Co-funded by the
Erasmus+ Programme
of the European Union

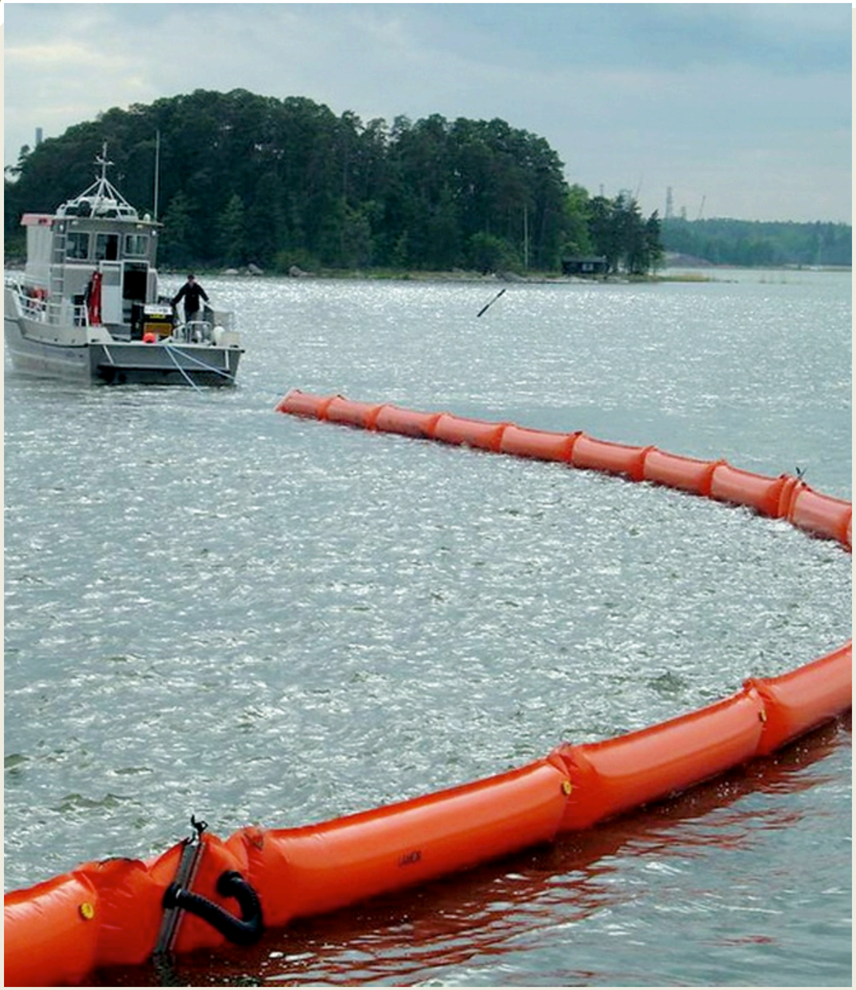
OCEAN ENVIRONMENTAL MANAGEMENT

LECTURE 8. POLLUTION CLEANUP

Ma.Sc. Dinh Thi Thuy Hang

MAJOR CONTENTS

- MECHANICAL METHODS
  - Containment
  - Recovery
- CHEMICAL METHODS
  - Dispersing agents
- OTHERS
  - In-Situ burning
  - Sinking
  - Enhanced biodegradation
  - Natural clean-up



MECHANICAL METHODS

CONTAIMENT:

- BOOMS

RECOVERY:

- BOOMS
- SKIMMERS
- SORBENTS: Absorbent vs. Adsorbent

Containment booms are used to control the spread of oil to reduce the possibility of polluting shorelines and other resources, as well as to concentrate oil in thicker surface layers, making recovery easier. In addition, booms may be used to divert and channel oil slicks along desired paths, making them easier to remove from the surface of the water.

Containment booms can be used to control the spread of oil

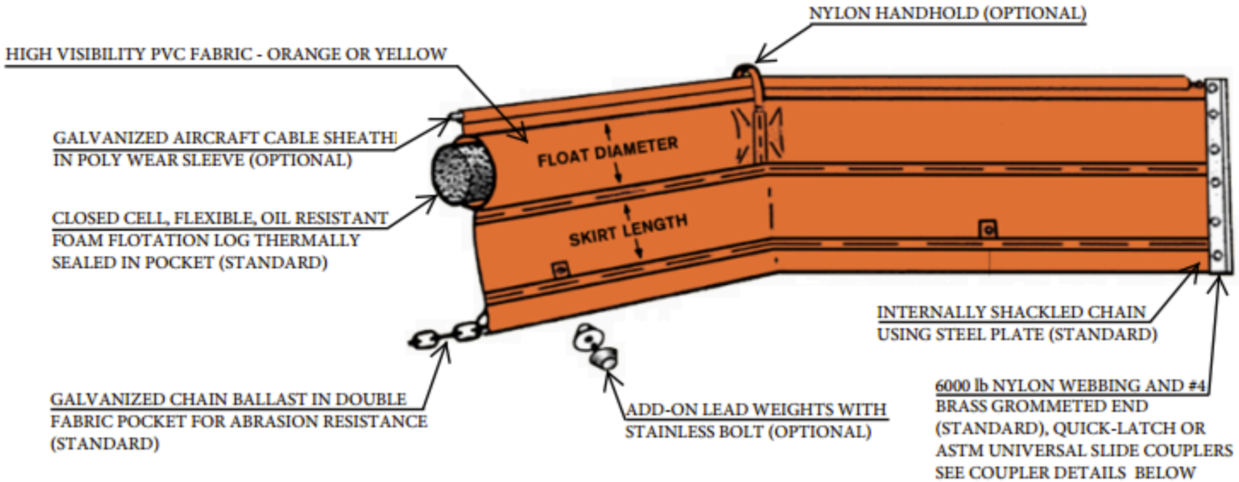
All booms generally share four basic characteristics:

