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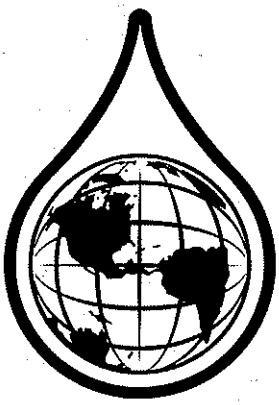

Sources of Oil to the Marine Environment

A discussion of the sources of oil that pollutes our marine environment.

Canada

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Environmental Achievement

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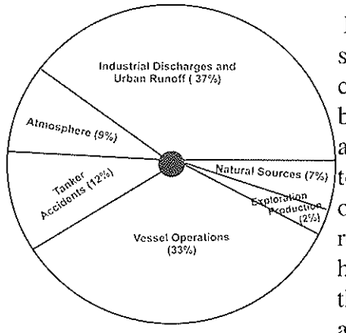
INTRODUCTION

It is interesting, and somewhat surprising, to realize that the oil which so concerns us when it is released to the ocean, actually began its existence in the oceans themselves. Petroleum is a fossil fuel that occurs naturally, and is produced from the decay of plant material. But this plant material actually originated in the ancient seas of the planet as tiny aquatic organisms. Over countless millions of years, immeasurable numbers of these organisms were incorporated into marine sedimentary rocks. As time progressed, natural physical and chemical forces acted on this material to eventually form petroleum. It is a fact that the greatest volume of the worlds oil reserves are now found in these sedimentary formations.

THE SOURCES

Oil enters the marine environment through a variety of pathways, but regardless of the route by which they enter, the sources of the oil are either natural, or the result of human activities.



Natural sources, such as oil seeps contribute a small but significant amount of the oil to the worlds oceans. The remainder, however, is strictly the result of human activities related to the exploration for oil, its production, transportation, refining, use, storage, and disposal.

Despite the many millions of tonnes of oil introduced to the world's oceans, however, there is fortunately little evidence of build up of oil residues in the sea. This is due to a number of factors, not the least of which is the ability of the marine environment to assimilate oil.

Natural Seeps

Natural seeps of oil occur on both the land and on the ocean floors. They have been known and described throughout recorded human history.

When petroleum exploration was in its infancy, oil seeps on land were used as potential indicators of commercially viable petroleum deposits. As a result, considerable effort was put into accurately locating and describing land based seeps. This was not the case for submarine seeps, where information on their location and abundance is limited. This is understandable in light of the obvious difficulty in observing the seeps and the relative lack of undersea exploration compared to that on land.

The number of reported submarine seeps is estimated to be in the hundreds world wide. This number continues to grow, however, as more detailed studies employing sophisticated equipment such as lasers and satellites, are conducted.

Some submarine seeps have been observed where the escaping oil seldom reaches the surface waters. Such seeps consist of heavy oil that form tar flows or mats on the ocean

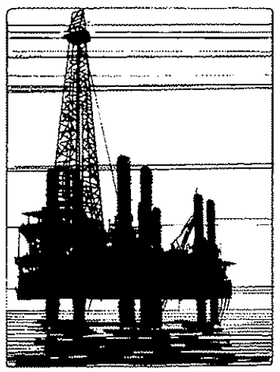
floor. Oil from several seeps along the coast of California does reach the surface and is blown by the wind onto the shore, where it undergoes constant degradation.

Because petroleum seeps are a natural occurrence, people often don't consider the oil that escapes from them to be a pollutant, or the seeps themselves to be significant contributors of pollutant to the oceans. However, although the calculations that have been made are obviously limited by the amount of available data, the best estimates indicate that these seeps contribute about seven to eight percent of the total amount of oil that enters the world's oceans, approximately two hundred and fifty thousand tonnes every year.

In Canada, there are a number of natural oil seeps, notably one off Baffin Island and another at Point Peele in Ontario.

Sources Resulting from Human Activities

At almost every stage of their life cycle, oil and oil products can be released either directly to the oceans or in places or under circumstances where it will enter the oceans.



Exploring for and producing oil offshore can result in releases of oil, either as a result of accidental blowouts or operational discharges. Crude oil can escape during transportation as a result of tanker and subsea pipeline accidents, or ships can release oil during routine maintenance operations.

