Marine pollution in Ethiopia

Abebe Araya

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MARINE POLLUTION

IN ETHIOPIA
MARINE POLLUTION IN ETHIOPIA

BY

ABEBE ARAYA

ETHIOPIA

A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of

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in

MARITIME EDUCATION AND TRAINING

(Marine Engineering)

Year of Graduation
1992
I certify that all the 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.

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Finally, I would like to express my sincere gratitude to my sponsors, the Carl Duisberg Gesellschaft (CDG) of Germany, and my employers, the Marine Transport Authority, for giving me the opportunity to study at this University.
One of the prominent problems facing the world today is Environmental Pollution — of land, sea and the atmosphere. Man's abuse and overuse of natural resources and his ignorance of the mechanisms of natural processes has led to the deterioration of the environment. Negligence and irresponsibility have in many instances caused irreparable damages.

For centuries mankind has exploited and polluted his environment without restraint. Massive deforestation is causing desertification. Industrialization has its side effects - ozone depletion, the green house effect, acid rain and marine pollution are the by-products of industrial development. Man may be destroying the environment he lives in, jeopardizing his future.

However, scientific researches and studies are leading to growing understanding of the environment and the implications of pollution. Today concern over environmental deterioration is increasing. International organizations like IMO have developed regulations such as MARPOL to prevent and control marine pollution. Nations are showing genuine interest in environmental matters.

Nevertheless, pollution is still regarded in many developing countries as a problem of industrialized nations. Furthermore, developing nations are too engrossed in their immediate economic and social problems to give serious attention to pollution. However, pollution is a world wide problem that they have to face sooner or later. For instance, most developing countries depend heavily on marine resources for their food, which pollution is threatening to destroy.
Ethiopia is a developing country with under-exploited marine resources which are vulnerable to marine pollution due to ship borne trade, coastal development and the major oil tanker traffic from the oil fields in the Persian Gulf. Ethiopia’s maritime infrastructure is ill equipped to prevent or combat pollution. Awareness of the causes and effects of marine pollution is still limited. Fortunately, no major pollution incident has occurred to date. Nevertheless, a major pollution accident can happen any time. The best way to counter the consequences of such an accident is to take appropriate measures to minimize its effects. Such measures need the setting up of an effective organization, the building up of technical capability, the preparation, implementation and enforcement of national laws and regulations, and educating people on environmental matters. The aim of this dissertation is thus to discuss the basic aspects of the environment, the causes of marine pollution in Ethiopia, their effects on the environment and to explain the measures that must be taken to prevent and control them.
GLOSSARY

Aerating  suppling with oxygen
Anaerobic  living in the absence of oxygen
Anoxic  inadequate oxygen content
Anthropogenic  induced by the activities of man
Biosynthesis  the production of a chemical compound by a living organism
Coalesce  unite, combine
Defoliation  causing of leaves to fall
Diffusion  to pass or become transmitted
Emulsion  mixture of two liquids not completely miscible
Eutrophication  over abundance of nutrients
Fauna  animal life
Flora  plant life
Intertidal  above low tide mark
Invertebrate  lacking spiral column
Phytoplankton  very small sea plants
Radioactivity  the emission of radiant energy
Sludge  muddy solid matter
Substrate  the base on which an organism lives
Thermocline  a sharp temperature gradient or change
Turbulent  agitated, not uniform flow
ABBREVIATIONS

BOD  biochemical oxygen demand
COD  chemical oxygen demand
CFC  chlorofluorocarbon
EEZ  exclusive economic zone
FAO  Food and Agricultural Organization
GESAMP  Group of Experts on the Scientific Aspects of Marine Pollution
HF   high frequency
IMO  International Maritime Organization
ITOPF  International Tanker Owners Pollution Federation
MEPC  Marine Environment Protection Committee
MSC  Maritime Safety Committee
MTA  Marine Transport Authority
OSC  on-scene commander
ULCC  ultra large crude carrier
UNDP  United Nations Development Programme
UNEP  United Nations Environment Programme
VHF  very high frequency
VLCC  very large crude carrier

UNITS

gC/m².yr.  gram carbon per square meter per year
mg/l  milli gram per litre
ml-O₂/l  milli litre of oxygen per litre
pCi/kg  pico curie per kilogram
pCi/l  pico curie per litre
ppm  parts per million
INTRODUCTION

For thousands of years Man has been interacting with the environment he lives in. For centuries he has been constantly struggling to develop his ability to utilize the natural resources available to him. In doing so he has changed his environment. With advances in the technological capabilities of Man the changes have become more drastic. In the majority of cases these capabilities have been and still are utilized in exploiting natural resources without giving due considerations to the irreversible changes that are brought upon the environment. Man's endeavour in subduing nature has been futile. Air pollution, marine pollution acid rains, global warming, deforestation, etc. are the by-products of man's attempt at taming nature. Needless to say pollution has become one of the major problems facing mankind today.

So what is pollution. Pollution may be defined as the introduction of substances or energy into the environment that result in damage to the natural and living resources or harm to human health. Certainly such a definition is oversimplified. Pollution is a wide and complex topic that requires a more detailed explanation. But before attempting to explain some of the many faces of pollution a brief look at the environment we live in is necessary.

The planet Earth is made up of complex and inter-related physical, chemical, biological and human cultural systems which interact with each other to form what we call the environment.

To fully understand the systems and their relationships requires the analysis of each system and the reconstruction of each as it fits in the environment. However, it is not the intent of this paper to give analysis of environmental systems. But a brief description of the most important systems is necessary to elaborate the links or
relationships that exist between them.

1.1 THE ENVIRONMENT

The four most important systems of the environment are the Atmosphere, the Lithosphere, the Hydrosphere and the Biosphere.

1.1.1 The Atmosphere

The atmosphere is a fluid system of gases and suspended particles which forms a gaseous envelope around the Earth. Its components are nitrogen, oxygen, argon, carbon dioxide and water vapour together with suspended particles such as water droplets, dust, soot and other minor gases.

The atmosphere acts as a filter for solar and other extra-terrestrial radiation. Moreover, it is a major source of oxygen, carbon dioxide, and nitrogen which are vital to the existence of living things.

1.1.2 The Lithosphere

The lithosphere is that part of the Earth that comprises the crust and the upper part of the mantle. The crust constitutes chemical elements from which the minerals and rocks of the lithosphere are composed. These elements are the basic nutrients from which plants and other microorganisms produce their food. Rocks formed from these elements are broken down by weathering into small particles which mix with organic compounds. The organic compounds come from death or excretion of living organisms. This mixture is called the soil. The soil system supports the life of plants, microorganisms and animals which make up the land-based biomass.
1.1.3 The Hydrosphere

The hydrosphere includes the oceans, seas, lakes and rivers. The oceans and seas are made up of water, crystalline rocks and dissolved minerals which have been carried down into them from the land. Because of the dissolved nutrients it contains, the hydrosphere is able to support the life of thousands of marine plants and animals.

1.1.4 The Biosphere

The biosphere consists of all the living organisms that inhabit the lithosphere, hydrosphere, and the atmosphere. The organisms in the biosphere are classified into the plant and animal biomasses which incorporate an enormous number of different kinds of organism. Each kind of organism is distinct and reproductively isolated from any other kind of organism.

The systems which were briefly discussed above are actively interacting with each other. Not a second passes without some form of energy transfer occurring between them. To give an example, a typical sea consists of a large number of different organisms, both plants and animals, each represented by a population of individuals. Each population occupies a certain amount of space. These organisms form a complex marine community growing and living together. The sea also contains air, sediments and rotting remains of once living things which are just as important to the marine community as the living organisms. Together they make up one environment which we call the Ecosphere. The living things in the ecosphere are interdependent. They are also dependent on the non-living things present in the ecosphere. The interdependence is
very important in the daily life and in the continuity of life of the living things. Therefore, a change in one system or group will have an effect on the other system(s) or group. Though the marine community was cited as an example here, similar interdependencies exist in other communities as well.

Under natural circumstances, environmental systems exhibit a state of equilibrium. They are capable of self-regulation within controlled limits. That is to say they are able to damp the amplitude of departures from the average state. However, in the course of time natural changes occur. Nevertheless these changes are slow and their effect is felt over a long period of time, usually in hundreds of years time. But the activities of man are probably shortening these periods and bringing changes faster than the existing ecosystem's ability to adjust. This could lead to drastic environmental changes that may destroy the existing natural equilibrium. (I.D. White, D.N. Mottershead, S.J. Harrison; H.V. Thurman)

As briefly explained above, the environment we live in is a set of very complex, inter-related, and interacting systems which must be seen and dealt with in unity. Man's interaction with the environment has to take into account the delicate equilibriums and relationships of these systems. Pollution violates the natural laws that govern the environment. Hence, Man's attitude towards his environment must change. He must learn to live in harmony with nature. His existence depends upon his ability to utilize natural resources without endangering the future of his species.

Ethiopia is a young maritime nation still attempting to develop its marine resources. This development may take a wrong turn by following the path of outdated development
wrong turn by following the path of outdated development concepts. As the world has belatedly come to realize development without giving due consideration to the environment is bound to fail. To avoid costly and probably irreversible mistakes developing countries like Ethiopia must change their approach to development and find ways of protecting their resources from further deterioration. Pollution is one form of environmental deterioration. Luckily, marine pollution is a minor problem in Ethiopia today. Nevertheless, unless measures are taken to prevent and control it from the start it may get out of hand very easily, with dire consequences.

The intention of this paper is to impart some basic knowledge about marine pollution and its effects on the environment and discuss ways of preventing and controlling it. It is hoped that this will bring to the attention of people concerned with the maritime activities in Ethiopia, and the public in general, the consequences of pollution.
CHAPTER II — THE SEA
THE SEA

2.1 INTRODUCTION

The sea covers approximately 70% of the earth’s surface area. It supports the lives of millions of organisms and is an important habitat providing 90% of the living space of the planet. Moreover, the sea is a major medium of transport as well as a significant source of minerals.

2.2 THE PHYSICAL CHARACTERISTICS OF THE SEA

The sea may be subdivided into regions in terms of depth and distance from the coast:
1. The "Littoral" region which extends immediately from the coast down to a depth of about 30m.
2. The "Continental Shelf" which extends down from the littoral region to a depth of about 130m.
3. The "Continental Slope" which descends rapidly from the continental shelf to depths of about 3000m.
4. The "Continental Rise" which is a gently sloping region at the end of the continental slope extending to depths of around 4000m.
5. The "Ocean Floor" or "Abyssal Plain" which extends from the base of the continental rise and reaches to depths of about 5000m.
6. The "Mid-Oceanic Ridges" which rise from the abyssal plains to about 2000m from the surface.
7. The "Hadal Region" which is the region of deep ocean trenches in the abyssal plain extending to depths of 6000m and in many cases upto depths below 10000m.

2.2.1 Temperature

The sea exhibits far less temperature variations than land.
With the exception of shore and shallow waters, the temperature range between the extreme hottest and coldest parts of the sea is around 30-35°C. Generally surface water varies in temperature from place to place and seasonally. For example, in low latitudes, except in semi-enclosed areas like the Persian Gulf and the Red Sea, the highest surface temperature is between 26°C and 30°C. However, the layers at the depths of the oceans have fairly constant temperatures.

2.2.2 Density

The density of sea water is slightly higher than that of fresh water. It ranges from 1.024 to 1.03 g/cm³ depending on salinity, pressure and temperature. In low latitude regions temperature is the predominant factor affecting the density of sea water. In areas of high latitude salinity may have a significant effect on density.

2.2.3 Viscosity

The viscosity of sea water depends on temperature and salinity. Increased salinity leads to higher viscosity. In low latitude regions the higher temperatures of the sea water reduce the viscosity but this may be counteracted by higher salinity in some areas. In regions of high latitude sea water is usually more viscous due to the lower temperatures.

2.3 THE CHEMICAL PROPERTIES OF SEA WATER

Sea water is a complex solution of fresh water and other inorganic chemicals. The chemicals are dissolved in water from rocks on land and delivered to the oceans via streams and rivers. Thus, sea water is a solution of many chemical elements which characterize its salty nature. Some of the
major elements (ions) contained in sea water are:
Sodium, potassium, calcium, magnesium, chlorine, bromine,
fluorine, sulphates and hydroxides.
The average saltiness or salinity of sea water is 35 parts
per thousand. It has been found that the chemical
composition of sea water is similar throughout the oceans
with only slight differences. Moreover, the salinity and
concentration of chemicals in sea water is constant, which
indicates that natural chemicals are introduced into the
sea in equal amounts as to those being removed. Most of the
natural chemicals deposited into the oceans are lost to the
sediments in the ocean floor and some are lost to the
atmosphere by evaporation.

2.4 THE BIOLOGICAL CHARACTERISTICS OF THE SEA

The marine environment is a habitat for hundreds of
thousands of living organisms. Due to its high stability
and chemical composition it is able to support the life of
simple single-celled plants and animals, and more complex
organisms. The water and the dissolved chemical nutrients
facilitate the existence of simple organisms. These
organisms do not require specialized organs to regulate,
support or adjust themselves to sudden changes in the
environment.
The distribution of living organisms in the sea primarily
depends on the availability of sunlight and food
(nutrients). Sunlight which is one of the basic
requirements for the production of food through
photosynthesis can penetrate the sea to a certain depth
only. Hence, marine plants, the primary food producers, are
restricted to grow near the surface to get sufficient
sunlight for photosynthesis. Moreover, chemical nutrients
carried by rivers into the oceans are mostly deposited near
the shore, thus living organisms are more abundant close to
the coasts. This zone is called the Neritic zone. It is
part of the Pelagic environment which encompasses the ocean water. Below the Neritic zone is found the Oceanic zone. This zone receives sufficient light in its upper boundaries to support photosynthesis and some plants are able to live there. Below the Pelagic zone is located the Benthic environment which constitutes the ocean bottom. The ocean bottom does not receive sunlight, thus can not support photosynthesis.

In general marine organisms may be classified as the Plankton which float on or near the sea surface, the Nekton which include all animals that can freely swim and move about in the sea, and the Benthos that live on or in the ocean bottom. (R.S.K. Barnes; R.V. Tait)

2.5 MARINE POLLUTION

2.5.1 Introduction

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

The marine environment is a major source of food for mankind. As world population increases the demand and consumption of sea-food will grow simultaneously. Notably the developing world depends on sea food for much of its protein. The terrestrial environment, though it is the primary source of food, is not reliable. The ever changing climate, floods, drought, etc. and man’s misuse of land resources have limited its productivity. However, the
marine environment is far less affected by climatic changes and can be the most important source of food for the future if properly handled. Moreover, marine organisms not only serve as food but are also part of the natural beauty of the sea. Coastal areas are an important tourist attraction which generate substantial revenues.

2.5.2 CAUSES OF MARINE POLLUTION

The major causes of marine pollution are:
A) Sewage and other wastes
B) Oil
C) Chemicals
D) Nuclear wastes and
E) Atmospheric gases

A) Sewage and other wastes

Sewage and other land-based wastes are the main marine pollutants. Ports, coastal towns, industries and agricultural areas are the primary sources of these pollutants. Most ports are situated on estuaries, hence, urban and industrial wastes may be discharged directly into the estuaries. Inland industrial wastes can be carried by rivers into the sea. Coastal towns and industries usually discharge their sewage and wastes into the sea. Runoff of fertilizers and insecticides from agricultural areas, caused by rainfall, drains into rivers and eventually ends up in the sea. It is estimated that 44% of the global marine pollution originates from land-based sources (GESAMP 1990).

B) Oil

The main sources of oil pollution are ships, refineries, offshore platforms and dry docks.
Ship wrecks and collisions, though they do not happen frequently, may cause extensive pollution when they occur. Routine ship operations such as loading and unloading by tankers, oil tank cleaning, leakages, engine room bilges, dry docking, etc. cause a great deal of pollution. It is estimated that 1.5 million tons of oil is entering the sea every year from these sources alone (IMO, 1989).

Offshore platforms may discharge a considerable amount of oil in a blow out. However, oil enters the sea from platforms mostly during routine drilling operations.

Refineries discharge oil into the sea as a result of cooling operations and from leakages in pipelines and occasionally from storage tank explosions. The above sources are believed to cause around 13% of the total marine pollution in the world (GESAMP 1990). It should be noted, however, that oil pollution is also caused by, atmospheric fallout of hydrocarbon emissions from vehicles, natural seeps from oil deposits close to the earth's surface, and biosynthesis of plant remains which become fossilized under marine conditions.

C) Chemicals

The chemicals referred to here are the hazardous substances other than oil which are carried by dry bulk carriers, liquid chemical tankers, container and general cargo ships. Chemicals carried by dry bulk carriers include fertilizers and sulphur. Those transported by liquid chemical tankers include petrochemicals, sulphuric acid, caustic soda solution, etc. Chemicals carried on container and dry cargo ships include pesticides, weed killers, and tetra-ethyl lead. Accidents related to ships carrying chemicals have occurred occasionally. Some of the chemicals are very toxic. They
can cause considerable damage to marine life and are hazardous to human health.

D) Nuclear Wastes

Nuclear wastes originate from nuclear power and fuel reprocessing plants, nuclear weapons testing and to some extent from nuclear-powered ships and submarines. Nuclear power and fuel reprocessing plants use a large amount of cooling water. The water is contaminated by radioactivity from the nuclear fuels. The cooling water is discharged into rivers and estuaries or directly into the sea. The discharge also contains radioactive liquid wastes resulting from handling of used fuel rods from reactors. Nuclear weapons testing has introduced some 200 radioisotopes to the environment. These find their way to the sea through fallout.

