OIL SPILLS

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Abstract

An oil spill is a release of a liquid petroleum hydrocarbon into the environment due to human activity, and is a form of pollution. The term often refers to marine oil spills, where oil is released into the ocean or coastal waters. Oil spills include releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, and heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil. Spills may take months or even years to clean up.

During that era, the simple drilling techniques such as cable-tool drilling and the lack of blowout preventers meant that drillers could not control high-pressure reservoirs. When these high pressure zones were breached the hydrocarbon fluids would travel up the well at a high rate, forcing out the drill string and creating a gusher. A well which began as a gusher was said to have "*blown in*": for instance, the *Lakeview Gusher blew in in 1910*. These uncapped wells could produce large amounts of oil, often shooting 200 feet (60 m) or higher into the air. A blowout primarily composed of natural gas was known as a gas gusher.

Releases of crude oil from offshore platforms and/or drilling rigs and wells can be observed*: i) Surface blowouts and ii)Subsea blowouts. These* blowouts are caused by *i) Reservoir pressure; ii) Formation kick; and iii) Well control. Meanwhile,* well blowouts can occur during: *i) the drilling phase; ii) well testing; iii) well completion; iv) production; or v) workover activities.* As the technology developed, blowout preventers became standard equipment, and gushers became a thing of the past. In the modern petroleum industry, uncontrollable wells became known as blowouts. There has been a significant improvement in technology, well control techniques and personnel training that has helped to prevent them occurring.

Despite being symbols of new-found wealth, gushers were dangerous and wasteful. They killed workmen involved in drilling, destroyed equipment, and coated the landscape with thousands of barrels of oil; additionally, the explosive concussion released by the well when it pierces an oil/gas reservoir has been responsible for a number of oilmen losing their hearing entirely; standing too near to the drill at the moment it contacts the oil reservoir is extremely hazardous. The impact on wildlife is very hard to quantify, but can only be estimated to be mild in the most optimistic models -realistically, the ecological impact is estimated by scientists across the ideological spectrum to be severe, profound, and lasting.

No two oil spills are the same because of the variation in oil types, locations and weather conditions involved. There are four main methods of response: *1) Leave the oil alone so that it breaks down by natural means.; 2) Contain the spill with booms and collect it from the water surface using skimmer equipment.; 3) Use dispersants to break up the oil and speed its natural biodegradation.; and 4) Introduce biological agents to the spill to hasten biodegradation.*

Cleanup and recovery from an oil spill is difficult and depends upon many factors, including: *i) the type of oil spilled; ii) the temperature of the water (affecting evaporation and biodegradation), and iii) the types of shorelines and beaches involved*.

Several methods for cleaning up oil spill can be used that include*: i) Bioremediation; ii) Dispersants act as detergents; iii) Dredging; iv) Skimming; v) Solidifying; and vi) Vacuum and centrifuge.*

To Prevention Oil Spill in *Coastal petroleum facilities:* All production and loading terminal facilities and refineries and land must subject to strict government environmental protection policy requirements concerning the purity of water discharge into the sea. Oil companies ensure their discharges are well under the limit of 30 parts per million in water.

To Prevention Oil Spill in *Oil transport:* Undersea oil pipelines are wrapped in special coatings to prevent corrosion and they are provided with an outer protective coating of concrete which also gives the line sufficient weight to keep it on the ocean floor. Often these lines are buried beneath the seabed as an additional safeguard.

Steps to Prevention Oil Spill***: i) Seafood Sensory Training***; ***ii) Secondary containment*** - methods to prevent releases of oil or hydrocarbons into environment.; ***iii) Oil Spill Prevention Containment and Countermeasures (SPCC) program*** by the United States Environmental Protection Agency.; and ***iv) Double-hulling*** - build double hulls into vessels, which reduces the risk and severity of a spill in case of a collision or grounding. Existing single-hull vessels can also be rebuilt to have a double hull.

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INTRODUCTION

The petroleum industry's safety record of handling oil and its products in many country has been excellent and has been maintained throughout the last two decades of rapidly increasing volumes produced and transported in national waters. Oil spills from offshore production have been insignificant and, while there have been some spills arising from shipping accidents, none has had a lasting adverse impact on the marine environment.

Nevertheless the oil industry, aware of a concern about the possible impact of oil spills on the marine environment, has stepped up its efforts to protect the ecosystems surrounding its operations. Defense against potential marine pollution is a combination of prevention and cure. In addition to the introduction of more rigorous inspections and safeguards on all its installations and tanker fleets, the industry has established, the best equipped marine oil spill response and training centers.

An oil spill is a release of a liquid petroleum hydrocarbon into the environment due to human activity, and is a form of pollution (Fig.2). The term often refers to marine oil spills, where oil is released into the ocean or coastal waters. Oil spills include releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, and heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil. Spills may take months or even years to clean up[1].

Oil also enters the marine environment from natural oil seeps[2] . Most human-made oil pollution comes from land-based activity, but public attention and regulation has tended to focus most sharply on seagoing oil tankers.

This article sight some light on the oil spill and its types with special focus on oil spill releases of crude oil from drilling and wells. Environment effect, cleaning up, recovery and methods that used to estimate the volume of spills are also emphases.

Fig.1: Deepwater Horizon oil spill on June 25, 2010.

Fig.2: A beach after an oil spill

Fig.3: Oil Slick from the Montara oil spill in the Timor Sea, September, 2009.

2. SOURCES OF THE OIL IN THE SEA

The risks and responsibilities associated with oil in the sea should be put in their true perspective (Figs.1, 2 & 3).

By far the highest contributor to oil in the ocean (~ 37 %) results from a mix of materials and wastes which make up urban run-off and the discharge from land - based industrial plants. These materials reach the sea via storm water drains, sewage outfalls, creeks and rivers.

Another ~7% is oil which seeps naturally out of fissures in the sea bed. Oil and tar stranded on the beaches, was first noticed by European during the early 1800s. Now it is known to come from cracks in the ocean seabed and is particularly noticeable after earth tremors in the region.

Only 14 % of the oil in the sea is directly attributable to the world's oil industry. ~2% of this occurs in spills during the exploration and production phase from rigs and platforms, and 12 % is attributable to accidents involving oil tankers.

Another 33 % occurs during the operation of vessels other than those used by the oil industry. Usually these are cargo vessels which may be involved in collisions which spill fuel oil or they may discharge waste oil from ballast tanks during a voyage.

The remaining 9 % of oil in the oceans is absorbed from the atmosphere.

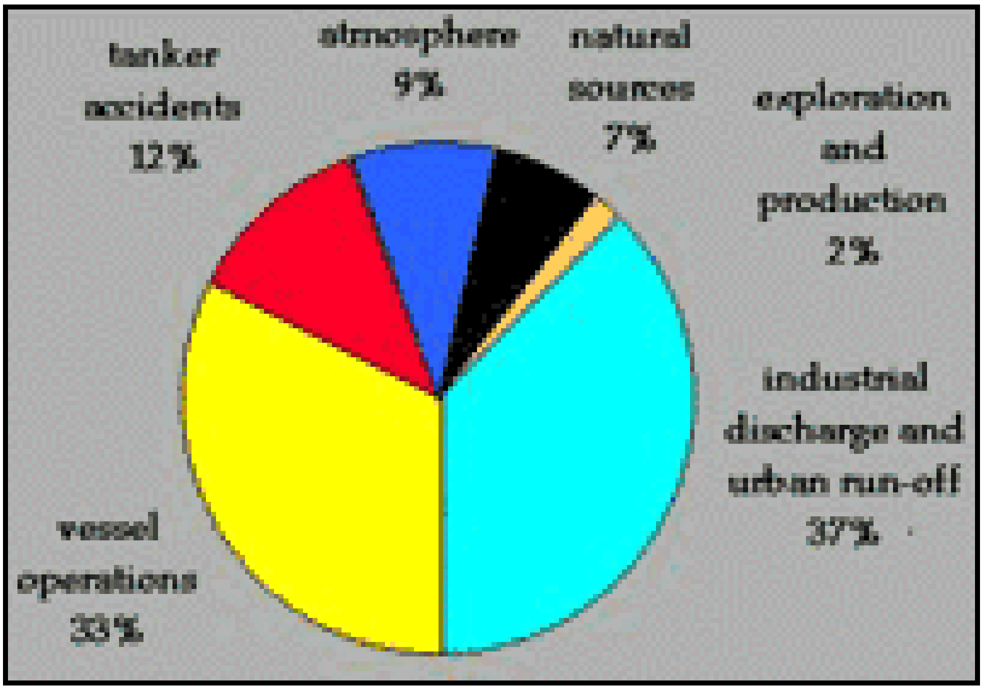


Fig.4 : Major inputs of petroleum to the marine environment

3. BLOWOUT

A *blowout* is the uncontrolled release of crude oil and/or natural gas from an oil well or gas well after pressure control systems have failed [3]. Prior to the advent of pressure control equipment in the 1920s, the uncontrolled release of oil and gas from a well while drilling was common and was known as an *oil gusher, gusher* or *wild well*.

