMPACT ON OCEAN ECOLOGY

Oceans, which cover 71% of the earth's surface and contain 97% of the world's water, constitute the marine environment (Goosens, 1999). Oceans and seas are the center of the earth's ecology and they sustain a great diversity of life on this planet. They also affect climate by interacting with the atmosphere. Moreover, as a primary source of living and nonliving natural resources, oceans meet much of the human needs and provide protein, energy, and means of transportation, employment, and recreation. They also support many other economic, social and cultural activities (Asaduzzaman, 1998).

However, many human activities on land, in the oceans and in the air cause damage to the marine environment, its biodiversity and eco-system. Pollutants are many and they cause various degrees of harm to the marine environment. The 1982 United Nations Convention on the Law of the Sea (UNCLOS) defines pollution of the marine environment in Article 1(4) as follows:

> The introduction by man, directly or indirectly, of substances or energy into the marine environment including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, the impairment of quality for use of seawater and reduction of amenities.

Oil is the most significant pollutant of the sea in terms of frequency and quantity carried across the oceans by ships as well as the fact that ship's operations are also a source of oil pollution (IMO, 1998; Asaduzzaman 1998; Sasamura,1990). It refers to a wide range of material including petroleum (crude oil), bunker fuel, petrol and lubricants (Donaldson, 1994). Crude oil is toxic when fresh and in bulk coats and smothers organisms (Gold, 1998). After weathering, it forms floating tar balls and when washed up on the coast reduces the quality of beach amenities. Petroleum products such as petrol are particularly toxic but also extremely volatile and hence evaporate quickly from the sea's surface (Donaldson, 1994). The polluting oil, however, does not come from ships only, it has many other sources. In this chapter these sources will be identified and ship source oil pollution will be discussed in detail, particularly operational discharges from ships. Thereafter, the biological impact of such discharges will be highlighted with the need to improve the present regulatory limit by reducing the discharge standard to zero ppm.

1.1 Sources of oil in the oceans

The sources of oil in the sea can be categorized into natural sources, offshore oil production, marine transportation, coastal, municipal, and industrial waste and runoffs and ocean dumping.

1.1.1 Natural Sources

There are two ways for oil to enter the sea from natural sources. One is natural seepage, which occurs due to the escaping of oil from fractured rock strata (Cowell, 1976). The other is erosional input, which assumes a portion of organic carbon transported by all rivers into the sea is petroleum.

1.1.2 Offshore Oil Production

Operational discharge and accidents are two main causes of oil pollution input from offshore oil production. Operational discharge, often termed as produced water meaning oil when extracted from an oil reservoir, extracts a certain amount of water with it. This water is processed to reduce the oil content in it and then discharged into the sea. Oil pollution input from accidents involves minor spills caused by leaking, seeping and oozing, as well as severe accidents, e.g. blowouts.

1.1.3 Marine Transportation

Operational discharges from ships and spills from accidents are also causes of oil pollution input from shipping activities. Accidents like collision, allision, grounding etc. due to bad navigation or steering failure; fire due to bad housekeeping and structural failure such as the ‘Erika’ incident due to poor maintenance, are all reasons for oil spills at sea. Operational discharge, on the other hand, is the intentional discharge of oil or oil-water mixtures from ships resulting from their operation, and in particular concerns the discharge from engine rooms or machinery spaces. This latter aspect is the focus of this dissertation.

1.1.4 The Atmosphere

Unburnt fuel oil carried by exhaust gasses from different engines and boilers and refined oil exposed to the open air are the reasons for oil input from the atmosphere. When fuel oil is not burnt properly due to various faults of the engine, the exhaust gasses carry a part of this unburnt oil into the atmosphere. Similarly, a highly refined petroleum product, when exposed to the air, easily volatilizes and enters into the surrounding atmosphere. After a certain time these oil droplets, mixed with rain or snow, will come back to the earth and find their way into the sea.

1.1.5 Municipal Waste

Municipal waste is mainly the drainage from households and similar places in the municipal area. Oil in various forms is used everyday for heating, cooking, body massaging, health care, beauty care etc. All these oils, after use, are washed down the drain into the drainage system.

1.1.6 Industrial Waste

Industrial waste that carries oil can be divided into non-refinery and refinery industrial wastewater. Some non-refinery industrial wastewater is discharged into municipal drainage systems. However, a large part of it is discharged directly through coastal effluents. This fraction is sizable and cannot be neglected. Refinery industrial wastewater, on the other hand, is discharged either after treatment into estuaries or without treatment into municipal drainage systems. Both systems cause severe pollution.

1.1.7 Urban and Rural Run-off

These constitute the treated and untreated wastewater that has been discharged into the interior rivers and carried into the sea.

1.1.8 Ocean Dumping

Ocean dumping is another source of oil pollution, which is related to the sludge and underflows of municipal wastewater treatment plants. The sludge is usually carried into barges and dumped into the sea or discharged through pipelines. Dumping of this kind also brings large amounts of oil into the sea every year. However, dumping by barges falls under the source of maritime transportation and is dealt with in the London Dumping Convention, 1972.

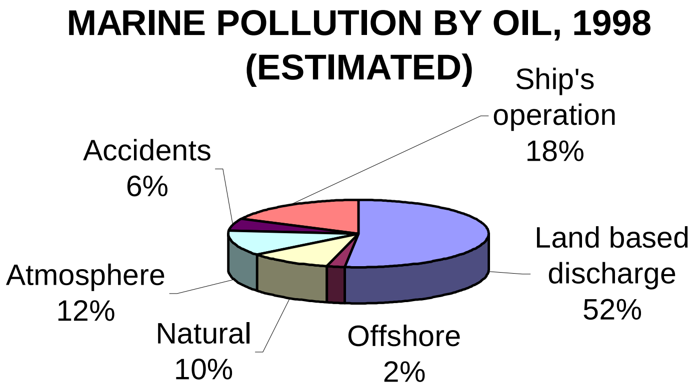
A 1998 estimate of the different sources of oil in the oceans is presented in Table 1 and their relative percentage is shown in Figure 1 below. Table 1 shows the total oil input from land-based sources, namely, industrial, municipal wastewater, urban sediments and rivers to be 1,260,000 tons in 1998, whereas, that from ship

TABLE 1: Estimated oil input into the sea, 1998

SOURCE OF OIL INPUT INTO SEA	ESTIMATED TONS/YEAR
Natural (erosion, filtering etc.)	250,000
Atmosphere	300,000
Industrial discharges	350,000
Municipal waste water	750,000
Urban sediments	120,000
Rivers	40,000
Oil tanker operations	150,000
Ship's bilges	250,000
Terminal operations	30,000
Shipyards/dry dock	3,000
Accidents (average from 1988 to 1997), spills > 7 tons	144,000
Offshore	50,000
Scraps	5,000
Total	**2,442,000**

Source: Pardo, 2001 (METNET Project, EU.)

FIGURE 1: Percentage of different oil input sources



Source: Compiled from Table 1

sources amounted only to 582,000 tons. This amount of discharge from ship source is less than 50% of the land-based discharge. Figure 1 gives a clear picture of this fact, showing land-based discharge to be 52% and ship's operational and accidental discharges to be 18% and 6% respectively.

The reason for such reduced oil input from ship sources compared to land-based sources can be attributed to the existence of the International Convention for the Prevention of Pollution from Ships, MARPOL 73/78. Shipping is an international trade and as such requires unified and harmonized regulations to deter pollution. MARPOL 73/78 was the answer to such requirements. Presently, as of July 31, 2001, there are 116 countries that have ratified and/or acceded the Convention and are bound by its provisions in respect of prevention and control of pollution from shipping activities. Prevention of pollution from land-based sources, however, remains under the domain of national legislation of individual countries but these legislations are not fully effective to control such pollution. Article 207 of the UNCLOS 82, requires States to adopt laws and regulations to prevent, reduce and control such pollution from land-based sources. The same Article also obliges governments to harmonize their policies at the regional level and to endeavor to establish global and regional rules on this matter. However, to date, as Table 1 and

Figure 1 demonstrate, relatively little progress has been made to prevent, reduce and control pollution from land-based sources compared to marine transport pollution sources.

1.2 Oil from shipping activities

The first documented shipment of petroleum took place in 1539, when a Spanish ship the 'Santa Cruz', transported petroleum from Venezuela to alleviate the gout of Emperor Charles I (Cowell, 1976). Much later in 1859, when oil was discovered in the United States of America (USA) (Royal Dutch, 1983; Ratcliffe, 1985),the new era of civilization had begun. To meet the demand of industrialization the first cargo of oil was transported from the USA to Great Britain in barrels in the holds of the 224-ton brig 'Elizabeth Watts' (Mards, 1982; Marton, 1984).

In those early days, oil production was relatively small, hence, the amount transported was limited and the pollution caused by such small vessels was negligible. However, at the end of the First World War, oil gained in demand as a source of energy as well as a source for production of certain chemical products and synthetic materials (Young, 1973). After the Second World War, with the increased development of the world economy, the demand for oil increased sharply.

With the development of the world's economy and the increased demand for oil, the oil industry also developed very quickly. A faster and cheaper way to get to the destination became the sole motto of transportation. Shipping, as the cheapest mode of international bulk transport became the central carrier for the oil industry. However, oil spilled, due to accidents or discharged due to tank washing and deballasting operations during transportation and causing pollution to the sea, raised concern in many ports and terminals around the world. This concern heightened with the increase in the size of the tanker due to economies of scale and profit maximization (Ma, 2000). The first tanker of 100,000 deadweight tons (dwt) was delivered in 1959 and an order for a 200,000 dwt was placed in the mid 1960s (IMO, 2000a). Thereafter, to meet the ever increasing demand for energy sources of this modern world, the frequency of carriage and carrying capacity of ships also increased greatly. This in turn increased the threat of polluting the marine environment from operational discharges even further.

As mentioned in the introduction, this dissertation examines operational discharges from ships. Table 2 and Figure 2 below shows there are a number of sources of operational discharges largely related to the process of ship ballasting and tank washing of tankers as well as the discharge resulting from machinery spaces or engine rooms of all kind of ships.

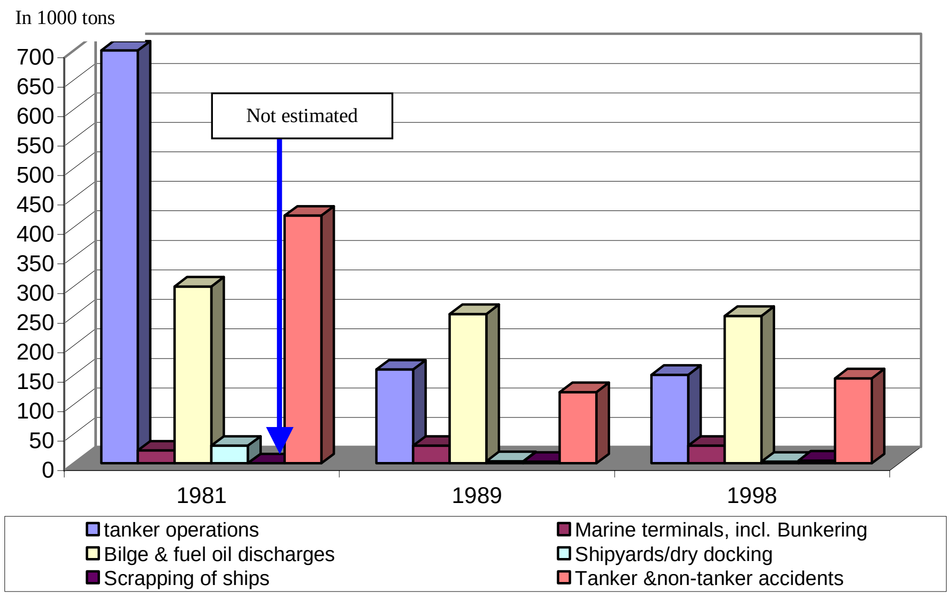
TABLE 2: Comparison of oil discharges into the sea from maritime transport activities in different decades

SOURCE OF POLLUTION	**1981**	**1989**	**1998**
Tanker operations	700,000	159,000	150,000
Marine terminals, including bunkering	22,000	30,000	30,000
Bilge and fuel oil discharges	300,000	253,000	250,000
Shipyards/dry docking	30,000	4,000	3,000
Scrapping of ships	Not estimated	3,000	5,000
Tanker accidents	400,000	114,000	144,000
Non-tanker accidents	20,000	7,000	
TOTAL	**1,472,000**	**570,000**	**582,000**

Sources: Adapted from National Academy of Science and National Research Council, 1985, MEPC 30/INF.13 (19 September 1990) and Pardo, 2001.

It will be seen in Chapter 2 that international regulations were initially aimed at restricting and eliminating operational discharges due to ballasting and tank washing operations of cargo tanks from tanker ships. However, this source is not yet fully eliminated (see Table 2 and Figure 2). Nevertheless, MARPOL73/78 regulations requiring changes in design and construction of ships and equipment to ensure

Figure 2: Comparative graph of oil inputs into the sea from maritime transport activities in different decades



Source: Compiled from Table 2

correct operational procedures, have substantially reduced the amount of operational discharges from tanker operations, and also, almost eliminated it as a source of pollution. The operational pollution resulting from engine room discharges of all kinds of ships including tankers, however, remains a major source of marine pollution at present. This dissertation primarily focuses on the latter source, i.e., oil and oil-water mixture intentionally discharged from machinery spaces.

1.2.1 Operational discharges from the engine room

These discharges take place due to the pumping out of engine room bilges from all engine-driven or mechanized vessels plying the seas. During engine operations, different types of oil, along with water, leak from pumps, engines, tanks etc., and accumulate at the bottom of the engine room, an area called the bilge. This accumulated oily-water mixture from bilges needs to be pumped out from time to time to prevent flooding and to eliminate the risk of fire hazards (M'Gonigle and

Zacher, 1979, p. 22). In addition, heavy oils used as bunker fuel for the engine, are purified on board ship prior to use. This purification of oil generates some sludge, which also requires pumping out. Furthermore, some ships, such as container vessels and fishing vessels, carry ballast water in their fuel oil tanks (although an IMO resolution suggests not to) to maintain stability (Sasamura, 1990). This oily water is also pumped out in the course of time.

1.2.2 Regulatory control of tank discharge vs. engine room discharge

In the early days, the operational discharges from cargo tanks of a tanker and from the engine room of all ships were considered routine operations and hence carried out without any obligations. However, introduction of pollution prevention conventions such as OILPOL, 1954 initially and later on MARPOL 73/78, which came into force in 1983, reduced and controlled such pollution incidents. The comparison table 2 for oil input into the sea from maritime activities in different decades, and its graphical representation in figure 2 shows a remarkable reduction in oil input from tanker operations. Tanker operational discharge decreased dramatically from 700,000 tons in 1981 to 159,000 tons in 1989 and thereafter to 150,000 tons in 1998. The reason for such a remarkable reduction can be attributed to a variety of technological advances in tanker operations influenced by the MARPOL 73/78 Convention.

Technological innovation such as the Load-on-Top (LOT) system, followed by Crude Oil Washing (COW) and Segregated Ballast Tanks (SBT), along with overall tighter regulations internationally, have probably reduced oil discharge into the sea from ballasting and tank cleaning operations to the lowest-ever minimum. However, the remaining 150,000 tons of oil coming from tanker operations is assumed to be the contribution from old tankers that are still operating at sea under a ‘grandfather clause’ of MARPOL 73/78.

The recent decision of the early phasing out of these older tankers by IMO (IMO, 2000, p 22; MEPC 46/23, 2001) will further improve the situation. The whole tanker fleet, after completion of the phasing out program by 2015, will be equipped with segregated ballast tanks to carry enough water to provide stability and maneuverability under normal weather conditions. Only during bad weather, or in unavoidable circumstances would ballasting of cargo tanks be a necessity, hence chances of pollution occurring would be minimal. The author firmly believes that after the phasing out of older tankers the world's oceans will be much safer and cleaner.