However, radioactivity also occurs naturally. The sea contains radioactive isotopes of the chemicals dissolved in it. Sea water has a radioactivity of about 340 pCi/l. Marine sands have a radioactivity of 5000 to 10000 pCi/kg and marine muds 20000 to 30000 pCi/kg (R.B CLARK).

E) Atmospheric Gases

Gases emitted to the atmosphere from various land-based industries, vehicles and ships find their way to the sea through fallout and precipitation. These gases include oxides of carbon, sulphur, nitrogen, petrochemicals and other hydrocarbons. Volcanic eruption fallout and, as mentioned earlier, fallout from nuclear explosions also find their way to the sea from the atmosphere.

It is estimated that the atmosphere is the source for about 33% of the pollutants to the marine environment (GESAMP 1990).
2.5.3 EFFECTS OF MARINE POLLUTION

A) Health Risks from Sewage and Organic Wastes

Human sewage contains bacteria, pathogens, viruses and the eggs of intestinal parasites. When sewage is discharged into the sea, without treatment, the parasites mentioned above may contaminate the water posing threat to public health. Incidents of typhoid, hepatitis, gastro-intestinal diseases and respiratory diseases have been connected to sewage contamination of sea water. People bathing in sea water near sewage fallouts or eating sea food harvested from these areas are prone to these diseases.

Organic wastes enrich the sea area they are discharged into with nutrients. Luxurious growth of phytoplankton occurs in these areas. However, some of the phytoplankton contain dangerous toxins. For example, bivalve molluscs accumulate these toxins without any risk to themselves but present a serious hazard to those that feed upon them. These toxins cause nausea, loss of balance, defects of vision, and in severe cases, convulsions and death in human beings.

B) Biological Effects of Sewage and Waste Disposal at Sea

Sewage and organic wastes discharged into the sea contain nitrates and phosphates in large amounts. If the discharge is relatively small the nitrates and phosphates enrich the nutrient content of the sea thus enhancing the growth of phytoplankton and other planktons. However, large quantities of sewage and waste lead to over enrichment of nutrients which results in the enormous growth of phytoplankton but retards the growth of other plankton. This is caused by the depletion of oxygen at or near the surface by the enormous growth of phytoplankton, which deprives the rest of the community of oxygen resulting in
the death of many zooplankton and other animals.

C) Health Risk From Oil Pollution

Direct ingestion of some petroleum hydrocarbons by humans may cause serious illness or even death though incidents of such nature occurring due to marine oil pollution are rare. But there are reports indicating fin erosion in fish and tumours in some molluscs in areas heavily polluted by oil. Moreover, oil contains some compounds which are toxic to marine organisms. Eggs, young animals and some marine plants have been known to die from oil toxins. Sea birds, however, seem to be the most affected by oil pollution. Thousands of birds die every year due to oiling.

D) Commercial Damage from Oil Pollution

Oil pollution damages shell fisheries the most. Shellfish beds are heavily contaminated by oil and the damage may persist for several years. Fish tainted by oil are generally repulsive to the human taste and therefore cannot be sold on the market. The tourist industry is also greatly affected by oil pollution. Tourist resorts suffer dearly when their beaches are polluted by oil. The cost of beach cleaning can be beyond the means of the industry.

E) Health Risk from Chemical Pollutants

Different chemicals present different health risks when discharged into the sea. For instance, mercury is toxic to both plants and animals in the sea. Its toxicity becomes lethal as a result of bioaccumulation and biomagnification in the higher organisms in the food chain. Mercury is said to cause convulsions and loss of neuromuscular co-ordination in humans. Halogenated hydrocarbons such as
DDT are suspected of causing the thinning of eggs in some birds which results in breakage during incubation. Polychlorinated Biphenils (PCBs) reduce the hatchability of eggs in birds and cause reproduction failure in seals.

F) Health Risk from Radioactive Pollutants

Radioactive substances discharged into the sea may be ingested by marine organisms. Radioactive substances, like their stable isotopes, can be bioaccumulated thus posing a health threat to higher organisms in the food chain. Exposure to radioactive substances causes leukemia, cancer of the bone, thyroid, and lungs in humans. (R.B.Clark)

As explained briefly above the marine environment is a complex environment which is sensitive to external activities, especially human activities. 75% of the world population lives in coastal areas. This has led to the rapid industrialization of coastal areas. Industries produce a lot of waste which is discharged into the sea. Coastal developments have destroyed marine habitats like wetlands, mangroves and coral reefs. Though the oceans are vast and capable of assimilating a large amount of waste, there is a limit to the amount they can absorb in a specified time and area. If humans are to ensure the continuous use of the biological resources of the sea then the policies and strategies governing present technological practices of production and waste management must change. The world has to revise its concept of development or ignore it and face the consequences of pollution.

In recognition of the threat of marine pollution to the environment a number of international agreements have been developed and ratified by many nations. A few examples are The Law of the Sea Convention, MARPOL (73/78), LDC, regional agreements like the PARIS and OSLO conventions, and UNEP's regional seas programmes.
The question now is how effectively are these agreements being executed. How willing and determined are states to implement these conventions. Is the cost of implementing some of the conventions too high, especially for developing nations. How willing are states to co-operate with each other.

To answer these and other related questions is not an easy matter and it is out of the scope of this paper. However, the questions point to some of the basic problems which need genuine responses.

In the following chapters marine pollution in Ethiopia will be discussed. The topics will look into the problems of marine pollution in the coastal areas of the country and assess measures taken to control or prevent it and suggest ways of improving the methods of control and prevention.
3.1 INTRODUCTION

The Red Sea is one of the oldest seas mentioned in recorded history. The Bible and ancient Egyptian and Greek histories contain some reference of the Red Sea. The Red Sea was an important trade route for ancient Egyptians, Greeks, and Romans who traded myrrh, frankincense and spices with the land of "Punt" and India. Over the centuries, the Red Sea developed to an important sea route for Arabs and Turks in their trade with India. In modern times it is a major traffic artery linking the Middle East and the Far East to Europe.

The Red Sea was given several names in different languages but the present name stuck due to European influence. The name Red Sea probably came from the red coloured pigment of the extensive blooms of the algae Trichodesmium Erythreum which occasionally occupy the sea. However, the name may also reflect to the red colour of the sea and the surrounding mountains during sunset.

3.2 PHYSICAL AND CHEMICAL FEATURES

3.2.1 Location and Size

According to the International Convention for the prevention of oil pollution from ships the "Red Sea" area includes the Red Sea proper, the Gulfs of Suez and Aqaba in the north and the Strait of Bab al-Mandeb in the south. Thus, the Red Sea extends south-eastward from Suez (at 30\(^\circ\) N) for about 1930 kms to the Strait of Bab al-Mandeb (at 12\(^\circ\) 30'N).

The width of the Red Sea increases from north to south. The maximum width is 360 km at 16\(^\circ\) N. The average breadth
is 280 km. The average depth is 490 m, though depths over
2500 m have been recorded between 22° and 19° N. It covers
an area of approximately 438,000 m².

3.2.2 Climate

The Red Sea area is very hot. Mean annual temperatures
range from 22°C in the north to 30°C in the south. The area
is very humid in the summer. The northern part of the Red
Sea has northerly and northwesterly winds for most of the
year while the southern part gets northerly winds in the
summer and southerly winds in the winter. Rainfall is
scarce in the Red Sea area. Average rainfall is less than
20 cm a year.

3.2.3 Sea Temperature and Salinity

There are practically no rivers flowing into the Red Sea
except one from the Sudan. Due to the high temperatures of
the area evaporation loss is high, more than 200 cm a year.
Hence, salinity is very high, from 40 to 41 parts per
thousand.

Surface and sea temperatures are relatively high in the Red
Sea. Surface temperatures reach 31°C during August and 26°C
in February in the south, and 26°C in August and 19°C in
February in the north. The temperature of the deep water is
around 21°C even at depths of 1000 m.

3.3 BIOLOGICAL FEATURES

The flora and fauna of the Red Sea are mainly of tropical
origin similar to those found in the Indian and Pacific
oceans. However, plants and animals of Mediterranean origin
are also present, especially in the northern part of the
Red Sea. The tropical plants of the Red Sea include some
flora which are present in coral reefs and mangrove
forests. The coral reef ecosystem plays a major role in the life of plants and animals of the Red Sea. Red Sea coral reefs have two forms. They are either of the coral island type or coast fringing reefs. Coral reefs are a haven and food source for many organisms like sponges, sea-urchins, sea-cucumbers, starfish etc. The Red Sea is a habitat for some 500 to 1000 different kinds of fish. (R. Lapidoth-Eschelbacher)

3.4 PRODUCTIVITY

The upper layers of the Red Sea (the epipelagic zones) are relatively poor in nutrient content. There are no significant nutrient rich upwellings in the region and there is little input of freshwater and associated run-off of nutrient rich soil material (UNEP. N.64). This limits the numbers of higher animals the open sea can support.

3.5 OXYGEN CONTENT

The amount of oxygen dissolved in sea water is determinant in the primary production of marine plants. The concentration of oxygen that can be dissolved in sea water depends on temperature and salinity. The higher the temperature and salinity the less the oxygen that can be dissolved in sea water. Hence, the amount of oxygen in the Red Sea is less than in the cooler and less saline seas. The amount varies from 4.5 ml-O$_2$/l in the northern part to 4.0 ml-O$_2$/l in the southern part of the sea. Thus the amount of O$_2$ limits the production of phytoplankton and affects the rest of the community indirectly. (A.J. Edwards & S.M. Head).
3.6 THE ETHIOPIAN RED SEA COAST

3.6.1 History

One of the largest countries in the Red Sea region, Ethiopia has an area of about 1.2 million km². It has a coast of 1011 km from north to south. The Ethiopian territory includes the Dahlak Archipelago off the coast of Massawa and the islands of Fatma and Haleb in the south near Assab.

Known history of ancient Ethiopia (also known as Abyssinia) dates back to 2000 B.C. The kingdom of Axum, forerunner of present Ethiopia, was a trading nation which had ports in the Red Sea coast. In its hey days the Axumite kingdom controlled the southern Red Sea even occupying Yemen on the opposite coast. The Axumites traded with the Egyptians. They exchanged pearls, incense, ivory, gold, monkeys and peacocks with copper and other artifacts from the north. During this time Adulis and Zula near Massawa in the north developed into commercially important centers. Their importance continued up to around the 6th century A.D. after which the Axumite civilization declined. However, after the decline of the kingdom sea trade still continued between these ports and Yemen, though at a lower level. The advent of Islam led to the isolation of Abyssinia which was largely Christian at that time. The importance of the ports further declined. Since then the coastal region which had been under the rule of Axumite kings fell under the control of Ottoman Turks and Egypt and later in the 19th century was colonized by Italy. After World War II the region came under British occupation which ended when the region was federated and later united to Ethiopia.

During the Italian colonial period the present ports of Massawa in the north and Assab in the south emerged as the main ports.
3.6.2 PHYSICAL ENVIRONMENT

3.6.2.1 The Coastal Zone

The Ethiopian Red Sea coast, as is the case in the rest of the Red Sea coasts, is characterized by mangrove stands and along the Dahlak islands by coral reefs. The coastal waters are fairly shallow averaging a depth of 100 m with a deeper coast north of Massawa. Though the marine fauna and flora of the Ethiopian coast is expected to be similar to the rest of the Red Sea coasts, no adequate information exists on the extent of species distribution and critical habitats like corals, mangrove stands and sea grass (UNEP, N.64).

A) Temperature

As is typical of the Red Sea coasts, the average temperatures in the Ethiopian coast are high. For instance, the mean monthly air temperature of Massawa for the winter months is about 27°C and for the summer months it is around 33°C.

B) Humidity

The Ethiopian coast and generally the southern Red Sea coast have high average humidity values ranging from 60% to 80%.

C) Rainfall

The Ethiopian coast receives very little rain. The southern part receives little or no rain during the whole year. The northern part receives some rain, usually not more than 150
mm per year during the months of October to February.

D) Winds

North-east monsoon winds prevail in the period from July to September and south-west monsoon winds from October to March over the southern coast. However, in the northern part north-east winds are more prevalent.

E) Tides

Average tidal range has been observed to be in the region of 0.9 meters both at Massawa in the north and Assab in the south (T.M.Haves).

3.6.3 PRODUCTIVITY

As stated earlier the Red Sea has low productivity. However, though there have been limited studies carried out it is believed that the coasts of Ethiopia and northern Yemen have greater marine productivity than the northern Red Sea coasts (A.J.Edwards & S.M.Head).

3.6.4 FISHERY

Ethiopia’s fishery is currently at subsistence level. The Red Sea fishery which used to have outputs of around 25000 tons annually is now reduced to about 400 tons per annum. This decline was caused by the political situation in the country. The catch consisted mainly of herring, anchoveta, grey mullets, jacks, snappers, groupers, emperors and queen fishes (FAD, 1983b). If properly and fully exploited the fishery could produce more than double the previous maximum of 25000 tons. Ethiopian and FAD experts estimate that 66000 tons of fish per year could be produced of which 50000 tons would be sardine and anchovy, 5000 of shark.
10000 of other food fish and 600 tons of shrimp and lobster (T.M.Hayes). Needless to say this can provide the population with much needed protein.

3.6.5 COASTAL DEVELOPMENT

The Ethiopian coast, with the exception of Massawa and Assab, is dotted by small fishing villages and settlements. Owing to the harsh climatic conditions large settlements or towns have not developed. The ports of Massawa and Assab currently have only around 50000 inhabitants each. Massawa and Assab are the main ports for import and export of commodities of the country. Nearly 85% of all imports and exports pass through these ports. Major activities in the ports are mainly related to the handling of cargo. Other industrial activity is limited—un hospitable climatic conditions being one of the causes. At present Massawa has one cement factory, one diesel power station, two small fish meal factories, and one salt production facility. Assab has one oil refinery, two diesel power stations, and one salt production facility.

3.6.6 TOURISM

Foreign tourism is virtually non existent. Due to its proximity to the hinterland, notably to the city of Asmara, Massawa has some local tourism. Currently one tourist class hotel and other small hotels cater for local tourists. The main attraction in Massawa is the sandy beach of Gurgusum and the Dahlak islands. Assab on the other hand is very remote from the hinterland and practically has no tourism of any sort. The hotels cater mostly for business people.

3.6.7 SOURCES OF MARINE POLLUTION

The main sources of marine pollution in the Ethiopian coast
notably in the Massawa and Assab areas, are the municipality sewerage systems, the power stations, the oil refinery in Assab, and the shipping industry. Other coastal settlements contribute little to marine pollution.

A) Municipality Sewage and Waste Water

Massawa and Assab discharge their sewage and waste water into the sea without treatment. Both towns do not have adequate waste water and sewerage systems. Most of the towns' sewage and waste water is collected in septic tanks and pit latrines.

B) Power Stations

Power stations use a lot of oil for lubrication. The power stations at Assab and Massawa discharge used oil into the sea without any sort of treatment.

C) Oil Refinery

The Assab oil refinery discharges effluents into the sea. Moreover, pipes and storage tank leaks and breakages also contribute to the oil pollution. In addition, spills from discharging and loading terminals and bunkering terminals contribute to the oil pollution.

D) Ships

Ship traffic to and from the ports represents the major pollution threat to the area. Spillages, bilges, tank washing and dirty ballast pose significant pollution threat.

Knowledge of the physical, chemical and biological characteristics of the Red Sea, or of any sea for that
matter, is essential in determining the effects of pollution on that particular environment. Physical and chemical properties of the sea affect the fate of spilled oil. The living resources in the sea respond differently to pollution according to their biological characteristics. Further, knowledge of these characteristics is essential in choosing the right methods and techniques for effectively and safely fighting or controlling pollution.

Since the most important pollutants in the Ethiopian coast are oil and land-based sewage the two will be discussed in some detail in the following chapter.
CHAPTER IV

SEWAGE AND OIL POLLUTION
4.1 SEWAGE POLLUTION

4.1.1 INTRODUCTION

As noted earlier, sewage represents the largest volume of waste, from land-based sources, discharged into coastal waters, rivers and estuaries. Sewage is primarily organic in nature. Upon discharge it is degraded by bacteria resulting in the oxidation of organic molecules to stable inorganic molecules. When sewage enters the sea or river the aerobic bacteria present in the water utilize dissolved oxygen to degrade the organic molecules in the sewage. A typical oxidation result may be chemically written as:

\[ C_6H_{12}O_6 + 6O_2 = 6H_2O + 6CO_2 \]

The organic molecule, glucose, is oxidized by aerobic bacteria to form water and inorganic carbon dioxide which are stable compounds (R.B.Clark).

Aerobic bacterial activity reduces the amount of dissolved oxygen in the water which will in time be replenished by the uptake of oxygen from the atmosphere.

Anaerobic bacteria also degrade organic waste, without the use of oxygen. However, this process is slow and produces toxic end-products such as hydrogen sulphide and methane. Sewage is composed of complex organic chemicals which require different amounts of oxygen for complete degradation. To analyze the exact composition of sewage is extremely difficult. Thus, indirect methods are used to determine the amount of oxygen required for complete oxidation of sewage material. The analysis of the amount of oxygen needed to degrade sewage is important because it helps in determining the quantity and quality of sewage
that can safely be discharged into the water without seriously depleting the oxygen. Depletion of oxygen will result in the death of those organisms living in the water which depend on oxygen for respiration and photosynthesis. There are two indirect methods of measuring the oxygen demand for complete oxidation.