(1) An above-water "freeboard" to contain the oil and to help prevent waves from splashing oil over the top of the boom

(2) A flotation device

(3) A below-water skirt to contain the oil and help reduce the amount of oil lost under the boom

(4) A "longitudinal support," usually a chain or cable running along the bottom of the skirt, that strengthens the boom against wind and wave action; may also serve as a weight or ballast to add stability and help keep the boom upright.



Containment Boom Detail

Booms can be divided into several basic types.

Fence booms have a high freeboard and a flat flotation device, making them least effective in rough water, where wave and wind action can cause the boom to twist.

Round or "curtain" booms have a more circular flotation device and a continuous skirt. They perform well in rough water, but are more difficult to clean and store than fence booms.

Non-rigid inflatable booms come in many shapes. They are easy to clean and store, and they perform well in rough seas. However, they tend to be expensive, more complicated to use, and puncture and deflate easily.

When a spill occurs and no containment equipment is available, barriers can be improvised from whatever materials are at hand.

Improvised booms are made from such common materials as wood, plastic pipe, inflated fire hoses, automobile tires, and empty oil drums. They can be as simple as a board placed across the surface of a slow-moving stream, or a berm built by bulldozers pushing a wall of sand out from the beach to divert oil from a sensitive section of shoreline.

Improvised booms

Impact factors

- Shifting tides
- Currents
- Wind
- Waves
- Rough and choppy water
- Mechanical problems
- Improper mooring

Booms working in rough sea

Generally, booms will not operate properly when waves are higher than one meter or currents are moving faster than one knot per hour.

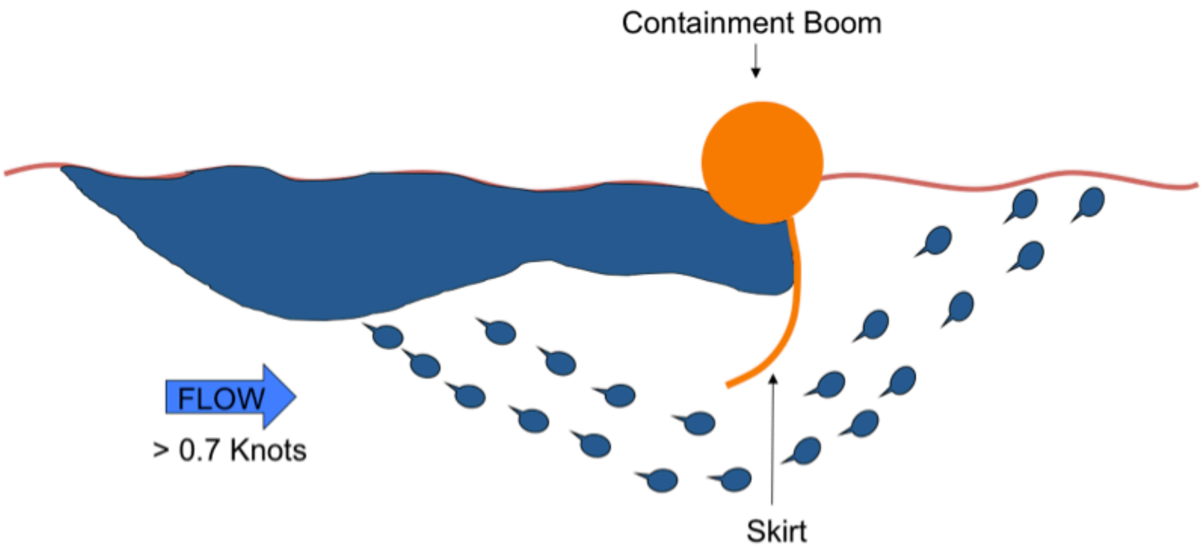
OPERATIONAL BOOM FAILURE

There are five basic types of operational boom failure:

- Entrainment
- Drainage
- Splash over
- Submergence
- Planning

Loss of oil occurring when friction between the water and oil causes droplets of oil to separate from the slick and be pulled under the boom is called entrainment.