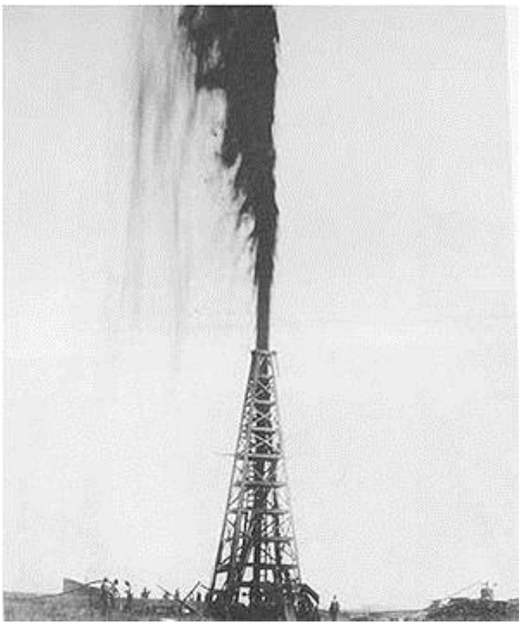


Fig.5 : The Lucas Gusher at Spindletop, Texas (1901).

Gushers were an icon of oil exploration during the late 19th and early 20th centuries. During that era, the simple drilling techniques such as cable-tool drilling and the lack of blowout preventers meant that drillers could not control high-pressure reservoirs. When these high pressure zones were breached the hydrocarbon fluids would travel up the well at a high rate, forcing out the drill string and creating a gusher. A well which began as a gusher was said to have "*blown in*": for instance, the *Lakeview Gusher blew in in 1910*. These uncapped wells could produce large amounts of oil, often shooting 200 feet (60 m) or higher into the air (Fig.5).[4] A blowout primarily composed of natural gas was known as a gas gusher.

Despite being symbols of new-found wealth, gushers were dangerous and wasteful. They killed workmen involved in drilling, destroyed equipment, and coated the landscape with thousands of barrels of oil; additionally, the explosive concussion released by the well when it pierces an oil/gas reservoir has been responsible for a number of oilmen losing their hearing entirely; standing too near to the drill at the moment it contacts the oil reservoir is extremely hazardous. The impact on wildlife is very hard to quantify, but can only be estimated to be mild in the most optimistic models -realistically, the ecological impact is estimated by scientists across the ideological spectrum to be severe, profound, and lasting.[5]

To complicate matters further, the free flowing oil was — and is — in danger of igniting.[6] One dramatic account of a blowout and fire reads:

> *"With a roar like a hundred express trains racing across the countryside, the well blew out, spewing oil in all directions. The derrick simply evaporated. Casings wilted like lettuce out of water, as heavy machinery writhed and twisted into grotesque shapes in the blazing inferno."*[7]

The development of rotary drilling techniques where the density of the drilling fluid is sufficient to overcome the downhole pressure of a newly penetrated zone meant that gushers became avoidable. If however the fluid density was not adequate or fluids were lost to the formation, then there was still a significant risk of a well blowout.

In 1924 the first successful blowout preventer was brought to market[8]. The BOP valve affixed to the wellhead could be closed in the event of drilling into a high pressure zone, and the well fluids contained. Well control techniques could be used to regain control of the well. As the technology developed, blowout preventers became standard equipment, and gushers became a thing of the past.

In the modern petroleum industry, uncontrollable wells became known as blowouts and are comparatively rare. There has been a significant improvement in technology, well control techniques and personnel training that has helped to prevent them occurring.[3] From 1976 to 1981, 21 Notable gushers blowout reports[3] are available as following:-

1) Lucas Gusher at Spindletop in Beaumont, Texas in 1901 flowed at 100,000 barrels (16,000 m³) per day at its peak, but soon slowed and was capped within nine days. The well tripled U.S. oil production overnight and marked the start of the Texas oil industry.[9]

2) Masjed Soleiman, Iran in 1908 marked the first major oil strike recorded in the Middle East.[9]

3) Lakeview Gusher on the Midway-Sunset Oil Field in Kern County, California of 1910 is believed to be the largest-ever U.S. gusher. At its peak, more than 100,000 barrels (16,000 m³) of oil per day flowed out, reaching as high as 200 feet (60 m) in the air. It remained uncapped for 18 months, spilling over nine million barrels (380 million gallons /1.4 million m³) of oil, less than half of which was recovered.[4]

4) A short-lived gusher at Alamitos #1 in Signal Hill, California in 1921 marked the discovery of the Long Beach Oil Field, one of the most productive oil fields in the world.[9]

5) The Barroso 2 well in Cabimas, Venezuela in December 1922 flowed at around 100,000 barrels (16,000 m³) per day for nine days, plus a large amount of natural gas.[29]

6) Baba Gurgur near Kirkuk, Iraq, an oilfield known since antiquity, erupted at a rate of 95,000 barrels (15,000 m³) a day in 1927.[9]

7) The Wild Mary Sudik gusher in Oklahoma City, Oklahoma in 1930 flowed at a rate of 72,000 barrels (11,500 m³) per day.[9]

8) The Daisy Bradford gusher in 1930 marked the discovery of the East Texas Oil Field, the largest oilfield in the contiguous United States.[10]

9) The largest known 'wildcat' oil gusher blew near Qom, Iran on August 26, 1956. The uncontrolled oil gushed to a height of 52 m (170 ft), at a rate of 120,000 barrels per day. The gusher was closed after 90 days' work by Bagher Mostofi and Myron Kinley (USA).[11]

10) The largest underwater blowout in U.S. history occurred on April 20, 2010 in the Gulf of Mexico at the Macondo Prospect oil field. The blowout caused the explosion of the Deepwater Horizon, a mobile offshore drilling platform owned by Transocean and under lease to BP at the time of the blowout. While the exact volume of oil spilled is unknown, as of June 3, 2010 (2010 -06-03), the United States Geological Survey (USGS) Flow Rate Technical Group has placed the estimate at between 35,000 to 60,000 barrels (1.5–2.5 million US gallons; 5,600–9,500 m³) of crude oil per day.[12]. The extent of the flow is attributable to the depth of the well; at over 4,000 feet (1,200 m) underwater the technical ability to regain control is made far more difficult than in shallow water or on land.

*Table 1: Notable Offshore Well Blowouts**

Year	Rig Name	Rig Owner	Type	Damage / details
1955	S-44	Chevron Corporation	Sub Recessed pontoons	Blowout and fire. Returned to service.
1959	C. T. Thornton	Reading & Bates	Jackup	Blowout and fire damage.
1964	C. P. Baker	Reading & Bates	Drill barge	Blowout in Gulf of Mexico, vessel capsized, 22 killed.
1965	Trion	Royal Dutch Shell	Jackup	Destroyed by blowout.
1965	Paguro	SNAM	Jackup	Destroyed by blowout and fire.
1968	Little Bob	Coral	Jackup	Blowout and fire, killed 7.
1969	Wodeco III	Floor drilling	Drilling barge	Blowout
1969	Sedco 135G	Sedco Inc	Semi-submersible	Blowout damage
1969	Rimrick Tidelands	ODECO	Submersible	Blowout in Gulf of Mexico
1970	Stormdrill III	Storm Drilling	Jackup	Blowout and fire damage.
1970	Discoverer III	Offshore Co.	Drillship	Blowout (S. China Seas)
1970	Discoverer II	Offshore Co.	Drillship	Blowout (Malaysia)
1971	Big John	Atwood Oceanics	Drill barge	Blowout and fire.
1971	Unknown	Floor Drilling	Drill barge	Blowout and fire off Peru, 7 killed.
1972	J. Storm II	Marine Drilling Co.	Jackup	Blowout in Gulf of Mexico
1972	M. G. Hulme	Reading & Bates	Jackup	Blowout and capsize in Java Sea.
1972	Rig 20	Transworld Drilling	Jackup	Blowout in Gulf of Martaban.
1973	Mariner I	Sante Fe Drilling	Semi-sub	Blowout off Trinidad, 3 killed.
1974	Meteorite	Offshore Co.	Jackup	Blowout of Nigeria
1975	Topper III	Zapata Offshore	Jackup	Blowout and sinking.
1975	Mariner II	Sante Fe Drilling	Semi-submersible	Lost BOP during blowout.
1975	J. Storm II	Marine Drilling Co.	Jackup	Blowout in Gulf of Mexico
1976	Petrobras III	Petrobras	Jackup	No info.

