1991

Marine pollution in Sri Lanka

G.L.R. Abeysekera
WMU

WORLD MARITIME UNIVERSITY

MARINE POLLUTION IN SRI LANKA

by

G.L.R.ABEYSEKERA

SRI LANKA

A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of Master of Science in Maritime Education and Training (marine engineering).

Year of Graduation 1991

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

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

Signature: G. L. R. Abeysekera

Date: 14 OCT. 1991

Supervised and assessed by :
M. KIMURA
Professor
Maritime Education and Training
World Maritime University

Co-assessed by:
Per Eriksson
Former chairman
Maritime Safety Committee (IMO)

MARINE POLLUTION IN SRI LANKA

BY

G.L.R. ABEYSEKERA

MET(E)-91

TABLE OF CONTENTS

Acknowledgements

A dissertation of this kind can not be produced without assistance from others. There are many who helped me directly and indirectly.

Firstly I express my sincere appreciation to the International Centre for Ocean Development of Halifax, Canada and the Ceylon Shipping Corporation for making it possible for me to study at the World Maritime University.

Secondly I wish to express my sincere gratitude to the professor M.Kimura and lecturer R.R.Fiebrandt for their guidance and advice on the preparation of this paper.

Last but not least I wish to thank my wife Kalyani, colleagues and friends for their support and inspiration for the successful completion of this paper.

LIST OF ANNEXES

LIST OF ABBREVIATIONS

BCC	British Ceylon Corporation
BOD	Biological Oxygen Demand
CDL	Colombo Dockyard Limited
CEA	Central Environmental Authority
CIC	Chemical Industries (Colombo) Ltd.
CLC	International Convention on Civil Liability for oil pollution damage
COD	Chemical Oxygen Demand
cSt	Centistoke
CZMP	Coastal Zone Management Plan
DDT	Dichlorodiphenyltrichloroethane
DWT	Deadweight tons
EIA	Environmental Impact Assessment
FUND	International Convention on the establishment of an international fund for compensation for oil pollution damage
GCEC	Greater Colombo Economic Commission
GRT	Gross Registered Tons
IOPC FUND	International Oil Pollution Compensation Fund
IMO	International Maritime Organization
IPZ	Investment Promotion Zone
IOC	International Oceanographic Commission
ITCZ	Inter Tropical Convergency Zone
Kg/Hr	Kilograms per hour
Km	Kilometer
Km/Hr	Kilometer per hour
m	Meter
MARPOL	The International Convention for the Prevention of pollution from ships
Mg/l	Milligrams per liter

ml	milliliter
MPPA	Marine Pollution Prevention Authority
MSc	Master of Science
m/sec	meters per second
MT	Metric Tons
MTA	Million Tons Annually
MW	Megawatt
NARA	National Aquatic Resources Agency
OILPOL	The International Convention for the Prevention of Pollution of the sea by Oil
OSC	On Scene Co-ordinator
pH	The logarithm(base 10) of the reciprocal of the hydrogen ion concentration
ppm	parts per million
SACEP	South Asia Co-operative Environmental Programme
STB	Segregated Ballast Tank
SILDA	Sri Lanka Institute of Development Administration
SPBM	Single Point Buoy Mooring
TBT	Tributyltin Oxide
ULCC	Ultra Large Crude Carrier
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
USD	United States Dollar
VHF	Very High Frequency
VLCC	Very Large Crude Carrier
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

A highly delicate balance exists between the sea, the land and air. These three parameters are interlinked and form man's immediate environment, the earth. The earth is shared by man, with birds, beasts, trees and flowers, in short, all the flora and fauna of this planet.

It is estimated that approximately 71 per cent of the global surface consists of oceans. Therefore man had valid reasons to believe that oceans have an enormous capacity to assimilate pollution. Due to this reason large amounts of operational and accidental wastes were dumped into the sea. Unfortunately only a few believed that there could be a dangerous environmental crisis ahead of us. Therefore the situation was not re-checked to find out whether the initial assumption was correct.

In recent decades, man has slowly discovered that the capacity of the oceans to assimilate the wastes of the human society is not endless. Therefore the modern man has to develop an attitude of responsibility towards his environment deeper than that of his forebears.

In Sri Lanka serious concern for environmental problems is a relatively recent phenomenon although there was intense

utilization of coastal resources during the past few decades. Very few studies have been carried out to ascertain the exact situation of pollution in the environment. Therefore, limited scientific information and data with reference to Sri Lanka is available.

There are many varieties of coastal resources in the country. They are finfish, invertibrate fauna and coastal vegetation including seaweeds and coastal minerals. They provide a base for a number of vital economic activities such as fisheries, mining, coastal recreation and tourism, and coconut based industries. Therefore unacceptable levels of pollution in the coastal and marine environment could lead to serious economic, political and social problems in the country.

In the recent past shipping related activities have increased significantly in the country. An offshore buoy system for the discharging of crude oil was started in 1988. Sri Lanka is situated in the vicinity of a major international shipping lane. Each year large numbers of vessels including 5000 tankers pass within five miles of the southern coast of the country. It is very clear that the possibility of a major accident is extremely high. Therefore oil pollution is given a special reference throughout this report. It is also felt imperative to devote a separate chapter to discuss an effective national contingency plan to deal with accidental oil spillages.

Industrial and domestic pollutants are discharged or dumped into coastal waters of the country. Unfortunately, rivers are used to a considerable degree as conduit pipes in the transportation of these wastes.

Marine pollution is not confined to the immediate environment in which it has occurred. Due to the prevailing conditions of the wind patterns, waves, tides and the monsoonal weather, pollution in one area may find its way eventually to another part. Therefore this project begins by giving a brief account of the physical environment of Sri Lanka.

Marine pollution will not be controlled until there is control over the polluting substances released into the oceans, predominantly as a result of human activities. In order to achieve this, an establishment of a well balanced and practical marine pollution policy, with the back-up legislations, scientific management approach and project implementation would be necessary.

The purpose of this project is to document, identify and discuss the current state of the marine environment of Sri Lanka. Longer-term issues connected with the increase in levels of atmospheric, carbon-dioxide and other greenhouse effect gases are not dealt with in this report.

CHAPTER 2

PHYSICAL ENVIRONMENT OF SRI LANKA

2.1 INTRODUCTION

Sri Lanka is situated off the southern tip of India between 5 degrees 55 minutes and 9 degrees 51 minutes North and 79 degrees 41 minutes and 82 degrees 54 minutes East. The island covers an area of 65,610 square Km and is separated from the Indian sub-continent by a narrow strip of the sea called Palk Straight. The Bay of Bengal lies to the North. The maximum length of the island from Point Pedro in the north to Dondra Head in the South is 435 kilometers and the maximum width, from Colombo to Sangamankanda, is 225 kilometers.

The Mahaweli, Kelani, Kalu and Walawe rivers which spring up from the central hilly region, play an important role in irrigation as well as generation of hydro-electric power.

2.2 CLIMATIC CONDITIONS

The climate is greatly influenced by two monsoons, namely the South-West (May to October) and North-East (December

to March). The winds in the area undergo a complete shift between January and July as a result of monsoons. This annual cycle is dominated by the heating and cooling of the Asiatic continent.

2.3 WIND PATTERNS

The velocity of winds across Sri Lanka are usually less than 50 Km/Hr. Only weak and variable breezes exist in inter-monsoonal periods. Throughout the season, winds intensify and often change direction during the afternoon. By early March the trade winds (locally the North-East monsoon) cease to blow over the island. The winds of the Northern Inter-Tropical Convergency Zone (ITCZ) now operate from south to north and typical equatorial convergence storms are experienced all over the country, usually during late afternoon. During the month of May, the ITCZ passes to the north towards southern India and rainfall is received all over the country, but concentrated over the south-western reliefs. In June, the ITCZ is over northern India, the south-west monsoon is at peak force, and the south-western quarter of the island and the windward slopes receive all the rain. The northern and eastern parts only get occasional rain from convection storms formed during the periods of calm called the "monsoon break". Although both the Bay of Bengal and the Arabian sea are areas of cyclogenesis, the majority of tropical convection storms with winds in excess of 120 Km/Hr follow paths north of the island.

However, once every ten or fifteen years, cyclones come closer and cross over the island causing considerable damages to the coastal areas of northern and eastern parts of the country. The cyclones of December 1964 and

November 1978 are ample evidence of the violence of these storms. The fringing coral reefs along the coastline were particularly damaged by such cyclones, as shown by the large quantities of coral rubble washed ashore.

2.4 WAVES, TIDES AND CURRENT SYSTEMS

Much of the swell that affects Sri Lanka originates in the south Indian Ocean (40-50 degrees South), under the influence of westerly depressions and storms. This moves northwards and is felt most along the coasts of the southern half of the island. Most large waves have a southerly component, but they rarely reach a height of over two meters. The highest waves are during the South-West monsoon season, but the effective fetch is only about 800 Km. between the Maldive Island chain and Sri Lanka. During the North-East monsoon, the northerly winds blow over short stretches of water from the north and even when blowing across the Bay of Bengal are not steady enough to generate large waves. By and large the energy of the waves is relatively low during this period as well as during the inter-monsoonal periods (Swan, 1981).

Several types of currents are found around Sri Lanka. Many currents from the Bay of Bengal and the Arabian Sea as well as the equatorial region meet in this area and are affected by the monsoons. The strongest currents are felt along the Southern coastline. Coastal currents over the continental shelf are parallel to the coastline and are stronger off the east coast than off the west coast. In addition to the distinctive patterns of currents in the Bay of Bengal and the Arabian sea, the equatorial oceanic zone is characterized by westerly flows.

The massive water exchanges result in current velocities of about one meter per second or more between October and January around the Little Basses reef off the southern coast of Sri Lanka.

Strong currents (2.5-3.0 m/sec) are also experienced, especially during the monsoons in the waters between Sri Lanka and India. The coastal currents are complicated by the interaction of shelf topography, contour of coastline, water depth, wind intensity and direction as well as wave incidence and tidal influence.

The period between tides is approximately 12 hours and is thus semidiurnal. The seas of Sri Lanka are micro-tidal with a tidal range between 75 centimeters during spring tide and 25 centimeters at neap tide. The tidal range is higher around Colombo and is least around Delft and Trincomalee. Weather conditions can give rise to monthly tidal level variations. Tidal waves move southwards along the west coast of India, towards Sri Lanka twice a day so that the west coast of the island experiences high tide synchronously. The tidal crest which arrives at Galle in about 12 minutes time then moves in an anti-clockwise direction heading eastwards and northwards reaching the east coast port of Trincomalee and the north-eastern coast some six hours later.

2.5 SOIL, SAND AND SEDIMENT

Presently a major part of the sand and sediment supply to the coastal areas comes from the land due to the eroding forces of rain, storm-water run-off, streams, rivulets, and rivers. The supply of sand to the eastern and western littoral between Hambantota and Point Pedro and between

Hambantota and Puttlam was estimated to average 100,000 and 250,000 cubic meters per year respectively.

All rivers do not supply their full load of sand and sediment to the sea. A part of it is deposited in flood plains in their lower reaches. Another part enters lagoons which acts as traps for coarser materials including sand.

Most of the larger rivers that make substantial contributions of sand to the littoral zone are located between Chilaw and Kumana along the south-west coast.

2.6 SHORELINE GEOMORPHOLOGY

2.6.1. BEACHES

Sri Lanka has a coastline of about 1700 Km. Over three fourth of the coastline consists of beaches. The characteristics are based on wave energy, supply of beach material, contour of the coastline and the nature of coastal and submarine landforms. Most of the island's beaches act as a barrier and supported by lagoons, swamps and ill-drained terrains, and are sometimes contained between headlands or river outfalls. Some barriers are islands not connected to the mainland, e.g. Karativu Island.

Due to the low tidal range and low wave energy the beaches are relatively narrow in Sri Lanka. The width of the beach deposits vary; it is a maximum on the west coast near Chilaw and on the coast near Kalkuda.

2.6.2. CORAL REEFS AND DEPOSITS

Coral reefs of Sri Lanka are situated along the sections of the southwestern coastline. In this part the beaches are usually poorly developed and large rivers do not enter.

Coral reefs are also found along the southern and eastern coasts, near headlands such as Dondra, Tangalle, Kalkudah, Elephant Point, Foul Point and between Nilaveli and Mullaitivu.

On the western coast they are found north of the Kalpitiya Peninsula in the Gulf of Mannar.

CHAPTER 3

SOURCES OF OIL POLLUTION

3.1 INTRODUCTION

Petroleum is a natural substance, consisting mainly of hydrocarbons and small amounts of other organic compounds. Oil has entered the oceans in small quantities every year for centuries and part of the oceans have accommodated long term influxes of such oil into their communities and ecosystems with little adverse effects. Nevertheless the modern influx of petroleum into the marine environment is on a larger scale, occurring rapidly and probably of a different nature. Therefore even those areas free of oil exploration and production activity are nonetheless subjected to potential pollution resulting from various man made activities.

Marine-based pollution from petroleum hydrocarbons originate either from marine transportation, port handling, dry docking or tanker accidents.

Natural seepages also cause pollution but there is very little, if anything, man can do about them.

Oil pollution in the sea began with the introduction of fuel oil in ships and increased with its usage and carriage of oil in bulk form. Oil pollution has probably been increasing ever since.

3.2 MARINE TRANSPORTATION OF OIL

Oil producing countries consume only a marginal percentage of their large production. Therefore, a major portion of it continues to be transported by tankers to various parts of the world.

Oil movement at sea (in million tons)	1971	1980	1989
Crude oil	1,110	1,319.3	1,097.0
Product oil	255	268.9	381.3
Total	1,365	1,588.2	1,478.3

Overview of oil movement at sea
(British Petroleum Statistics Review)

The Middle East is the largest oil exporting region in the world. The main importing areas are Western Europe, the U.S.A. and Japan.