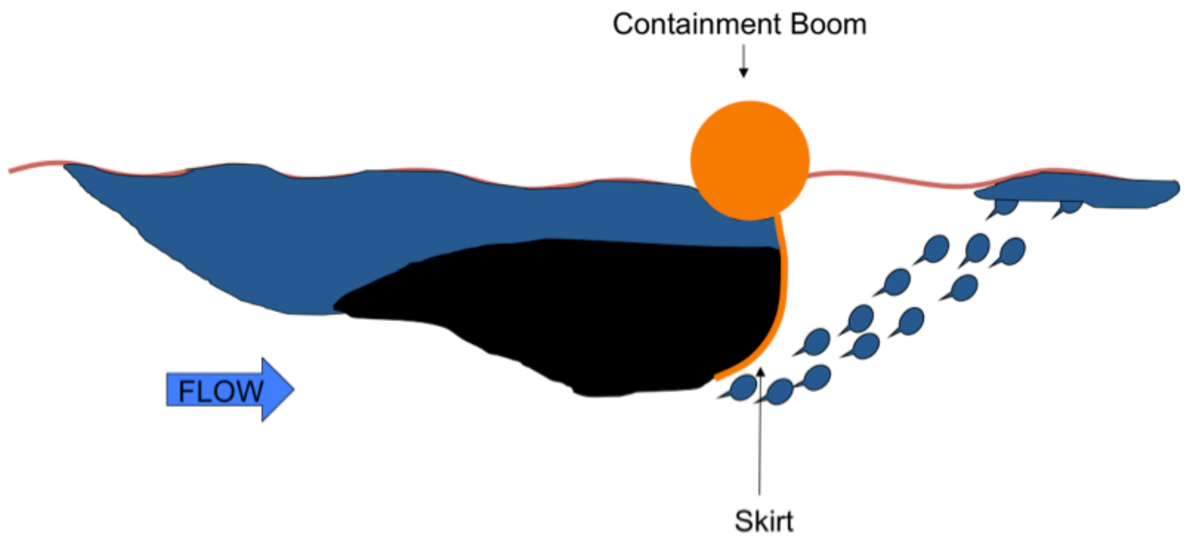
Entrainment occurs at current velocities between 0.7 and 1.0 knots.



Entrainment

Drainage typically occurs when small oil spill containment boom is used and too much oil causes the oil to flow down the face of the boom and exit on the other side.

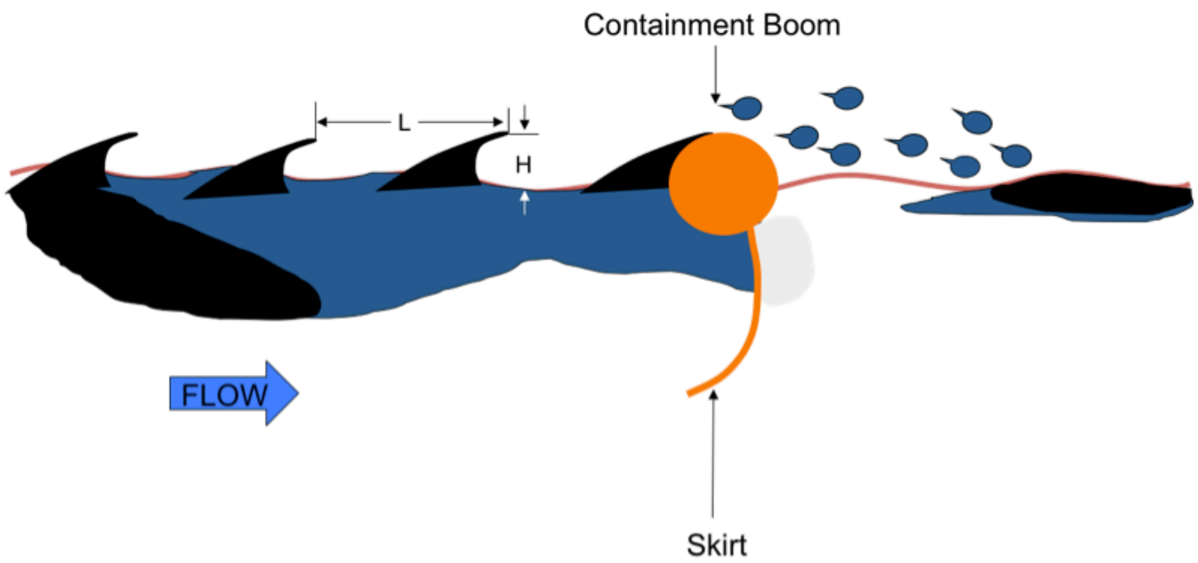
Similar to entrainment, drainage failure involves leakage from large pools of oil that are collected by the oil spill containment boom.



Drainage

Splashover may occur in choppy water when the wave height is greater than the freeboard of the oil spill containment boom. Splashover often times occurs when the wave length to height ratio is less than 10:1.

