MARE
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OCEAN ENVIRONMENTAL MANAGEMENT

Lecture 7. Oil spill

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MAJOR CONTENTS

- Properites of oil
- Fate of oil spills
- Impacts of spilled oil
- Case study

PROPERTIES OF OIL

RELATIVE DENSITY

The **specific gravity or relative density** of an oil is its density in relation to pure water, which has a specific gravity of 1. Most oils are less dense or lighter than sea water. This parameter helps to determine whether or not the oil will float, and give a general indication of other properties of the oil. For example, oils with a low specific gravity tend to contain a high proportion of volatile components and to be of low viscosity.

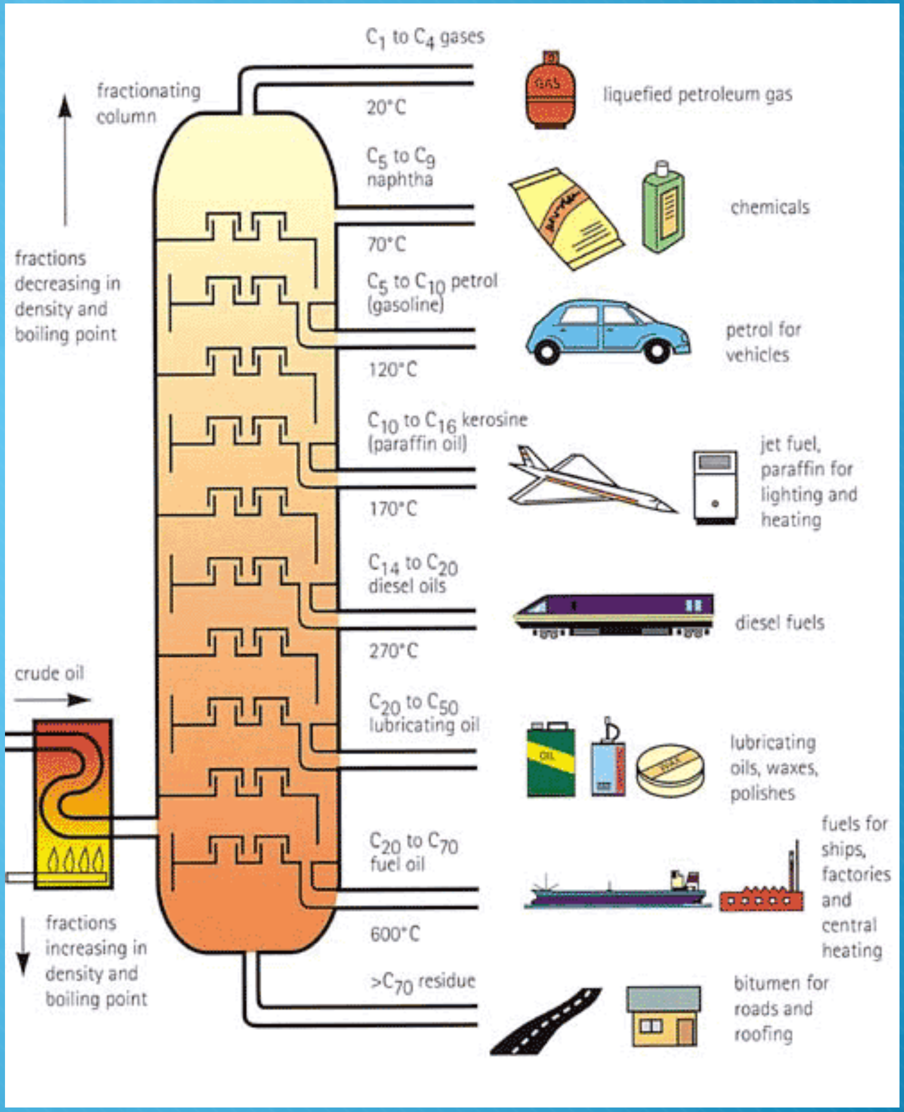
1 minute video

Density - Why oil floats on water

https://www.youtube.com/watch?v=mcVeGufZAsM

DISTILLATION CHARACTERISTICS

The distillation characteristics of an oil describe its volatility. The distillation characteristics are expressed as the proportions of the parent oil that distil within given temperature ranges. Some oils contain bituminous, waxy or asphaltenic residues, which do not readily distil even at high temperatures and are also likely to persist in the marine environment for extended periods.



VISCOSITY

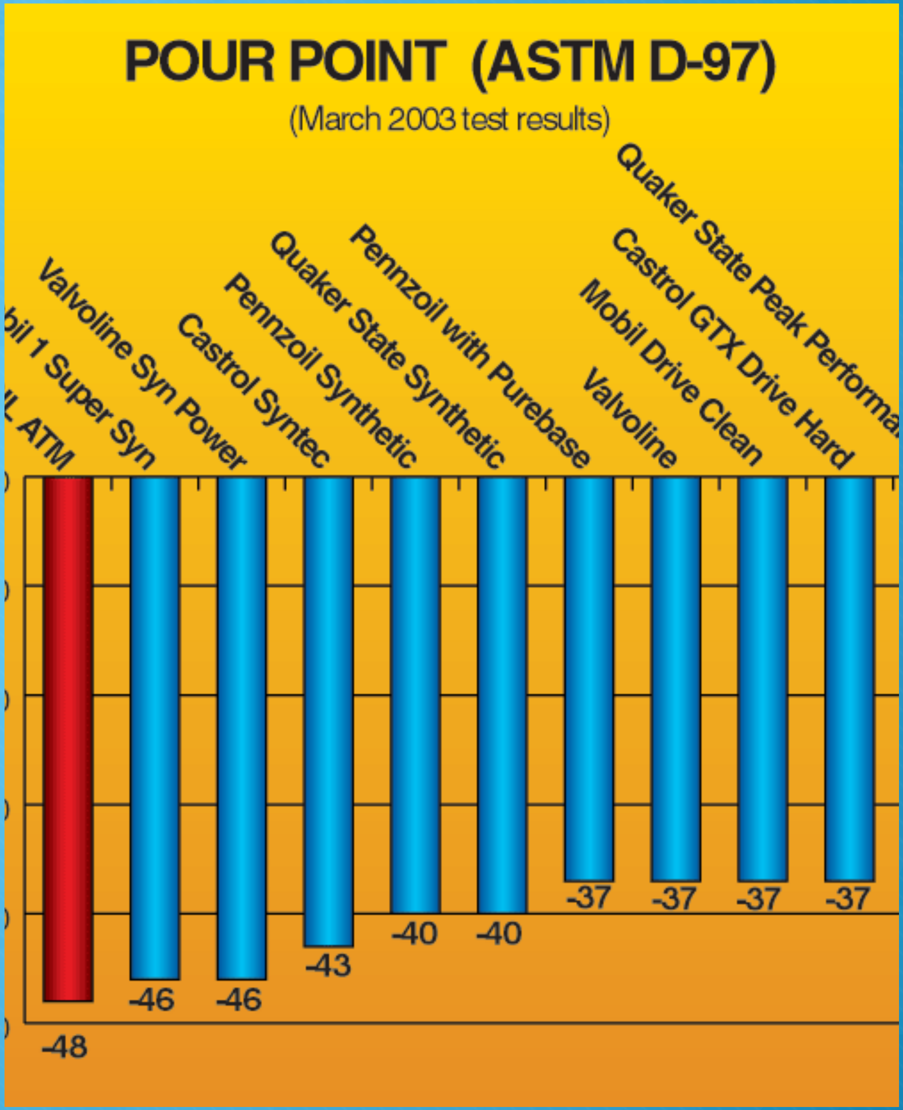
Viscosity is the resistance of a fluid to shear, movement or flow. The viscosity of an oil is a function of its composition. As oil weathers, the evaporation of the lighter components leads to increased viscosity. Viscosity also increases with decreased temperature, and decreases with increased temperature.