The total estimated average annual quantity of oil (in tons) in 1989 that entered the marine environment due to marine transportation activities is summarized as follows:

Tanker operation		
Crude Oil - Long haul	45,600	
Crude Oil - Short haul	20,300	
Product - Long haul	20,800	
Product - Short haul	71,900	
Subtotal		158,600
Drydocking		4,000
Marine terminals, including bunkering operations		30,000
Bilge and fuel oil		
Machinery space bilges	64,400	
Fuel-oil sludge	186,800	
Oily ballast from fuel tanks	1,400	
Subtotal		252,600
Accidental spillage		
Tanker accidents	114,000	
Non-tanker accidents	7,000	
Subtotal		121,000
Scrapping of ships		2,000
TOTAL		568,200

(MEPC 30/INF.13, 19 September, 1990)

3.2.1 DISCHARGES FROM TANKERS AND NON-TANKERS

It has been estimated that oil pollution due to operational discharges of tankers and non-tankers are quite significant. The increase in number of sea-going vessels has promoted the increase in oil pollution.

The latest statistics confirm that the world fleet is set firmly in an expansion phase after the period of recession between 1982 and 1988. By the end of June 1990, the world fleet had risen to 423.6 million gross tons, an increase of 13.1 million tons on the year. (Lloyd's List, NOV. 90)

WORLD'S MERCHANT FLEET

	1971	1980	1989
Number of ships	55,014	78,832	76,100

WORLD'S TANKER FLEET

Number of tankers	6,292	7,112	6,383
Total dead weight tons	169,354,743	339,801,719	247,556,000

(from Lloyds Register of shipping statistical tables)

After a tanker has discharged her cargo, a part of it remains in the tank, caught mainly on the inside plating of the tank and its strengthening members.

This is called the clingage and varies largely according to the type of cargo carried, from 0.1% to 1.0% of the total cargo. The average for the crude being about 0.4%.

If the clingage were to remain, a number of consequences would follow. For instance, the risk of an explosion would be increased. Reduced cargo carrying capacity is also unacceptable to the consignee. The clingage must therefore be regularly removed and this has traditionally been done by washing the tanks with seawater. Before 1960 this water mixture was discharged into the sea without separating the clingage. This means that about 0.4% of the total oil carried on board of tankers were lost to the world oceans.

Other situations where cargo tanks require thorough cleaning would be for the clean ballast; gas-freeing for entry (inspection or to carry out repairs) and when the next cargo is incompatible with crude oil.

In those instances the tanks also are normally washed at sea. Although washings are to be retained on board, in a number of occasions these are pumped overboard, thus contributing to oil pollution of the sea.

The entire cargo in a tanker can not be discharged. A small amount from each tank and inside the piping systems remains unpumpable, depending on the arrangement and the efficiency of the stripping pumps. This amount will later enter into a mixture with the tank washings or with the ballast water.

After discharging the oil, the cargo tanks are usually filled with sea water for the purpose of stability.

This ballast gets contaminated with the unpumpable oil inside the tank. Subsequently the mixture is pumped out to sea in order to load cargo again.

Another source of pollution due to operation of vessels are the bilge and fuel oil discharges. This can be divided into three types, machinery spaces bilges, fuel oil sludge and oily ballast from fuel tanks.

Bilge water contains a mixture of water, fuel oil and varieties of lubricating oils. It has been estimated that steam tankers generate about 5 gallons a day and motor tankers and other ships generate about 15 gallons of bilge water a day. Therefore the total amount of bilges generated by all the ships in the world is quite large. The majority of ships retain the bilges or discharge ashore according to the international rules and regulations. However, a considerable amount of bilges are pumped out to the sea by the rest of the vessels without separating the oil.

The worldwide annual use of Bunker C or other heavy oils for marine applications is about 108 million metric tons. Before being used in marine engines, residual bunker fuel is purified on board the vessel to remove harmful impurities such as sludge and water. For the present estimate, 0.3% of the quantity of heavy fuel oil used for diesel engines is collected after purification. Normally this quantity of sludge is kept on board to transfer to shore facilities in a port. However, in practice, due to insufficient sludge holding tank capacities on board and the unavailability of shore reception facilities in most of the sea ports large numbers of vessels pump sludges into the sea.

Water ballast for tankers is carried in washed cargo oil tanks or in SBTs (segregated ballast tanks). Therefore no contamination of water ballast with fuel oil should occur. However non-tankers, particularly fishing vessels, carry water ballast in fuel oil tanks due to various stability reasons. It is estimated that 2% of non-tankers practice this method. Therefore it has been estimated that the annual quantity of oil discharged by this activity is about 1,400 metric tons.

The Indian Ocean contains the world's busiest oil tanker traffic. From the Arabian Sea one tanker shipping route to the Far East passes off Dondra, on the southern coast of Sri Lanka. It is estimated that 80 percent of Japan's (second largest oil importing country in the world) oil follow this course. This amount is increasing rapidly with the increasing amount of oil imported to Japan. 232MT of crude oil and its products were transported along this tanker route in 1985 (British Petroleum, 1986).

JAPAN'S OIL CONSUMPTION IN MILLION TONS

1987 - 207.9
1988 - 220.4
1989 - 241.4

In addition to the tanker route very busy shipping lanes between the Far East and Europe also pass through the territorial waters of the island. Dondra Head (the southern tip of Sri Lanka) acts as a focal point of the navigational route. Due to these reasons the sea lane passing the southern coast of Sri Lanka carries a heavy volume of international traffic of various types of vessels causing significant amounts of oil pollution.

Tanker accidents close to the coast cause very serious damages to the marine environment of the country. In certain instances, like the one quoted below, such accidents have resulted in polluting areas far away from the point of occurrence.

On 19 December 1989 the Iranian tanker KHARG 5 (284,000 DWT) suffered a series of explosions following heavy weather damage in the Atlantic Ocean off the north-west coast of Africa. During this accident about 70,000 tons of crude oil was spilled into the sea 100 nautical miles from the Moroccan coastline. Subsequently it has been reported that small amounts of emulsified residue and sheen have approached the Moroccan coast.

Tankers and cargo vessels enter drydocks every two to three years for the purpose of hull painting, tank cleaning, maintenance and surveying. Drydocks to accommodate very large tankers are available only in certain countries. Since the beginning of the last decade Dubai (United Arab Emirates) and Bahrain have been providing such facilities. It has been reported that these yards are not only financially competitive but located in the Middle East where most of the world tankers trade. Therefore tanker owners mostly use these yards for drydocking of their vessels.

It is essential that cargo compartments are cleaned prior to drydocking the vessel to avoid the risk of explosion. Therefore, it is quite possible, although international regulations govern this operation, that some of the tankers would be pumping out tank washings close to Sri Lanka during their ballast voyage from the East for drydocking in the above mentioned countries.

Annex 3.2.1 summarizes observations of oil slicks and other floating pollutants over the entire Indian Ocean down to 40 degrees south latitude. From those observations it can be seen that the highest concentration of pollution is around Sri Lanka.

3.2.2 ACCIDENTAL OIL DISCHARGE

As noted earlier in this report the tanker traffic at the south and southwest coasts of Sri Lanka is very heavy. It is estimated that annually about 5,000 tankers pass through this area (Hayes Terence, 1980). Therefore the probability of an accident is considered very high, although there have been no major disasters up to the present time.

Accidents to ships could occur due to collision, grounding, fire/explosion, breakdown or structural failures. Such accidents, depending on the circumstances, could spill large quantities of oil into the sea.

The first major tanker accident was the TORREY CANYON, which ran aground in 1967 on the Seven Stones Rocks off the southwest coast of England. The vessel was a complete wreck and 100,000 tons of crude oil was lost.

The second major incident was in March 1978 when the supertanker AMOCO CADIZ ran aground off the northwest coast of Brittany, France. Efforts to free the tanker were unsuccessful. Because of the extensive press coverage the entire world witnessed this incident. During the 18 days after the grounding, the entire cargo of 223,000 tons of crude oil was spilled into the ocean.

Another recent catastrophe of this nature was the tanker EXXON VALDEZ, which ran aground on Bligh Reef near Valdez, in Prince William Sound, Alaska, on the March 24, 1989. This incident spilled about thirty thousand tons of oil into the sea.

On 29 June 1989 the Maltese tanker PUPPY P collided with a Panamanian bulk carrier, WORLD QUINCE in the middle of the Arabian Sea. The PUPPY P reportedly spilled over one million gallons of furnace oil which later polluted the west coast of India.

On 29 December 1989 the Spanish supertanker ARAGON leaked 350,000 gallons of crude oil into the North Atlantic ocean north-east of the island of Madeira.

3.3 POLLUTION OF HARBOR WATERS

Sri Lanka straddles the great sea routes linking the East and West and features prominently in the far-flung commercial activities of the early maritime nations in the world. Arab coasters, Greek and Roman galleys as well as Persian merchantmen visited the ancient ports of Sri Lanka.

However, it was with the coming of the Portuguese in 1505 that Colombo became known to the emerging maritime nations of the Western world. From the early period of Portuguese rule, and the later eras under the Dutch and British, the Port of Colombo gradually developed as a popular port in the Indian Ocean.

There are three major ports in Sri Lanka. Oil pollution in the vicinity of these ports are generally high due to

the nature of the facilities provided by them.

3.3.1. PORT OF COLOMBO

The first major development and expansion of the port started in 1950 and by 1956 there were 3200 meters of deepwater quays. Additional terminals were constructed since then and the port of Colombo over the years has reached a new high in terms of productivity. According to statistics published by the Sri Lanka Ports Authority, the port traffic has increased significantly during the past few years. In 1987 the port ranked 38th among 337 container ports of the world as assessed by the World Container Port Traffic League. (Containerization International).

3.3.1.1 BUNKERING SERVICE

The Port of Colombo provides bunkering services for vessels through the Ceylon Petroleum Corporation. For this purpose five barges are employed with capacities ranging from 450 to 1,000 tons and discharge capacity between 50 to 300 tons per hour. The grades of fuel oil available for the supply are Marine Fuel Oil 180cst., Marine Fuel Oil 120cst., Marine Diesel and Marine Gas Oil. The quantity of bunkers supplied exceeds 400,000 tonnes annually.

3.3.1.2 OIL WHARF

Two berths are available with discharging and loading facilities for tankers. The 390 meters long North Pier with a draught of 10 meters contains pipelines for naptha, white oil, gas oil, fuel oil, base oil, and crude oil.

For discharge to the refinery, 13 Km distant and the oil installations, 6.5 Km distant, booster pumps have been installed.

The pollution from oil terminal operations is due to spillage, to human error, overfilling of tanks and disconnecting hoses without adequate drainage. In addition, line or hose failure, submarine pipe line rupture, storage tank rupture and bunkering operations are also causes of spillages.

3.3.1.3 SINGLE POINT BUOY MOORING (SPBM)

An SPBM was constructed approximately three miles from the breakwater and commenced operations in 1988. The main reason for such a facility was to use Very Large Crude Oil Carriers to import crude and pump direct to the refinery through a submarine piping system. However, there is obviously an increased potential for pollution in this type of operation.

In general, all precautions taken when loading or discharging at a conventional berth or jetty are fully applicable. However, there are a number of additional precautions which must be taken. During bad weather the mooring system becomes particularly important. Excessive movement of the vessel may cause the rupture of the hose. In the worst conditions the SPBM system may get damaged unless prior precautions are not taken.

3.3.2 PORT OF GALLE

This port is situated on the south-west coast of Sri Lanka at latitude degrees 6, 01 minutes North and longitude

degrees 80, 13 minutes East. The Port of Galle has an area of 320 hectares, and two general cargo vessels could be handled at present at alongside berths.

3.3.3 PORT OF TRINCOMALEE

The Port of Trincomalee was formally a British naval base, and situated on the north-east coast of the island. It is Asia's largest natural harbor with unlimited draught and the capability to shelter over a hundred of the largest ships.

3.3.3.1 OIL STORAGE FACILITIES

Oil tank farms consisting of 98 vertical fixed roof storage tanks with a capacity of 10,000 tonnes each are located in this port between elevations of 6 metres and 27 metres above sea level. Three 12-inch diameter pipes are available from the No.1 jetty for loading and discharging facilities.

3.4 DRYDOCKING AND SHIP REPAIRS

The Colombo Dockyard Limited (CDL) is the biggest ship repairer in the country and the only company to own drydocking facilities in the Port of Colombo. CDL was formed in 1974 to acquire the three graving docks in the Port of Colombo which were then owned and operated by the Colombo Port Commission. Due to the sound commercial performance in the ship repair business since its inception, CDL is now recognized and accepted the world over as one of the biggest in the South Asia region. Therefore the number of vessels calling mainly for repairs has been increased over the years.

CDL's range of activities are dry dock repairs, machinery repairs, hull repairs, pipe repairs and electrical and electronic repairs. The company owns and operates a total of four dry docks which are capable of handling vessels of any size up to capacities of 100,000 DWT.

The dry dock specifications of CDL are as follows:

DOCK NO.	NORMAL CAPACITY (DWT)	LENGTH (m)	WIDTH (m)	HEIGHT (m)
1	30,000	213	26	9.7
2	8,000	107	16.5	6.7
3	8,000	122	16.0	5.5
4	100,000	236	44.0	8.9

Afloat repairs are carried out alongside seven repair berths totalling up to 750 meters in length.

Pollution of harbor waters is inevitable during dry docking and afloat repairs. This will contribute a large amount if proper facilities are not available or due consideration is not given by the management to control pollution.

3.5 HYDROCARBON WASTE FROM REFINERIES

Crude oils are complex mixtures containing large numbers of chemical compounds ranging from dissolved gases to compounds which are solids at room temperature. All components are hydrocarbons other than water and trace contaminants. Typical crudes also contain small amounts of sulphur, nitrogen, oxygen, and a number of metals in

small quantities.

The purpose of refining is to separate the crude oil into marketable components, to change the original components ratio and its properties to meet the customer's demand, and to remove impurities detrimental to product quality.