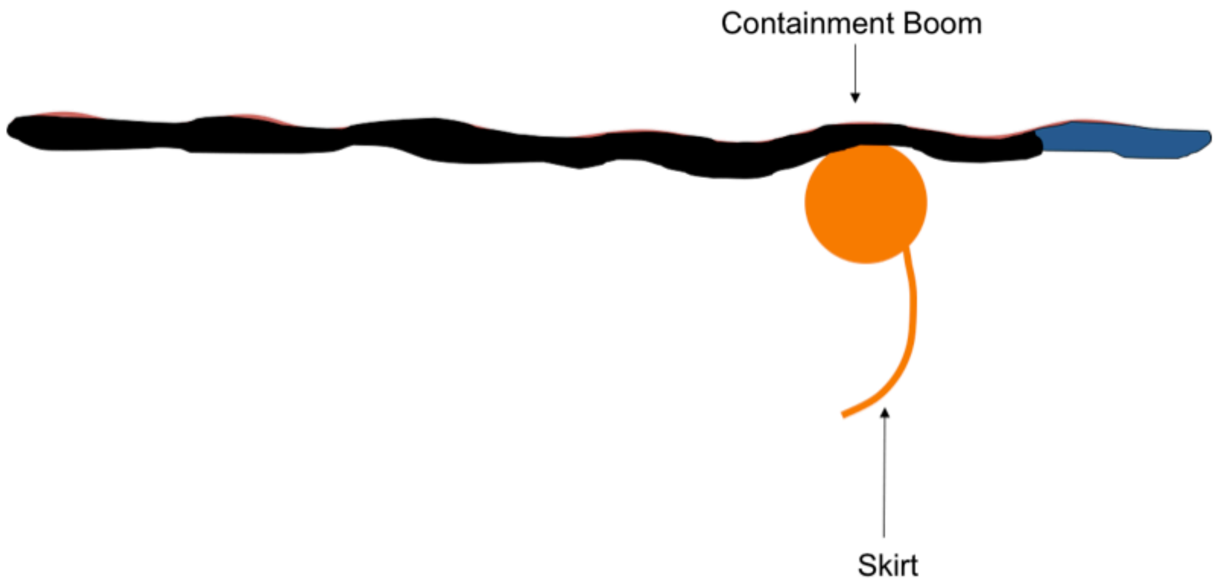
A secondary boom should be deployed to collect any oil droplets that may escape over the oil spill containment boom.



Splashover

Submergence may occur when a boom is deployed or anchored in a fast current or is being towed at a high velocity.

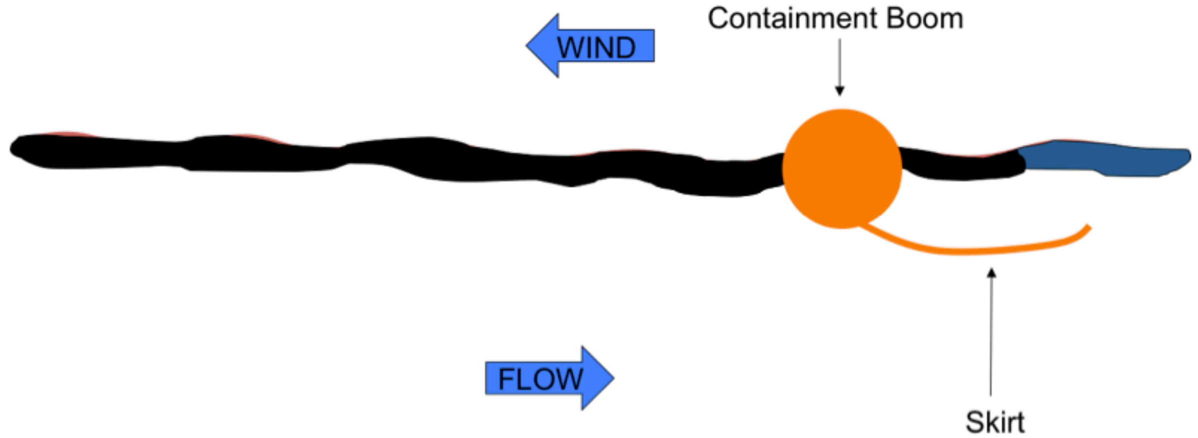
Submergence is not common as entrainment failure usually occurs prior to the speed needed for submergence.



Submergence

Planning failure is a common failure when strong wind and current are present in opposite directions.

This failure is most likely to occur when the oil spill containment boom has inadequate ballasting or when internal tension member is near or above the waterline.



Planning failure

MECHANICAL METHODS

CONTAIMENT:

- BOOMS

RECOVERY:

- **BOOMS**
- SKIMMERS
- SORBENTS: Absorbent vs. Adsorbent

When used in recovering oil, booms are often supported by a horizontal arm extending directly off one or both sides of a vessel.

Sailing through the heaviest sections of the spill at low speeds, a vessel scoops the oil and traps it between the angle of the boom and the vessel's hull.

In another variation, a boom is moored at the end points of a rigid arm extended from the vessel, forming a "U"- or "J" shaped pocket in which oil can collect.

In either case, the trapped oil can then be pumped out to holding tanks and returned to shore for proper disposal or recycling.