FLASH POINT

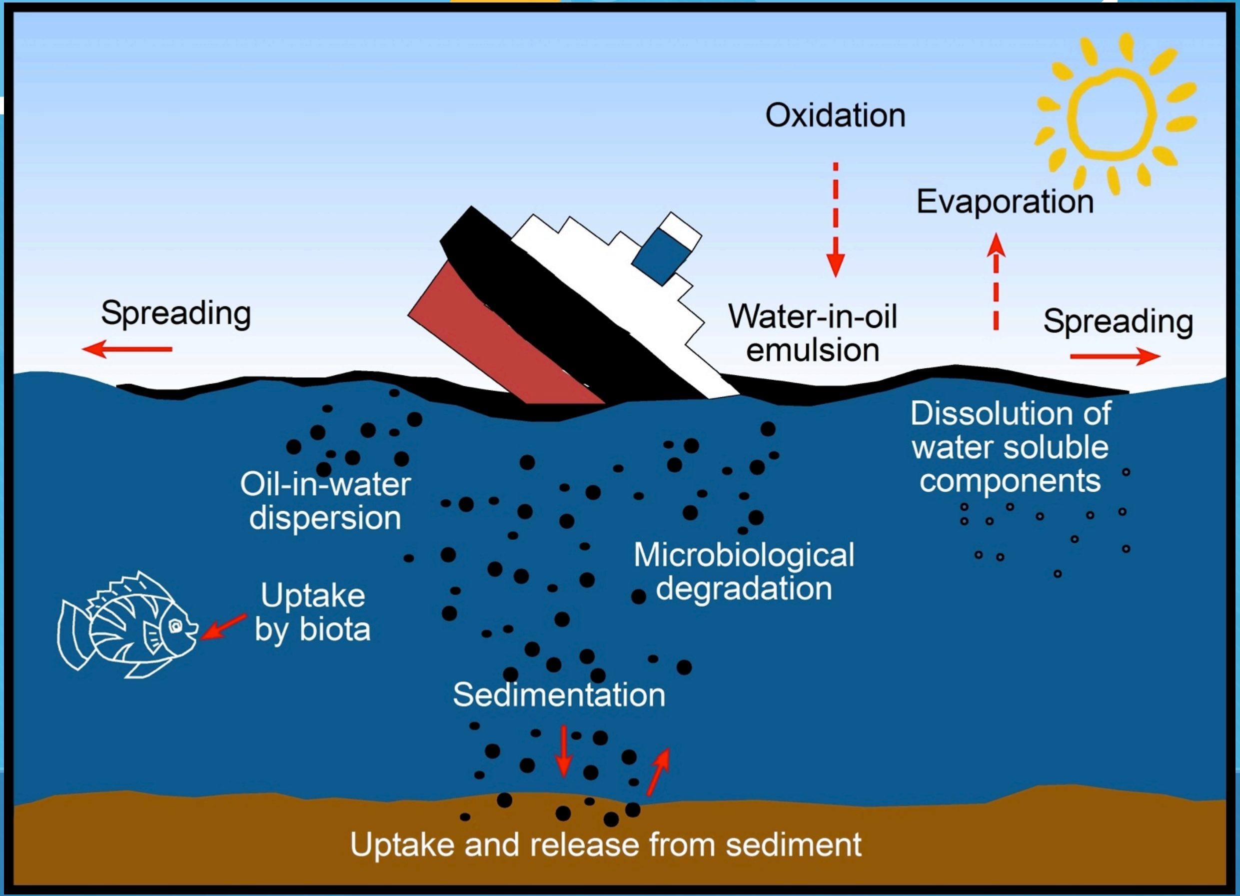
The temperature at which the vapour over a liquid will ignite when exposed to an ignition source. A liquid is considered to be flammable if its *flash point* is less than 60°C. Gasoline and other light fuels can ignite under most ambient conditions and therefore are a serious hazard when spilled. Many freshly spilled crude oils also have low *flash points* until the lighter components have evaporated or dispersed.

POUR POINT

The lowest temperature at which an oil will appear to flow under ambient pressure over a period of five seconds. The *pour point* of crude oils generally varies from -60 °C to 30 °C. Lighter oils with low *viscosities* generally have lower *pour points*.



FATE OF OIL SPILLS



WEATHERING PROCESSES

Processes related to the physical and chemical actions of air, water and organisms after oil spill. The major weathering processes include spreading, evaporation, dispersion, emulsification, dissolution, oxidation, sedimentation and sinking, and biodegradation

SPREADING

Spreading over the sea surface begins as soon as oil is spilled. The speed at which this takes place largely depends upon the viscosity of the oil, which in turn depends both on the oil composition and the ambient temperature. Fluid, low viscosity oils spread more quickly than those with a high viscosity. At low temperature, an oil will tend to be more viscous than at higher temperature as viscosity is inversely proportional to temperature.