1976	W. D. Kent	Reading & Bates	Jackup	Damage while drilling relief well.
1977	Maersk Explorer	Maersk Drilling	Jackup	Blowout and fire in North Sea
1977	Ekofisk Bravo	Phillips Petroleum	Platform	Blowout during well workover.[15]
1978	Scan Bay	Scan Drilling	Jackup	Blowout and fire in the Persion Gulf.
1979	Salenergy II	Salen Offshore	Jackup	Blowout in Gulf of Mexico
1979	Sedco 135F	Sedco Drilling	Semi-submersible	Blowout and fire in Bay of Campeche Ixtoc I well.[14] [16]
1980	Sedco 135G	Sedco Drilling	Semi-submersible	Blowout and fire of Nigeria.
1980	Discoverer 534	Offshore Co.	Drillship	Gas escape caught fire
1980	Ron Tappmeyer	Reading & Bates	Jackup	Blowout in Persian Gulf, 5 killed
1980	Nanhai II	Peoples Republic of China	Jackup	Blowout of Hainan Island.
1980	Maersk Endurer	Maersk Drilling	Jackup	Blowout in Red Sea, 2 killed
1980	Ocean King	ODECO	Jackup	Blowout and fire in Gulf of Mexico, 5 killed.[9]
1980	Marlin 14	Marlin Drilling	Jackup	Blowout in Gulf of Mexico
1981	Penrod 50	Penrod Drilling	Submersible	Blowout and fire in Gulf of Mexico
1985	West Vanguard	Smedvig	Semi-submersible	Shallow gas blowout and fire in Norwegian sea, 1 fatality.
1981	Petromar V	Petromar	Drillship	Gas blowout and capsize in S. China seas
1988	Ocean Odyssey	Diamond Offshore Drilling	Semi-submersible	Gas blowout at BOP and fire in the UK North Sea, 1 killed.
1989	Al Baz	Sante Fe	Jackup	Shallow gas blowout and fire in Nigeria, 5 killed.[29]
1993	Actinia	Transocean	Semi-submersible	Sub-sea blowout in Vietnam. .[9]
2001	Ensco 51	Ensco	Jackup	Gas blowout and fire, Gulf of Mexico, no casualties[17]
2002	Arabdrill 19	Arabian Drilling Co.	Jackup	Structural collapse, blowout, fire and sinking.[18]

2004	Adriatic IV	Global Sante Fe	Jackup	Blowout and fire at Temsah platform, Mediterranean Sea[9]
2007	Usumacinta	PEMEX	Jackup	Storm force rig to move, causing well blowout on Kab 101 platform, 22 killed.[9]
2009	West Atlas /Montara	Seadrill	Jackup / Platform	Blowout and fire on rig and platform in Australia.
2010	Deepwater Horizon	Transocean	Semi-submersible	Blowout and fire on the rig, subsea well blowout, killed 11 in explosion.
2010	Vermilion Block 380	Mariner Energy	Platform	Blowout and fire, 13 survivors, 1 injured.[15]

* Data from industry information.[3][9]

3.1. CAUSE OF BLOWOUTS

3.1.1. Reservoir pressure

Petroleum or crude oil is a naturally occurring, flammable liquid consisting of a complex mixture of hydrocarbons of various molecular weights, and other organic compounds, that are found in geologic formations beneath the Earth's surface. Because most hydrocarbons are lighter than rock or water, they often migrate upward through adjacent rock layers until either reaching the surface or becoming trapped within porous rocks (known as reservoirs) by impermeable rocks above. However, the process is influenced by underground water flows, causing oil to migrate hundreds of kilometers horizontally or even short distances downward before becoming trapped in a reservoir. When hydrocarbons are concentrated in a trap, an oil field forms, from which the liquid can be extracted by drilling and pumping. The down hole pressures experienced at the rock structures change depending upon the depth and the characteristic of the source rock.

3.1.2. Formation kick

The downhole fluid pressures are controlled in modern wells through the balancing of the hydrostatic pressure provided by the mud used. Should the balance of the drilling mud pressure be incorrect then formation fluids (oil, natural gas and/or water) begin to flow into the wellbore and up the annulus (the space between the outside of the drill string and the walls of the open hole or the inside of the last casing string set), and/or inside the drill pipe. This is commonly called a kick. If the well is not shut in (common term for the closing of the blow-out preventer valves), a kick can quickly escalate into a blowout when the formation fluids reach the surface, especially when the influx contains gas that expands rapidly as it flows up the wellbore, further decreasing the effective weight of the fluid.

Additional mechanical barriers such as blowout preventers (BOPs) can be closed to isolate the well while the hydrostatic balance is regained through circulation of fluids in the well.

A kick can be the result of improper mud density control, an unexpected overpressured gas pocket, or may be a result of the loss of drilling fluids to a formation called a thief zone. If the well is a development well, these thief zones should already be known to the driller and the proper loss control materials would have been used. However, unexpected fluid losses can occur if a formation is fractured somewhere in the open-hole section, causing rapid loss of hydrostatic pressure and possibly allowing flow of formation fluids into the wellbore. Shallow overpressured gas pockets are generally unpredictable and usually cause the more violent kicks because of rapid gas expansion almost immediately.

Early warning signs of a well kick are:

- Sudden change in drilling rate;
- Change in surface fluid rate;
- Change in pump pressure;
- Reduction in drill-pipe weight;
- Surface mud cut by gas, oil or water.

The primary means of detecting a kick is a relative change in the circulation rate back up to the surface into the mud pits. The drilling crew or mud engineer keeps track of the level in the mud pits and/or closely monitors the rate of mud returns versus the rate that is being pumped down the drill pipe. Upon encountering a zone of higher pressure than is being exerted by the hydrostatic head of the drilling mud at the bit, an increase in mud returns would be noticed as the formation fluid influx pushes the drilling mud toward the surface at a higher rate. Conversely, if the rate of returns is slower than expected, it means that a certain amount of the mud is being lost to a thief zone somewhere below the last casing shoe. This does not necessarily result in a kick (and may never become one); however, a drop in the mud level might allow influx of formation fluids from other zones if the hydrostatic head at depth is reduced to less than that of a full column of mud.

3.1.3. Well control

The first response to detecting a kick would be to isolate the wellbore from the surface by activating the blow-out preventers and closing in the well. Then the drilling crew would attempt to circulate in a heavier kill fluid to increase the hydrostatic pressure (sometimes with the assistance of a well control company). In the process, the influx fluids will be slowly circulated out in a controlled manner, taking care not to allow any gas to accelerate up the wellbore too quickly by controlling casing pressure with chokes on a predetermined schedule.

In a simple kill, once the kill-weight mud has reached the bit the casing pressure is manipulated to keep drill pipe pressure constant (assuming a constant pumping rate); this will ensure holding a constant adequate bottom-hole pressure. The casing pressure will gradually increase as the contaminant slug approaches the surface if the influx is gas, which will be expanding as it moves up the annulus and overall pressure at its depth is gradually decreasing

This effect will be minor if the influx fluid is mainly salt water. And with an oil-based drilling fluid it can be masked in the early stages of controlling a kick because gas influx may dissolve into the oil under pressure at depth, only to come out of solution and expand rather rapidly as the influx nears the surface. Once all the contaminant has been circulated out, the casing pressure should have reached zero.