Recovery booms

MECHANICAL METHODS

CONTAIMENT:

- BOOMS

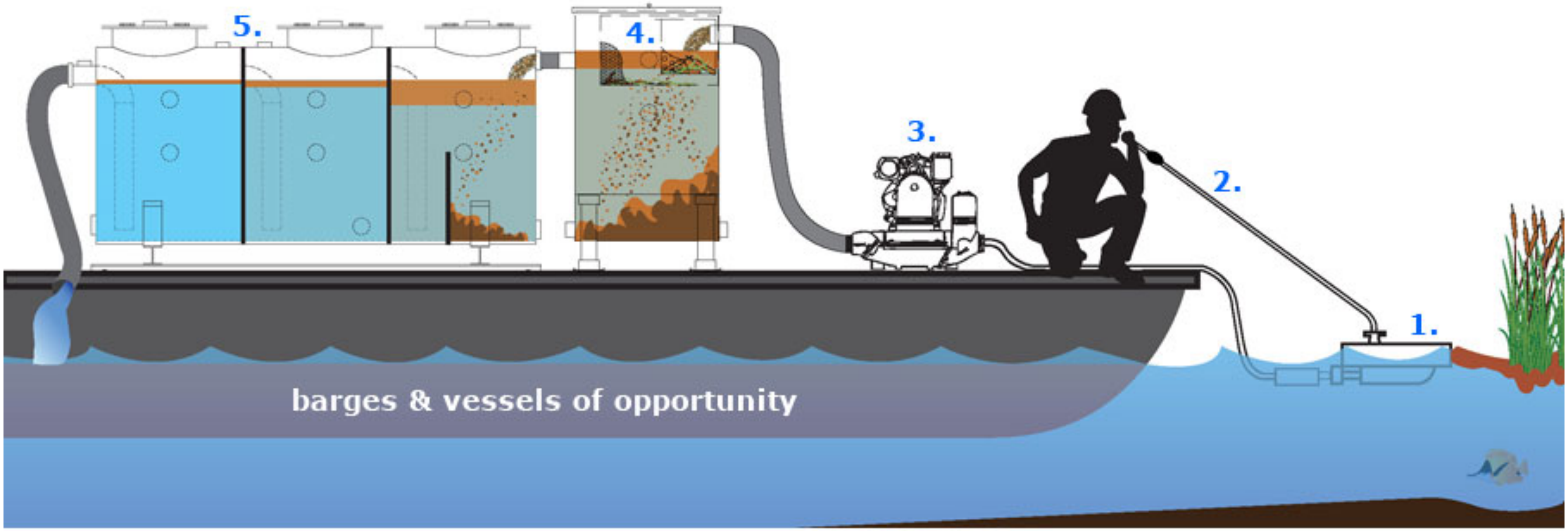
RECOVERY:

- BOOMS
- **SKIMMERS**
- SORBENTS: Absorbent vs. Adsorbent

Skimmers

A skimmer is a device for recovery of spilled oil from the water's surface. Skimmers may be self-propelled and may be used from shore or operated from vessels. The efficiency of skimmers depends on weather conditions. In moderately rough or choppy water, skimmers tend to recover more water than oil.

Skimoil™ GulfSHOT Skimmer & Separator System for Coastal Workboats & VOP



1. skimmer 2. control wand & suction valve 3. pump or suction system 4. knock-out strainer 5. knock-out interceptor separator

Oleophilic (oil-attracting) skimmers use belts, disks, or continuous mop chains of oleophilic materials to blot the oil from the water surface.

The oil is then squeezed out or scraped off into a recovery tank.

Oleophilic skimmers have the advantage of flexibility, allowing them to be used effectively on spills of any thickness.

Some types, such as chain or "rope-mop" skimmers, work well on water that is choked with debris or rough ice.

Oleophilic *(oil-attracting)* skimmer

Weir skimmers use a dam or enclosure positioned at the oil/water interface.

Oil floating on top of the water will spill over the dam and be trapped in a well inside, bringing with it as little water as possible.

The trapped oil and water mixture can then be pumped out through a pipe or hose to a storage tank for recycling or disposal.

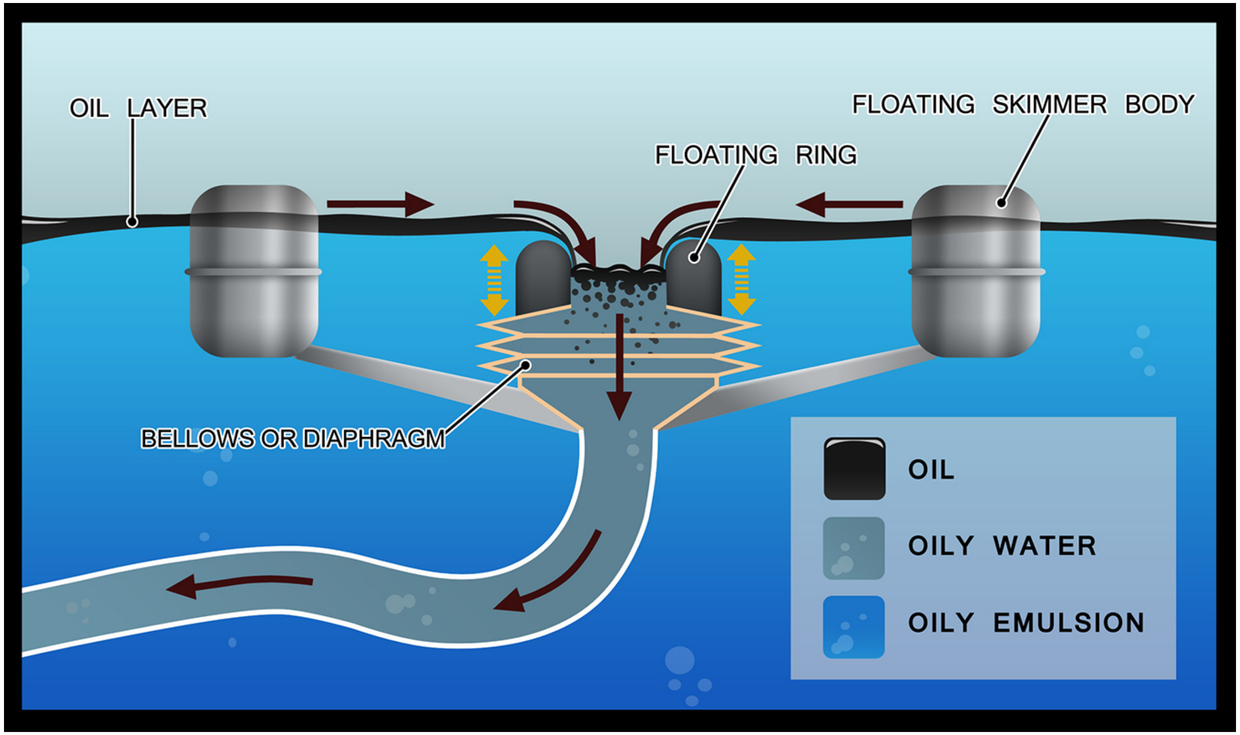
These skimmers are prone to becoming jammed and clogged by floating debris.