SPREADING

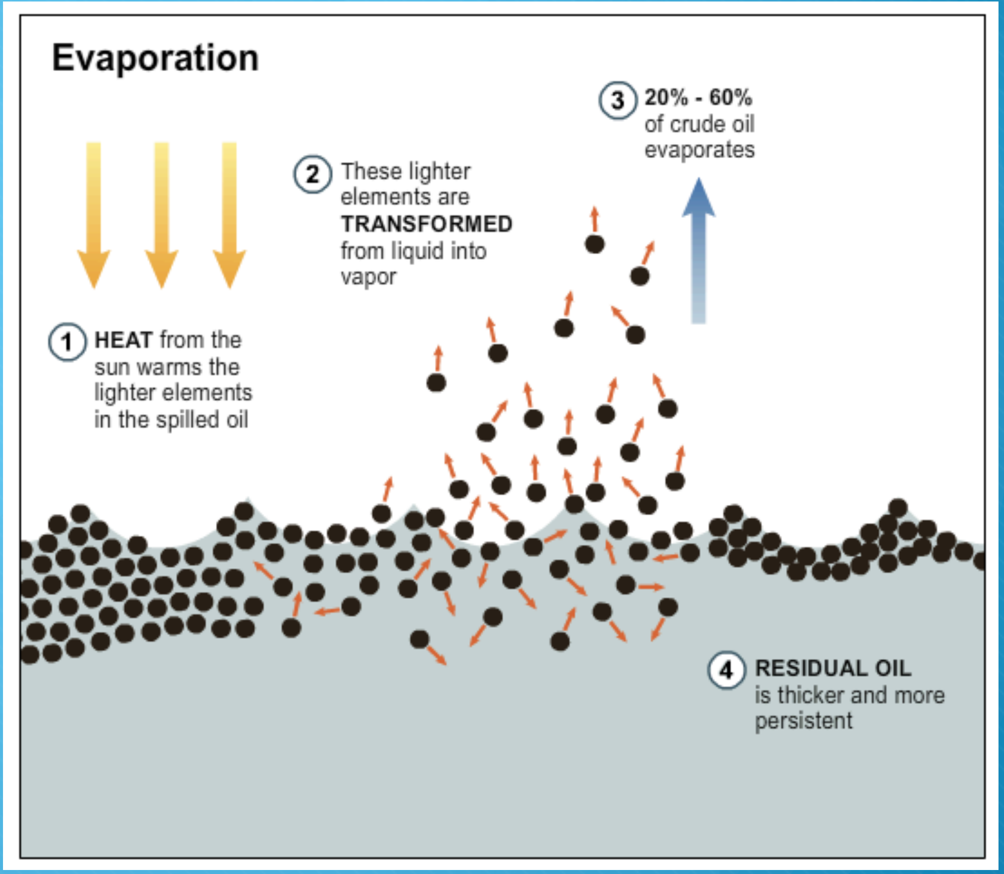
continued

After a few hours the slick will typically begin to break up due to the action of winds, wave action and water turbulence.

In addition to the oil type, the rate at which oil spreads is determined by prevailing environmental conditions such as temperature, water currents, tidal streams and wind speeds. Higher ambient temperatures, stronger winds and sea surface currents usually result in a more rapid rate of spreading.

EVAPORATION

The rate of evaporation and the speed at which it occurs depend upon the volatility of the oil. An oil with a large percentage of light and volatile compounds will evaporate more than one with a larger proportion of heavier compounds. For example, gasoline, kerosene and diesel, which are all light products, tend to evaporate almost completely within a few days. In contrast, little evaporation will occur from a spilled heavy fuel oil.