4.1.2 CHEMICAL OXYGEN DEMAND (COD)

COD is measured by adding potassium permanganate or potassium dichromate with sulphuric acid to a sample of sewage material. The sample is then analyzed after a standard interval of time to determine the amount of oxidant remaining. From this the amount of oxidizable material in the sample can be calculated. Hence, the quantity of oxygen required to degrade the material can be determined.

4.1.3 BIOCHEMICAL OXYGEN DEMAND (BOD)

BOD is determined by measuring the oxygen concentration before and after bacterial digestion of the sample of sewage material. Bacteria and nitrates may be added to the sample if necessary. This gives a direct measure of oxygen utilization in bacterial degradation of the sample. BOD is now the standard method of measuring pollution load of organic sewage effluents. (R.B.Clark)

The amount of sewage material that can be discharged safely into the sea depends upon the oxygen concentration in the sea, the viscosity and speed of the water, and, the size and density of the sewage particles. Normally sea water can oxidize sewage material with a BOD of about 8.0 -8.5 mg/l. However, sewage material usually has a BOD far more greater than this, usually about 500 mg/l (R.Johnston). Therefore, to minimize sewage pollution
it must be diluted in some way. If the sewage is discharged into a large volume of water with sufficient movement for mixing, then the problem can be minimized. Another problem affecting sewage pollution is the size and density of sewage particles. Large sized particles of sewage tend to settle to the bottom. Hence, if the appropriate dilution factor is to be determined the settlement characteristics of the sewage must be known. The amount of oxygen dissolved in sea water also determines the rate of sewage oxidation. Oxygen concentration fluctuates with the amount of sunlight during the day. In summer photosynthetic activity by plants increases the content of oxygen dissolved in the water. In winter, long nights reduce photosynthesis, thus, oxygen is not supplemented. However, high water temperature which is usual in summer decreases the amount of oxygen dissolved in water. But low water temperature in winter tends to increase the oxygen concentration.

To summarize, the amount of sewage that the sea can accept depends on the physical and chemical properties of the sewage, and on the topographic and hydrographic characteristics of the sea itself.

4.1.4 SEWAGE DISPOSAL IN THE ETHIOPIAN RED SEA COAST

The main urban areas of Massawa and Assab dispose of their sewage directly into the sea without any treatment. The sewerage systems are not well developed. In Massawa only part of the town is connected by sewage pipe lines. This system directly discharges into the sea near the shore. The rest of the town discharges its sewage into pits and septic tanks. Moreover, open air defecation is common both on land and near the shore. During the rainy season this is washed into the sea. Assab has practically no sewerage system. The town’s sewage is collected in pits and septic tanks. Most of the sewage
is absorbed by the soil and in areas near the coast it seeps into the sea. Open air defecation is also common. As in Massawa, during the occasional torrential rains, this is washed into the sea.

4.1.5 IMPLICATIONS OF SEWAGE POLLUTION IN THE RED SEA

The Red Sea is a semi-enclosed sea with limited interaction with the Indian Ocean and the Mediterranean Sea. No significant upwellings exist to aid in mixing. Because of these reasons the time taken for pollutant dispersion is relatively long. Moreover, the Red Sea is a very warm sea. Due to the high temperature of the sea the amount of oxygen dissolved in the sea is very low. This limits the amount of pollutants that the bacteria in the sea can degrade. Sewage discharged into the sea is known to enhance the growth of phytoplankton as it contains large quantities of nitrates and phosphates. The growth of abundant phytoplankton benefits the rest of the food chain. However, excessive sewage discharge may lead to eutrophication, i.e. over-abundant phytoplankton growth. This uses up the already low amount of oxygen as the vegetation decays. Thus, the existence of other organisms can be seriously affected.

In prolonged warm weathers a thermocline may develop separating the cold and dense bottom water from the warm surface layer. The deep layers are then cutoff from oxygen replenishment from the atmosphere (R.B. Clark). The Red Sea experiences occasional seasonal thermoclines that may cause serious oxygen depletion in the deep layers where bacterial degradation of sewage material uses up the oxygen. Hence, the likelihood of anoxic conditions being created at the bottom layers, if a large amount of sewage is discharged into the sea, is increased by such thermoclines. Though no records exist of anoxic conditions.
created by thermoclines in the Red Sea, thermoclines have killed off a large amount of benthic animals in the Atlantic Ocean and the North Sea near sewage outfalls. A strong thermocline developed in the spring and summer of 1976 near the New York sewage dumping grounds. Bottom oxygen concentrations were reduced over an area of 1200 km². It is estimated that 143,000 tons of the clam Spisula were killed as a result. Similarly heavy mortality of bottom fauna were observed in the North Sea in 1975 (R.B.Clark).

Such conditions could have dire consequences to the Red Sea fisheries.

As explained above the Red Sea is very sensitive. Therefore sewage disposal must be carefully monitored. The present practice of sewage disposal in Massawa and Assab is hazardous, both to marine life and humans. The ports of Massawa and Assab are fast expanding in size and population. The present drive by the state to modernize these ports is attracting a lot of investment and with it settlers. Furthermore, in the event of the discovery of oil in the area an economic boom may follow entailing further industrial and population growth. This will inevitably lead to sewage disposal problems. At present the coast is relatively clean. Sudden economic growth may, however, change the situation. Uncontrolled sewage disposal poses some health risk besides eutrophication. Typhoid fever, hepatitis and intestinal diseases are not uncommon in Massawa and Assab. These diseases are associated with bathing in sewage contaminated waters and eating sea food coming from such areas.
4.2 OIL POLLUTION

4.2.1 INTRODUCTION

Oil is a complex mixture of hydrocarbons. Crude oil is a mixture of a large number of organic chemicals. These organic chemicals contain from 4 to 26 or more carbon atoms per molecule. These chemicals may vary in composition from light volatile liquids or oases to those that are heavy and waxy or semi-solid and tarry. The lighter volatile chemicals are mostly very toxic and chemically active while the heavier ones are less toxic and relatively inert.

4.2.2 EFFECTS OF OIL IN THE SEA

Crude oils vary widely in physical properties and chemical composition. For instance, crude oil from Kuwait differs from North Sea crude oil. The toxicity of different fractions of crude oil increases from paraffins to naphtalenes and olefins to aromatics. Moreover, within a series of hydrocarbons the smaller molecules are more toxic than the larger ones. However, the less toxic and heavier fractions are more persistent than the lighter toxic fractions.

When crude oil is spilled into the sea its composition changes quite rapidly due to evaporation and dissolution of the lighter fractions. (R. Johnston)

The variety of compounds released in different proportions affect the plants and animals exposed to them to varying degrees. The organisms’ maturity, age, time of year, and other factors affect their susceptibility to oil pollution damage. The toxins contained in oil may immediately damage eggs, microplanktons and the young fauna. Oil which has not been removed by evaporation sinks down to the bottom of the sea and is incorporated in the sediments. This oil can kill bottom feeding animals like crabs, shrimps, lobsters, and
bivalves. Sedimented oil is persistent and may contaminate commercial shellfish beds for several years. Oil pollution at times kills off some organisms and brings about change in the ecosystem of the polluted area. Due to the absence of the eliminated organisms other organisms may start to thrive. This can change the original food chain thus, affecting the higher animals in the community. Such occurrences are known to have caused decrease of commercial fish in some polluted areas.

4.2.3 OIL INPUT INTO THE SEA

World wide oil input from major sources has been estimated to be around 5 million tons each year. The following is a breakdown of the different inputs that make up the total.

<table>
<thead>
<tr>
<th>Transportation:</th>
<th>in millions of tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>tanker operations</td>
<td>0.60</td>
</tr>
<tr>
<td>tanker accidents</td>
<td>0.30</td>
</tr>
<tr>
<td>dry docking</td>
<td>0.25</td>
</tr>
<tr>
<td>other shipping operations</td>
<td>0.12</td>
</tr>
<tr>
<td>other shipping accidents</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Fixed Installations:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>offshore oil production</td>
<td>0.06</td>
</tr>
<tr>
<td>coastal oil refineries</td>
<td>0.06</td>
</tr>
<tr>
<td>terminal loading</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Other Sources: in millions of tons

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>industrial waste</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>municipal waste</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>urban run off</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>river run off</td>
<td>1.40</td>
<td></td>
</tr>
<tr>
<td>atmospheric fall out</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td>natural seeps</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4.94</strong></td>
<td></td>
</tr>
</tbody>
</table>

(Source: R.B. Clark)

As can be gathered from the above statistics quite a considerable amount of oil is added into the sea intentionally or by accident.

With increasing industrialization and development oil consumption is mounting globally. World oil consumption was over 63 million barrels per day in 1988. World tanker fleet, though smaller in quantity than a few years ago, has increased dramatically in size. In the 1950s ships of 30,000 dwt were regarded as very large. Today tankers of 200,000 dwt are common place with nearly 400 of their size or over in operation (IMO, 1989).

Though the decrease in the number of ships has lowered the number of accidents, the increased size means more oil is carried per ship than before. Nowadays large bulk carriers, other than tankers, carry more bunkers than a 20,000 dwt tanker.
Accidents or collisions can be disastrous to the surrounding area particularly if the area is environmentally sensitive. The Torrev Canyon (1967), the Amoco Cadiz (1978) and the Exxon Valdez (1989) accidents are vivid examples of catastrophic consequences of accidental oil pollution. However, routine tanker and shipping operations, industrial activities, municipal wastes and atmospheric fallout contribute a lot more to the input of oil into the sea than accidents. Heavy concentration of pollutants in ports, harbour and coastal areas, where wind and tide tend to accumulate such matter give rise to chronic pollution problems that lower the aesthetic and recreational value of coast lines besides creating a risk to public health and marine life (IMO, 1989).

4.2.4 OIL INPUT INTO THE RED SEA

Currently the Middle East is the largest oil producing area in the world. About 30% of the world's oil production is from the Middle East. This trend is likely to continue as an estimated 55% of the globe's proven reserves of oil are located there. The northern part of the Red Sea including the Gulf of Suez is one of the fastest developing oil production areas. The majority of production and new exploration is mostly off shore.

Since the time the Suez Canal was widened and deepened the amount of crude oil passing through the Red Sea from oil fields in the Persian Gulf and the Red Sea itself has increased. About 100 million tons of crude oil per annum passes through the Gulf of Aden, the Red Sea and the Suez Canal on its way to the refineries in Europe. Clearly there exists a potential danger of pollution from production and transportation. Along the Egyptian and Saudi Arabian Red Sea coasts, and the Gulf of Suez, oil pollution is becoming a serious
problem. Many kilometers of coast line, sand beaches and fringing coral reefs are severely oiled (A.J. Edwards and S.M. Head).

4.2.5 OIL INPUT INTO THE ETHIOPIAN RED SEA COAST

At present the main sources of land-based oil input into the Ethiopian coast are the oil refinery and the power stations at Assab and Massawa. Oil tankers and dry cargo ships calling at these ports are the other causes of oil pollution in the area. They cause more oil pollution than the land-based sources.

A) The Assab Oil Refinery

The oil refinery at Assab was established in the 1950s by the Ethiopian government with assistance from the government of the U.S.S.R. The refinery is the sole petrochemical industry in the country. It produces:

1. Gasoline of various grades
2. Liquified petroleum gas
3. Kerosene and jet fuel
4. Automotive and industrial diesel
5. Fuel oils including bunker
6. Lubricating oils and

The effluents from the various processes in the refinery pass through separator systems, treatment plants and settling ponds before being discharged into the sea. The discharge pipe extends into the sea for about 20 meters. The oil content of the effluent is reported to be 3.5 mg/l but on occasions it can rise to 15 to 20 mg/l. To further improve the quality of effluent discharge the refinery has undertaken to install a sand filter system (T. Bekele).
B) Diesel Power Stations

The diesel power stations in Assab and Massawa discharge waste oil into the sea directly. There are no treatment plants or retaining ponds. No specific quantitative or qualitative data of these waste loads exist. However, the oil slicks around the discharge areas are certain to damage the marine life in the area.

C) Ships

Around 500 ships per year call at Assab of which 51 are crude and product carriers. About 190 ships per year call at the port of Massawa. 7 or 8 are product carriers that supply the oil storage facilities (Melaku D.). Some of these ships discharge oil and oily residues intentionally or accidentally. Even though there are laws prohibiting the discharge of oil or oily mixtures from ships they are not strictly enforced. Vessels berthed in the port piers do not normally discharge any effluents. But ships at anchorage, awaiting permission to enter port, do discharge oily residues and bilges from machinery spaces without fear from port authorities as there are no patrol boats monitoring pollution.

The crude oil discharge and product loading berth at Assab handles all the tanker and product carrier operations. No major spills have occurred to date, however, minor spills due to pipe leakages, valve failures, etc. do occur from time to time. The berth is frequently oiled and muddy bottoms can be seen around the area. Similar conditions exist in the port of Massawa.

It is clear from the discussions above that measures taken for the prevention and control of oil pollution are not adequate. Proper equipment for combating oil pollution are not available. National legislation to give effect to the international conventions dealing with pollution is still
under preparation. Several reasons may be given as to the delay in taking action against marine pollution. Some of the reasons may be:
a) The maritime industry has been given the proper recognition it deserves only recently.
b) No major spills or any immediate threat to the environment by pollution have been encountered to force the government into action, and
c) Lack of adequate knowledge of the consequences of marine pollution.

Nevertheless, with the establishment of the the Marine Transport Authority in 1978, the maritime industry particularly, the ports have received some attention. The Marine Transport Authority (MTA) has been striving to modernize the port facilities, improve safety standards, and prevent and control marine pollution.

Still a lot has to be done. The fact that the living resources of the sea are as important to the country as the sea is as a means of transportation has yet to be driven home. Fortunately the Ethiopian Red Sea coast is not polluted. However, the region is in the route of oil traffic to and from the Middle East. A major accident causing massive oil pollution can occur any time in Ethiopian waters. But with the proper administrative, legislative and technical measures its effects can be minimized.

Before embarking onto the discussion of marine pollution prevention and control it is worthwhile to mention some of the most important habitats and living resources of the Red Sea which are directly affected by marine pollution.

4.2.6 THE OPEN SEA

As mentioned earlier the Red Sea epipelagic zone, i.e from
the sea surface to 100m below, is poor in nutrient content. The two most probable causes for this condition are:

a) the absence of nutrient rich upwellings and  
b) the lack of fresh water input with nutrient rich run off  
These facts limit the quantity of living organisms that the open sea can support (UNEP, N.64).  
Obviously, pollution can worsen this condition.

4.2.7 ENCLODED SEA BOTTOM HABITATS

The Red Sea enclosed soft-bottom habitats are located in bays, sharms and mersas. Sharms and mersas are coastal areas extending inland up to 10kms. They are partly or completely closed off by coral fringing reefs from the open sea. Several mersas are located in the north Ethiopian coast.

Enclosed soft-bottom habitats are critical marine habitats with limited water exchange. These habitats support mangrove strands and sea grass beds. They are also nursery grounds for fish and shrimp. They are sheltered, thus, ideal for recreational use and scientific research (UNEP, N.64). However, because of their enclosed nature and delicate physical and chemical characteristics they are especially sensitive to pollution.

4.2.8 LIVING RESOURCES

A) Mangroves

Mangroves are halophytic plants that live in the intertidal fringe of tropical shallow waters. Mangroves have special roots which grow in anaerobic muds. They receive oxygen through aerating tissue which have small pores on the special roots (A.J.Edwards and S.M.Head).

Mangrove stands are mostly found in areas of enclosed soft-bottom habitats. There are three species of manroove in the
Red Sea - the Avicennia Marina, the Rhizophora Mucronata and the Bruguiera Gymnorhiza. The most widely spread and abundantly found is the Avicennia Marina. It can be seen along the shores of the Ethiopian coast. Mangroves are important nutrient traps and are refuges for large numbers of marine creatures. They are also important bird breeding areas and the main source of green vegetation in an otherwise barren coastal zone. Pollutants can interfere with the aerating tissue and may reduce oxygen diffusion to the underground root system. Oil pollution is known to cause defoliation and death of mangrove seedlings, and mortality of invertebrates which inhabit the mangrove areas (UNEP, N.64; Ormond; P.Vine).

B) Sea Grass

Sea grass beds occur along both coasts of the Red Sea. They are found on soft-bottom substrates in the lower intertidal and shallow waters. There are about a dozen of sea grass species in the Red Sea. Three are particularly abundant - the Halophila Stipulacea, the Halophila Ovalis, and the Halophila Uninervis. Sea grass beds support the whole shallow water ecosystem. They act as nutrient traps for organic material, they are also a good shelter and vital nursery grounds for many species of fish and shrimps. Sea cows (dugongs) and green turtles feed upon sea grass meadows. Undoubtedly, sea grass beds are of great significance to the primary productivity in the Red Sea. Although no records exist of the effect of pollution on sea grass beds in the Red Sea, reports from other areas indicate retardation of growth due to oil pollution (P.Vine; UNEP, N.64).

C) Coral Reefs

Coral reefs are formed from large masses of biogenic
(created from living substances) rocks and sediment. Reefs contain living corals and algae. The corals and algae produce calcium carbonate of which the reef mass is composed of.