Sometimes, however, companies drill underbalanced for better, faster penetration rates and thus they "drill for kicks" as it is more economically sound to take the time to kill a kick than to drill overbalanced (which causes slower penetration rates). In this case, calling a well-control specialist is usually unnecessary as qualified personnel are already on site.

Capping stacks are used for controlling blowouts. The cap is an open valve that is closed after bolted on.

3.2. TYPES OF BLOWOUTS

Fig.6: Ixtoc I oil well blowout

Well blowouts can occur.[3]:-

i) *during the drilling phase,*
ii) *during well testing,*
iii) *during well completion,*
iv) *during production, or*
v) *during workover activities*

3.2.1. Surface blowouts

Blowouts can eject the drill string out of the well, and the force of the escaping fluid can be strong enough to damage the drilling rig. In addition to oil, the output of a well blowout might include sand, mud, rocks, drilling fluid, natural gas, water, and other substances (Fig.6).

Blowouts will often be ignited by an ignition source, from sparks from rocks being ejected, or simply from heat generated by friction. A well control company will then need to extinguish the well fire or cap the well, and replace the casing head and hangars. The flowing gas may contain poisonous hydrogen sulfide and the oil operator might decide to ignite the stream to convert this to less hazardous substances.

Sometimes, blowouts can be so forceful that they cannot be directly brought under control from the surface, particularly if there is so much energy in the flowing zone that it does not deplete significantly over the course of a blowout. In such cases, other wells (called relief wells) may be drilled to intersect the well or pocket, in order to allow kill-weight fluids to be introduced at depth. Contrary to what might be inferred from the term, such wells generally are not used to help relieve pressure using multiple outlets from the blowout zone.

3.2.2. Subsea blowouts

Fig.7: Deepwater Horizon drilling rig blowout, 21 April 2010

Subsea wells have the wellhead and pressure control equipment located on the seabed. They vary from depths of 10 feet (3.0 m) to 8,000 feet (2,400 m). It is very difficult to deal with a blowout in very deep water because of the remoteness and limited experience with this type of situation.[13]

The Deepwater Horizon well blowout in the Gulf of Mexico in April 2010, in 5,000 feet (1,500 m) water depth, is the deepest subsea well blowout to date (Fig.7).

3.2.3. Underground blowouts

An underground blowout is a special situation where fluids from high pressure zones flow uncontrolled to lower pressure zones within the wellbore. Usually this is from deeper higher pressure zones to shallower lower pressure formations. There may be no escaping fluid flow at the wellhead. Underground blowouts can be very difficult to bring under control, and if left unchecked the fluids may find their way to the surface or ocean floor nearby.

3.3. METHODS OF QUENCHING BLOWOUTS

Although several experimental methods exist which attempt to capture as much oil as possible from a blown out well, they are very far from perfect, capturing between 20 - 50% of the leaking oil, by optimistic estimates. Ideally, the well could be made to stop gushing oil entirely - thus putting a stop to the cumulating pollution.

3.3.1. Use of nuclear explosions

On Sep. 30, 1966 the Soviet Union in Urt-Bulak, an area about 80 kilometers from Bukhara, Uzbekistan, experienced blowouts on five natural gas wells. It was claimed in Komsomoloskaya Pravda that after years of burning uncontrollably they were able to stop them entirely.[25] The Soviets lowered a specially made 30 kiloton nuclear bomb into a 6 kilometers (20,000 ft) borehole drilled 25 to 50 meters (82 to 160 ft) away from the original (rapidly leaking) well. A nuclear explosive was deemed necessary because conventional explosive both lacked the necessary power and would also require a great deal more space underground. When the bomb was set off, it proceeded to crush the original pipe that was carrying the gas from the deep reservoir to the surface, as well as to glassify all the surrounding rock. This caused the leak and fire at the surface to cease within approximately one minute of the explosion, and proved over the years to have been a permanent solution. A second attempt on a similar well was not as successful and other tests were for such experiments as oil extraction enhancement and the creation of gas storage reservoirs. All these Soviet nuclear blasts were on land and did not involve oil. That being the case, the general principles involved are the same.[14]

4. ENVIRONMENTAL EFFECTS

Fig.8: Surface Scoter covered in oil as a result of the 2007 San Francisco Bay oil spill. Less than 1% of oil soaked birds survive, even after cleaning.

The oil penetrates into the structure of the plumage of birds, reducing its insulating ability, thus making the birds more vulnerable to temperature fluctuations and much less buoyant in the water (Fig.8). It also impairs birds' flight abilities to forage and escape from predators. As they attempt to preen, birds typically ingest oil that covers their feathers, causing kidney damage, altered liver function, and digestive tract irritation. This and the limited foraging ability quickly causes dehydration and metabolic imbalances. Hormonal balance alteration including changes in luteinizing protein can also result in some birds exposed to petroleum.[19]

Most birds affected by an oil spill die unless there is human intervention.[20][21] Marine mammals exposed to oil spills are affected in similar ways as seabirds. Oil coats the fur of Sea otters and seals, reducing its insulation abilities and leading to body temperature fluctuations and hypothermia. Ingestion of the oil causes dehydration and impaired digestions. Because oil floats on top of water, less sunlight penetrates into the water, limiting the photosynthesis of marine plants and phytoplankton. This, as well as decreasing the fauna populations, affects the food chain in the ecosystem. There are three kinds of oil-consuming bacteria. Sulfate-reducing bacteria (SRB) and acid-producing bacteria are anaerobic, while general aerobic bacteria (GAB) are aerobic. These bacteria occur naturally and will act to remove oil from an ecosystem, and their biomass will tend to replace other populations in the food chain.

4.1. Types of risks and potential impacts

The industry recognizes that various risks and consequences are associated with petroleum exploration and production activities. These are carefully identified and minimized as activities may take place in, or near, environmentally important areas. Environmental impact assessments are undertaken to identify areas of environmental concern and provide the basis for the development and implementation of an environmental management strategy. Baseline studies are usually conducted to accurately describe the environment before any work commences. Direct and indirect environmental effects are monitored. Direct effects are those which may affect the ecology of a particular site or area and whose source is easily identified, while indirect impacts are those which do not affect a localized area (Table 2). The risk and consequence of oil spills is of greatest environmental concern however, dredging, the physical effects of equipment and ship movement including anchoring, drilling, routine discharges including kitchen wastes, noise, artificial lights, and air emissions are all matters that are carefully considered.

Table 2: Management of Direct and Indirect Environmental Impacts

Direct Potential Impact or Risk	Indirect Potential Impact or Risk	Comment
Ship movements		
The risk of an oil spill is directly related to: a) frequency of ship movement; b) physical and mechanical condition of a ship and its equipment; and c) performance of crews. Oil spill risk is minimised through achieving appropriate standards and adequate training. Impacts of an oil spill may be severe on sensitive organisms and/or habitats. In the event of an oil spill, sophisticated oil spill contingency plans aim to prevent, contain and minimize impacts. Open ocean impacts likely to be less than coastal impacts. Dredging navigation channels, if necessary, may disturb and modify the sea floor. Dredge spoil is dumped under permit in locations of minimal impact.	Noise, lights and physical presence of ships may affect the movement of sensitive species. Effects are of short duration and impacts are likely to be minimal.	
Seismic surveys		
Air based energy sources in seismic arrays generate sounds and may have potential impacts on organisms within range. To avoid adverse impacts, surveys are adapted or scheduled to avoid seasonal migrations or key breeding locations.	Avoidance behaviour by some species may affect feeding. Impacts are likely to be of short duration	APPEA is funding a 3 year research project commencing in 1996 to provide better information on potential impacts and environmental effects in Australian conditions
Drilling rig placement		