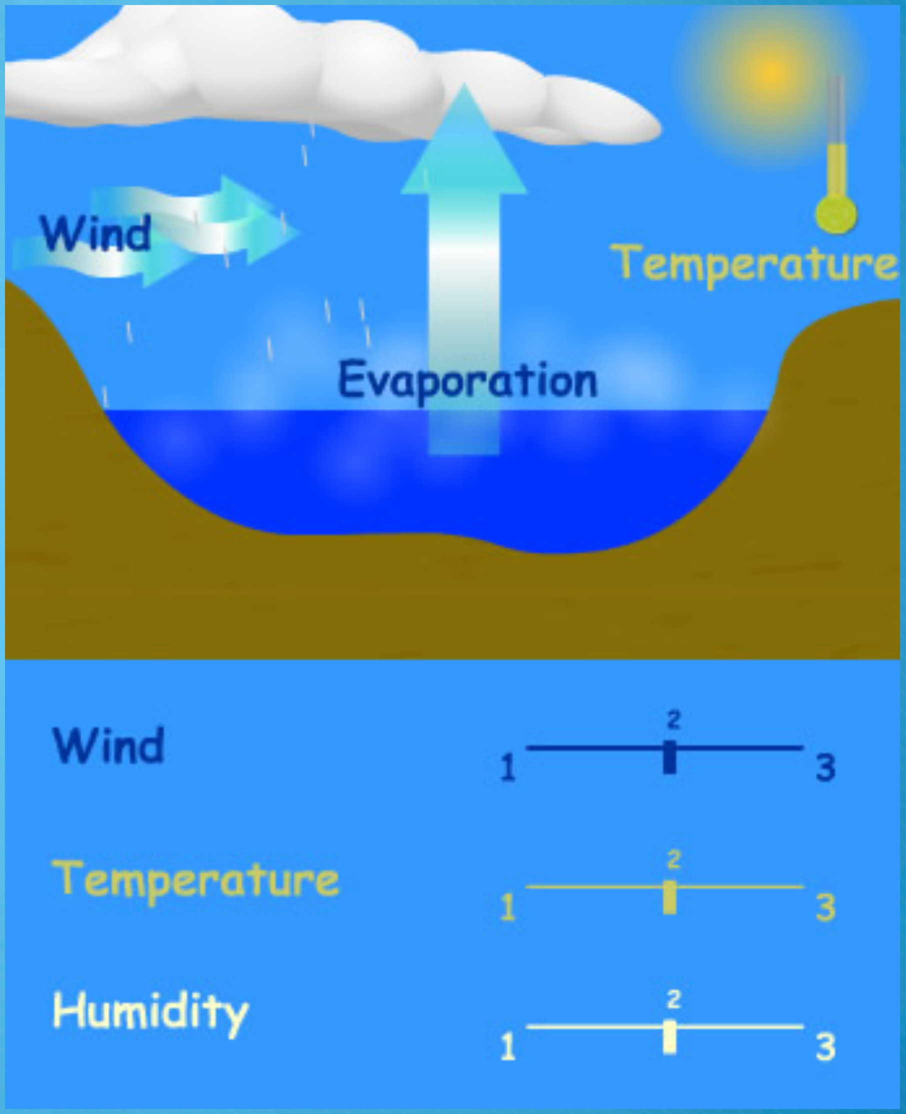


EVAPORATION

continued

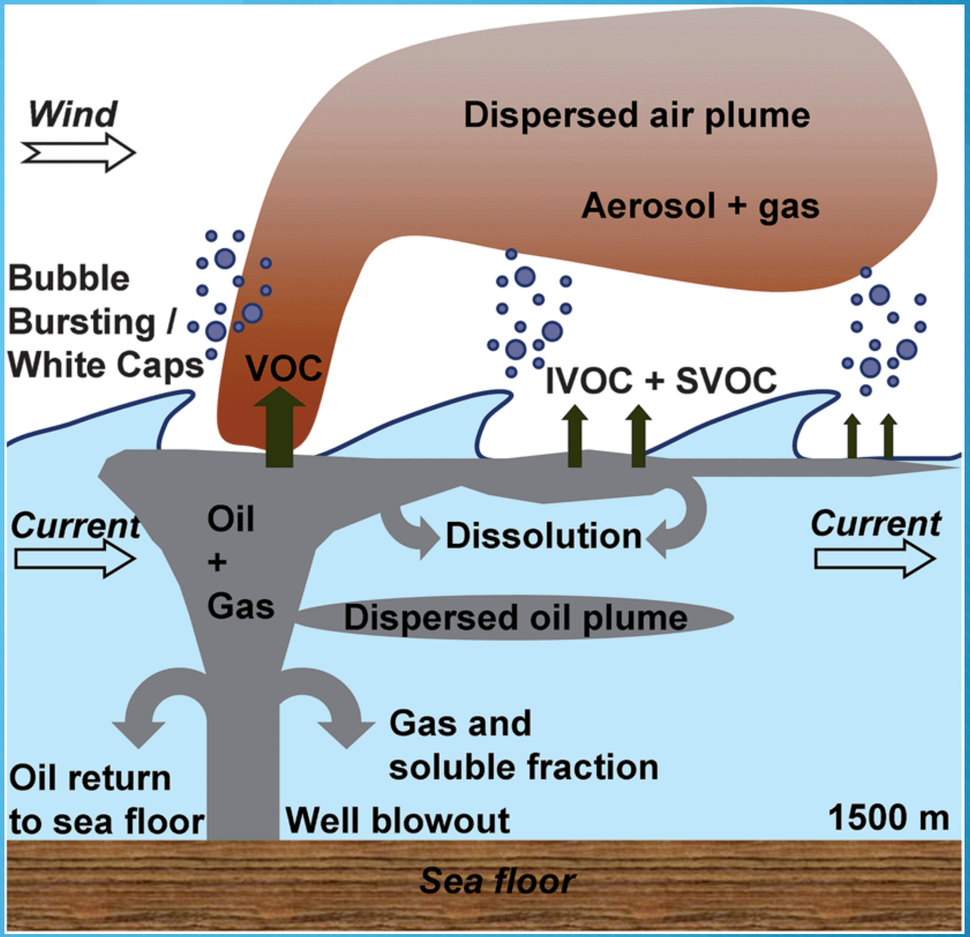
In temperate climates, those components of the oil with a boiling point under 200°C tend to evaporate within the first 24 hours. The rate of evaporation can increase as the oil spreads, due to the increased surface area of the slick.

Rougher seas, high wind speeds and high temperatures also tend to increase the rate of evaporation and the proportion of an oil lost to the atmosphere by this process.



DISPERSION

Waves and turbulence at the sea surface can cause some or all of a slick to break up into fragments and droplets of varying sizes. These become mixed into the upper levels of the water column. Some of the smaller droplets will remain suspended in the sea water while the larger ones will tend to rise back to the surface. They may then reform a slick or spread out to form a very thin film.



DISPERSION

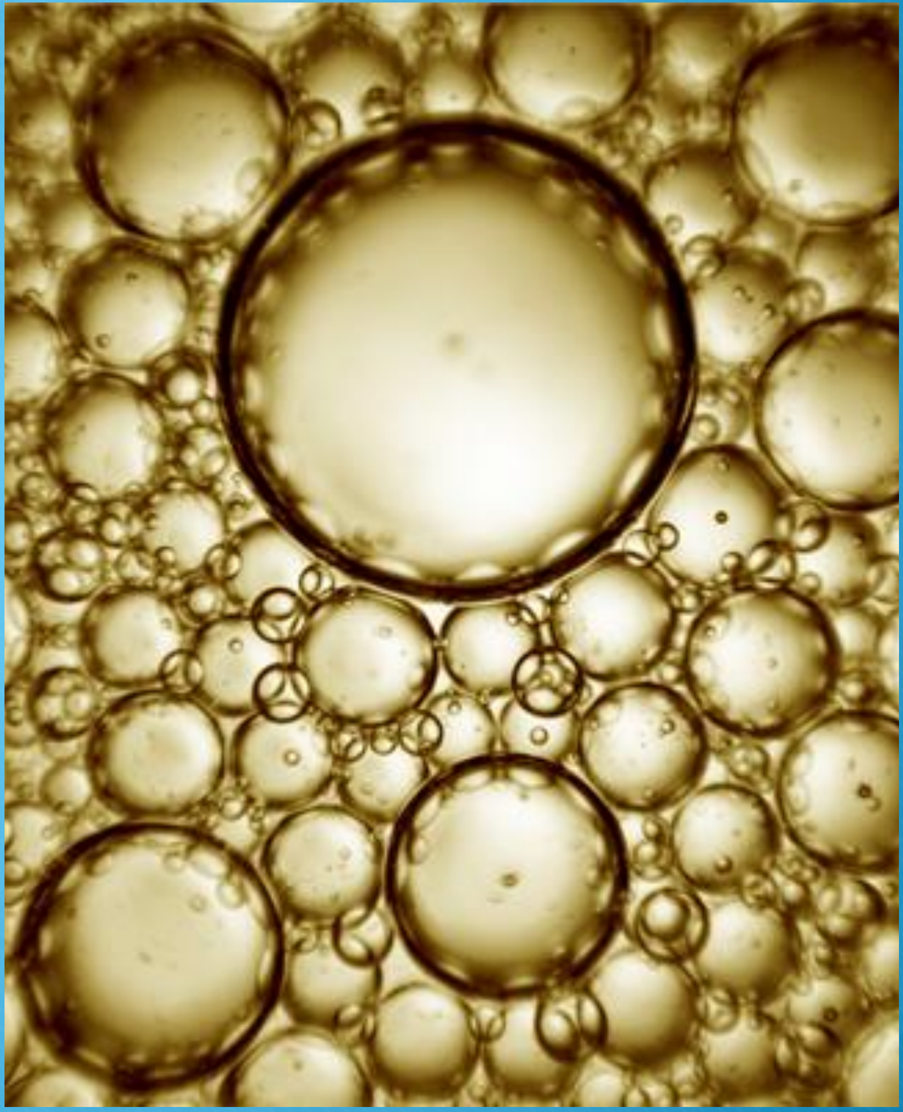
continued

Dispersed oil droplets have a greater surface area to volume ratio than floating oil. This encourages other natural processes such as dissolution, biodegradation and sedimentation to occur.

The speed at which an oil disperses is largely dependent upon the nature of the oil and the sea state. Dispersion occurs most quickly if the oil is light and of low viscosity and if the sea is very rough.