However, the same Table 2 and Figure 2 reveal that the largest single source of oil entering the sea through shipping activities in the years of 1989 and 1998 is bilge and fuel oil discharges from the machinery spaces of all ships. The reason for such a large amount of discharge could be that the old ships are still fitted with 100-ppm oily water separators rather than 15-ppm oil filtering equipment. A regulation to equip all vessels with a 15-ppm oily water separator and oil filtering equipment became mandatory from 1998 through an amendment to MARPOL 73/78 in 1992 (see chapter 2). In this regard one can be optimistic that statistics after 1998 would show a dramatic reduction.

However, with the 15-ppm regulatory limit of oil discharge, there is apprehension that the total discharge of bilge oil will remain a substantial amount (National Research Council, 1985; El-Maghrabi, 1988). Moreover, many scientists believe that the presence of even minute oil particles in the sea has adverse effects on the marine eco-system and its biodiversity. This dissertation considers the view that even the legally allowed level of oil discharge can have a severe impact on the oceans. The biological effects of oil on fish and other living organisms at sea are described below.

1.3 Biological impact of oil on the oceans

The biological effects of discharged oil from ships depend on many factors including: the type of oil discharged, the quantity of oil, season, the hydrographic situation (saline content, temperature, wave turbulence, currents, winds, oxygen conditions) and the construction of the ecosystem affected (Lidgren & Norby, 1980, p. 32; Gin, Huda, Lim & Tkalich, 2001))

Lidgren & Norby (1980) also state that a discharge of crude oil or some oil products from a ship may cause:

- the elimination of sensitive species
- non-lethal effects – for example behavioral disturbances, malformations
- the absorption of oil components into the tissues
- changes in the physical or chemical environment
- fouling of beaches (p. 32).

The extent and permanency of this influence varies greatly. On beaches exposed to powerful waves, for example, the oil can vanish within a year in a natural manner. However, in calm creeks, wetlands and bays it can remain unchanged for many years.

The environmental effects of oil may be characterized according to their permanency as short-term and long-term effects. The dramatic short-term effects are easy to observe but it is difficult to evaluate the long-term effects, as they are not immediately evident. For this reason it is also difficult to quantify the production loss or the loss of functional importance due to oil pollution.

In the short-term, birds are mostly affected by oil discharge. Only a small oil spot of 2x3 cm^2 on the breast of a wild duck can cause its death due to loss of heat in a cold sea (Lidgren, & Norby, 1980, p. 33). The oil destroys the water-repellant qualities of the plumage. The birds also injure themselves by swallowing the oil while cleaning their plumage. They can develop pneumonia, hemorrhage from the lungs or the intestinal tissues, degeneration of the liver, and kidney damage.

It is observed that adult fish being able to swim quickly leave the polluted area as soon as they can. Thus, the risk of fish dying exists mainly in enclosed waters or when there are very large discharges. It is also observed that the light oil, being more toxic, causes more death of fish than crude oil (Lidgren, & Norby, 1980; Gin & et al, 2001).

The non-lethal effects of discharged oil on fish are more serious in the long-term than the direct deaths caused. Oil pollution in non-lethal concentrations may produce behavioral disturbances in fish, e.g., changes in the digestion of food, reproductional disturbances, disturbances in the migratory pattern, genetic disturbances, an increased sensitivity to disease, etc. In addition to this, the fish may acquire an oily taste or smell, making them unpalatable for human consumption (Gold, 1998).

Many fish are pelagic during their development stages and the eggs, larvae, or spawn float in the water layer near the surface. Due to their limited ability to swim in these stages they are more subject to oil pollution than adult fish. The oil also has a negative impact on the hatching of fish eggs (Lidgren, & Norby,1980; Gin & et al, 2001).

Research has also shown that hydrocarbons have a greater influence on the function of sense organs and so can influence the behavior of fish and invertebrates by reducing or changing sensory information reaching their brain (Blaxter & Hallers-Tjabbes, 1992). An experiment showed that the sub-lethal effects take place at a much lower concentration than the lethal effects and yet the sub lethal effects may become lethal in the long run. The fact is that the crude oil contains toluene, benzene and phenol and when discharged into the sea each of these ingredients affects the marine organisms, e.g., fish and invertebrates in various concentrations.

1.3.1 Fish

Blaxter & Hallers-Tjabbes (1992) reviewed such sub-lethal effects of the ingredients of oil on fish at various concentrations and noted that;

> Toluene at about 4 ppm causes abnormal orientation of larval medaka (Stoss & Haines, 1979) while newly feeding Pacific herring become inactive and feeding is impaired in 10-ppm benzene (Struhsaker et al., 1974). Rainbow trout embryo exposed to 25 ppm benzo[a]pyrene during late organogenesis hatched equally well as controls but their subsequent upstream orientation has changed (Ostrander et al., 1990). Juvenile coho salmon, when tested in a Y-maze, avoided xylene, benzene and toluene concentrations of 3-4 ppm (Maynard & Webber, 1981). Fingering rainbow trout were more prone to predation by adults when exposed to 7-ppm phenol (Schneider et al., 1980).

> Using more complex mixture Webber et al. (1981) found that migrating adult Pacific salmon avoided mixtures of aromatic hydrocarbons at 3.2 ppm or higher while Boehle (1986) found that cod avoided water containing more than 0.1 ppm of petroleum hydrocarbon. Oil is known to damage the olfactory epothelium in salmon (Babcock, 1985). Hellsrtrom & Doving (1983, quoted by Boehle) claimed, using electro physiological techniques, that cod can detect petroleum hydrocarbons at 0.0001 ppm. Pearson et al. (1983) found that sediment polluted with oil at an initial concentration of 3.5 ppm was unattractive to burrowing sand lance (p 51).

1.3.2 Invertebrates

It has been also observed that sediment polluted with oil, especially the water soluble fraction (wsf), has an impact on the sensory perception and behavior of invertebrates. Blaxter & Hallers-Tjabbes (1992) also reviewed such impacts on the invertebrates and noted;

> An initial concentration of 3.5 ppm oil in the surface layer proved to be unattractive for burrowing little neck clam Protothaca staminea; this resulted in an increased rate predation by the Dungeness crab, Cancer magister (Pearson et al., 1981)
>
> Low concentrations of crude oil or its derivatives were found to affect food recognition in gastropods and in several crustaceans. The snail Nassarius obsoletus was no longer attracted to oyster extract in water containing 0.01 ppm of the water-soluble fraction (wsf) of kerosene (Jacobson & Boylan, 1973). 0.025 ppm of the wsf of Prudhoe Bay Crude Oil reduced the food search behavior in the shrimp Pandalus americanus (Malins et al., 1982). Different phases of the food search behavior of Homarus americanus were suppressed at 0.08 – 0.15 ppm of the wsf of No 2 Fuel Oil (Atema et al., 1979; Atema et al., 1981). … The feeding signal to Gammarus olivii was completely suppressed at 1 ppm oil and partly suppressed at 0.1 ppm oil in G. olivii and also in Idotheca baltica (Milovidova, 1974). The number of Cancer magister individuals responding to food was reduced at 0.27 ppm wsf of Prudhoe Bay crude oil (Pearson et al.,1981b).
>
> Chemical stimuli related to reproduction and defense behavior can also be suppressed by low concentrations of oil products (Johnson, 1979). 0.015 – 0.06 ppm wsf of Prudhoe Bay crude oil suppressed the reproductive chemotaxis of the dorid nudibranch Onchidoris bilamellata, which resulted in reduced reproduction, and 0.05 ppm impaired the defense response of the sea urchin Strongylocentrouts droebachiensis resulting in increased predation by the starfish Pycnopodia helianthoides. The alarm response of Nassarius obsoletus to a damaged conspecific was enhanced at 0.1 – 0.05-ppm wsf of No 2 Fuel oil (Atema, 1976) (p.51).

The above evidence of scientific research clearly shows that the regulatory limit of 15-ppm oil discharge is neither safe for the marine environment nor beneficial for human beings, as it affects the food chain.

1.4 Discussion

Marine pollution as a whole has been discussed in this Chapter including various sources of oil input into the sea. However, the focus has been on marine transportation with an emphasis on operational discharge, especially discharge from machinery spaces. The present statistics have revealed that the discharge of bilge oil from machinery spaces is the largest source of oil pollution from shipping activities (see Table 2/Figure 2) and requires stricter regulations to be controlled (Wells, 2001).

There is a growing apprehension however, that even with a 15-ppm discharge limit (effective from 1998 for existing and new ships), the aggregated amount of bilge oil discharged from ships all over the world could be substantial. Moreover, scientific evidence shows that the present regulatory limit of 15-ppm oil discharge is not safe for marine organisms and may destroy the food chain in the long run. These situations call for an improvement in standards, especially when the technology is available to do so, by reducing the regulatory limit of discharge to zero-ppm or close to it.

It is understood that sufficient improvement has been made in the cargo operation of tankers such as the inclusion of LOT, SBT and COW systems to eliminate pollution from ballasting and tank washing. A discharge from SBT is a discharge of clean ballast and hence does not pollute the environment. However, discharge from machinery spaces needs to be addressed. To address the problem of reducing the regulatory discharge limit to zero-ppm, it is necessary to understand the international law-making process concerning the marine environment. The next Chapter will deal with the development of the legal regime on marine pollution.

CHAPTER 2

DEVELOPMENT OF THE INTERNATIONAL LEGAL REGIME ON MARINE POLLUTION

The previous Chapter examined the impact of oil on the ocean and the causes of ships' operational discharges, particularly discharges from engine room. This Chapter will examine the international legal response to this problem.

One of the roles of law is to prevent someone from doing something that is or that might be injurious, harmful, and hazardous to others and to the society in general. Laws are formulated to protect society by preventing, restricting or eliminating such injurious or harmful activities. For example, the discharge of tank washings from cargo tanks was found to be harmful in the early days of the 20th century because they were a fire hazard to ports and raised health risks in coastal resorts. The fishermen and the owners of the beach resorts, whose living was jeopardized by such activities, organized protests and pressurized governments to take action against such harmful activities (Pritchard, 1987). Indeed, a signed petition of 18,000 residents of the Isle of Wight was presented to the British Prime Minister in 1925.

That was the beginning of the formulation of laws against marine pollution. This Chapter will discuss the development of laws addressing intentional ship source oil pollution of the oceans, from its initial stage in the early 20th century to the regulatory limit of oil discharge of 15-ppm existing at present. The discussion will outline the development of the international regulations, OILPOL 1954 Convention, MARPOL 1973 Convention and its protocol in 1978 and its amendment that produced the current regulatory limit of 15-ppm discharge from the engine room. Thereafter, the possibilities to improve the discharge standard by reducing the regulatory limit of discharge from engine room to zero-ppm will be explored.

2.1 Development prior to 1954

During and immediately after the First World War, there was a dramatic increase in the demand for oil. This was partly due to the replacement of coal by oil as a source of power. This also correspondingly increased the tanker movements at sea, which in turn, increased operational discharges from tankers in the form of ballasting, deballasting and tank washings as discussed in Chapter 1. This resulted in an oil layer containing highly flammable substances such as naptha, benzene and gasoline (Terrel, 1987) in the major oil loading and discharging ports or terminals. Thus, many ports and oil terminals had fires and a lot of properties were damaged and lives were lost (Pritchard, 1987; Yi, 1988). Moreover, the fishermen and the resort owners were experiencing damage to fisheries and amenities. As a result, some industrialized countries formulated national rules to restrict such oil discharges from ships.

2.1.1 National Legislation

U.K. and U.S.A. were among the earliest countries to develop domestic regulations against oil pollution that influenced the international legal regime.

2.1.1.1 The U.K.

The United Kingdom was one of the earliest countries that made rules to control oil discharges from ships. In 1918, the British Admiralty and Ministry of Shipping issued wartime regulations to the masters of ships (Pritchard, 1987). These regulations instructed the shipmasters to discharge oily ballast and cleaning water from their ships outside the three-mile territorial water limit. They also suggested taking proper precautions against leakages of oil when loading, unloading or re-fueling in ports (Pritchard, 1987, p 1).

The British Government subsequently set up its first national law against oil pollution, the so-called Oil in Navigable Waters Act of 1922, which entered into force on 1st January 1923 and became the first national law against pollution. In this Act, the three-mile discharge zone entered into the statutes. It also included a maximum fine of £100 for a ship or land installation causing oil or oily wastes to escape into British territorial waters. Moreover, the use of an oily water separator to separate oil from an oil-water mixture and the provision of reception facilities to receive waste oil from ships, were suggested but not made part of the new Act (Pritchard, 1987). However, for commercial reasons shipmasters preferred the zone system. Moreover, effective oily water separators were not technically and commercially available at that time (Pritchard, 1987).

2.1.1.2 The U.S.A.

The United States of America, the principal center of the oil trade during 1920s, had also suffered from harbor fires. It was believed that a flare or an electric wire accidentally dropped into the river, could destroy the entire New York harbor. This would be over $11.5 billion in annual trade at stake. Fire underwriters and New York harbor officials in 1921 secured the designation of a 25-mile zone within which it was prohibited to discharge oily wastes from ships (Pritchard, 1987, p 2).

The United States of America, issued its first national law against oil pollution, the Oil Pollution Act of 1924, on 7 June 1924 (Pritchard, 1987). This Act proved to be more stringent and effective than the British Act. It empowered enforcement by the U.S. Coast Guard as well as by port officials. It also defined oil in a broader perspective and imposed higher sanctions of $ 2000 for an offence (Pritchard, 1987, p 7). In addition, oil pollution was described as a penal offence in the Act. The Act also adopted a zonal system to drive away oil pollution to outside territorial waters.

These U.K. & U.S.A. regulations, although only at a national level, initiated the zonal system of controlling oil pollution. However, these Acts in reality diverted oil pollution away from ports but onto the coastal areas in the vicinity of the ports. The oil so discharged beyond the three-mile territorial water drifted to coastal areas where even no port existed. Thus the Acts, instead of reducing or controlling pollution, simply transferred the pollution from one area to another. For this reason, the UK and the USA did not consider the situation of oil pollution control as being satisfactory. As the biggest oil supplying country at that time, the USA urgently felt it was necessary to set up an international agreement to curb oil pollution at sea.

2.1.2 International Regulatory activities

Initiatives were taken to reduce or eliminate marine pollution through an international agreement in 1926 and 1935 but failed to achieve any fruitful result.

2.1.2.1 The 1926 Draft Convention on Oil Pollution

A Conference was called in Washington, D.C to discuss the adoption of effective measures against oil pollution of the sea (Pritchard, 1987). Twenty seven delegates representing thirteen major maritime nations attended the conference from 8 to 16 June, 1926. The participating countries were Belgium, Britain, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, and the United States (Pritchard, 1987, p 16). This was the first ever, international conference on oil pollution control at sea.

At this Conference, the discharge standard of 500 parts per million (ppm) was considered negligible. However, a condition was attached to the definition of negligible pollution, to the effect that oily discharges which left a trail in the ship’s wake sufficient to form a film on the surface of the sea, visible to the naked eye in daylight and in clear weather would be prohibited. Usually, the ‘visible sheen’ of oil in the ship’s wake, came from the discharge of oily water at the last stage of its pumping, when the oil and water interface was reached. The oil content in this mixture was believed to be as high as 10,000-ppm (Pritchard, 1987, p 19).

The Conference also agreed to establish the pollution control zone within which persistent oils or oily mixtures may not be discharged. The width of the zone was to be decided by the coastal States, but the zone could not exceed 50 nautical miles from the nearest coastline and 150 miles in exceptional circumstances (Pritchard, 1987). This was an innovative step given that the limits of the territorial sea were still undetermined and contested.

These standards and the zone system were the first to set up the international limits on ships intending to discharge their oily wastes or ballast water into the waters, then generally considered as high seas. The situation of implementing these standards and the zone system to control oil pollution internationally, however, was not entirely satisfactory. Nevertheless, it did produce some positive results. On the request of the British government, the ship owners of seven major maritime countries voluntarily accepted the fifty-mile discharge prohibition zone (M'Gonigle and Zacher, 1979, p 83). Therefore, it can be said that the 1926 draft Convention had taken the first step of combating oil pollution at sea internationally, although, it had the unfortunate fate of never entering into force.