Coral reefs fringe most of the Red Sea coast line with some extending many kilometers offshore. The major coral reef area in the Ethiopian coast is the Dahlak Archipelago. They are highly productive ecosystems. Their productivity is much higher than the pelagic community. Pelagic production level is estimated to be around 20-50 gC/m².yr, while that of the reef community is around 10,000 gC/m².yr. The reason for such a high rate of productivity of the coral reefs is their ability to retain and recycle all nutrient material that comes their way. Moreover, corals are able to absorb nitrogen and phosphorous compounds from sea water. Coral reefs support and shelter algal growth, primary and secondary consumers, and the adults and the young of commercially important fish. They support a major part of the Red Sea artisanal fishery. They are very sensitive to change in the quality of water and air. Thus any form of pollution can seriously affect them. (A.J. Edwards & S.M. Head; Lewis; UNEP, N.64).

D) Sea Birds

The Red Sea is a habitat for a number of bird species some of which are endemic to the region. There are sixteen species of sea birds which breed in the region. Some of these are known to nest in the Dahlak Archipelago in northern Ethiopia (S.J. Edwards and S.M. Head).

The variety of sea birds are an added beauty to the region. Since some of them are endemic they are a potential tourist attraction. Pollution, particularly, oil pollution can adversely damage the birds physically and by contaminating their nesting areas. It is known that thousands of birds die every year world wide due to oiling.
E) Red Sea Fish

The Red Sea is inhabited by many hundreds of species of fish and marine fauna, with about one hundred of them considered to be endemic. Though very limited assessment has been done on the fish resources of the region the estimated potential appears to be much higher than the actual exploitation. Mackerels, anchovies, sardines, herrings, tunas, mullets, jacks and shrimps are some of the commercial fish caught by the coastal states.

In Ethiopia, as noted earlier, the fish caught are composed of herrings, anchovies, mullets, emperors, jacks, queen fish and shrimps. Though the catch has considerably dwindled in recent years due to political reasons the potential for a substantial amount of catch is still there. The department of fisheries together with FAO have estimated the potential yield to be around 50,000 tons per year (FAO, 1983b). This does not include the potential catch of demersal fish such as shrimps of which no assessment has been done. Given the above estimates are fairly correct the fisheries can be developed into a viable industry that can generate a significant amount of foreign currency. At present fishing activities are on subsistence level. The fisheries need reorganizing and structuring. In line with this the government is considering joint ventures with the private sector and licensing foreign vessels to carry out commercial fishing.

However, there ought to be another reason, probably more important, for developing the fisheries. Ethiopia, particularly the northern part, has been hit by recurrent droughts and consequent famines during recent decades. In most parts of north Ethiopia the amount of precipitation has dropped considerably over the past 20 years. Some climatologists claim that the drought in sub-Saharan Africa is intensifying progressively as a result of
climate change (D.Kemp). But an interesting fact is that
drought has been prevalent in the region for hundreds of
years. Past meteorological data attest to this. The
present situation seems unusually severe because the
drought is now affecting millions of people whereas in the
past the afflicted number of people was a lot less.
Besides, climatic changes, growth of population, economic,
social, and political problems of the region have also
contributed to the matter.
Whatever the case, if past meteorological data can be
trusted to predict the climate of the future then droughts
are likely to hit the region repeatedly.
In light of these facts developing reliable sources of
food, which can be sustained in the long run, should be the
priority of the governments in the region. The sea is one
possible source which must be taken into consideration. It
is estimated that about 5 million cattle perished in the
droughts in Ethiopia in recent years. Nowadays the number
of cattle, the main source of animal protein in the
country, has decreased significantly. Needless to say, Red
Sea fish can be an important source of protein supplement
to the diet of the people in the drought stricken areas
which happen to be close to the coast. The Ethiopian marine
fishery reserves, probably the largest in the region, if
fully exploited, can provide about 1.8 kg of fish per
capita every year (A.J.Edwards and S.M.Head). Clearly a
significant amount, especially if the coastal and near
coastal population of around 4 million is only considered.
Thus, the rational development of the fisheries on a
sustainable basis offers a reliable source of food where
repeated droughts and growing population have rendered land
resources unreliable. Maintaining such a reliable food
source, however, requires the prevention and control of
pollution in addition to the proper management and
conservation of the resources.
CHAPTER V

MARINE POLLUTION PREVENTION
5.1 INTRODUCTION

"Prevention is better than cure". This old saying can never be emphasised more. Preventing a disaster be it pollution or any other catastrophe is the best remedy considering the social, economic and political implications that such disasters entail.

Ideally effective pollution prevention methods would completely eliminate accidental and intentional pollution. However, in practice, accidents or negligence can be curbed but can not be totally eliminated. Nevertheless, to avoid costly remedial measures every effort has to be done to implement preventive measures wherever possible and whenever feasible. Today a number of national regulations, regional and international conventions have been established to prevent marine pollution. These conventions have been able to considerably decrease pollution if not to stop it completely. For instance, since the introduction of MARPOL 73/78 the amount of oil entering the sea has been lowered significantly. In 1973, the United States National Academy of Sciences (NAS) estimated the amount of oil entering the sea due to maritime transportation to be about 2 million tons per year. In 1980 NAS estimated that around 1.5 million tons of oil was entering the sea. This indicates a considerable decrease from previous years. The Steering Group on Casualty Statistics of IMO reported that in the 1970s the serious casualty rate per hundred tankers at risk averaged 2.29 per year. In recent years specifically, since 1986 this figure has went down to 1.83 per year —another evidence that prevention is improving the situation.

Prevention of pollution requires a global effort. Every society has to be aware of the dangers that pollution can
bring. Unless nations are ready to bear their responsibilities in safeguarding the environment, the quest for a better world would be in vain.

5.2 MARINE POLLUTION PREVENTION IN ETHIOPIA

Ethiopian maritime history dates back to 2000 b.c. Ancient Abyssinian traders used to sail to neighboring states in those days. During the time of the Axumite kingdom, which lasted from the 1st century a.d. to the 6th century maritime trade reached its peak. With the decline of Axum, however, this trade also declined and the maritime sector lost its significance until the time of the Italian colonization. After World War II the Ethiopian government set out to modernize the ports of Massawa and Assab. Legislations were proclaimed to administer and regulate maritime activities. The following are the maritime proclamations decreed over the years:

5.2.1 The Maritime Proclamation of 1953

The Maritime Proclamation no.137 was issued in 1953. It dealt with:
- Jurisdictional matters related to the control and administration of the territorial waters and the Maritime Domain of Ethiopia, as designated by this proclamation.
- Jurisdiction, administration and control over the marine industries and enterprises established in the country and over Ethiopian ships and vessels on the high seas and elsewhere.
- Delimitation of the right of using the territorial waters for the purpose of transportation, trade and fishing.
- Property rights like exploration, requisition, and taxes and dues.
- The defence of the Maritime Domain, and
- Regulations and penal provisions related to international
agreements and conventions.

5.2.2 The Maritime Court Procedure Rules of 1955

These rules issued in 1955 gave the Ministry of Justice the power to make procedural rules relating to:
- Civil and criminal proceedings
- Maritime investigation
- Marine liens, mortgages and loans
- Appeals, and
- Court fees

5.2.3 The Maritime Code of 1960

This legislation by far the most comprehensive was issued in 1960. The Maritime Code contains 371 articles pertaining to:
- Regulation of maritime employment
- Ships, ship owners, managers and ship masters
- Ship contracts
- Maritime collisions
- Salvage and assistance
- General average
- Insurance
- Penal, and
- Miscellaneous provisions

5.2.4 The Marine Transport Proclamation of 1978

This Proclamation established the Marine Transport Authority under the general guidance and supervision of the Ministry of Transport and Communications and defines the purposes, powers, and duties of this Authority. The Marine Transport Proclamation no. 139/78 empowers the Marine Transport Authority (MTA) to:
- Operate and regulate port services, determine and
regulate light houses, buoys, marine and sub-marine cables, harbour and port structures, and installations.

- Regulate the manufacture, possession, use, sale and purchase of vessels.
- License and control seafarers, pilots and other persons working on board,
- Inspect, license and regulate all port and vessel services and facilities,
- Determine and regulate the conditions under which passengers' goods and mail may be transported in vessels and recommend the tariffs to be charged by marine transport service organizations,
- Control and prevent marine pollution. (Melaku D.)

As can be deduced from above, the proclamations of 1953, 1955 and 1960 were mainly concerned with judicial and commercial issues related to the maritime sector. It was not until 1978, with the proclamation establishing MTA, that the government gave due attention to the problem of marine pollution.

Since its creation MTA has been involved in a number of activities to modernize the facilities at the ports, improve the quality of port services, strengthen safety measures, and discourage marine pollution.

The ports of Massawa and Assab are under-developed. Understandably, the government undertook as first priority the improvement of the ports. A substantial amount of capital was invested in the procurement of port equipment, construction of facilities, and restructuring the ports' layouts. As marine pollution was of little problem, it was relegated to a position at the bottom of priorities. However, MTA was aware of the need to prevent and control marine pollution and has given some attention to it.

Ethiopia joined the International Maritime Organization (IMO) in 1975. Since then the government and MTA have been strengthening their relationship with IMO. IMO missions in
maritime safety and administration, maritime legislation, and port operations and administration. have visited Ethiopia. In 1982 an IMO mission on marine pollution prevention visited Ethiopia and agreed to arrange a seminar on pollution. In April 1983, a National Seminar on Marine Pollution, Control and Response was held in Assab for representatives of the maritime and related industries. This seminar examined the global state of marine pollution and the Ethiopian case. The participants were also familiarized with methods and strategies employed by a maritime administration to prevent and control pollution. Despite this progress, however, the government has not yet ratified the following international conventions related to marine pollution:

1) The International Convention for the Prevention of Pollution of the Sea by oil (OILPOL.54).
2) The International Convention on Civil Liability for oil pollution damage (CLC.69).
3) The International Convention Relating to Intervention on the High seas in cases of oil pollution casualties (Intervention.69).
4) Convention on the establishment of an International Fund for Compensation of oil pollution damage (Fund.71).

The reason for not ratifying these conventions is, in part, the absence of national legislation to give effect to their application. Advisory services were requested from IMO for the preparation of a comprehensive maritime code and related regulations. Currently a committee of legal experts from the Ministry of Transport, the Ministry of Justice, and IMO consultants are drafting a new maritime legislation that will enable national implementation of international conventions.
5.3 INTERNATIONAL AND REGIONAL CONVENTIONS FOR THE PREVENTION OF MARINE POLLUTION

A number of international and regional agreements have evolved during the last three decades to help decrease the amount of pollutants being discharged into the sea. The most important international conventions dealing with the prevention of marine pollution and the regional agreement pertaining to the Red Sea are briefly discussed below:

A) The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78)

Though a convention dealing with oil pollution was already in force (OILPOLL.74), it was realized that a new set of regulations and rules were required to combat the growing threat of pollution from sources other than oil. MARPOL was thus introduced by IMO in 1973. The MARPOL convention deals with all the technical aspects of pollution from ships except disposal of waste by dumping (which is covered by another convention). The convention contains two protocols and five annexes dealing with the prevention of various forms of pollution. The five annexes are:

i) Prevention of pollution by oil from ships.
ii) Control of pollution by noxious liquid substances carried in bulk.
iii) Prevention of pollution by harmful substances carried in packaged form.
iv) Prevention of pollution by sewage from ships and
v) Prevention of pollution by garbage from ships.

Annexes I and II are mandatory for States ratifying the convention. Annexes III, IV and V are optional and can be accepted by States according to their needs. Annex I in principle prohibits the discharge of oil or oily mixtures into the sea.
The restrictions include:
a) Limitation of the total quantity of oil which a tanker may discharge in ballast voyage to not more than $\frac{1}{30,000}$ of the amount of cargo carried.
b) Limitation of the rate at which oil may be discharged to a maximum of 60 litres per mile traveled by the ship.
c) Prohibition of discharge of any oil whatsoever from the cargo spaces of a tanker within 50 miles of the nearest land.

The regulations require the fitting of oil-discharge monitoring equipment and control system, oily-water separating equipment and filtering system, slop tanks, sludge tanks, piping and pumping arrangements. Tankers of 20,000 tons dwt or above are required to be fitted with segregated ballast tanks for carrying clean ballast water, and crude oil washing of cargo tanks. New oil tankers are also required to meet certain subdivision and damage stability requirements for staying afloat in case of collision or stranding. A new provision requiring new tankers to be built with double hull or equivalent design has also been incorporated into the regulations.

Annex II deals with the requirements and control measures for noxious liquid substances. Noxious liquid substance residues are required to be discharged into reception facilities until certain concentrations and conditions are complied with. Discharge is not permitted within 12 miles of the nearest land.

The convention also designates as "Special Areas" those seas which are of either enclosed or semi-enclosed nature. Because of their vulnerability to pollution, discharge of oil or oily mixtures is completely prohibited in these areas except in some circumstances. The "Special Areas" are the Mediterranean Sea, the Black Sea, the Baltic Sea, the Red Sea and the Gulfs area.

Under annex II only the Baltic and Black Sea are designated as special areas.
The States bordering the "Special Areas" are required to provide reception facilities for receiving oily wastes from ships operating in the area. The ratification of this convention by Ethiopia is overdue. With increasing traffic in the region the probability of accidents and intentional discharge of wastes is increasing. And with the expanding of activities in Assab and Massawa the number of ships calling at the ports is growing rapidly. As mentioned earlier, operational discharge from ships is a major cause of pollution in the area. Thus, ratification and incorporation of the convention into the national legislation will greatly assist in the enforcement of the convention requirements and will discourage ships from discharging effluents. Moreover, the Ethiopian Shipping Lines Corporation vessels have to comply with MARPOL regulations as the majority of their shipping activity is to the Mediterranean, North Sea and Baltic ports where MARPOL requirements are strictly enforced. Therefore, whether the State ratifies the convention or not Ethiopian ships have to fulfill these requirements. Then provided reception facilities are made available there is no reason why the State should not ratify the convention and enforce MARPOL regulations on other ships calling at its ports.

B) The International Convention relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (Intervention, 69)

The Intervention Convention establishes the right of a coastal state to take appropriate measures as may be necessary to prevent, mitigate or eliminate danger to its coast line or other related interests from pollution by oil or the threat from oil pollution in the event of a maritime casualty. It empowers the coastal state to take action as is necessary in consultation with interested parties. in
particular, the flag state(s) of the ship(s) involved, and the owners of the ship(s) or cargoes in question. This convention applies to all sea going vessels except war ships or other vessels operated by a State and used on non-commercial services. In view of the increasing threat posed by hazardous substances other than oil, carried by ships, a protocol was adopted to cover the hazardous substances listed in the annex to the protocol or which have similar characteristics to those substances. The convention has a significant role in the prevention of pollution from reaching the coast of a State. As is known coastal waters are the most vulnerable to pollution. The Red Sea coasts are especially very sensitive to pollution because the fish breeding and nursing grounds are located near the coasts. Mangroves and coral reefs, the mainstay of the Red Sea fishery are also located at the coasts. Thus, preventing pollutants from reaching the coast is very important. The ratification of this convention by Ethiopia is, therefore, crucial to safeguarding its coastal habitats.


The LDC convention prohibits the dumping of certain hazardous wastes and other substances into the sea. Under the convention, special permits are required for the dumping of a number of identified materials and a prior general permit for other wastes. The convention will particularly help in fighting unlawful dumping of wastes into the sea. For States like Ethiopia it could become an instrument for combating dumping of industrial and nuclear wastes from other countries and taking the necessary action if such dumping occurs. (IMO, 1992)
D) The Regional Convention for the Conservation of the Red Sea and the Gulf of Aden Environment

This regional convention, initiated by the coastal states of the Red Sea and the Gulf of Aden under UNEP’s regional seas programme, is designed to protect the marine environment and coastal areas of the Red Sea and Gulf of Aden for the benefit of the present and future generations. The aims of these convention are:

- to prevent and abate pollution of the marine environment in the waters of the Red Sea and Gulf of Aden by oil and other harmful or noxious materials arising from human activities on land or at sea.

- to ensure that the processes of industrial development and land use are carried out in such a manner as to preserve marine resources and coastal amenities and not lead to the deterioration of the marine environment.

- to develop an integrated management approach to the use of the marine environment and the coastal areas, thus achieve environmental and development goals in a harmonious manner.

- to carry out planned research, monitoring, and assessment programme on marine pollution in the region, and

- to foster co-operation and co-ordination of action on a regional basis with the aim of protecting the marine environment of the Red Sea and Gulf of Aden.

The convention was adopted in 1982 by the governments of Egypt, Jordan, Saudi Arabia, Somalia, Sudan, Arab republic of Yemen, People’s Democratic Republic of Yemen, and the Palestine Liberation Organization. It entered into force for this countries in 1985.

The ratification of this regional convention is very important for Ethiopia. The prevention and control of marine pollution, monitoring and environmental assessment, scientific research and development, and concerted regional action can only be effectively and economically
accomplished through regional co-operation and co-ordination. This convention offers such opportunities. (UNEP, 1983)


This convention was ratified by Ethiopia in 1982. The convention defines sea boundaries, redistributes resources, rights, and responsibilities. It establishes a framework for the management of all major uses of the oceans and provides a comprehensive set of international environmental laws. It contains articles prohibiting marine pollution and permits coastal states to make laws and regulations to protect the marine environment.

Needless to say, the implementation of the international and regional conventions discussed above is very important to Ethiopia.

Moreover, some additional measures have to be taken to improve the capability of pollution prevention. A few will be mentioned here.

5.4 PREVENTION MEASURES

5.4.1 Traffic Separation Scheme

Besides the improvement of existing navigational aids such as light houses, buoys and break water lights, a traffic separation scheme should be introduced in the ports of Assab and Massawa in accordance with IMO regulations. The scheme could, for instance, divide the traffic lane for in bound and out bound vessels. This scheme can, if desired, be improved and modified as the traffic increases and/or the type of cargo and size of ships calling at the ports changes. Traffic separation schemes reduce maritime
collisions and thus indirectly decrease the probability of pollution arising from such accidents.