Pipelines or fuel storage tanks on land can rupture, sending oil into rivers that empty into the oceans, and used engine oil that is dumped down drains and into sewers can end up in the sea. Even industrial and household sewage contains waste oil that may eventually make its way to marine waters. Air pollution, mainly from cars and industrial operations, also eventually results in the addition of a large amount of hydrocarbons into the ocean.

In effect, then, the impact of humans and their use of petroleum and its products results in the input to the marine environment of significant quantities of crude oil and its derivatives, not only from the land and sea, but from the air as well.

Atmospheric Sources

Petroleum hydrocarbons enter the ocean from the atmosphere by a rather circuitous route. Most of the air pollution can be attributed to exhaust fumes from vehicles and air emissions from industry.

When an internal combustion engine is operating perfectly, the only wastes that are produced are water and carbon dioxide. But since nothing ever works perfectly, in actual fact the exhausted wastes also include slight

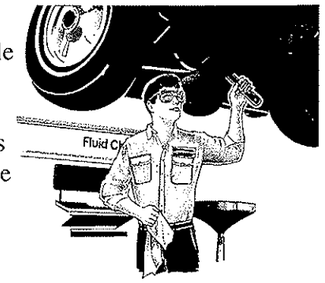
amounts of lube oil as well as unburned or partially burned fuel. It has been estimated that direct oil emissions from engines in near-perfect technical conditions range from 0.1 to 0.25 liters per 1000 kilometers.

Rain and other types of atmospheric precipitation wash this material from the air and carry it to land, to rivers and streams, and to the ocean.

Because of the nature of the problem, and the fact that no spills result, atmospheric fallout is of much less concern to the general public than other sources of oil pollution. However, despite the difficulty of accurately assessing the global extent of this type of pollution, estimates have determined that approximately nine percent, or about two hundred and ninety thousand tonnes of oil enter the oceans each year as a result of air pollution.

Land Sources

Oil will enter the marine environment from sources on land as a result of the practices of industry and other users. One of the most significant of the pollutants is waste **lubricating oil**, which can and often does end up in waterways that lead to the sea. Passenger cars account for about seventy percent of the lubricating oil consumed worldwide.



Approximately eighty percent of motor vehicle oil has to be dealt with during oil changes. An average oil change uses about five liters, and the waste oil can be effectively re-used as fuel or re-refined.

In previous years, waste lube oil was generally used as a dust suppressant on roads in rural areas, or on roads under construction. Though its use for this purpose is becoming less common as environmental controls become more stringent, nevertheless, runoff from roads can add to the contaminant load of the oceans. Even if lube oil is not deliberately spread on roads to reduce dust, leakage and deliberate dumping on the ground can result in significant contamination of road surfaces. During periods of storms or heavy rains, this oil will be flushed down into the sewers. It has been estimated, for example, that every year, the oily runoff from a city of about five million people can contain as much oil as that spilled from a large tanker.

When oil is released down sewers and drains, part of it will accumulate below ground and the rest will eventually make its way to the sea.

Estimates of the amounts of waste that reaches the oceans differ because of the variability in the parameters used to make the determinations. These include such things as the amount of oil that remains in the soils, the amount degraded before it reaches the oceans, the effectiveness of treatment, the

efficiencies of the different internal combustion engines, and so on. Notwithstanding these constraints, some estimates have put the amount of spent lubricants entering the oceans as high as two million tonnes per year, though in actual fact the quantity is probably less.

Refineries located on or near shorelines also release oil to the marine environment. This oil can be released as a result of a number of different operations. Process water from the refining operation itself can be contaminated from contact with oil. Ballast water from ballast water treatment plants may contain oil residues, and runoff and drainage from the site may entrain oil that has been released as a result of small spills and minor leaks. These relatively lightly contaminated waters will generally pass through the normal oil-water separators and be released into rivers, harbours and the ocean .

Older facilities which lack more modern technologies for reducing the oil content in their effluent discharges will usually release significantly more oil.

