Understanding Black Tides

Cedre

Learning guide

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I experienced my first oil spill in March 1978, with the *Amoco Cadiz* in Portsall, Brittany (France). I met with the stench and the horror of black waves that we unsuccessfully attempted to stop using a pathetic boom. I truly believed the marine and shoreline populations to be destroyed forever. I cursed those who had done that. But things quickly changed. In the Easter holidays I scowled as I heard visitors from the big cities exclaiming that the sea was no longer all black like they had seen on TV. When the summer arrived, I enjoyed the clean beaches at Portsall, along with many others. Then I followed in awe the gradual restoration of the populations. But I gritted my teeth at the lenient words of Amoco's lawyers, minimising the spill.

The response to oil spills and other forms of accidental water pollution is the occupation of the men and women of *Cedre*. We all entered into this field via a personal experience which taught us to be wary of taking things at face value. We have all come to realise through first hand experience that it is a highly controversial, and even passionate, issue. As specialists, we have the responsibility to take all the points of view and facts into account, in the most objective and rigorous manner.

It is with this in mind that we designed this learning guide, produced with financial support from Total but written entirely and independently by ourselves. It goes hand-in-hand with a website dedicated to the same issue. For more information, log on to www.black-tides.com, www.cedre.fr or www.planete-energies.com.

Michel Girin
Directeur of *Cedre*

The words and expressions marked by • in the text are defined in the glossary. Those marked by * are referenced in the bibliography.

Oil

Why is so much oil transported by sea?

- What is oil?
- Transporting oil
- Oil in our everyday lives

WHAT IS OIL?

The origins of oil

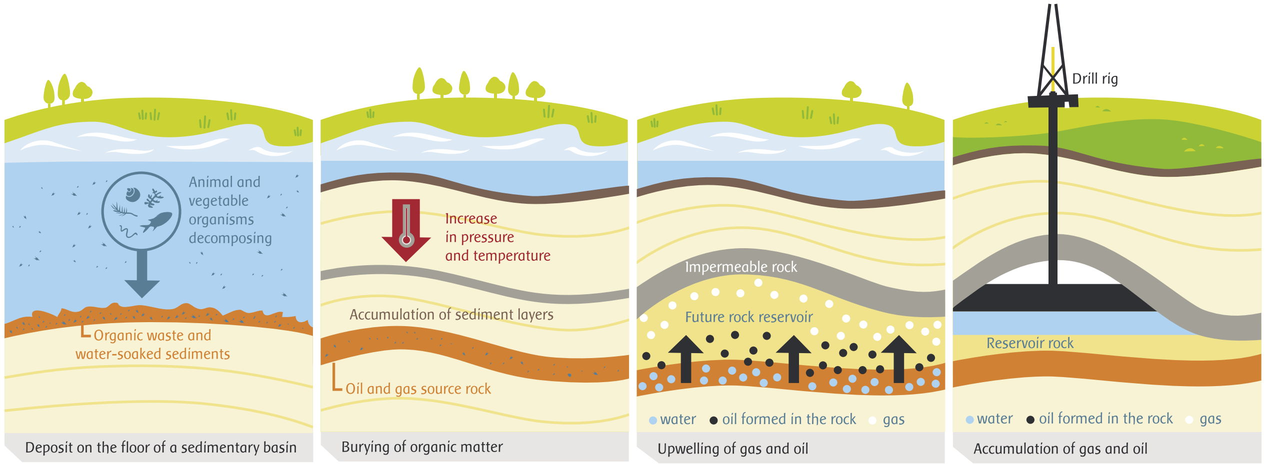
Crude oil• is a result of the transformation of organic (animal and vegetal) debris from marine populations, under great pressure and in the absence of oxygen. This waste, mixed with sediments and gradually buried by new layers which are deposited, undergoes molecular changes under the combined effect of an increase in temperature and pressure. It thus becomes a liquid or a paste made up essentially of hydrocarbons•, molecules made of hydrogen and carbon assembled in chains which vary in their degree of complexity. As well as hydrocarbons, variable proportions of sulphur, nitrogen, oxygen and traces of various metals are present.

Over time, from the moment it is formed, oil begins to migrate towards the surface of the earth. On its way, it meets porous rocks, known as reservoir rocks, where it accumulates and forms oil reservoirs.

Every crude oil is a unique blend of thousands of hydrocarbons. Crude oils vary not only from one reservoir to another, but also within the same reservoir. Hydrocarbons are mainly liquids which are lighter than water at atmospheric pressures and temperatures typical for human life. ■

The word petroleum• comes from the latin *petra* (rock) and *oleum* (oil) meaning 'rock of oil'.

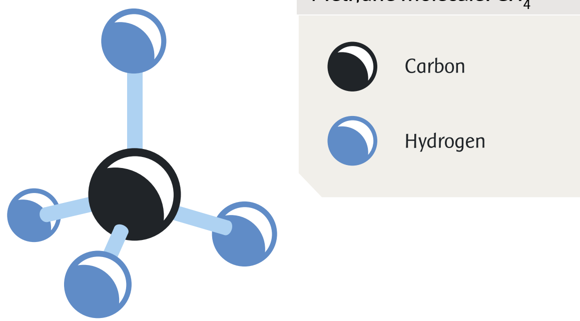
Origins of oil



More information

To find out more about the oil and gas chain, log on to www.planete-energies.com.

The simplest hydrocarbon•
Methane molecule: CH_4



TRANSPORTING OIL

Quantities and modes of transport

Practically all crude oil• and vast quantities of refined products• are transported over long distances. All transportation, whether by sea or by land, involves the risk of accidents.

Transportation of oil via pipelines•, from the exploitation area to the consumption destination, is certainly safer than transportation by vessel, train or truck. However it is not exempt from all risks. There have been many cases of leaks due to negligence, carelessness or even malicious attacks. Moreover, pipelines cannot fulfil all demands since it is not always possible to build them due to physical or political constraints.

For these reasons, half of the oil consumed worldwide is transported by sea. For this purpose, recent Equasis statistics attest to some 9,130 oil tankers worldwide, representing 15% of the world fleet in terms of number and 30% in terms of tonnage.

In 2003, 1,700 million tonnes of crude oil and nearly 500 million tonnes of refined products (e.g. petrol, kerosene, fuel oil, bitumen) were transported by sea. With an average capacity of 100,000 tonnes of oil per tanker, this equates to around 22,000 journeys made by oil tankers between oil producing countries and oil consuming countries, over considerable distances. The average voyage for an oil tanker lasts two weeks and includes at least one passage in a high risk zone.

In addition, coastal tankers, barges and canal boats cover a multitude of coastal and river routes, with several hundreds or thousands of cubic metres of refined products onboard. Finally, many oil-based chemicals (e.g. benzene) are transported by sea and river in special chemical tankers, containers and barges.

→ Of the 3.5 billion tonnes produced annually worldwide, about half is exported by from the Middle East, Africa and Latin America to North America, Europe and South East Asia.

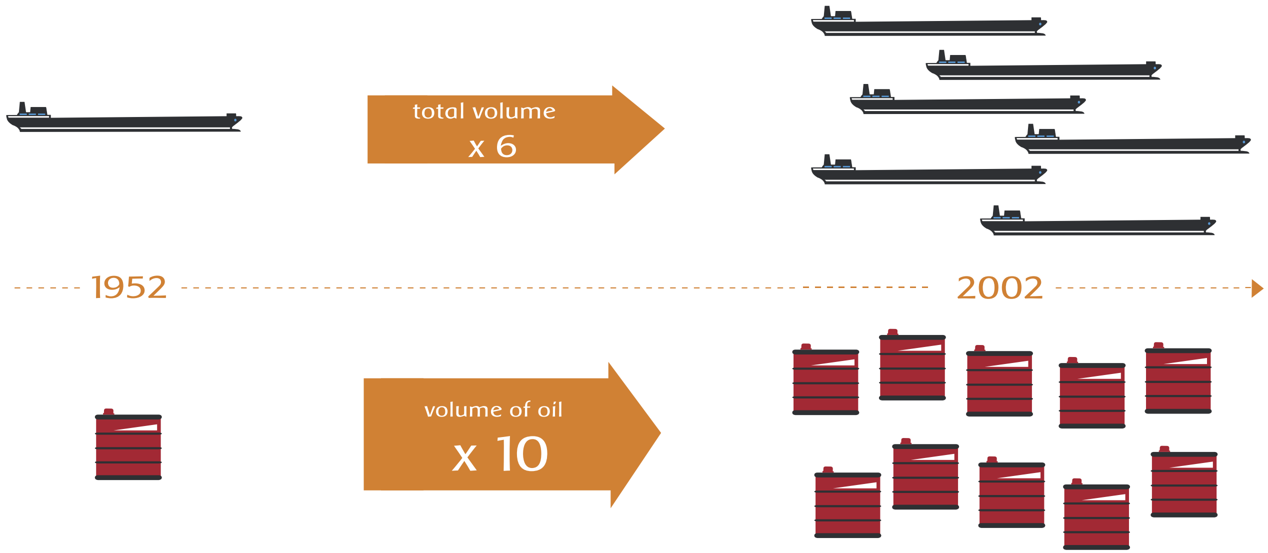
Production and consumption

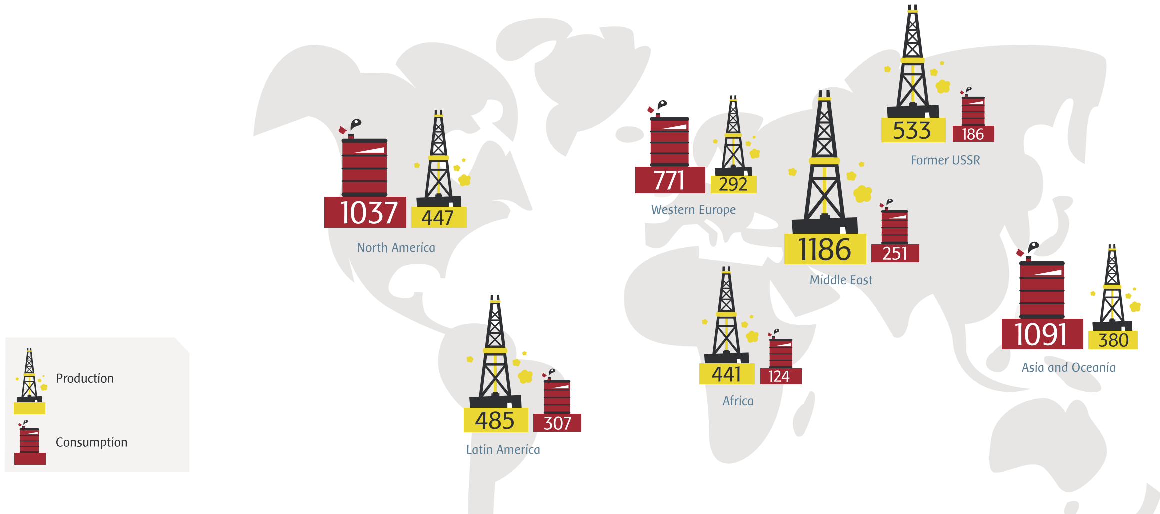
Worldwide consumption of crude oil has been continuously increasing since the end of the 1970s. Consumption has now reached some 3.5 billion tonnes per year and represents 40% of world energy consumption. This level of consumption is accounted for by the energy needs of industrialised countries and vastly surpasses their own resources. The oil industry can be broken down into two distinct parts, which have arisen owing to geographic, economic and technical factors:

- exploration and production, located in regions of the world where oil reservoirs can be found
- refinery and distribution, closely linked to the geographical location of the consumption zones.

Evolution of the tonnage of oil transported worldwide

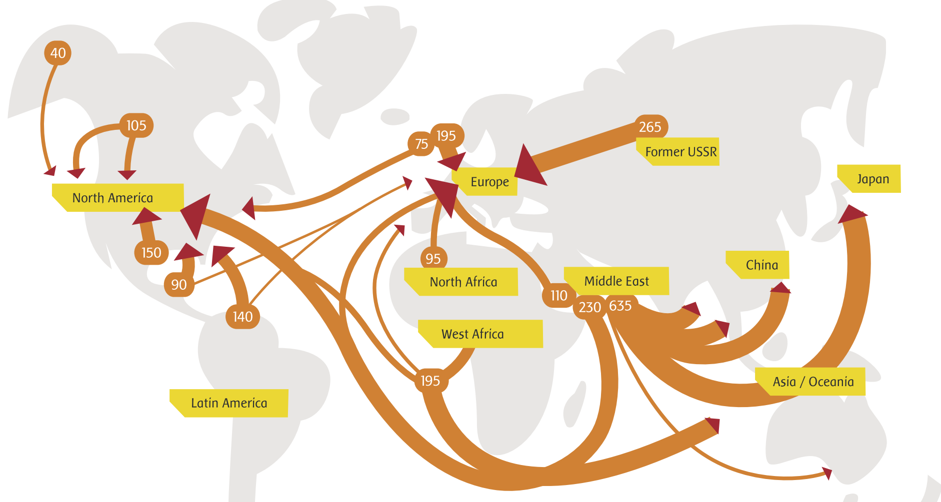
Sources: designed based on BAUQUIS P.-R., BAUQUIS E. *Comprendre l'avenir : pétrole et gaz naturel** and from Catastrophes maritimes. *Sciences Ouest*, 2002. n°185, p.20





Source: designed based on COMITÉ PROFESSIONNEL DU PÉTROLE *Pétrole 2004 : éléments statistiques**

Worldwide oil production and consumption in 2004 (millions of tonnes)



Source: designed based on COMITÉ PROFESSIONNEL DU PÉTROLE *Pétrole 2004 : éléments statistiques**

Main worldwide oil transportation routes in 2004 (millions of tonnes)

High risk zones

High risk zones tend to be areas such as straits and capes where several vessel routes meet.

Examples of danger zones are the Pas-de-Calais (between France and Great Britain), the Strait of Gibraltar (Spain), the Strait of Malacca (between Malasia and Indonesia) and the Bosphorus (Turkey). The increase in exportation of Russian oil across the Baltic Sea has created heavy traffic in this area, thus causing risks.

In France, every day more than 300 vessels sail by the furthest point of Brittany in one direction or another, transporting more than 600,000 tonnes of dangerous goods (petroleum products, chemicals, radioactive or explosive substances). This area is one of the most dangerous in the world. It holds the tragic world record of the greatest tonnage of hydrocarbons spilled in accidents involving vessels.

High concentrations of vessels produce an increased risk of oil spills, which could be due to defects in a vessel's structure, collision, or grounding.

However, the risk would neither be eliminated nor even significantly reduced if refining were to be carried out entirely in the countries where oil is produced. If consumption patterns remain as they are today, many more refined products will have to be transported over long distances, including some which require delicate handling and may be more dangerous for the environment than crude oil.

Transportation of refined products

A considerable volume of refined products• is already transported each year. The routes taken vary according to fluctuations in supply and demand, with the main volumes being transported from one industrialised country to another. The nature of the products also varies, from the lightest highly volatile• petrols• (gasolines•) to heavy fuel oils• which have less of a propensity to evaporate, characterised at less than 10%.

Heavy fuel oils for thermal power stations are in great demand by countries, such as Italy, which choose not to use nuclear power to generate electricity, and are dreaded pollutants. The worst oil spill• Japan has ever seen was caused by the wrecking of a Russian oil tanker•, the *Nakhodka*, on 2 January 1997. The vessel was transporting a cargo of heavy fuel oil from Shanghai (China) to Vladivostok (Russia). The oil spills caused by the *Erika* (France, 1999) and the *Prestige* (Spain, 2001) also involved heavy fuel oil.

Overturned bow of the *Nakhodka*

Risk management

The variety of potential risks affecting oil tanker• routes vary in nature and by virtue of the geographical location. The main crude oil• transportation routes are statistically the areas where a major accident is most likely to happen. However even minor transportation routes can become the site of a disaster.

Risks should therefore be assessed according to a number of factors and the best possible precautionary measures should be put in place throughout the production lifecycle, from the extraction of crude oil to the distribution of refined products•. It is crucial to be well organised in order to avoid all spills caused by negligence and to effectively combat accidents.

Routes of the *Prestige* and the *Erika*

OIL IN OUR EVERYDAY LIVES

Products of oil refinery

Refining involves separating hydrocarbons• into groups of products with similar boiling points (known as oil fractions•). Petrols• evaporate at ambient temperatures. Lubricating oils only evaporate at over 400°C. The different oil cuts• separated by this process are cleared of the impurities present in crude oil•.

Compounds which are useful for the chemical industry, in particular solvents and plastics, are also separated out. The overall consumption of petroleum• products and their different usages: transport, heating, electricity generation, household products, varies considerably from one country to another.

A refinery• by night (Provence, France)

Consumption

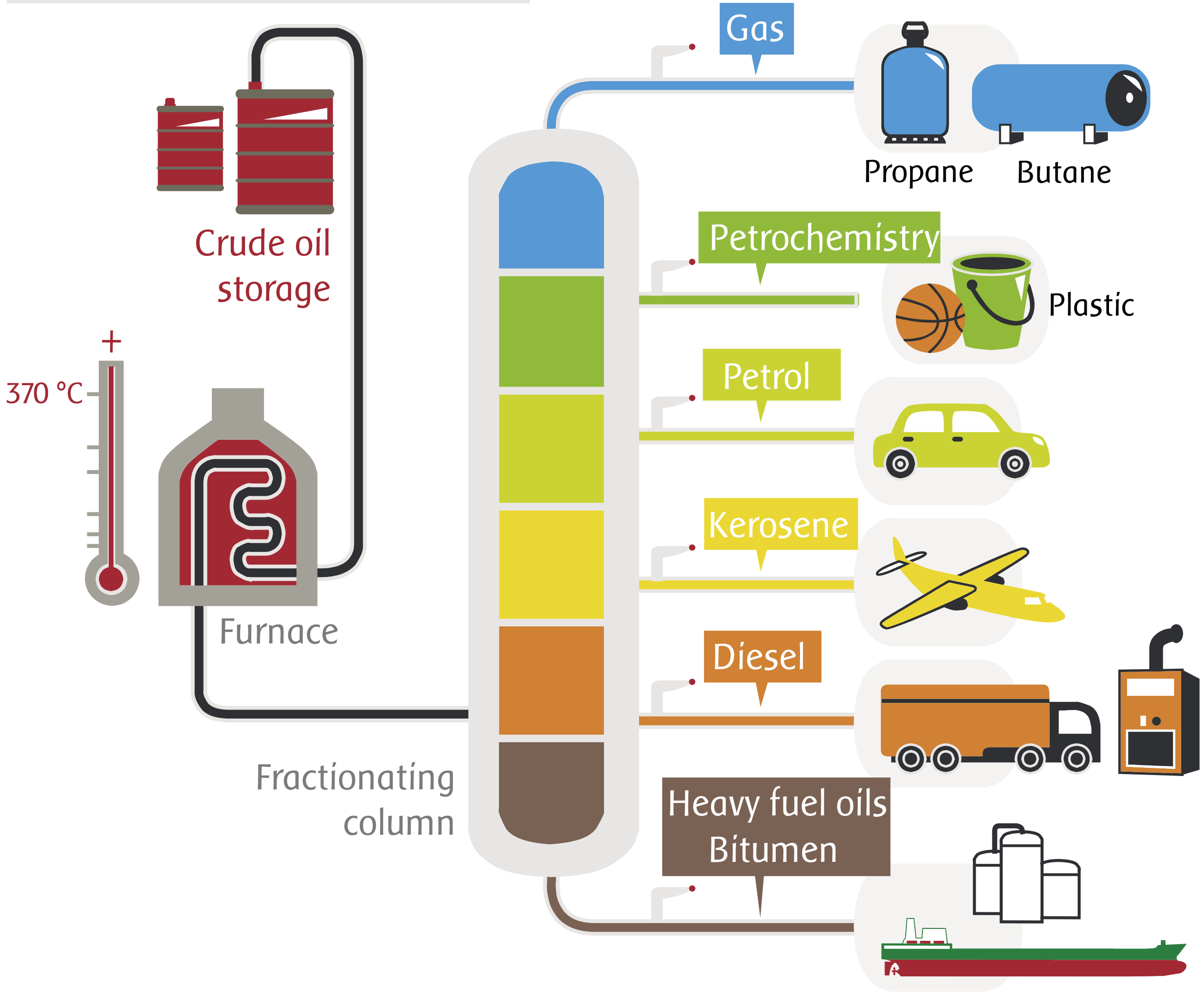
Petroleum• products are used for many different purposes. They are used as fuel for transport, in the home for heating, cooking and other daily requirements, in industry, in the public works sector, in the petrochemical industry, in agriculture... More than half the oil consumed in the world is used for transport. Furthermore, the worldwide consumption in this sector is continually rising, increasing from 42% of the share of world oil consumption in 1973 to nearly 58% in 2004.

The use of oil for generating electricity has fallen considerably in recent years. According to Key World Energy Statistics 2006 Edition, in 1973, oil represented nearly 25% of the fuel used to generate electricity. By 2004 this figure had dropped to under 7%. Today, petroleum products are only one source of energy amongst many others. In 1973, oil represented some 45% of the total primary energy supply, in comparison to 34% in 2004. Meanwhile, other more "noble" uses of oil are developing.