Physical placement of drilling rig may cause localized damage, depending on the nature of the sea floor, however the area, if affected, is very small.		
Anchoring		
Localised physical damage may be observed.		Minimized by avoiding seabed structures of environmental or other significance.
Drilling		
When drill cuttings are discharged overboard impacts are limited to the immediate area surrounding the drill site. Drilling fluids are comprised of clays, and include metals such as barium, and a range of additives depending on the type of rock being drilled. Harmful constituents are generally recycled or removed before discharge to the ocean. Monitoring of drilling impacts reveals only minor adverse impact beyond the immediate discharge zone.	Suspended sediment in the water column may reduce the amount of light reaching the sea floor. This may reduce plant growth until the particulate material settles. Effects of short duration. Localized effects may be impact on the food chain. Such effects can be minimized by reducing levels of toxic components, and/or removing or recycling fluids before discharge.	Generally, no toxic oil-based drilling fluids are used in Australia, hence discharges of these substances to the marine environment are very rare. Drilling is undertaken for a relatively short period of an oil filed operation, e.g., 3 months to 3-4 years. Ocean environments facilitate the rapid dispersion, resulting in minimal seabed impact. In very sensitive environments, waste from drilling operations may be collected and stored onboard for disposal on land.
Platform placement		
Habitat disturbance can be minimized through careful placement. A site is chosen after an	Platforms often attract marine life and can act as artificial reefs. They often become important	

environmental impact assessment has been undertaken.	resting points for seabirds and seals.	
Produced formation water (PFW)		
Hydrocarbon traces in PFW may have localized impacts. Although PFW is of low toxicity, it is often warmer than the ocean when discharged and may cause possible local effects when organisms make inadvertent contact.	Cumulative and/or sublethal impacts may occur from long exposure to low levels of particular hydrocarbons. PFW may have a salt content greater or less than sea water causing localized transient salinity levels which are unlikely to affect nearby organisms.	Low regulatory limits for hydrocarbons and rapid dispersion ensures that impacts are within meters of discharge. APPEA is funding a 2 year research project to assess and improve current management practices for PFW discharge.
Reinjection		
Reinjection of water or gas down wells is sometimes used to increase the amount of oil recovered.	Reinjection of gas decreases the volume of gas that might be otherwise flared (reducing emissions of greenhouse gases).	Reinjection of gas or water is costly but where possible, is often a more environmentally sound option than discharge to the environment.
Sewage		
Increased nutrient content in the water column.	May increase population numbers of some organisms.	Quantities are small and treated before discharge. Dispersion rapidly dilutes any effect.

4.2. Greenhouse

Exploration and production activities result in the release or emission of several greenhouse gases, notably carbon dioxide and methane. Small quantities of other gases such as the hydrocarbons propane and butane, and other products of fuel combustion are also released. The industry recognizes the need to carefully manage and reduce the levels of emissions, and is participating in the Federal Government's Greenhouse Challenge program to voluntarily address the issue of emissions.

Greenhouse gases are those gases suspected of contributing to global warming in the lower atmosphere (Table 3). The primary greenhouse gas emitted by human activities is carbon dioxide from energy use, including transport and industrial processes, land use change and forestry and energy production.

Table 3: Greenhouse Gases

Greenhouse Gas	Description
Carbon dioxide (CO_2)	CO_2 is the dominant greenhouse gas in Australia and effectively accounts for about 75% of all greenhouse gas emissions.
Methane (CH_4)	CH_4 is a very effective greenhouse gas with a high global warming potential (GWP), and although present at much lower levels than CO_2 may have significant impact because of this higher GWP. The main source of CH_4 is from agriculture (mainly livestock).
Nitrogen oxides (NOx)	Nitrogen oxides consist of nitrogen oxide (NO) and nitrogen dioxide (NO_2). NOx is a small component of greenhouse emissions (<1%).
Nitrous oxides (N_2O)	N_2O is a gas produced both naturally and by combustion of fuels. The majority of N_2O (80%) is produced from agriculture. They mostly come from burning fuel (cars and power stations).
Volatile organic compounds (VOC's)	Volatile organic compounds are hydrocarbons (excluding methane) which are capable of forming oxidants (particularly ozone) by reactions with nitrogen oxides in the presence of sunlight. Major sources of VOC's are vehicles, solvents and process industry emissions.
Carbon monoxide (CO)	CO is generated as a result of incomplete combustion (e.g., poorly maintained wood heaters and cars), and reacts preferentially with naturally occurring hydroxyl radicals in the lower atmosphere. This has the effect of increasing the lifetime of VOC's and so enhances the formation of photochemical smog (largely ozone).
Hydrogen sulphide (H_2S)	H_2S is a toxic gas occurring naturally during decomposition. Natural gas is normally treated to remove this H_2S to form sulphur or it can be burned. H_2S forms SO_2 during the combustion process or photochemically when released to the atmosphere.
Sulphur dioxide (SO_2)	SO_2 results in dry acid deposition and in the formation of acid rain thereby increasing the acidity of soils. This is a major problem in the Northern hemisphere, but is not a significant pollutant in Australia except in a few instances.

Atmospheric releases from oil and gas production activities are attracting increasing interest from both industry operators and regulatory authorities. Concerns focus on the contribution from industry sources to national emissions.

5. ESTIMATING THE VOLUME OF A SPILL

By observing the thickness of the film of oil and its appearance on the surface of the water, it is possible to estimate the quantity of oil spilled. If the surface area of the spill is also known, the total volume of the oil can be calculated.[22]

Appearance	**Film thickness**			**Quantity spread**	
	inch	**mm**	**nm**	**gal/sq mile**	**L/ha**
Barely visible	0.0000015	0.000038	38	25	0.37
Silvery sheen	0.000003	0.000076	76	50	0.73
First trace of color	0.000006	0.00015	150	100	1.5
Bright bands of color	0.000012	0.0003	300	200	2.9
Colors begin to dull	0.00004	0.001	1000	666	9.7
Colors are much darker	0.00008	0.002	2000	1332	19.5

Oil spill model systems are used by industry and government to assist in planning and emergency decision making. Of critical importance for the skill of the oil spill model prediction is the adequate description of the wind and current fields. There is a worldwide oil spill modelling (WOSM) program.[23] Tracking the scope of an oil spill may also involve verifying that hydrocarbons collected during an ongoing spill are derived from the active spill or some other source. This can involve sophisticated analytical chemistry focused on finger printing an oil source based on the complex mixture of substances present. Largely, these will be various hydrocarbons, among the most useful being polyaromatic hydrocarbons. In addition, both oxygen and nitrogen heterocyclic hydrocarbons, such as parent and alkyl homologues of carbazole, quinoline, and pyridine, are present in many crude oils. As a result, these compounds have great potential to supplement the existing suite of hydrocarbons targets to fine tune source tracking of petroleum spills. Such analysis can also be used to follow weathering and degradation of crude spills.[24]

Table 4: Largest Oil Spills [a]

Spill / Tanker	Location	Date	Tons of crude oil	Barrels	US Gallons	References
Kuwaiti oil fires [b]	Kuwait	January, 1991 - November, 1991	136,000,000-205,000,000	1,000,000,000-1,500,000,000	42,000,000,000-63,000,000,000	[25]
Kuwaiti oil lakes [c]	Kuwait	January, 1991 - November, 1991	3,409,000-6,818,000	25,000,000-50,000,000	1,050,000,000-2,100,000,000	[26]

Lakeview Gusher	United States, Kern County, California	May 14, 1910 – September, 1911	1,200,000	9,000,000	378,000,000	[27]
Gulf War oil spill [d]	Iraq, Persian Gulf and Kuwait	January 19, 1991 - January 28, 1991	818,000–1,091,000	6,000,000–8,000,000	252,000,000–336,000,000	[15] [28]
Deepwater Horizon	United States, Gulf of Mexico	April 20, 2010 – July 15, 2010	560,000-585,000	4,100,000-4,300,000	172,000,000-180,000,000	[[29]
Ixtoc I	Mexico, Gulf of Mexico	June 3, 1979 – March 23, 1980	454,000–480,000	3,329,000–3,520,000	139,818,000–147,840,000	[14][16]
Atlantic Empress / Aegean Captain	Trinidad and Tobago	July 19, 1979	287,000	2,105,000	88,396,000	[30][31]
Fergana Valley	Uzbekistan	March 2, 1992	285,000	2,090,000	87,780,000	[9]
Nowruz Field Platform	Iran, Persian Gulf	February 4, 1983	260,000	1,907,000	80,080,000	[32]
ABT Summer	Angola, 700 nmi (1,300 km; 810 mi) offshore	May 28, 1991	260,000	1,907,000	80,080,000	[30]
Castillo de Bellver	South Africa, Saldanha Bay	August 6, 1983	252,000	1,848,000	77,616,000	[30]
Amoco Cadiz	France, Brittany	March 16, 1978	223,000	1,635,000	68,684,000	[9][30][33]
MT Haven	Italy, Mediterranean Sea near Genoa	April 11, 1991	144,000	1,056,000	44,352,000	[30]
Odyssey	Canada, 700 nmi (1,300 km; 810 mi) off Nova Scotia	November 10, 1988	132,000	968,000	40,656,000	[30]