The process by which the crude oil is manufactured into various products is complex. At the initial stage of the refining process the crude oil is separated into different fractions based on their boiling ranges. Some of the lighter and intermediate fractions are blended into products. Heavier products may be further processed.

The oil refinery of Sri Lanka is owned and operated by the Ceylon Petroleum Corporation, which is a government organization. Presently the entire business of importing, exporting, refining, marketing and distributing petroleum products is handled by the Ceylon Petroleum Corporation.

This oil refinery is situated about 11 kilometers from Colombo and has a design capacity of 6900 metric tons of crude per day. It produces gasoline, kerosene, avtur gas oil (diesels), fuel oils, liquified petroleum gas, low aromatic white spirits, bitumen and chemical naptha.

The refining process consists of the following units:

(a) Crude Distiller
(b) Naptha Unifier
(c) Platformer
(d) Gasoil Unifier
(e) Visbreaker
(f) LPG Merox Unit
(g) Kerosene Unifier
(h) Vacuum Distillation Unit
(i) Bitumen blowing unit
(j) Depropaniser
(k) Kerosene Merox unit

PRODUCTS PROCESSED IN THE REFINERY BY DISTILLATE (IN TONNES)

	1983	1984	1985
Light distillates.	247,304	270,745	255,534
Middle distillates.	590,328	733,086	652,477
Heavy ends.	520,474	693,003	635,153
TOTAL	1,358,106	1,696,834	1,543,164

All the refineries in the world, depending on their management, contribute to pollution by discharging oil through their wastewater system into the sea, rivers or municipal facilities. This plant is no exception but the exact amount of oil discharged to the environment is not available to be produced in this report. However, according to the available reports the refinery and

adjoining nylon plant generate about 4,000 tons of effluents per day containing oils, sulphides, aromatics, ammonia, cyanides, washings and process water.

The oil leakages from various points add up to a considerable amount. Water drained from overhead accumulators contains traces of oil apart from other chemical pollutants separated from hydrocarbons, and are discharged into the wastewater system. Oil drains from sampling points also flow into the same system. Moreover, the crude distillation unit is supplied with large amounts of water. This water coming out from it contains emulsified oil.

Another source of pollution from this refinery system is from the energy generation units. They constitute the following plants.

(a) Power plants consisting of two turbo-generators of capacity 4.5MW each.

(b) Four boilers of total steam capacity 127,000 Kg/Hr.

With reference to worldwide refinery oil discharges into the world's oceans it has been estimated that Asia-Pacific and Latin America regions contribute most.

GEOGRAPHIC AREA	CRUDE OIL REFINERY CAPACITY (MTA)	TOTAL HYDROCARBON DISCHARGE IN REFINERY WATERWAYS (MTA)	HYDROCARBON INPUT INTO WORLD OCEANS (MTA)
USA	960	0.0048	0.002
CANADA	115	0.0046	0.001
LATIN AMERICA	420	0.0315	0.025
ASIA-PACIFIC	550	0.0413	0.021
CHINA	90	0.0068	0.002
MIDDLE EAST	190	0.0143	0.005
USSR AND EASTERN EUROPE	740	0.0555	0.018
WESTERN EUROPE	1,050	0.0420	0.014
AFRICA	90	0.0068	0.003
TOTAL	4,205	0.1948	0.10 (best estimate)

MTA = millions tons annually

3.6 OFFSHORE OIL AND GAS

It is difficult to estimate the amount of oil entering the oceans from oil and gas exploration activities. One guess is that, due to normal operations, about 20,000 metric tons of oil is discharged annually into the marine environment. The major threat of pollution comes from

accidental discharges due to well blowouts, structural failure of platforms, failure of equipments and collisions. Incidents of this nature could be extremely disastrous.

In Sri Lanka exploration for offshore oil and gas has been given priority in the development strategy of the country. Thirteen offshore blocks have been designated for exploratory activities on a production-sharing basis.

The details of exploratory wells drilled by Sri Lanka onshore and offshore are as follows:

YEAR	ONSHORE/ OFFSHORE	WELL NAME	STATUS
1974	onshore	Mannar-1	dry hole
1975	onshore	Mannar-2	dry hole
1976	onshore	Mannar-3	dry hole
1976	offshore	Palk Bay-1	dry hole
1976	offshore	Delft-1	dry hole
1981	offshore	Perl-1	dry hole
1981	offshore	Pedro-1	dry hole

No operations since 1981

(source - Oil and Sri Lanka, Statistical Review.)

Although these wells did not strike oil or gas, information collected has been useful and exploratory work is being continued. A seismic survey from Colombo to

Mannar has been completed and interpretation of data is now in progress.

3.7 FISHERY HARBORS

There are seven fishery harbors in Sri Lanka. These harbors cater the needs of about 9,600 mechanized fishing vessels using diesel, kerosene or petrol powered engines. Most of the harbors contain terminals for supplying fuel to these vessels. Therefore it is found that spillage of oil from these vessels and the process of refueling results in a slick of oil constantly prevailing in and around the harbor areas. (Alwis)

CHAPTER 4

OTHER SOURCES OF POLLUTION

4.1 INTRODUCTION

The principal cause of environmental pollution is human settlement and activity above and beyond the natural recoverable capacity of the environment. It is thus a result of man's use (or misuse) of land and water resources for the purpose of development. This is noted in the modern method of agriculture using high inputs of chemical fertilizer and pesticides. Sewage and waste disposal caused by the large migration of people from the villages to the towns results in disposal problems. New industrial plants are built whose wastes and residues are dumped onto the land, surface waters and sea or emitted into air.

Persistent pollutants eventually end up in the sea. Atmospheric pollutants are washed by rain on to the land. Pollutants on land get leached into ground water and find their way into lakes, rivers and finally the sea.

4.2 MICROBIAL POLLUTION

The main reason for microbial pollution around Sri Lanka's marine environment is due to contamination of human faeces. The sources of such pollution can be divided into two categories.

1. Point source discharges

These are mainly from the sewage system serving the city of Colombo. The existing outfall from the North Colombo area flows into the Kelani Ganga from Madampitiya. The South outfall extends 82 meters offshore at Wellawatte. The northern outfall carries approximately seventy percent of the total sewage flow from the system.

Other point source discharges are connected to the various urban centers on the coast. Canals, open waterways and storm water drains carry the raw sewage and waste water into the major rivers or directly into the sea.

2. Open defaecation

A more wide spread source of pollution results from open defaecation practiced by the population on the beaches throughout the coastal area. This is a quite common habit of the large number of people particularly in the suburban and rural areas who have no access to any type of toilet facilities.

Under the south-west coastal area water supply, sewerage and drainage project, a proposed master plan is to be implemented for the improvement of the existing sewerage system in Colombo and the sewering of other urban and

peri-urban areas along the south-west coast of the island. For the rest of the urban centers, sewerage systems would be planned on completion of the water supply schemes with Galle and Negombo as the two priority areas.

4.3 POLLUTION FROM INDUSTRIAL WASTES

4.3.1. WATER POLLUTION

The main causes of this type of pollution are the sewage and domestic waste from Colombo and other municipal and town council areas and industries.

Most of the industries in the country do not have waste treatments plants. The "soda process" of one of the paper mills has failed to recover the alkali and the attempted chemical recovery system has accordingly been abandoned. Hence there are numerous fish kills in the Walawe Gange, as well as much fiber and organic pollution.

At Valaichchenai the lagoon water has turned brown and bottom sediment to black due to the wastewater from a similar industrial complex situated in the same area.

As a result of such incidents the fish population has decreased; even the corals and reefs out at sea are probably affected.

Similarly the large textile industries also contribute to the pollution of rivers, canals and lagoons, and finally the sea.

4.3.2. COLOMBO CANAL SYSTEM

There are a number of outlets into the Kelani River from the Colombo Canal system. The sea outfalls for the canal system are situated at Wellawatte and Galle Face (from Beira Lake). The major sources of pollution of these canals are slums, industrial discharges and outflows from the city's sewers.

The BOD (biological oxygen demand) of the canal water is very high varying from 20-350 mg/l with the presence of heavy metal traces. These are from repair garages, workshops and numerous industries including electroplating and textile printing.

The measure of oxygen demand is termed as biochemical oxygen demand (BOD). This is the amount of oxygen necessary for the functioning of bacteria engaged in decomposing or breaking down of organic matter. Bacteria use oxygen to breakdown complex compounds. Thus the more organic material there is in a given volume of water, the higher the BOD.

The sources contributing to wastes, in addition to shanties, are as follows:

Mutuwal main drain - Timber Depot, Star Toffee

St. Sebastian north - Sedawatte Mills (Oil)

St. Sebastian South - Levers, Jafferjees, BBC (oil,soap) CIC sewer overflow

Urugodawatte	-Lankem (pesticides), Cyntex (textiles), Refuse dump
Dematagoda North	-Stanley Power Station, Kolonnawa factory, Petroleum Corporation Installation.
Dematagoda South	-Oil Mills, municipal dump.
Mahawatte Ela	-Ayuvvdedic hospital.
Heen Ela	-Milk Board, Marketing Department Cannery, municipal dump.
Kirillapone	-Dairy farm, municipal dump, concrete works.
Wellawatte	-Municipal sewage outlets.

(Source: UNEP 74)

Locks are maintained between canals and the harbor and Beira Lake on one side and the Kelani River on the other side. Sand bars at the ocean outfalls at Wellawatte and Dehiwala make the system land locked for at least part of the year. Therefore due to the stagnation many areas become choked with growths of water fern (Salvinia) and water hyacinth (Eichhorinic). Dissolved oxygen levels are very low and certain areas are completely anaerobic with generally acidic conditions.

The original canal system started by the Dutch and continued by the British made it possible for a boat to travel by these inland waterways from Kalpitiya to Kalutara.

4.3.3 THE BEIRA LAKE

One outlet for part of the Colombo storm water is the Beira Lake with its spill at Galle Face. This lake shows a high degree of eutrophication with the formation of water blooms from time to time. A detailed study of the hydro-biology of this lake and its productivity found generally high dissolved oxygen levels, and a high pH and low levels of carbon dioxide and ammonia. (Costa, 1978)

4.3.4 LUNAWA LAGOON AND NORTHERN BOLGODA LAKE SYSTEM

In the southern part of the city, the drainage takes place through the Bolgoda Canal and Weras Ganga through the Panadura River and Lunawa Lagoon to the sea.

In the metropolitan limits of this area there is a marked confusion in connection with the establishment and expansion of industries and discharge of industrial wastes. In this area, as elsewhere in the city, large numbers of factories are often found side by side with residential areas. This has created problems due to air and noise pollution by the factories, which is further aggravated when operations continue throughout the night. Among the pollution-causing establishments in this area are an asbestos product factory, a shoe factory, a galvanizing plant, a confectionery plant, pharmaceutical plants, a pesticides packing plant, the paint industry, Ceylon Transport Board depots and

workshops, saw mills and textile factories.

Of them all, only one factory making synthetic paints for vehicles treats its effluent. All others make no effort at all to treat their effluents. Wastewater enters drains and ditches and ultimately ends up in the lagoons. Meanwhile, they cause pollution of ground water and wells and as a result acres of cultivated land have become marshy, polluted with oil, dyes and oxygen consuming organic compounds.

The wastes received by lagoons cause poisoning of aquatic organisms and particulate matter which discolor the water causing turbidity, and choking the vegetation along the bottom. Among the complaints about the lagoons are lowering of the fish catch, the disappearance of particular species from certain areas, and an oily taint in some fish which prevents them from being sold in the market. The ditches and streams feeding them are discolored and completely anaerobic with the formation of hydrogen sulphide.

Similar problems can be seen in the eastern and northern parts of Colombo, including the industrial estate of Ekala, and around Ja-Ela up to Negombo. It is only in the Katunayake Investment Promotion Zone (IPZ) that the factory effluent and sewage undergo treatment.

4.3.5 THE KELANI RIVER

Large numbers of water-using industries are situated in the lower Kelani area. Such industries add untreated waste water back to the river. Annex 4.3.5 lists most of these together with their effluents.

One of the effects observed has been a high chromium content from the wastes of the leather factory and private tannery effluents.

A large amount of the city's sewage is discharged untreated. As a result periodic fish kills with symptoms of ammonia poisoning have been recorded.

4.4 POLLUTION BY COTTAGE AND SMALL INDUSTRIES

4.4.1 BATIK PRINTING

Small backyard units carrying out Batik (wax) printing of garments and textile are widely scattered in the island. These units discharge effluents high in dyes, oils and organic compounds into ground and surface waters.

These establishments are found all over the island and especially close to places of tourist interest.

4.4.2 COCONUT BASED INDUSTRIES

(a) Brown Fiber

It has been estimated that approximately 91,000 tonnes of brown fiber, equivalent to 717 million coconut husks, are produced annually in Sri Lanka (Coconut Development Authority). This is carried out in about 1,000 mills mainly in the coconut triangle. The pith or coir dust accumulates as large hillocks outside each mill; these contribute to ground water pollution. In addition, in certain cases, nearby streams are used for the soaking process.

(b) White Fiber

This is more serious from the point of view of surface water. About 5,000 to 7,000 MT of this kind is produced from 40 to 55 million husks. The bulk of the retting (3-9 months duration) is carried out in lagoons and in pits at the sides of rivers where there is slow movement of water, from Bentota to Kirinde. Some inshore retting is done at Dondra and the fiber from this is used for marine cordage and tug boat hawsers.

The retting process is highly anaerobic, with the production of toxic hydrogen sulphide and organic compounds with high oxygen demand which lower the oxygen content in the lagoon water. This affects and limits the type of fauna which can live and breed in this area.