Noble usage

Rather than simply being burnt, oil is now increasingly used for other purposes through petrochemistry•. With the use of natural gas, it allows the production of plastics, fibres, rubbers, synthetic detergents, fertilisers, solvents, pesticides, medicines and many other products with an incommensurable added value over combustion.

Products obtained from crude oil• refinery•



These products are used in a wide range of contexts, from daily life (plastic containers, furniture, coatings), to advanced technology (computer parts, materials for aerospace industry), public works (permeable felt, watertight films), human and animal health (syringes), transport (tyres, paint) and many other sectors.

Certain products such as anti-adherents or dispersants can even assist in oil or chemical spill response. Others, however, like pesticides can themselves be sources of water pollution in the event of inappropriate usage. Plastic bags and bottles can also become pollutants if they are dumped in the environment or accidentally dropped into a river or the sea.

What not to do: plastic objects dumped in the environment

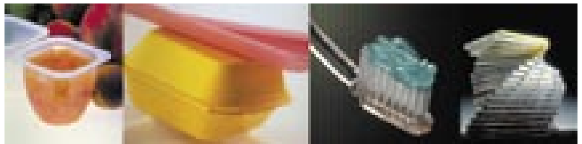
Good usage and recycling

The transportation of crude or refined oils by sea is recognised as a source of pollution. However each one of us can cause pollution by petroleum products through failure to recycle man-made products properly, or at all. Plastic bottles and bags, popular due to their convenience, have thus become a real problem over the last few decades as they are often carelessly thrown away in the natural environment.

Manufacturers contribute to the proper usage of noble products formed by petrochemistry, through recommendations to users. They also contribute to packaging recycling costs in a growing number of regions of the world through a sales-based contribution.

When plastic, a product derived from oil, is recycled it can be made into non-food packaging, watches, tubes, winter clothing...

It takes 10 water bottles to make a fleece jumper.



Petroleum products with high added value

Sorting for recycling

In many areas voluntary contribution collection points have been established. They are designed to take different types of waste (glass, paper, cardboard, newspapers etc.). All items must be correctly separated to be accepted, in order to facilitate their recycling.

Pollution

Where does oil on the beach come from?

- Water pollution
- Black tides
- Natural discharge

WATER POLLUTION

Definitions

Definitions of water pollution are mainly based on spills caused by human activity. They exclude natural seepage of hydrocarbons•, eruptions on the seabed close to the coast, mudflow on the continental slope and inflow of sediment by flooding rivers. Natural phenomena are not part of the definition of the word pollution as it is used here.

More information

Water pollution: Industrial and institutional wastes and other harmful or objectionable material in sufficient quantities to result in a measurable degradation of the water quality.

(Source: Environment Canada's on-line glossary, www.ec.gc.ca/water/en/info/gloss/e_gloss.htm. Reproduced with the permission of the Minister of Public Works and Government Services, 2006.)

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

(Source: United Nations Convention on the Law of the Sea)

The world's oceans are subject to many incidences of direct pollution, caused by human activity taking place on its surface, in its waters and on its shores. These activities, such as maritime transport, fishing, aquaculture, tourism, exploitation of sand and gravel, underwater drilling, coastal industries, national defence activities, bring varying quantities of mineral, organic, chemical and radioactive discharge, in the form of solids, liquids or gases.

However, in many coastal areas, the impact of these direct discharges at sea is minimal in comparison to pollution from the water system and atmospheric movements. Air pollution from industrial, automotive and urban sources and discharge into rivers from household, industrial and agricultural sources, for the most part end up in the sea.

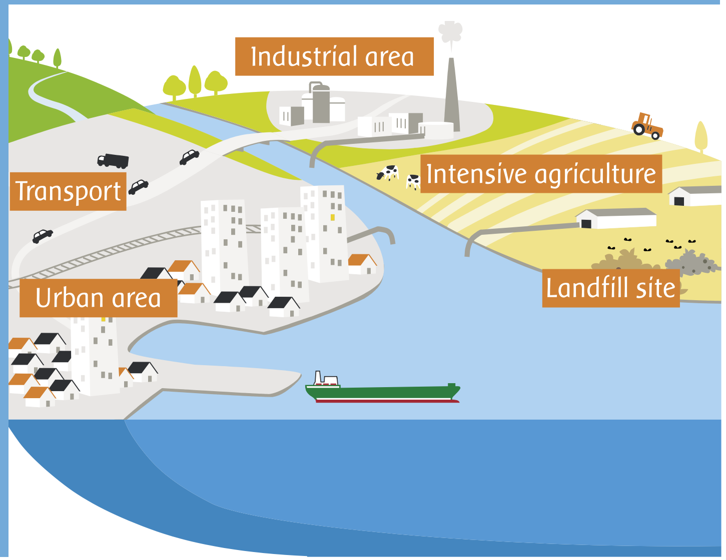
Problems

The vast majority of releases of hydrocarbons• into the marine environment can be described as chronic pollution•: permanent or semi-permanent discharges from either authorised or illicit sources. Authorised discharges are subject to certain standards designed to limit their impact on the environment in identified areas, and are restricted to certain levels considered acceptable by national authorities or international commissions. Illicit discharge can take on a number of forms: exceeding the levels specified by the regulating authorities, non conformity to product specifications, discharge in an unauthorised area...

There is not always an adequate capability and/or will to monitor or sanction the breaching of regula-

Pollution en route to the sea

All forms of human activity are the source of specific types of pollution. Urban areas produce solid and liquid waste, part of which enters the water system. Industrial facilities deliberately or accidentally release chemicals into the drainage network. Land washing by rainfall sweeps fertilisers and pesticides from agricultural fields into the water system. Transport accidents occasionally pollute rivers and streams. All these forms of pollution are carried by the water system into estuaries and finally into the sea.



Industrial discharge into a river

tory standards on discharges into the marine environment. Today the prevention of illicit discharge is more a privilege of rich countries than a worldwide reality. Many poorer countries have more urgent preoccupations than the monitoring and prevention of illegal discharges, starting from catering for the basic nutritional needs and physical safety of their people.

In addition to chronic pollution, accidental pollution also occurs: minor or major spills of oil, chemicals, organic matter or other substances. Accidents can be caused by negligence, design flaws, poor maintenance or human or mechanical errors and can be exacerbated by extreme weather conditions, high winds and strong currents.

Oil spills tend to be one of the first examples of marine pollution that comes to mind owing to high media interest and immediate visible, dramatic effects. Preventing and fighting against oil spills should not be isolated actions following in the wake of a major spill but rather should form part of an ongoing, long-term strategy of continuous improvement in prevention of, preparedness for and response to marine pollution of all types to promote cleaner oceans for ourselves and for future generations.

This fight against pollution is no easy task. Banning all maritime transportation of crude oil is not a realistic option, nor would it eliminate oil spills.

Effectively combating all forms of pollution depends first and foremost on understanding how pollutants are released into the environment and how they behave in that environment. The battle must be fought on many fronts to reduce the risk of spills. However, reduction will never equate to its complete eradication. When prevention fails there is no one unique response solution, but a multitude of possible response options amongst which the most suitable combination must be found.

Arrival of pollutant on the coastline

Sheen in a stream polluted by hydrocarbons

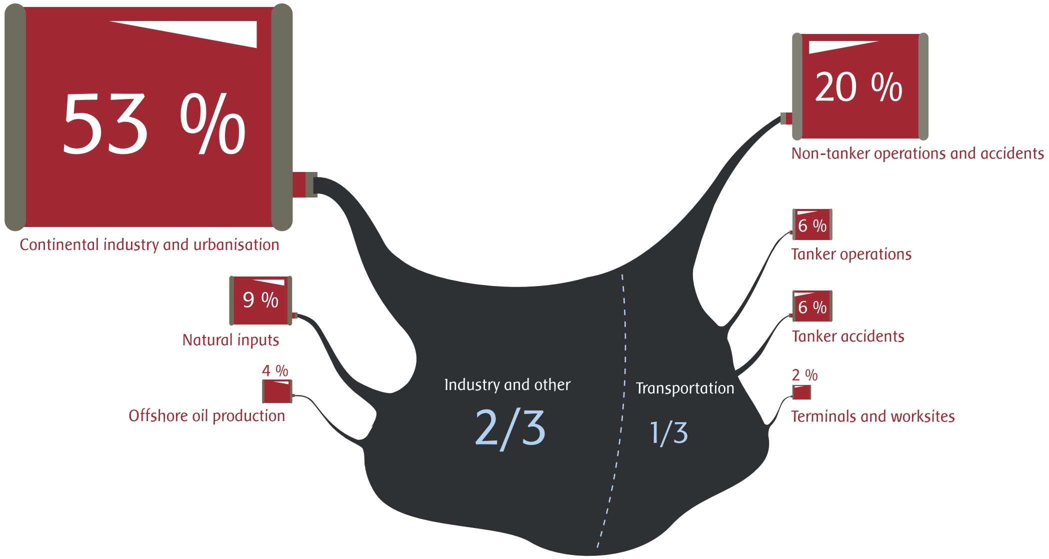
BLACK TIDES

Oil spills

To develop suitable prevention and response strategies, it is essential to identify the sources of oil discharge into the marine environment, as well as their contribution to the phenomenon of "black tides"•. This is no easy task. Although accidents involving oil spills• may be well documented, the same cannot be said for the rest. For example, incidences of operational discharge• can only be assessed approximately. In the same way, the reliability of data on industrial and urban discharge is highly variable from one country to another. The extent of discharge from natural sources can only be estimated in a very general fashion. It is therefore not surprising to see considerable variation in the quantities quoted from one document to another.

Sources of hydrocarbons• in the marine environment in 2000

Source: data from CLARK. *Marine pollution**



The diagram below presents the data used as a reference in the work of the International Maritime Organization. Only direct discharges into the water have been included here, excluding the share of atmospheric emissions that rain and streams transfer into the water. The method used to estimate such sources varies from one documentary source to another, generating estimations that are not always consistent.

Disasters and tar balls

Nearly all oil transported by sea arrives safely at its destination. However, sometimes a technical or human failure, often in extreme weather conditions, can cause a vessel to lose all or part of its cargo at sea, which can lead to the tide coming in black.

If a teacher asked a class to explain what the term "oil spill"• meant, the first image that would be brought to mind is no doubt that of a big oil tanker• ripped open, spilling hundreds of thousands of tonnes of oil on the nearby shores. Two recent cases are likely to be mentioned by European pupils: the dramas of the *Erika* and the *Prestige*. American pupils are liable to refer to the *Exxon Valdez* accident in Alaska. Japanese pupils will use the example of the *Nakhodka*. In each region of the world, one or two incidents will be referred to that marked collective memory. Other accidents, less serious although they were the news of the moment, may also be mentioned, such as the grounding• of the coastal tanker the *Jessica* in the Galapagos Islands. Whatever the accident, the pupils will tend to concentrate on the images shown on television and in the press of black waves which taint the rocks and the beaches, of exhausted, oiled birds or seals waiting to

Arrival of a large oil spill

die, of men in stained oilskins wading in unending expanses covered in a thick, sticky substance.

The guilty parties identified at a first glance are obvious: giant oil tankers, glibly referred to as "ships of shame". They are accused of sailing too close to the coast to arrive a few hours early at their destination, as instructed by anonymous, profit-greedy, shipowners• unmindful of the environment and hidden behind a flag of convenience•.

Oil spill•: definitions

The accidental release of oil, or other petroleum• products usually into freshwater or marine ecosystems, and usually in large quantities. It can be controlled by chemical dispersion, combustion, mechanical containment•, and absorption. (Source: EEA multilingual environmental glossary, http://glossary.eea.europa.eu/EEAGlossary, October 2006)

A form of pollution in which oil from various sources leaks into the water. (Source: US Environmental Protection Agency)

Black tide•: definitions

Large-scale oil pollution at sea (Source: American Dialect Society)

A major oil slick which threatens to reach and pollute the shore (Source: ZILBERBERG. *Elsevier's Dictionary of Marine Pollution*)

It is only after this first wave of shocking images that it is possible to try and tease out other ideas, by asking questions such as: you have mentioned oil tankers, but can a black tide• be caused by a spill on land? By an explosion on an oil rig? By the wrecking of a trawler or a cargo ship? By a terrorist or otherwise malicious act? By an act of war? Where do the tar balls•, patties• or patches that can often be found on certain beaches or rocky coasts come from? Are these types of oil spills?

These questions inevitably provoke conflicting replies and different stances. One pupil might mention a major oil spill caused by an explosion on an oil rig in the Gulf of Mexico. Another might refer to the oil spill caused by the sabotage of Kuwaiti oil wells• during the Gulf War. Yet another might speak of oil tankers sunk by missiles during the Iran-Iraq War. The notion of voluntary discharge may be brought up, in relation to the presence of oily marks on beaches.

In fact, it is of little importance what examples the pupils draw upon, as long as they allow them to overcome the single vision of an oil spill as a disaster caused by an oil tanker. Oil spills can be large or small. They can result from accidental shipwrecking due to collision, grounding or explosion; from chronic pollution•; from malicious or foolish acts; from technical failure or from natural disasters. They can occur in open seas, on the shore or come from inland via rivers. Oil spills are part of the vast and multifaceted issue that is water pollution, which concerns us all and brings to the fore our collective responsibility towards future generations.

Eye witness: The black tide inches to shore. And Spain holds its breath.

"White waves are crashing on to golden sands along Spain's beautiful 'coast of death'. Bright fishing boats throng the harbour and seabirds go about their business without a care in the world. At first sight, and from a distance, there seems nothing wrong with the long chain of coves and beaches that stretch along the Galician coast from La Coruna to this beautiful mountain-surrounded harbour on the very edge of Europe, despite the much-publicised oil pollution of the last week.

It is when you get closer that you notice the difference. The first thing to hit you is the smell [...]

Down the shore the rocks are clearly blacker than even the darkest should be. Close up, it seems that they have been painted a glistening uniform black and it is from that the smell is coming. The high tide marks of the beaches are also daubed with oil. The boats are in harbour because they are not allowed to fish."

Discharging oil at sea is not totally prohibited

The International Maritime Organization has set the authorised concentration of oil in discharge from tankers and non tankers in the open sea at 15 parts per million (ppm).

In sensitive maritime zones (known as "special" zones), discharge from oil tankers is prohibited. Discharge of propulsion fuel and lubricating oil is authorised for non-tankers within the 15 pm limit. All discharge is banned in the Antarctic special zone.

National regulation can set the thresholds for discharge of hydrocarbons in the water by classified industrial plants, within limits determined according to the natural assimilation capacity of the surrounding environment. These regulations vary from one country to another.

Symbolic images of the *Amoco Cadiz* oil spill (Brittany, France)

Unforgettable oil spills

The term "oil spill" does not simply mean the presence of hydrocarbons in the marine environment. It refers to a violent spillage concentrated in a specific area, surpassing the natural assimilation capacities of the surrounding environment. Like other phenomena, oil spills have their world records. Accidents involving oil tankers rank top in number, but not in quantity, where they come after acts of war and eruptions on offshore wells.

It is not however necessary for a spill to be record-breaking in terms of volume to mark history. For instance, the *Exxon Valdez* oil spill in Alaska, which attracted considerable media coverage, is today by far the most expensive spill in history, with some 2.5 billion Dollars spent on clean-up and compensation of victims, plus a fine of 4 billion Dollars which the Exxon group appealed. However this oil spill "only" involved 40,000 tonnes of crude oil. More recently, with a 20,000 tonne spill of heavy fuel oil, the *Erika* disaster provoked reactions from the general public similar to those caused 21 years earlier by the 227,000 tonnes of crude oil spilled by the *Amoco Cadiz*. Three years later, the 64,000 tonnes of heavy fuel oil spilled by the Prestige off the coast of Galicia hit some of the areas previously affected by the *Erika* and brought post-*Erika* emotions back to life.

What causes an oil spill to mark history is a combination of its size, the specific geographical location and the political context in which the response unfolds.

The 20 unforgettable oil spills* (estimations)

Sources: produced using data from *Cedre*, Cutter Information Corp., and the Institut Français du Pétrole

1	~800,000 t	26 January 1991	Kuwaït	Gulf War
2	~500,000 t	3 June 1979	Gulf of Mexico	Offshore well IXTOC 1
3	299,000 t	2 March 1992	Uzbekistan	Fergana well
4	276,000 t	19 July 1979	Tobago, Caribbean	Oil tanker *Atlantic Express*
5	260,000 t	28 May 1991	Angola	Oil tanker *ABT Summer*
6	250,000 t	4 February 1983	Iran	Nowruz offshore wells
7	250,000 t	5 August 1983	South Africa	Oil tanker *Castillo de Belver*
8	227,000 t	16 March 1978	Brittany, France	Oil tanker *Amoco Cadiz*
9	144,000 t	11 April 1991	Genoa, Itlay	Oil tanker *Haven*
10	121,000 t	18 March 1967	Wales, Great Britain	Oil tanker *Torrey Canyon*
11	115,000 t	19 December 1972	Gulf of Oman	Oil tanker *Sea Star*
12	103,000 t	23 February 1980	Greece	Oil tanker *Irenes Serenade*
13	101,000 t	13 May 1976	Galicia, Spain	Oil tanker *Urquiola*
14	84,500 t	5 January 1993	Shetland Islands, Great Britain	Oil tanker *Braer*
15	73,000 t	15 February 1996	Wales, Great Britain	Oil tanker *Sea Empress*
16	67,000 t	3 December 1992	Galicia, Spain	Oil tanker *Aegean Sea*
17	64,000 t	13 November 2002	Galicia, Spain	Oil tanker *Prestige*
18	40,000 t	24 March 1989	Alaska, USA	Oil tanker *Exxon Valdez*
19	27,000 t	27 July 2003	Pakistan	Oil tanker *Tasman Spirit*
20	20,000 t	12 December 1999	Bay of Biscay, France	Oil tanker *Erika*

Landmark spills

Torrey Canyon

On 18 March 1967, the Liberian oil tanker• the *Torrey Canyon*, operated by a subsidiary of the Union Oil Company of California, loaded with 119,000 tonnes of crude oil•, grounded between the Isles of Scilly and the British coast. Despite the mobilisation of all the available response means, several oil slicks drifted in the Channel and hit the British then the French coastline over a period of weeks. Royal Air Force bombers were sent to set fire to the vessel. At sea, dispersants• were used, which turned out to be more toxic than the oil spilled.

This accident brought to light a risk that had previously been neglected in Europe. It triggered the creation of the first elements of French, British and European oil spill• prevention and response policies and the conception of the international convention on the compensation of oil spill victims.

Amoco Cadiz

On 16 March 1978, the Liberian oil tanker the *Amoco Cadiz*, transporting 227,000 tonnes of crude oil, suffered damage to her steering mechanism, and despite two unsuccessful towing attempts, grounded on Portsall Rocks, on the coast of north Finistère (Brittany, France). The entire cargo spilled out gradually as the vessel broke up on the reef, progressively polluting 360 km of shoreline from Brest to Saint Brieuc. This was the largest oil spill caused by the grounding• of a tanker ever recorded in the world. This accident caused the French Government to revise its oil spill response plan (the Polmar Plan), to reinforce its equipment stockpiles• (Polmar stockpiles) and to impose traffic lanes in the Channel.

The *Amoco Cadiz* broken in two off the coast of Portsall (Brittany, France)

The French state and the local communities affected embarked upon a long and difficult lawsuit against the company Amoco in the United States. After 14 years of proceedings, they eventually obtained 192 million Euros of compensation, less than half of the claimed amount.

Exxon Valdez

On 24 March 1989, the oil tanker the *Exxon Valdez* grounded in Prince William Sound (Alaska, USA) with 180,000 tonnes of crude oil onboard. Nearly 40,000 tonnes flooded into the sea, affecting 1,700 km of coastline. The accident was a major psychological shock for the USA and the Exxon group, who had not imagined such a disaster possible. Tens of thousands of volunteers and unprecedented means were mobilised to save birds and mammals and to clean up the shoreline, beach by beach.

Legal action was taken by the American administration, associations and individuals against Exxon, which turned to its insurers.

With judgements on appeal, the case is still not closed at the time of writing. However, with nearly 2.5 billion Dollars paid so far and a fine which could ultimately reach 4 billion Dollars, it is by far the most expensive oil spill in history.

Pressure washing rocks at Prince William Sound (Alaska, USA)

Recent spills in Europe

Europe holds the record for the largest number of major spills over the last two decades.

Haven

On 11 April 1991, the Cypriot oil tanker• the *Haven*, anchored off the coast of Genoa (Italy), was loaded with 144,000 tonnes of crude oil• when she caught fire, exploded and broke in three. One of the parts sank on the spot, the others sank during towing. Despite considerable response operations at sea, oil slicks drifted westwards, thus hitting various parts of the Ligurian coast and finally reaching the French Riviera impacting as far as Hyères.

The *Haven* incident raised a number of fundamental questions on ecological damage and the restoration of the affected seabed, within the framework of a national law on the compensation of environmental damages.