Weir skimmer

A suction skimmer operates like a household vacuum cleaner. Oil is sucked up through wide floating heads and pumped into storage tanks.

Although suction skimmers are generally very efficient, they are vulnerable to becoming clogged by debris and require constant skilled observation.

Suction skimmers operate best on smooth water where oil has collected against a boom or barrier.



Suction skimmer

MECHANICAL METHODS

CONTAIMENT:

- BOOMS

RECOVERY:

- BOOMS
- SKIMMERS
- **SORBENTS: Absorbent vs. Adsorbent**

Sorbents

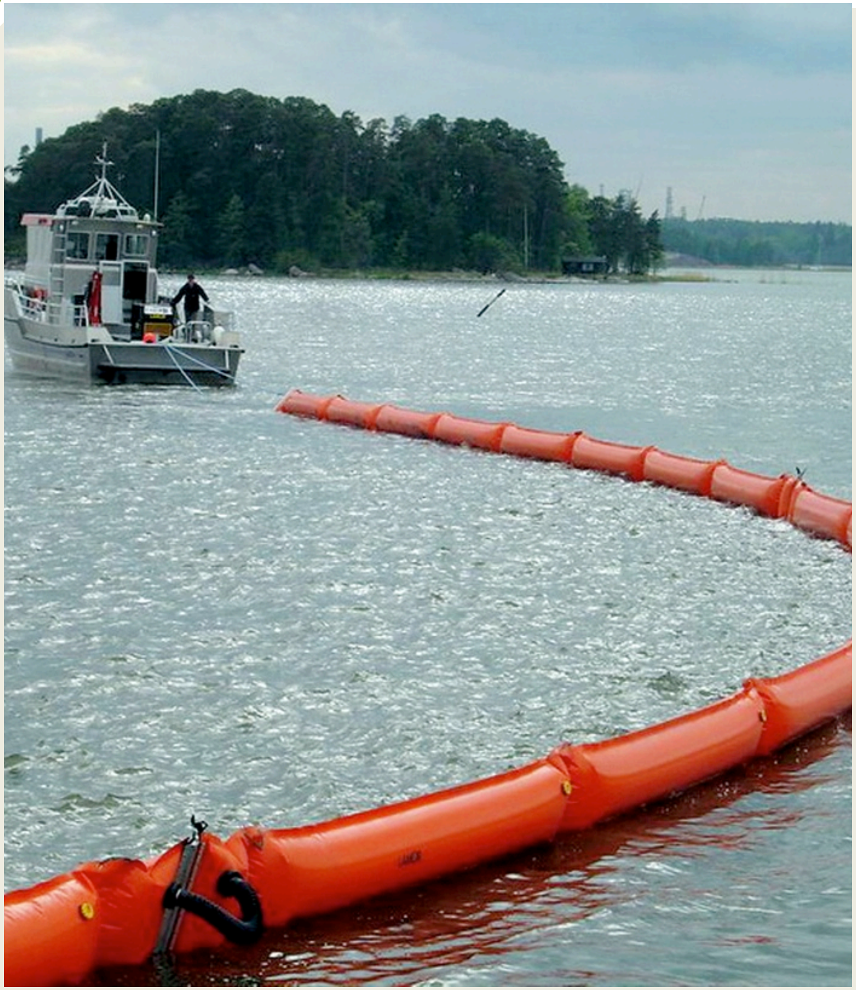
Sorbents are materials that soak up liquids. They can be used to recover oil through the mechanisms of absorption, adsorption, or both. Absorbents allow oil to penetrate into pore spaces in the material they are made of, while adsorbents attract oil to their surfaces but do not allow it to penetrate into the material.

The following characteristics must be considered when choosing sorbents for cleaning up spills:

- Rate of absorption - the rate of absorption varies with the thickness of the oil. Light oils are soaked up more quickly than heavy ones.
- Oil retention - the weight of recovered oil can cause a sorbent structure to sag and deform. When it is lifted out of the water, it can release oil that is trapped in its pores.
- Ease of application - sorbents may be applied to spills manually or mechanically, using blowers or fans. Many natural organic sorbents that exist as loose materials, such as clay and vermiculite, are dusty, difficult to apply in windy conditions, and potentially hazardous if inhaled.