5.4.2 Education, Training and Research

The importance of educating port and shipping industry personnel in environmental and related sciences can never be more stressed. There are very few people educated in environmental studies, especially in the marine field, in Ethiopia. Key people in the maritime sector need to be trained in marine environment sciences and conservation management. Training should also be given to middle management personnel in the protection and conservation of the marine environment. Their awareness of the ecological problems caused by pollution is crucial to the effective implementation of pollution prevention measures.

Moreover, the general public should be informed and made aware of marine pollution and the importance of protecting and conserving the marine environment through the mass media, by distributing leaflets, by setting exhibitions and through public seminars. Individual awareness contributes a great deal in preventing pollution. Long term education and short term courses can be financed through regional programmes and funds can be obtained from international organizations and UN bodies. The facilities at the World Maritime University (WMU) offer a great opportunity for training people in specialized maritime affairs which emphasize environmental protection.

Recently the University of Asmara, in northern Ethiopia, has opened a marine biology department and is conducting some research in the Red Sea coast. The University could collaborate with other regional and international universities, UNEP, IMO, etc. in carrying out research on living resources and critical habitats in the region. Such
research is crucial in identifying areas and habitats sensitive to pollution.

5.4.3 Environment Protection Agency

There is no government organ responsible for environmental issues in Ethiopia. An environmental agency should be formed as a matter of urgency to deal with environmental problems. The proposed agency should be charged with the duty of:

a) preparing a national environmental strategy.
b) developing environmental protection and management
c) preparing of a national environmental legislation and enforcing such legislation.
d) conducting environmental research and studies
e) setting up environmental impact assessment procedures and related functions.
f) ensuring that environmental issues are taken into consideration during planning and implementation of developmental activities.

A marine environment protection and conservation department may be created within the agency to deal with marine environmental problems. Some of the duties which such a department may perform are:

a) draft marine pollution control measures in co-operation with MTA and other related organizations.
b) conduct research with respect to marine pollution and control
c) participate in the work of and give advice relating to the environment to governmental and other organizations
d) co-operate with other regional and international organizations dealing with environmental aspects in conducting research, education and other common goals.

(R.D.Munro & J.G.Lammers

The Universities of Addis Ababa and Asmara and the Science and Technology Commission can collaborate and set up a team
5.4.4 Reception Facilities

MARPOL 73/78 requires that maritime administrations ensure the availability of adequate reception facilities for receiving wastes from ships. The availability of reception facilities is more emphasized in ports located in "Special Areas". As mentioned earlier, the discharge of oil and oily wastes is prohibited in "Special Areas". But to effectively control ships from discharging in these areas adequate reception facilities must be provided in the ports and oil record books must be checked regularly to make sure that waste oil has been discharged in reception facilities and not at sea.

Despite the need for reception facilities in ports, particularly, in "Special Areas", many ports around the world do not have these facilities. The main reason put forward by port authorities is that capital and running costs of reception facilities are too high. Since it is recommended that these facilities are to be provided free of charge most ports are reluctant to provide them. Ship owners are also not inclined to pay for waste reception as it is cheaper to dispose of their waste into the sea illegally. Whatever the case, vast quantities of waste is still being discharged into the sea due to lack of adequate reception facilities. With these difficulties in mind, IMO published a series of guidelines for the provision of reception facilities in ports. The guidelines were prepared by the Marine Environment Protection Committee (MEPC) of IMO to assist ports, particularly, those in developing countries. These guidelines provide estimates of the average quantities of oily wastes generated on board various kinds of ships. These estimates help in selecting a suitable and economical facility. Thus ports can estimate the volume of oily waste they are likely to handle using
these guidelines and work out the capacity of the reception tanks required. The cost of handling the waste can then be calculated. This cost may be added to the overall port charges or a minimum amount may be charged to the ships. Unless the charges are kept low ships will find other means of disposing of their waste— a most likely place is the sea if control measures are not adequate. The quantity of oily waste handled by most large ports is usually considerable. Oil recovered from these wastes is, therefore, sufficient enough to be sold as fuel oil in the market, and hence, installation of a recovery plant may be feasible. Reports from some large ports indicate that such operations are profitable. However, the quantity of waste oil received in medium sized and small ports may not be large enough to justify the installation of a recycling plant in the model of large ports. Thus, low cost reception facilities have been designed to meet the requirements in medium and small ports.

A typical layout and design of a low cost reception facility will be discussed here. Three or four mobile tanks of 20 or 25 ton capacity with the necessary piping and hoses for connection to ships are installed on a hard surface, usually a concrete slab, within the port area. The mobile tanks are kept in the designated port area but can be moved when required. The tanks are connected to each other by a common piping system. This system is then directed to an oil/water separator. The separator is connected to a filter unit so that oil can be separated on site. The filter unit is fitted with an oil monitor at its outlet side to check the oil content of the water which is to be disposed into the sewerage system or the sea (see figure - alt.1 ).

Operation - Oily waste from ships is collected by one or more of the mobile tanks. The tanks may be pulled by a port
truck, a tractor or forklift. After collection the tanks are returned to their designated area and the oily waste is allowed to settle for a period of time (one day is usually enough).

The settled water is then manually drained off into the oil/water separator by opening a drain valve under the tanks. The remaining oil content in the tank can be transferred to one of the tanks to make a full tank for later transport to the refinery plant. The water in the separator is pumped to the filter unit where it is further purified. The oil collected in the separator is pumped back into one of the mobile tanks and sent to the refinery. After some time the filter unit may clog and has to be backwashed. Again the oil phase is pumped back to the mobile tanks.

An alternative set up using one mobile tank and one large stationary tank may also be used (see figure - alt.2). The recovered oil after undergoing purification in the refinery is sold as fuel for industries. Thus this kind of reception facility, due to its relatively low capital and running costs, can cover operational costs and may even bring in some profit. (K.J. Kenton & J. Hedberg).

In Ethiopia similar reception facilities can be installed in Assab and Massawa at a reasonable cost. Cheap labour cost will be an advantage.

The ports, the Ethiopian Shipping Lines Corporation and the Assab oil refinery are run by the State. Thus an agreement can be easily reached as to the initial funding of the reception facilities. The ports and the shipping line can contribute to the capital cost and operation of the facilities. The Assab refinery can receive the waste oil and refine it. The recovered oil may then be sold locally or to ships depending on its quality.

In Assab setting up the alternative with four mobile tanks is preferable because more ships call there. In addition, since the refinery is located at Assab, oil transport to
the refinery may necessitate the use of more than one mobile tank. In Massawa, however, since fewer ships call at the port and there is no refinery plant there, the alternative with a large stationary tank and one mobile tank may be better. The stationary tank should be made large enough to hold the oil waste until it can be transported to Assab for refining. Massawa gets refined products from the refinery at Assab on a regular basis by a coastal tanker. This tanker may be used to carry the waste oil on its way back to Assab since it returns on ballast without any cargo. However, the feasibility of such an arrangement needs to be studied. Another alternative may be to use the waste oil as fuel for operating the furnaces at the glass factory in Asmara which is near by. Providing reception facilities for ships calling at the ports of Assab and Massawa is a necessity.

The Red Sea is a "Special Area". Ships are prohibited from discharging oily wastes in this area because of its sensitivity to pollution hazards. But unless reception facilities are provided in the ports ships are bound to discharge their waste into the sea illegally. Monitoring ships in the open sea is rather expensive if not impossible. The best way to avoid waste discharge into the sea is, thus, to provide reception facilities at no cost or low cost to the ships. This will encourage ship owners to use the reception facilities. Hence, much of the pollution can be avoided. Moreover, Ethiopian Shipping Lines’ vessels mostly trade in Europe. On their return voyage they pass through the Mediterranean Sea which is also a "Special Area". The vessels accumulate considerable quantities of oily residues from their entrance to the Mediterranean until they reach the Ethiopian ports. To receive the oily residues from the vessels reception facilities must therefore be provided.
ALTERNATIVE 1.

4 TANKS 25m$^3$ EACH

FILTER UNIT

RECOVERED OIL

OIL/WATER SEPARATOR

WATER TO DISCHARGE

ALTERNATIVE 2.

TANK 100m$^3$

FILTER UNIT

OIL FLOAT

RECOVERED OIL

OIL/WATER SEPARATOR

WATER TO DISCHARGE

(K.J. Kenton & J. Hedberg)
Furthermore, reception facilities for Annex V wastes must be provided. This can be done by preparing old containers or barrels for receiving glass, plastics, paper, and trash separately. The glass and paper can be recycled in the glass and paper factories in Addis Ababa and Asmara, if found feasible. Plastics and trash may be dumped in the municipal landfills.

Annex IV has not yet entered into force but may enter into force shortly. Therefore, reception facilities must be considered later.

Annex II vessels do not call at the ports at present. So no need for reception facilities.

Obviously, marine pollution prevention requires stringent regulations, strict enforcements, and co-operation between people, organizations, nations and regions. It also requires awareness of the dangers pollution entails. This is probably the most important since a considerable amount of pollution occurs due to the ignorance and carelessness of people.

Pollution prevention may be expensive at times. However, nothing should be considered as too expensive in protecting the environment.
CHAPTER VI

MARINE POLLUTION CONTROL
6.1 SEWAGE POLLUTION CONTROL

6.1.1 Introduction

Pollution from sewage discharge into the sea is cause for concern especially in heavily populated coastal areas. Sewage discharges into the sea are, a public health hazard, decrease the ammenities of the shores and cause eutrophication.

Though total prevention of sewage discharge into the sea may not be possible or economical, it is desirable that the quality and quantity of discharge be controlled. Sewage discharges should be treated or dispersed and diluted to low concentrations so that they can be assimilated into the receiving water without detectable effects.

There are various stages of sewage treatment. Depending on the quality of effluent that is required sewage may be subjected to:

6.1.2 Primary Treatment

Here sewage is filtered to remove large solids and is comminuted to reduce it to a slurry. Grit is removed and the remainder of the sewage is led to settlement tanks. The liquid from the settlement tanks is then discharged into the receiving waters. The sludge which has settled in the tanks is disposed of elsewhere.

6.1.3 Secondary Treatment

The liquid effluent from the primary treatment may be subjected to further treatment if a greater reduction of
BOD is required. The liquid is passed through filter beds of rock or coke. The beds provide large surface area for bacterial degradation. The liquid from the outflow is then discharged into the receiving waters and the sludge material is disposed of.

6.1.4 Tertiary Treatment

If still, further treatment of the liquid is desired to produce a high quality effluent, then, the liquid from the secondary treatment may be kept in sedimentation ponds or passed through sand or earth filters to remove suspended solids (R.B. Clark).

Raw sewage can also be discharged untreated, without causing discernible effects. If outfall pipes are extended to locations which are well flushed by sea waves or currents, hence, with better dispersal and dilution. It must be noted, however, that the amount of raw sewage discharged into the sea should not exceed acceptable limits.

6.2 SEWAGE POLLUTION AND DISPOSAL IN THE ETHIOPIAN RED SEA COAST

As noted earlier, the ports of Massawa and Assab, the two towns with sizeable populations in the region, do not have adequate sewerage systems. Sewage is discharged untreated into the sea. Outfall pipes are not located in suitable places for good dispersal and dilution. The quality and quantity of sewage discharged into the sea is not known. No regulations for controlling sewage pollution exist.

One of the matters that should be given priority is the preparation of a master plan for setting up modern sewerage systems in both ports.

- The sewerage systems should be designed so that the sewage is discharged via outfalls. The number of these
outfalls should be kept to a minimum.
- The present practice of using pits should be abandoned because it is hazardous to human health.
- Open air defecation at or near the shores is currently common. This is a major cause of beach pollution and diseases and, thus, must be prohibited.
- The establishment of primary treatment plants must be given due consideration. However, sewage treatment can be costly so no more sewage must be treated than is necessary. To offset some of the expenses, sludge from the treatment plants can be sold as fertilizer in the hinterland where it is badly needed. For instance, nearly half of sewage sludge produced in the U.K. is used as fertilizer and soil conditioner (R.B. Clark).
- Outfall pipes should be made long enough and must be located in deep waters, well flushed by waves and currents, and away from public bathing beaches. Water quality monitoring at the outfalls must be carried out periodically. With proper monitoring advantage can be taken of the natural capacity of the sea to degrade sewage. This may help avoid the need to build expensive secondary and tertiary treatment plants.
- Sewage disposal on or near coral reefs can cause turbidity, thus, obstructing light from penetrating to deeper waters. This limits coral reef growth which depends on light for food production and skeleton formation (A.J. Edwards & S.M. Head).
Hence, outfall pipes must not be located near coral reefs.
6.3 OIL POLLUTION CONTROL

6.3.1 Introduction

Preventing oil pollution completely, though much desirable, is very difficult to accomplish if not impossible. Oil spills due to routine operation of ships or accidents cannot be avoided entirely. As noted earlier, normal operations of cargo and tanker ships generate a lot of oily residues which must be disposed of in some way. These residues can be discharged into reception facilities. And by installing the equipment required by MARPOL regulations their effect on the marine environment can be minimized in case they are discharged overboard.

However, accidents or collisions that cause oil pollution are bound to happen every once in a while. Improved navigation aids, better safety measures, better weather forecasting and good communication systems have decreased the number of accidents and collisions, but still, accidents cannot be eliminated totally. Accidents can discharge considerable amounts of oil into the sea. For instance,

- The tanker Torrey Canyon was wrecked in 1967, and deposited around 40,000 tons of oil on the beaches of Cornwall (U.K.) and Brittany (France).
- The Ekofisk offshore oil field in the North Sea blew out in 1977, and discharged an estimated 30,000 tons of oil into the sea.
- In 1978, the tanker Ammoco Cadiz was wrecked on the coast of Brittany (France) with 223,000 tons of crude oil.
- The Ixtoc I oil well in the Mexican coast blew out in 1979, and discharged an estimated 350,000 tons of oil into the Gulf of Mexico.
- The Exxon Valdez was grounded in Alaska in 1989, spilling
approximately 11 million gallons of oil. Similar though less spectacular accidents have also occurred elsewhere. Once oil is spilled in large amounts it usually costs a considerable amount of money for clean-up besides the ecological and economical problems it creates.

How can an oil spill be cleaned-up and controlled from contaminating a wide area. There are a number of ways of controlling oil spills. Some of them will be discussed here. But before discussing the artificial means of dealing with oil spills it is worthwhile to look into the natural degrading processes that an oil spill is subjected to when discharged into the sea.

6.3.2 SPREADING

As oil is spilled over the sea it immediately starts to spread due to its weight. Gravitational forces pull on the oil and force it to spread over the water. The rate of spreading depends on the amount of oil spilled, the viscosity of the oil, the temperature of the oil and the surroundings and hydrographical conditions such as currents, tides and winds. Thus, an instantaneous spill of a large amount of oil spreads more quickly than a slow discharge. High viscosity oils spread rather slowly compared to low viscosity oils.

A few hours after a spill the rate of oil spreading slows down due to the decreased weight of the oil (after initial spreading) and effects of surface tension. At this stage the oil slick breaks up to form narrow bands. Further spreading continues due to wind, wave and, if it is close to the shore, tidal currents. The rate of spreading depends on the strength of the wind, force of wave turbulence and tidal range. Temperature also affects the rate of spreading. Oil spilled at temperatures below its pour point will hardly spread at
all. The pour point is the temperature below which an oil will not flow.

6.3.3 EVAPORATION

The volatility of the components of spilled oil is the main factor in determining the rate of evaporation of the oil. The more volatile the components the higher the rate of evaporation. The initial spreading rate of the oil also affects the rate of evaporation. If the spreading is rapid it covers a wide area, in effect increasing the surface area of the oil. Increased surface area accelerates the rate of evaporation of the volatile components. Moreover, high temperatures, strong winds, turbulent seas and waves increase the rate of evaporation. Refined products such as gasoline and kerosine have a high rate of evaporation and if spilled they may evaporate completely in a matter of a few days. Heavy crude oil and fuel oils because of their density and viscosity do not evaporate readily, if at all.

6.3.4 DISPERSION

Dispersion is caused by waves and turbulence at the surface of the sea. Waves and turbulent seas break up the oil slick into droplets of varying sizes. Small droplets remain suspended in the water and mix with the water column. In doing so they increase their surface area thus enhancing further weathering by other natural processes such as sedimentation and biodegradation. Large droplets rise back to the surface and may coalesce with other droplets to form slick or spread out in a very thin film. The thickness of slick and degree of spreading influence the rate of dispersion. The thinner the slick the smaller are the oil droplets formed. The greater the degree of spreading the thinner the oil films become, thus, smaller droplets can be formed.
6.3.5 EMULSIFICATION

Spilled oil tends to form water-in-oil emulsions by absorbing water. Rough sea conditions accelerate formation of emulsions. The stability of emulsions depends on the chemical properties of the oil. If the oil contains asphaltenes more than 0.5%, then it tends to form stable emulsions. Heat, sunlight and calm sea conditions may separate out emulsions into oil and water. The rate of emulsification is influenced by the viscosity of oil. High viscosity oils absorb water slowly thus slowing emulsification. Low viscosity oils usually absorb water rapidly.

As waves move the emulsified oil they cause the water droplets contained in the emulsion to become smaller and smaller. This makes the emulsion more viscous and difficult to disperse or evaporate.