A unique situation sometimes occurs where the water is too shallow for large tankers to offload at a dock. In these instances, the tanker may unload its cargo into a pipe that runs out from the shore to a point where the water depth is sufficient for the tanker. The pipe is generally connected to a flexible hose that rises up to a floating, anchored buoy. This arrangement is known as a single buoy mooring system. Because of the distance that the buoy can be from shore, the ship and the mooring system are more exposed to the idiosyncrasies of weather and waves than would be the case if they were tied to a dock. As a result, spills of oil may occur more frequently during the offloading process.

Most refineries store large quantities of both crude oil and refined products in bulk storage tanks. These "tank farms" represent a potential source of oil spills, not only large volume spills from tank ruptures, but also smaller leaks and spills from regular, routine operations such as product transfers, valve leaks and tank cleaning. Oil spilled in this manner could find its way to the ocean.

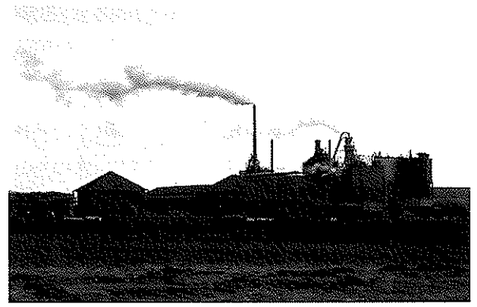
Municipal sources of oil discharges are varied, and the amount of discharge will depend on such factors as the contribution and type of industry, the legislation that applies to such facilities as service stations, the environmental requirements for industry, and the design, operation and maintenance of the various industrial and municipal treatment systems.

Heating fuel stored in bulk by commercial suppliers can spill from both above-ground and below-ground storage tanks. Spills can also occur from institutional and home fuel storage tanks, as a result of ruptures in the tank and mishandling during tank filling. The oil from these spills can flow directly to a water source or saturate the ground and find its way into cracked or abandoned storm drains which flow to the sea.

Municipal and industrial wastes almost always contain some oil, and if the

communities and the industries are located along or near the coast, this oil almost inevitably ends up in the ocean. Estimates of the amount of oil entering the ocean globally from such sources range as high as six hundred thousand tonnes per year.

Other industries which have been identified as discharging significant amounts of oil are those manufacturing **chemicals and allied products; blast furnaces and steel producers; food and related industries, and textile mills**.



In the chemical and allied products industry, the amount of oily discharges depends to a large extent on the type of chemical produced. The iron and steel industry produces oil during hot forming and cold rolling operations, and estimates have been made that as much as one kilogram of oily discharge per tonne of steel can be expected. In the textile industry, it is estimated that approximately 50mg/L of oil is discharged as a result of wool scouring and dyeing operations.

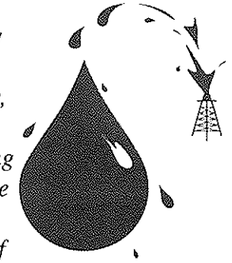
In total, the amount of oil that ends up in the oceans as a result of industrial and municipal discharges and urban runoff is estimated to exceed 1,200,000 tonnes annually.

Marine Sources

There are many operations that take place in the marine environment which can result in the release of oil to the oceans. Most of these are associated with the production and transportation of oil, and the routine operation of vessels involved in these functions.

Offshore exploration and production

Operational activities related to the exploration for oil and its subsequent production can result in the escape of oil to the sea. Accidental pipe and tank ruptures, valve failures and tank overflows can add to marine contamination. But the most spectacular of oil discharges from operations of this type is the **"blow out"**, when oil gushes uncontrollably from a well drilled into the oil reservoir. *During the Gulf War, deliberate blow outs were initiated in Kuwait by retreating Iraqi troops, in the first instance of the use of oil as a weapon against the environment. One of the largest oil spills ever recorded was the 1979 blow out of the Ixtoc 1 oil well in the Gulf of Mexico, when an estimated 450,000 tonnes of oil were released.*



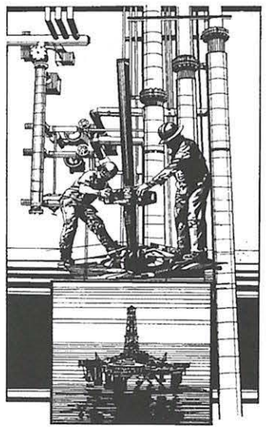
Oil pollution can also result from sub-sea blow outs, when oil under pressure passes through a section of fissured rock and leaks out over the ocean floor.