EMULSIFICATION

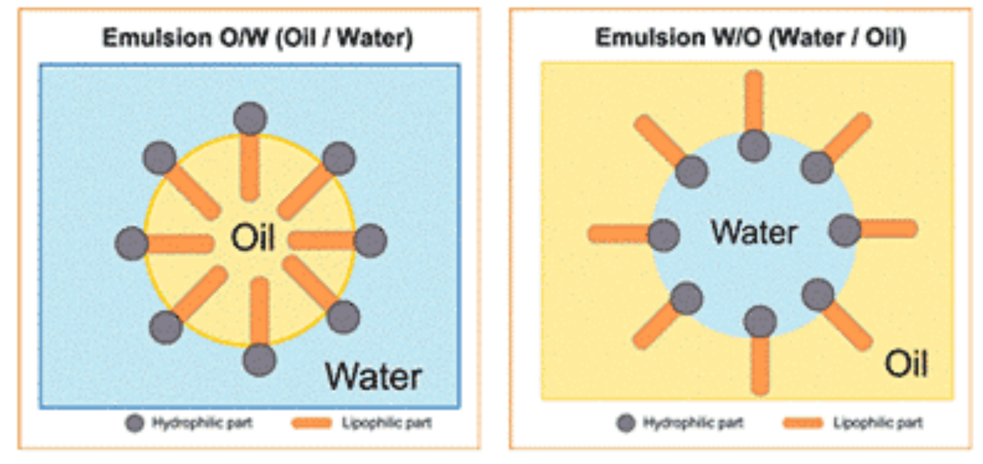
Emulsification of crude oils refers to the process whereby sea water droplets become suspended in the oil to form a water-in-oil emulsion. This occurs by physical mixing promoted by turbulence at the sea surface. The emulsion formed is usually very viscous and more persistent than the original oil and is sometimes referred to as chocolate mousse because of its appearance. The formation of these water-in-oil emulsions causes the volume of pollutant to increase between 3 and 4 times. This slows and delays other oil weathering processes, and can complicate the response.



EMULSIFICATION
continued

Oils with an asphaltene content greater than 0.5% tend to form stable emulsions which may persist for many months after the spill has occurred. Oils containing a lower percentage of asphaltenes are less likely to form water-in-oil emulsions.

Emulsions may separate into oil and water again if heated by the sun under calm conditions or when stranded on shorelines.



DISSOLUTION

Water soluble compounds in an oil may dissolve into the surrounding water. This occurs most quickly when the oil is dispersed in the water column.

Components that are most soluble in sea water are the light aromatic hydrocarbons compounds. However, these compounds are also those first to be lost through evaporation, a process which is 10 -1000 times faster than dissolution. Most crude oils and all fuel oils contain relatively small proportions of these compounds making dissolution one of the less significant processes.

OXIDATION

Oils react chemically with oxygen either breaking down into soluble products or forming persistent compounds called tars. This process is promoted by sunlight, but is very slow and even in strong sunlight, thin films of oil break down at no more than 0.1% per day. The formation of tars is caused by the oxidation of thick layers of high viscosity oils or emulsions. This process forms an outer protective coating of heavy compounds that results in the increased persistence of the oil. Tarballs, which are often found on shorelines and have a solid outer crust surrounding a softer, less weathered interior, are a typical example of this process.

SEDIMENTATION

Very few oils sink in the marine environment. When floating oil is getting close to the shore, sedimentation can occur. Indeed, once all the lighter compounds have evaporated and the slick has weathered at sea, some oils can be close to the density of seawater. When floating, semi submerged or dispersed oil comes into contact with suspended sediment, the sediment can bind to it. This particularly happens in shallow waters. If the contamination's heavy, then dense 'tar-mats' can form on the seabed near shore.

SEDIMENTATION
continued

Oil stranded on sandy shorelines often becomes mixed with sand and other sediments. If this mixture is subsequently washed off the beach back into the sea it may then sink.

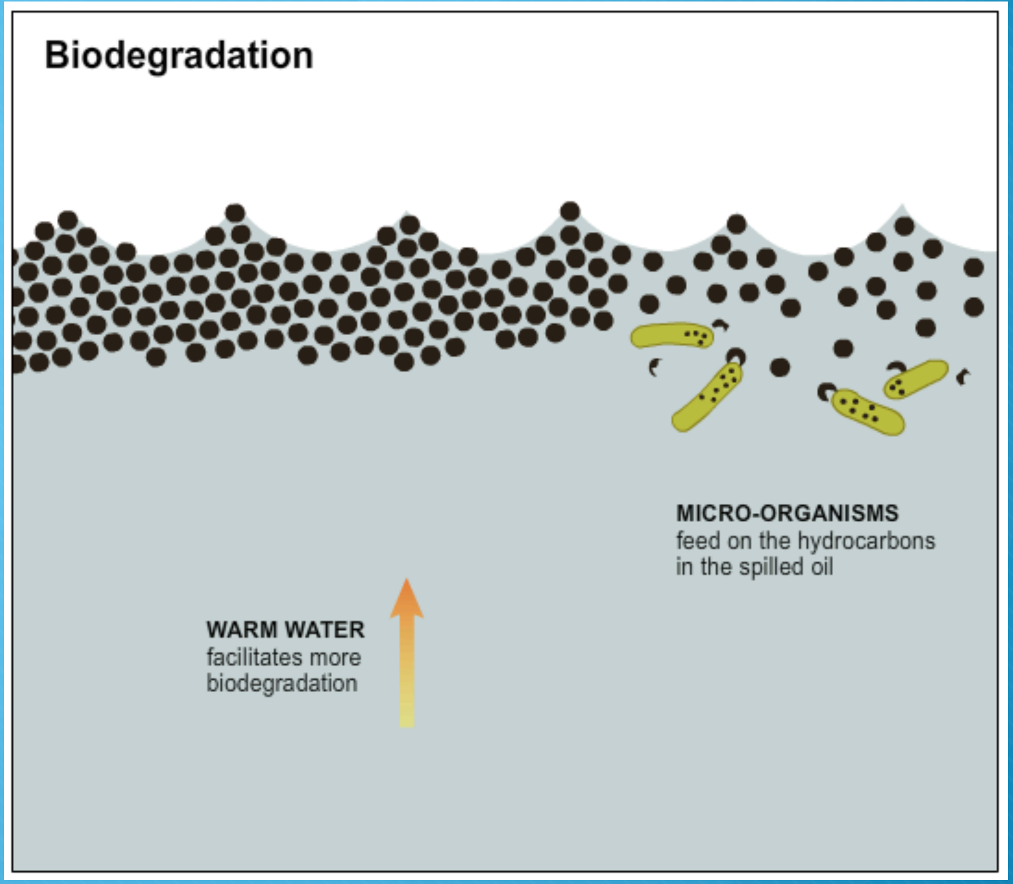
In addition, if the oil catches fire or is voluntarily after it has been spilled, the residues that sometimes form can be sufficiently dense to sink.

BIODEGRADATION

Sea water contains a wide range of micro-organisms that use hydrocarbons as a source of energy and can partially or completely degrade oil to water soluble compounds and eventually to carbon dioxide and water.