The *Haven* on fire (Italy)

Sea Empress

On 15 February 1996, the Liberian oil tanker the *Sea Empress*, loaded with 130,000 tonnes of crude oil, grounded on rocks at the entrance to Milford Haven port (Wales, Great Britain). The vessel could only be freed five days later, after having lost more than half of her cargo. Despite the application of dispersant• and the mobilisation of six sea response vessels, the pollution affected more than 100 kilometres of coastline. Fishing was banned for several months in the surrounding area. Following this incident, the question of compensation raised major issues relating to indirect economic damages.

Erika

On 12 December 1999, the Maltese tanker the *Erika* was caught in a storm and broke in two off the coast of Brittany (France), with 31,000 tonnes of heavy fuel oil• onboard. Nearly 20,000 tonnes polluted over 400 km of French coastline, with significant consequences for the fishing and tourist industries. The fuel which remained imprisoned within the wreck was pumped out in the summer of 2000. Thousands of compensation claims were lodged by individuals, companies, local communities and the French State.

Wrecking of the *Erika* (Brittany, France)

The accident brought to light the limitations of the French pollution response• organisation when confronted with such extensive pollution and insufficient international compensation funds. This led to the limits of existing international compensation arrangements being substantially increased, and to the establishment of a supplementary fund (third tier fund).

Prestige

On 13 November 2002, the Bahamian oil tanker the *Prestige*, en route for Singapore carrying 77,000 tonnes of heavy fuel oil, requested assistance due to damage to her hull, off the coast of Cape Finisterre (Galicia, Spain). The crew was air-lifted to safety and the vessel was taken in tow. After 6 days of towing in search of a port of refuge•, the vessel broke in two and sank in 3,500 m deep waters. Over 60,000 tonnes of fuel drifted at sea. Unprecedented response operations suceeded in recovering a third of this fuel at sea.

During the following weeks, the remaining fuel polluted more than 1,000 km of Spanish and later French coastline, triggering the largest response operation ever seen in Europe. Despite efforts to seal the wreck, the seeping continued, forcing the Spanish authorities in the summer of 2004 to organise and carry out a pumping operation on the wreck, 3,500 m below the water surface, a technological first.

Impact of oil spills

Oil spills impact on the surrounding environment, natural populations and economic activities. The quantity of pollutant spilled largely determines these impacts. However the nature of the pollutant, the location and the context also play a major role.

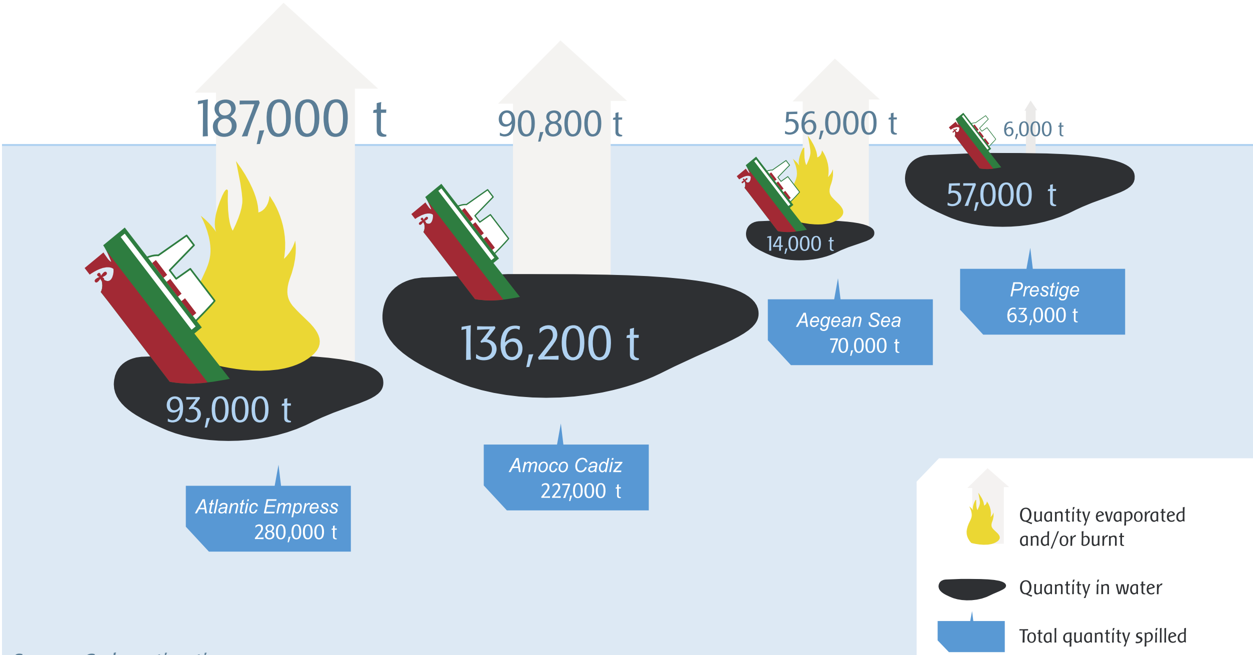
The lighter the product, the more easily it evaporates in the atmosphere, thus reducing the quantity of pollutant remaining in the marine environment. Certain crude oils, such as North Sea oil, are so volatile that the volume spilled can reduce by more than 40% through evaporation alone. At the opposite end of the spectrum, the heavy fuel oils from the *Erika* and the *Prestige* did not reduce in volume by even 10% through evaporation.

In the event of a fire, the quantity of spilled oil that will affect the environment can be considerably reduced. However, fire can cause other dangers and air pollution.

The extent and form of the pollution which reaches the shore is influenced by the distance separating the spill location and the coast, the shore morphology and permanent and seasonal winds and currents. The nature of the shore renders it more or less sensitive.

Subsequent arrivals of oil in a previously affected area after a break of several months or years can exacerbate the imbalance in recovering populations and economic activities, with the risk of pushing them into an irremediable situation.

Each case is therefore unique and it is easy to think of the particular oil spill with which we are familiar as far worse than that experienced by others. ■



Source: *Cedre* estimations

Distribution in the air and the water of tonnage of oil spilled

Impact on the fauna

Impact on the shore

NATURAL DISCHARGE

Natural sources of hydrocarbons

Oil spills• are always thought of as affecting an otherwise hydrocarbon•-free marine environment so the percentage of discharge from "natural sources" may come as a surprise to some readers.

Various coastal areas located around eroded sedimentary basins or faults between plates of the Earth's crust harbour natural seepage of fossil fuels. This is the case in particular on the coasts of Alaska, California, the Gulf of Mexico, the Red Sea, the Caspian Sea and Borneo Island, where sheen• and oil slicks are regularly seen independently of any pollution caused by man. There also exist, inland and on certain shores, outcrops• of asphaltic sands, from which hydrocarbons are carried into the water system or directly into the sea. These sites are historically the source of the first human exploitations of oil.

Natural seep at Coal Oil Point

The most studied natural seep field is in California, near Santa Barbara, off the coast from Coal Oil Point Natural Reserve. The seepage is estimated at 150,000 m^3 of gas and 20 tonnes of oil per day. This seep is the subject of many publications of the University of California.

The reference works consulted agree on an estimated total of around 250,000 tonnes per year of seepage from natural sources for the period 1990-2000, which represents 10% of all oil released into the marine environment. However, no exhaustive inventory of natural seepage locations exists and this figure could therefore be out by a factor of ten. We should be cautious of routinely accusing man when confronted with a localised oil spill, evidence of tar balls• or sheen in inshore pools. Nature itself may have a role to play in these unpleasant phenomena.

It is important to know the locations of natural oil seeps. These sites are important sources of information on the influence of oil on the natural environment. They also rightly reduce the notion of the purity of natural sites, which is asserted whenever an oil spill is caused by human activity.

We can neither stop natural seepage today, nor predict seeps which may appear tomorrow. We can only respond to their effects where necessary, with the same techniques and means as for pollution provoked by man.

Seeps of mineral hydrocarbons are not the only natural source of hydrocarbons in the marine environment. Life is also a source of hydrocarbons. Many hydrocarbons are in fact natural minor components of living matter. A number of oils and aromatic• essences are present in many vegetal and animal species as biogenic hydrocarbons. When organisms which produce these substances die, hydrocarbons are released on the seabed and into sediments. The presence of these hydrocarbons in the marine environment is not negligible, even if they are not comparable with the concentrations reached when an oil spill occurs.

A site's return to its original state following an oil spill does not therefore necessarily imply a total absence of hydrocarbons in the water and sediment. The mineral hydrocarbons from the spill disappear in time, either by mechanical removal or by degradation into products which can be assimilated by the natural environment.

The submarine the *Nautile* discovered an oasis of life 2,000 m deep, a haven for flourishing fauna thriving on methane

Sources

What are the sources of oil spills from human activity?

- Release on land
- Oil tanker accidents
- Operational discharge
- Surveillance and deterrence
- Terminals, worksites, platforms

RELEASE ON LAND

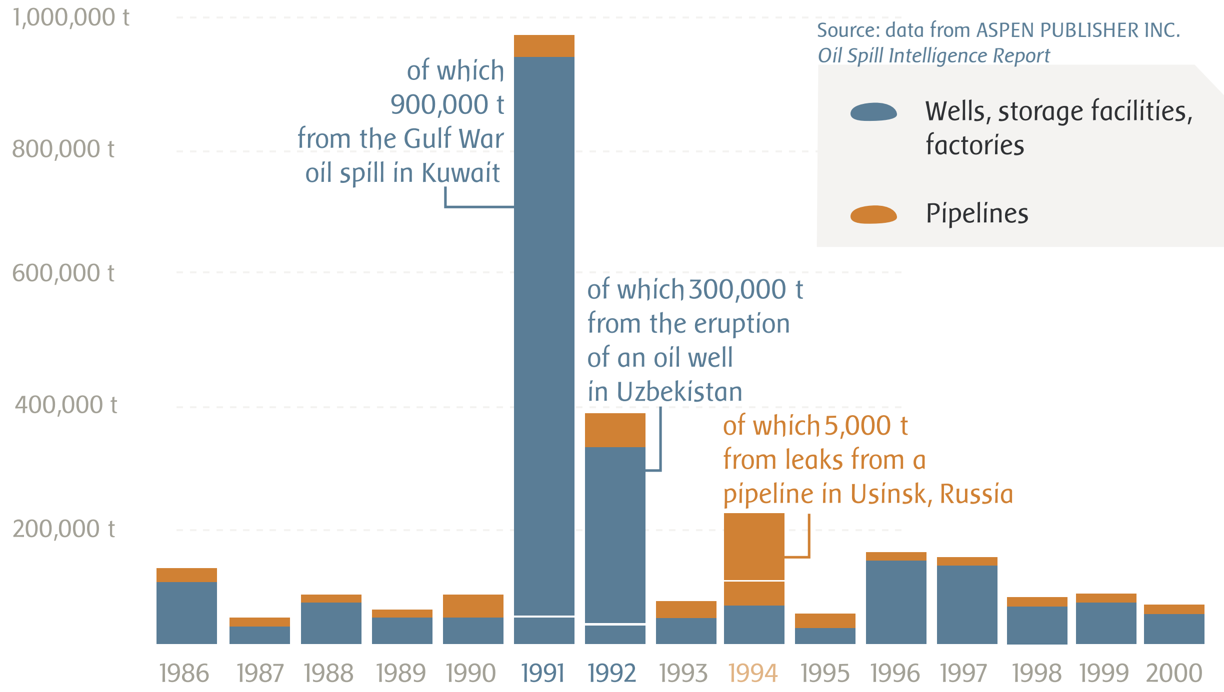
Facts and figures

Many spillages of oil and petroleum• products occur every day all over the world, when filling, emptying and cleaning tanks or pipes, or in the everyday running of factories, pipelines•, or oil wells• on land. These spills may result from technical failure, negligence, vandalism, accidents or armed conflict.

Some components of all oil products are partially volatile• and degradable. Products, such as those which form petrol• for vehicles, contain a large quantity of components that evaporate quickly, reducing residual volumes. However, they remain toxic before evaporation•.

After a spill, the majority of the product evaporates and the rest is biodegraded during its journey as run-off or through the sewer or drainage system. Other more persistent substances may flow into this system and end up in the sea, where they contribute to shoreline pollution by forming sheen•, tar balls• and patches.

In Europe and North America, these spills concern sufficiently small quantities of oil that we do not generally find images of widespread oiling of sites, as with major oil spills•. However, some regions of the world are affected by such forms of chronic pollution• on a near permanent basis. The surrounding shores are constantly marked by oily slicks and tar balls, which, when put together, can create localised oil spills.



Oil spills caused by industry and wars in the world in tonnes per year

Statistics

A detailed statistical report exists, providing estimations of the volume of oil spilled due to accidents in storage facilities, industrial plants, pipelines•, trucks and railways. It was published up until 2000 by the American editor Aspen Publisher Inc., in *International Oil Spill Statistics*. Other sources, such as the International Maritime Organization (IMO), maintain statistics on shipping losses for the international community, which provides a partial picture of the magnitude of oil spill issues.

The Aspen statistics show significant peaks in certain years due to one or two major accidents. Thus in the period 1986-2000 there are three peaks, one caused by a war (1991), one by oil well• eruptions (1992) and one by a leak in a damaged pipeline (1994).

During the 1990s, multiple leaks in certain pipelines in the former USSR reached such an extent that the European Union feared major water pollution in the Baltic Sea. As a consequence, a project was set up to assist in the rehabilitation of these systems. In 1999, the new independent States of the former USSR signed an agreement with the European Union for the modernisation and extension of their pipeline networks. Within the scope of this agreement, the Interstate Oil and Gas Transport to Europe (INOGATE) project provides technical support for the rehabilitation, rationalisation and modernisation of the oil and refined product* supply networks in the participating countries.

The physical safety of on land oil transportation networks and depots is one of the operators' and authorities' major concerns. It is therefore an important area for cooperation. Thus in 2002-2003, the European Union provided 10 million Euros to finance a regional study on a satellite surveillance system for the prevention of accidents and the detection of leaks in oil infrastructures.


Gas pipeline linking the Argentinean and Chilean networks


Pipeline network in Venezuela

According to the US National Academy of Sciences, release from land-based industry and urbanisation are the main sources of oil spills in the world. Thanks to stricter regulations and greater awareness in industry, these spills fell from 2.7 million tonnes in 1973 to 1.2 million in 1981, and their proportion of all spills from 46% to 36%. The increase in industrial activity caused their input to rise in 1989 to 50%. These figures, published in 2003 by the US National Academy of Sciences in *Oil in Sea III: Inputs, Fates and Effects**, should be treated with some caution, as they are not statistics but rather represent the estimates of experts involved in the programme.

Pollution from a pipeline in Alaska due to an irresponsible act

In October 2001, American news agencies and specialised bulletins devoted numerous pages to an exceptional event: the perforation of a pipeline transporting crude oil* from Prudhoe Bay to the port of Valdez by a bullet fired by a drunken reveller.

This was not the first time such an incident had occurred. There have been around fifty known cases of angry or inebriated gunmen targeting the pipeline, without ever actually piercing it. However one bullet hole was enough to cause significant damage. The hole was scarcely 1.2 cm in diameter, but it was positioned just above a valve and at the bottom of a hill. The oil spurted out under pressure, to over 20 metres, and took two days to stem using a watertight clamp. In total, 970 tonnes of crude oil were released over a hectare of tundra. The response involved 200 people and considerable resources for initial clean-up*, which was completed in the spring after the thaw. The person responsible was severely fined.

Prevention

It is a major priority for specialists in environmental protection to reduce the frequency and volume of land-based releases and, in the event of a spill on land, to contain the pollution at its source and to prevent it from flowing into rivers

A basic precaution, which is mandatory in many countries, involves providing oil storage tanks with a containment basin (with a watertight base enclosed by an earthen dike or a concrete wall) able to contain the volume released if the tank were to give way. Many industrial facilities where oil is refined, processed into chemicals, or stored for distribution to commercial markets, have engineered systems to contain spilled oil and direct it to settling• basins and waste water treatment facilities, ensuring oil is treated before leaving a site. Complex systems can be set up for pipelines• in high risk zones (sabotage, earthquakes) involving automatic devices (pressure sensors connected to alarms, automatic valves) and human surveillance (aerial surveillance, network of video cameras, terrestrial patrols).

The effectiveness of regulations depends on the level of enforcement, which is determined by the capability of the authorities and the motivation of the industry and local people. Land-based pollution is generally the result of frequent small spills due to negligence, poor upkeep, and indifference towards the environment. Unfortunately, ensuring that this type of pollution is controlled cannot always be a priority for the national authorities in many poor or politically unstable countries. ■

OIL TANKER ACCIDENTS

Facts and figures

In a study on the sources of oil spills•, the US National Academy of Sciences provides the following statistics on spills due to oil tankers•:
- 1973: 200,000 t (3.4% of total discharge)
- 1981: 400,000 t (12.3% of total discharge)
- 1989: 114,000 t (unknown % of total discharge)
- 2000: 162,000 t (6% of total discharge).

With the exception of 1989, these quantities do not represent the actual spill volumes for the year displayed, but rather are averages over each 8-year period, taken from annual statistics provided by the International Tanker Owners Pollution Federation Ltd (ITOPF). The data gives us an accurate picture of the extent of spills, including the parts which evaporated or burnt.

Pipelines as targets

Colombia: repeated sabotage

The 700 km long Colombian pipeline• put into operation in 1985 between Caño Limon and Covenas, near the Venezuelan border, seemingly holds the world record for sabotage by guerrilla warfare. By the end of 1997, it had suffered 495 attacks, causing spills totalling an estimated 145,000 tonnes. In 1999, the 46th explosion of the year caused a spill in the Limon River, causing several tens of cubic metres of oil to flow downstream to Venezuela. In 2001, a renewal of guerrilla warfare resulted in no less than 117 spills during the first 8 months of the year.

Iraq: one sabotage attack amongst others

On 14 September 2004, saboteurs attacked a location where several pipelines met to cross the Tigris River near the city of Beiji, 250 km north of Baghdad. The burning crude oil• escaping from the fractured pipelines ran downhill into the river. It took 3 days to control the fire. The attack occurred just as technicians had finished repairing two valves damaged by a previous explosion.

Causes of accidents

According to insurers' statistics, 80% of oil tanker• accidents which cause oil spills• at sea are a result of human errors: badly handled manoeuvres, neglected maintenance, insufficient checking of systems, lack of communication between crew members, fatigue, or an inadequate response to a minor incident causing it to escalate into a major accident. From a more practical point of view, analysis of the circumstances surrounding accidents (see diagram "Causes of oil tanker accidents") demonstrates the high proportion of spills due to groundings• and collisions.

Collisions are generally due to manoeuvring errors, especially in poor visibility and/or busy shipping traffic areas. Groundings are also often a result of manoeuvring errors, often made worse by high winds, challenging currents and bad weather. The grounding of the *Sea Empress* at the entrance to Milford Haven port, Wales (Great Britain) is one such example. However, equipment failure is a more common cause of groundings than of collisions. The grounding of the oil tanker the *Braer* in the Shetland Islands, Scotland (Great Britain), resulting from seawater entering into a fuel tank•, causing engine failure, is a classic example of technical failure.

Wreck of the *Aegean Sea* by La Coruña, Spain

Preventative measures

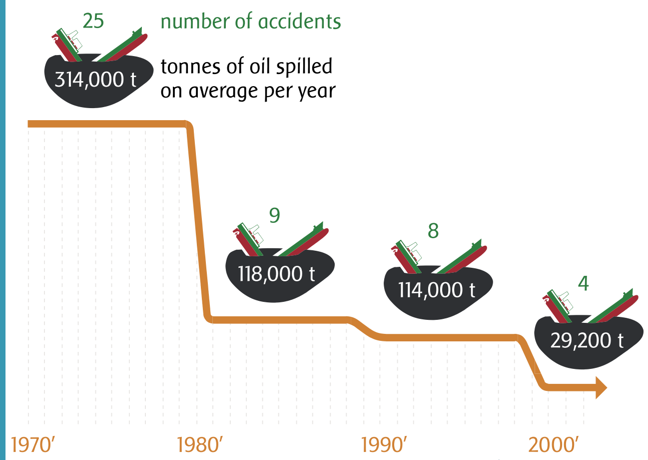
The most exposed countries have reacted to the dangers generated by the vessels which frequent their ports and waters through different preventative measures, on a national scale, or through decisions made by the International Maritime Organization, such as the implementation of traffic separation schemes•, the use of ocean salvage and rescue

Oil tanker spills

The International Tanker Owners Pollution Federation Ltd keeps an up-to-date database on the Internet (www.itopf.com), on oil spills of over 700 tonnes, from oil tankers•, ore carriers and tank barges which have occurred all over the world since 1967. Information is also provided on various aspects of the spills and their consequences.