6.3.6 DISSOLUTION

Spilled oil can dissolve in sea water slightly. The rate of dissolution depends on the oil composition, degree of spreading, temperature of the water, degree of dispersion and turbulence. The lighter components of crude oil are more soluble than the heavier components. However, only around 1 ppm of oil can be dissolved in sea water. Hence, dissolution does not contribute much to the removal of oil from the sea surface.

6.3.7 OXIDATION

Spilled oil is exposed to atmospheric oxidation on the surface of the sea. The extent and rate of oxidation depends on the form in which the oil is present in the water. Thin layers or small droplets of oil will be oxidized much more readily than thick layers or large
droplets or emulsion. The greater surface-to-volume ratio of small droplets and thin layers allows better access of the oil to oxygen. Some hydrocarbon molecules in the oil will be broken down into soluble products when oxidized and other molecules will be oxidized to form persistent tars. Hence, oxidation may aid in the weathering process of spilt oil in one way and worsen the condition in another way. Overall, the net effect of oxidation in the weathering process may be minor.

6.3.8 SEDIMENTATION

Sufficiently dense crude oils may sink in sea water. However, all crude oils have specific gravities less than water. Sea water has greater specific gravity than fresh water. Therefore, oil can only sink in sea water if sediment particles or organic matter adhere to it. Shallow waters contain a lot of suspended particles which may assist in the sedimentation of oil. The open sea, with less suspended particles, is not likely to aid in the sedimentation process. Oil stranded in sandy shorelines is mixed with sediments and may be washed off the shore and sink. Oil stranded in sheltered shorelines may remain there for a considerable time because of the absence of waves and turbulence.

6.3.9 BIODEGRADATION

Some marine bacteria, yeasts and moulds can utilize oil as a source of carbon and energy. Each type of micro-organism is able to degrade a specific group of hydrocarbons in the oil. The different micro-organisms degrade the various hydrocarbons in the oil. Biodegradation is dependent on the amount of oxygen and nutrients, such as nitrogen and phosphorus present in the sea. The micro-organisms need oxygen for degrading the hydrocarbons and nutrients for
food. Temperature also affects the rate of biodegradation. Micro-organisms require oxygen, nutrients and the right temperature to multiply rapidly. Biodegradation is possible only in an oil/water interface because the micro-organisms live in water. Oil droplets increase the interfacial area available and are biodegraded rapidly. Sedimentation very much reduces the rate of biodegradation as the amount of oxygen and nutrients are low in the bottom of the sea.

To summarize the processes of spreading, evaporation, dispersion, emulsification and dissolution influence the weathering of oil in the initial stages of a spill, while oxidation, sedimentation and biodegradation are processes that take long time and their outcome determines the final fate of spilled oil.

The natural processes described above are the basis for determining what actions to be taken during an oil spill accident. The understanding of the processes is also important in the selection of clean-up equipment and techniques.

<table>
<thead>
<tr>
<th>Line Length</th>
<th>Probable time span of any process.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line Width</td>
<td>Relative magnitude of the process both through time and in relation to other contemporary processes.</td>
</tr>
</tbody>
</table>

Source: Exxon Production Research Company
6.4 CHEMICAL DISPERSANTS

Chemical dispersants are artificial means of dispersing oil. Dispersants contain a surface-active agent with a molecular structure arranged so that part of the molecule has an affinity for oil (oleophile) and the other part has an affinity for water (hydrophile). This characteristic of dispersants enables them to decrease the interfacial tension between oil and water. Hence, finely dispersed oil droplets are formed. As noted earlier these droplets have a large surface area compared to the original slick. If the droplets are small enough they will be suspended in the water as their velocity of rising is very slow.

Moreover, dispersants prevent the recombining of droplets after they are formed. The surface-active agent remains at the oil/water interface for sufficient time and thus, acts as a barrier between droplets.

6.4.1 Dispersant Effectiveness

The effectiveness of dispersants depends on the viscosity of the oil they are applied to. Dispersants are capable of dispersing most oils and emulsions with viscosities less than or about 2000 centistokes (cSt). For viscosities greater than 2000 cSt their effectiveness decreases considerably. Generally, dispersants are ineffective with viscous emulsions or oils with pour points around or above the ambient temperature.

6.4.2 Types of Dispersant

There are two main types of dispersants used nowadays:

a) Hydrocarbon or conventional dispersants - which are applied to the oil without diluting with sea water before use.

b) Concentrate or self-mix dispersants - which have alcohol
or other solvents and contain a higher concentration of surface-active agents than hydrocarbon dispersants. These dispersants can be diluted with sea water before use. Concentrate dispersants if applied without dilution do not need strong mixing, usually the wave action is sufficient. Because of this property and the relatively lower application rates required they are more widely used at sea.

6.4.3 Dispersant Application

Caution has to be taken when and where to use dispersants. Generally, dispersants should be used in the open sea and deep waters, or where the water exchange is good. Marine environments such as the coral reefs, manorove stands, sharms and mersas of the Red Sea are very sensitive to toxicity and, hence, dispersants should not be used in these areas. Dispersant spraying on sandy beaches may be done after consulting experts. The importance of the resources affected by the oil spill will also determine the application of dispersants. Dispersants are toxic. Their toxicity to various organisms should be analyzed before application. (IMO, 1982; Institute of Petroleum)

6.5 OIL POLLUTION CONTAINMENT

To stop or minimize the spread of oil at sea containment and recovery equipment is required. There are various methods for containment and recovery. The most common methods will be discussed briefly here.

6.5.1 BOOMS

Booms are barriers designed to divert or contain spilled
oil from reaching pollution sensitive areas. There are two kinds of boom design:

6.5.1.1 Curtain Booms

These booms are made of flexible screen supported by an air floatation chamber or a solid material and a sub-surface skirt fitted with some sort of ballast and tension material usually a chain fitted in a pocket at the bottom of the skirt. Curtain booms have good wave following capabilities, moderate escape velocities and are fairly easy to clean.

6.5.1.2 Fence Booms

These booms look like fences. They are held upright by buoyancy. The buoyancy is provided by solid material incorporated in the boom or by external floats. But external floats generate turbulence which leads to escape of oil even at low water velocities. Fence booms are more suitable for calmer waters where current velocities are low.

6.5.1.3 Boom Efficiency

Boom efficiency is a function of the oil type and water velocity. Low viscosity oil escapes at lower water velocity than higher viscosity oil. Oils with low viscosity escape under the boom as droplets sheared from the oil layer. High viscosity oil tends to accumulate at the boom face and flows down the face to the underside of the boom and escapes. Turbulence, wind and waves cause water velocity higher than the escape velocity under normal conditions, thus lowering boom efficiency. The size of the boom also determines its efficiency. An optimum freeboard to prevent oil splash-over should be selected. Short section lengths of boom are easier to handle and can keep the boom intact.
if a section fails. However, they take longer time to connect hence, cannot be deployed quickly. In general booms should be sufficiently strong to withstand rough handling. They should be reliable and easily deployable.

(Source: ITDPF)

Figure 1: Curtain boom with air flotation. Combined ballast and tension chain fitted in a pocket at the bottom of the skirt.

Figure 2: Fence boom with solid flotation. Ballast weights fitted at intervals along the skirt.

Figure 3: Escape of oil from a boom
1) splashover by wave action
2) flow down the face of the boom
3) droplets sheared from the underside of the contained slick
6.5.2 NETTING SYSTEMS

Nets are used to recover solid tar balls and contain viscous oils. They can be designed to be light, strong and long enough to contain oil slicks over a wide area of sea. They offer less resistance to water movement, thus, can be used in faster water currents.

There are two basic designs of net systems:

6.5.2.1 Purse Seine Type

This is similar to the fishing purse seine. It is used to enclose the oil slick and contain it. The oil can then be recovered.

6.5.2.2 Trawlina Type

This is similar to a fish trawling net. It has a detachable cod-end. It is towed along the sea surface to collect oil slicks.

6.6 IMPROVISED BOOMS AND BARRIERS

When commercially built booms are not available booms can be made from locally available materials. Wood, bamboo, oil drums, hoses, rubber tyres, wire mesh filled with straw, coconut husks, etc. can be used for making booms with sorbent material.

6.7 BUBBLE BARRIERS

Perforated pipes located beneath the water surface can be used as barriers when air is pumped into them. The rising air bubbles create a counter-current that can hold oil
slicks against a water velocity of about 0.7 knots. Bubble barriers are used where other conventional barriers would block movement of ships. They may be used to protect entrances to ports.

6.8 OIL RECOVERY

Recovery of oil slick is essential to prevent its escape and contamination of other areas. Several equipment are available for recovering oil.
Some of the commonly used are:

6.8.1 SKIMMERS

Skimmers are floating equipment with some supporting arrangement and pump to transfer recovered oil to a storage tank.
There are two basic types of skimmers:

6.8.1.1 Suction Skimmers

Suction skimmers suck in oil from the sea surface by a pump or air suction system directly or through a weir. Suction skimmers accumulate a large volume of water together with oil and this must be separated in large storage tanks. One advantage of sucking a large volume of water is when dealing with viscous oils. The water keeps the oil fluid.

6.8.1.2 Adhesion Skimmers

These skimmers have belts, drums, discs or synthetic ropes which incorporate oleophilic material. Adhesion skimmers recover a higher ratio of oil in relation to water. These skimmers are suitable for recovering medium viscosity oils between 100 and 2000 cSt. Heavy oils are very viscous and
can stick to the adhesive surfaces and removal can be difficult.

6.8.1.2 Skimmer Performance

Skimmers are not effective in steep waves and currents. Small skimmers are easily pitched around in waves, hence, they cannot be positioned at the oil/water interface. Large skimmers cannot follow the wave profiles because of their greater inertia and this affects their performance. In addition, the viscosity of oil determines the efficiency with which skimmer pumps operate. High viscosity tends to slow down the skimmer pumps, decreasing their efficiency.

6.9 SORBENTS

A sorbent is any material which can recover oil through absorption or adsorption. There are three basic kinds of sorbents:

a) Natural organic materials - such as straw, peat moss, coconut husks and hay feathers;

b) Mineral based materials - such as volcanic ash and vermiculite;

c) Synthetic organic materials - such as polyurethane foam and polypropylene fibres.

Sorbents are used during the final stages of oil clean-up or to help remove thin films of oil from inaccessible locations.

6.10 MANUAL RECOVERY

Buckets, shovels and loaders can be used to clean-up oil from areas where access is difficult or where recovery by skimmers is not convenient.

( ITOPF: Exxon; R.B.Clark; Wardely-Smith ).
There is no organized structure nor adequate equipment to fight or control oil pollution in Ethiopia. Little attention has been paid to the need for establishing a response organization that is capable of combating accidental spills. The establishment of such an organization is a necessity that cannot be emphasized more. In the following pages a contingency plan for combating oil spills in case of accidents will be discussed based on a draft plan previously prepared. However, more details have been added to elaborate on the plan and some comments are also included.
Figure 4a:
Netting system of the purse seine type for oil containment and recovery using two vessels to corral floating oil.

Figure 4b:
Oil trawl for collecting floating solid oil into a detachable cod-end.

(Source: ITOPF)
Figure 5b:
Fixed oil barrier constructed with straw bales and wire netting nailed to wooden stakes.

Figure 5a:
Improvised boom made from bamboo, rope, wire, timber and filled with rice straw sorbent.

(Source: ITOPF)
Figure 6: Bubble barrier created by compressed air pumped through a submerged pipe with openings at regular intervals.

(Source: ITOPP)
Belt skimmers

A belt conveys the oil from the water surface by adhesion. Upward rotating belts carry the oil to their top limit where it is scraped or squeezed off into a storage tank. Conversely, downward rotating belts first submerge the oil which then surfaces behind the belt, due to its buoyancy, into a defined area within the vessel. Operational limit - for upward rotating belts 0.5 knots, see state 1; for downward rotating belts 2 knots, see state 2. Preference - medium viscosity oils but upward rotating belts also tolerate heavier material.

Oleophilic rope skimmers

A central tension core rope, through which is interwoven oleophilic strands forming a long continuous mop. The floating mop is pulled by powered rollers around a return pulley. The rollers squeeze the oil into a storage tank. Operational limit - see state 3. Sensitive to increasing viscosity. Preference medium viscosity oils.

Disc skimmers

Discs rotate through the oil / water interface. Oil adheres to the disc surface, is removed by scraper to a central collection point and is pumped to storage. Operational limit - see state 2. Sensitive to emulsified oils, waves, debris. Preference - medium viscosity oils.

(Source : ITOPF)
6.11 NATIONAL CONTINGENCY PLAN

6.11.1 INTRODUCTION

Oil spills will continue to occur as long as oil is transported by ships from source to destination. Accidents and operational discharges cannot be avoided completely. To abate oil spill damage a number of preventive and safety measures have been adopted and put into effect. In line with these measures a contingency plan must be prepared in advance to respond to oil spill accidents and hence, minimize environmental damage. Such response requires a careful pre-planning and setting up of oil combat capabilities at local, national, regional and international levels.

The plans at all levels should be similar and compatible with each other for ease of application and understanding. The objectives of the plan should be:

a) To develop functional systems for reporting and detection of oil spillages or other hazardous materials;

b) To identify the potential sources of oil spills and high risk areas, vulnerable resources at risk, and hence set priorities for protection;

c) To ensure that prompt response is made either to prevent or control pollution;

d) To ascertain the welfare and health of the public and the marine environment;

e) To install correct and environmentally sound response techniques for the clean-up and disposal of oil spills;

f) To set up a system by which complete and accurate records can be kept of all the costs of oil spill clean-up and recovery.

The ever increasing density of maritime traffic, especially oil tankers, in the Red Sea poses a high risk of marine pollution from collisions and groundings. Such accidents
can damage beaches, sea birds, fish and other marine life, particularly in the inter-tidal zones, with subsequent loss of amenities and food resources.

In accordance with the guidelines of IMO a draft Ethiopian national contingency plan had been prepared but it was not reviewed by the concerned Ministries and, hence, has not been implemented.

The draft plan will be discussed here together with some comments.

6.11.2 SCOPE

6.11.2.1 Area of Responsibility

The draft contingency plan demarcates the area intended for response as defined by the Territorial Seas Act, i.e. the 12 mile territorial sea. However, the spatial organization of the seas under the Law of the Sea Convention have not been considered. The Contiguous Zone and the Exclusive Economic Zone must be delineated and agreed upon with neighboring States and clearly demarcated so that each State can take responsibility of its own area.

6.11.2.2 Area of Interest

By agreement with the neighboring States the Area of Interest should be monitored collectively and in cooperation. This area is the zone outside of the Area of Responsibility.

6.11.3 ORGANIZATIONAL PLAN

The draft plan proposes the Marine Transport Authority to be designated as the lead agency of the government responsible for the implementation and enforcement of the plan. However, the Ethiopian Navy should be given the
responsibility for initiating action and assessing the oil spill incident. The Navy possesses the necessary transport, communications equipment and labour force which is suitable for such an operation.

The following government agencies are proposed to participate as supporting agencies and should be part of the emergency committee:

1) The Armed Forces - the Ground Forces and the Air Force
2) The Ethiopian Petroleum Corporation
3) The Ethiopian Shipping Lines Corporation
4) The Ministry of Agriculture - Fisheries Department
5) The Ministry of Foreign Affairs
6) The Science and Technology Commission and
7) Customs and Immigration

1) The Armed Forces

The Air Force can assist in aerial surveillance of ship traffic and oil spill movement in cases of accidents, by providing aircraft, helicopters and manpower. It can also provide ground to air communication between co-ordination centres and the oil spill site.

The Ground Forces can assist by supplying labour force and vehicles in cases of shore clean-up.

2) The Ethiopian Petroleum Corporation

This corporation can assist in the chemical analysis of spilled oil and other technical matters and in receiving recovered oil.

3) The Ethiopian Shipping Lines Corporation

The Shipping Lines can provide tankers or tank barges for transferring oil from damaged ships and for temporary storage of recovered oil.
4) The Ministry of Agriculture

The Department of Fisheries can provide information regarding locations of known fishing and nursery grounds. This information will help in deploying pollution combating equipment to protect these areas and for choosing the right chemical dispersant if the need arises.

5) The Ministry of Foreign Affairs

This Ministry may assist in notifying foreign governments of activities which pertain to oil spill accidents involving their vessels. The Ministry may help MTA in conducting negotiations with foreign owned vessels, cargo owners and insurers and in negotiations regarding compensation and indemnification.

6) The Science and Technology Commission

This Commission, in collaboration with the National Meteorology Authority and the National Mapping Enterprise, can provide information regarding the topography of the area by supplying charts, maps and areal photographs and can supply information on wind and sea currents to determine the movement of spilled oil.

Area Mapping - a survey and mapping of the coast line, marine resources and critical habitats is very essential in the prevention and control of oil pollution. The Ethiopian Red Sea coast has not been surveyed or studied in depth. What little information there is dates back to the 1960s. The government should start a survey of the region to identify and locate critical marine habitats and living marine resources. This will help in deciding which critical areas have to be given priority for protection. It will also help in deciding where to locate...
pollution fighting equipment, the clean-up techniques to be used and the type of equipment required. It will also facilitate the rapid deployment of the right equipment to sensitive areas.

7) Customs and Immigration

The Customs and Immigration authorities can assist in expediting customs and immigration formalities so that foreign technical experts and equipment can reach the affected area without delay.

The agencies mentioned above together with the lead agency, MTA, may form a committee to formulate procedures for the provision of the resources and technical assistance that may be required of them in cases of oil pollution incidents. The committee should establish spheres of responsibility within the agencies and the various functions that an agency must undertake have to be clearly defined.