Sea Star	Iran, Gulf of Oman	December 19, 1972	115,000	843,000	35,420,000	[9][30]
Irenes Serenade	Greece, Pylos	February 23, 1980	100,000	733,000	30,800,000	[30]
Urquiola	Spain, A Coruña	May 12, 1976	100,000	733,000	30,800,000	[30]
Torrey Canyon	United Kingdom, Isles of Scilly	March 18, 1967	80,000–119,000	587,000–873,000	24,654,000–36,666,000	[9][30]
Greenpoint Oil Spill	United States, Brooklyn, New York City	1940 –1950s	55,000–97,000	400,000–710,000	17,000,000–30,000,000	[34]

a) Oil spills of over 100,000 tons or 30 million US gallons, ordered by tons . *One ton of crude oil is roughly equal to 308 US gallons or 7.33 barrels approx.; 1 oil barrel is equal to 35 imperial or 42 US gallons.*

b) Estimates for the amount of oil burned in the Kuwaiti oil fires range from 500,000,000 to nearly 2,000,000,000 barrels. 732 wells were set ablaze, while many others were severely damaged and gushed uncontrolled for several months. The fires alone were estimated to consume approximately 6,000,000 barrels of oil per day at their peak. However, it is difficult to find reliable sources for the total amount of oil burned. The range of 1 to 1.5 billion barrels given here represents frequently-cited figures, but better sources are needed.

c) Oil spilled from sabotaged fields in Kuwait during the 1991 Persian Gulf War pooled in approximately 300 oil lakes, estimated by the Kuwaiti Oil Minister to contain approximately 25,000,000 to 50,000,000 barrels of oil. According to the U.S. Geological Survey, this figure does not include the amount of oil absorbed by the ground, forming a layer of "tarcrete" over approximately five percent of the surface of Kuwait, fifty times the area occupied by the oil lakes.[26]

d) *Estimates for the Gulf War oil spill range from 4,000,000 to 11,000,000 barrels. The figure of 6,000,000 to 8,000,000 barrels is the range adopted by the U.S. Environmental Protection Agency and the United Nations in the immediate aftermath of the war, 1991-1993, and is still current, as cited by NOAA and The New York Times in 2010.*[28] *This amount only includes oil discharged directly into the Persian Gulf by the retreating Iraqi forces from January 19 to 28, 1991. However, according to the U.N. report, oil from other sources not included in the official estimates continued to pour into the Persian Gulf through June, 1991. The amount of this oil was estimated to be at least several hundred thousand barrels, and may have factored into the estimates above 8,000,000 barrels.*

6. CLEANUP AND RECOVERY

Fig.9: Clean-up efforts after the Exxon Valdez oil spill.

Fig.10 : A US Navy oil spill response team drills with a "Harbour Buster high-speed oil containment system".

Cleanup and recovery from an oil spill(Figs 9 & 10) is difficult and depends upon many factors[35], including:-

i) the type of oil spilled,
ii) the temperature of the water (affecting evaporation and biodegradation), and
iii) the types of shorelines and beaches involved.

6.1. Methods for cleaning up:

Methods for cleaning up include:-

- ***Bioremediation:*** use of microorganisms[35] or biological agents[36] to break down or remove oil.

  Bioremediation Accelerator: Oleophilic, hydrophobic chemical, containing no bacteria, which chemically and physically bonds to both soluble and insoluble hydrocarbons. The bioremedation accelerator acts as a herding agent in water and on the surface, floating molecules to the surface of the water, including solubles such as phenols and BTEX, forming gel-like agglomerations. Undetectable levels of hydrocarbons can be obtained in produced water and manageable water columns. By overspraying sheen with bioremediation accelerator, sheen is eliminated within minutes. Whether applied on land or on water, the nutrient-rich emulsion creates a bloom of local, indigenous, pre-existing, hydrocarbon-consuming bacteria. Those specific bacteria break down the hydrocarbons into water and carbon dioxide, with EPA tests showing 98% of alkanes biodegraded in 28 days; and aromatics being biodegraded 200 times faster than in nature they also sometimes use the hydrofireboom to clean the oil up by taking it away from most of the oil and burning it.[37] Controlled burning can effectively reduce the amount of oil in water, if done properly.[38] But it can only be done in low wind, and can cause air pollution.[38]

Fig.11: Oil slicks on Lake Maracaibo.

Fig.12: Volunteers cleaning up the aftermath of the Prestige oil spill.

- ***Dispersants act as detergents***, clustering around oil globules and allowing them to be carried away in the water.[39] This improves the surface aesthetically, and mobilizes the oil. Smaller oil droplets, scattered by currents, may cause less harm and may degrade more easily. But the dispersed oil droplets infiltrate into deeper water and can lethally contaminate coral. Some dispersants are toxic to corals.[40] *Watch and wait:* in some cases, natural attenuation of oil may be most appropriate, due to the invasive nature of facilitated methods of remediation, particularly in ecologically sensitive areas such as wet-lands.[41]
- ***Dredging***: for oils dispersed with detergents and other oils denser than water.
- ***Skimming:*** Requires calm waters

- ***Solidifying:*** Solidifiers are composed of dry hydrophobic polymers that both adsorb and absorb. They clean up oil spills by changing the physical state of spilled oil from liquid to a semi-solid or a rubber-like material that floats on water. Solidifiers are insoluble in water, therefore the removal of the solidified oil is easy and the oil will not leach out. Solidifiers have been proven to be relatively non-toxic to aquatic and wild life and have been proven to suppress harmful vapors commonly associated with hydrocarbons such as Benzene, Xylene, Methyl Ethyl, Acetone and Naphtha. The reaction time for solidification of oil is controlled by the surf area or size of the polymer as well as the viscosity of the oil. Some solidifier product manufactures claim the solidified oil can be disposed of in landfills, recycled as an additive in asphalt or rubber products, or burned as a low ash fuel. A solidifier called C. I. Agent Solutions is being used by BP in granular form as well as in Marine and Sheen Booms on Dauphin Island, AL and Fort Morgan, MS to aid in the Deepwater Horizon oil spill cleanup.

- ***Vacuum and centrifuge***: oil can be sucked up along with the water, and then a centrifuge can be used to separate the oil from the water - allowing a tanker to be filled with near pure oil. Usually, the water is returned to the sea, making the process more efficient, but allowing small amounts of oil to go back as well. This issue has hampered the use of centrifuges due to a United States regulation limiting the amount of oil in water returned to the sea.[42]

6.2. Combat techniques

No two oil spills are the same because of the variation in oil types, locations and weather conditions involved. However, broadly speaking, there are four main methods of response (Fig.13):-

1. Leave the oil alone so that it breaks down by natural means.
2. Contain the spill with booms and collect it from the water surface using skimmer equipment.
3. Use dispersants to break up the oil and speed its natural biodegradation.
4. Introduce biological agents to the spill to hasten biodegradation.