(c) Desiccated coconut

About 40,000 metric tons of desiccated coconut is produced annually in Sri Lanka. There are about 65 mills, processing up to 100,000 nuts per day. The coconut water and wash water is high in oxygen demanding organics and oil, which pollute nearby surface or subsoil water and fields. (UNEP 74)

4.4.3 ARRAK DISTILLERIES

These are situated at coastal townships such as Seeduwa, Wadduwa, Paiyagala, Maggona, Beruwala and Alutgama. The washing from toddy distillation consists of high concentrations of organics such as sulphur compounds which create pollution in streams and oceans. Copper and tin are also dissolved out from the stills.

4.4.4 RUBBER

In the primary production of rubber from latex the formic or acetic acid is used for coagulation. On completion of the process the serum together with the acids is discharged into the streams. The annual production of 140,000 MT of rubber results in a total discharge of of 300,000 tons of serum and acid. These are toxic to aquatic life and create an oxygen demand in the water.

Since a great deal of oxygen is necessary to support a population of bacterial decomposers in a region of high industrial effluent or domestic waste (sewage) there is often insufficient oxygen in the water to also support normal flora and fauna.

Approximate figures of oxygen demands of the waste products indicated above.

Industry	BOD(mg/l)	COD(mg/l)
Rubber and latex (including block rubber and latex)	750 - 5,300	900 -8,000
Tannery	1,500	
Distillery (toddy/ molasses) starch processing	2,000	
Textiles; batiks	1,000	6,300
Meat & fish packing	1,000	
Coconut husk retting	1,000	2,200
Paper & pulp	1,000	
Sewage	100-300	

4.5 POLLUTION FROM AGRICULTURAL ACTIVITIES

a. Fertilizers

A large percentage of fertilizers and pesticides used in agriculture end up in the ground and surface waters and eventually join the sea. For example it is estimated that

half of the DDT ever used on land is now in the seas.

An International Rice Research Institute study estimated that 83 percent of applied fertilizer entered surface and subsoil waters. Inadequate storage of the fertilizer will cause groundwater pollution as well.

Fertilizers containing nitrogen compounds and phosphates aid eutrophication of fresh water bodies. Algae (Microcrocystis Aeruginosa) is known to produce toxins which cause death to animals. It could possibly cause poisoning of lagoon and estuarine organisms although no reports are available of mass mortality of fish.

(b) Pesticides

Various types of pesticides are being used in Sri Lanka, a major portion of which is normally leached out; only about 0.1 percent reach the target organisms.

Of the persistent organochlorine pesticides the usage of DDT was over 2.5 million pounds in 1971. However in 1972 the use of this chemical for agriculture was banned and subsequently replaced by Malathion and Fenetrothion.

4.6 DUMPING OF DREDGED SPOIL

Another source of possible damage to marine organisms and plant communities is from the dumping of dredged spoil. About 80 to 90 percent of all material dumped at sea results from dredging. It has been estimated that in the world an average of 215 million tons of this material is dumped at sea annually.

In Sri Lanka dredging is carried out to build new fisheries harbors and maintain approach channels of Colombo and Galle harbors. In the past there have been no biological studies carried out to determine the sites for such dredged spoil deposition. Therefore it is quite possible that substantial damage has been caused to coastal areas due to this activity. (Alwis)

4.7 LAND POLLUTION - SOLID AND LIQUID WASTES

This includes dumping of solid and liquid wastes on land. Among these are large amounts of domestic refuse and garbage collected from urban centers. Sometimes such wastes are dumped along the canal banks and even the beaches and estuaries (e.g. mouth of the Kalani River). Degradation products are leached out by rain water and seep in to ground water which will finally find its way into surface water and the sea. Fuel oils and used lubricants from garages and factories also seep into ground water.

CHAPTER 5

ENVIRONMENTAL IMPACT DUE TO COASTAL AND MARINE POLLUTION

5.1 INTRODUCTION

Large numbers of contaminants are released to coastal waters due to various activities by man and nature. Only a small part of those contaminants spread beyond the limits of the continental shelf. The bulk remains in coastal waters and builds up to significant levels.

High levels of pollution cause disastrous impacts on the economy, ecology, public health and the social life of the country. The increase of nutrients results in eutrophication and microbial contamination from sewage causes human diseases.

In addition to the aforesaid facts the author wishes to take the opportunity to discuss in this chapter how the marine communities react to pollution in tropical waters around Sri Lanka. However, it should be noted that far less research on estuarine and coastal marine pollution has been done in the tropics than in temperate areas.

5.2 SIGNIFICANCE OF ENVIRONMENTAL CONCENTRATION OF COMMON CONTAMINANTS

Sri Lanka is a tropical country where the temperature of the surrounding sea water is about 30 degrees Celsius. As a result the behavior of certain pollutants at this temperature would be different compared to temperate zones.

Respiratory rates of tropical marine organisms are higher on the average than those of comparable organisms from colder regions when all rates are measured at the normal environmental temperatures. Although respiratory adaptations to latitude temperature differences exists, it is generally not complete (Scholander et al,1953).

In the case of non-gaseous, slightly soluble pollutants such as oil and many insecticides the concentration rates may be greater in tropical marine organisms. This is because these substances are generally more soluble and thus may reach higher concentrations in warm water than in cold. The solubility of gases that do not react with seawater decreases with increasing temperature. Therefore oxygen is less soluble in warm water. For example seawater of 33 percent salinity saturated with air will contain 6.56 ml of oxygen per liter at 8 degrees Celcius and only 4.32 ml per liter at 30 degrees Celcius.

If these factors are taken into consideration, the warmer waters around Sri Lanka (1) will have less oxygen present to start with and (2) the rate of oxygen removal will be greater. Thus oxygen levels will drop faster and further, at a given concentration, by oxygen-consuming pollutants like oil and sewage.

By virtue of the lower oxygen concentration of warmer waters, combined with the higher respiratory rates, the organisms must live at oxygen levels closer to their lethal limits than do the biota of cooler waters. "Nature would have made life easier for fish if she could have arranged things so that the amount of oxygen water can hold in solution increased with rising temperatures." (Jones)

5.2.1 CRUDE OIL

Crude oils are complex mixtures of hydrocarbons of various molecular weight and structure. In crude oil there are three main chemical groups namely, paraffinic, naphthenic and aromatic.

As crude oil touches the sea water a proportion of lighter components spreads out very rapidly. These are toxic, volatile and evaporate faster. As a result the plankton which lives at the surface or near surface of the sea is exposed to the highest concentration of water-soluble constituents leaching from the floating oil. Plankton are floating plants and animals. They form the basis for the marine food chain and include the eggs and young stages of fish, shellfish and many bottom-living animals.

Heavier fractions of crude oil disperse after forming an emulsion with water. Emulsification takes two forms. Oil-in-water emulsion is formed on the surface and then dispersed by the wind and wave action. Water-in-oil emulsion contains compounds of high molecular weight and is known as "mousse". The emulsification process increases the toxic effects of a spill by distributing the oil through the water column and into the sea sediment.

The time required for the complete bacterial degradation of heavier fractions is dependant on various factors. However the oxygen requirement for this process is very large. For example the complete oxidation of one gallon of crude oil requires all the oxygen dissolved in 320,000 gallons of air-saturated sea water (Blumer 71). Therefore bacterial degradation of oil may cause ecological damage through oxygen depletion.

Another example which affects reduced oxygen content in the sea water is from the floating oil films. These films help to cut down the air transfer rate across the air/water interface.

Crude oil in water produces a number of toxiological effects which can be summarized as follows:

Lethal toxicity - Soluble aromatic hydrocarbons in relatively low concentrations are considered harmful to adult animals. It is also lethal in even lesser concentrations to larvae. Fish and bivalves are moderately sensitive to this chemical.

Sublethal effects- Physiological or behavioral abnormalities can occur to species exposed to low/medium hydrocarbon concentrations. In addition certain disturbances may take place in the form of reduced fertility rate, inactive mating responses, and abnormal larval growth.

Direct coating with oil - Mortality can result from restricted gills or digestive tracts, suffocation and asphyxiation, on irritation of mucous membrane.

Tainting seafood - Even relatively little exposure can taint fish and shellfish.

Oil pollution interferes with recreational activities such as bathing, boating, angling, and diving. Tourist trades could be effected due to the tar lumps, consisting of heavy hydrocarbons, on the coastline. These tar balls are difficult to remove from sea shore and hence a large labor force will be required for this operation.

Certain industries rely on clean seawater for their normal operations. Therefore oil contamination can greatly affect their activities. If substantial quantities of oil are drawn through intakes, condenser efficiency will drop requiring a reduction in output or total shutdown. Similarly, operations of desalination plants are also subjected to severe problems.

5.2.2 SEWAGE

Sewage can be converted into fertilizer when it is not contaminated with high levels of metals, oils and organic chemicals. However in most cases it may be economical to dispose of it at rivers, estuaries and the sea.

Unfortunately, sewage has a high BOD and many island waters have experienced serious harmful effects from oxygen depletion and excessive nutrient concentrations. In coastal waters it can cause localized oxygen depletion zones.

Once settled on the bottom, the sewage sludge forms an organic rich sediment which is a very unsuitable environment for most benthic animals.

The public health risk associated with sewage has been discussed separately in this chapter.

5.2.3 TRACE METALS

Insecticides, fungicides, weedicides and fertilizers used for agricultural and epidemic eradication programs are the chemical substances causing pollution of coastal waters in Sri Lanka. Industries also contribute large amounts of chemicals to the coastal environment.

Although there is no recorded evidence of major damage in Sri Lanka, there is evidence of similar situations in other countries. Therefore the author wishes to provide the following information for the benefit of the reader.

MERCURY

Mercury is or has been used in a number of industries including chloro-alkali, paper, pesticide, pharmaceutical and anti-fouling paints.

High levels of mercury have been observed in muscles of the fish and shellfish found in the contaminated water. Some species, namely tunny, swordfish, marlin, and some other large pelagic fish, naturally contain high concentrations of this metal. There are several reasons for this. These fish are large carnivores at the end of food chain, and their diets therefore contain high levels of mercury due to bioaccumulation and biomagnification.

Mercury is a well known neuro-toxin to humans. Mercury poisoning resulting from pollution of the sea occurred during 1950s and 1960s at the small coastal town of

Minamata in Japan where the population is dependent on fishing for a livelihood. There it was shown that mercury from a chemical manufacturing plant was accumulating in fish and shellfish which were then eaten by the local population. This resulted in an outbreak of "Minimata Disease" which effected some 2000 cases of whom 73 died and 700 were severely and permanently disabled. Since this incident several countries introduced legal standards for mercury in food offered for sale. The WHO recommended a maximum tolerable consumption of mercury in food of 0.2mg of methyl mercury or 0.3mg of total mercury per week.

Cadmium

Like mercury, cadmium was first identified as a toxic element after an incident of "itai-itai" disease in Japan. Although there is some doubt now whether this incident was related to cadmium poisoning, other incidents have confirmed that this metal is potentially hazardous. It is reported that nausea and vomiting in human beings results after consuming oysters contaminated with cadmium or zinc. Therefore because of its toxicity and persistence, cadmium, like mercury, is considered as a "black list" metal.

Tin

Antifouling paints containing organic tin compounds are widely in use on seagoing vessels. Out of these TBT is extremely toxic and is lethal to a variety of planktonic organisms. The sub-lethal effects due to low concentrations of TBT have a greater consequence to commercial shell-fisheries. At this level TBT causes

gross thickening of the shells of oysters, reducing the size of the animal inside and rendering them unmarketable. In certain marine species (e.g. Nucella) the oviduct and female genital opening becomes overgrown by the developing penis, so that the egg capsules cannot be laid. Therefore in areas frequented by shipping and small boats its population has been seriously reduced or eliminated altogether because of the failure of reproduction (Marine Pollution-Clark).

5.3 FISHING

The fishing industry in Sri Lanka is primarily artisanal. The availability of the various exploited species vary according to the seasons. Therefore artisanal fisherman do not specialize on one particular fishery but use different fishing gear according to the season.

This sector provides employment to about 74,000 people in fishing and about 20,000 in related ancillary occupations such as marketing, boat building, and ice making. (UNEP 62)

At present this industry supplies about 70% of the animal protein consumed by the population. The total fish production during the year 1981, 1982, and 1986 were 203,586, 200,000 and 175,410 metric tons respectively. It has been said that the reason for the drop of production was due to civil unrest in the northern and southern parts of the country.

The exports from fishery products bring the country much needed foreign exchange, and in 1989 this figure was Rs.845 million (approximately USD 21 million). The major

seafood items exported consist of shrimps, lobsters, and cuttlefish. Ornamental fish and crabs are exported as live products. Shark-fins, Beche de Mar and sea weeds are exported in dried form. Other products which form a minor sector of fishery exports are fish liver oil, sea shells and fish meal.

The fishing industry is one sector which can be affected due to the pollution of marine waters. Certain kinds of fish avoid the affected areas and make it difficult to find them again. Some fish die or are injured. Pollution also causes the reduction of quality and quantity of the fish in addition to the drop in demand. For example, following the TORREY CANYON incident the demand for fish in England dropped by 25%. In another similar incident it has been reported that fish production dropped by 83% and took two months for conditions to improve.

In conclusion, potential threats to the fishing industry in Sri Lanka from pollution may be summarized as follows:

1. Direct harm to fish and shellfish stocks.

2. Drop in production - increase of fish prices, loss of revenue, possible loss of jobs.

3. Contaminated fish - health hazard to the unaware consumer.

4 Loss of foreign exchange to the government.

5. Commercial species become tainted and are rendered unsalable.

6. Possible loss of foreign markets.

5.4 TOURISM

The tourist industry in Sri Lanka represents a major industry where the country earns foreign exchange. The total number of persons employed in this sector is estimated to be about 48,000 (1987). About 9000 rooms are available in 128 hotel units scattered mostly on the coastal belt of the island.

Sri Lanka attracts foreign tourists mainly because of the sunshine, white sandy beaches and warm clean waters. Therefore it is essential to provide a pollution free marine environment to maintain this industry at the optimum condition. A major oil spill near the coast would greatly jeopardize this industry.