6.11.4 OPERATIONAL PLAN

The draft plan has designated the general manager of MTA as the overall responsible person for ensuring that appropriate response is made to any incident. The general manager will be assisted by the relevant port manager who will be the on-site representative of MTA. However, this plan should be amended and a Navy designated on-scene commander should be appointed as on-site representative. The port manager's responsibilities are already too many. His normal duties keep him very busy and, thus, it may not be wise to add more responsibilities on him. The job of an on-scene commander (OSC) requires full time commitment when an accident occurs. Hence, the Navy, which has little to do except routine patrolling
during peace time is best suited to take the job of an OSC. The Navy-designated OSC will be in charge of the response and will co-ordinate the operation and utilization of manpower and equipment. The OSC should be able to communicate with the agencies concerned and request and receive assistance as necessary. He should be appropriately trained for carrying out his responsibilities.

But the general manager of MTA may appoint the port manager or other port officers as co-ordinators to lead initial response to oil pollution incidents within port limits. If additional assistance is required it may be requested from the national OSC. Port personnel designated to combat oil pollution within port limits must be given appropriate training.

The OSC will be assisted by team leaders who are directly responsible to him. A team leader will be responsible for directing on-site work to make sure that proper techniques and the right equipment are used in fighting the oil spill. Team leaders should be trained in the use of all pollution combating equipment and in the proper techniques of controlling oil pollution.

A labour force consisting of manpower acquainted with the operation of oil pollution combating equipment should be placed under each team leader. This labour force will be mobilized to areas where it is required. The manpower may be supplied by the Navy and the Ground Forces.

6.11.5 MOBILIZATION PROCEDURE

6.11.5.1 Notification

An oil spill incident may be reported by a vessel, patrol boats, port authority or the general public. To receive information regarding oil spills information centres must be identified. Their telephone, telex, fax and radio frequency numbers must be made known through the public.
media. Upon receipt of information of an oil spill incident the recipient centre should relay the information to the on-scene commander without delay. The OSC will in turn notify the general manager of MTA. The general manager will then alert the concerned agencies.

The information received should contain:
- name or identification of incident reporter
- date and time of information received
- position of incident
- source and cause of incident
- estimated amount of oil spilled, and
- type of oil spilled (if possible)

The OSC should continually inform the general manager of MTA and concerned agencies of the movement of the oil spill.

6.11.5.2 Assessment

As soon as enough information is collected from the oil spill the OSC should evaluate the situation and decide upon the correct method of response. The OSC may organize aerial surveillance of the spill and collect oceanographic and meteorological data to estimate the probable speed and direction of movement of the spill. If the spill is moving towards the open sea the preferred response may be to let the oil disperse naturally. The movement should be monitored regularly since it may move towards another country's shore in which case the government of that country must be notified without delay. If the spill is moving onshore then the OSC may decide upon a response technique depending on the information available and the area affected. The response could be either containment and recovery, or chemical dispersion, or shore line clean-up.
6.11.5.3 Implementation

Mechanisms for the implementation of the plan should be established and the OSC must be able to mobilize the resources and manpower available from the agencies concerned. The general manager of MTA must be authorized to commit financial resources and expend funds to a prescribed limit should the need arise.

If the extent of the spill is large and cannot be controlled by the national resources available then the general manager should be authorized to seek assistance from neighboring states, regional and international organizations.

6.11.6 RESPONSE EQUIPMENT AND RESOURCES

The following vessels and equipment from government agencies are available for use in response activities:

Assab Port Administration

- One tug boat, 1400 HP, equipped with VHF/FM, HF/SSB communications equipment, dispersant spraying system with two four-nozzle spray arms (no breaker boards), general service pump with proportioner for dispersant mixing with sea water, and dispersant storage tank.
- One tug boat, 1400 HP, with VHF/FM, HF/SSB communication equipment, offshore dispersant spraying system (with breaker boards), general service pump for dispersant application, and dispersant storage tank.
- One tug boat, 600 HP, VHF/FM equipment, not fitted with dispersant equipment.
- Two pilot boats, with VHF/FM equipment, 75 & 125 HP, no spray equipment.
- One Cooper Pealer mobile dispersant spray unit with hose and lances.
Massawa Port Administration

- Two tug boats, 350 HP each, with VHF equipment, no dispersant equipment.
- One pilot boat with VHF/FM equipment, 75 HP.
- One Cooper Feole mobile dispersant spray unit with hose and lances.

The Ethiopian Navy

- Fast patrol boats fitted with full communications equipment.

The Ethiopian Air Force

- Fixed wing aircraft and helicopters for surveillance.

Other Organizations

The following aircraft are available from Admas Air and The Ministry of State Farms:
- One Cessna 320 C
- One Cessna Aerocommander
- One Piper Aztec
- Ten crop spraying Cessna Aqwaons and Piper Pawnee fitted with Micron air spray equipment

The Ethiopian Petroleum Corporation

- One vacuum truck

Natural Resources

Some indigenous materials were identified during the Ethiopian National Seminar on Marine Pollution Prevention, Control and Response, in 1983, as effective absorbents of
both crude and bunker oil.

These materials are:
- dried date palm fibres and
- dried palm fronds

At present no specifically designed oil pollution combating equipment other than those specified above are available in Ethiopia. The purchase of additional equipment must be given due consideration. The amount and type of equipment to be procured at national level may be decided upon after agreement with neighboring States on the equipment to be purchased at regional level.

6.11.7 CLEAN-UP OPERATIONS AND TECHNIQUES

Clean-up techniques should be stated in the plan. The method of clean-up used depends on the location, environment and type of oil spilled. Containment and recovery of oil is generally preferred but the use of chemical dispersants may be necessary in some cases. The conditions of application of dispersants and the types to be used must be stated in the plan. The progress of clean-up operations should be monitored using inputs from surveillance and site supervisors to re-assess response decisions.

There are various clean-up techniques. A clean-up technique must be chosen in accordance with the environmental and physical conditions of the affected area.

During the clean-up of the recent massive oil pollution in the Gulf different techniques were developed and tested. The methods and techniques used there can benefit Ethiopia because of the similarity of the Red Sea and Gulf regions. The results and recommendations on the techniques used are available to the Government of Saudi Arabia and possibly IMO, and, may be requested from them.
6.11.6 DISPOSAL OF RECOVERED OIL AND DEBRIS

Oil pollutants contaminating beaches and the water surfaces within bays and lagoons may have to be removed. In removing oiled beach material consideration must be given to the possible future erosion of the area. Thus it may be necessary to replace the removed material by new material from a similar environment.

The oil debris and sand must be disposed of in some way. The high ambient temperatures of the Red Sea may make it favourable to use the oil debris and sand for land farming and sanitary land fill operations. These disposal methods may be environmentally acceptable. However, disposal sites should be selected so that they are not near to water courses or there is no danger of oil leaching back into the sea.

Disposing of recovered oil can be a particularly difficult problem. It is usually suggested that disposal pits be excavated near the shore line. These pits could be lined with plastic and used as temporary storage before transporting the oil to the refinery. The recovered oil may then be processed in the refinery at Assab and sold on the market.

It should be noted that the excavation of disposal pits must be carefully done and made to last for a reasonable time in areas which are far from Assab as transportation to the refinery at Assab may take some time.

At times the recovered oil may not be suitable for processing in the refinery. There are many unpaved (dirt) roads in Ethiopia where the recovered oil may be used as road oil. Oiling dirt roads significantly reduces the amount of dirt blown up to the air by vehicles and thus, improves visibility and the quality of the surrounding air.
6.11.9 RESTORATION

After clean-up operations restoration of the affected areas may be necessary. The lead agency, MTA, should consult with other concerned organizations to determine the extent of restoration required. The required restoration may be replacing contaminated beach sand, replanting mangrove stands and sea grasses. Moreover, post spill monitoring may be required in areas having high environmental sensitivity to determine the long term effects of the spill on the marine environment.

6.11.10 COMMUNICATIONS

Systems and procedures for effective communication between the DSC, field sites, vessels and air craft involved should be established. A communication centre with telephone, telex, and radio communications systems should be selected. This centre may also be used as information centre for receiving and disseminating information concerning the incident. It is suggested that the communications centers at the Naval Base in Massawa and the Southern Naval Command in Assab be used for this purpose. In addition the HF/SSR communications equipment at the ports of Assab and Massawa and the Civil Aviation's communications equipment may be used to relay reports and receive information as required.

6.11.11 TRAINING AND EXERCISES

The plan should take into account the needs for training and exercises. They must be clearly defined in the plan. Training is required at all levels and programmes must be developed accordingly. Regular exercises are needed to ensure personnel readiness, and to test equipment performance and availability. The government or the lead agency can arrange for sending personnel to help in
combating oil pollution in neighbouring States in case of incidents, thereby getting valuable experience. For instance, Saudi Arabia and Egypt have some experience with oil pollution accidents and thus have acquired some knowledge in combating oil spills. Arrangement could be made to send personnel to these countries for some training through regional training programmes. Besides, UNDP, IMO and UNEP can provide some assistance by giving on site training and supplying training material such as manuals and films.

6.11.12 RECORD KEEPING AND PREPARATION OF CLAIMS

To process claims without delay it is important that records be kept and maintained accurately. Claims must be based on actual costs incurred as a direct result of an incident. It must be noted that claims should be reasonable. Documentation demonstrating how the claim has been calculated should be prepared. The following procedures may be applied when preparing claims:

a) Marking the area affected by the spill and describing the extent of pollution and identifying the areas most heavily contaminated. Maps, charts and photographs can be used to show these areas;

b) Summary of events including a description of the work carried out and the working methods chosen in relation to the circumstances prevailing during the incident;

c) Evidence linking the oil pollution to the ship involved in the incident (e.g. chemical analysis, relevant wind and current data, observations of floating oil movements);

d) Dates on which work was carried out (weekly or daily costs);

e) Labour cost (number and categories of labourers, rates of pay);

f) Material cost (consumables, shelter, facilities, etc.).
g) Equipment cost (rental, repair, depreciation);
h) Transport cost (type of vehicles, vessels and aircraft used, rate of hire or cost of purchase, no. of hours operated);
i) Cost of final disposal of recovered oil and debris.
A daily record of the above listed expenditures should be kept. Log sheets may be prepared to record such expenses.

6.11.12.1 Third Party Claims

The following procedures may be adopted for third party claims:

Replacement and repair costs

1) Description of the extent of pollution damage to property;
2) Description of items written off or damaged and needing replacement or repairs;
3) Cost of replacement or repair;
4) Labour cost incurred;

Economic loss

1) Nature of loss including demonstration that loss resulted directly from the incident;
2) Figures indicating profits earned in previous periods and profits lost during the time damage was suffered;
3) Method of assessment of loss;

Preparation of claims is not covered in the draft plan. Since the accurate and complete recording of claims is essential for cost recovery from the provisions of CLC and FUND convention it must be included in the contingency plan.
6.11.13 PLAN REVISION

Periodical review of the plan is necessary to incorporate experience gained from actual incidents and training exercises.
(IMO, 1982; IMO/UNEP, 1985; IMO, 1988)

6.12 The International Convention on Civil Liability for Oil Pollution Damage (CLC, 69)

The purpose of this Convention is to ensure that parties who suffer from oil pollution damage resulting from maritime casualties involving oil-carrying tankers are adequately compensated.

The liability for such damage lies with the ship owner from whose ship the polluting oil escaped or was discharged. The Convention requires ships covered by it to maintain insurance or other financial security in sums equivalent to the owner’s total liability for one incident. Only ships carrying more than 2000 tons of oil in bulk as cargo are required to maintain insurance in respect of oil pollution damage. This does not apply to warships or other ships owned by a State and used for non-commercial purposes. Commercial ships owned by a State are subject to liability and jurisdiction provisions but are not required to carry insurance.

Ship owners are exempted from liability only in such cases where:

a) damage resulted from an act of war or a grave natural disaster;

b) damage was entirely caused by sabotage by a third party or;

c) damage was wholly caused by failure of authorities to maintain navigational aids.
In 1984 a Protocol was adopted to increase the limit of liability because the limits of the 1969 CLC were too low for adequate compensation in the event of a major oil spill incident. (IMO, 1992)

The Convention only covers oil tankers carrying persistent oil in bulk as cargo. Spills arising from other ships and damage caused by non-persistent oil are not covered by the Convention. For damage from spills not covered by the Convention States are free to apply national laws or legislate as they consider appropriate.

6.13 The International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND, 71)

The FUND Convention was created to supplement the CLC. The main functions of the FUND Convention are to provide supplementary compensation to those who cannot obtain full and adequate compensation for oil pollution damage under the CLC, and to indemnify the ship owner for a portion of his liability under the CLC.

The FUND is financed by parties who receive crude oil and heavy fuel oil in FUND member States.

The FUND pays compensation to any person suffering oil pollution damage and is unable to obtain full and adequate compensation under the CLC for one of the following reasons:

a) No liability for pollution damage arises under CLC because the ship owner can invoke one or more of the exemptions under the CLC (described above).

b) The ship owner is financially incapable of meeting his obligations and his insurance is insufficient to satisfy the claims for compensation for pollution damage.

c) The damage exceeds the ship owner's liability under the CLC.

The FUND does not pay for pollution damages resulting from
an act of war or if the damage is caused by a warship.
For damages not covered by the FUND States are free to
apply national laws or legislate as they consider
appropriate.
States must be parties to the CLC in order to become members
of the FUND. (M. Jacobsson)

Ethiopia has not ratified the CLC and the FUND Convention.
Ratification of these conventions is essential considering
the grave economic consequences that oil spill disasters
entail. Only an international scheme can provide sufficient
compensation for loss or damage due to oil pollution. For
instance, the Exxon Valdez oil spill has resulted in clean-
up and compensation costs which have been estimated at over
1 billion US dollars. This is a staggering amount for
countries like Ethiopia.
The amount to be paid for membership is reasonable.
Ethiopia does not import much oil, hence the amount that it
must pay for membership and the annual contributions it
must make are insignificant. The compensations that the
FUND covers far outweigh the contributions that the State
has to pay.
For compensations not covered by CLC and the FUND the
Government should establish national laws to deal with
them.

6.14 REGIONAL CONTINGENCY PLAN

The potential risk of substantial pollution by oil from the
shipping traffic in the Red Sea and the Gulf of Aden and
the vulnerability of the region to oil pollution calls for
the co-operation of the States in the region to provide
effective measures to deal with such incidents.
Being aware of this threat to the marine environment the
Contracting Parties to the Regional Convention for the
Conservation of the Red Sea and the Gulf of Aden
Environment have agreed to sign the Protocol concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency. The aims of the Protocol are:

1) To create co-operation between the Contracting Parties in taking the necessary and effective measures to protect the coastline and related interests of one or more of the Parties from the threat and effects of pollution due to the presence of oil in the marine environment resulting from accidental spills;

2) To promote the establishment of contingency plans and means for combating pollution either individually or through bilateral and multilateral co-operation. The means shall include ships, aircraft, pollution combating equipment, and manpower for operation in cases of emergency;

3) To create the possibility of initiating operations to combat pollution by oil and other harmful substances at the regional level; and

4) To promote and develop regional training programmes for combating pollution.

The Regional Contingency Plan is intended to facilitate:
- information exchange between States concerned;
- use of vessels, aircraft and oil spill response equipment;
- stockpiling of oil spill combating equipment and storing them in convenient areas;
- clear definition of command structure and liaison for joint response operations;
- arrangements for the assumption of the lead role by the State in whose waters a pollution incident occurs;
- identification of priority of coastal and sea areas;
- arrangements for vessel operation in and overflying of the territory of other States;
- the conduct of paper and live exercises to test the adequacy of the plan; and others.

Regional contingency plans provide opportunity for cost
effective and efficient means of combating oil pollution of the marine environment. The Ethiopian government should, again, seriously consider becoming party to the Regional Convention and its Protocol. Developing countries like Ethiopia cannot cope with massive oil spills on their own. Regional co-operation facilitates the pooling of resources, manpower, know how and experience to effectively combat pollution. It is now recognized even by highly industrialized nations that pollution from, say, a very large crude carrier (VLCC) is beyond the resources of a single country to deal with. In light of this, developed nations in the Baltic Sea, the North Sea and the Mediterranean Sea have developed regional contingency plans to combat pollution of the marine environment.

Bilateral and sub-regional agreements for establishing centres for combating major marine pollution incidents have been found to be effective. Given the expense and logistical difficulties involved in establishing regional centres, it is felt that such functions could be best undertaken at the bilateral or sub-regional levels. IMO, UNEP and UNDP have established a sub-regional response centre in the Philippines which has become successful. The establishment of a response centre similar to that in the Philippines has been requested by the States bordering the Gulf of Aden, namely Yemen, Somalia and Djibouti and is been studied by UNDP and IMO. UNDP and IMO can help fund the purchase of oil pollution combating equipment and provide fund for training of personnel. For the response centre in the Philippines, IMO, from UNDP funds, has supplied equipment and training. Therefore, Ethiopia and its neighboring states, Sudan and Yemen, can agree to set up such a centre with financial and technical aid from UNDP and IMO. The equipment can be stockpiled at an agreed location and training and operational matters can be discussed by the OSCs designated by each of the countries.
Not long ago an international convention was adopted by the IMO General Assembly which deals with oil pollution response and preparedness. It will be worthwhile to briefly discuss the importance of the Convention, especially to developing countries like Ethiopia.