Following the 1926 conference, many maritime nations made their own standards for the control of oil pollution in their own pollution zones. Some of these standards were stricter than those set up by the 1926 draft Convention. For example, Spain in 1925, and Portugal in 1927, issued circulars prohibiting the discharge of oil by ships within six miles of their coast. The British Government had lodged a protest against the Spanish circular since it exceeded the normal territorial water limit of three nautical miles (Pritchard, 1987). The dispute regarding the limits of the territorial sea was the major setback of this Convention and hence it failed to enter into force.

2.1.2.2 The 1935 Draft Convention on Oil Pollution

In 1935, at the initiative of the British government, the League of Nations passed a resolution for the preparation of a draft convention and an international conference on oil pollution (Pritchard, 1987). The draft league Convention, stylistically and legally superior to that of the 1926 draft Convention, was prepared and circulated to governments on November 27, 1935. Despite favorable replies to an oil pollution agreement, the draft Convention was never signed and the proposed diplomatic conference never summoned.

Both the 1926 and 1935 Conventions, in spite of their failure to enter into force, focused on some of the relevant issues such as the enforceability of zonal arrangements, monitoring and verification of compliance with the discharge provisions, the magnitude of penalties, reception facility requirements, and the distribution of enforcement jurisdiction between flag and coastal states (Mitchell, 1994, p 83).

2.2 The 1954 Oil Pollution Conference and Convention

Although the UK and USA initiatives prior to the Second World War failed in controlling oil pollution by ships internationally, the draft agreements had facilitated negotiations that arose after World War II. A dramatic increase in crude oil demand also increased the discharge of persistent crude oil after tank-cleaning and ballast operations (Kirby, 1968). The number of complaints of spoiled beach resorts and the large number of dead seabirds grew rapidly in the United Kingdom and elsewhere in Europe. The British Government took the initiative again to call for the international control of oil pollution by ships.

2.2.1 The International Convention for the Prevention of Pollution of the Sea by Oil, 1954 (OILPOL)

From 26 April to 12 May 1954, an international Conference on pollution of the sea sponsored by the British Government, was held in London. The delegates from thirty-two countries representing 95% of world shipping, participated in the conference. After much discussion, the conference drafted a convention, which became the first internationally agreed treaty on the control of oil pollution at sea, called the International Convention for the Prevention of Pollution of the Sea by Oil, 1954 (OILPOL). This Convention accepted a fifty-mile zone for control of discharge levels both from the engine room and cargo area of ships, and that the discharge of oily mixture within this zone containing more than 100 parts per million (100-ppm) of the oil in the mixture would be an administrative offence. However, it failed to impose any restrictions on discharges made outside the zones or on total discharges, thus relying on the redistribution of discharges outside the zones to mitigate the environmental damage (Mitchell, 1994). The parties to the Convention were required to ensure the provision of reception facilities for non-tanker ships but not for tankers. The master of the ship needed to record all ballasting, cleaning, and discharge operations in a newly developed oil record book. Port states could inspect these books but were not allowed to delay the ship. Moreover, inspections were limited in that their objective was to provide evidence to flag states for the prosecution of violations. It was also agreed that the penalties for violation outside territorial waters should be the same as within the territorial waters. Furthermore, all parties to the Convention were required to report to the Secretariat regarding the installation of reception facilities and application of the treaty as well as actions taken on violation referred to them for prosecution.

The Convention entered into force on 26 July 1958. Despite its drawbacks, Sasamura (1990), a Japanese expert on marine pollution and a former official of International Maritime Organization (IMO), described the 1954 Convention as a significant achievement for the maritime community. Through this Convention, the marine community first tackled the problem of pollution and took controlling measures at the international level at a time when the world community in general was not particularly conscious of the need for environmental protection.

2.2.2 OILPOL 1954 amendments

OILPOL 1954 was amended twice in 1962 and 1969, and the amendments entered into force in 1967 and 1978 respectively. At the conference in 1962, a number of amendments to the 1954 Convention were passed, including an extension of the zones subject to prohibition. The whole of the Baltic and the North Sea were made prohibited zones. As a first step towards a total prohibition of oil discharges, all new tankers over 20,000 gross tonnages were banned from discharging operational discharges in excess of 100 ppm, thus requiring the installation of equipment to ensure compliance. It was further decided that the member states should take suitable measures to encourage the setting up of shore reception facilities at loading ports for oily residues from ships.

On 21 October 1969, the Intergovernmental Maritime Consultative Organization (IMCO), which is now called the International Maritime Organization (IMO), passed further amendments to the Convention at its 6^{th} Assembly. The Assembly, being under pressure from the oil companies and the major maritime nations, accepted the Load On Top (LOT) method for tank cleaning and withdrew the prohibited zones and the 100-ppm discharge limit for operational discharge from the cargo tank area of a tanker. However, the regulatory limit for engine room discharge remained the same at 100-ppm. The 1969 amendments brought in restrictions on operational discharge in the following ways:

For oil tankers

Operational discharges of oil due to ballasting and tank washing of cargo tanks from tankers were allowed only when all the following conditions were met:

1. the total quantity of oil which a tanker may discharge in any ballast voyage whilst under way must not exceed 1/15,000 of the total cargo carrying capacity of the vessel;
2. the rate at which oil may be discharged must not exceed 60 liters per nautical mile traveled by the ship; and
3. no discharge of any oil whatsoever must be made from the cargo spaces of a tanker within 50 miles of the nearest land.

A new form of oil record book was appended to the 1969 amendments to reflect the approved practice of LOT.

For machinery spaces of all ships

The discharge from machinery space bilges was allowed only when all of the following conditions were met:

1. the rate at which oil may be discharged whilst the ship is underway must not exceed 60 liters per nautical mile being traveled by the ship;
2. the oil content of any bilge water discharged must be below 100 parts per million; and
3. discharge must be made as far as practicable from land.

It was assumed that the establishment of the instantaneous rate of discharge of 60 liters per nautical mile would produce a sheen on the water, which would break up and disperse in a period of two to three hours. With the acceptance of the 1969 amendments, the oil companies were able to eliminate the equipment-dependent standard of the 1962 requirement for the operational discharge from new tankers. However, in exchange they had to accept a standard for ballast discharge, based on a standard of no “visible trace” within the zones. This was a significant achievement because any sighting of discharge from a tanker could be considered as a violation and hence be prosecuted. This amendment also brought some changes in the underlying principle of pollution regulation. The 1926, 1935, 1954, and 1962 rules had all permitted discharges except in prohibited zones (Mitchell, 1994). However, the new rules in 1969 prohibited discharges in all oceans except under certain conditions. It was also a requirement for the first time in the international rules, to reduce the amount of oil entering the oceans from shipping activities rather than aiming to redistribute them.

In 1971, OILPOL, 1954 was further amended to incorporate the cargo tank size in the Convention to limit the hypothetical oil outflow in the case of collision or grounding. Tanks were to be arranged so that oil spills would not exceed 30.000 cubic meters. The size of the center tanks and side tanks could not exceed 50,000 cubic meters and 22,500 cubic meters respectively. These regulations were applicable only to new ships.

In comparison with the 1926 Convention, the 1954 Convention was the first to receive international validity; as the 1926 Convention had never been ratified by interested states. The standards for discharging oily water or tank washings were stricter than those of 1926. Moreover, the 1954 Convention endorsed LOT, while the 1926 Convention had not taken any effective measures to handle the oil residues left in tanks, meaning that the zone system could not be observed easily. Furthermore, the 1954 Convention made the 50 nautical mile zone compulsory for discharge from the cargo space of a tanker, and recommended engine room discharge to be made as far from land as practicable, while the 1926 Convention stipulated the zone system as being at the discretion of the port State. This meant the near coastal areas, as discussed earlier, would suffer pollution again, because the discharged oil would be driven back onto the coasts.

Nevertheless, after nearly 20 years of operation, OILPOL 1954 was found to have some inherent shortcomings. It could not meet the demands of continuous changes that had been taking place in the shipping industry, especially in the pollution controlling aspect at sea. Thus it was necessary to develop a new convention to replace the old one.

2.3 The 1973 Conference on Marine Pollution

To replace the OILPOL 1954 Convention, IMO convened an international conference at its head office in London from 8 October to 2 November 1973. The conference was attended by over 600 delegates from 71 countries with a heightened concern over oil pollution, as the sea borne oil trade increased from 158 million tons in 1954 to 1366 million tons in 1973 (Mitchell, 1994). The objectives of the conference were:

1) To draft a comprehensive convention that would completely eliminate the willful and intentional discharges of oil and noxious or hazardous substances other than oil into the seas by ships and other marine crafts and minimization of accidental spills by all kind of ships at sea.
2) To achieve by the end of the decade, complete elimination of pollution by normal operations of ships, and,
3) To expand the scope of the Intervention Convention to cover substances other than oil causing pollution at sea (Pritchard, 1987).

2.3.1 The International Convention for the Prevention of Pollution from Ships (MARPOL 73)

The 1973 conference produced a new convention called the International Convention for the Prevention of Pollution from Ships (MARPOL), which had a broader scope than any other previous agreements. The Convention applied to oil platforms as well as ships and included refined as well as crude oil. It dealt not only with oil, but other forms of marine pollution except the disposal of land-generated waste into the sea by dumping (which was covered by London Dumping Convention, 1972). Most of the technical measures were included in five annexes to the Convention which dealt respectively with the following:

Annex I	Oil
Annex II	Noxious liquid substances carried in bulk (e.g. chemicals)
Annex III	Harmful substances carried in packages (e.g. tanks and containers)
Annex IV	Sewage
Annex V	Garbage

This dissertation considers only Annex I, oil pollution.

In the 1973 Conference, discharge regulations for the operational discharge of oil were discussed. The United States proposed stricter regulations, such as the extension of tanker zones from 50 miles to 100 miles, reduction in the rate of discharge from 60 to 30 liters per mile, and clean ballast to be defined as containing less than 10-ppm oil instead of 15-ppm (M'Gonigle and Zacher, 1979, p 113). Unfortunately, the United States received very little support for these proposals.

As a result, the character of discharge regulations accepted in this Conference remained the same as in the 1969 amendments. However, the maximum discharge for new tankers was reduced from 1/15,000 to 1/30,000 of their cargo carrying capacity and for non-tankers a prohibition on all discharges in a twelve (12) mile zone was made instead of the vague statement stipulated in 1969 amendment to the OILPOL 1954 Convention, that they discharge "as far from land as practicable".

Another important addition to the discharge regulation was a provision allowing for the creation of "special areas", where the scientific evidence suggests that the threat to the marine environment is great. No discharge would be allowed in this area except for "clean ballast" that is, no "visible trace" as under 1969 amendments or less than 15-ppm oil content. A number of such areas were agreed on for the enclosed seas surrounding Europe and the Middle East – the Mediterranean, Baltic, Black, and Red Seas and Persian (Arabian) Gulf, but not the North Sea (Mitchell, 1994, p 95; M'Gonigle and Zacher, 1979, p 113). However, outside the tanker zone and special areas, discharges below 60 liters per mile remained legal (see Table 3a).

This Conference also adopted equipment standards to comply with the performance standard of discharge regulations. Regulations 14 through 18 include requirements for slop tanks, oil monitoring systems, oily water separators, filtering systems, oil/water interface detectors, special piping arrangements and storage tanks. The most important technical innovation at this Conference was the inclusion of regulation 13 requiring segregated ballast tanks for all tankers over 70,000 dwt. With regard to non-tankers, segregated ballast tanks were not specifically prescribed, however, a requirement was made in regulation 14 for all new non-tankers over 4.000 tons gross tonnage, not to use their fuel tanks for ballast.

The 1973 convention, can thus be defined as a historical landmark in international environmental regulation. For the first time, after the unsuccessful attempt in 1960s, it showed a shift of regulation from performance standard to equipment standard i.e. the use of equipment as a means of ensuring compliance with the discharge standard. Hence the use of oily water separators, monitoring devices, and SBT were made mandatory for certain categories of ships.

The Convention also sought to improve implementation, enforcement and compliance. Delay in the ratification of amendments was addressed through the "Tacit Acceptance" method. Enforcement was achieved through exacting compliance to the equipment standard. This was established through an initial survey conducted by national governments and ship classification societies and documented in the International Oil Pollution Prevention (IOPP) Certificate. States were given expanded rights to inspect the IOPP Certificates of ships entering their ports and to determine whether a ship met the equipment requirement. According to article 5(2) of the Convention , if a ship was found in violation, governments were obliged to "take such steps as will ensure that the ship shall not sail until it can proceed to sea without presenting an unreasonable threat of harm to the marine environment" (IMO, 1997, P 6)

The convention also included significant changes in the compliance system. Acceptance and compliance responsibility for equipment standards such as SBT, oil discharge monitoring unit, oily water separator etc., shifted from the Master to the owner of the ship, and from port or coastal State's vigilance for oil spill detection to equipment verification, as a means of preventing the problem. It also shifted the site of potential violation from the open ocean to the shipyard. Thus, a change took place in the compliance information and non-compliance response system. The new Convention also specified the rights of detention, which posed a significant deterrent threat should any country choose to use them. In addition, it made modest improvements in reception facility requirements and reporting requirements.

A final factor that influenced the pollution control at this time was the dramatic increase in oil prices after 1973. The value of oil shot up from USD 3 per barrel to USD 30 a barrel (Gold, 1998, p 39). This provided a better insight into the benefits that could be achieved by using oil waste reduction technologies such as LOT, SBT and COW. Moreover, a slump in the tanker industry at this time forced many tankers which could not meet the present standard, to be phased out. This overall situation resulted in the beginning of a better compliance environment.

However, the MARPOL 73 Convention, which required mandatory acceptance of Annexes I and II, failed to generate enough ratifications to enter into force quickly. This was partly due to technical problems in ratifying Annex II dealing with chemicals, the economic challenges to ship owners to meet the new equipment standards, and to States in meeting reception facility requirements. In 1976 and 1977, a series of accidents involving oil tankers led to increased concern about safety and pollution. IMO was asked to call a conference to consider further measures including changes to MARPOL 73 and the International Convention for the Safety of Life at Sea, 1974 (SOLAS)

2.4 The 1978 MARPOL Protocol

The conference on Tanker Safety and Pollution Prevention was held on February 6, 1978 in which a protocol to the MARPOL 73 Convention was adopted. The Protocol arising from this special conference became an integral part of the 1973 Convention and together they are known as MARPOL 73/78.

The discussion in this Conference was mainly centered around the construction and design of tankers to avoid accidental spills and operational discharges due to ballasting and tank washing. This was influenced by the announcement or threat made by the President of the United States, Jimmy Carter on March 17, 1977 on several unilateral preventative measures against accidental and operational pollution, known as the "Carter initiative" (Mitchell, 1994, p 101; M'Gonigle and Zacher, 1979, p 131). These included the requirement of double bottoms and other systems to prevent accidental spills, segregated ballast tanks on all tankers over 20,000 dwt to prevent operational spills and an annual tanker inspection.

The Conference finally agreed on the requirement of segregated ballast tanks in protective locations, crude oil washing and inert gas system for new crude tankers over 20,000 dwt (M'Gonigle and Zacher, 1979, p 140). Existing crude tankers over 40,000 dwt could either be equipped with segregated ballast tanks or use the crude oil washing system (Mitchell, 1994; M'Gonigle and Zacher, 1979). The conference also agreed to require unscheduled inspection on a regular basis to verify compliance. The IOPP certificate and oil record book were modified.

In addition, to facilitate the early entry into force of MARPOL 73/78 Convention, ratification of Annex I on oil pollution was separated from Annex II dealing with chemicals. It also made the equipment standard of 1973 Convention mandatory for ships delivered after June 1982, irrespective of the date of new rule's entry into force, thus removing the incentives for countries in delaying ratification to slow the rule's impact. MARPOL 73/78 finally came into force on 2nd October 1983.