In spite of the dramatic impact of oil well blow outs, however, they occur very infrequently. The much larger number of small but fairly constant releases which occur

during routine operations normally account for a significant hydrocarbon input. These releases are generally associated with the disposal of drilling muds and the release of production and displacement water.

Drilling mud, used to lubricate the drill pipe and bit, is a dense liquid that may be water-based or oil-based. By the time it is ready for disposal, water-based mud may be contaminated with up to eight percent oil. Since oil can't be removed from water-based muds, and because the amounts are considered to be relatively small, these muds are usually dumped overboard. Since tens of tonnes of mud may be disposed of from a single platform over a year, the total amount of oil entering the ocean from this source can be significant.

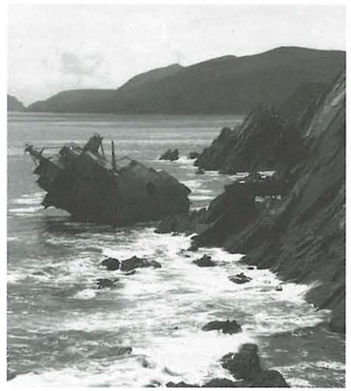
Production water is the water that is always present with the oil in the subsurface reservoir. It is pumped to the surface along with the oil and is generally treated to remove any entrained oil, then discharged overboard. Regardless of the effectiveness of the treatment, all the oil can't possibly be removed, so that during the course of the drilling operation, a significant amount of oil enters the ocean via this route.



Displacement water replaces oil pumped from storage tanks on the offshore production platform into receiving tankers. This avoids the creation of explosive air spaces. When newly produced oil is pumped into the storage tanks, the water is replaced. Steps are taken to remove oil dispersed in the displacement water before it is released, but a considerable quantity of oil will still be discharged over time.

Although it is difficult to accurately determine the amounts released, offshore oil exploration and production probably results in a contribution of approximately two percent, or roughly fifty thousand tonnes, to the total yearly input of oil to the oceans.

Tanker Accidents



After it is produced, oil has to get to its consumers. The bulk of it is transported in tankers, which carry crude petroleum and fuel from oil fields and refineries to distribution centers along a tanker network that covers the globe. The first oil tanker was built in Germany in 1886, and could carry a cargo of three hundred deadweight tons (dwt) (1 deadweight ton = 2,240 lb). Times have changed and tankers have grown, and the largest tankers sailing today, the so-called ULCCs or Ultra-large crude carriers, have

cargo capacities of up to 500,000 dwt and lengths of over 1200 feet. The potential and actual **accidental disasters** that can result when these tankers run into trouble make huge headlines globally. The spill of 100,000 tonnes of oil from the "Torrey Canyon" off the coast of Britain in 1967, for example, effectively alerted the world to the potential dangers of transporting petroleum in large quantities. Other dramatic and spectacular accidents followed.

The "Arrow" struck Cerberus Rock at the entrance to Chedabucto Bay, Nova Scotia, in 1970, spilling its cargo of ten thousand tonnes of Bunker C. The greatest amount of oil lost from a tanker occurred in 1978, when the "Amoco Cadiz" ran aground in the English Channel, spilling 220,000 tonnes and creating an ecological disaster whose effects were felt for over a decade.

Each year hundreds of tankers ply the waters of eastern Canada on their way to ports in the region or further afield. The amount of shipping that occurs in the area makes this region the most prone to oil spills from tankers and other vessels. Indeed, the two largest spills in Canadian waters, those from the "Arrow" (9000 tonnes) and the "Kurdistan" (7000 tonnes), occurred here.

Although there is considerable media focus on disasters such as these, in fact the amount of oil released in spills from tankers is only about twelve percent of the total input to the marine environment, or about 400,000 tonnes annually.

Routine Tanker Operations

By far, the major contribution of oil from oil tankers comes not from accidental spills, but from routine maintenance operations performed aboard ship. In order to better grasp the reasons for this, it is useful to have at least a basic understanding of the way in which tankers operate.