Many types of marine micro-organism exist and each tends to degrade a particular group of compounds in crude oil. However, some compounds in oil are very resistant to attack and may not readily degrade.

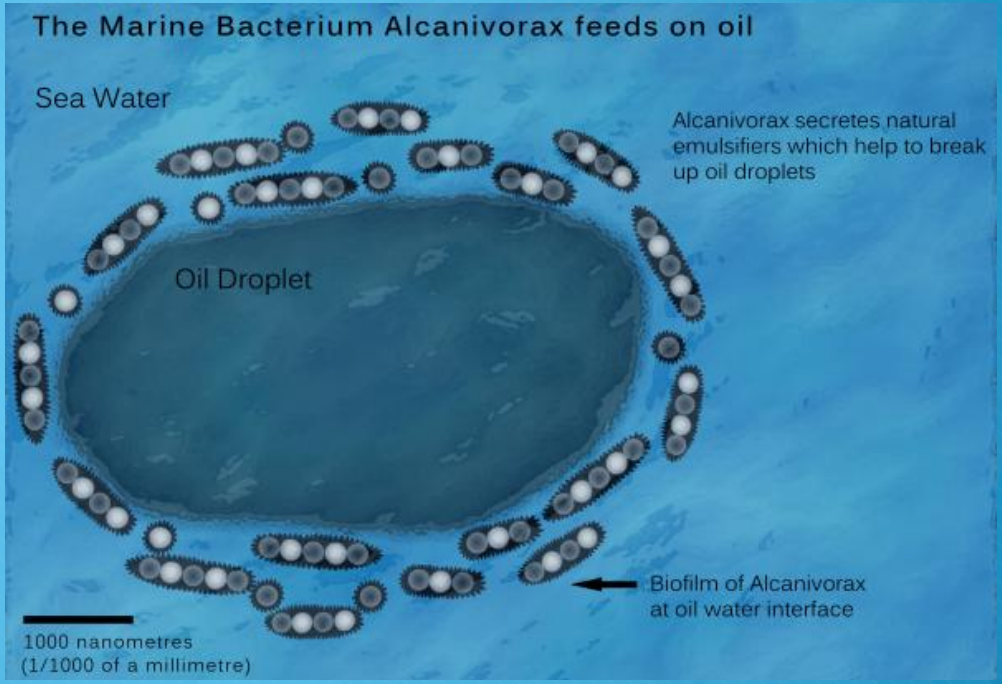
The main factors affecting the efficiency of biodegradation, are the levels of nutrients in the water, the temperature and the level of oxygen present.



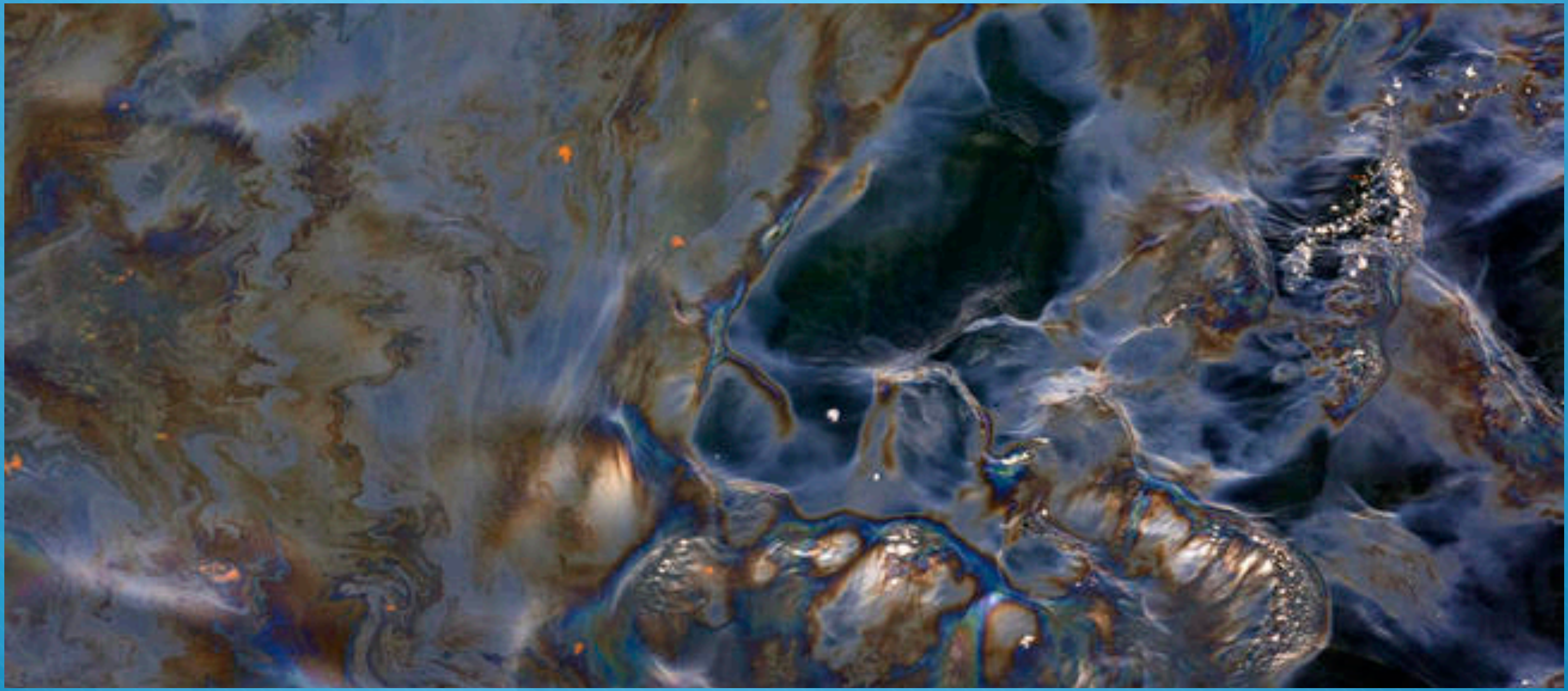
BIODEGRADATION

continued

As biodegradation of oil requires oxygen, this process can only take place at the oil-water interface since no oxygen is available within the oil itself. The creation of oil droplets through dispersion, increases the surface area to volume ratio of the oil, and therefore increases the area available for micro-organisms to attach to the surface of the oil and for biodegradation to take place.