MAJOR CONTENTS

- MECHANICAL METHODS
  - Containment
  - Recovery
- **CHEMICAL METHODS**
  - **Dispersing agents**
- OTHERS
  - In-Situ burning
  - Sinking
  - Enhanced biodegradation
  - Natural clean-up

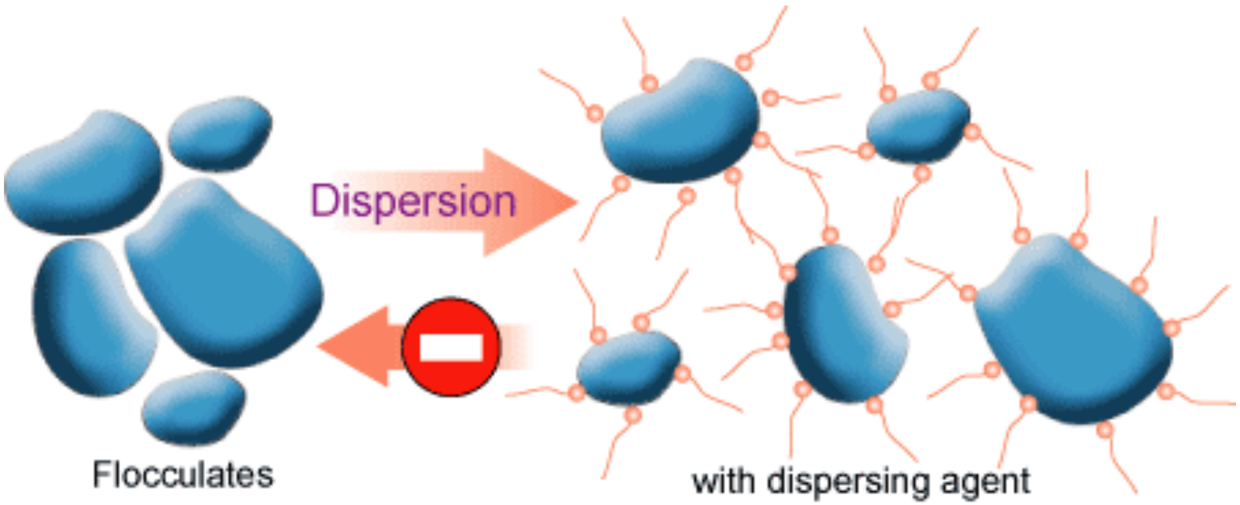


CHEMICAL METHODS

Chemical treatment of oil can be used in place of mechanical methods, especially in areas where untreated oil may reach shorelines and sensitive habitats where a cleanup becomes difficult and environmentally damaging.

Dispersing agents, also called dispersants, are chemicals that contain surfactants, or compounds that act to break liquid substances such as oil into small droplets.

In an oil spill, these droplets disperse into the water column, where they are subjected to natural processes - such as wind, waves, and currents - that help to break them down further. This helps to clear oil from the water surface, making it less likely that the oil slick will reach the shoreline.



Dispersing agents

Environmental factors, including water salinity and temperature, and conditions at sea influence the effectiveness of dispersants.

Studies have shown that many dispersants work best at salinity levels close to that of normal seawater. While dispersants can work in cold water, they work best in warm water.

Helicopters are often used to apply dispersants to large areas

Reasons of using dispersants

An initial reason for using dispesants is to prevent potential damage to the birds, fish, marine mammals, and other natural resources; fouling of shorelines, and contamination of drinking water sources.