5.5 SALT INDUSTRY

The total requirement of table salt is produced in the country by the government owned Sri Lanka National Salt Corporation.

The process adopted for the production of salt is by solar evaporation of the seawater. Therefore the sun-energy and the wind are important factors for the industry in addition to clean seawater.

The salt pans are situated in the districts of Puttalm, Trincomalee, Hambanthota and Mannar. A large number of employment opportunities have been provided to the people of those areas. More than one thousand permanent and

about two thousand temporary laborers work for this organization.

Apart from the creation of employment, this industry has helped the government to save foreign exchange by producing the salt locally.

Production in metric tons	year
76,858	1985
106,320	1986
121,817	1987

(Annual production of table salt in Sri Lanka)

5.6 HUMAN HEALTH

In Sri Lanka increasing amounts of untreated sewage is added to the coastal waters. Two major outfalls discharge the Colombo area sewage and are located in the south and north of the city. It has been noted that these outfalls are situated in close proximity to the coast and therefore could increase the micro organisms in the prime recreational and bathing areas in Mt.Lavinia and Hendala.

All human sewage contains bacteria, pathogens, viruses, and the eggs of intestinal parasites. Therefore bathing in waters receiving such inputs, and consuming contaminated fish and shellfish are the causes of a variety of infections.

The same urban sewage which causes bathing problems is often responsible for acute gastro-intestinal disorders following consumption of contaminated seafood. Molluscs and other seafood are particularly susceptible to contamination by pathogens. More important are the bivalves which filter large volumes of sea water and retain pathogenic bacteria and viruses. Most of these shellfish are popularly eaten raw or only partially cooked; this largely increases their potential to cause diseases.

Infectious hepatitis is the most common viral disease caused by seafood. Numerous outbreaks of this disease revealed that the molluscs that grow in sewage-contaminated water are very effective carriers of this virus.

5.7 CORAL REEFS

Coral reefs probably are the most extensive shallow marine communities on earth. These are the most biological productive of all natural communities. In Sri Lanka reef fishes and shellfish provide high-quality protein for people living near the sea.

Dredging is one of the causes for the destruction of coral reefs. Dredge-suspended sediments exert both biological and chemical oxygen demands. Therefore the coral reef communities may not be able to tolerate low oxygen levels caused as a result of this activity.

In some areas, particularly in the south and southwest coasts of the country, collection of aquarium fish and coral, trampling and anchor damage, and sewage and oil

discharges from ships are major threats to the coral reefs.

The effects of oil on corals and their associated fauna largely depend on the toxic components and the duration of the oil exposure. Observation of oiled corals suggest that several sub-lethal effects could occur such as interference with the reproductive process, abnormal behavior and reduced growth rate.

5.8 MANGROVES

Mangrove swamps are often hot, fetish, mosquito-ridden and almost impenetrable. As a consequence they are generally held in low regards. However this plant has varied value to the man. The wood is widely used as fuel and the roots are effective sediment binders and therefore often planted for erosion control. In addition, important functions of mangrove communities are those of providing food and shelter for a large variety of fish and shellfish.

Oil in sufficient quantities may close the openings of the air breathing roots of mangrove trees. This will lead to the imbalance of the salt content causing leaves to drop and eventual death to trees.

In Sri Lanka exploitation in most of the sites has exceeded the ability of mangroves to recuperate. Therefore several commercial food species such as penaeid prawns which depend upon them are now endangered.

5.9 SEA GRASS

Extensive areas of sea grass are found in the straits between India and Sri Lanka and along the northern and western coast of Sri Lanka.

These are less susceptible to damage from oil, still, shallow beds of sea grass can suffer destruction from severe oil spills.

It has been shown that sea grasses are more sensitive to fresh light crude or light refined products than to weathered oils. More widespread damage can be expected from repeated contamination or if oil penetrates into sediments where it may persist for several years.

Estuarine disturbances such as industrial and agricultural runoff have damaged sea grass beds in Sri Lanka (Salm). In addition sewage discharges and overfishing are also known to have an effect on this habitat.

CHAPTER 6

PREVENTION AND CONTROL OF MARINE AND COASTAL POLLUTION

6.1 INTRODUCTION

The term "pollution" has been used in different ways and has been applied as a convenient word to satisfy different needs. There are five categories which cover the range of approaches to pollution (Springer). The extreme ones are "pollution as any alteration of the existing environment" and "pollution as the right of the territorial sovereignty". In the first category even a single drop of oil in any ocean would constitute pollution in international law. The second denies extraneous control. Further categories are "pollution as damage", "pollution as interference with other uses of the environment" and "pollution as exceeding the assimilative capacity of the environment". The last two are of certain significance.

"Control" measures are intended to contain pollution whereas "preventive" measures, if properly enforced, would eliminate it. However in this concept sometimes a conflict arises between the preventive measures and "progress". In other words if pollutants are to be

completely stopped in reaching the marine environment then such a measure would definitely hinder the industrial and agricultural progress of a country. Therefore a certain amount of pollution, considering the overall capacity of the oceans for assimilation, would seem to be inevitable in order to keep the wheels of genuine human progress turning.

The approach to "control" should optimize the balance between the industrial progress which produces pollution, and extreme cleanliness which depends upon the strongest curbs. To achieve this is not easy because it is not always clear how much effort and financial resources are justified, what time scale is available and what mechanisms are most effective.

Over the past decades, there has been a gradual development of practical control strategies, at national, regional and international levels. The implementation, however, varies depending on the state and their preferred approach to the pollution problem. These approaches have many aspects in common and all have the objective and economic way.

6.2 INTERNATIONAL AGREEMENTS

6.2.1 THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION OF THE SEA BY OIL, 1954 (OILPOL)

The 1954 Oil pollution Convention (for which IMO became the depository in 1959) was the first major attempt by the maritime nations to curb the impact of oil pollution. It was adopted in London.

The convention prohibits the intentional discharge of oil and oily mixtures by certain ships in specified areas of the oceans. Thus, ballast discharges have to be confined to permitted areas and must be recorded in an oil record book.

OILPOL was amended in 1962 to narrow the permitted areas for pollutant discharges, but it was the wreck of the TORREY CANYON in 1967 which fully alerted the world to the great dangers that transported oil poses to the marine environment.

The 1969 amendments prohibited oil discharges through the normal operation of a ship except under the following conditions:

1. The total quantity of oil which a tanker may discharge in any ballast voyage must not exceed 1/15000 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 travelled by the ship.

3. No discharge of any oil whatsoever may be made from cargo spaces of a tanker within 50 miles of the nearest land.

Two further amendments for this convention were made in 1971. One dealt with the environmentally vulnerable waters of the Great Barrier Reef of Australia.

The second amendment dealt with tank sizes of the tankers. It was considered that smaller tank sizes may result in less pollution damage particularly due to accidental

damage. Neither of these amendments have entered into force.

6.2.2 THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973, AS MODIFIED BY THE PROTOCOL OF 1978. (MARPOL 73/78)

On the 2nd of October 1983, MARPOL 73/78, which is widely regarded as the most important single instrument addressed in the prevention of marine pollution at the global level, came into force.

This convention consists of 20 articles in the main body, two protocols and five annexes which set out the actual prevention regulations as follows:

ANNEX 1 : Pollution by oil.

ANNEX 2 : Pollution by noxious liquid substances carried in bulk.

ANNEX 3 : Pollution by harmful substances carried in packages, portable tanks, freight containers or rail road tank wagons etc.

ANNEX 4 : Pollution from sewage from ships.

ANNEX 5 : Pollution by garbage from ships.

The first two annexes are mandatory while others are optional.

According to the convention certain regions, viz the Mediterranean Sea, the Black Sea, the Baltic Sea, the Red

Sea and the "Gulf Area", have been designated as "special areas" in which any discharge of oil in concentrations of 15ppm and above is not allowed. MARPOL 73/78 prohibits discharges of machinery space bilges, which contain leaked oil, unless the bilge water is first passed through oil-water separating equipment and the oil content in the affluent is less than 15ppm or, when the ship is at least 12 miles from shore and proceeding en route, less than 100ppm.

The measures adopted within MARPOL 73/78 have had tremendous implications for the shipping industry; loss of cargo space due to the introduction of segregated ballast tanks and dedicated clean ballast tanks, investment in crude oil washing as well as oil separating equipment and oil monitoring meters and training of the crew. The provision of the reception facilities for oil wastes in sea ports, the treatment of such wastes and their ultimate safe disposal also involve additional expenditure for the parties to the Convention.

6.2.3 INTERNATIONAL CONVENTION ON CIVIL LIABILITY FOR OIL POLLUTION DAMAGE, 1969 (CLC 1969)

The purpose of this convention is to form a basic structure on which the regimes of liability and compensation for oil pollution damage from ships are based. Only the oil carried in bulk as a cargo is considered for the compensation according to this convention.

Liability for damage from pollution is placed on the shipowner. However liability can be avoided if he proves that damage ensued by reason of insurrection, civil war,

hostilities, an act of war or an act of God. Further exceptions absolving the shipowner from liability include instances of proven damage resulting from an act or omission by a third party.

In most cases the grounds for exemption are very limited, and the owner will, therefore, be liable for pollution damage in almost all incidents which occur under normal circumstances. However, under certain conditions, the shipowner is entitled to limit his liability to approximately USD 160 per ton of the ship's tonnage or approximately USD 17 million per incident.

As the CLC Convention was no longer able to fully meet the demands of major pollution incidents, a protocol was developed in 1984 at the IMO. This protocol raised the liability limits for ships up to 5000 GRT to about USD 3.9 million. For vessels between 5,000-140,000 GRT, 3.9 million plus USD 550 for each additional tonnage. For ships exceeding 140,000 GRT the limit was raised to about USD 78 Million.

6.2.4 INTERNATIONAL CONVENTION ON THE ESTABLISHMENT OF AN INTERNATIONAL FUND FOR COMPENSATION FOR OIL POLLUTION DAMAGE 1971 (FUND CONVENTION)

The FUND convention was established as a supplementary convention to CLC convention. The intention was to supplement the inadequate maximum compensation limits, because for very large pollution incidents, the CLC limits may not be adequate. Parties eligible to be members of the FUND Convention must have been, in the first instance, parties to CLC.

There is a provision for compensation for those who may suffer pollution damage but cannot obtain the full amount from CLC. Thus, injured parties whose state is bound by the FUND Convention may receive compensation even if the damage is caused by a vessel of a non-contracting state. The key feature in the thinking behind the convention is the consideration that it is unfair for shipowners alone to bear full financial consequence of oil pollution from tankers.

The 1971 FUND Convention consists of a fund financed from levies on the import and export of oil in contracting states.

The compensation payable by the IOPC FUND in respect to an incident is limited to an aggregate amount of approximately USD 79 million including the sum actually paid by the owner (or his insurer) under the CLC Convention.

6.2.5 THE INTERNATIONAL CONVENTION RELATING TO INTERVENTION ON THE HIGH SEAS IN CASE OF OIL POLLUTION CASUALITIES, 1969 (INTERVENTION 1969)

This Convention states that except for warships and other non-commercial state vessels, parties are permitted to take such measures on the high seas as may be necessary to prevent, mitigate or eliminate grave and imminent danger to their coastline or related interests from pollution or threat of pollution of the sea by oil following upon a maritime casuality or acts related to such casualty which may reasonably be expected to result in major harmful consequences.

The convention came into force on 6 May 1973. In 1975 a protocol covering substances other than oil was added which entered into effect in 1983.

6.2.6 THE UNITED NATIONS CONVENTION ON THE LAW OF THE SEA 1982 (UNCLOS 82)

The traditional uses of the sea were related to navigation/shipping and fishing. Subsequently new resources of the sea have been discovered and developed, namely, oil and gas under the continental shelf. Therefore in 1982, the United Nations Convention on the Law of the Sea was adopted to regulate the diverse use of the sea.

Under article 19 of this convention, marine pollution is clearly considered to be prohibited as an act prejudicial to the peace, good order or security of the coastal state. Under article 21 coastal states are permitted to make laws and regulations for the protection of the marine environment.

The Law of the Sea Convention's part XII provides excellent overall direction for operational developments put in place through the IMO conventions that have been widely accepted. Greater marine environmental consciousness throughout the world has led to the need to protect the marine environment with commensurate legislative action. (E.Gold)

6.2.7 INTERNATIONAL CONVENTION FOR THE SAFETY OF LIFE AT SEA 1974 (SOLAS 1974)

This convention is not directly related to the maritime pollution control. However its implications are far reaching. SOLAS 1974 contain number of specific regulations and codes in connection with the safe practices in ship operation. Ignoring of ship safety procedures will lead to accidents and may cause marine pollution.

6.3 REGIONAL AGREEMENTS

6.3.1 SOUTH ASIA CO-OPERATIVE ENVIRONMENTAL PROGRAMME (SACEP) TO WHICH SRI LANKA IS A MEMBER.

United Nations Environment Programme (UNEP) served as a focal point for environmental action and co-ordination within the United Nations System. It deals with monitoring of selected environmental parameters to provide governments with the information necessary to understand, anticipate and control adverse environmental changes.

Therefore, in 1981, a preparatory high level ministerial meeting was held in Sri Lanka where representatives from most of the countries in the region were present. As a result SACEP was created in January 1982 and seven countries including Sri Lanka ratified the articles of the association.

Among the subjects SACEP has identified to improve the quality of environment within the region, the following

items refer to the control and prevention of pollution.

1. Environmental legislation.

2. Environmental education and training.

3. Tourism and environment.

4. Conservation of corals, mangroves, deltas and coastal areas.

5. Environmental impact assessment and analysis for development.

6. Regional Seas Programme.

Under this programme a study of environmental legislation in the member countries was carried out and assistance has been given to train national legal draftsmen to draw up effective environmental legislations.
Another approach SACEP adopted to control the pollution within the region is by way of environmental education. SACEP's governing council has given high priority for this concept. Therefore representatives of governments have been invited for various meetings to develop a plan of action. Such environmental education activities involve the concept of sea management in many of the participating countries.