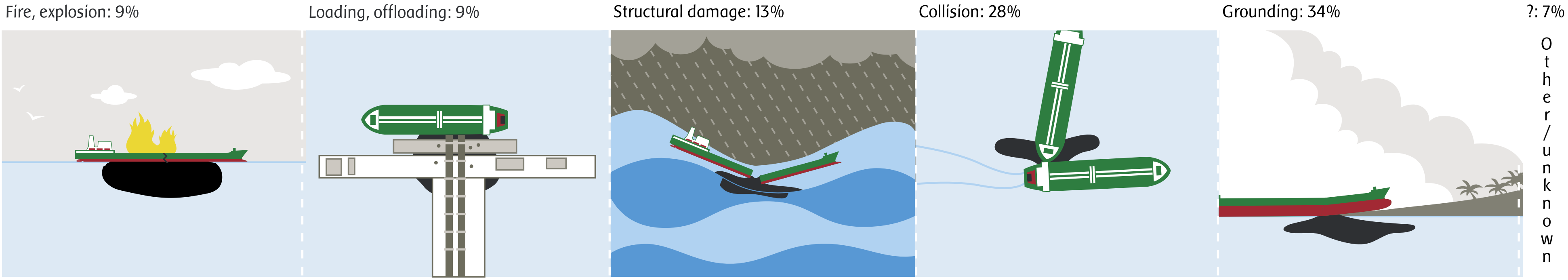
This data brings to light the fact that a little more than 5.5 million tonnes of oil were spilled in the world's seas by oil tanker accidents during the 30 year period from 1970-2000, totalling nearly 182,000 tonnes per year with a peak of 640,000 tonnes in 1979. Since then, despite a bad year in 1991, the tendency is towards a considerable decrease. In the decade from 1990 to 1999, 73% (830,000 tonnes) of the total amount spilled (1,140,000) was caused by only 10 accidents.

Number of oil tanker accidents causing spills of over 700 t



Source: data from ITOPF, 2004

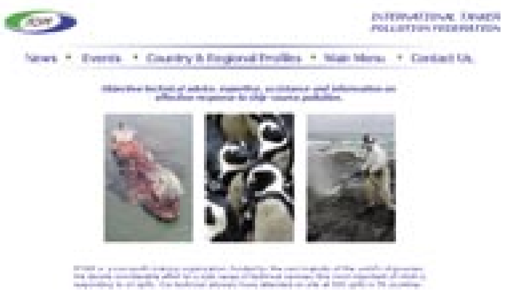
Causes of oil tanker accidents (spills of over 700 tonnes)



Source: ITOPF, 2004

More information

ITOPF is a mutual organisation providing technical advice on pollution response for shipowners of oil tankers. ITOPF experts contribute to response operation management, impact assessment and environmental restoration operations around the world. See below the home page of ITOPF's website, which is an indispensable source of information on accidents, their causes and response carried out. For further information, see www.itopf.com.



tugs, the introduction of double hulls and segregated ballast tanks, and the reinforcement of the powers of maritime authorities of the Coastal State concerning passing ships and specific standards to be respected by vessels offloading in the ports of a particular country.

The prevention of oil tanker accidents requires many varied administrative and technical measures. Just five examples of prevention strategies will be outlined here:

- a technical measure: the double hull
- three administrative measures: compliance checks, places of refuge and traffic separation schemes
- a practical measure: involvement of the oil industry.

Double hull

The double hull is often presented as a solution to the problem of oil spills. It is certainly an effective solution for minor breaches resulting from collisions or groundings at low speeds. However, it does not protect against collisions at full speed, fire, explosions, breaking during a storm or dislocation on reefs, all of which can generate major oil spills.

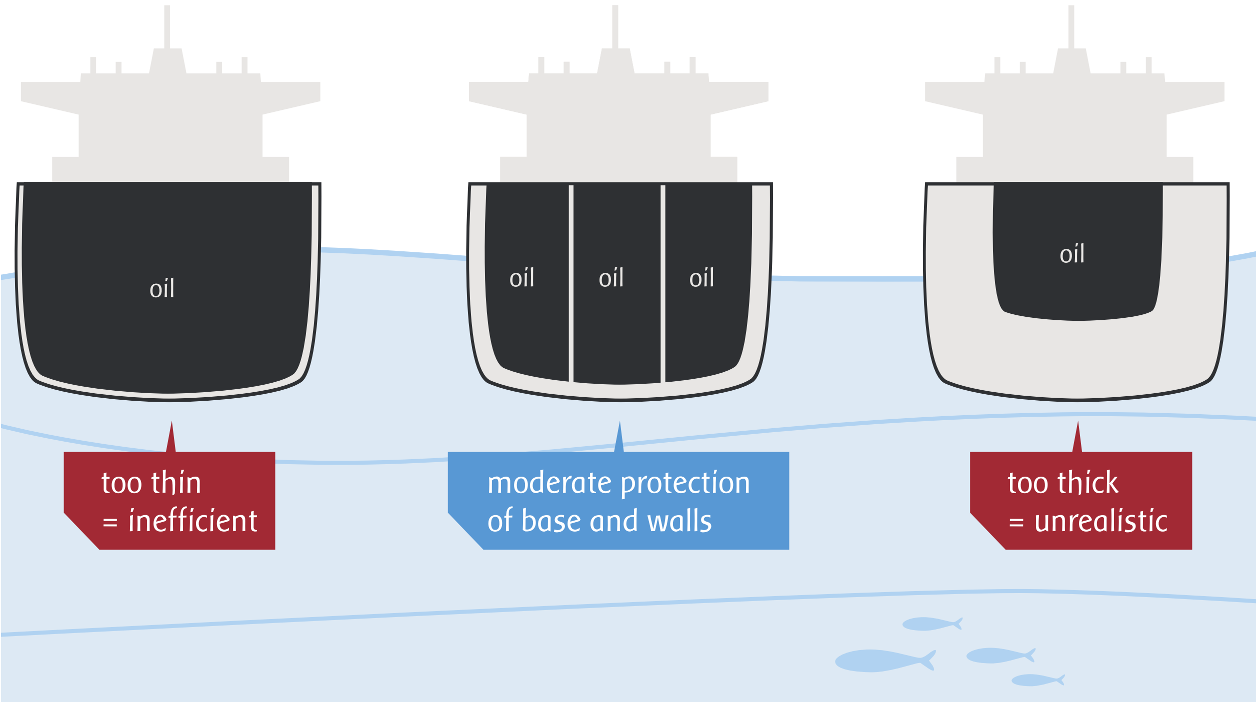
Furthermore, it makes inspecting vessels more difficult to carry out. It inevitably increases vessels' prices, tonnage and maintenance costs. The benefit of the double hull is comparable to that of a motorbike helmet: it acts as a useful form of protection, but is not a cure all solution.

The US was the first country to impose requirements making the double hull mandatory for all vessels frequenting its ports. The implementation of this legislation in the US complies with the following timescale:

• 1994 for new vessels
• 2009 for existing vessels with a gross tonnage• of more than 5,000 (14,000 m3)
• 2015 for all remaining vessels.

This decision, made under pressure from the media and public opinion as a reaction to the *Exxon Valdez* incident in Alaska, gave rise to lengthy debates in the maritime community and the International Maritime Organization.

After the *Erika* disaster in France, Europe wished to move towards a global solution through the International Maritime Organization, involving the phase out of single hull tankers by 2010. Faced with the difficulty of reaching an agreement, the delegations decided to create a more flexible worldwide rule: remaining single hull tankers would be allowed to operate worldwide until 2015, but concerned countries (notably the European countries) would choose to ban these vessels from their ports as of 2010.



Possible structures for a double hull tanker

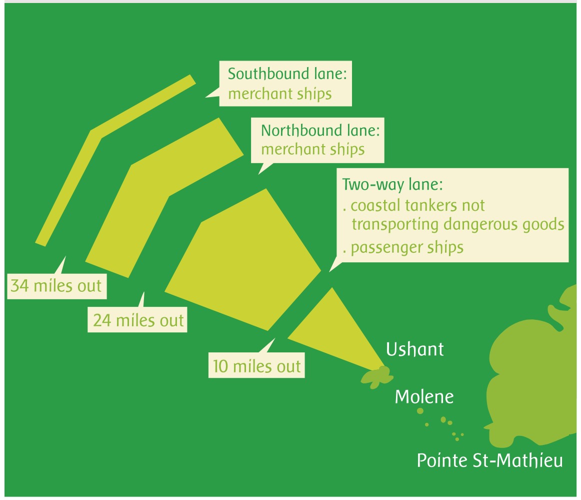
Compliance checks

Both national legislation and international regulations put in place by the International Maritime Organization within the framework of the international Marpol Convention function through checks for compliance. Marpol came into force in 1983 and its annexes are constantly being revised. The convention states that all vessels must possess a certificate of compliance defining a set of standard safety techniques. In the event of non-compliance, the vessel may be banned from leaving port by inspectors from its State of registration (Flag• State) or the State in which it puts into port (Port State).

In order for checks to be more effective, the European countries signed a Memorandum (known as the Paris Memorandum) in 1982 which introduced a common vessel inspection system and set minimum check quotas. The *Erika* and *Prestige* accidents highlighted the lack of these checks in certain countries, due to an insufficient number of inspectors.

Inspector onboard a docked vessel

International regulation in heavy traffic areas
Circulation in the Ushant traffic separation scheme



The French ocean rescue and salvage tug the *Abeille Bourbon*

Traffic separation schemes

The world's first traffic separation scheme was established in the Dover Straits (English Channel) in 1967, in a bid to reduce the number of shipping accidents in this high risk area. This scheme became the first mandatory traffic scheme in 1971. Similar schemes have now been brought into force in the majority of the highly congested shipping areas of the world.

In France, a mandatory traffic separation scheme was set up off the coast of Ushant Island in Brittany, as a result of the *Amoco Cadiz* disaster. A high sea tug, the *Abeille Bourbon*, is permanently on standby. As the upshot of several incidents, a system came into force in this high risk area in May 2003. These vessels must indicate the nature of their cargo to Corsen Marine Rescue Coordination Centre which manages the Ushant traffic separation scheme. The authority to have a vessel suffering structural damage towed is in the hands of the *Préfet maritime* (maritime prefect), where the vessel does not comply with formal notice to be assisted.

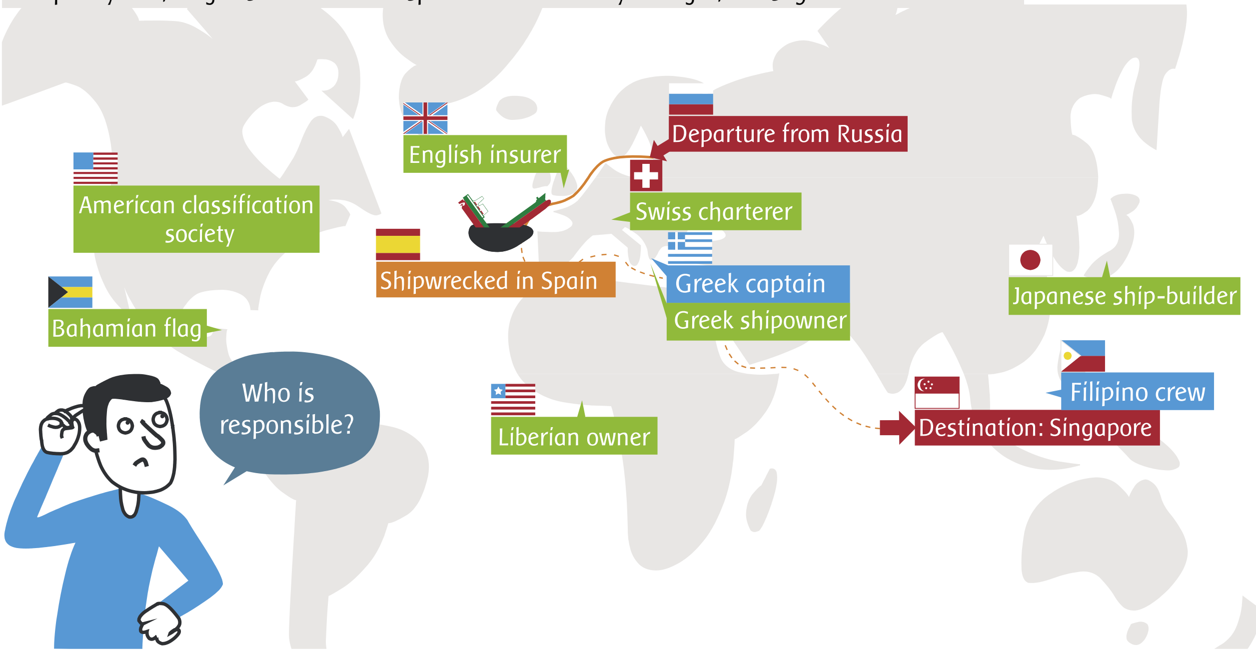
Similar traffic separation schemes are in place in other parts of Europe, such as the Spanish Cape Finisterre and the Strait of Gibraltar. These schemes aim to reduce the risk of collision and ensure that vessels transporting dangerous goods remain far from the coast. Ocean rescue tugs are also on standby in various accident black spots such as the Shetland Islands (Scotland, Great Britain) and the north coast of Spain.

Involvement of industry

When an oil spill occurs, the sharing of responsibility between the shipowner, the crew provider, the charterer, the cargo owner, the ship-builder, the worksites involved, the classification society which checked the work, and the authority in charge of the salvage attempt is often complex. Once a ship is loaded with oil or petroleum products, the cargo can change owners several times during a journey. It is therefore difficult to identify the responsible party and it is often very tempting to point to the most visible and solvent participant: the oil company involved.

Oil groups have therefore invested in prevention by creating vetting units, in charge of assessing the quality of chartered vessels. They possess contingency plans for accidental pollution coming under the responsibility of their safety and environmental management teams. These plans dictate the roles and responsibilities of each party when confronted with an accident, in order to contain and recover the spill as quickly as possible and to limit the consequences, by providing the response authorities with the group's intervention resources.

Complexity of the organisation of oil transportation and liability during the *Prestige* accident



The problem of liability

The highly international nature of the different participants in maritime transportation in no way simplifies the process of identifying the legally liable party in the event of an oil spill•. The International Maritime Organization, which served as a basis for establishing the International Oil Pollution Compensation Funds (IOPC Funds•), therefore introduced the principle of objective responsibility of the vessel itself, independent of all notion of fault or blame. The simple fact that a tanker is a source of pollution gives victims access to the IOPC Funds, and therefore access to the possibility of compensation.

Places of refuge

The recent wrecking of the *Prestige* off the coast of Spain highlighted a problem which was all too familiar to specialists: accommodating ships in distress carrying hazardous substances. The *Prestige* suffered serious damage to her hull and was kept at sea for 6 days as there was no salvage plan to direct the vessel to a pre-established place of refuge•. Consequently, the European Commission requested the early application of a directive which came into force in February 2004 stating that all member States must establish plans to accommodate vessels in distress in the waters of their jurisdiction and publish lists of ports of refuge•.

At the time of writing, not all member States have published these lists, which constitute a very sensitive subject area for the coastal inhabitants of the country. Some countries have chosen to establish decision-making methodologies and to refer to places rather than ports of refuge•. Others are still undecided as to the question of whether the places of refuge, dictated by the maritime authorities, should only be known to these authorities or should become public knowledge.

This issue is all the more sensitive when it comes to the question of the legal liability of the national authorities if the vessel towed to a place of refuge causes serious damage to the environment in this place or on the way there. Added to this is the currently unresolved issue of levels and methods of compensation for those affected by any resulting damaged. ■

OPERATIONAL DISCHARGE

Oil tankers

All high sea vessels are equipped with ballast tanks, which can be filled with seawater to improve stability when carrying little or no cargo, to correct the vessel's trim or to reduce her list. Previously, the fuel tanks and some of the cargo tanks of oil tankers used to carry out this job. When these tanks were emptied, significant quantities of oil mixed with seawater were discharged into the ocean. Operational discharge from a vessel can thus be compared to oil from a number of cars or trucks being released into the environment when changing the engine oil.

The attention paid to the pollution of the sea by oil tanker accidents triggered an awareness of the importance of operational discharge. In 1973, the volume of deliberate discharge was five times greater than accidental spills according to the US National Academy of Sciences. Such high volumes required worldwide control measures. These measures were brought in by the International Maritime Organization within the framework of the Oilpol Convention (1954) and reinforced by the Marpol Convention (1973, 1978), which also extended them to non-tankers.

Oilpol banned the release of polluted waters in certain zones, so-called special zones, such as the Mediterranean Sea, and established authorised discharge thresholds elsewhere. Marpol, which came into force in 1983, introduced even more restrictive discharge standards and imposed new ship-building rules for new vessels. All new tankers with a deadweight tonnage equal to or greater than 20,000 tonnes had to be equipped with segregated ballasts, situated defensively to contribute to the protection of cargo tanks in the event of collision or grounding. Depending on their size and age, and according to a predefined timescale, existing vessels were to be equipped with segregated or dedicated ballasts (oil tanks equipped with a crude oil washing system to be put into action before using tanks as ballasts), with the transfer of washing residues into specific reservoirs (slop tanks).

Discharge at sea was restricted to less than 1/30,000 of the cargo volume per journey for vessels built after 1996, with the introduction of load-on-top techniques. This system involves pumping oily mixtures resulting from tank cleaning operations into special slop tanks. The mixture is then separated by settling and the water portion is pumped into the sea, leaving only crude oil. At the loading terminal, fresh crude oil can then be loaded on top of the remaining oil.

These regulations and the investment of certain countries in remote sensing of operational discharge led to positive results. According to the US National Academy of Sciences, operational discharge from oil tankers fell from 1,080,000 tonnes in 1973 to 700,000 tonnes in 1981,and then to 159,000 tonnes in 1989, with a slight increase to 163,000 tonnes in 2000. It is however important to note that these figures are not statistical data but estimations of the most likely situation, based on the proportion of oil tankers which fulfil the Marpol Convention criteria and on the waste reception facilities in ports.

Crude oil washing

The crude oil washing method involves cleaning out tanks not with water but using crude oil, i.e. the cargo itself. The solvent action of the crude oil makes the cleaning process far more effective than when water is used. The process is usually completed by a final water rinse, but only a small volume of water is used. This method is accepted as a possible alternative to the system of segregated ballasts onboard existing tankers and constitutes an additional requirement onboard new tankers.

Crude oil washing introduces dangers due to the accumulation of explosive gases in the cargo tanks as the cargo is offloaded. This is why the protocol relating to the 1974 SOLAS Convention, adopted at the 1978 International Conference on Tanker Safety and Pollution Prevention (TSPP) and brought into force in May 1981, stipulates that an inert gas system must always be used when crude oil washing is carried out.

Degassing, deballasting and operational discharge

Degassing* is an operation which involves freeing fuel tanks* and crude oil* tanks of the gases which remain when the tanks have been emptied. Onboard a vessel, the most practical and cost-effective solution involves expanding the gases using vapour, ventilating and rinsing the tank with water.

Deballasting* is an operation which involves emptying out the contents of a ballast* tank, i.e. a reservoir that can be filled, or partially filled, with water to load down or lighten a vessel to improve her stability and trim. Empty fuel tanks, or on an oil tanker* crude oil tanks, constitute natural ballasts. Ballasting (filling of ballast tanks) with water rinses out the oil and waste they contain.

When degassing and deballasting occur anywhere other than in treatment plants they constitute discharge at sea, producing trails of sheen* where onboard separation is insufficient. However degassing and deballasting are only part of operational discharge* of hydrocarbons*. The majority of deliberate discharge is caused by hydrocarbon residues unfit for propulsion. This affects all vessels. In modern tankers, there are two different types of residues: waste waters and fuel residue. Waste waters from the bilge are pumped from the engine sump into settling* tanks. They are then filtered and separated by an oily water separator* to a limit of 15 ppm*. If the concentration is higher than 15 ppm, they are returned to the bilge water drain tanks*. Fuel residues (known as sludge*) and engine oil must be discharged on land or burned onboard (and are stored in tanks called slop tanks* on oil tankers).

IMO regulations in the document *Marpol 73-78** for crude oil washing, segregated ballast tanks and dedicated clean ballast tanks, in force since 1993

New tankers	
Transporting refined products*, deadweight* of 30,000 tonnes or more.	Segregated ballast tanks in defensive position (situated in such a way as to contribute to the protection of cargo tanks in the event of collision or grounding*).
Transporting crude oil, deadweight of 20,000 tonnes or more.	Segregated ballast tanks in defensive position, crude oil washing.

Existing tankers	
Transporting crude oil, deadweight of 40-70,000 tonnes.	Segregated ballast tanks, crude oil washing or dedicated clean ballast tanks.
Transporting refined products, deadweight of 40,000 tonnes or more.	Segregated ballast tanks or dedicated clean ballast tanks.

Aerial view of a vessel illegally discharging

Non-tankers

More than 72,000 merchant ships enrolled on the Lloyd's Register, register of maritime navigation, and several tens of thousands of other vessels constantly plough through the seas. They transport varying quantities of oil and fuel for their own use, and up to several thousand tonnes for the largest passenger boats and container ships.

All these vessels are equipped with oil residue recovery systems, generated by filtering heavy fuel oils• before using them as propulsion fuel. They also have waste water drain systems and separators onboard. The residues from settling and filtering accumulated during journeys need to be disposed of for treatment in ports. However, the lack of facilities in some places, the time spent and the cost generated by these operations in a deballasting station• in port can mean that vessels dispose of all or part of the contents of their recovery tanks at sea.