From the point of view of prevention of operational discharge due to tank washing, the 1978 protocol simply endorsed the implication of a new technology, the crude oil washing (COW) system, to the compliance system already established under the original 1973 MARPOL Convention. Inclusion of both SBT and COW technology in a tanker would reduce the operational discharge significantly. For instance, a tanker of 100,000 dwt that would normally generate 248 tons of oil without any pollution control measures, would generate 168 tons using SBT and 100 tons using COW, but only 53 tons if the tanker used both technologies (Waters, Heaver, and Verrier, 1980, p 128). In any case, this Conference provided a good insight into the strength of states' commitments in reducing oil pollution. However, in this Conference no changes were made in the regulation of operational discharges from engine room (see Table 3a).

TABLE 3: Operational discharge standards for oil: 1954 to 1983 (Pre-MARPOL)

Convention (in force)	Ship type	Ship age	Discharge limit: Within zones	Discharge limit: Outside zones	Maximum total discharge
OILPOL 54 (1958 – 67)	Tanker	All	<100 ppm, <50 miles + special areas {III (1), Annex A (1)}	No Standard	None
	Non-tanker	All	Upon entry into force as far as practicable from land {III (2)}	No Standard	None
			3 years after entry into force <100 ppm, <50 miles + special areas {III (2), Annex A (2)}	No Standard	None
1962 Amendment (1967 – 78)	Tanker	Existing[1]	<100 ppm, <50 miles + special areas {III (a), Annex A}	No Standard	None
		New[1]	<100 ppm, <50 miles + special areas {III (c), Annex A}	< 100 ppm	None
	Non-tanker	Existing[1]	Upon entry into force as far as practicable from land {III (b)}	None	None
			3 years after entry into force <100 ppm, <50 miles + special areas {III (b), Annex A}	< 100 ppm	
		New[1]	<100 ppm, <50 miles + special areas {III (c), Annex A}	< 100 ppm	None
1969 Amendment (1978 – 83)	Tanker	All	Clean ballast, <50 miles {III (b,c)}	<60 l/m	<1/15,000 tcc
	Non-tanker	All	As far as practicable from land, <60 l/m, <100 ppm {III (a)}	<60l/m, <100 ppm	None

1 Art. III(c) applies to all new vessels above 20,000 gross tonnage and gives a definition of ‘new’

Source: Adapted from Molenaar, 1998, p 68

TABLE 3a: Operational discharge standards for oil: 1983 through to the present

Convention (in force)	Ship type	Ship age	Discharge limit		Maximum total discharge
			Within zones	Outside zones	
MARPOL 73/78 (1983 – 93)	Tanker >150 grt	Existing[2]	<15 ppm, <50 miles + special areas {I/9(1)(a), 10}	<60 l/m	<1/15,000 tcc
		New[2]	<15 ppm, <50 miles + special areas {I/9(1)(a), 10}	<60 l/m	<1/30,000 tcc
	Nontanker > 400 grt and tanker machinery spaces[4]	Existing[2]	<15 ppm, <12 miles + special areas {I/9(1)(b), 10}	<100 ppm	None
1992 Amendment (1993 – present)	Tanker > 150 grt	Existing[2]	<15 ppm, <50 miles + special areas {I/9(1)(a), 10}	30 l/m	<1/15,000 tcc
		New[2]	<15 ppm, <50 miles + special areas {I/9(1)(a), 10}	30 l/m	<1/30,000 tcc
	Nontanker > 400 grt and tanker machinery spaces[4]	Existing[2]	Before 6/7/98[3] <15 ppm, <12 miles + special areas {I/9(7), 10}	<100 ppm	None
			After 6/7/98[3] <15 ppm, <12 miles + special areas {I/9(2)(b), 9(7), 10}	<15 ppm	None

2 For definition of ‘new’ see Reg. I/1(6 and 26)
3 Effective by 6 July 1998 for ships delivered before 6 July 1993, provided these ships can operate with oily-water separating equipment (<100 ppm)
4 For non-tankers < 400 grt see Reg. I/9(2) and 10(2)(b)
grt gross tonnage
ppm parts oil per million parts water
tcc total cargo capacity
l/m liters of oil per nautical mile

Source: Adapted from Molenaar, 1998, p 69

2.4.1 MARPOL 73/78 amendments

MARPOL 73/78 was amended several times after 1978. Amendments in 1992 and 1994 that have affected the oil discharge standards and strengthened the enforcement provisions are mentioned below.

The 1992 amendment

In this amendment, the discharge rate from cargo spaces of tankers outside special areas was reduced from 60 liters per nautical mile to 30 liters per nautical mile. In addition, discharge from the engine room of tankers of 150 grt and above, and non-tankers of 400 grt and above, the permitted discharge of oil-water mixture at sea was reduced from 100-ppm to 15-ppm for ships built after July 6, 1993. However, a 5-year period of grace was given to existing ships until July 6, 1998 (see Table 3a)

The 1994 amendment

In this amendment, an authority was given to port State inspections to ensure the crews' ability to carry out essential shipboard procedures relating to pollution prevention.

2.5 Discussion

This chapter has focused on the legal regime from its developmental stage in the early 1920s up to today, prescribing various regulatory limits of discharge. Table 3 and 3a provides a summary of these discharge standards from the OILPOL 1954 Convention to the present regulatory limit of a 15-ppm discharge, including the 1992 amendment to the MARPOL 73/78 Convention. It has been noted that prescriptive standards of discharge alone, e.g., OILPOL 1954 were not enough to control pollution effectively. Equipment standards, corresponding to the performance standards of discharge regulations improved the result, as observed from the after effects of MARPOL 73/78 Convention as shown in Table 2 and Figure 2.

Despite the success of MARPOL 73/78 in regulating and reducing oil pollution due to operational discharges from ships, it is clear that the setting of a regulatory limit of 100-ppm or 15-ppm was not carried out on the basis of scientific research into ecological carrying capacity of the oceans or on the impact of oil. The criteria however, was set only on the physical appearance of water, neglecting the fact that oil contained could still be harmful to marine environment, its biodiversity and ecosystem.

First in 1926, a discharge of 500-ppm oil content was considered negligible pollution with a condition of no “visible sheen”. It is, however, discussed that the visible sheen was produced at the last stage of discharge when the oil water interface was reached. The oil content at this stage could have been as high as 10,000-ppm, which was certainly very harmful for the marine environment as we know today. However, it is believed that the Washington Conference in 1926 established the definition of oil pollution control, using a standard of water contamination within the limit of available technology and not on absolute protection of the marine environment.

Thereafter, OILPOL 1954 set the limit to a 100-ppm discharge, both for engine room and cargo space, without any scientific research. However, an experiment was carried out in Warren Springs Laboratory in the U.K., for discharging tanker operations at the rate of 60 liters of oil per nautical mile. The experiment established that an instantaneous rate of discharge of 60 liters of oil per nautical mile would produce a sheen on the water, which would break up and disperse in a period of only two to three hours. However, the experiment did not mention any harmful effects on the living organisms of the oceans. This 60 liters of oil per nautical mile criteria was incorporated in the 1969 amendments to the 1954 OILPOL Convention for the operational discharges from tanker operations instead of 100-ppm (see section 2.2.2). The regulatory limit of engine room discharge, however, still remained at 100-ppm.

MARPOL 73/78 introduced discharge criteria like “15-ppm” or “no visible trace” or “clean ballast” which also have no scientific validity. However, current scientific evidence as noted in Chapter 1 shows, even 0.1-ppm or less oil content in water is harmful for fish and invertebrates (see section 1.3). Therefore, the setting up of 15-ppm criterium as opposed to the American proposal of 10-ppm in 1978, brought comparatively more harm and damage to the marine environment and in turn threatens the security of the human food chain. Accordingly this dissertation would recommend an amendment to the MARPOL 73/78 Convention to reduce the regulatory limit of discharge to zero-ppm that shall come into force in 2013, at the last phase of the phasing out plan for old (existing MARPOL) tankers.

Such an amendment would stipulate a complete prohibition of discharge of oil or oily mixture from ships into the sea, designated as special areas, and within fifty miles from the nearest land, except where the ship has in operation oil filtering equipment and/or an oily water separator or similar equipment, capable of producing a zero-ppm discharge. Outside these areas, ships may discharge oily mixture with 15-ppm oil content or as per national regulations. This amendment would apply to ships, whose construction contract would be signed after June 30, 2005 or delivered after June 30, 2008. Existing ships would have a five-year period of grace to install such equipment by June 30, 2013.

Such an amendment made now, would facilitate the industry to comply with the regulation fully and effectively in installing the required equipment by 2013, when the old (existing MARPOL) tankers would be phased out. Thus, with no or minimal pollution from tanker operations after the complete phasing out in 2015, and no pollution from machinery spaces, the world's oceans would be much safer and cleaner. However, in order to make the case of changing the standard it must also be possible for people to comply with a zero-ppm discharge.

The overall argument of this dissertation is that the ecological carrying capacity or environmental impact should be a key to setting goals and that regulations should be designed to encourage technological innovations. Nevertheless, if regulations are too far ahead of technological development and commercial possibility, then efforts to alter the regulatory standard will certainly fail. The first two Chapters have shown the reasons for altering the standard to zero-ppm and the gradual improvement with standards relating to equipment-based standards. The next chapter will examine the technological or equipment developments that would enable the establishment of a discharge regime of zero-ppm from the engine room in the near future.

CHAPTER 3

DEVELOPMENT OF THE TECHNICAL REGIME

Technology is the tool of development. The innovation or invention of new technology influences the existing structure of a system. Advances in technology can influence the existing legal system of a country in that the laws will change to accommodate and support its use. At the same time, laws can also influence the development of technology by creating requirements and setting practices, which prompt technological innovations to meet the requirements, e.g., MARPOL 73/78 regulations. For example, effective oily water separators for engine room discharge were produced only after the adoption of the Convention.

The focus of this Chapter is technological advancements that have been made to prevent and eliminate oil pollution from engine room discharges of ships, under the influence of MARPOL 73/78. Thereafter, it shall focus on the technological improvements that have been made so far and can support changes in the regulatory limits that this dissertation is aiming for, i.e., a zero-ppm discharge.

The concept of using oily water separators to reduce or to prevent pollution of the seas from machinery space discharge started in the 1920s at the initiative of the British Government (Pritchard, 1987). Ship owners, especially tanker owners, were encouraged to install such equipment in machinery spaces on board. However, this equipment was neither efficient nor cost effective at that time. Despite their inefficiency, the use of oily water separators on board gradually increased. A survey in 1933 showed that 24% of British vessels had been equipped with oily water separators (Pritchard, 1987, p 63). Moreover, by 1935 Japanese and Canadian vessels were also slowly being equipped with separators. Further, Italian and German Ship owners were extending their support to install such equipment on new ships.

The reason for not developing an efficient oily water separator for machinery spaces until the late 1970s can be attributed to the mechanism of international legislation. The OILPOL 1954 convention, and its amendments in 1962 and 1969, had prescribed a 100-ppm discharge from machinery spaces both for tankers and non-tankers. However, the convention had failed to make it a mandatory requirement to install such pollution prevention equipment on board. As such, the shipping industry also paid less attention to install a separator that would strictly comply with the regulatory limit.

However, MARPOL 73, which adopted an equipment standard to ensure compliance with the performance standard, brought a change in the industry's attitude. The Convention required the installation of a separator on board that discharges effluent with an oil content of 100-ppm or less for existing ships and 15-ppm or less for new ships. Non-compliance with the regulation would result in the detention of the ship in foreign ports as well as in the home port. This penalty was the key issue for compliance and the industry searched for regulation compliant separators. As a result, the separator industry developed different technologies and produced different types of separators. In this Chapter the 100-ppm and 15-ppm separators that are currently in use will be discussed first, then the problems associated with these separators in achieving the regulatory limits and finally how those problems have been overcome and the technological possibilities created to reduce oily water discharge to zero or close to zero-ppm.

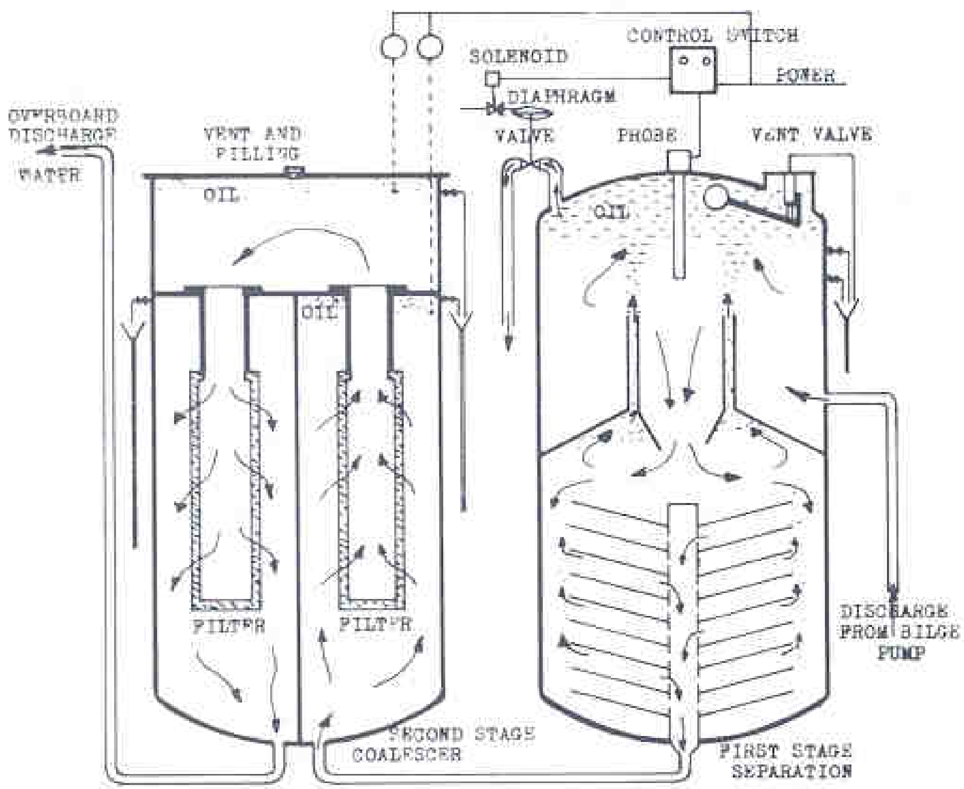
3.1 Oily Water Separators currently in use

Oily water separators and oil filtering equipment are required as noted in Chapter 2, under the regulation 16 of Annex I of MARPOL 73/78 to facilitate the control of regulatory limits of bilge water discharge from the machinery spaces of ships. The principle of separation and operational procedure of a separator is described below.

3.1.1 The 100-ppm gravity separator

The operating principle of the gravity separator is the difference in density of oil and water. To put the separator into operation, it is first filled with clean water. The oily mixture is then pumped into the separator using a low speed pump. As the mixture enters the separator, it starts to separate into oil and water in the upper chamber due to a difference in densities, the oil tending to rise to the upper part (see figure 3).

Figure 3: Oily water separator



Source: McGeorge, 1984, p 110

Further separation takes place at the lower chamber, where the mixture passes through a series of dished plates. The oil droplets, due to adhesion to the plates, separates out from the mixture and then coalesces with other droplets and flows out into the upper chamber. Oil thus accumulated in the upper chamber is drained out to a slop tank by operating a manual valve or a solenoid control automatic valve. The water discharged at the end of this operation contains about 100-ppm of oil, which is passed downward through a central pipe. The discharge of such water from the engine room was acceptable under the OILPOL 54/62/69 Convention.