6.3.2 SOUTH ASIAN SEAS REGION ACTION PLAN OF UNEP

This programme is adopted by the Governing Council of the UNEP to manage and control the marine environment within the South Asian region. The states involved are the

coastal member states of SACEP.

With respect to the content of the action plan under development it was agreed that the following priority areas of regional concern should be considered.

a. Environmental assessment

The assessment component would concentrate on monitoring pollution from human settlements, oil pollution from coastal and maritime sources, pollution from agriculture activities, pollution from industrial sources, including toxic and noxious substances and environmental degradation resulting from other causes, such as coastal erosion and sedimentation.

b. Environmental management

The management and conservation component consists in general terms of coastal zone management.
c. Legal component

The relationship between the countries of the broader region are agreed upon within the framework of the Articles of Association of SACEP. A document will be prepared by UNEP on the legislative aspects relevant to the action plan.

d. Institutional arrangements

It was agreed that UNEP would co-ordinate preparation activities leading to the adoption of the action plan, in close collaboration with SACEP, and with the co-operation and assistance of international organizations as

appropriate.

e. Financial arrangements

UNEP is assisting the states of the South Asian Seas region in activities leading to the development of the action plan.

f. Supporting measures

Other supporting measures include, information exchange, data banks, clearing house, education, training and development of human resources and promotion of environmental awareness.

6.4 NATIONAL POLICIES AND STRATEGIES FOR ENVIRONMENTAL PROTECTION AND MANAGEMENT IN SRI LANKA.

Interest in the coastal problems in Sri Lanka dates as far back as the nineteen forties. During that time only engineering solutions were considered. For example structures were built to curb coastal erosion. The number of agencies involved to execute coastal protection projects were the Department of Public Works, Railway, Highways, Irrigation and Water Supply and Drainage Department. However the lack of understanding of the subject, and poor planning resulted in large scale waste of human and financial resources.

Recognizing the need to deal with the problems at the national level a coast protection unit was established in the Colombo Port Commission in 1963. Again, in 1978, a Coast Conservation Division was established in the Ministry of Fisheries.

6.4.1 NATIONAL ENVIRONMENT ACT 47 OF 1980

Prior to 1980, Sri Lanka did not have a comprehensive environmental control statute or a single governmental agency exclusively charged with environmental control responsibility. Therefore recognizing the need for a control agency for the conservation of the environment the government in 1980 enacted the National Environmental Act 47 of 1980.

The act provided for the establishment of the Central Environmental Authority (CEA) as the lead agency for the co-ordination of all activities connected to the protection of the environment.
Therefore the government declared priority areas through CEA for the management of the environment. They include:

1. Preparation of a national conservation strategy.

2. Establishment of a national environment reference center.

3. Direction of a public awareness programme on the environment.

4. Building and strengthening of capabilities of district environmental agencies.

5. Professional development for environmental protection and management.

6. Introduction of Environmental Impact Assessment (EIA) procedure.

7. Development of a national environmental code.

8. Strengthening of environmental policy monitoring capacities.

While the CEA acts as the leading agency for policy-making and co-ordination of the environment there are several authorities responsible for the various aspects of the marine environment.

6.4.2 THE COAST CONSERVATION ACT NO.57 OF 1981

Recognizing the magnitude of the possible impacts of coastal activities on the environment and its resources, it was felt imperative that specific regulations directed towards controlling activities in the coastal areas were necessary. The existing rules and regulations were found to be weak and fragmented. The Coast Conservation Act No.57 of 1981 was therefore formulated and the law became operative in 1983. The elements of the Act which are directly related to the protection of the marine environment and other ecosystems such as coral reefs, mangroves, estuaries are as follows:

1. PERMIT PROCEDURE

   Development activities within the coastal areas are governed by a permit procedure. Therefore control of pollution could be established in the marine environment.

2. ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

   EIAs will be made mandatory for all the projects deemed

to have significant impact on the environment. In the future, therefore, development projects will be evaluated not only on their economic feasibility but also on their environmental suitability. Inclusion of pollution controls and preventive measures can be made compulsory in the developing projects. As a result impacts could be minimized.

3. COASTAL RESOURCES SURVEY AND THE COASTAL ZONE MANAGEMENT PLAN (CZMP)

This plan contains proposals for effective management of the coastal zone of the country. These proposals ensure further development of the coastal areas without damaging the environmental conditions.

6.4.3 MARINE POLLUTION PREVENTION ACT NO. 59 OF 1981

The main sources of marine pollution are industrial sources, sewage outfalls, rivers with intense upstream activities, dumping of dredged spoil, oil slicks in and around fisheries harbors and offshore/inshore shipping activities.

Several of the statutes had some provision related to marine pollution. For example, according to regulations under the Coast Conservation Act one of the criteria to be used in determining the suitability of development projects within the coastal zone is that it does not cause marine pollution. Similarly the Greater Colombo Economic Commission Act (G.C.E.C.Act) has a provision to execute measures as may be necessary in the area of its authority.

These fragmented rules and regulations in the various

existing statutes may have been adequate to manage the environmental pollution problems experienced in the past. However, the threat of marine pollution has increased significantly in the recent past due to the intensive development in the country. Therefore it was recognized that a comprehensive pollution prevention regulation was urgently required. This led to enactment of the Marine Pollution Prevention Act No.59 of 1981. The Ministry of Trade and Shipping was identified to implement the Act which contains eight parts.

PART 1-Establishment of the Marine Pollution Prevention Authority.

This body shall have vested powers for prevention, reduction and control of pollution in Sri Lanka waters both from sources offshore and on land.

PART 2-Prevention of pollution -criminal liability.

If any oil or other pollutant is discharged or escapes into Sri Lanka waters from any ship, the owner, operator, master or the agent of the ship shall be guilty of an offense and shall be liable on conviction to a fine not exceeding one million Rupees.

PART 3-Prevention of pollution -Civil liability.

The owner or the operator of a ship carrying more than two thousand metric tons of oil in bulk as cargo which enters or leaves a port in Sri Lanka or enters or leaves Sri Lanka waters or a terminal shall have in respect to that ship a valid certificate of insurance or any other

financial security.

PART 4-Preventive measures against pollution.

All ships in Sri Lanka waters shall carry record books relating to oil and other pollutants.

PART 5-Reception facilities and equipment on board ships.

The Authority shall have the power to provide reception facilities within or outside any port in Sri Lanka to enable ships using such ports or traversing Sri Lanka waters to discharge or deposit oil residues or other pollutants.

PART 6-Marine casualties.

PART 7-Implementation of International Conventions.

The Minister shall have the power to take such steps as may be necessary to give effect to the provisions of any international convention on marine pollution which the government of Sri Lanka may ratify, accept, accede or approve.

PART 8-Miscellaneous provisions.

Powers to board any vessel within Sri Lanka waters and conduct inspections to determine whether the vessel complies with the requirements laid down by the act. Power to detain a ship which has caused pollution damage is also included in this part of the act.

6.5 DONDRA HEAD TRAFFIC SEPARATION SCHEME

Another significant step taken by Sri Lanka to minimize pollution as a result of possible maritime casualties is the proposed traffic separation scheme.

The established traffic separation scheme is shown in annex 6.5. This scheme has been developed according to the IMO regulations and comprises a 3 mile inshore traffic zone, a two mile separation zone, 3 mile west bound traffic zone, a 3 mile separation zone and a 3 mile east bound traffic zone. Under this scheme, the internal traffic would have to maintain a minimum distance of 5 miles from Dondra Head. The laden tanker lane which would normally be the east bound lane will be 11 miles off Dondra Head.

6.6 ENVIRONMENTAL EDUCATION IN SRI LANKA

A significant step has been taken in Sri Lanka to establish degree courses in environmental studies or related sciences. Increased attention is being given by the universities on environmental themes.

Currently there are three universities which offer courses in the following fields:

- A M.Sc. course in environmental sciences conducted by the Department of Zoology of the University of Colombo.

- A M.Sc. course in forestry conducted by the Department of Biology at the University of Sri Jayewardenepura.

- A M.Sc. course in town and country planning; and a M.SC. course in environmental engineering at the University of Moratuwa.

6.6.1 PROFESSIONAL ENVIRONMENTAL TRAINING

A number of training programmes outside the general education system are conducted by various agencies in the government. They range from civil service staff colleges to research institutes.

Environmental administration has been introduced into the induction and in-service training programmes for public officers at the Sri Lanka Institute of Development Administration (SLIDA). Marine environment is included in the training module on environment for the new recruits to the Sri Lanka Administrative Service.

At the National Institute of Business Management (NIBM), training modules have been changed to incorporate environmental dimensions. About 3,000 participants, consisting of employees of the public and private sector enterprises enroll at this institute to participate in such programmes annually.

6.7 MARITIME ADMINISTRATION

The object of the maritime administration is to provide the government with the machinery which would enable it to satisfactorily and efficiently undertake those functions included in the maritime law of the country. Maritime administration is also responsible, inter alia, to ensure implementation of international maritime conventions, and national rules and regulations, framed under the Maritime

Law.

To date, Sri Lanka has ratified the following marine pollution conventions and intergovernmental liability and compensation schemes.

1954 OILPOL

1969 INTERVENTION

1969 CIVIL LIABILITY

1971 FUND

Therefore the Government of Sri Lanka, having ascertained that a vessel in one of her ports is in violation of the above regulations and thereby threatens damage to the marine environment shall take administrative measures against that vessel.

The international standards of the safety of life at sea, prevention of pollution of the marine environment and the working and living conditions on board ships can only be effectively monitored by regular surveys and inspections. Therefore the administrations play a major role by duly carrying out these functions thereby contributing to control and prevention of marine pollution.

In Sri Lanka the international classification societies are designated to conduct surveys and issuance of relevant certificates.

CHAPTER 7

OIL SPILL CONTINGENCY PLANNING

7.1 INTRODUCTION

As noted in the previous chapters there are large numbers of marine based resources situated along the coastline of Sri Lanka. These resources are now threatened by a probable oil spill from recently increased shipping related activities. Some of these activities have been identified as follows:

1. Heavy volume of tanker traffic (including ULCCs and VLCCs) in addition to large numbers of cargo vessels passing through the southern coast of the country.

2. The construction of the new oil pier in the Port of Colombo.

3. Occasional tanker lightering operations off Colombo and Trincomalee.

4. Coastal tanker traffic between Colombo, Galle and Trincomalee.

5. The establishment of an offshore SPBM five miles west of the Port of Colombo.

6. The growing bunker supply trade.

7. Increase in size of the vessels calling at the port of Colombo.

Although every effort is made to keep crude oil related activities safe, accidents do occur causing damages to marine environment. Hence, in order to respond effectively for such incidents careful pre-planning is absolutely necessary. This pre-planning is often referred to as contingency planning. In order to prepare the plan it is necessary to identify the following vital factors:

1. Resources to be protected

2. Possible risks

3. Equipment, material and manpower to be mobilized

4. Establishment of communication

At present there is no proper oil spill contingency plan available in Sri Lanka. Therefore it is extremely important to develop and implement a suitable plan without delay.

7.2 SCOPE

An oil spill contingency plan is an anti-pollution arrangement intended to respond fast and effectively to a spill of oil in the marine environment. Such an

arrangement should be able to minimize or possibly eliminate pollution damage to the resources. In order to do so the plan should be able to marshall the required human and material resources immediately after such an incident occurs.

The worst case of an oil spill in the waters of Sri Lanka can be expected from a large tanker accident off the southern coast. To implement a response plan for such an incident is beyond the capability of the country. Major oil spillages often have transboundary implications. Therefore the government must take necessary action to promote a regional plan in order handle larger spills.

According to the activities (No.2 to No.6) given in the introduction of this chapter small to medium size spills can be expected in the marine environment. Therefore the most suitable plan to be developed will be for oil spills of about 2000 tons. This is approximately the bunker capacity of large container vessels calling at the port of Colombo. The capacity of coastal tankers is also very close to this figure.

To formulate and implement an oil spill contingency plan would require a considerable amount of funds. Therefore the CEA should set up a central fund for this purpose. The government and its relevant organizations such as Ceylon Petroleum Corporation and Ports Authority will be able to provide an annual financial contribution to this fund. In addition legislation should be formulated to make the industries using hazardous substances pay a contribution to this fund. Importers of these substances should pay a contribution to the fund according to the amount and the nature of their imports.

The structure of the plan should be flexible and suitable for minor spills as well. This plan also should be compatible with the regional arrangements. This way the transition from one level to another will be ensured.

For clarity, the plan has been divided into two main stages, preparation and action.

7.3 PREPARATION

7.3.1 PHYSICAL FEATURES OF THE COASTLINE

An oil slick will not usually stay in the same place but will move under the influence of external factors. The most important of these factors are winds, waves, tides and currents.

Knowledge of the nature of the coastline is therefore kept handy. The coastline should be mapped in such a way as to indicate with clarity all the physical features indicating, among other things, cliffs, rocks, mangroves, sea ports, fishing ports, estuaries, beaches of interest to tourism, reefs and sea water intake areas to various industries.

7.3.2 LOCAL OCEANOGRAPHIC FACTORS

Certain oceanographic factors prevailing in the entire territorial waters are necessary to study prior to preparation of the plan. Such studies should lead to the following findings:

1. Identification of currents, their speed and direction during the entire year.

2. Preparation of tide tables.

3. Hydrographic knowledge _ water depth, sandbanks, nature of the seabed, etc.

4. The maximum and minimum height of the waves at different locations.

7.3.3 METEOROLOGICAL CONDITIONS

The following information regarding meteorological conditions, among other things, will be required for the preparation of the national contingency plan.