When a tanker travels from its port of loading to the discharge port, some of the oil will cling to the sides of the tank. After unloading, this oil, known as clingage, will remain and may constitute up to 0.5 percent of the cargo. In the case of a ULCC, this could amount to almost twenty five hundred tonnes! This oil has to be removed on a regular basis. When a tanker unloads its cargo, so much weight is removed that the vessel rides too high in the water and its stability may be seriously compromised. The tanker must therefore take on seawater to act as ballast on its return trip. The amount of ballast usually ranges between 25% and 50% of the total cargo capacity. Any ballast put into tanks that haven't been cleaned will be contaminated with the clingage. Prior to 1978, this "dirty" ballast was pumped directly overboard during tank cleaning operations. Obviously, with this method of tank cleaning and ballast discharge, tremendous quantities of oil were entering the world's oceans.

Because of the concerns raised by both governments and the public, as well as

environmental organizations, about the amounts of pollution arising from these types of tanker operation, several new and more effective methods and techniques have been developed. As a result of an international agreement reached under the International Maritime Organization (IMO), more efficient ballast handling techniques will be required on all tankers above a designated size.

These developments have considerably reduced the amount of oil in the ballast generated by tanker operations. However, a significant quantity of oil still enters the oceans as a result of routine tanker procedures. The amount of oil expelled into the marine environment from this source is estimated to be approximately 700,000 tonnes per year.

General Ship Sources

Oil also enters the marine environment as a result of discharges not only by tankers, but by all kinds of vessels in the course of their normal operations.

While oil forms the cargo in tankers, it is also used as a fuel and a lubricant by all ships, and hence the potential for its escape to the oceans is always present.

Fuel is stored in tanks in the ship, some of which may be large enough that when the fuel is used, ballast water may have to be taken aboard to maintain the vessel's stability. It is inevitable that this water will become contaminated with oil. Oils will also drain down through the ship to collect in the bilge water.

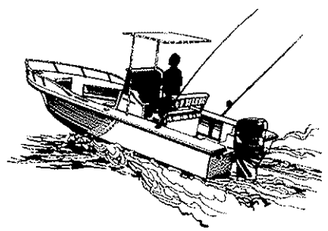
Ballast water contaminated with fuel oil has to be disposed of before the tank that contained the ballast can be filled with fuel. In many instances this oily water is simply dumped overboard. Ships exceeding 80 tonnes in weight that use fuel tanks for ballast water now have to be equipped with oil-water separators, which allows the oil to be retained while the water is pumped overboard. These are not 100% efficient, however, and inevitably some oil is released with the water.

During the course of normal operations, oily water will collect in the bilges of a ship. This results from spills and leaks, not only of fuel, but of lubricating oil as well. When the bilge water is discharged, the oil is released as well.

The amount of oil discharged to the oceans in the form of oily ballast and bilge water is estimated to be about 300,000 tonnes annually.

Other Sources

Several other sources contribute oil to the marine environment, and while they may not be significant in terms of the volume discharged, they represent a very visible and constant reminder of the pollution of our environment. For example, the spills that occur during routine fuelling and operation of pleasure craft such as **outboard motor boats and sail boats**, usually occur near shore and often in sheltered marinas. As a result they may attract a great deal of attention and generate considerable public concern.



Commercial fishing boats are also a source

of oil pollution. As with other vessels, the bilges of these boats become contaminated with oil which may be discharged overboard when the bilges are pumped.

CONCLUSION

While it is the catastrophic oil spills, such as those that result from the groundings of supertankers and spectacular oil well blow outs, that rivet our attention and make global headlines, they are by no means the most important sources of the oil that enters and pollutes our oceans. Even the regular operation and routine maintenance of tankers and other ships, while contributing significantly to the total amount of oil in the seas, are not the most significant sources of marine oil pollution.

Over the years, however, people have mistakenly believed that oil pollution in the oceans is a result of huge tanker spills and oil well blowouts at sea, events that are well beyond their control. The reality is that the greatest input of oil to the oceans is the result of human activities on land, and that, with the exception of natural seeps of petroleum, **all** oil pollution is a result of the normal, routine activities and practices of human beings as they go about their daily lives.

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