3.1.2 The 15-ppm separator

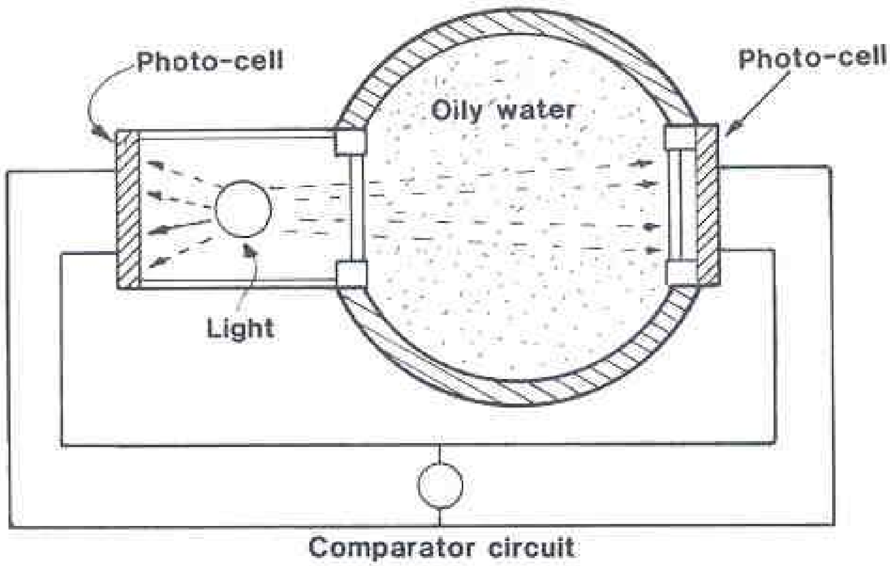
However, the 1973 MARPOL Convention brought in the stricter standard of the 15-ppm discharge. To achieve such a discharge, a second stage coalescing unit is incorporated in series with the gravity separator unit, now termed as the first stage. Water drained from the first stage enters into the right-hand chamber of the coalescing unit (see figure 3). In this chamber suspended solids and oil (partially) are removed. The coalescing insert in the left hand chamber removes the rest of the oil in the form of small droplets. These droplets coalesce into larger droplets and float

upwards to the collection space. Oil from the second stage is collected manually through the collection cocks. Water discharged after the second stage operation contains less than 15-ppm of oil. However, to ensure a discharge of 15-ppm, an oil content monitoring unit is required for the engine room.

3.1.3 Oil content monitoring unit

The oil discharge-monitoring unit works on the principle of comparing output from two photocells placed across the oil discharge-sampling pipe (see figure 4). A strong light shining directly through onto them illuminates both photocells. The photocell on the left is a reference cell whereas the photocell on the right is the working cell or

Figure 4: Oil content monitoring unit



Source: McGeorge, 1984, p 111

the measurement cell. As the oily mixture passes through the sampling pipe, the light reaching the right cell decreases with the increasing oil content of the mixture. The effect of such reduced light on the measuring cell compared to that of direct light on the reference cell is registered on a meter, calibrated to show oil content.

3.2 Problems with separators

The use of oily water separators has certainly reduced pollution from the machinery spaces of ships. However, discharge water exceeding the regulatory limit of oil content still remains a technical problem. As discussed earlier, the oil and water separating technique is mechanical, which basically promotes the growth of oil droplets through impingement and coalescence (Ngueyen, 2001). Since oil has a lower density than water, it floats and accumulates at a collection point. This separation process is only effective for treating non-soluble oil and water mixtures (Ngueyen, 2001).

However, the non-soluble oil and water mixture in the bilge is not a reality (see Table 4). One reason for this is that the waste oil and water, together with solvents (wash detergents) mix and create an emulsion (MEPC circ. 289). Another reason is that the fuel oil, lubricating oil and hydraulic oil contain additives, which are emulsion-causing elements. Besides, all non-polluting solvents are also strong emulsion-causing elements (marinfloc, 2001a).

Table 4: Potential bilge water components

Lubricating oils	Hydraulic fluids – organic
Hydraulic fluid – aqueous	Corrosion preventative – filming
Flushing oil	Corrosion preventative – displacing
Diesel	White spirit
Greases and waxes	Emulsification agents
Bilge cleaner	Fire fighting foam

Source: Murton (2001)

The presence of such a stable emulsion and various other surfactants reduce the effectiveness of the separators by limiting the collision, coalescence and settling of water droplets (Ngueyen, 2001). As a result, the oily water separator in fact often fails to produce an effluent, compliant with the 15-ppm regulation. This results in greater pollution of the marine environment than the present regulation allows. To overcome such problems, research was carried out in different parts of the world and the researchers came up with very encouraging results.

3.3 New or Emerging Technology and Techniques

The researchers in their quest, invented new technologies and techniques such as the membrane technology, flocking (chemical dosing) technology and bacteria-based technology. In the following sections these technologies will be described and discussed to promote a better understanding for the reader and showing that technology at present is available to improve the discharge standard from 15-ppm to zero or close to zero-ppm.

3.3.1 Membrane Technology

There are many kinds of membrane technology presently available on the market but ultra filtration and ceramic filtration are currently being used on board ships for bilge water treatment. In this section ultra filtration technology will be discussed first followed by ceramic filtration technology.

3.3.1.1 Ultra filtration membrane technology

This is a two-stage system utilizing velocity reduction, differential specific gravity and coalescence, followed by ultra filtration to separate and remove free oil and emulsified oils (Ngueyen, 2001). Ultra filtration uses thin film membranes of engineered fiber with pore sizes ranging from 0.001 micron to 0.01 micron. These membranes create an effective and mechanical barrier to the passage of oil molecules but allow permeates to pass through.

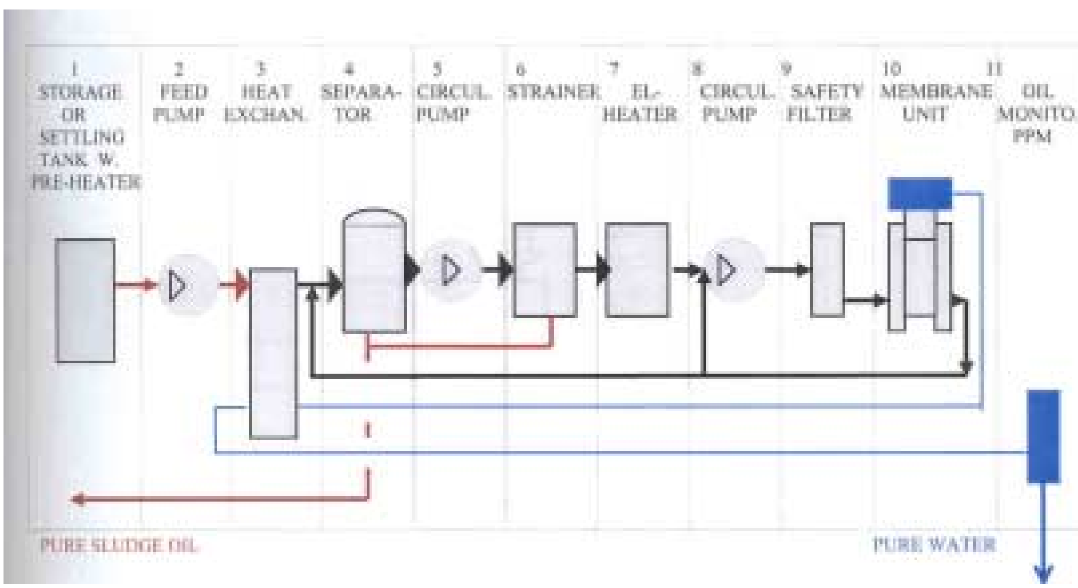
The advantages of these membranes, as explained by Nguyen (2001), are that they repel more oil, absorb more water and are seldom fouled by free oils. In addition, the engineered pore structure creates a surface filter at the outer skin rather than entrapping the oil molecules in the inner part of the pores. This process of filtration facilitates the easy cleaning of the membranes.

The operation, as mentioned before, is carried out in two stages. In the first stage of the system, the oily water mixture is passed through a basket strainer into a conventional coalescent type separator to remove most free oils and solids. The water discharged from the first stage is then pumped into the second stage through a primary bag filter. In the second stage, water is pushed through ultra filtration membranes, which remove the emulsified oils and soluble contaminants. The permeated water thus processed through membranes virtually becomes free from oil, with less than 5-ppm oil content.

Companies like Coffin World Water System in United States and Martex International a/s in Denmark have developed the ultra filtration method. The operational procedure of the Martex Oily-Water Separator as described in their manual (2001a) is based on the molecular difference of oil and water to purify the emulsion in a membrane filtration unit. The water and oil, received after filtration can be used in boilers and incinerators respectively. The system operates as follows.

The oily water mixture is first stored in a storage tank after passing through a pre-filtration unit (see figure 5). It is then drawn by a feed pump and passed to the oily water separator through a heat exchanger. In the separator, free oils and most of the solids are removed but the emulsion passes away to a circulating pump that boosts the emulsion through an automatic filter and a preheater. The automatic filter removes all solid particles of size more than hundred microns and the preheater heat up the emulsion to a temperature of 50 degree centigrade.

Figure 5: Martex Ultra filtration membrane separator



Source: Martex International A/S (2001)

A second booster pump then draws the heated emulsion and passes it through a safety filter of 100 microns to the membrane filter. The membrane purifies the emulsion into pure water and waste oil, using cross flow filtration. The water flows through the membranes and is continuously led out of the system whereas membranes withhold the oil. The residual emulsion from the membrane is re-circulated through the separator until it breaks down into pure water and oil. Pure water thus received is passed through the heat exchanger and an oil discharge-monitoring unit before discharging to the sea. The company guarantees less than 2-ppm oil in the discharged water after processing.

The advantages claimed for this system are:

- The unit is automatically operated, and is controlled (stop/start function) by a level switch in the waste water/oil tank.
- The membrane filter has a self-cleaning (automatic) circulation process, which back flosses the membrane plates using a soap solution. The unclean water is channeled into the waste water/oil tank while the plates are cleaned.
- It is unaffected by cleaning agents and detergents.
- Cross flow filtration reduces fouling and clogging of the membrane plates.
- Automatic outflow termination when oil content exceeds 2-ppm with the aid of a built in alarm.
- No use of expensive chemicals or any other additives
- Low cost operating system
- The separator has no upper limit capacity. The company is presently able to supply separators with a capacity of 3-80 tons/day

3.3.1.2 Ceramic micro filtration membrane technology

This system essentially uses a porous, chemically inert ceramic tube to remove oils, grease and solvents. The pore size of the micro-filtration membrane or the ceramic tube is 0.2 micron whereas the molecular size of the oil molecules is far less than this size (Murton, 2001). This creates a problem in separation. However, this problem has been overcome by maintaining a stable emulsion of oil water mixture prior to the separation. “Solvation of the oil droplets produces a stable emulsion that is large enough to be retained by the micro-filtration membrane” (Murton, 2001, p 26).

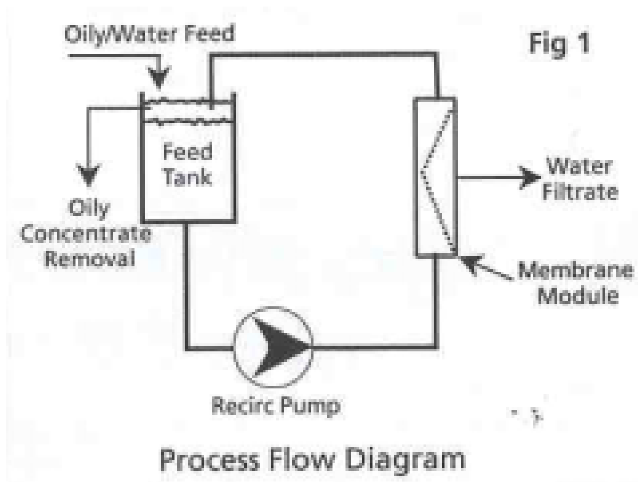
The stable emulsion that is essential for the effective separation of oil and water can be produced by various methods.

- Pre mixing in the feed tank
- Ultrasonic emulsification

- Shear mixing within the membrane system (The shear mixing system is proved to be the most successful method).

The ceramic micro-filtration system operates by feeding the oily water mixture into a feed tank from where free oils are separated out from the top (see figure 6).

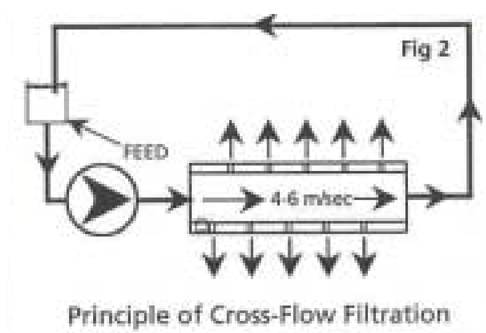
Figure 6: Ceramic micro filtration system



Source: Murton, 2001, p 26

Thereafter a re-circulating pump draws the oily water mixture from the bottom of the tank and circulates it through the ceramic filter and back to the feed tank. This process of circulation continues until a stable emulsion of the mixture is achieved.

Figure 7: Principle of Cross-flow filtration



Source: Murton, 2001, p 26

The velocity of the flow of the mixture is carefully controlled in the range of 4 to 6 meters per second to prevent surface polarization and the build up of a fouling layer on the inside of the tube (Murton, 2001). However, the membrane unit is not a single tube but rather comprises of a monolith with several flow channels (see figure 7) (Murton, 2001). The emulsification takes place not only as a result of shear introduced by the re-circulation pump but also by inducing high turbulence adjacent to the membrane surface (Murton, 2001).

As soon as the stable emulsification is achieved or observed, the water is allowed to pass through the membrane with the emulsion being retained in the feed tank and ultimately separated out on a batch or semi-continuous basis (Murton, 2001). However, care should be taken not to overwork the emulsion so that it breaks down. A fine balance is to be maintained between creating an emulsion and overworking it to achieve an efficient separation.

The producing companies of ceramic micro-filtration technology, Alan Cobham Engineering and Biodesign, claims a reduction of oil content in the effluent water as low as 0.5-ppm. In a statement Colin Murton (2001), the business development manager of Alan Cobham Engineering explained: ‘We’ve conducted trials and ended up with much less than the regulatory limit of 15-ppm; we’ve ended up with 0.5-ppm – and that’s with solids and everything, not just bilge water’ (p 25).

The advantages claimed for this system are simple, cost effective and reliable. The system needs a low surface area and has less stringent requirements of cleaning and hence reduction or elimination of the use of chemicals. The cross flow configuration ensures maximum performance and minimum maintenance. The system is of course, fully automated.

However, the efficient separation greatly depends on the ability of the system’s pretreatment stage to produce a stable emulsion, which must be large enough to be retained by the 0.2 micron rating of the micro-filtration membranes (Nguyen, 2001). Another concern is the ability of the fragile ceramic material to withstand the harsh demands of shipboard operations (Nguyen, 2001). The capacity of this system ranges from 3 to 10 cubic meters per day, that is about 3-10 tons/day.

3.3.2 Flocking or Chemical dosing Technology

There are also many systems that use chemical dosing technology like Centribilge of Alfa Laval and EBBWCS of Marinfloc. However, the discussion in this section will be restricted to those systems capable of producing effluent with an oil content of less than 5-ppm. Alfa Laval claims to achieve less than 10-ppm oil content in the effluent, whereas, Marinfloc claims to achieve 0 – 3-ppm only. Following is a discussion of the Marinfloc system.

3.3.2.1 Marinfloc bilge water cleaning system

Detergents and some additives used in oil are emulsion-causing elements. When emulsion is formed it creates a bonding between water and oil (Marinfloc manual, 2001). The Marinfloc system uses chemicals to break the bonding formation in water and collect the pollutants. The chemicals also make the new bonding formation work faster by gathering the pollutant either at the bottom (sedimentation) or flow to the surface (floatation) (Marinfloc, 2001a).

In theory, two steps must be completed in order to remove fine, colloidal suspended solids or emulsified liquids from water. Firstly, the interparticle repulsion force has to be overcome by neutralizing the surface charge of the particles sufficiently (Marinfloc, 2001a). This is done by adding the required amount of chemicals (polymer) with the result that the repulsive force is adequately counteracted, and at the same time natural attractive forces resume functioning. This process is known as coagulation (Marinfloc, 2001a).