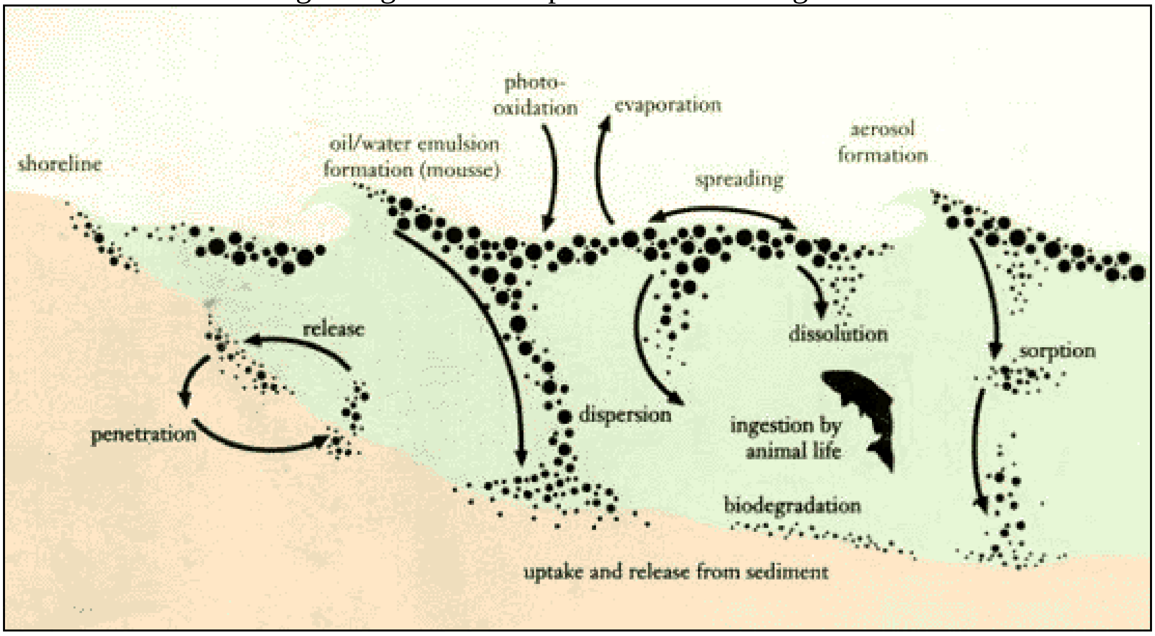


Fig.13 : Processes Following a Spill. Often the response involves a combination of all these approaches.

Natural dispersion: If there is no possibility of the oil polluting coastal regions or marine industries, the best method is to leave it to disperse by natural means. A combination of wind, sun, current and wave action will rapidly disperse and evaporate most oils. Light oils will disperse more quickly than heavy oils.

Booms and skimmers: Spilt oil floats on water and initially forms a slick that is a few millimeters thick. There are various types of booms which can be used either to surround and isolate a slick, or to block the passage of a slick to vulnerable areas such as the intake of a desalination plant or fish farm pens or other sensitive locations.

Boom types vary from inflatable neoprene tubes to solid, but buoyant material. Most rise up about a meter above the water line. Some are designed to sit flush on tidal flats while others are applicable to deeper water and have skirts which hang down about a meter below the waterline.

Skimmers float across the top of the slick contained within the boom and suck or scoop the oil into storage tanks on nearby vessels or on the shore.

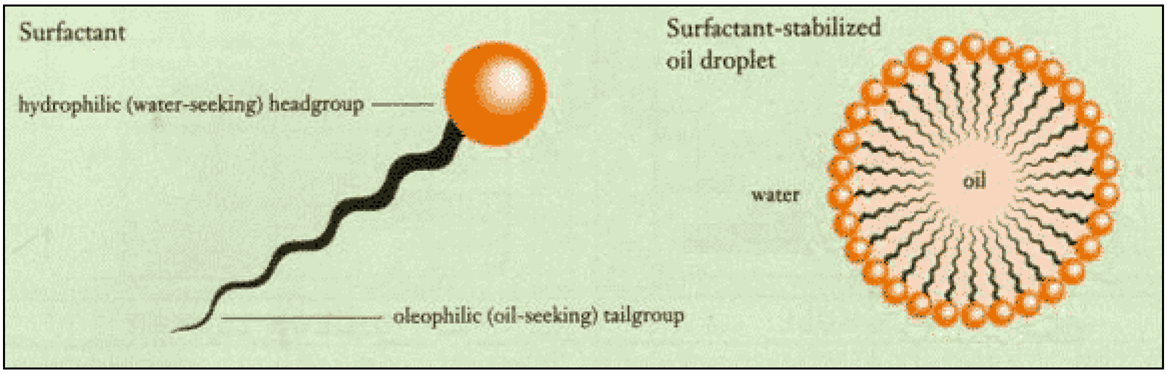
However booms and skimmers are less effective when deployed in high winds and high seas.

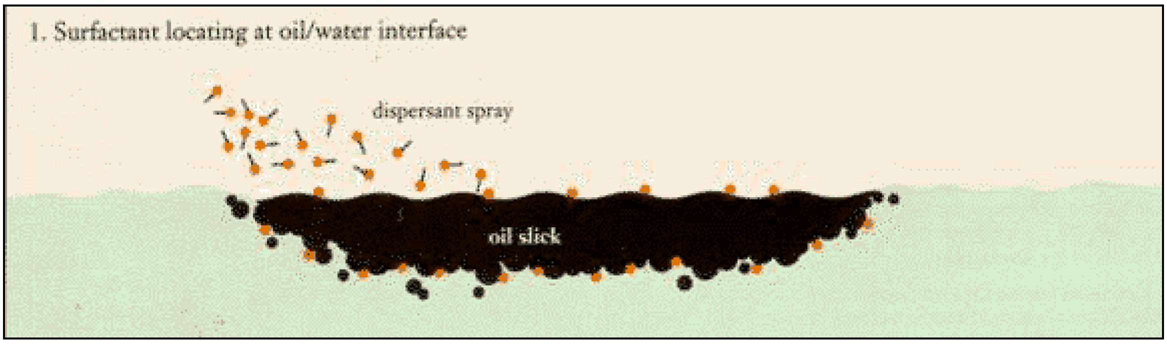
Dispersants: These act by reducing the surface tension that stops oil and water from mixing. Small droplets of oil are then formed which helps promote rapid dilution of the oil by water movements. The formation of droplets also increases the oil surface area, thus increasing the exposure to natural evaporation and bacterial action.

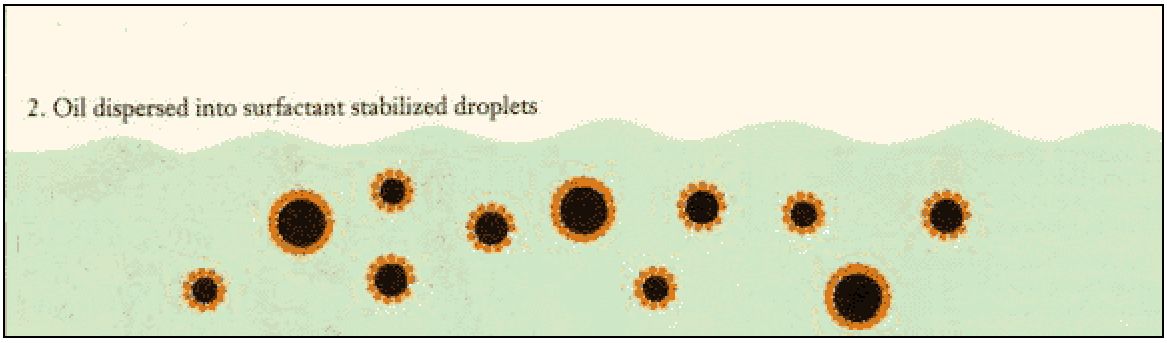
Dispersants are most effective when used within an hour or two of the initial spill. However they are not appropriate for all oils and all locations. Successful dispersion of oil through the water column can affect marine organisms like deep water corals and seagrass. It can also cause oil to be temporarily accumulated by subtidal seafood.

Decisions on whether or not to use dispersants to combat an oil spill must be made in each individual case. The decision will take into account the time since the spill, the weather conditions, the particular environment involved and the type of oil that has been spilt.

6.3. How dispersants work







Bioremediation: Most of the components of oil washed up along a shoreline; can be broken down by bacteria and other micro-organisms into harmless substances such as fatty acids and carbon dioxide. This action is called biodegradation. The natural process can be speeded up by the addition of fertilizing nutrients like nitrogen and phosphorous which stimulate growth of the micro-organisms concerned.

However the effectiveness of this technique depends on factors such as whether the ground treated has sand or pebbles and whether the fertilizer is water soluble or applied in pellet or liquid form.

6.4. Equipment used for cleaning up

Equipment used for cleaning up oil spill includes:[38]

- ***Booms:*** large floating barriers that round up oil and lift the oil off the water

FireBoom: Hydro-Fireboom is fire resistant water cooled boom that is an effective fire resistant barrier to prevent the spread of oil fires on water.

Containment Booms: Choose from our complete line of containment boom for inland, nearshore, coastal and offshore applications.