This discharge constitutes the main source of pollution by non-tankers. Degassing and deballasting of their fuel tanks and accidents, causing several tens of litres to several thousand cubic metres to be spilled, can also add to this pollution, on a more exceptional basis.

According to the US National Academy of Sciences, these spills totalled 400,000 tonnes in 1973, double the amount spilled by oil tanker accidents. The reinforcement of surveillance and the installation of separators onboard new vessels meant that the quantities fell to 320,000 tonnes in 1981, then 260,000 tonnes in 1989. The situation seems to have deteriorated since, with an estimated 555,000 tonnes in 2000, making non-tankers the number one source of oil discharge by maritime transportation.

These figures should however be handled with care. Due to a lack of statistics, they are simply estimates for each category of vessel. The fluctuation from one estimate to another may be more a reflection of the inaccuracy of the data than of a real change. In reality, the actual quantities may in fact be greater than these estimates, which only take into account the merchant ships listed in Lloyd's Register.

Possible modifications to the Marpol Convention and to regional agreements are currently being investigated, to continue to reduce these volumes by introducing rules for non-tankers similar to those which apply to tankers. Thus their operational discharge must now no longer have a hydrocarbon content of over 15 ppm. It is unfortunately not always easy to impose restrictive and expensive measures upon thousands of independent shipowners•, who may be more concerned by financial and practical implications than environmental protection. ■

Aerial observation of a vessel followed by a polluted wake

SURVEILLANCE AND DETERRENCE

Pollution observation

In an attempt to mitigate the consequences of illicit discharge from vessels, certain countries have invested in surveillance and deterrence strategies and tools.

In the North Sea area for example, airborne surveillance is carried out within the framework of the Bonn Agreement, an agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances. The contracting parties to this agreement are Belgium, Denmark, France, Germany, the Netherlands, Norway, Sweden, the United Kingdom and the European Economic Community.

Aerial surveillance is achieved in these States through the coordination of national flight plans, cooperation in areas of mutual interest and the setting up of special flights, such as Tours d'Horizon•, Joint Flights and Aerial Surveillance Exercises. Furthermore, surveillance is facilitated through the standardisation of reporting formats (the standard format pollution report is known as a POLREP) and by working together in improving existing systems and developing new techniques to enhance the information obtained.

At national level, France, for example, has chosen to integrate pollution surveillance into aerial patrols by the French Navy and Customs, the latter providing three planes fitted with specialised remote sensing• equipment. Thanks to revision of the relevant texts and the creation of specialised courts, France is now one of the most tightly regulated countries in the world in terms of the detection of operational pollution from maritime transport.

A case of illegal discharge

On 24 March 1998, a Royal Air Force aircraft, whilst on a routine patrol, observed the Norwegian liquid petroleum• gas carrier the *MT Havrim* illegally polluting off the west coast of the Outer Hebrides in Scotland. The crew photographed the slick, estimated to be seven miles long and 300 yards wide, and reported it to Stornaway Coastguard. The report was immediately passed on to the Marine Pollution Control Unit.

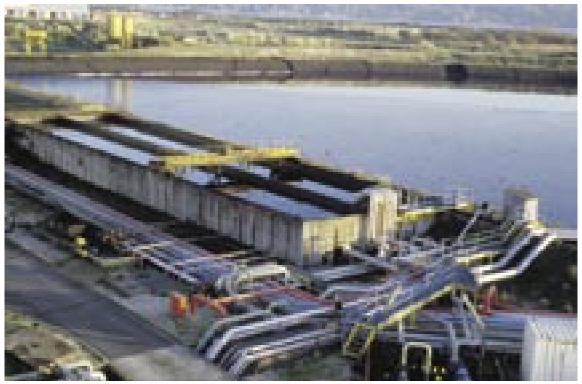
The Marine Safety Agency was alerted and two surveyors boarded the vessel on her arrival in Pembroke, Wales. The tanker was subsequently detained and the owner put up a bank guarantee of £255,000. At an emergency court hearing on 30 March 1998, the owners were fined a total of £20,000 for illegal discharge of engine oil bilges.

Waste reception

Regulation and control must inevitably be accompanied by the development of waste reception facilities. Many tanker ports are now equipped with a specialised reception station (deballasting station•), but many of the stations in poorer countries are insufficient or out of service, their tanks• full of semi-solidified oily sludge•. As these countries have no pollution surveillance resources for their coasts, it remains very tempting for ship operators to discharge oily waste from their vessels in these areas. ■

More information

Deballasting stations are reception and recycling facilities for bilge residues and waste waters with which all the world's ports should be equipped to take oily waste from vessels in port for a stopover or for repairs. This oily waste, stored on-board vessels in designated tanks (slop tanks•), is pumped into the station's reservoirs, where it is separated from the seawater and solid waste• it contains by settling•. They oily fraction is sent to a refinery• for recycling or is directly reused if it is mainly composed of heavy fuel oil•. After purification, the water is returned to the natural environment.
Deballasting stations are classified facilities, with discharge standards which must be respected, autosurveillance procedures and periodic checks.



TERMINALS, WORKSITES, PLATFORMS

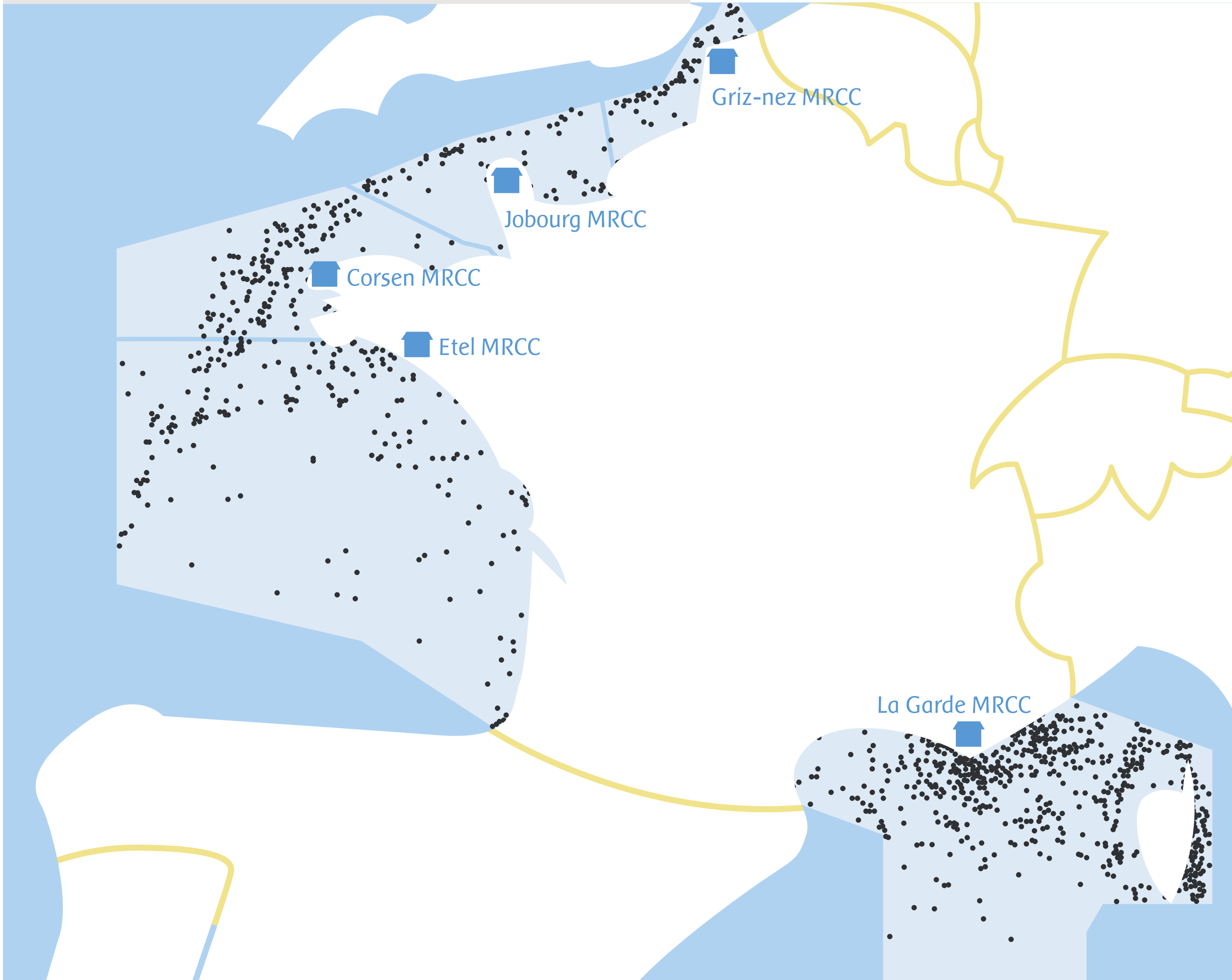
Terminals and worksites

The world record for the largest oil spill• is held by a spill at a terminal• during the first Gulf War in Kuwait. Aside from such acts, oil spills from terminals and worksites have significantly decreased, falling, according to the US National Academy of Sciences, from 253,000 tonnes in 1973 to 50,000 in 1981 and 37,000 in 1989, with an increase to 80,000 tonnes in 2000. Once again, these figures are not accurate statistics but rather estimates in which the main component of the progress recorded is the decrease in spills at sea from the bilge and tanks• of vessels before entering dry dock• for repairs.

Up until the late 1970s, it was common practice to discharge waste at sea before entering dry dock, in order to avoid the cost of its removal by the shipyard or simply because the vast majority of non-tanker ports did not have waste reception facilities. A worldwide effort is currently being made to reduce discharge before stopovers, repairs and demolition.

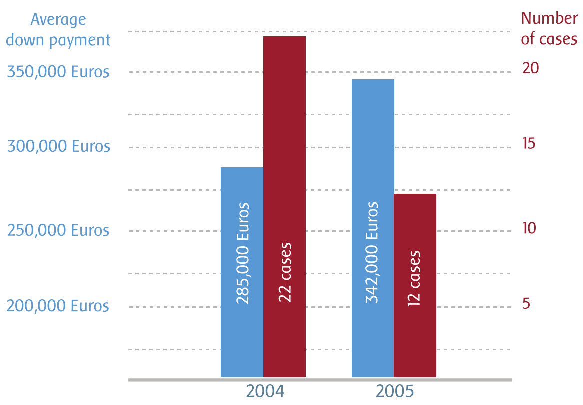
Other causes of such spills, in particular the rupture of hoses during fuel supply operations and oil leaks during repair of vessels, result from failures in safety procedures similar to those in industrial installations on land. Once again, the problem is making operators aware that a small, occasional spill, which may seem negligible, is another contribution to the worldwide input, the overall volume of which is unacceptable.

POLREPs in mainland France's surveillance zones from 2000 to 2004

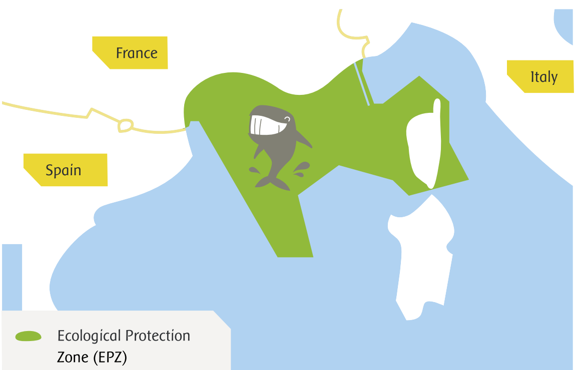


Sources: data from the French Customs and Navy

Fishing ports and marinas are no exception. Small overflows from fuel tanks when transferring fuel, or when loading oil onboard are frequent occurrences. They are the main source of sheen that can often be seen in ports.



Evolution of bank guarantees for illicit discharge in French territorial waters and EEZ (the fine imposed is generally around 90% of the bank guarantee)



French protection zone for marine mammals in the Mediterranean

Gulf War oil spill

On 26 January 1991, when the Iraqi army left Kuwait, it sabotaged a large part of the oil wells, the Mina al Ahmadi oil terminal and anchored oil tankers, in a bid to cause maximum damage to the country's oil industry.

Between 700,000 and 900,000 tonnes of oil were spilled at sea over a number of weeks, before international strike teams managed to stem the flow.

This was the largest known oil spill in human history.

Explosion of oil wells during the Gulf War

Coastal State or Flag State?

On 18 March 2005 the Norwegian chemical tanker the *Trans Artic* was caught illegally discharging off the French coast. The case was due to be judged in the court of Brest (Brittany, France) on 18 October 2005, when Norway claimed its right as the Flag State to judge the case, based on the Montego Bay Convention. On 29 December 2005, the shipowner was convicted in Bergen, Norway, and handed a 360,000 Euro fine.

This result however left the French civil parties affected by the pollution unsatisfied, as they had thus far received no compensation for the damages incurred. The court of Brest subsequently exerted its right, as the Coastal State, to undertake proceedings. On 7 June the very same case was therefore judged for a second time, this time in France, where the captain was handed a 50,000 Euro fine, with a further 300,000 Euros in the case of a repeat offence. This exceptional case therefore resulted in a dual conviction.

Former practices

In an article from 27 March 1998, Lloyd's List, a daily paper on the world of maritime insurance, quotes the testimony of a former captain of an oil tanker on the practices in the early 1950s, when vessels barely hit the 25,000 tonne mark. The following extract is of particular relevance.

"...She was not only single hulled but riveted, and leaked a small and regular proportion of her cargo into the ocean from many loose rivets as she steamed from load port to discharge port... Tank cleaning before drydocking in Todd's Yard at Brooklyn was quite remarkable by today's standards. The ship steamed at slow speed up and down the east coast of the US, just outside the 50 mile limit, for about 10 days while the crew were busy cleaning tanks and dumping all the sludge straight over the side..."

Ship-building and common practices have since changed, thankfully.

This article appeared in Lloyd's List on March 27 1998. For more information visit www.lloydslist.com.*

Offshore oil platforms

Today, offshore oil extraction makes up nearly a quarter of worldwide production, with more than 20,000 platforms of all sizes and designs, found in four main areas: the Gulf of Mexico, the Persian Gulf, West Africa and the North Sea.

The US National Academy of Sciences estimates the volume of operational discharge• and accidental spills from this sector of activity at 80,000 tonnes in 1979, 50,000 in 1981 and 100,000 in 2000.

The accidents mostly involve the spillage of a few cubic metres to a few tens of cubic metres, resulting from pipes bursting or from human errors. These incidences are mainly concentrated in areas where the material is old and the safety procedures deficient (Caspian Sea, Black Sea, Red Sea and China Sea). Occasional major accidents caused by an oil well• eruption or an act of war can be added to the list of causes of large-scale oil slicks. One of these incidents holds second place in the ranking of oil spill• world records.

The prevention of this kind of incident relies on two complementary measures: reinforced safety for accidents and rigorous checks for the discharge of drilling mud and exploitation fluids.

The North Sea oil fields, located in the centre of one of the richest fishing areas in the world, are particularly advanced in terms of prevention and safety.

The platforms there operate under permanent surveillance by satellite, remote sensing• planes and specialised, mainly Norwegian and British, vessels. Personnel from the safety services and the oil industry meet periodically to research new and

An oil terminal accident

On 7 August 1997 at 12:20 am, the oil tanker• the *Katja* was berthing when she hit a wharf• in the oil terminal• of Le Havre, and 190 m^3 of propulsion fuel spilled into the port. Despite immediate intervention, part of the pollution was carried out of the port with the receding tide, causing small-scale pollution of the surrounding area. The prevailing weather conditions saved the British coastline, but caused the pollutant to be washed up on the French shores of Calvados.

The Ixtoc I blow out

On 3 June 1979, in the Gulf of Mexico, the offshore platform Ixtoc 1, run by the national company Petroleos Mexicanos, was destroyed by a blow out. A fire broke out. The blow out was not reduced until 23 March 1980, by which time half a million to possibly even a million tonnes of oil had been released. Between a third and half of this oil burned. The remainder spread out to form drifting slicks in the Gulf of Mexico. Some of the slicks reached the coasts of Texas, triggering the activation of a regional oil spill response plan on 9 July. Localised clean-up operations were undertaken, followed by an in-depth impact study, involving the analysis of over 4,000 samples (water, sediment, flora and fauna).

improved safety solutions. The laboratories financed by the oil industry study the potential long term effects of exploitation on the marine populations.

Large-scale response exercises are carried out regularly by specialists from the industry and the administrations in charge of spill response at sea. ■

Pollution response* exercise in the North Sea

Impact

Which consequences need urgent mitigation?

- First effects
- Evolution of oil
- Pollution at sea
- Pollution of the shoreline
- Impact on flora and fauna
- Factors affecting impact
- Economic impact

FIRST EFFECTS

Psychological shock

The impact of slicks generated by minor, occasional incidences of discharge of oil at sea or in rivers is often thought of in terms of tar-like patches and oiled birds. The oil sticks to rocks, boats, skin, feathers... However it does not stop there. Limpets in rock pools affected by the oil can temporarily lose their adherence capacity, much to the delight of prawns and crabs. Oysters in farms can acquire an "oil-like" taste, which can take several weeks, or even several months, to disappear. Small localised populations can show a variety of known effects, which are rarely fatal for the flora and fauna, but quite real and sometimes detrimental to certain coastal activities.

When an oil spill• occurs, these known effects are quickly forgotten in a dramatic image of perceived doom: that of a "black death" which destroys all life in its path, leaving a desert in its wake for years, or even generations, to come. This image, often largely conveyed by the media via the familiar image of an oiled bird, dominates our thoughts. However, a few months later - or a little more than a year in the worst case scenario - the fishing boats come in with fish in their nets and flocks of seabirds in their wake. The seaweed fields are still there, as are the populations of coastal pools. The only visible remnants of the oil spill are the waste storage facilities, gradually emptied and rehabilitated, mud still impregnated with oil at the base of estuaries, and marks of oil on the rocks and cliffs. After a few years, the sole reminders of the disaster that can be found are a piece of wreck or a giant anchor in a small port, photos on café walls, the unextinguished anger of local people and in some cases a major lawsuit. Was the ecological catastrophe predicted by scientists and the media at the time of the accident in fact an excessive dramatisation? Or is the apparent return to normal a deceptive impression? These two questions bring us to a fundamental issue: the evolution of oil spilled in water. ■

Symbolic image: an oiled bird

Cleaning minor oil stains

On the skin:

Spread butter or oil on the affected area and remove after a few minutes. Then wash the skin with soap and water.

On clothes:

Apply a small amount of lamp oil (liquid fuel sold for heating appliances) to the stained material to remove the oil.

Reaction to the *Exxon Valdez* spill

"The excitement of the season had just begun, and then, we heard the news, oil in the water, lots of oil killing lots of water. It is too shocking to understand. Never in the millennium of our tradition have we thought it possible for the water to die, but it is true."

"We walked the beaches, but the snails and the barnacles and the chitons are falling off the rocks, dead. We caught our first fish, the annual first fish, the traditional delight of all; but it got sent to the state to be tested for oil. No first fish this year" (Chief Walter Meganack, Port Graham, 1989).

The Exxon Valdez disaster: readings on a modern social problem, 1997 Edition, by J. Steven Picou, Duane A. Gill and Maurie J. Cohen

EVOLUTION OF OIL

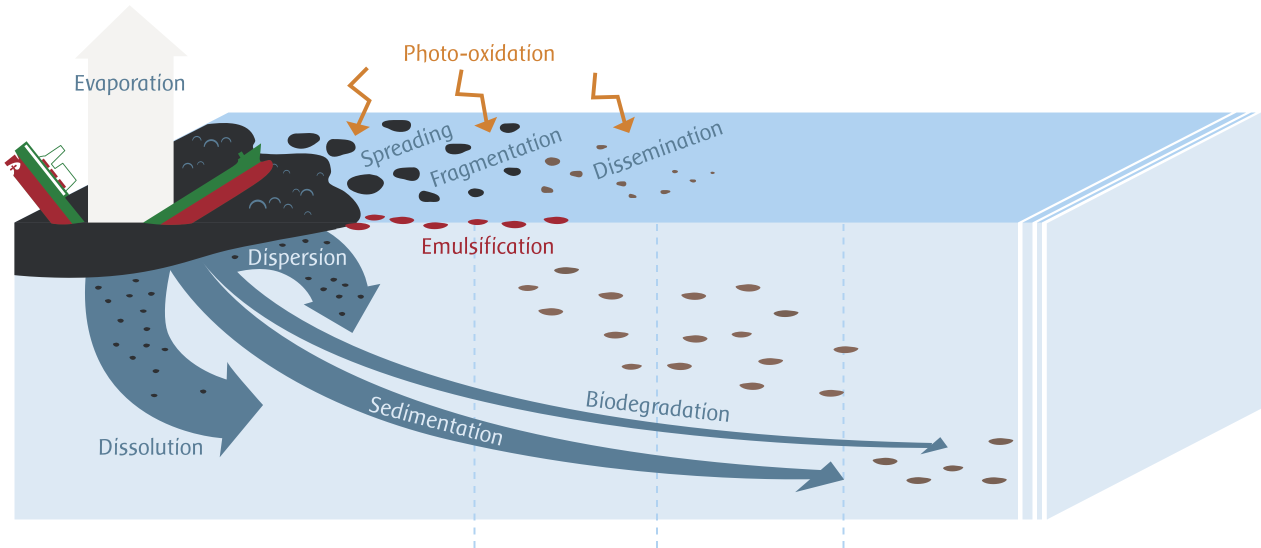
Gradual transformation

Oil is a mixture of thousands of molecules, mainly hydrocarbons•, which are mostly insoluble and lighter than water. When oil is spilled, it immediately begins to spread. In calm seas, it tends to form an oily film several tens of millimetres thick.