Secondly, the particles are to be bound together to form larger particles that according to Stokes' Law will settle or float more rapidly (Marinfloc, 2001a). This process of forming settleable particles from destabilized colloidal particles is called flocculation. The use of polymeric flocculants (chemicals) can increase both the size and settling rate of the pollutants and hence can quicken the separating process.

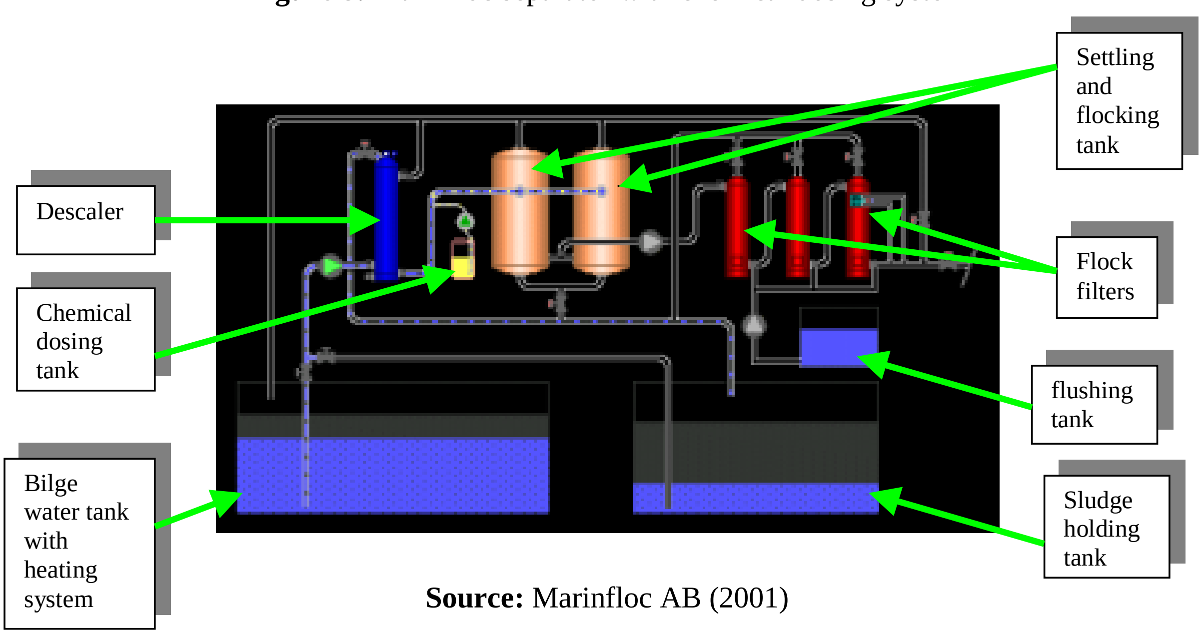
Flocculation again, is a two-phase process. The first phase is termed agglomeration, in which microflocs are attached together forming larger particles. To promote floc growth, high molecular weight flocculant polymers are added. These polymers bind microflocs together due to their numerous absorption sites (Marinfloc, 2001a). Unlike coagulation, flocculation with polymers must be accomplished in a slow mixing mode. Rapid or violent agitation will break the flocks as they are formed, reducing particle size and thereby increasing settling time (Marinfloc, 2001a).

The second phase of flocculation involves physical entrapment. As flocks begin to settle or are trapped on a filter medium, they capture smaller, unattached microflocs, further improving the removal of pollutants (Marinfloc, 2001a).

3.3.2.2 Operating Procedure

The operational system of marinfloc is divided into five parts, namely, temperature adjustment, gravimetrical discharge of free oil sludge, emulsion breaking, settling and filtering. The operation begins with bilge water being preheated to about +50^{0}C

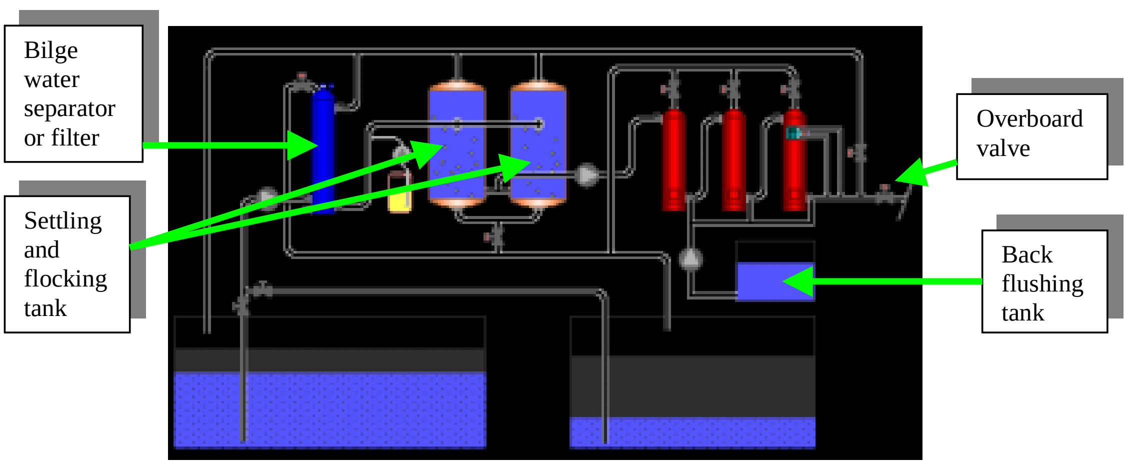
Figure 8: Marinfloc separator with chemical dosing system



Source: Marinfloc AB (2001)

in the bilge water tank and then fed to the oil descaler where all free oil is separated (see figure 8). The oil sensor, after sensing oil, activates the oil release valve to drain the free oil to the sludge holding tank. The bilge water then passes from the descaler to the flocculation tank, when flocculants (chemicals) are dosed into it. The dosages normally vary from 200-300-ppm depending upon the quality of the bilge water (Marinfloc, 2001). A high-level switch activates when the flock tank is full to stop the feed pump, however, the overflowing from the tank continues for a few more minutes to remove any free oil. In the flock tank, the flocculation sequence starts and goes on for about 25-50 minutes (Marinfloc, 2001). The emulsions are now broken, and the major part of the flocks have settled down at the bottom but a few will remain in suspension (see figure 8 a). The flock tank is emptied during the

Figure 8 (a): Marinfloc separator with chemical dosing system



Source: Marinfloc AB (2001).

discharge cycle through the filter stages: stabilizer, coarse filter and the fine filter, where all flocks and impurities will be trapped and the clean water will be pumped overboard after passing through the oil discharge monitoring unit. However, if the discharge monitor indicates an oil content of more than 15-ppm, the oil will be re-circulated back to the bilge water tank and the process will begin again.

Moreover, if the pressure drop across the filter stages exceeds more than 0.5 bar above the working pressure, a back flushing sequence starts automatically. As soon as the pressure returns to normal the discharge cycle resumes and continues until the low level switch in the flocculation tank is activated. The remaining flocks and impurities are then drained from the flock tank into the sludge tank.

Furthermore, the sludge tank is emptied into the bilge water tank via oil descaler or oily water separator to keep the sludge concentrated. The company claims that sludge treated in this way contains very little water, and water pumped overboard contains less than 3-ppm oil (Marinfloc, 2001a). The capacity of the separator varies from 2 – 45 m^3/day (Fairplay Solution, 2001, June).

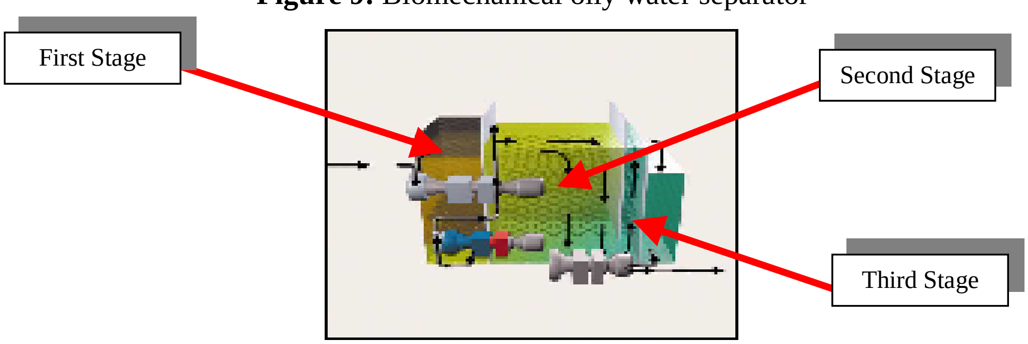
3.3.3 Bacteria Technology

This technology uses naturally occurring bacteria to destroy emulsified oil, grease and other contaminants in the bilge water (MER, 2000). Presently, two different systems are available on the market namely, bioremediation and biodispersion.

3.3.3.1 Bioremediation

The US based company Ensolve Biosystems has developed a biomechanical oily water separator that uses a combination of mechanical separation and bioremediation to treat bilge water(Dyck, 2001; Marine Equipment News, 2001). The patent name of the oily water separator is PetroLiminator™ 630 and operates in three stages (see figure 9).

Figure 9: Biomechanical oily water separator



Source: Ensolve, 2001

Stage 1 (heavy phase separation) allows for the initial separation and removal of pure oil. Stage 2 (emulsified oil degradation) contains safe non-pathogenic microorganisms (bacteria) that convert all hydrocarbons into harmless end products (Ensolve, 2001). Stage 3 (clarifier) allows for the removal of solids and clean effluent.

Figure 9 (a): Biomechanical oily water separator ,stage 1

Source: Ensolve, 2001

In the first stage (see figure 9a), contaminated bilge water is pumped directly into the system. This stage separates oil from water and allows sludge or suspended solids to collect in the bottom of Stage 1. In this stage, there is also an oil probe that allowspure oil to pass through a solenoid-operated valve into a waste oil tank. The remaining oily mixture is continuously pumped into the second stage.

Figure 9 (b): Biomechanical oily water separator ,stage 2

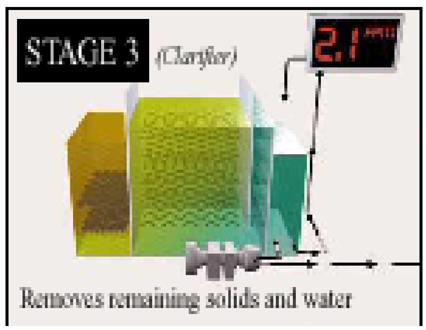
Source: Ensolve, 2001

In the second stage (see figure 9b), oily water passes through a support medium, a honeycomb-like matrix, to which hydrocarbon-degrading bacteria are attached (MER, 2000). The bacterium secretes polysaccharide, a biological 'glue', which tightly binds them to the support medium. This strong binding minimizes bacterial washout due to the flow of water through the system or the motion of the ship (Ensolve, 2001).

Oil and related contaminants are degraded in this biological layer as the safe and non-pathogenic bacterium actually consumes the hydrocarbons (Ensolve, 2001). Detergents and other emulsifier break the oil into smaller pieces and actually help the bacterium to consume them at a faster pace.

The third stage or the final stage (see figure 9c) allows for any remaining solid

Figure 9 (c): Biomechanical oily water separator, stage 3



Source: Ensolve, 2001

particles to be further devoured by the bacteria prior to discharging the effluent overboard. The effluent is continuously monitored by an oil discharge-monitoring unit to prevent any discharge more than 15-ppm.

This separator was first installed in an ore carrier named “James T Barker”, operating in the Great lakes (MER, 2000). The Superintendent of the company confirmed in a statement as mentioned in MER (2000, p 63), “We’ve got oil in our bilge water effluent down to two and even one part per million.”

The Ensolve Company claims the following advantages for the bioremediation system:

- Reliable and easy to use. No filters or beads to clean.

- Saves money – drastically reduces the need to offload oil-contaminated water in port.
- Automated or manual operation – the automatic system can operate 24 hours per day, 7 day per week. The control panel provides for manual override if necessary.
- Easy upkeep – supplied with an easy to use kit and starter nutrients
- Compatible with strong degreaser and detergents, it actually prefers emulsified oil.

3.3.3.2 Biodispersion

Biodispersion is a biological process that promotes dispersion of oil and thus forms an important phase of remediation (Canadian Environmental Protection, 2001). Since prevention is often better than cure, treating oil pollution at source, namely in the engine room bilge well or in the bilge tank, with bacteria may help to eliminate or reduce pollution of the seas from the operational discharge of machinery spaces. The bacterium types that are used for this system are namely, *pseudomonas*, *pseudoalkaligenes* and *phenylobacterium immobile* (Fairplay Solution, 2001, February). This system to be effective, uses a medium that is oleophilic (oil attracting) and supports the growth of oil-eating bacteria.

The bacteria follow four stages for the microbial use of oil. First, a physical process of dispersion by which oil is broken down into smaller globules. For this reason, bacteria are kept in contact with polluting oil rather than dispersing them into the larger mass of polluted water. Being oleophilic, the bacteria remain attached to the oil layer and slowly transform oil into ever-smaller droplets that can be absorbed easily (Fairplay Solution, 2001, February; Waste Water Technology, 1999). This assimilation process then metabolizes the oil into glucose, which in turn is broken down into carbon dioxide and water (MER, 2001).

This four-stage treatment process is somewhat similar to that of Ensolve's biomechanical bilge water separator (MER, 2001). However, incorporation of this biodispersion system with a Marinfloc oily water separator has been tested (MER, 2001) without any negative result to the flocking. Hence, it is expected that combination of marinfloc and biodispersion system will reduce the oil content in the effluent to 0-ppm in future.

The advantages of the biodispersion system as described by the company are as follows:

- The bacteria are aerobic since the entire process of utilization of oil is achieved through oxidation.
- The bacteria are maintained in an Oleophilic Suspension of Physiologically Active Bacteria Culture (OSPABC) and are thus not lost in water.
- Action of bacteria is almost instantaneous and does not require any additional nutrients for their growth and multiplication.
- Less expensive. The bacteria cost $10 per liter

3.4 Discussion

The above discussion shows that technological development is a continuous process. The separator industry in the recent past has developed many new technologies to comply with the regulatory limit of the MARPOL Convention. The introduction of the coalescing type of filter ensured compliance with the 15-ppm regulatory limit. However, the same filter failed to separate oil effectively from an emulsified mixture or mixture containing oil dispersants, resulting in a discharge above the regulatory limit and causing pollution of the oceans.

However, the technology, with its never-ending process of development, has found a solution to this problem. New technologies such as the membrane filters, the flocking/chemical dosing system and the bacteria system have now become available. These technologies are not only effective in achieving the current regulatory discharge limit but go beyond and reduce the oil content to even 0.5-ppm (see ceramic filtration).

The cost of these new technologies, however, is higher than the technologies currently being used. Nevertheless, the increased cost is compensated through a lower generation of sludge and more purified water, which can be used in incinerators as fuel and in boilers as feed water respectively. Moreover, due to the lower generation of sludge, the cost of transferring this sludge to a reception facility would also be reduced. Hence, the use of the new technology would become cost effective. It is also believed that production of this equipment in a greater quantity all over the world would reduce the price as well. The manufacturers have confirmed their intention to the author to expand their production houses all over the world in the near future.

The scientific observations discussed in Chapter 1 revealed that even an oily mixture of less than 0.1-ppm is harmful for the marine environment and threatens to destroy our food chain in the long-run. This Chapter provides information that current technology can produce a 0.5-ppm discharge and these technologies will soon be commercially available around the world. It is therefore clear, that on the basis of the carrying capacity of the marine environment and available technology, redefining the discharge standard for engine room discharges is both a necessity and possibility. With the ongoing development of current technology, a zero-ppm discharge standard is achievable, provided an amendment is made in the regulation stipulating such a regulatory limit. The amendment shall enter into force at a future date as suggested in Chapter 2 of this dissertation.

However, even if a zero-ppm discharge standard is adopted and new technologies are developed, the problem of non-compliance with the regulatory standard needs to be addressed. The next Chapter outlines some of the reasons for non-compliance with the current 15-ppm regime, and provides an overview of the current compliance and enforcement regime under MARPOL 73/78.