- ***Skimmers:*** skim the oil ; **Oil Skimmers:** Elastic skimmers can be used for industrial or emergency response applications. Elastic drum skimmers, for highly selective recovery, plus a range of weir skimmers are also available.

- ***Vacuums:*** remove oil from beaches and water surface

  Vacuum Systems:
  - PACS – (Portable Air Conveyance System) trailer mounted vacuum unit
  - MiniVac – diesel driven mobile vacuum units
  - All Terrain Vac - high powered vacuum system mounted on ATV towable chassis with walking beam suspension
  - DrumIt – a vacuum head for open top drums

Boats: A range of vessels for supporting oil spill response operations plus trash and garbage collection boats.

- ***Sorbents:*** large absorbents that absorb oil

- ***Chemical and biological agents:*** helps to break down the oil
- ***Shovels and other road equipments:*** typically used to clean up oil on beaches

6.5. Oil Spill Prevention

Although statistics show that historically the oil industry is directly responsible for only a small proportion of marine oil spills, the oil companies- individually and collectively - do not take the risk of spills lightly. There are strict regulations governing all facets of their operations from the exploration / production phase through to the delivery of refined petroleum products.

The majority of offshore exploration and production wells are drilled using water-based drilling fluids. In the special instances when oil based fluids are needed, strict control of the well circulatory system ensures that no oil from the drilling fluid is discharged into the sea. In addition, to cope with any sudden influx of pressure from an underground reservoir, every well drilled is fitted with a series of valves called blowout preventers. These immediately shut off the oil and/or gas flow in the event of an emergency to prevent hydrocarbons reaching the surface in an uncontrolled rush. As a result of improved technology, blow outs are virtually a thing of the past.

Above the water line, special deck drains on each rig and platform collect any waste fluids and channel them into settling tanks where oil is separated out, put into containers and sent to shore for treatment and disposal.

Coastal petroleum facilities: All production and loading terminal facilities and refineries and land must subject to strict government environmental protection policy requirements concerning the purity of water discharge into the sea. Oil companies ensure their discharges are well under the limit of 30 parts per million in water.

Oil transport: Undersea oil pipelines are wrapped in special coatings to prevent corrosion and they are provided with an outer protective coating of concrete which also gives the line sufficient weight to keep it on the ocean floor. Often these lines are buried beneath the seabed as an additional safeguard (Fig.14).

The integrity of oil tankers is more difficult to control because the business of tanker operations is complex and fragmented. Oil company-owned vessels make up only ~15 % of the world fleet. Oil company-chartered tankers add another 20%.

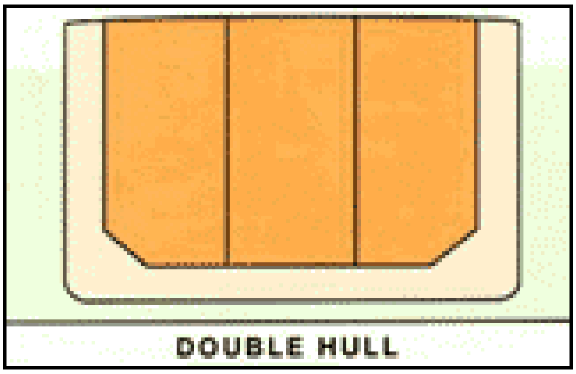


Fig.14: The vessels under oil company control are subject to stringent checks and regulations concerning structural integrity, safety, maintenance and crew training. Unfortunately, not all tanker owners, charterers and countries registering tankers have the same high standards. Hence vessels vary in quality and in the degree of maintenance and crew competence.

However, oil companies are working with ship certification societies, insurers and the International Maritime Organization to impose stricter control and inspection of all tankers and their operations around the world. Through rigorous vetting procedures, oil companies seek to ensure that only vessels of high quality are engaged for the trade in oil and petroleum products in Australia.

Vessels owned and operated by the oil companies are subject to stringent operating and maintenance requirements. A number of designs have been introduced for new vessels - including double hulls and mid-deck tank designs - to minimize oil loss from tankers in the event of a serious accident at sea.

In the USA, the Oil Pollution Act (1990) has made it mandatory for all tankers built after June 1990 to have double hulls if they are to enter US ports. However, in other countries there is likely to be further debate on design alternatives before regulations are formally adopted governing construction of new vessels.

The oil industry-funded researchers are also investigating safety measures that can be applied to the existing fleet. These include a redesigned ballast tank system, and a vacuum system which, in the event of a ruptured hull, causes water to enter rather than oil to spill out.

Steps to Prevention Oil Spill

- ***Seafood Sensory Training***- in an effort to detect oil in seafood, inspectors and regulators are being trained to sniff out seafood tainted by oil and make sure the product reaching consumers is safe to eat.[43]
- ***Secondary containment*** - methods to prevent releases of oil or hydrocarbons into environment.
- Oil Spill Prevention Containment and Countermeasures (SPCC) program by the United States Environmental Protection Agency.
- ***Double-hulling*** - build double hulls into vessels, which reduces the risk and severity of a spill in case of a collision or grounding. Existing single-hull vessels can also be rebuilt to have a double hull.

9. SUMMARY AND CONCLUSIONS

An oil spill is a release of a liquid petroleum hydrocarbon into the environment due to human activity, and is a form of pollution. The term often refers to marine oil spills, where oil is released into the ocean or coastal waters. Oil spills include releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, and heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil. Spills may take months or even years to clean up.

During that era, the simple drilling techniques such as cable-tool drilling and the lack of blowout preventers meant that drillers could not control high-pressure reservoirs. When these high pressure zones were breached the hydrocarbon fluids would travel up the well at a high rate, forcing out the drill string and creating a gusher. A well which began as a gusher was said to have "*blown in*": for instance, the *Lakeview Gusher blew in in 1910*. These uncapped wells could produce large amounts of oil, often shooting 200 feet (60 m) or higher into the air. A blowout primarily composed of natural gas was known as a gas gusher.

Two types of blowouts can be observed*: i) Surface blowouts and ii)Subsea blowouts. These* blowouts are caused by *i) Reservoir pressure; ii) Formation kick; and iii) Well control. Meanwhile,* well blowouts can occur during: *i) the drilling phase; ii) well testing; iii) well completion; iv) production; or v) workover activities.*

Despite being symbols of new-found wealth, gushers were dangerous and wasteful. They killed workmen involved in drilling, destroyed equipment, and coated the landscape with thousands of barrels of oil; additionally, the explosive concussion released by the well when it pierces an oil/gas reservoir has been responsible for a number of oilmen losing their hearing entirely; standing too near to the drill at the moment it contacts the oil reservoir is extremely hazardous. The impact on wildlife is very hard to quantify, but can only be estimated to be mild in the most optimistic models -realistically, the ecological impact is estimated by scientists across the ideological spectrum to be severe, profound, and lasting.

In 1924 the first successful blowout preventer was brought to market. The BOP valve affixed to the wellhead could be closed in the event of drilling into a high pressure zone, and the well fluids contained. Well control techniques could be used to regain control of the well. As the technology developed, blowout preventers became standard equipment, and gushers became a thing of the past. In the modern petroleum industry, uncontrollable wells became known as blowouts and are comparatively rare. There has been a significant improvement in technology, well control techniques and personnel training that has helped to prevent them occurring.

Estimating the volume of a spill can be estimated by observing the thickness of the film of oil and its appearance on the surface of the water, it is possible to estimate the quantity of oil spilled. If the surface area of the spill is also known, the total volume of the oil can be calculated.

No two oil spills are the same because of the variation in oil types, locations and weather conditions involved. There are four main methods of response: *1) Leave the oil alone so that it breaks down by natural means.; 2) Contain the spill with booms and collect it from the water surface using skimmer equipment.; 3) Use dispersants to break up the oil and speed its natural biodegradation.; and 4) Introduce biological agents to the spill to hasten biodegradation.*

Cleanup and recovery from an oil spill is difficult and depends upon many factors, including: *i) the type of oil spilled; ii) the temperature of the water (affecting evaporation and biodegradation), and iii) the types of shorelines and beaches involved*.

Therefore, Several methods for cleaning up oil spill can be used that include*: i) Bioremediation; ii) Dispersants act as detergents; iii) Dredging; iv) Skimming; v) Solidifying; and vi) Vacuum and centrifuge.*

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