Water movement quickly breaks this film up into slicks, which drift on the water surface, separated by areas of open water, and, for some of the oil, into droplets which are dispersed in the first few metres of the water column•. The air, wind, light, swell and the water itself affect these slicks by a combination of physical and chemical processes: evaporation•, emulsification•, dissolution•, oxidation•, sedimentation•. Aquatic organisms biologically break up the molecules of certain hydrocarbons, a process known as biodegradation•.

Evaporation affects volatile compounds, generating the oily smell which accompanies an oil spill•. These are mainly well-known substances such as gases (methane, ethane, propane, butane, etc.) and solvents (benzene, toluene, etc.). After several hours, a quarter, a third, or sometimes as much as half of the volume spilled is released into the atmosphere, in the form of gases and vapours. The higher the temperature and the stronger the wind, the quicker the evaporation process occurs. The mass of hydrocarbons in the water is reduced, whilst the density of the remaining pollutant increases and significant atmospheric pollution is produced. Only a very small part of the components of oil dissolve, mainly the aromatic• elements (benzene, toluene, etc.). This process is 10 to 100 times slower than evaporation. The amount of evaporable compounds which dissolve is therefore generally very low.

Depending on the oil's viscosity• and the meteorological conditions, the motion of the sea mixing the oil and water can lead to water being incorporated in the oil. This can happen from a few hours and up to a few days after the spill. This reverse emulsification forms a stable substance, with a consistency comparable to mayonnaise. The amount of water incorporated varies from a fifth to four fifths of the total volume of the emulsion•, considerably increasing the volume of pollutant that needs to be recovered. The resulting product, which is often referred to as "chocolate mousse•" because of its appearance, is no longer dispersible. After several weeks of physical and chemical break down of its components, this "mousse" will form residues which may drift at sea for months before being deposited on beaches in the form of tar balls•.



Evolution of oil spilled in water

Evolution of oil in water

A litre of oil can spread over a surface area the size of half a football pitch.

(Source: WALKER J., MAWET D.-P. *Les marées noires : leurs origines et leurs effets sur l'environnement et l'homme**).

The oxidation process comes into play at the water surface on slicks and in open water on droplets. In this case the process is more specifically that of photo-oxidation•. This is a slow process, directly linked to light intensity and slick thickness, and breaks down less than one hydrocarbon chain in a thousand per day in intense sunlight. As a consequence, it has little part to play in the short term fate of an oil spill.

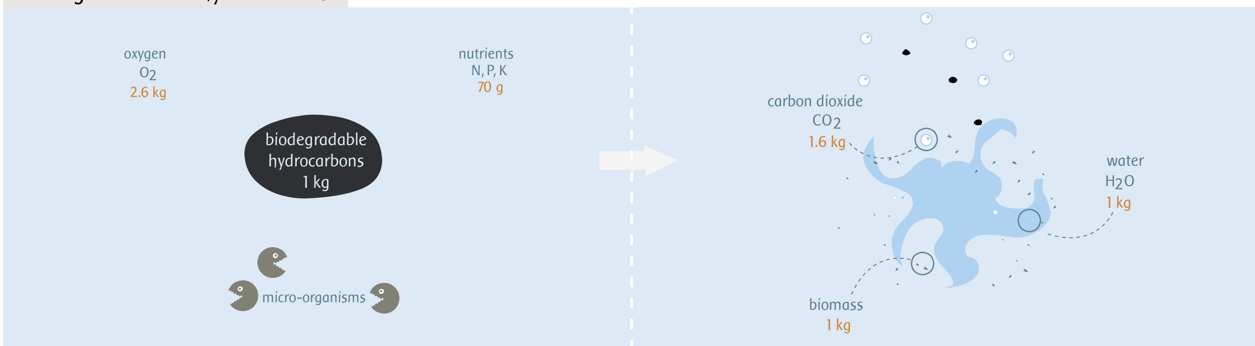
Recovery of "chocolate mousse"

Sedimentation affects a small fraction encompassing the heaviest products, including sludge• deposits, which settle into the depths of the sea. This phenomenon occurs over a long period of time and concerns generally only a small part (less than a twentieth) of the spill, except for very thick and heavy oils. Sedimentation is of great significance if a spill occurs in a shoreline environment where the oil can mix with sand or sediments, causing it to sink, such as happened in the *Braer*, *Erika* and *Prestige* incidents, making the oil very difficult to detect and recover.

Biological degradation or biodegradation is much slower than the previous processes. Biodegrading organisms are mainly bacteria (micro-organisms) which are naturally present in the marine environment. They gather and multiply on the surface of droplets, slicks and "chocolate mousse". The bacteria absorb certain hydrocarbons and use them as a source of metabolic energy. Living in water and using oxygen, they act at the oil-water interface. They are therefore far more efficient in reducing the remaining mass of oil when they occur on widely spread, fine droplets than on thick "chocolate mousse" or heavy products which settle on the seafloor and become incorporated in the sediments. Their widespread multiplication at the time of a spill can occur at the expense of other species, thus altering the ecological balance in the affected areas.

Weathering of oil in *Cedre*'s polludrome• (flume test): formation of a "chocolate mousse"

Biodegradation of hydrocarbons



More information

Oil, water and chocolate mousse: the title of a document published by Environment Canada on their website, providing in particular explanations on how to simulate an ecological spill experiment.

www.ec.gc.ca/ee-ue/default.asp?lang=En&n=937D1B31.

POLLUTION AT SEA

Impact

Oil slicks, droplets and "chocolate mouse•" particularly affect organisms which come to the surface to breathe, dive into the water to find food, or aggregate at or near the water surface. Oiling can be specific to certain organs, and interfere physically with the organism's movement, feeding and/or other actions. Oil slicks also have repercussions for floating solid waste•, navigation buoys, vessels, fishing gear, shellfish farming, rafts, net pens and so on.

Of all that can be oiled or intoxicated, the victims which particularly concern us are two groups of organisms: seabirds and mammals. Their lives depend on regular contact with the water surface; in the case of seabirds to find food and rest between flights, and for mammals, to breathe at the water surface. Hydrocarbons• on the water surface present a major risk of ingestion, inhalation and soiling of their fur or feathers.

The oiling of bird feathers causes a loss of thermal insulation, buoyancy and lift. For mammals that lick their coats, oiling leads to the risk of ingestion of oil. Other threats to wildlife are the risks of direct ingestion, irritation of the eyes and nostrils, inhalation of toxic vapours, suffocation by coating with oil as well as longer term toxic effects impairing the organism's metabolism.

Oiling of birds' plumage

(Source: IPIECA. *A Guide to Oiled Wildlife Response Planning*)

"The first, and often most important, effect on birds is external contamination of the feathers from contact with oil. This can cause a disruption of the delicate feather structure which traps warm air next to the body and keeps cold air and water away from the skin. Oil contact temporarily disrupts this intricate structure of barbs and barbules, thus interfering with the bird's ability to thermo-regulate. Most animals in these circumstances quickly become hypothermic (or hyperthermic) and will seek shelter to stay alive. Those reaching shore are often unable to find food, because of the individual's inability to return to the sea to feed. They become dehydrated and hypoglycaemic and are prone to predation."

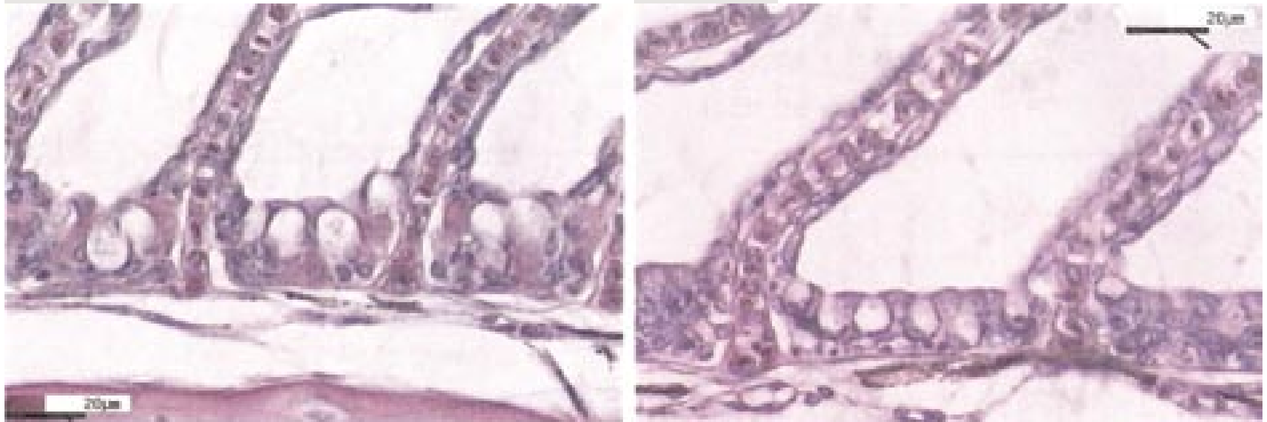
Oil particles dispersed in the water can accumulate on sensitive epithelial tissue (gills, mucous membranes, etc.), clog them up and lead to degeneration. Animals with affected filtering mechanisms can ingest enough oil to suffer a toxic effect whilst being incapable of feeding. Organisms with oiled gills are incapable of ensuring their oxygenation, and soluble hydrocarbons can enter the bloodstream through the respiratory tract. These cases are particularly common in filtering molluscs and open water and bottom-dwelling fish, when natural or chemical dispersion causes high concentrations of oil to enter the water column and persist for several days.

Oiling in the open sea also affects the surface layers of plankton. Plankton is the first element in the food chain which large marine mammals feed on.

Mammals are therefore also affected by the pollution, as are pelagic fish. The effects of the pollutant can be locally and temporarily significant for certain plankton populations which migrate from a few tens of metres deep at night, to near the surface during the day. However, the short duration of the cycle of these species and the high level of agitation of the water mean that the organisms lost due to the pollution are soon replaced, thus limiting the impact on the food chain.

Control

Intoxicated



Epithelial tissue from the gills of a control fish (left) and an intoxicated fish (right).
The intoxicated tissue shows a reduction in the thickness of the gill epithelium and the destruction of certain cells.

POLLUTION OF THE SHORELINE

When an oil spill reaches the shoreline, or occurs very near the coast, the phenomena of soiling and coating in oil can have an impact on the populations in the intertidal zone and the various human activities which take place by the sea. Marine birds and mammals are also obvious victims, such as numerous species of birds feeding on the foreshore at low tide

Rocky coast polluted by oil (↑)
Aerial view of a polluted rocky coast (↓)

and nesting on the seafront, or marine mammals resting on the shore. However, the algae, fish and shellfish which live in coastal pools, on the rocks and in the sand or mud, are inevitably affected.

Depending on the type of shoreline, the impact can range from being relatively limited to, at the other end of the spectrum, extremely dramatic. The sensitivity of different substrates• to oil varies considerably, from rocky coasts to pebble beaches, gravel, course-grain sand, fine-grain sand, marshland, coral reefs, and so on.

Rocky coasts

Exposed, steep rocky coasts provide an ideal surface to which large quantities of oil can stick. They are fairly quickly cleaned by the mechanical effect of subsequent wave action, and therefore suffer relatively little from oil spills•.

Rocky outcrops•, which may be submersed at high tide or in heavy swell, can be more severely affected, especially if the outcrop contains rock pools rich in flora and fauna, where thick layers of oil are likely to accumulate.

Beaches

Pebble, gravel and course-grain sand beaches are high risks areas in terms of profound contamination. Most hydrocarbons• can easily enter gaps and flow so deep that it is practically impossible to remove them without seriously damaging the populations living within the sediment substrate•.

Fine-grain sand beaches tend to retain oil on the surface, as the oil is most likely too viscous to penetrate into the depths through the fine spaces. Oil may accumulate along the high tide mark• and be covered over with a layer of clean sand of varying thickness. Beach growth• may cause layers of oil to be covered with sand, creating alternate layers. Buried oil is very problematic as the layers of oil may be uncovered by waves and swept away to then pollute other areas.

Mudflat and traces of pollution on the bank (↑)
Marshes polluted by the *Prestige* pollution (↓)

Mudflats and marshes

Intertidal marshland, including fish ponds, oyster pits and marshes, is particularly vulnerable. The networks of channels favour the transportation of oil towards very sheltered areas where low energy regimes and fine sediment retain them for long periods of time. Oil quickly and severely affects the populations of invertebrates living in the sediment, and the parts of plants in contact with the water. Human intervention in this type of site can lead to risks of disruption to the site and alteration of the ecological balance. Intervention in these areas should be well planned and carried out carefully.

Marine marshes in temperate areas, like tropical mangroves, are particularly sensitive to oil pollution. The respiration of the aerial roots of mangrove trees can be seriously impaired by even a thin lens of oil. Furthermore, numerous species live in these areas, some permanently, others on a seasonal basis, for many at the juvenile stage, when they are particularly vulnerable.

Oiling of a mangrove swamp during the season when young prawns feed there before heading out to sea can have serious consequences for coastal fishing and the biodiversity of the surrounding environment for several months, or even years.

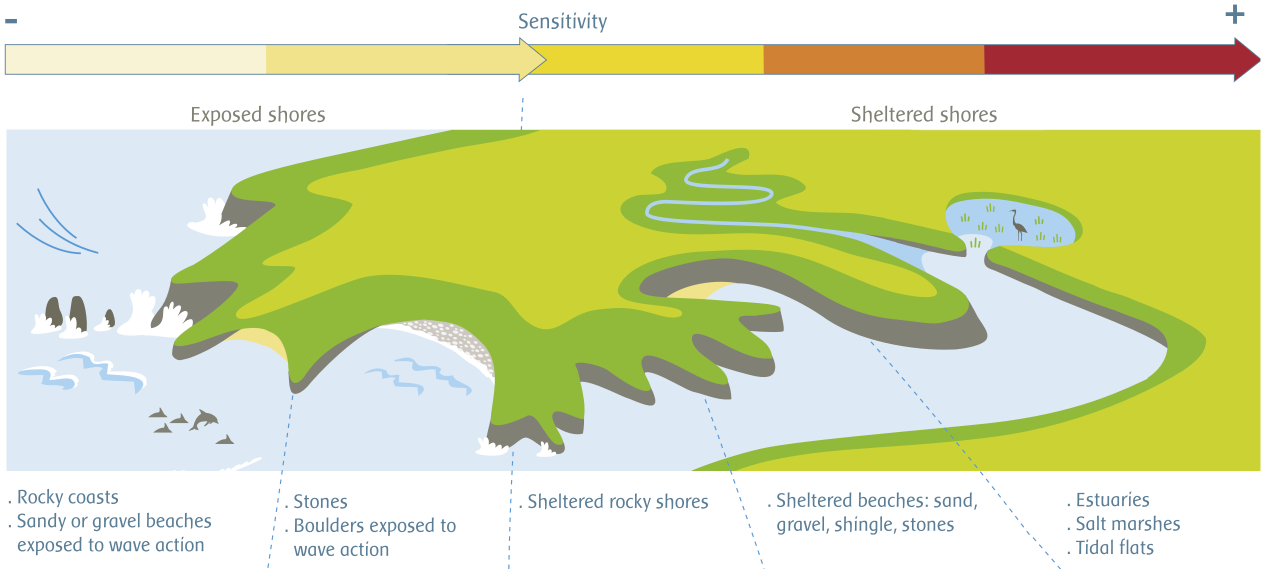
Coral reefs

Coral reefs are protected by mucus secreted by their polyps and thus generally resist small, isolated accidents fairly well. In addition, a protective layer of water usually remains between the corals and the surface oil slick. However, repeated pollution incidents can have a serious impact on them, as can large-scale oiling of the surface layer of reefs (the only living part of the reef) caused by the tides and swell. Some of the many species of fish, invertebrates and marine algae which live in coral habitats can be severely impaired even if the coral itself has only suffered mildly.

Pollution of a mangrove swamp

Sensitivity of intertidal ecosystems

Source: data from O'SULLIVAN A.J., JACQUES T.G. *Impact Reference System**



Human coastal activities

The arrival of oil at the shoreline can be detrimental to many human activities. Leisure activities are obviously affected. Going to the beach, swimming in the sea, recreational fishing, diving, surfing, sailing all become impossible amongst oil slicks, causing economic and social consequences which can be very significant in popular tourist regions. Port activities may also be interrupted, in particular when booms must be deployed to protect the vessels in port. Shellfish breeders and collectors can no longer work on the foreshore•, where their produce is oiled.

Aquacultural production at sea is inevitably affected. Coastal fishermen can no longer use their nets and other gear. The equipment that they cannot retrieve in time, or that they attempt to use, may be soiled. Aquacultural production basins find themselves without a water supply, as the polluted water would contaminate their products. The same goes for salt marshes.

Industrial and tourist activities which require a constant seawater supply (desalination stations, electric power stations, thalassotherapy centres, marine aquariums, etc.) can also be affected. All facilities and tools for human activity on the shoreline can be impaired, whether they are permanent (quays, seawalls) or floating (buoys, boats).

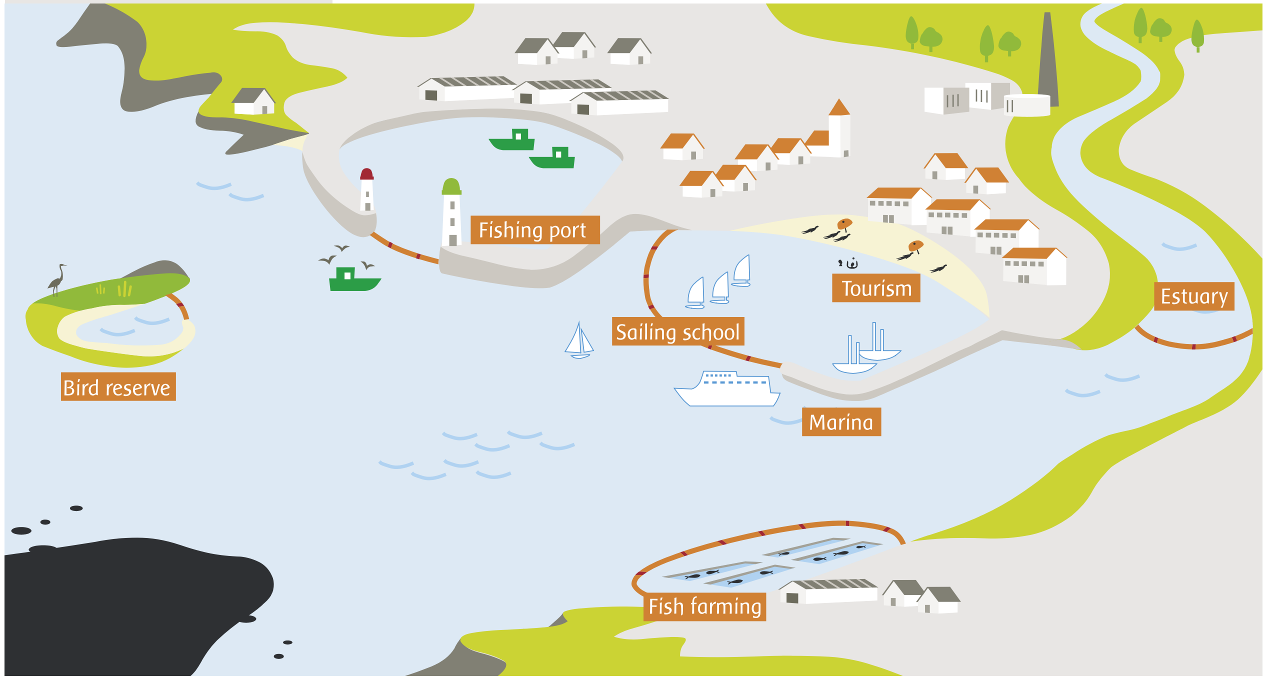
If the impact is mild and transient, it may generate only a slight inconvenience. If it is more serious, it can paralyse activities until clean-up is complete, or impose the destruction of stocks destined for future production. ■

Aerial view of an oyster farm

Cleaning up a marina

Protecting the port of Ploumanac'h (Brittany, France) during the *Tanio* pollution using booms

Protecting sensitive areas



IMPACT ON FLORA AND FAUNA

Besides the purely physical effect of oiling, flora and fauna can suffer from contact with oil through ecotoxicological and, in some cases, genotoxic• phenomena.