CHAPTER 4

THE ENFORCEMENT REGIME UNDER MARPOL 73/78 AND NON-COMPLIANCE CULTURE

The previous Chapters have discussed the role of technology in the formulation of international regulations to prevent and control operational oil discharges from ships, in particular oily water mixtures from engine room bilges, into the marine environment. The problem remaining here is achieving compliance with the regulatory standards, irrespective of the standards stipulated in the regulations. For this reason, it is necessary to establish a mechanism or process of exacting compliance with the regulations, called enforcement. Member States that are party to the MARPOL 73/78 Convention require enacting national laws and issuing regulations, which will constitute the legal framework for enforcement.

The 1982 UNCLOS and MARPOL 73/78, both oblige contracting parties to enforce laws and regulations relating to the prevention, reduction and control of pollution of the marine environment from vessels flying their flag and from foreign vessels operating within their jurisdiction. A system of enforcement takes many forms and involves surveys or inspections of ships to ensure they comply with the minimum technical standards; surveillance or monitoring to ensure compliance with the discharge standard; and imposing sanctions or punishment to ships that violate the standard.

This Chapter will briefly describe these current systems of compliance and enforcement regimes first and thereby explore the possible implications on these systems of changing the regulatory limit to zero-ppm, and how they can be overcome. Finally, factors that pose obstacles in achieving effective enforcement and develop a non-compliance culture, and their possible solutions, will be discussed.

4.1 Survey/Inspections and Certification

Survey or inspection is a physical examination or check of equipment to ensure that their performance is in compliance with the regulations. Regulation 4 of Annex I of MARPOL 73/78 requires such a survey or inspection mechanism for flag States to guarantee that their ship's structure, equipment, fittings, arrangements, and material fully comply with the applicable requirements of Annex I, before a ship is put into service or when issuing the five-year International Oil Pollution Prevention (IOPP) Certificate. After that the survey timing varies. The force behind the survey is that a ship, which fails to pass the quality test, cannot sail until it has been brought up to MARPOL's standards (Griffin, 1999).

The survey requirement under flag State control is the most detailed, highly time consuming and requires an acquired level of technical skill (Gold, 1998). For this reason, the Administration is allowed to delegate such a function to the recognized Classification Societies [Annex I Regulation 4 (3)(b)] including the issuance of the appropriate statutory certificates on behalf of the flag State [Annex I Regulation 5(2)]. However, the State remains responsible for the actions of these organization(s) concerned and for ensuring that its vessels, their equipment and crew comply with the provisions of MARPOL 73/78.

Under the new Harmonized System of Survey and Certification (HSSC), MARPOL ships and equipment are subject to an initial survey, mandatory annual surveys, intermediate surveys, and a renewal survey (IMO Resolution A.746 (18), 1993; Larsson, 2001).

4.1.1 Initial survey

An initial survey is a complete examination of plans, drawings, specifications of equipments, their documents, oil record books, manuals, overall condition of the ship and its equipment in order to approve and issue the IOPP certificate for the first time to a new building ship or an existing ship registering for the first time.

4.1.2 Mandatory annual survey

A mandatory annual survey is carried out at an interval of twelve months after the initial survey. It is a general examination to confirm that the ship and its equipment are in satisfactory condition and the certificates are valid. It is mainly a visual examination to ensure no unapproved modifications have been made to the equipment or its connecting pumping and piping system. However, certain tests may be carried out to ascertain the proper functioning of the equipment.

4.1.3 Intermediate survey

An intermediate survey is a thorough examination and tests of all equipment to ensure compliance with the applicable requirements and that no unapproved modifications have been made. Certificates are also checked for their validity. This survey is carried out during six months prior to, or not later than six months after the half way date of validity of the IOPP certificate i.e., on either the second annual survey or on the third annual survey. Once an intermediate survey is carried out, the annual survey in that year is automatically superseded.

4.1.4 Renewal survey

A renewal survey is again a complete examination of certificates and survey of the condition of the ship and its equipment in order to renew the IOPP certificate for a further five years. This also include an inspection confirming that no unapproved modifications have been made.

4.1.5 Additional survey

An additional survey is an inspection, either general or partial according to the circumstances, to be made after a repair resulting from an investigation or whenever any important repairs or renewals are made.

4.1.6 Port State Control Inspection

In addition to the flag States obligations, port States also have some authority to inspect ships and detain those which fall below MARPOL’s standards. The port State authority is contingent on whether a ship at a port or an offshore terminal has an

IOPP Certificate. If a ship has no Certificate, a port State may conduct a full inspection. If, however, a ship is carrying a valid certificate from a flag State, the port State is obliged to honor the document as if it were its own (Article 5(1), MARPOL 73/78). The vessel must be accepted as passing MARPOL 73/78's standards. The only time the port State can go beyond the IOPP Certificate and conduct a complete inspection is, if there are "clear grounds" for believing that the condition of the ship or its equipment does not correspond substantially with the particulars of that certificate (Article 5(2), MARPOL 73/78). Intervention would be warranted, for example, if a crew had removed monitoring equipment, which was originally listed on the ship's certificate (Griffin, 1999).

4.2 Surveillance/Monitoring

A second component of the enforcement regime is surveillance or monitoring of vessel discharges. MARPOL 73/78 requires all parties to co-operate in detecting ship violations and to use "all appropriate and practicable measures of detection and environmental monitoring, adequate procedures for reporting and accumulation of evidence" (Article 6(1), MARPOL 73). If a State has evidence of a MARPOL 73/78 violation, it must forward the proof to the flag State responsible for the deviant vessel (Article 6(3), MARPOL 73). Evidence of violation or illegal discharge is collected through visual observation and/or remote sensing processes.

4.2.1 Visual observation

Visual observations can be made from satellites, aircraft, ships, and land based observers. However, it is difficult to assess the nature of an oil spill, its extent and volume from the deck of a ship or from land. Thus it is ideal to observe the illegal discharge from immediately above the area of interest by using planes and helicopters. It is sometimes difficult to assess from visual observations whether certain spills result from operational discharges or are non-Annex I products or vegetable oil. An enquiry on board would normally resolve the problem.

4.2.2 Remote sensing

Airborne remote sensing systems are an efficient means of detecting discharges of oil at sea and supplying information for use as evidence. The data collected from the area of interest through sensors can be examined either in flight or after landing. In addition stills or frozen images and conventional high-resolution photographic prints annotated with date, time, position, and other mission data can be stored or transferred to the ground via an image link. The operating principle of remote sensing instruments is based upon the comparison of radiation or reflection from the unpolluted sea to the radiation or reflection from the polluted sea. The pollution or trace of oil so detected normally exceeds the MARPOL regulatory limit of 15-ppm.

Although, the aerial and sea borne detection systems are quite effective, their performance can be hampered by meteorological conditions, as well as being restricted to daylight hours. For this reason, satellite monitoring has been introduced in the recent past to monitor illegal discharges day and night irrespective of weather conditions. This enables the officials to trace back the origin of any slick by allowing them to trawl back through satellite data and establish exactly when the oil was released and, more importantly, by which ship (Reyes, 2001).

From the above description of the monitoring system, one can see that although UNCLOS and MARPOL more importantly oblige States with the responsibility of policing the oceans, building such an infrastructure is very expensive. As a result most developing nations with financial constraints and other economic and social priorities fail to meet this demand. Even within developed nations, who have this infrastructure, most of the violations are not caught on the high seas for several reasons. First, it is very expensive to monitor many millions of ocean miles with planes, helicopters or satellites. Secondly, once an oil slick is discovered, it is difficult to build up sufficient evidence to link it to a particular ship (Curtis, 1985) and more so to a particular person (Lidgren & Norby, 1980). Without a picture of a long slick of oil trailing behind a vessel, the usual method of detecting a MARPOL 73/78 violation is to observe a discharge while a ship is berthed in a port.

MARPOL 73/78 also gives port States the authority to conduct discharge inspections on any ships berthed in a port or an offshore terminal under their jurisdiction (Article 6(2), MARPOL 73). In this inspection, the port State would look mainly at a ship's Oil Record Book (ORB) in which the ship's crew records all movements of oil during a voyage. If a ship has oil discharge monitoring equipment installed, this too will become an important evidence (Curtis, 1985). Finally, if a ship does not have normal amounts of dirty ballast or oily residues stored in its slop tank, this would be a prima facie evidence of an improper operational discharge (Griffin, 1999).

4.3 Sanctions/Punishment

The last component of the enforcement regime is the punishment of vessels, which have illegally discharged oil. Once a flag State has received notice or evidence that one of its ships has violated MARPOL 73/78, it must investigate. If this obligatory investigation turns up enough or sufficient evidence to bring an action against the vessel, then the flag State must initiate a legal proceeding to judge the matter. In the spirit of co-operation, it must then promptly inform the party which reported the violation, of the action taken (Article 6(4), MARPOL 73).

When punishing a ship, the flag State must impose penalties that are "adequate in severity to discourage violations of the present Convention and shall be equally severe irrespective of where the violations occur" (Article 4(4), MARPOL 73). The regime of UNCLOS also prescribes the imposition of sanctions with respect to marine pollution violations committed by foreign vessels within and beyond the territorial sea of a State party.

Since sanctions can be very effective as a compliance tool, it is necessary for States to prescribe sanctions that are at least in harmony with applicable systems in neighboring States or territories. This action would avoid the perception that some States have less stringent sanctions than others and would prevent the potential polluter or violator from finding a safe haven to pollute. A swift and effective mechanism to impose sanctions will also have a greater effect in preventing marine pollution from ships (Ketkar, 1995; Wells, 2001).

From the above discussions on different aspects of enforcement, it is apparent that the changing regulatory limit to zero-ppm will not have any negative effect on the present enforcement mechanism. Once the oily water separator and/or filtering equipment is type approved by the administration after proper examination and inspection, its functionality on board ship would be ensured. The surveys followed thereafter, is only to ensure its functionality and that no unauthorized modification has been made to facilitate illegal discharge.

However, success or failure of standard setting efforts along with effective implementation depends largely on an administrative enforcement mechanism of the member states, shipping industry, classification societies, and compliance by ship owners and operators and most importantly by the competent crew of the ships. The following section discusses some of the reasons for ineffective enforcement and non-compliance with the present regulations.

4.4 Reasons for non-compliance

As mentioned earlier, a concerted effort from all sources is required for an effective implementation and enforcement mechanism, and compliance culture. However, there are many contributing factors that can give rise to a breach of MARPOL's discharge standards as described below.

4.4.1 Inability to enforce the MARPOL Convention

Developing nations, even after ratifying the MARPOL Convention, often fail to enact the same into their national legislation, due to the lack of political will and commitment to safeguarding the environment. Moreover, other welfare issues assume greater national priority in these countries. Some of the flag States, due to financial constraints, also fail to build up adequate administrative infrastructures with qualified and competent surveyors, and technical back up, to meet the demands of the maritime industry and traffic in their ports; they may not even have a reception facility. These countries, may delegate the inspection and certification of equipment to the Classification societies, however, there is a widespread belief at present that the Classification societies are “incompetent, inept and in some cases corrupt” (International Commission on Shipping, 2000, p 32). As a result, a country with no legal tool to curb pollution, or no political commitment to protect the environment or absence of environmentally concerned activists or with no or limited mechanism of enforcement, becomes a “safe haven” for the potential polluters.

4.4.2 Misinterpretation of MARPOL regulations

As discussed earlier, MARPOL 73/78 is a very technical and highly complex Convention. It is difficult for a legislative drafter, who has no technical background to understand all its technical meanings adequately and comprehensively and incorporate them into the framework of national legislation accordingly. Moreover, a legal person may make it too wordy, unclear, pompous and dull (Wydick, 1978) for the reader, usually the user of the regulation, to understand it correctly. This misunderstanding and/or misinterpretation of regulations may result in violations of discharge standards.

Another reason could be the text of the Convention, which is produced in several IMO official languages. The meaning of some technical words or expressions in one language may not mean the same in another language. A literal translation of the whole text into another language may differ substantially in the real meaning and objective of the original text. Hence, it may give rise to an ineffective and inadequate legislation in some part of the world. To reduce such differences, many unified interpretations of the Convention’s texts are prescribed in the consolidated version of the MARPOL 73/78 Convention. However, the author believes that this unified interpretation has also some complication in its implications and may some time stand out as the cause for non-effective compliance.

The differences between legal systems/frameworks can be another reason for non-uniformity in the compliance mechanism. Many countries follow English Common

Law and many follow French Civil Law, derived from their former colonial rules. This legal system of a country bears direct influence on the implementation procedure of international conventions (Beick-Baffour, 2000). Since, MARPOL is not a self-executing Convention, as it requires some form of legislative transformation prior to enactment into national legislation, the existence of different legislative frameworks in different member states causes delays in its prompt and harmonious adoption (Beick-Baffour, 2000). These delays and non-harmonious processes of adoption also lead to a situation of non-compliance cultures within some member States of a region.

Even within a member State, various government agencies, industries and nongovernmental organizations may remain responsible for implementing the Convention. On the process of implementation, one or more agencies may lose some valuable empirical information by aggregating violation of one provision with compliance with another (Mitchell, 1994) leading to a mismatch regulation and hence improper compliance or violation.

4.4.3 Crew incompetence

A competent crew/seafarer is a person who has received adequate theoretical knowledge, gained enough practical experience and has passed through a process of evaluation to mark his/her level of competence. Competent crews are essential to observe safety and pollution prevention regulations efficiently. However, to reduce operational costs and increase profit margins, some owners employ inexperienced and unskilled crew (Ma, 2000). Incompetent crew who are not familiar with the operational procedure of pollution prevention equipment, their automation and fail-safe methods and maintenance procedures may cause a violation by opening the wrong valve or following the wrong procedure of operation. Being unaware, the crew may even neglect the required maintenance of the oily water separator and/or filtering equipment such as changing filters or back flushing the filters. For this reason, an amendment to the MARPOL Convention was made in 1994, authorizing port States to make inspections and ensure that the crews are able to carry out essential shipboard procedures relating to marine pollution prevention (IMO, 1997; 1998).

4.4.4 Equipment failure or incapability

The pollution prevention equipment may fail to function at its optimum capacity due to various reasons such as old age, blockage of filters/membranes, or failure to carry out routine maintenance of the equipment, as mentioned earlier. Moreover, if the discharge-monitoring unit is not used in a proper way, or is not kept in good working condition, this will lead to violation and hence non-compliance to the regulations (Goossens, 1999).

Besides, the authority may have approved oily water separating equipment with inadequate capacity for a specific ship for the purpose of pollution prevention. It is to be noted that the quantum of sludge and oily water generated in the machinery space is primarily dependent on its power plant capacity. The quantum of sludge is dependent on the bunker quality and rate of fuel oil consumption; the quantum of oil and water leakage is governed by standard of housekeeping. Inadequate capacity or poorly maintained equipment would cause delay and the accumulation of excess sludge on board that will eventually tempt the crew to discharge it illegally, thus violating the discharge standard.

4.4.5 Lack of Reception facilities and Commercial gain

A ship keeps generating wastes while operating at sea. Oily wastes (sludge) and slop generates mainly from purifying bunker fuel, treatment of bilge water and from cargo residues of a cargo tank. Slops and sludge thus generated are stored in their respective tanks. However, the capacity of these tanks are limited and requires emptying from time to time to make room for further generated slops and sludge. One probable way to discharge such slops and sludge legally is to transfer them into a port reception facility when calling at a port. If such facilities are not available in the port the ship is calling at, the crew depending on how motivated they are, would be tempted to discharge the slops illegally into the sea especially during the hours of darkness.

Besides, most commercial operators will try to improve the level of profit by reducing operational costs. Discharging slop or oil sludge ashore means incurring fees to the reception facility authority, and may also mean an extended stay in port, if there is a line up for the use of the facility. This in turn, will result in extra port charges. It may as well mean a change of berth to discharge slop, causing an additional pilotage fee, mooring and unmooring charges, tug hire etc. Thus the process of slop/sludge discharge into a reception facility, although, sounding as a very easy and simple operation, certainly involves huge operational costs on the part of the owner.