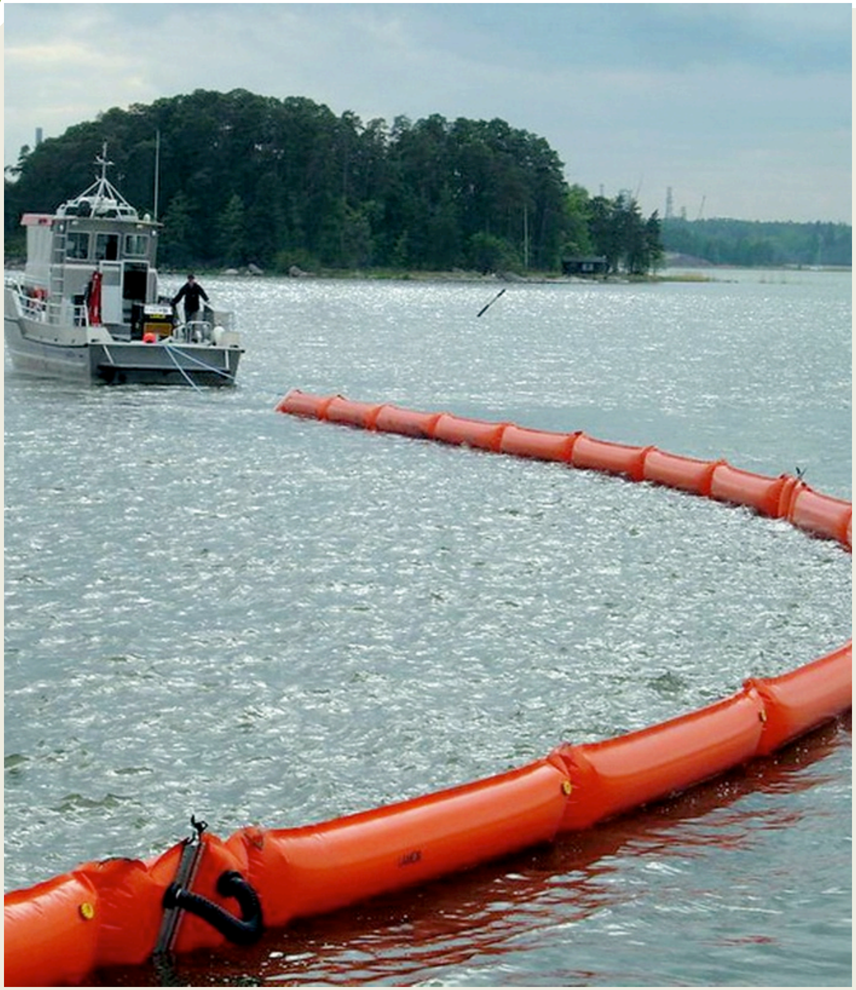
Dipersing an oil spill will make it less visible, and may reduce its economic an ecological impacts provided the water volume, which it disperses into, is great enough. If the oil is dispersed into small volume of water with poor circulation, the ecological impact may in fact be increased (National Research Council, 1989).

Examples:

- An open-sea spill is moving onshore, but waves are too high to permit the use of booms and skimmers, the use of dispersants is the best choice.
- If tidal currents are so strong that oil would be carried under a boom, resurface, and threaten a sensitive area chemical dispersants are used instead.

MAJOR CONTENTS

- MECHANICAL METHODS
  - Containment
  - Recovery
- CHEMICAL METHODS
  - Dispersing agents
- **OTHERS**
  - In-Situ burning
  - Sinking
  - Enhanced biodegradation
  - Natural clean-up



IN-SITU BURNING

In order for oil on water to burn, the slick must be relatively fresh and at least 3 mm thick. Since volatile components in the oil begin to evaporate as soon as the spill occurs, the potential for burning decreases with time. Depending on wind speed and temperature, as much as 50% of an oil slick can evaporate in 24 hours or less. Once this occurs, it may be impossible to ignite the oil remaining on the water surface. In addition, burning at the sea surface is not generally effective due to the rapid transfer of heat to the water (swift et al., 1969). However, where spilled oil cannot flow well, as in the arctic and on ice, there has been effective use of burning as a cleanup technique (national research council, 1989).

Elements affecting the use of burning include water temperature, wind direction and speed, wave amplitude, slick thickness, oil type, and the amount of oil *weathering* and *emulsification* that have occurred.

Oil layer thickness, weathering, and emulsification are usually dependent upon the time period between the actual spill and the start of burn operations. For many spills, there is only a short "window of opportunity" during which in-situ burning is a viable option.

Impact factors

- Burning produces a tarry residue, which could be difficult to clean up. Under optimum burn conditions, about 10% of the oil will remain on the water as burn residue.
- Burning also creates black smoke, which could violate air quality control regulations and present a health hazard for nearby communities.
- Burning produces a variety of toxic chemicals which may adversely affect human health and welfare.
- The combustion products from burning can travel great distances before falling to earth.

Environmental impacts of in-situ burning of spills

SINKING

The addition of chalk or treated sand has been used or proposed as a means of sinking oil. However, sinking is seldom completely effective initially, and some oil tends to resurface. Moreover, oil that sinks to the bottom contaminates benthic life and degrades more slowly than when floating, dispersed, or dissolved in water.

A large number of powdered and granulated materials of high density are available which, if distributed over the oil, will absorb it and sink it. There are difficulties, of course, in applying light powdery materials in open-sea, such as windy conditions. A more serious drawback is that many sinking materials do not render the oil permanently immobile and release of the oil, causing re-pollution after some time, can normally be expected.

ENHANCED BIODEGRADATION

Constituents of oil degrade naturally when attacked by bacteria, algae, protozoa, and marine fungi. Enhancement of biological degradation has been proposed using specially chosen bioengineered microbes. However, microbes that degrade hydrocarbons are readily available everywhere in nature, except in polar waters where the rates of breakdown are very slow and variable. It does not appear necessary in most cases to enhance their action.

NATURAL CLEANUP

If oil strands on a shoreline, attempts are usually made to remove it using mechanical means, by flushing, by manual pickup, or by physically removing the substrate. In most cases, shoreline cleanup is expensive and may be environmentally damaging. However, the only method for cleaning and restoring public beaches and accessible shorelines near fisheries and industrial areas is removal of oil. Natural removal is another method for dealing with spilled oil. Oil left alone is eventually removed from water surfaces and shorelines by different natural means, including evaporation, photooxidation, physical dispersion, sedimentation, and biological degradation. These processes may take several years, but are considered acceptable for remote areas.

THANK YOU FOR YOUR ATTENTION !

Any questions?