Direct effects

The direct effects caused by oil vary from one taxonomic group to another and within the same taxonomic group, from one species to another. Furthermore, organisms in the first stages of their development may be more seriously harmed than adults. Within the same species, the eggs, larvae and juveniles are generally more sensitive than the adults. However, this tendency, which may seem perfectly normal to us, as we are often tempted to see the young as more fragile than adults, is not a hard and fast rule. The larvae of certain segmented worms are more resistant to hydrocarbons• than the adults.

Lethal effects

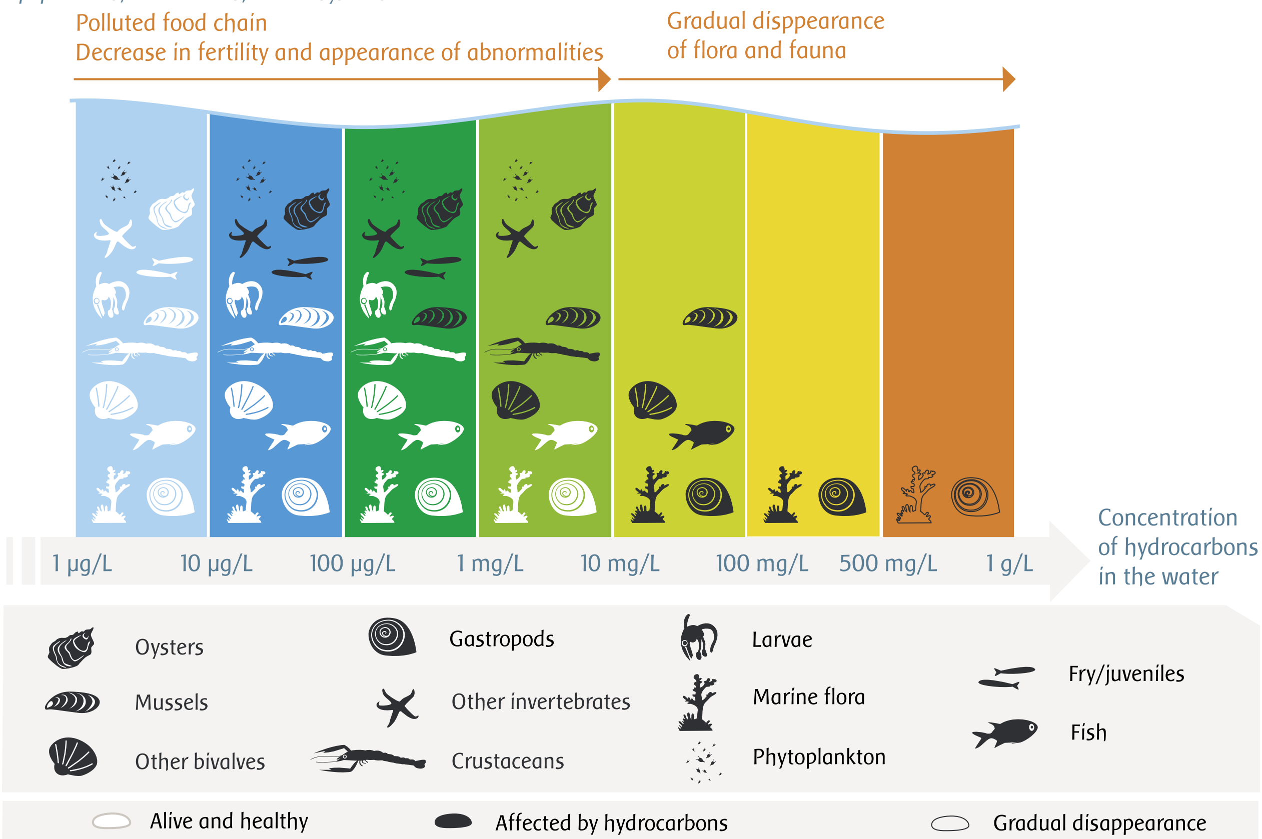
Aside from deaths caused by the effects of oiling, certain constituents of oil are incorporated in the water column•, taken up by the biota, and can be toxic for marine plants and animals. This toxicity can be acute, causing the rapid death of organisms exposed to oil by contact or ingestion, or causing serious disturbance to their basic functions. Delayed toxicity occurs when the organism's survival capacity is diminished, i.e. when there is a reduction in its growth rate, rate of reproduction, resistance to stress or to biological attack (illness, parasites, predators).

Acute toxicity is measured by the Lethal Dose 50 (LD50), the dose likely to kill 50% of the organisms to which it is administered over a given period. This expression of toxicity can be explained by the fact that all the members of a population do not have exactly the same sensitivity to any given toxic product. The LD50 measures the average sensitivity of a test population for a certain species.

Many laboratory-based studies have been carried out to determine the most toxic components of different oils. These are mainly aromatic• compounds (polycyclic aromatic hydrocarbons• or PAHs•), which are fairly soluble and therefore quickly available for marine organisms. Agitation in the surrounding environment is a significant factor in the generation of

Effect of hydrocarbons on marine organisms

Source: data from HYLAND J.L., SCHNEIDER E.D. *Petroleum hydrocarbons and their effects on marine organisms, populations, communities, and ecosystems*



concentrations of aromatic compounds. In conditions of mild turbulence, only the most soluble aromatic compounds enter the water mass. The others quickly evaporate before they have the chance to dissolve in the water. In strong turbulence, the least soluble volatile compounds also enter the water column.

Polycyclic aromatic hydrocarbons are the contaminants present throughout the marine environment; on the one hand, due to their high stability and, on the other hand, because of the multiplicity of their sources (burning fuel, various industries, incinerating waste, etc.). The higher molecular weight PAHs are considered the primary contaminants of both marine and terrestrial ecosystems for their potentially carcinogenic and mutagenic effects. Their toxicity results from the formation of metabolites (epoxides, dihydrics) by organisms, which bind with the DNA and result in malfunctioning.

Sublethal toxic effects

These are the effects which reduce the capacity of a population to retain an internal balance within its community.

This loss of balance can take the form of reduced growth rates or fertility (alteration of gametes), or increased mortality in larvae and juvenile stages. It can disturb communication between individuals or between them and the environment, causing, for example, an alteration in their migratory behaviour. It can also lead to stunted growth, either through a loss of appetite or a reduction in their capability of transforming food into energy. Finally, it can produce various physiological or behavioural changes. These changes can generate a reduction in resistance to stress and the capacity to find or consume food. Furthermore, they can also lead to late egg-laying and brooding.

Laboratory-based studies have shown a decrease in the activity of planktonic algae when in contact with non lethal concentrations of oil. Others have demonstrated behavioural troubles in crustaceans, in particular as concerns feeding. Others have brought to light a reduction in the adherence capacity of shellfish to rocks by their foot or their byssus•. These effects are however not always important, nor necessarily negative: cases of acceleration of metabolic activity have been observed in certain algae and high tolerance to the ingestion of oil has been demonstrated in certain seabirds.

In order to compare the results of laboratory-based experiments and the reality of the field, simplified natural environments (mesocosms) were constructed in several thousands to several tens of thousands of litres of seawater. Experiments, carried out in a mesocosm, provided interesting scientific results, which were however difficult to relate to real pollution in the natural, open environment. This is due, in particular, to the difficulty in reproducing, in these volumes of seawater, all the effects of dilution and agitation which occur in the natural environment, as well as the processes of recolonisation.

These sublethal effects of oil spills• therefore remain a vast and controversial subject for heated debates, which can be all the more intense when it comes to discussions about the compensation of medium and long term damages. In any one botanical or zoological group, these effects differ considerably between taxonomic groups and from one species to another, in relation to the physiology and the behaviour of the organisms. For example, in birds, a distinction can be made between species that are highly vulnerable to oil spills, being completely dependant on the marine environment (puffins, common guillemots, cormorants…) and species with a high adaptation capacity, which are therefore mildly vulnerable (gulls, terns, albatrosses…).

Cleaning an oiled seal (←)
Feeding in a clinic (→)

Bioaccumulation of hydrocarbons

The incorporation of even minimal quantities of hydrocarbons• in the tissue of a marine organism, through uptake of dissolved fractions across the gills or skin or direct ingestion of the pollutant, can affect its predators. If the pollutant is not broken down in the course of the organism's metabolic processes, it can become increasingly concentrated all the way along the food chain. This is the phenomenon of bioaccumulation• of chemicals through the food chain until they reach considerably higher concentrations than those found in the water.

At every link in the food chain, organisms consume around 10 kg of matter from the level below to produce 1 kg of their own living matter. If a contaminant passes from one level to another without being broken down, its concentration in the living matter multiplies nearly ten times at each link in the chain. Organisms at the top of the chain can therefore be exposed to very high concentrations of a product which did not affect the organisms further down the chain and can be detrimental to their health.

Hydrocarbon bioaccumulation is often put forward as a major concern when an oil spill• occurs. It has never been definitively proven in the case of oil spills, a subject which was broached in a French study, published under the title "Marées noires et environnement" (black tides• and the environment), which is discussed in detail in the final chapter (p95). This lack of proof does not imply that the risk does not exist. Fortunately however, many of the components of oil and petroleum• products are biodegradable at some level of the food chain. Only the rarer, high molecular weight PAHs• tend to have a significant bioaccumulation potential as far as the highest levels of the food chain. Therefore bioaccumulation, if indeed it occurs, is generally of a sufficiently low level to be masked by other clearer phenomena in the incidence of an oil spill.

Tainting

An alteration of the taste and smell of seafood is one of the phenomena which can often be observed after an oil spill•. Simple contact of hydrocarbons• present in the water with the skin or gills can give marine animals a taste and smell considered unacceptable by consumers. Such a taste, sometimes clearly perceived as an "oil-like" taste, sometimes simply recognised as different from the usual taste, is known as tainting•.

This particular effect is a serious issue in the management of the consequences of an oil spill. Molluscs, such as oysters and mussels, can absorb, through filtering, considerable quantities of hydrocarbons present in water. For example, a 20 gramme oyster filters some 48 litres of seawater per day. It can multiply the concentration of a pollutant in its tissues by 70,000 in relation to the surrounding environment.

Tainting can occur very quickly. It only takes a few hours to a few days of contact for the taste and smell to alter. Tainting can be tested through olfactory or organoleptic tests and can be quantified by analyses of the total hydrocarbon content in the organism's tissues. When transferred into hydrocarbon-free water, or when the pollution has ceased, the animals naturally purge themselves of the pollutant in a few weeks to a few months.

The tainting of crustaceans, fish and shellfish is common during an oil spill. The immediate response from authorities is to temporarily ban their collection or sale. It must then be determined whether the contaminated animals can be put on the market

Sea bass in an experimentation tank (↑)
Organoleptic test on sea bass (↓)

after decontamination or if they should be destroyed as a precaution. This question is an important issue in terms of the protection of consumers and the local economy, as well as the market reputation of the local seafood industry.

Indirect effects

Marine plants and animals do not live in isolation from each other. They develop in an environment teeming with a wide variety of biological interaction. This interaction goes from predator/prey relationships to situations of dependence, symbiosis, parasitism and other situations in which an organism or group of organisms provides a shelter or another necessity for one or several species in the community.

Members of all the groups of organisms - algae, bacteria, invertebrates, fish, birds, mammals – can be affected by an oil spill•. All damages caused by oil to individuals of a group may lead to changes in the structure and functioning of the biological community. Four broad types of indirect effects can be distinguished:

- death by starvation of organisms whose usual source of food is polluted, and where alternative food supplies are not available
- disturbance of certain interactions between species, due to the elimination or reduction of certain species
- large-scale proliferation of organisms which prey on the food usually consumed by other species present in the environment
- modification of habitats due to the loss of key species, such as seagrasses or mangroves, or the impacts of clean-up operations, such as the alteration or disappearance of the substrate•.

All these effects are temporary. After the imbalance caused by the pollution, then the proliferation of resistant, recolonising organisms, the former balance is gradually restored, except if new pollution arrives. However, this return to normal can take years. ■

Follow-up of botanical restoration

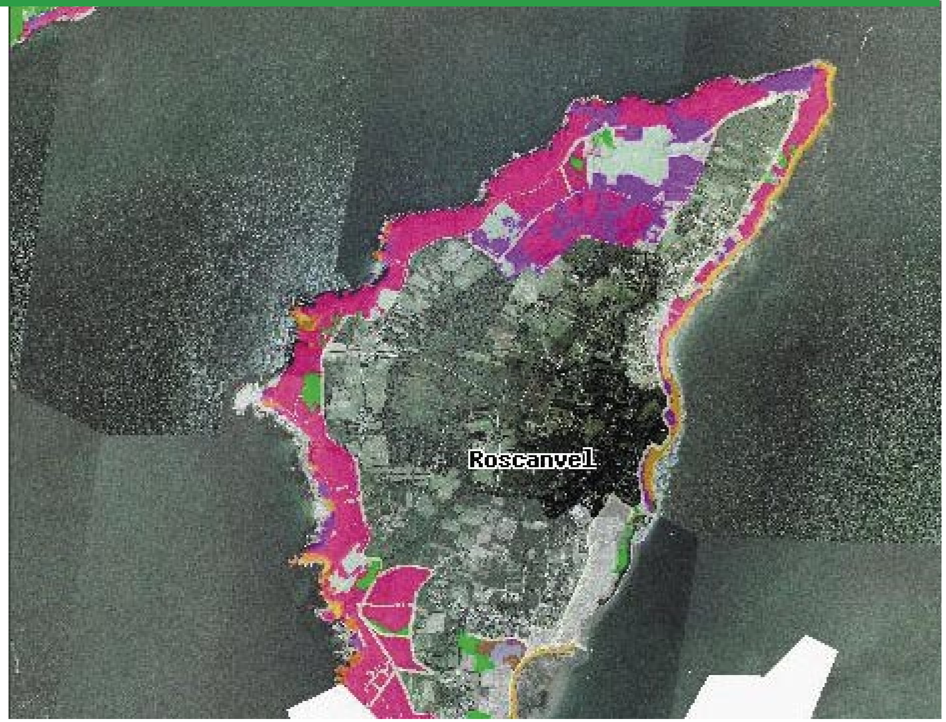
Reference condition

The contamination of the environment and the ecological impact of pollution can only be fully appreciated when compared to reference values providing an accurate representation of the situation before the accident. The creation of reference conditions• is the only way of demonstrating the causal relationship between the spill of pollutant and the effects subsequently observed. This implies that the information provided by these reference conditions must be coherent with the particular needs of the ecological follow-up, in order to provide an objective impact report. To fulfil this need, and due to a growing demand for information on the state and evolution of benthic flora and fauna, Ifremer (the French Research Institute for Exploitation of the Sea), for example, launched and coordinated in 2001 and 2002 a strategy for setting up a new surveillance and reference data network for coastal benthic populations, known as the Rebent network. This network has been up and running since 2003. For more information, see www.rebent.org.

A reference condition of vegetation on land (France)

In 2000-2002, the French National Botanical Conservatory in Brest coordinated the development of a reference condition* for shoreline flora and fauna in Brittany and the Pays de la Loire (France). This work came as a response to the need, which had become apparent in the aftermath of the *Erika* oil spill, for a specialised tool to provide information on the issues affecting vegetation, which could act as a decision-making aid in the use of contingency plans for marine pollution. This reference condition made use of previously acquired knowledge and provided a diagnosis of the flora (species) and the patrimonial shoreline vegetation (vegetation communities or habitats), with a particular focus on formatting the information necessary for those responsible for the fate of the natural heritage. To the information which was already available was added an interpretation of aerial digital photos georeferenced by the work of botanists and phytosociologists who listed, mapped and described in detail the sites of different species of vegetation and their habitats of high patrimonial value. The map below shows the Roscanvel peninsula in Finistère, France, on a scale of 1:25. For more information see www.cbnbrest.fr/botalittoral/ (French only).

- Salt marsh
- Brackish to halophilic prairie
- Salt marsh and/or brackish vegetation
- Aerohaline grass and chasmophytic vegetation
- Sandy or pebble beach
- Dune
- Small water body, pool, basin
- Moor and/or bush
- Wooded area
- Nitrophilous wild land or ruderalised area
- Shell bed with or without vegetation
- Bare muddy or sandy substrate, creeks
- Humid non halophilic prairie, bog, megaphorb herb layer or reed bed
- Agricultural land bordering shoreline
- Urbanised or man-made area
- Coastal path, road or embankment
- Mosaic of habitats



FACTORS AFFECTING IMPACT

Spill characteristics

The quantity and type of oil spilled determine, to a great extent but not exclusively, the significance of the impact on the marine environment.

A spill of several thousand tonnes will cause a lot more damage to the aquatic environment than a spill ten times smaller, although the oil type will play a significant part in the nature and extent of any damage caused. A spill of heavy fuel oil• is likely to cause much more damage than a crude oil• spill of a corresponding size. A spill of a slightly evaporable substance will in the same way be more damaging for the sea and the foreshore• than a spill of a highly evaporable substance.

The duration of spillage also plays an important role. A sudden violent release will concentrate the effects on a smaller area than a long, slow leak. Furthermore, if the effects are brutal, they may not be as likely to last as long.

The spill location is a fundamental factor in its impact. A spill in the open sea, such as that of the *Prestige*, will lead to limited impact spread over a very vast length of shoreline, over a long period, whereas a spill on the coast will have a massive effect over a more limited distance.

Spill context

The prevailing weather and sea conditions (wind, swell, tides, currents, salinity, temperature) influence

Drift of fuel oil slicks from the *Erika*

the viscosity•, spread rate, dispersion and destination of the oil slicks. Thus a drastic change in the wind direction saved the French Charente-Maritime region from a serious threat of pollution from the *Erika*, but instead impacted the Pays de la Loire region.

The time of year is also a factor which should be taken into account. The influence of the seasons on the water temperature and biological cycles is by no means negligible. Many species are more sensitive to oil pollution during their reproduction, nesting and migratory periods. For annual vegetation, the most sensitive time is the beginning of the growth period.

Other factors which directly influence the impact are the duration of exposure, the form and concentration of hydrocarbons•, the thickness of deposits, the degree of contamination of the substrate• and the chemical evolution of the hydrocarbons. Many of these are related to the degree of energy and water exchange in the receiving environments.

Finally, the presence of other pollutants and/or previous exposure to oil can increase the sensitivity of certain organisms to pollution, reduce the survival capacity of a biological community or cause the population of resistant species to grow in relation to sensitive species.

Mitigating impact

Suitable spill response measures taken at sea mitigate the impact of the spill on land. The choice of shoreline protection, recovery and dispersion measures is therefore extremely important. It is essential to reduce the arrivals onshore as far as possible, without aggravating the impact on the marine environment.

It is common to find long lists of damages caused by inadequate or excessive shoreline clean-up operations in pollution follow-up reports. However, without clean-up, pollution is likely to subsist for a long time or be reclaimed by the sea and continue to pollute other previously unaffected sites.

The key to successful shoreline clean-up is to remove what is necessary but no more, thus restricting the damage to beach entranceways and surfaces used for temporary waste storage to a bare minimum. It is therefore essential to ensure good communication between operational managers, response specialists and environmental experts. ■

ECONOMIC IMPACT

Response and clean-up expenses

Response specialists, bird and mammal salvage teams, professionals and volunteers gather in the area affected by an oil spill•. Specialised equipment and operators are called upon for response and clean-up. This major mobilisation of human and technical resources requires considerable, complex financing. The use of private means for slick surveillance and response at sea and on land (aircraft, fishing boats, public works equipment, agricultural equipment) adds further expenditure which can rapidly reach immense sums.

The oiling of fishing vessels and equipment and water intakes in aquaculture or industrial facilities leads to activities being suspended during clean-up, meaning a loss of time and money.

Clean-up worksite

Who manages response?

(Data source: ITOPF)

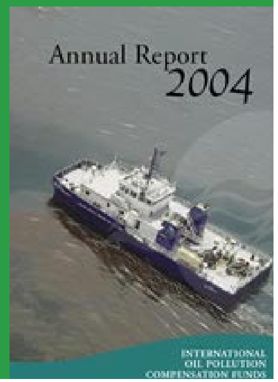
The authorities in charge of the organisation of oil spill response differ from one country to another. Within Europe, the competent authorities can be divided into three broad categories. Certain countries have chosen to place the responsibility for oil spill response in the hands of the ministry responsible for defence or internal security, such as Belgium, Denmark, France and Sweden. For others, it may be the ministry associated with maritime affairs which is in charge of response, for instance in Germany, Greece, the Netherlands, Spain and the United Kingdom. Finally, some countries have opted for the ministry for the environment, fisheries or natural resources, as is the case for Finland, Ireland, Italy and Norway.

Further expenses may be incurred to replace fishing equipment that cannot be brought in due to the impossibility of going to sea or equipment that is too damaged to be reused, for example pumps whose motors have overheated and blown. These replacements are not always immediately available, causing further delays and therefore further loss of revenue. All these costs are part of the immediate damages caused by oil spills, claimed from the polluter and his insurers, by those who have incurred them.

Two examples of costs

The 2004 annual report of the International Oil Pollution Compensation Funds (IOPC Funds•) positions the *Erika*'s case at 99.258 million Euros of clean-up costs and approved economic damages, with 65.883 million Euros still awaiting judgement for reimbursement. A further 334 million Euros of claims put on hold by the French State and Total should be added to these amounts. The sum total reaches an overall cost of a little over 499 million Euros, for 20,000 tonnes of fuel spilled, i.e. 25,000 Euros per tonne.