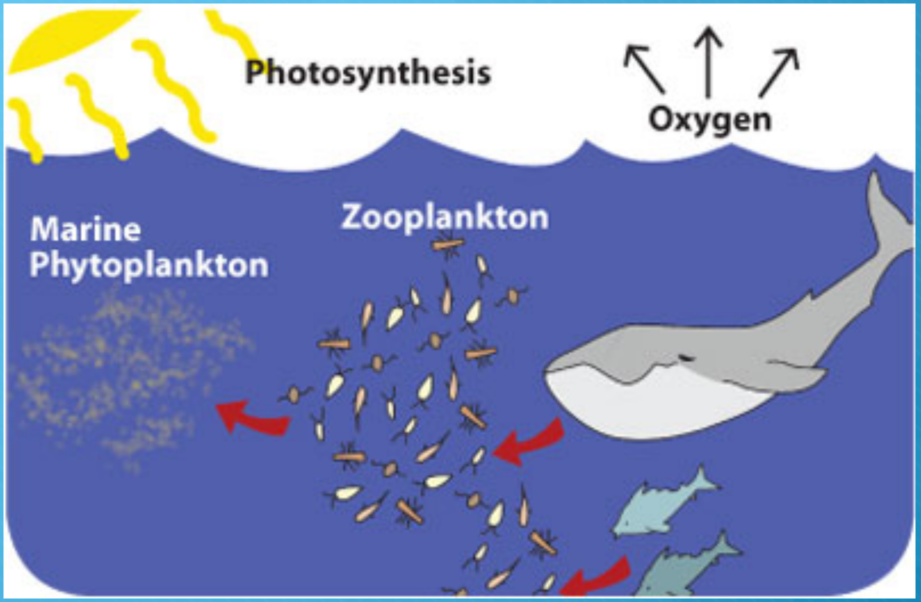
IMPACTS OF SPILLED OIL



Effects in Offshore and Coastal waters

PLANKTON

- It is well established that plankton is sensitive to oil exposure and consequently short-term impacts should be expected in the immediate vicinity of the oil.
- A large proportion of a given species will remain unaffected by the spill and it is rare for plankton mortalities following a spill to result in reduced adult populations.



FISH

- Adult fish tend to be more resilient. Reductions in wild fish stocks in offshore and coastal waters following oil spills have rarely been detected.
- Where mass mortalities have occurred, they have been caused by very high, localised concentrations of dispersed oil in shallow or confined waters.
- Fish mortalities can occur with cultured fish stocks where individuals are unable to actively avoid the oil.

SEABIRDS

- In open water, seabirds are some of the most vulnerable of all animals, and in some incidents large numbers may perish.
- Fouling of plumage is the most visible effect. Although cleaning and rehabilitation of birds may be attempted, success is often linked to the species of bird, and in many cases only a small fraction of those treated will survive.

SEA MAMMALS AND REPTILES

- The oil can potentially cause harm to nasal tissues and eyes and whilst mortalities caused by oil have been recorded.
- Mammals that rely on fur to regulate body temperature can be vulnerable to the effects of oil as they may be harmed or die from hypothermia or overheating if their fur becomes matted with oil.
- For marine reptiles, the greatest impact is probably away from the open sea and on their nesting beaches should they become contaminated with oil.

Effects in Shallow Inshore Waters and on Shorelines

SHORELINE

- Caused by the exposure of marine organisms to high concentrations of naturally or chemically dispersed oil.
- Impacted both by toxic effects of high concentrations of dispersed oil during high tide periods and also the smothering effect of oil at low tide

ABILITY TO SURVIVE

- Difficult to predict due to the sheer number of habitat types and variety of organisms that inhabit this marine zone.
- Many species and individual are inherently tough and resilient as they have evolved to survive in a highly dynamic environment with routine periodic fluctuations of tide temperature and salinity together with more extreme stochastic events such as storms

SENSITIVE HABITATS

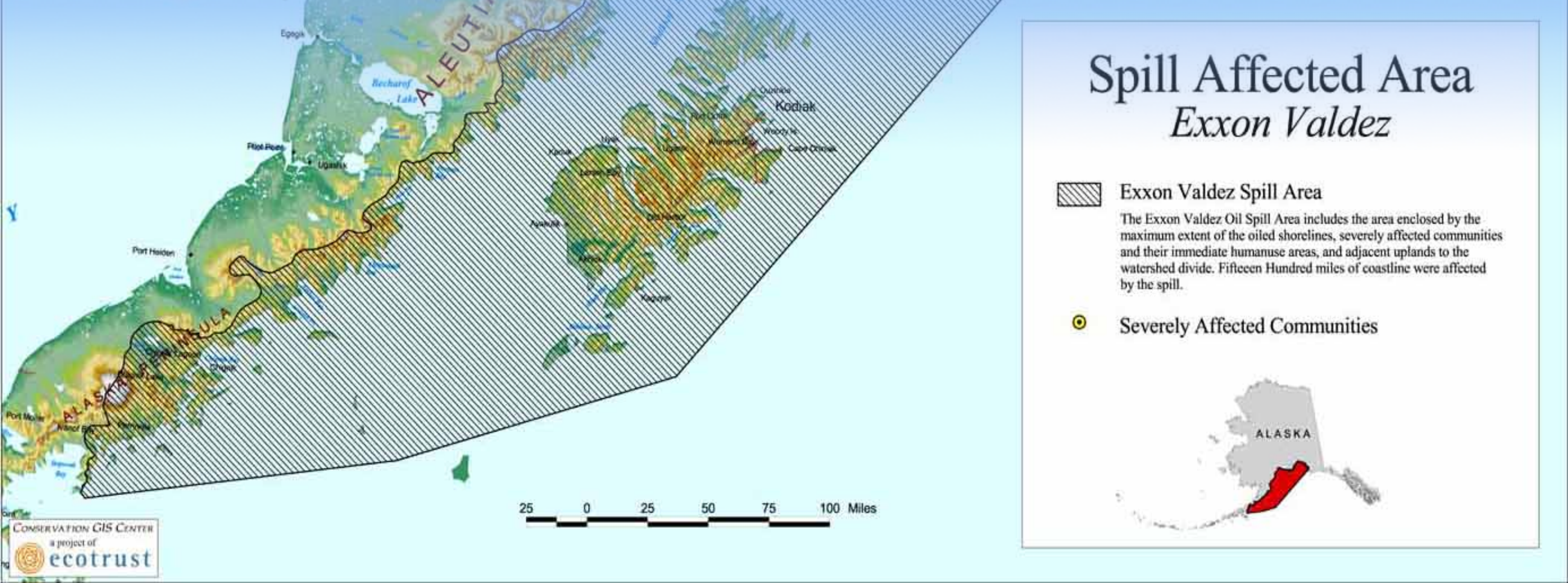
- Coral reefs, saltmarshes and mangroves: are important for providing coastal protection and nursery grounds for many commercially important invertebrate and fish species, and are at high risk of contamination during oil spills.
- Coral reefs are highly sensitive to dispersed oil and if impacted, can take a long time to recover.
- Both saltmarshes and mangroves are typical of sheltered shores and natural recovery of these complex ecosystems can take a long time.