Many owners do operate their ships with the highest standards in every respect, including environmental considerations. However, many others do not, and even some of the best ships in terms of navigation standards have a low standard of anti-pollution procedures (Gold, 1998). These owners, being very careless about the environment, pressurize crews to maintain schedules in port and avoid slops/sludge discharging ashore. This is especially observed in the case of liner shipping, where the scheduled timing of arrival and departure in and out of ports is strictly maintained. In return, the owner may offer a lump sum of money as remuneration or offer the crewmember an opportunity to be a permanent employee of the company. The crew lacking motivation in respect of marine pollution and its after effects, accepts the owner’s offer and violates the regulation by tampering with the oil discharge monitoring unit or by bypassing the oily water separator and discharging the slop directly into the sea.

The case history of the Royal Caribbean Cruise line versus United States of 1998 (Fields, 1999) reveals how the ill motivated crew of ‘Sovereign of the Seas’ in 1994 had bypassed the oily water separator and discharged the slops directly onto the sea. In a similar case the United States Coast Guard tracked down in May 2001, an Evergreen container ship which had also bypassed the oily water separator. The investigation of this case is presently in process.(Fairplay Daily News, 2001).

4.4.6 Difficulty in detecting violation and evidentiary proof in court

The successful enforcement of discharge standards depends on the existence of a detection mechanism that would ascertain with sufficient evidence that a violation has actually been committed (Molenaar, 1998).Violations in the coastal zones can be monitored with ships, planes, and/or advanced technology. However, this technology is very expensive. Developing nations with less financial resources and with pressing demands to meet other social and economic priorities, often fail to establish such a mechanism. Many developed nations, on the other hand, have established this system. However, they have also reduced the surveillance schedule time due to economic reasons.

Surveillance, whatever modern mechanism is adopted to detect a violation, still has difficulty in linking any illegal discharge to the offenders, particularly during severe weather conditions such as high wind speeds and dense fog or during hours of darkness (Molenaar, 1998). Moreover, there exists a limitation of the detection systems. An oil content greater than 15-ppm but less than 100-ppm cannot be observed under normal aerial surveillance conditions, as they never form continuous films or sheens with a length greater than few decimeters (Pardo, 1998). However, discharges between 50 and 100-ppm have been visible under very special conditions such as high discharge rate, low ship speed, low wind speed and calm sea (Pardo, 1998; MEPC 33/INF. 28, 1992).

The evidentiary proof needs to be presented in a court for the legal prosecution of the violator, if such evidence is admissible by that court. Presentation of evidence also involves the means by which it is gathered/obtained and what it shows or means (O'Donovan, 1989). This can mean a lengthy trial and often involves arguments of professionals working for both the defendant and the plaintiff with substantial expertise. Cormack (1989) observes image interpretation remains a very important and incompletely understood aspect of routine remote surveillance, particularly with regard to legal requirements. These arguments and counter arguments can create a fine balance in the minds of examining magistrates, judges or juries in respect of the validity of the evidence (O'Donovan, 1989), who have no knowledge of what this picture or satellite images mean. As such, an acquittal from the charge may result based upon other evidence available.

4.5 Discussion

It has been stated earlier that moving to a zero-ppm standard for engine room discharge will have no major implications for the current practices of the enforcement regime. However, introducing model legislation for a region can solve problems relating to non-compliance due to legislative inadequacy. The model legislation can harmonize the legal systems of different countries of the region by producing uniformity in the text, application, interpretation, and enforcement procedures (Mukherjee, 2000). Moreover, it is understood that a revision of Annex I is in progress at IMO, organizing the regulations and its unified interpretations in a systematic way (BLG 6/5/1-4, 2000). This action would hopefully reduce the problem of misinterpretation and misunderstanding in the near future.

Shipboard operations such as crew competency have been addressed through the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978 and its amendment in 1995 thereto. The International Safety Management Code (ISM) overseeing the company's commitment to prevent pollution and saving the environment through practices performed onboard ships and at shore establishments can also eliminate problems such as poor maintenance and equipment failure. The inadequate capacity of oily water separator can be dealt with by assigning its specific capacity for a specific range of engine power or a specific range of fuel consumption per day (DE 44/14/1, 2000).

The problem regarding evidentiary proof has been solved by supplementing image pictures with sample analysis, taken from the ship and from the site of violation. In Finland, this is solved by setting informal meetings between officials of the maritime administration and admiralty judges. Such interaction clarifies any doubt remaining in the minds of judges regarding the procedure of sample collection and interpretation of images. A different approach is taken elsewhere by appointing maritime personalities as the jury of the court, who being accustomed to the system of sampling and images, advise the judges on technical aspects of the trial. In Denmark, samples are collected by a qualified person from the ship and from the spilled area, being witnessed by two responsible officers, who seal and sign the sample afterwards. The analysis of the sample so collected is accepted by the court. A recent development on easy detection of illegal discharges from the engine room by using unique DNA tagging to mark heavy fuel oil bunkers will also have a positive impact on the enforcement and compliance regime as they could be traced to the offending ship (BLG 6/11, 2000).

The main problem that remains though, is the establishment of adequate reception facilities. Setting a zero-ppm discharge standard would eventually call for an urgent requirement for reception facilities all around the world for effective implementation and enforcement. The reception facilities shall be quick and easy to use, and shall not interfere with cargo handling. The developing countries with financial constraints would fail to meet that challenge. However, the author would like to suggest a solution to this effect by creating a reception facility fund.

If this could be brought to the notice of member States and an agreement could be reached in creating a fund for reception facilities where the oil exporting countries will be the main contributor. They shall contribute a small amount to this fund, on the basis of the quantity exported per year. This money will be handled by a committee formed under an IMO initiative, which will find the need for the establishment of a reception facility in a country, the financial assistance required or requested for and how and in what form this assistance can be made available to the country. This would be a continuous process for the purpose of renovation, modernization and automation of reception facilities around the world.

On the basis of the solutions and the suggestions that have been discussed, the author feels confident that changing the regulatory limit to zero-ppm is possible and will not have any negative effect on the current enforcement regime.

CHAPTER 5

CONCLUSION

The present study has revealed that eliminating the vessel source of oil pollution, especially operational discharges, has been a matter of international concern for many years. Much has been done to prevent and eliminate operational discharges due to the ballasting and tank washing of cargo tanks from tanker ships. The adoption of the OILPOL 54 Convention first and later MARPOL 73/78 has reduced pollution from these sources dramatically. Discharge from tanker operations has been reduced to the lowest minimum and is expected to have a zero pollution effect after the complete phasing out of pre-MARPOL tankers by 2007 and existing MARPOL tankers by 2015. All tankers will then be double hulled and equipped with SBT and hence, will not have any pollution effect from ballasting and deballasting.

However, the other main source of operational discharge from engine room bilge remains a major source of oil pollution from marine transportation, even with the 15-ppm regulatory limit. This dissertation has explained the reasons for the inability to maintain such a regulatory limit, such as the presence of detergents and emulsion causing elements in engine room bilge water. However, modern inventions and innovations, such as membrane filtration, chemical dosing and bacteria-based technology, have solved the problem of emulsion and detergent mixed oil discharge from the engine room. Even at this time, it is possible to reduce the oil content in discharged water to 0.5-ppm, which is very encouraging and a step ahead in the direction of the proposed setting of a zero-ppm standard.

However, as pointed out in Chapter 1, recent scientific studies reveal that even a 0.5-ppm oil discharge is also harmful for the marine environment, its eco-system and biodiversity and suggests an improvement in the discharge standard by reducing the regulatory limit to zero-ppm in coastal waters. The previous discharge standard setting, as this study has discussed, was not based upon any scientific research or estimation of ecological carrying capacity. With the information now available and the awareness that regulations can be used to generate technological improvements, standards should be set to achieve an optimal result, that is, zero-ppm in this case. The transition period necessary to meet the standard can then be adjusted based on issues of cost for new installations and retrofitting, and the quantity available.

This finding provides enough room for this dissertation to make a stronger suggestion for an amendment to the present regulation to bring about the proposed change of zero-ppm within coastal areas. The amendments shall stipulate a complete prohibition of the discharge of oil or oily mixture from ships into the sea, designated as special areas and within fifty (50) miles from the nearest land, except when the ship has in operation oil filtering equipment and/or an oily water separator or similar equipment, capable of producing a zero-ppm discharge. This amendment would apply to ships, whose construction contract would be made after June 30, 2005 or delivered after June 30, 2008. Existing ships would have a five-year period of grace to install such equipment by June 30, 2013.

Technical developments in the recent past assure us that the achievement of a zero-ppm discharge is possible. We are almost there with a 0.5-ppm discharge. It needs a little more time and patience on our part to reach the goal of zero-ppm discharge. However, this dissertation is not suggesting the adoption of a zero-ppm discharge with immediate effect. Rather, it suggests an amendment of the regulation now, which shall come into effect for all ships from 2013, during the last phase of the phasing out of existing MARPOL tankers. This action will give enough time to the shipping industry to adjust to the new regulation. More so, it will allow the separator industry to come up with separators that comply with the new regulatory limit of a zero-ppm discharge.

This study has also found that changing the regulatory limit to zero-ppm will not have any implication on the current procedure of the enforcement regime. Rather, it might reduce the burden of monitoring the coastal areas with planes, satellites and with their associated expensive equipment. Any discharge that produces a sheen or trace of oil will be a violation of the regulation and hence could result in prosecution. Since, less than a 50-ppm discharge cannot be detected even with a modern detecting system, changing the regulatory limit from 15-ppm to zero-ppm would not make any difference from the detection point of view. However, it will save the marine environment, its biodiversity and our food chain.

To facilitate detection of violation from shipboard discharge, the author would like to suggest the incorporation of a mini-data logger with the oil discharge monitoring unit. The data logger will register the discharged ppm, date, time, and any breakdown events, and if possible position of the ship. The print out from this data logger shall be made available to Port State Control Officers (PSCO) for cross checking with the Oil Record Book (ORB). This action will deter any illegal discharges inside the coastal areas.

However, as pointed out in Chapter 4, the problem or the factors leading to non-compliance with any standard must also be dealt with. In addition, greater efforts must be made to ensure the availability of reception facilities globally, prior to the adoption of a zero-ppm discharge criteria. Hence, it is necessary to take member States into confidence prior to making such a decision. One way, as suggested earlier, is to create a reception facility fund through the subscription of the oil exporting countries. This fund would support the establishment of new reception facilities as well as renovate and modernize the old reception facilities around the world.

It is also discussed in Chapter 3, that the bioremediation and biodispersion method reduces the quantity of sludge generation, thereby reducing the global need for reception facilities. The author optimistically hopes that the use of bioremediation or biodispersion methods in conjunction with other methods will make the requirement of reception facilities redundant in the near future. Further research in this respect would be very beneficial. untill this happens, a reception facility fund would operate as a transitional means to support the establishment of facilities or even support the research work to eliminate reception facilities. The developing nations that are unable to provide reception facilities at present due to economic hardships would greatly benefit through the creation of a fund as well as the outcome of research. This fund creation would also encourage them to ratify the MARPOL 73/78 Convention.

Considering all aspects of the legal, technical and enforcement regimes, this dissertation firmly believes that a change in the regulatory limit of operational discharges from the machinery spaces of ships is possible. An initiative taken in this regard is essential now. This finding accomplishes the first objective that has been outlined in the introduction of this dissertation.

As for the second objective of increasing the readers' general understanding of oil pollution and creating greater awareness of the impact of pollution on oceans, it is believed that the discussion on marine pollution in Chapter 1, as well as the discussion on pollution prevention mechanism including development of legal, technical and enforcement regimes in Chapters 2, 3 and 4 respectively, has certainly increased the readers' understanding of marine pollution, and perhaps created a greater awareness in them as to why the regulatory limit of a 15-ppm discharge needs to be reduced to zero-ppm. It is hoped that the readers will carry this awareness with them and motivate others, including their government mechanism, to take global action through IMO in amending the regulatory limits of discharge from machinery spaces to zero-ppm in coastal areas.

It is essential that IMO acts now and acts fast while the opportunity still exists. The technology is available and developing. The phasing out plan of pre-MARPOL and existing MARPOL tankers will demand new tonnage to be brought into the market in which the installation of zero-ppm discharge compliant equipment would be easy and less expensive for the owner. These two motivating factors for owners will produce a positive impact on the enforcement mechanism and, as a whole, will create a compliance culture. Therefore, protection of the marine environment would be better ensured.

It is to be understood that the world's oceans are interlinked and in fact make up only one ocean. Ships of different nationalities are crossing the seas and oceans everyday. However, the seas and oceans, the greatest common heritage of mankind, deserve more attention and care from us in regard to the protection and preservation of their biodiversity and the eco-system, which is also crucial to the security of the human food chain.

It is evidenced in this dissertation that marine pollution, even with 0.1-ppm oil discharge, is harmful, unacceptable, and unprofessional. Also, technology is available to prevent and eliminate such harmful discharges. It now requires the political will of all nations, especially parties to the MARPOL 73/78 Convention, to act accordingly. This dissertation, for the benefit of humanity, makes a humble request to all concerned to protect and preserve the marine environment, its biodiversity and eco-system with more wisdom and care than ever before.

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Convention (in force)	Ship type	Ship age	Discharge limit		Maximum total discharge
			Within zones	Outside zones	
OILPOL 54 (1958 – 67)	Tanker	All	<100 ppm, <50 miles + special areas {III (1), Annex A (1)}	No Standard	None
	Non-tanker	All	Upon entry into force as far as practicable from land {III (2)}	No Standard	None
			3 years after entry into force <100 ppm, <50 miles + special areas {III (2), Annex A (2)}	No Standard	None
1962 Amendment (1967 – 78)	Tanker	Existing[1]	<100 ppm, <50 miles + special areas {III (a), Annex A}	No Standard	None
		New[1]	<100 ppm, <50 miles + special areas {III (c), Annex A}	< 100 ppm	None
	Non-tanker	Existing[1]	Upon entry into force as far as practicable from land {III (b)}	None	None
			3 years after entry into force <100 ppm, <50 miles + special areas {III (b), Annex A}	< 100 ppm	
		New[1]	<100 ppm, <50 miles + special areas {III (c), Annex A}	< 100 ppm	None
1969 Amendment (1978 – 83)	Tanker	All	Clean ballast, <50 miles {III (b,c)}	<60 l/m	<1/15,000 tcc
	Non-tanker	All	As far as practicable from land, <60 l/m, <100 ppm {III (a)}	<60l/m, <100 ppm	None

Convention (in force)	Ship type	Ship age	Discharge limit: Within zones	Discharge limit: Outside zones	Maximum total discharge
MARPOL 73/78 (1983 – 93)	Tanker >150 grt	Existing[2]	<15 ppm, <50 miles + special areas {I/9(1)(a), 10}	<60 l/m	<1/15,000 tcc
		New[2]	<15 ppm, <50 miles + special areas {I/9(1)(a), 10}	<60 l/m	<1/30,000 tcc
	Nontanker > 400 grt and tanker machinery spaces[4]	Existing[2]	<15 ppm, <12 miles + special areas {I/9(1)(b), 10}	<100 ppm	None
1992 Amendment (1993 – present)	Tanker > 150 grt	Existing[2]	<15 ppm, <50 miles + special areas {I/9(1)(a), 10}	30 l/m	<1/15,000 tcc
		New[2]	<15 ppm, <50 miles + special areas {I/9(1)(a), 10}	30 l/m	<1/30,000 tcc
	Nontanker > 400 grt and tanker machinery spaces[4]	Existing[2]	Before 6/7/98[3] <15 ppm, <12 miles + special areas {I/9(7), 10}	<100 ppm	None
			After 6/7/98[3] <15 ppm, <12 miles + special areas {I/9(2)(b), 9(7), 10}	<15 ppm	None