1. Wind patterns and cyclonic disturbances throughout the year including the frequency, speed and direction.

2. Periods and locations where poor visibility exists.

Details of meteorological conditions and oceanographic factors in the country have been given in Chapter 2 of this report.

7.3.4 RESOURCES AT RISK

Sri Lanka has a large number of resources available on the entire coastline. These resources have been already discussed in the previous chapters.

In the event of an oil spill the entire coastline may not be fully protected. In such a situation it becomes necessary to identify the zones which should be given priority. Ecologically sensitive areas, fisheries,

estuaries, port areas, tourist beaches, sea birds and other resources likely to be affected should be taken into serious consideration in specifying such zones. However this will require consultation with experts in various government sectors such as the Ceylon Tourist Board, Fisheries Corporation, National Aquatic Resources Agency (NARA) and CEA.

7.3.5 CLEAN UP STRATEGY AND LOCATION OF EQUIPMENT

The clean up strategy should be determined in relation to the assessment of the spills and the agreed priorities for the protection of the resources. Selection of suitable equipment for the operation is made on the basis of the anticipated extent of the spill, the type of oil involved, and the prevailing weather conditions of the area.

With reference to the reasons given in 7.1 it can be said that the west coast of the country has a relatively high probability of an oil spill. The ports of Colombo and Galle are also situated in this region. Therefore the most suitable location to position and maintain the equipment is Colombo.

Procedures for mobilization and an inventory of equipment with other relevant details like operational instructions, types of machines, weights and dimensions are to be incorporated in the plan. If additional equipment and services are to be provided by the private contractors, industries or other parties as back up resources, such details with contractual terms and conditions should also be annexed to the plan.

When oil is spilled on the sea, its removal is often desirable. The most common approach is to use some form of barrier to restrict the movement of oil and to concentrate it into a thick layer so that it can be removed by using pumps or skimmers. Many types of such oil barriers have been developed. These include commercially available floating booms, netting systems, sorbent booms, bubble barriers and chemical barriers. Design of these vary considerably but they maintain the following common features:

1. Freeboard to prevent or reduce splashover.

2. Sub-surface portion (skirt) to prevent or reduce the escape of oil under the boom.

3. Floatation by air or some buoyant material.

4. Longitudinal tension components to withstand the effects of winds, waves and currents.

Recovery of contained oil can be carried out by using skimmers, pumps, sorbents, and manual techniques. All skimmers include an oil recovery element, some form of floatation and a transfer pump.

Commercially available oil equipment is expensive. Therefore for a developing country like Sri Lanka it may not be possible to purchase and stock all the required items. Certain items could be produced in the country by using locally available materials. For example, coconut husks and hay (paddy) could be used as a sorbant material.

7.3.6 PERSONNEL

The manpower requirement for the operation of the plan is based on the extent and the location of the spillage. Therefore, in case of a large spill, additional personnel may be required, particularly where manual cleaning of the beaches is involved.

The back up services available from government departments and private organizations should therefore be identified and attached to the operational plan.

Sufficient personnel should be readily available to carry out the following duties if required.

1. Control staff of various levels.

2. Communication system operators.

3. Manning crew for the vessels engaged in the operation.

4. Equipment operators and maintenance staff.

5. General labor force.

6. Support staff including specialists.

7. Relieving staff for operations of longer duration.

7.3.6.1 ON SCENE COORDINATOR (OSC)

The OSC is the coordinator on scene designated by the Marine Pollution Prevention Authority to lead and direct the entire operation. At the time of an oil spill it is

the duty of the OSC to assess the situation in order to decide the response action. Depending on this he will muster the required resources in accordance with the requirements.

The OSC must be a fully trained person to carry out this type of work. A senior officer from the Sri Lanka Navy will be most suitable for this position. However he should be given overseas training prior to appointment to this position.

7.3.7 TRAINING AND EXERCISES

The equipment for training and exercises should be clearly defined in the plan. Training programmes should be developed at all levels including shore clean-up personnel. Regular exercises will ensure that contingency plans function properly and all those likely to be involved in a spill become fully familiar with their particular responsibilities.

7.4 OPERATIONAL PLAN

7.4.1 INTRODUCTION

If natural dispersion forces are unable to remove an oil spill from the sea surface before it reaches the shore, then some action will be necessary to protect the resources which may be affected by it. In order to carry out this operation effectively prior planning and organizing is necessary. The plan therefore should describe the approved procedures for responding to an oil spill.

7.4.2 NOTIFICATION

Information from an accidental oil spill may come from the master of the vessel, cargo owner, salvor, port authority, navy or general public. However to identify the deliberate release of oil will require permanent monitoring of the sea lanes.

To receive information regarding any form of spill, centers must be identified and their telephone numbers, telex numbers, and radio frequencies published in the mass media of the country. These centers should be named as follows:

1. Colombo Radio
2. Sri Lanka Police
3. Sri Lanka Ports Authority

On receipt of information of an oil spill, the designated center will transmit a preliminary report to the OSC without undue delay. This report as far as possible should contain the following details.

- date and time of message received.
- position of the spill.
- source and cause of oil pollution.
- estimated amount of oil spilled.
- type of oil spilled.
- particulars of initial observer (to obtain further

details if necessary).

- date, time and the serial number of the report (for record purposes)

7.4.3 RESPONSE DECISION

All the information collected from an oil spill is referred to the OSC. Depending on the spill he should be able to evaluate the situation and decide the correct response action to be taken. He may use the services of the advisory committee if necessary.

This decision is dependent on various factors. The operational plan should provide various options to be considered during an oil spill. Such factors are listed as follows:

- leave the oil to disperse by natural processes.

- increase the dispersion rate by using chemicals.

- remove the entire amount of oil on the sea surface by mechanical means.

- only monitor the movement and behavior of the spill if none of the key resources are threatened.

- if resources are threatened, a decision has to be taken either to combat the oil at a distance or use booms and protect the resources.

- if the resources have been already affected, a decision to be made on the basis of priorities for the clean-up

operation.

Every effort should be made to prevent the oil reaching the high risk areas. Damages can then be minimized. Therefore it is preferable to deal with the oil spill when it is in the low risk areas.

7.4.4 CLEAN UP OPERATION

The proper procedure for the clean up operation should be established before the commencement of the operation. Subsequently the necessary equipment is mobilized with the required personnel. To control the clean up operation and to maintain overall surveillance of the oil spill at sea and ashore, an aircraft is to be used. Sri Lanka Air Force should be able to provide this facility when required.

When an oil spill occurs in the marine environment of Sri Lanka the spiller should be made fully liable for the clean up operation. If he does not comply the CEA should take over. However the spiller must reimburse the total cost incurred by the CEA. Therefore accurate records (number of personnel and equipment involved, number of hours worked, clean up location, and quantity of materials used) of the activities should be maintained on a daily basis.

The operation should be terminated as soon as the original condition of the environment is restored or no further cleanup is possible.

7.4.5 COMMUNICATION

Communication is a vital factor for the success of a counter pollution operation. Therefore sufficient equipment should be available to maintain rapid exchange of information between aircraft, vessels, land transport vehicles, shore clean up parties and the command post.

Efficient and user-friendly communication systems such as land telephone, telex, portable VHF sets, walkie talkies and cellular phones would be suitable for the operation duties. The Sri Lanka Army and Sri Lanka Navy should be able to provide such facilities promptly.

All the necessary telephone numbers, radio frequencies and call signs which are to be used during operations should be incorporated in the plan.

7.5 RESPONSE ORGANIZATION

A suitable response organization for an oil spill cleanup campaign is given in annex 7.5. The advisory body of it should include the following agencies.

1. Director of Merchant Shipping.

2. National Aquatic Resources Agency.

3. Coast Conservation Department.

4. Sri Lanka Ports Authority.

5. Ceylon Shipping Corporation.

6. Ceylon Petroleum Corporation.

7. Ceylon Fisheries Corporation.

8. Ministry of Foreign Affairs.

The resources available should be as follows:

1. Sri Lanka Police

2. Sri Lanka Army

3. Sri Lanka Air Force

4. Sri Lanka Navy

5. Ports Authority

6. Petroleum Corp.

7. Shipping Corp.

8. Government Department

7.5.1 LEAD AGENCY

Responsibility of all the activities concerning the control and protection of the environment of Sri Lanka lies with the CEA. The Marine Pollution Prevention Authority is proposed as the lead agency for the prevention of damage from oil spills. This authority is comprised of competent personnel from various sections of the government. Its roles and responsibilities are listed

as follows:

1. To prepare a complete oil spill contingency plan including, among other things, combating facilities, areas at risk, surveillance, communications, recovery and final disposal.

2. To provide overall supervision and control.

3. To coordinate with necessary governmental departments to achieve the best possible response action.

4. To develop an appropriate system for the detection and reporting of oil spills.

5. To maintain the records of the expenditures incurred during the clean up operations of an oil spill in order to facilitate cost recovery and conduct negotiations regarding compensation.

6. To train staff who will assist in the operation.

7. To purchase and maintain pollution clean up equipment.

8. To maintain liaison with other agencies both in the country and overseas.

9. To ensure that all agencies concerned as well as the general public are well informed about the existence of this office for oil spill matters.

7.6 THE USE OF CHEMICAL DISPERSANTS

The main component of these chemicals is a surface active agent. When evenly applied and mixed into floating oil, the chemicals promote the formation of finely dispersed oil droplets with a combined surface area much greater than the original oil slick.

The method of application depends mainly on the type of dispersant, the size and location of the spill. Small ships can be used to spray the chemicals after fitting the equipment on board. However this method will have serious limitations due to the low treatment area and the difficulties of locating the slick from the vessel. Therefore aerial spraying offers optimum use of the dispersants.

The Sri Lanka Air Force can provide an aircraft for this purpose. However arrangements have to be made so that at least one craft will be available and which can be modified at short notice.

The dispersants are toxic and different countries have different attitudes towards its usage. The reason is that these chemicals increase the hydrocarbon concentration in the water column, which may lead to biological damage. Therefore it is important that circumstances under which dispersants may be used are agreed upon, according to the order of priority, before the occurrence of a spill.

CHAPTER 8

CONCLUSION AND RECOMMENDATIONS

1. Surveillance of ports, the territorial sea and the exclusive economic zone is presently being conducted by the Sri Lanka Navy. These actions are mainly aimed to curtail smuggling and illegal fishing by unauthorized persons. However, this activity does not include oil spill investigation or tracing oil spills in the area.

2. Due to the very heavy vessel traffic along the south coast of the country there is a likely possibility of an oil spill. However there is no properly organized contingency plan presently in existence for any oil spill in the country. It is therefore necessary to establish a plan and implement it as soon as possible.

3. There are no specialized oil spill combating equipments available in the country which can be used during an oil spill. Certain items can be manufactured locally.

4. There is a further need for special efforts in education and training so that personnel engaged in the pollution control and the general public understand its importance of using the marine environment wisely. Pollution prevention and control should be included in the maritime training and education curriculum.

5. The shipping industry in Sri Lanka has improved significantly during the last two decades. This change is mainly due to the country's favorable geographical location. There is a strong possibility that the country will be a prominent shipping nation in the region. Therefore Sri Lanka should become a party to the MARPOL 73/78 convention without delay.

6. Reception facilities for oily residues, oily water or tank cleaning residues from vessels should be provided in all the sea ports. It is the responsibility of the Sri Lanka Ports Authority to arrange such facilities to the vessels in the harbor.

7. Adequate and proper reception facilities should be provided by the Colombo Dockyard Limited for the oily wastes and garbage from ships at their repair piers.

8. Regional discussions by way of conferences and workshops should be promoted by the Central Environmental Authority for the exchange of information and technology.

9. Supplementary legislation for effective environmental management should be drafted as necessary.

10. National and international liaison should be maintained with IMO, UNEP, IOC, WHO, SACEP and other organizations for all matters connected to marine pollution. Active participation in seminars and conferences on this subject is to be encouraged.

11. The present system of monitoring of harbor waters for possible pollution from vessels is not effective. Therefore, the Sri Lanka Ports Authority should implement continuous surveillance operations in ports to detect and prosecute pollution offenders.

12. Contaminants of refinery wastewater include large number of chemical substances in addition to oil. Therefore the oil refinery in the country should take adequate action to reduce the environmentally harmful effects of the wastewater system. This can be done by proper treatment of the wastewater.

13. Public awareness in environmental matters should be created by using the mass media, seminars and other programmes. The aim of this is to bring about a concerned alertness to environmental issues at mass level. This would eventually lead to practices that will reduce environmental hazards and lessen adverse impacts on the environment.

14. Sri Lanka has established an Exclusive Economic Zone of 200 miles which is also the pollution prevention zone. Although the Marine Pollution Prevention Authority has been vested adequate powers, a notable draw-back to the implementation of an effective pollution prevention action plan is the absence of a monitoring of potential pollution sources passing

shores. Therefore a monitoring system must be set up in co-operation with the regional countries.

15. A major oil tanker accident in the south part of the country (which is likely to occur sooner or later) will threaten not only the coast of Sri Lanka but also the Maldive Islands as well as the south coast of India during the northeast monsoon period, and Bangladesh during the southwest monsoon period. The effective response to such pollution emergencies is often beyond the capabilities of any one country. Regional anti-pollution arrangements are a valuable and economical way of supplementing national arrangements in effective combatting of major spillages of oil and noxious substances. Therefore such arrangements are to be proposed and formed within the region under the South Asia Co-operative Environment Programme.

16. The lower Kelani area has a large concentration of water-using industries and consequently send their untreated wastes water in to the river. Therefore effective controls and monitoring should be introduced to improve the quality of the river water.

17. Pesticide use has increased dramatically in the country and spillages and leachings from agriculture are entering coastal waters. CEA should looked into this problem to find out a suitable solution.

18. With a narrow continental shelf Sri Lank's coastal waters are rich in marine resources. About 90% of fish production comes from the coastal waters. Therefore enhancing the quality of the marine

environment is of great importance to the country.