6.15 The International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC, 90)

This Convention was adopted in November 1990 with the aim of providing a global framework for international co-operation in combating major incidents or threats of marine pollution. The Convention requires States to establish, nationally or in co-operation with other States, measures for dealing with pollution incidents. It also requires ships to have a shipboard oil pollution emergency plan. Similar arrangements for ports and offshore installations are being considered (MEPC 33/15). Furthermore, the IMO secretariat has recently drafted a programme for training in marine pollution preparedness and response. This programme stresses the needs of developing countries regarding training materials, facilities and funds. It recommends the training of people from developing countries in developed countries through specific programmes, fellowships and seminars (MEPC 33/15/2). Under the Convention establishment of stockpiles of oil spill combating equipment, holding of oil spill combating exercises and development of detailed plans for dealing with pollution incidents are required. States ratifying the convention have to provide assistance to others in the event of a pollution emergency and will be reimbursed for the assistance they provide. The Convention provides for IMO to play an important role in co-ordination of activities. The Convention has not yet been ratified.
However, it holds a great significance for every state. Major pollution incidents cannot be handled successfully and effectively by any one state, less so by a developing country. The Convention requires the co-operation of states so that they are prepared to help each other in emergency situations. The massive release of crude oil into the Persian Gulf during the Gulf war, the biggest oil spill in history, was combated by co-operation among States. IMO was called upon to co-ordinate response activities. Though the Convention was not in force, some of its measures were implemented. As a result a number of ecologically important sites in Saudi Arabia have been saved from the effects of the massive oil pollution. Such a spill could have only been tackled on an international scale. It is evident that this Convention is essential in bringing together expertise, know how, experience and equipment from many countries to combat emergencies that are too big to be handled by a single nation. Ethiopia and other developing nations stand to benefit from the ratification of this Convention and should do so without delay.
CHAPTER VII

AIR POLLUTION
7.1 INTRODUCTION

Air pollution is part of the general pollution problem which is causing deterioration of the environment. For many years man has been polluting the atmosphere relentlessly. The rate and amount of air pollution generated by human activities has been steadily growing. In recent years the amount of air pollution has reached such proportions that the problem has become global. Industries, vehicles, aircraft and ships require energy for operation. This energy comes largely from fossil fuels. Fossil fuels generate oxides of nitrogen, carbon and sulphur when burned. These oxides are gaseous in nature and are emitted to the atmosphere. Other chemical substances which originate from various activities are also emitted to the atmosphere. These emissions cause air pollution.

Ships consume an estimated 1 million tonnes of fuel oils annually. It is assumed that these fuel oils contain 2% of sulphur on the average. Hence, sulphur input into the environment will be about 2 million tonnes. Combustion of fuel oils in ships produces a considerable amount of NOx. It is estimated that maritime activities generate about 223,000 tonnes of NOx per year. SO2 and NOx are important greenhouse gases. In addition, Halons, the ship board fire-extinguishing media have a high ozone depleting potential (IMO, 1989).

In recognition of these facts, IMO, has urged member States to work on the prevention of air pollution from ships and other maritime activities. The MEPC has drafted proposals to reduce both SO2 (by 50% of the present levels) and NOx (by 30% of present levels) by year 2000 (MEPC 32/12). The 17th session of the Assembly has passed a resolution requesting the MEPC and the MSC to collect and assess
information on shipboard gas emissions, to develop implementation plan for reducing CFC emissions from ships, to prepare environmentally based standards for incineration of garbage and waste, and to develop a draft annex to MARPOL 73/78 regarding air pollution from ships. The resolution also urges member states to prevent the use of CFCs in new ships built after Nov. 1992 and the use of Halons in new ships built after Jul. 1992, except for "essential use" (A 17/res.719).

Moreover, the atmosphere is a source for about 33% of the pollutants to the marine environment (GESAMP). Therefore, reducing shipboard emissions will indirectly decrease marine pollution from the atmosphere.

In light of this it is considered worthwhile to discuss briefly the sources of air pollution and the effect they have on the environment. Understanding the implications of air pollution is very essential in taking the necessary measures to curb it.

7.2 ACID RAIN

Acid rain is produced from anthropogenic gases and is very harmful to the environment. Anthropogenic emissions originate from industrial activities. Sulphur dioxide is produced as a by-product of the metal smelting industry, the burning of coal and oil in power stations, and from fuel burned for space heating. Nitrogen oxides are produced from the burning of fossil fuels in internal combustion engines. Carbon dioxide is produced as a by-product of many industrial activities.

For more than a century the amount of sulphur dioxide, oxides of nitrogen, and carbon dioxide emissions from anthropogenic sources has been building up. As emissions increased and the gases were incorporated gradually into the atmospheric circulation the problem of acid rain has
intensified. Sulphur compounds generated by industries and other activities are said to be responsible for 65% of the acid rain in North America. Nitrogen compounds account for about 35%. In Europe, sulphur dioxide and oxides of nitrogen are blamed for 75% and 25% of the acid rain respectively. (D. Kemp)

7.2.1 Effect of Acid Rain on the Environment

A) Effect on the aquatic environment

Acid rain is generally believed to cause acidification of lakes and streams. The aquatic environment is especially vulnerable even to slight increases in acidity. Aquatic micro-organisms and fish are very sensitive to increases in the acidity of the water they live in. Many aquatic species are known to decrease in number and even to be wiped out in acidic environments. Moreover, acidic lakes contain toxic concentration of metals such as aluminium, mercury and zinc which cause the breakdown of salt-regulation systems and inhibit breathing in fish (D. Kemp). If present emission levels of sulphur dioxide and oxides of nitrogen are not decreased there exists a strong probability that lakes, streams and inland waterways throughout the globe will be fishless in the near future.

B) Effect on the terrestrial environment

In recent years evidence that acid rain is damaging forests is growing. The adverse effects of acid rain on vegetation has been demonstrated by tests. Acid precipitation intercepted by trees may promote chlorophyll degradation. Acid water also interferes with soil biology and chemistry, disturbing nutrient cycles and causing physical damage to plant-root systems. Increased acidity inhibits bacterial activity which is instrumental in releasing nutrients from
dead or decaying animal and vegetable matter. Forests in Europe and North America are showing a decline in growth rate. Trees are dying. The future of woodlands is in danger. Forest natural regeneration is decreasing in the northern hemisphere.

Though the problem of deforestation due to acid rain is currently confined to Europe and North America, there is no guarantee that it will not afflict forests in the tropics and the southern hemisphere.

C) Effect on human health

Industrial smoke and sulphuric acid originating from sulphur dioxide emissions are said to cause lung problems in humans. Sulphuric acid causes aggravated breathing problems. It is associated with as many as 4000 deaths in the United Kingdom. Moreover, there is some indication that acid rain has important indirect effects. For example, heavy metals such as copper, zinc, cadmium and mercury, released from the soil and bedrock by acid rain may eventually reach the human body via plants and animals in the food chain or through drinking water (P. Smith & K. Warr).

7.3 THE GREEN HOUSE EFFECT

The green house effect is caused by the reflection and refraction of solar radiation from the earth and atmosphere respectively. The atmosphere lets through most of the solar radiation coming from the sun, mainly short wave radiation. As it reaches the earth it heats up the surface. Some of the energy absorbed by the surface is re-radiated into the atmosphere. The atmosphere then re-emites some of this radiation back to the earth, thus, warming it. This phenomenon is known as the green house effect. It is an important characteristic of the environment which keeps the average global temperature at
about +15°C. If there was no greenhouse effect the Earth's average temperature would be around -18°C. This would have made life very difficult. The greenhouse effect is made possible by a number of gases present in the atmosphere. Of these carbon dioxide is the most significant. Some other important gases are methane, chlorofluorocarbons, nitrous oxide and water vapour.

7.4 GLOBAL WARMING

Global warming is one of the major pollution-induced problems threatening the world today. It is closely linked to the greenhouse effect. Naturally occurring greenhouse gases help maintain the moderate temperatures that exist on the surface of the Earth. However, additional emissions of these gases from human activities may lead to warming of the Earth. Carbon dioxide originating from the burning of fossil fuels and vegetation amounts to about 5 billion tonnes annually. The amount of methane present in the atmosphere has more than doubled recently. Cattle, rotting waste products, and rice paddies are the main sources of methane. The releases of these and other gases into the atmosphere has become so enormous that they have disrupted the natural regulating cycles. This has led to the intensification of the greenhouse effect which may result in global warming.

The Effects of Global Warming

Temperature increases due to global warming could lead to major environmental changes. Global warming may cause less precipitation and higher temperatures, causing reduction of yields in the grain producing areas of N.America and Russia. This would create serious food shortages in many parts of the world which depend on grain from N.America. Moreover, global warming can bring about a rise in sea
level. The sea level will rise caused by thermal expansion of ocean waters and melting of glaciers and ice caps. Sea level rise of only tens of centimeters could create very real danger to many low lying areas of the world. Many of the world's largest cities are built at sea level, and as a result, could be destroyed. (P. Smith & K. Warr)

7.5 OZONE DEPLETION

Ozone is an isotope of oxygen formed in the atmosphere by the action of the sun's rays on oxygen molecules. It is mainly concentrated in the stratosphere. It absorbs a very high amount of the lethal ultra-violet radiation. Because of this it is essential to the existence of life on Earth. The amount of ozone in the stratosphere, though naturally kept at a constant level, may be altered by some anthropogenic gases. Oxides of nitrogen, hydrogen and chlorine such as chlorofluorocarbons (CFCs), nitric oxide, and methane, can seriously decrease the amount of ozone. Once these gases are emitted to the atmosphere they are carried to the stratosphere where they react with ozone to form ordinary oxygen molecules. This effectively destroys the ozone.

Effect of Ozone Depletion

The loss of ozone in the stratosphere causes the sun's ultra-violet radiation to pass through to the surface without being filtered out. Ultra-violet causes skin cancer and radiation blindness. It is also believed to retard photosynthesis in plants and increase mutation. It can kill some of the micro-organisms in the sea which are a vital link in the marine food chain. Studies of atmospheric processes and systems are revealing the catastrophic damages to the environment that have resulted from emission of gases from various human
activities. Natural atmospheric cleansing processes can no longer work effectively as the amount of pollutants is becoming more than they can handle. The problem of air pollution will continue to grow unless a global effort is made to decrease the amount of pollutants being emitted to the atmosphere from various sources.
CHAPTER VIII

CONCLUSION AND RECOMMENDATIONS
8.1 CONCLUSION

Marine pollution has become a global problem today. Its effects and consequences are becoming evident in light of new information and experience. Nations and peoples are becoming aware of the hazards of marine pollution slowly but surely. International and regional conventions are being established to prevent, control and mitigate the effects of marine pollution on the environment.

However, the implications and consequences of marine pollution are not fully realized by many countries, especially developing ones. Marine pollution, as other forms of pollution, is a by-product of development. In the drive for economic growth and better living conditions nations have taken steps that in effect have degraded the economic base of their development, that is the environment. Marine pollution, like any other form of pollution, emanates from the misuse and abuse of the environment. Developing nations have much at stake. Their economies are largely based on the export of natural resources which environmental degradation and pollution are destroying. Basic requirements such as food and safe drinking water come from land and sea resources. Continued supply of these basic commodities needs the prudent management and protection of the land and sea resources. For instance, fish resources must be exploited in a sustainable manner and have to be protected from pollution hazards. This requires strong policies which will take measures to prevent and control pollution and misuse. Unless development and environment are coupled together in every sphere of human activity then the continuity of development will be put in jeopardy. Ethiopia is still in the early stages of developing its marine resources and has
not yet taken adequate measures for safeguarding these resources. The development infrastructure is not tuned to take environmental problems into consideration. Public awareness of pollution hazards is still low. Measures have to be taken to restructure the organizations in the maritime sector so that pollution and other environmental issues can be dealt with effectively. Above all the State’s development policies have to be reformulated so that development strategies have long term sustainable goals which take environmental issues into consideration.

8.2 RECOMMENDATIONS

To achieve a complete control of intentional pollution and to minimize accidental pollution regulatory frameworks must be developed and implemented nationally. This can only be done by providing an effective machinery for dealing with the scientific, technical and legal aspects of marine pollution. In light of this the present maritime organizational structure in Ethiopia may have to be restructured and more emphasis given to the protection of the environment.

I) Maritime Administration

The Maritime Administration of Ethiopia is currently a small department in the Marine Transport Authority (MTA). Though MTA is supposed to perform the functions of a maritime administration, its main activities are largely concerned with the administration and management of the ports and inland waters. Therefore, the creation of a maritime administration separate from the port administrations but under the supervision and statutory authority of MTA is necessary. The Maritime Administration should be tasked with:
- the implementation and development of national maritime rules and regulations,
- adoption of international conventions,
- port state control,
- registration, certification and manning of ships,
- inspection of ships,
- training,
- prevention and control of marine pollution,
- pilotage services and the training of pilots,
- setting-up of the office of Hydrography for preparing sea charts, and
- improving and developing fairways and others.

A well organized Maritime Administration will be able to effectively prevent and control marine pollution besides its other functions which also contribute to safeguarding the marine environment.

II) Environment Protection Agency

An environment protection Agency must be formed to deal with environmental matters. The Agency should have a department concerned with the marine environment. This department shall prepare marine pollution control strategies, conduct research in collaboration with the proposed maritime administration and other relevant organizations and institutions, develop co-operation with regional and international organizations in matters of marine environment conservation, protection and legislation.

III) National Oil Spill Response

A national oil spill response plan capable of effectively combating accidental oil pollution has to be developed. The maritime administration should be responsible for implementing the response plan. The response should be
supported plan should be supported by other concerned governmental organizations. The establishment of a regional contingency plan in co-operation with neighbouring states should be given due consideration and action should be taken to organize such a plan within the framework of the reginal seas programme of UNEP.

IV) Maritime Legislation

The Ethiopian Maritime Law which is under preparation should be finalized and incorporated into the National legislation as a matter of priority. This will facilitate the ratification and adoption of international conventions related to marine pollution. The proposed maritime administration should be directly involved in the development and evolution of maritime laws of the country.

V) International and Regional Conventions

The Ethiopian government should ratify the international conventions related to the prevention and control of marine pollution and the liability and compensation conventions. The government should also seriously consider to be party to the Regional Convention for the Conservation of the Red Sea and the Gulf of Aden Environment. The proposed maritime administration should actively participate in this process and must be given the responsibility for such matters. Pollution knows no boundries, hence, regional and international co-operation in combating and prevention of pollution, research, training and development of pollution fighting techniques etc. will be both effective and economical. Strong liasons with IMO, UNEP, UNDP etc. should be maintained and active participation in seminars, conferences and sessions in matters related marine pollution is highly recommended.
VI) Marine Resources

The exact extent and status of marine resources and critical habitats i.e. coral reefs, seagrass, mangrove stands, fish etc. is unknown. A broadscale survey to determine resources and habitats must be undertaken. This will help in identifying sensitive areas and in taking the necessary precautions in protecting the living resources and the critical habitats from pollution hazards.

VII) Coastal Development

Coastal development activities should be assessed for the possible impacts they may have on the environment. Industrial waste discharges into the sea should be evaluated beforehand for the degree of influence they have on the marine environment so as to eliminate or reduce any damaging effects. Development plans should take the marine environment into account before implementation.

VIII) Education and Training

Environmental sciences should be taught at all levels of education. Training should be given to people concerned with maritime affairs. Study and research on the marine environment of the country should be encouraged. A department of Oceanography should be formed at higher educational institutions. The marine biology department at the University of Asmara should be broadened to increase its scope and capabilities. Co-operation in research and education in the marine sciences with other regional and international institutions should be sought and encouraged. Public education programmes for informing and acquainting people with the marine environment and the hazards of pollution should be prepared and disseminated through the mass media. In this respect the maritime administration
should actively work in conjunction with educational institutions in the development of maritime education, research and application.

IX) Reception Facilities

MTA should provide reception facilities for oily residues and ship borne garbage.

X) Fines

The present deterrent penalties for unlawful discharge of pollutants should be upgraded to more realistic figures to discourage intentional discharges. This had been recommended by IMO representatives.

XI) Sewage

The sewage disposal systems in Assab and Massawa must be improved. Master plans for sewerage systems must be prepared and implemented. Primary treatment plants should be built. The plans should take into account future expansion and development of the ports and population growth. Sewage outfall pipes should be extended to the open sea and away from recreational beaches. The outfall pipes should be located in areas of turbulent waters and strong currents for rapid mixing and dispersion and they should be few in number.

XII) The effluent discharge pipe from the oil refinery at Assab must be extended from its present 20m length to reach the open sea where the rate of mixing is more rapid. Effluent discharge near shores is detrimental to fish nursery grounds and critical habitats.

XIII) Used oil from the power plants and port workshops at
Assab and Massawa should be discharged into reception facilities and sent to the refinery for recycling.

XIV) Surveillance and monitoring of the territorial waters for detecting oil spills and detaining of offending vessels should be carried out by the Navy in addition to its normal work.

XV) Diligent survey of ships calling at the ports should be carried out by the Maritime Administration for checking of proper certificates, oil discharge monitoring equipment etc.

XVI) Port facilities such as buoys, light houses, traffic separation schemes should be improved and up-graded in accordance with current international practice to minimize accidents, thus, lessen the probability of oil spill incidents.
PROPOSED MARITIME ADMINISTRATION
ORGANIZATIONAL CHART

Ministry of Transport & Comm.

Marine Transport Authority

Maritime Administration

Assab Port Administ.

Mossawa Port Administ.

In-Land Water Administ.

Safety and Survey Dept.

Legal Dept.

Pilotage and Marking Services

Regist., Cert. and Mann. Dept.

Training Dept.

Hydrographic Office