CASE STUDY

Exxon Valdez Oil Spill

Exxon Valdez Oil Spill

- Ocurred in Prince William Sound , Alaska in March 24, 1989 .
- Is one of the biggest environmental tragedies in history. This ship spilled a minimum of 10.8 million gallons.
- It cover 1,300 miles (2,100 km) at coastline and 11.000 square miles of ocean (28,000 km).



12 minute video

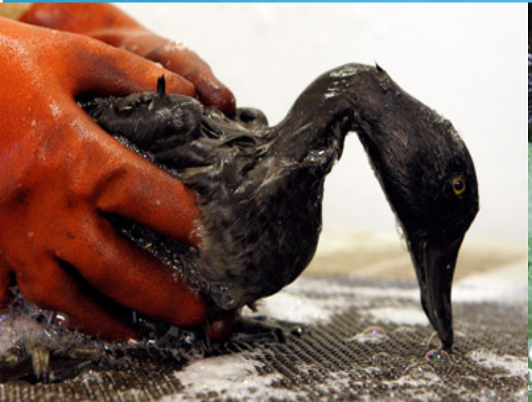
Exxon Valdez Oil Spill

https://www.youtube.com/watch?v=VaRdUHrUnBs

Environmental Consequences

It destroyed the microbial populations on the shoreline; many of these organisms are the basis of the coastal marine food chain, and others are certain bacteria and fungi, they make easy the biodegradation of oil.

Thousands of animals died immediately; the best estimates include 100,000 to as many as 250,000 seabirds, at least 2,800 sea otters, approximately 12 river otters, 300 harbor seals, 247 bald eagles, and 22 orcas, as well as the destruction of billions of salmon and herring eggs.



2 minute video

The Exxon Valdez disaster 20 years later

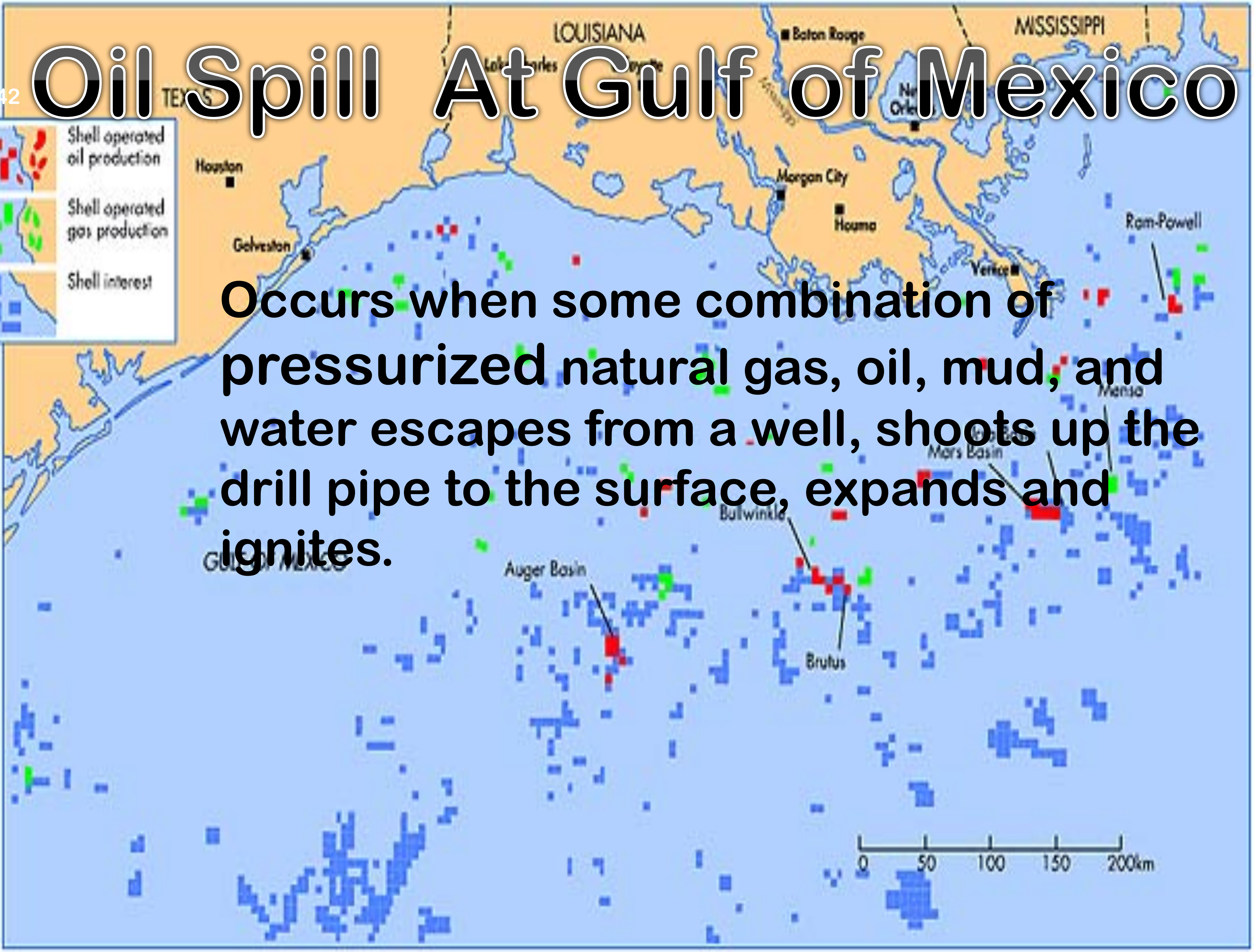
https://www.youtube.com/watch?v=MbjC9SMKCIE

CASE STUDY

Oil spill at Gulf of Mexico

Oil Spill At Gulf of Mexico

Occurs when some combination of pressurized natural gas, oil, mud, and water escapes from a well, shoots up the drill pipe to the surface, expands and ignites.



Oil Spill

- The catastrophic explosion that caused an oil spill from a BP offshore drilling rig in the Gulf of Mexico has reached the shoreline .This is on track to become the worst spill in history, surpassing the damage done by the Exxon Valdez taker. This Oil Spill was at the state of Louisiana at 48 miles out in the Gulf of Mexico from the mouth of the Mississippi.

- The official estimations of which 5,000 barrels (795,000 liters) would have spilled in the Gulf every day since the platform of perforation of Deepwater Horizon exploded weeks ago

- How big is the oil spill and how fast is it growing?
- The oil spill has grown in size since the initial accident as the oil spreads across the surface of the ocean.
- The lighter the oil is, the faster it can spread
- the oil spill has a circunference of about 600 miles (about 970 kilometers)
- The spill is big enough to be seen from space.

1 minute video

Oil spill at Gulf of Mexico 2010

https://www.youtube.com/watch?v=ttC7o3JxsxE

3 minute video

The underwater impact of the BP Oil Spill

https://www.youtube.com/watch?v=lY-PikuXTYY

THANK YOU

ANY QUESTIONS?