19. Effecting improved pollution prevention and control is not mainly a question of devising new rules and regulations, but of enforcing the existing ones. Improvements can be made by enhancing closer co-operation between the government, public and the industries.

20. Monitoring of the water quality at the river mouths, estuaries, lagoons and off-shore should be carried out in order to ensure effective control of marine pollution.

21. Steps should be taken to stop coral mining. Strengthening legislation to protect coral reefs from the effects of tourism such as souvenir and ornamental collectors will greatly promote this effort.

BIBLIOGRAPHY

1. UNEP Regional Seas Reports and Studies No.58

2. UNEP Regional Seas Reports and Studies No.62

3. UNEP Regional Seas Reports and Studies No.74

4. UNEP Regional Seas Reports and Studies No.115

5. Sri Lanka paper on protection of the marine environment and related ecosystems -D.H.Sadacharan

6. Problems of Marine Pollution and the Resolution of use conflicts in the coastal zone of Sri Lanka - Renton de Alwis

7. Marine Pollution -R.B.Clark

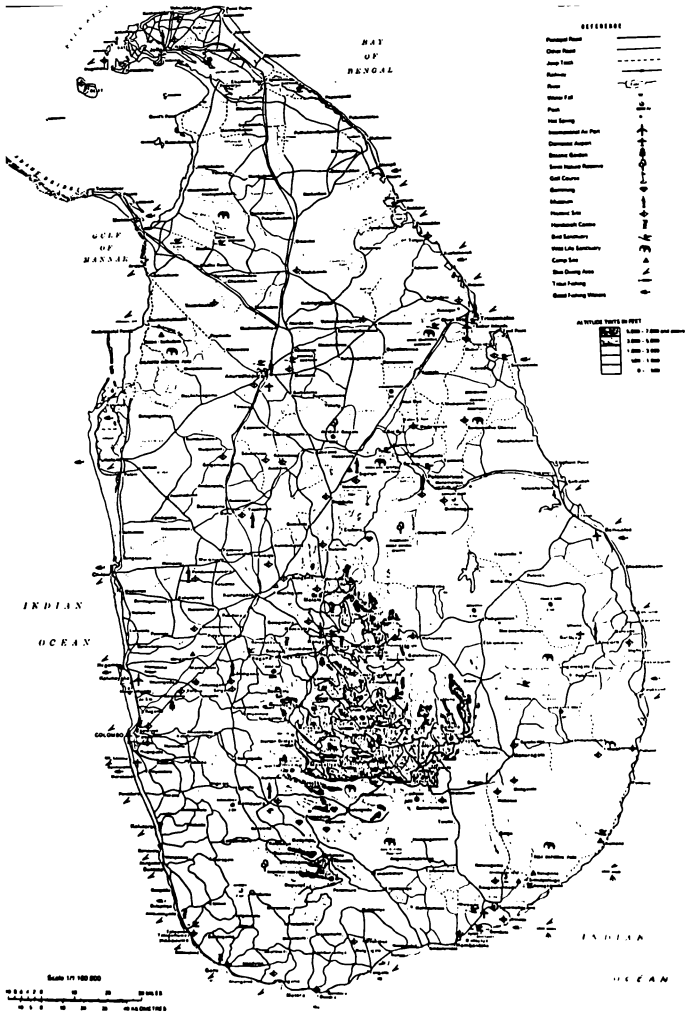
8. Impact of Marine Pollution on Society -Tippe & Kester

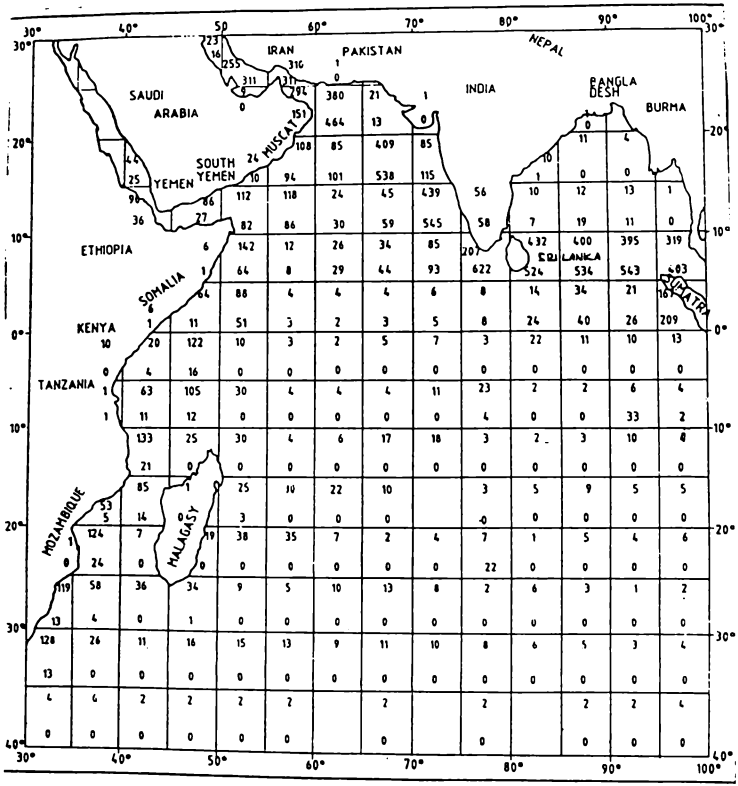
9. Handbook on Marine Pollution -Edgar Gold

10. Marine Pollution Prevention Act, No.59 of 1981 (Sri Lanka Government Publication)

11. Coastal Environmental Management Plan for the West Coast of Sri Lanka - United Nations

12. Response to Oil and Chemical Marine Pollution - D.Cormack


BAY
OF
BENGAL
GULF
OF
MANNAR
INDIAN
OCEAN
INDIAN
OCEAN
COLOMBO



ANNEX 3.2.1

Observations on oil slicks and other floating pollutants every 5° square in the Indian Ocean. The upper values indicate occasions when oil slicks were absent while lower values indicate occasions when oil slicks were sighted. Data collected 1975-1980, updated to 1984.
(Courtesy: Japan Oceanographic Data Centre)

ANNEX 4.3.5

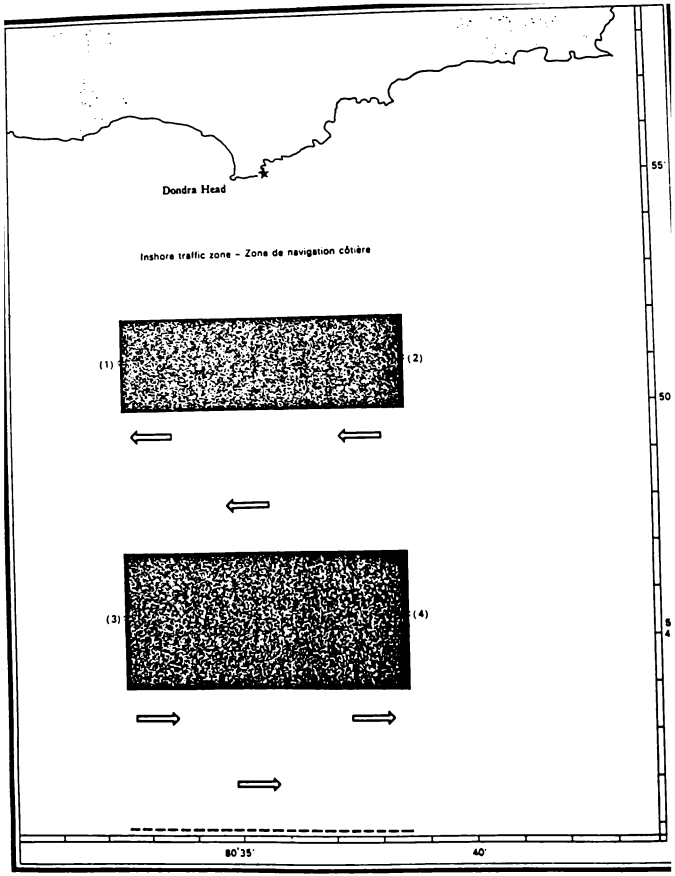
Major Treated Waste Discharges in the Lower Kelani Catchment

n from iver mouth	Location of effluent discharge	Name of Industry	Industry	Main components of effluents	Max. discharge (approx) Cu meters/day
1.2	Mattakkuliya	Ceylon Leather Products Corporation	Tannery - vegetable & chrome tanning	Salt renderings, oil, glue, hair, flesh, alkali, acid, chrome salts	50
1.5	Madampitiya	Madampitiya Sewage works	Sewage treatment	Untreated raw sewage - nearly 3/4 of city load	80,000
1.5	Madampitiya	Ocean & Food Trades	Food processing	Food processing wastes (organics) alkali, oil	100
	St. Sebastian Canal	British Ceylon Corp. Lever Bros., Sedawatte mills	Soup, vegetable, oils	Oil, sewage, alkali, cooling water	500
	St. Sebastian Canal	Ceylon Petroleum Corp., Kollonnawa	Storage and distribution	Oil, phenolics, washings	400
.2	Mattala	Ceylon Tyre Corp.	Motor vehicle tyres	Oil, cooling water	10,000
8	Kollonnawa	Kelani Tissa Thermal Power Stat.	Thermal power station	Oil, cooling water	30,000
	Sapugaskanda	Ceylon Petroleum Corporation	Crude oil refinery, Nylon proj.	Oils, sulphides, aromatics, phenolics, ammonia, cyanides, washings. Process wastes	4,000

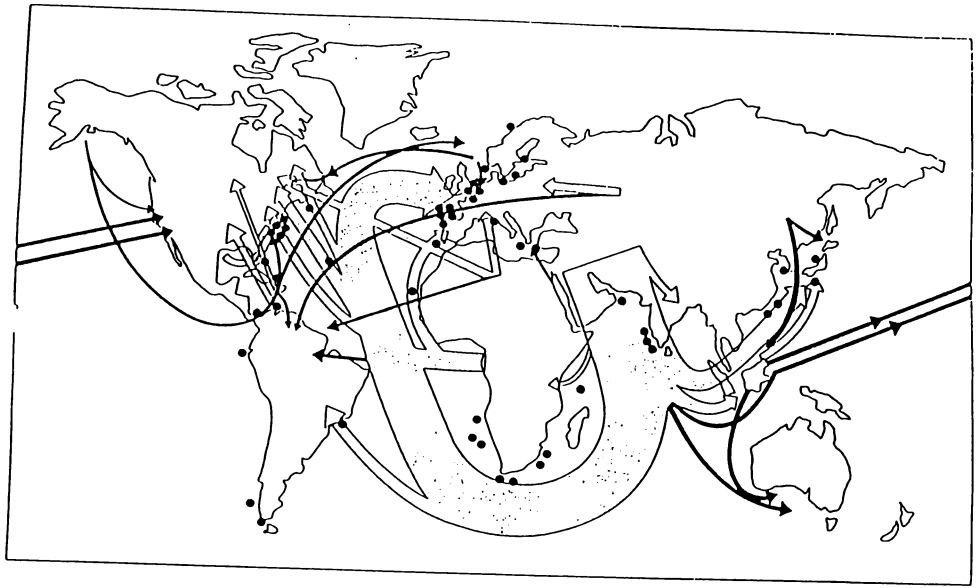
ANNEX 4.3.5 (CONT.)

Major Treated Waste Discharges in the Lower Kelani Catchment

km from river mouth	Location of effluent discharge	Name of Industry	Industry	Main components of effluents	Max. discharge (approx) Cu meters/day*
11.25	Sapugaskanda	State Fertilizer Manufact. Corp.	Urea from naphtha	Ammonia, urea, cooling water	9,000
12	Kelaniya	Tanneries	Vegetable and chrome tanning	see above	300
14.5	Ambatale	Water works Department	Water treatment plant	Wash water, alum floc and sediments	5,000
19.3	Kaduwela	Steel Corp., Oruwala	Steel rolling & wire drawing	Acid pickling waste, iron compounds washings	10,000
30.5	Hanwella	McCallum Breweries Migoda	Brewery	Process waste, bottle washings	250
33.8	GAL Oya	CMC Water works Labugama and Kalatuwawa	Water treatment plants	see above	1,200 4,500
37	Kosgama	Ceylon Plywood Corp., Wood working complex	Plywood, chip-board, furniture	Process and domestic waste	20,000



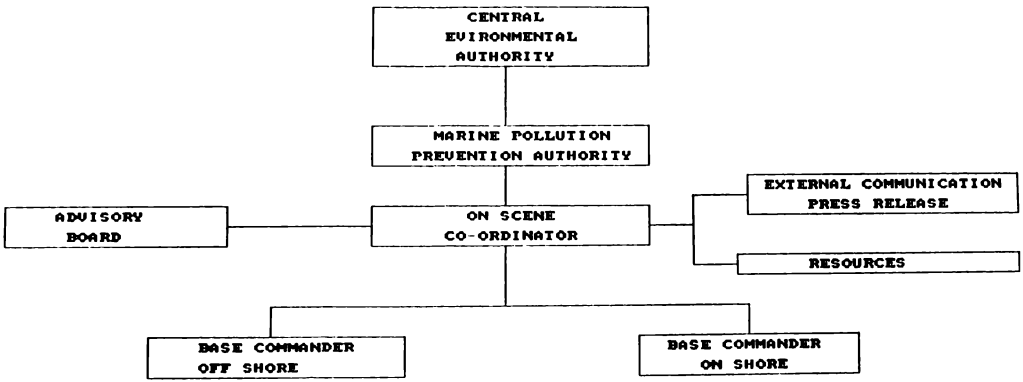
ANNEX 6.5 OFF DONDRA HEAD – AU LARGE DE DONDRA HE



Major oil movements and major tanker spills since 1974

ANNEX 7.0

RESPONSE ORGANIZATION FOR OIL SPILL CLEANUP CAMPAIGN



ANNEX 7.5