At the same date, the claims connected to the *Prestige* were calculated at 711.274 million Euros for Spain, 92.141 million for France and 3.305 for Portugal, giving a total of 806.72 million Euros for 63,000 tonnes of fuel spilled, i.e. 13,000 Euros per tonne.



Purely economic damages

The inaccessibility of coastal waters to fishermen and sailors together with fishing bans interrupt fish landings, and the buyers at fish markets find themselves without any produce to purchase. Suppliers of ice, fuel for fishing boats and food for aquaculture find themselves without any customers. Forbidden access to beaches leads to a decrease in the activity of restaurants, cafés and shops, which in turn reduce the produce they purchase for consumption.

Behind the economic operators directly affected by the material impossibility of continuing their activity or selling their produce, a chain of suppliers and customers find themselves affected to a varying extent, according to the dependence of their revenue on the activities disrupted by the pollution. Wages are suspended, local consumption decreases, social charges are no longer paid, and unemployment benefits must be allocated. Claimants also want to see secondary effects taken into account in compensation.

Expenditure: the cost of protecting an oyster farm using fine-mesh plastic netting

Expenditure and loss of revenue: closing off a port using a containment boom

Consumers of sea-related produce, tourism and other resources in the area hit by the pollution naturally turn to other areas to satisfy their needs. These other areas logically do their best to satisfy these new customers and build up their loyalty. Once the environmental situation has been re-established in the affected area, further expenses must be incurred to retrieve the lost clientele. Accurately assessing this expenditure is no easy task, all the more so as the loss of customers extends beyond the polluted area. The media rarely specifies the exact boundaries of the affected zone and easily assimilates peripheral areas to the actual pollution in overly simplified maps and diagrams. The damage in these circumstances is not a consequence of the pollution itself, but rather of the effect of the media.

Precise quantification of the various damages poses a multitude of complex problems and compensation claims are often the source of conflicts which must be resolved in court. Not only must the court determine the sum total of losses and expenditure to restore the situation, but also to what extent the losses and expenditure are really due to the pollution. ■

La Administración central estudia la posibilidad de adelantar el pago de las indemnizaciones

El seguro del 'Aegean Sea' dispone de 100 millones de dólares para reparar los daños

El Gobierno adelantará unos mil millones de las indemnizaciones

La CE dará a mariscadores una ayuda de más de 40.000 pesetas

El rastro de pérdidas del «Mar Egeo» tardará en disolverse

Siniestro del «Mar Egeo»

LA OFICINA DE RECLAMACIONES ESPERA RECIBIR UNAS 3.000 PETICIONES

Press cuttings commenting on the financial losses of victims of the *Aegean Sea* in Corunna, Spain (1992)

Response

How are response operations carried out?

- Organisational framework
- Carrying out response
- Response at sea
- Response on land
- Waste disposal

ORGANISATIONAL FRAMEWORK

International conventions

Because oil spills ignore international borders, the member States of the International Maritime Organization complemented the International Convention for the Prevention of Pollution from Ships (Marpol Convention) with the International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), which entered into force on 13 May 1995. The signatory countries agreed to set up national and regional response preparedness systems and to respond to accidental oil pollution. They developed international relations in this field and required all vessels flying their flag, offshore rigs in their jurisdiction and maritime ports on their territory to have contingency plans to combat any pollution incident for which they are responsible.

Regional cooperation

Over and above international conventions, coastal countries in particularly exposed maritime areas are often party to regional cooperation agreements and conventions with a specific section on accidental spills, in a bid to harmonise surveillance practices and response standards by facilitating exchange and mutual assistance between coastal countries. The most advanced agreements and conventions include standard format pollution reporting systems, lists of equipment stockpiles and specialists in each country which may be made available to partners, manuals for common usage by responders and regular mutual alert and cooperation exercises.

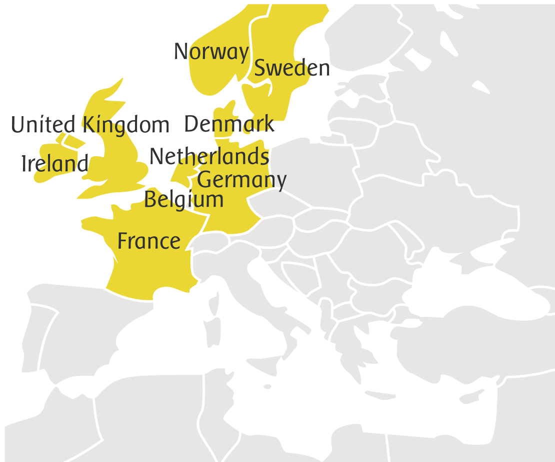
Regional conventions in force concerning EU countries

Source: data from the European Commission (Environment DG)

European Community Action Programme

Helsinki Convention

Barcelona Convention



Bonn Agreement

Agreements and conventions on operational and accidental release from maritime transportation and oil production cover all peripheral seas.

The conventions concerning the Mediterranean and the Caribbean instituted the creation of permanent bodies under the umbrella of the International Maritime Organization, known as regional marine pollution emergency centres (REMPEC in the Mediterranean and REMPEITC in the Caribbean).

Certain international agreements have more local vocations, such as the Ramoge Agreement, involving France, Monaco and Italy for the area from Saint-Raphaël (France) to Genoa (Italy). There are also several bilateral agreements in existence.

More information

Certain agreements or associated organisations have websites which provide information on regional maritime traffic, accident case histories, regional prevention and response measures and means for accidents and operational discharge*. The following sites are of particular interest:

- Bonn Agreement (North Sea): www.bonnagreement.org
- Helsinki Convention (Baltic Sea): www.helcom.fi
- Barcelona Convention (Mediterranean): www.unepmap.org
- REMPEC (Mediterranean): www.rempec.org
- REMPEITC (Caribbean): www.rac-rempeitc.org
- PACPOL (Pacific): www.sprep.org/publication/pub_ detail.asp?id=148

Other regional conventions and agreements cover numerous other maritime areas, outside of the European Union.

For instance, the Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP) was adopted in September 1994 as a part of the Regional Seas Programme of the United Nations Environment Programme (UNEP). This regional cooperation involves China, Japan, Korea and Russia. Within this framework, a Regional Oil and Hazardous and Noxious Substances (HNS) Spill Contingency Plan is currently being worked on.

Agreements in the European Union

- the Helsinki Convention on the protection of the marine environment for the Baltic Sea
- the Bonn Agreement for cooperation in terms of oil pollution response in the North Sea
- the Lisbon Agreement for the protection of the north-east Atlantic against pollution
- the Barcelona Convention for the protection of the Mediterranean Sea
- the Bucharest Convention on the protection of the Black Sea against pollution.

The example of France

France is a contracting party:

- for the Antilles, to the Cartagena Convention, on the Caribbean Sea and the Gulf of Mexico
- for the Réunion, to the Nairobi Convention for the protection, management and development of the marine and coastal environment of the eastern African region
- for French Polynesia and New Caledonia, to PACPOL (the Pacific Ocean Pollution Prevention Programme) on pollution response in the Pacific.

Finally, examples of bilateral agreements to which France is a contracting party are the Anglo-French Manche Plan for the Channel, the Franco-Spanish Biscay Plan for the Bay of Biscay and the Franco-Spanish Lion Plan for the Gulf of Lion.

Aerial surveillance

Cooperation in terms of aerial surveillance of operational discharge has been set up through the Bonn Agreement and the Helsinki Convention. The contracting parties carry out joint flights (known as tours d'horizon*) and exchange their observations of discharge, which are summarised on maps made available on the internet.

European environmental organisation

In 1981, the European countries set up a consulting committee for the control and reduction of pollution caused by oil spills• and spills of other dangerous substances at sea, within the framework of the Environment Directorate-General of the European Commission. In 2000, this committee created the Management Committee on Marine Pollution (MCMP), through which all European countries were represented.

The MCMP financed a permanent research programme, exchanges, exercises and training courses. Its members update the online Community Information System, which provides the responsible authorities in each country with permanent access to data on response arrangements and stockpiles• in other countries.

Through the MCMP, the European Commission also financed a specialised community intervention squad, capable of mobilising a group of experts and resources from member countries in a matter of hours to advise a European country or a country outside of the EU affected by an accident. In this way, each country can benefit from rapid and efficient support from other countries.

The pollution from the *Erika* triggered a decision by the European Parliament in 2000 to create a European Maritime Safety Agency (EMSA), based in Lisbon. The agency became operational on 4 December 2002, in a temporary base in Brussels.

EMSA's primary mission is to standardise and monitor maritime safety and the prevention of pollution, with a view to informing and improving on these aspects. EMSA has embarked upon an investigation into response means and strategies in the different European countries.

EMSA is also in charge of supporting European States in response to oil pollution at sea. In 2004, it was allocated a budget of 17.5 million Euros for 3 years to charter 4 high sea pollution response• vessels to be posted, in addition to national means, in the high risk areas of the Baltic Sea, the Channel, the Atlantic Ocean and the Mediterranean Sea. The first charters were contracted in early 2006. In addition, a European satellite imagery service in real time to assist with the detection of major pollution incidents and illicit operational discharge• is due to become operational in 2007. The agency has taken over previous major responsibilities of the MCMP, whose activities were terminated in 2006.

More information

Community information system: http://ec.europa.eu/environment/civil/marin/cis/cis_index.htm

European Maritime Safety Agency: www.emsa.eu.int

An example of European mobilisation

On 16 January 2001, the oil tanker• the *Jessica* grounded near the port of San Cristobal (Galapagos Islands) and began to spill her cargo into the waters of the Galapagos Marine Reserve classed as a world heritage site.

On 24 January, in agreement with the Ecuadorian Government, the European Commission sent a team of three specialists to assess the needs. The team made recommendations on the work in progress (in particular on recovering tar balls• on the shore). They identified the need for response training and the establishment of a contingency plan.

National organisation

As part of their obligations, all the signatory countries of international conventions have set up a national organisational framework for oil spill response.

Certain countries, such as the United States, require the polluter to mobilise and deploy the necessary human and material needs while the government agencies help to establish the objectives of the response and provide supervision. Through the 1990 Oil Pollution Act (OPA), the US requires all structures and vessels which may be liable to cause an oil spill to carry out mobilisation exercises and to possess a response plan, training certificates for their personnel and an assistance contract with a specialised pollution response services company. If the polluter can not be identified or is incapable of adequately responding, the Government will implement a response effort financed by a trust fund established from an oil import tax.

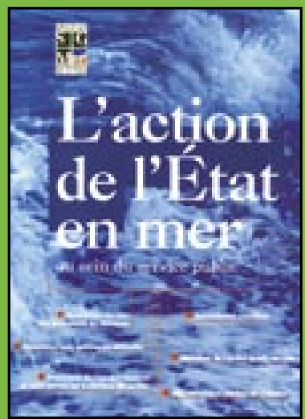
Europe has chosen the alternative option of placing their public services in charge of response. Unlike the United States, European countries do not have the power to impose the possession of a response plan or an assistance contract with a specialised pollution response company upon the vessels passing their coasts. European countries may therefore have to face a situation whereby the polluter is incapable of taking on response operations. This was the case for the accident involving the *Prestige*.

French and UK organisational frameworks

In the United Kingdom, the Maritime and Coastguard Agency is the authority responsible for pollution response in the marine environment. MCA comprises two directorates: the Directorate of Maritime Safety and Pollution Prevention (MSPP) and the Directorate of Maritime Operations (DMO). Under the responsibility of the DMO is the Counter Pollution Branch (CPB), which maintains stockpiles of equipment for pollution response at sea and onshore.

The UK coastline has been divided into 4 sections by the MCA: Scotland and Northern Ireland, Western, Eastern and Southern regions. Each region has a Maritime Rescue Coordination Centre (MRCC) and a Principle Counter Pollution and Salvage Officer (PCPSO).

Response is coordinated at national level by the Secretary of State's Representative for Maritime Salvage and Intervention (SOSREP), a position created in 1999. This coordinator has the power to bring under his control all the parties and organisations involved in an incident and to oversee, control and if necessary intervene in response operations in UK waters. He is appointed by the Government, but acts independently of all political power.



In France, the organisation of response and response preparedness is set out in an instruction known as the "Polmar instruction".

Response at sea is the responsibility of the *Préfets maritimes*, chief officers of the French Navy fulfilling a civil function. They must establish a response plan for their maritime region (Polmar Sea Plan), including an inventory of civil and military naval response means.

Response on land is the responsibility of mayors for small incidents and *Préfets de département* for pollution which affects several communes. The prefects coordinate the preparation and regular updates of departmental response plans (Polmar Land Plans). For major pollution incidents affecting several departments, zonal coordination is managed by the relevant *Préfecture de zone de défense*.

Cedre

The Centre of Documentation, Research and Experimentation on Accidental Water Pollution (*Cedre*) was created in 1978, in the aftermath of the *Amoco Cadiz* oil spill, in a bid to be more fully prepared for accidental water pollution and to strengthen the French national response organisation.

Cedre has the status of a non-profit making association and is responsible, on a national scale, for documentation, research and experimentation on pollutants, their effects and the response means and tools that can be used to combat them. Its expertise encompasses both marine and inland waters. Its response department is available around the clock to provide response authorities with emergency technical assistance and, if necessary, to send a specialist on site. *Cedre* has a workforce of 55 employees and is equipped with technical facilities for experimentation and training, where real spills can be recreated. Its annual budget, of nearly 4.5 million Euros, is provided by State subsidies and by public and private contracts.

See: www.cedre.fr

Polluter and partners

Aside from all notion of fault, the shipowner or the operator of the establishment at the source of the pollution, or one of their commercial partners, may voluntarily play a role in response. Their involvement, wherever possible, is sought after and appreciated by the authorities in charge.

In this regard, shipowners of oil tankers have at their disposal a technical advisory unit, the International Tanker Owners Pollution Federation Ltd. (ITOPF), which intervenes worldwide. Many also have access to crisis units, sometimes with personnel trained in pollution response.

The oil industry has created an association in charge of, amongst other things, promoting environmentally friendly response techniques, known as the International Petroleum Industry Environmental Conservation Association (IPIECA).

The main international groups have set up response cooperatives equipped with response resources prepared such that they may be delivered in a few hours across the world by aircraft.

Certain members of the oil industry also have an active policy of research collaboration to develop dispersants, bioremediation agents and anti-adherent biofilms made from alginates. They work towards refining clean-up techniques for sensitive sites or sites which are difficult to access, and to improve polluted wildlife rescue means.

Today, oil spill response often calls, according to the orders of the public authority in charge, upon a combination of national and international, public and private means. Furthermore, responders from both public and private sectors train and carry out exercises together, both on a national and international scale, to respond to pollution which ignores international borders.

Oil response cooperatives

The Total group created and manages the Fast Oil Spill Team (FOST), a rapid response structure based in Rognac, near Marseille (France). It is also a member of the largest emergency intervention oil cooperative which intervenes throughout the world, Oil Spill Response and East Asia Response Limited, which has bases located in Southampton (Great Britain), Singapore and Bahrain.

CARRYING OUT RESPONSE

Information

The first few hours and the initial actions taken to combat an oil spill are crucial. Retaining the maximum amount of oil in the tanks of a vessel in distress, dispersing a freshly spilt slick in the open sea, setting up containment booms efficiently and in time, mobilising well trained, equipped and supported teams at the appropriate moment, at sea and on land all constitute actions which work towards the same goal: to reduce the impact on nature and human activities.

The general response coordinator should constantly be able to adjust the response effort to respond to a situation which may evolve very rapidly. For this, he needs not only clear objectives and precise operational procedures, but also detailed information on the situation and its potential evolution. This information should be constantly added to and adjusted. The pollution must continually be located, its movement and fate predicted and its extent estimated. Coordinators must determine which sites to prioritise for response, organise response actions and eliminate false alarms which may be likely to draw upon response resources. This is no easy task in daylight and fair weather. It is extremely challenging at night and in bad weather. Analysing the situation at sea and forecasting its evolution in order to effectively manage response at sea and inform the land authorities of dates and locations of arrivals of pollution is a very difficult job. Remote sensing technology cannot, unfortunately, resolve all difficulties.

It may take several days for satellites to pass over the same geographical location and the accuracy and authenticity of such data is variable, as with airborne radars. The data obtained by land-based stations can be sent to users about one hour after its retrieval. The basic remote sensing tools continue therefore to be planes and helicopters. These two modes can work either simply as a means of visual observation by day or can use specialised sensors allowing observation by night and in a wide range of meteorological conditions.

Participation of an oil group in response

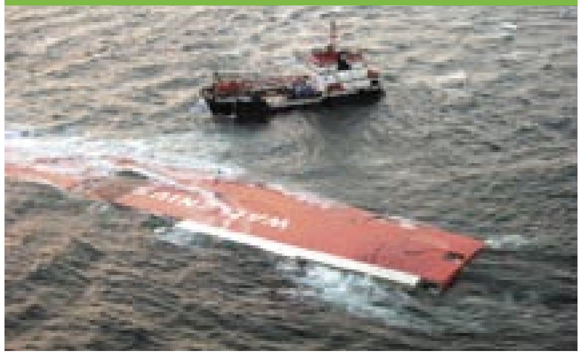
When the oil tanker the *Erika* sank, the French company Total (the cargo owner), in accordance with an agreement with the Polmar authorities, took responsibility for:

- clean-up operations on sites that were difficult to access, requiring specially trained personnel
- treatment of the wreck, to eliminate all risks of future pollution from the fuel oil which was trapped in the wreck
- treatment of the 270,000 tonnes of soiled materials recovered by shoreline clean-up teams.

French Customs' Polmar 2 plane

Participation of a shipowner in response

When the car carrier the *Tricolor* was shipwrecked in the Channel, the Scottish company Capital Bank and its insurers agreed to directly take on, under the direction of the French authorities, the removal of the vessel's bunkers, the cutting up and removal of the wreck and the recovery of the parts of the cargo spread over the seafloor.



Remote sensing of oil slicks

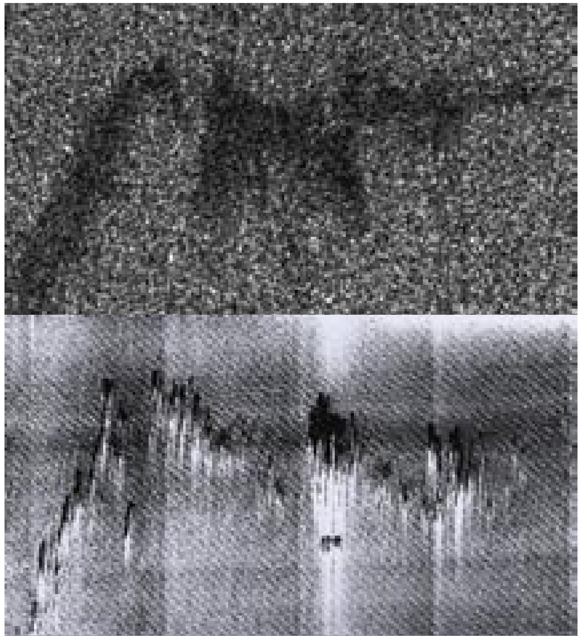
Aerial remote sensing

Remote sensing from aircraft is a complementary method of observation, in addition to observation by the human eye. A number of different sensing systems are able to detect the presence of hydrocarbons• on the sea surface, in certain sea and weather conditions. SLAR, the Side-Looking Airborne Radar, detects slicks according to differences in roughness (and therefore in reflection) of the water surface. Ultraviolet sensors can outline, in daylight, the borders of slicks. Infrared sensors identify the thickest areas of slicks by day and night. Microwave radiometers (MWR) distinguish and quantify slicks, however in practice their use remains relatively inaccurate. The laser fluorosensor, a heavier and less practical scientific tool, can distinguish the main oil categories, through the use of several reception channels.

The French Customs have two specially equipped planes for remote sensing pollution and recording data (Polmar 2 and 3). They are each fitted with a SLAR, a microwave radiometer, an infrared sensor and an ultraviolet sensor.

Satellite remote sensing

Satellites equipped with radar (SAR - Synthetic Aperture Radar) are a new means of detecting hydrocarbons at sea. Operational surveillance in the North Sea by SAR imagery has demonstrated that this observation technology, which is not affected by the level of cloud cover or daylight, enables aerial reconnaissance flights to be accurately orientated. After the example of airborne radar imagery, satellite radar imagery reliably shows discharge from vessels, thanks to the linear form of this discharge, over vast areas (to the order of 300,000 km^2). However, the use of this imagery meets with three principal constraints. First, the radar imagery requires advanced analysis to avoid false alarms or detection errors. Secondly, the number of satellites is not yet sufficient to provide daily cover. Finally, the treatment of imagery in real time is possible, but at a non negligible price. The cost of surveillance per square kilometre is nevertheless considerably lower than that of aerial cover. However, aerial surveillance remains necessary as it can be both flexible and focused.



Comparison of signatures of slicks observed by satellite and plane. The SAR signature of the slick obtained by satellite (↑) and the infrared signature obtained from the French Polmar 2 plane (↓) are in concordance with each other.

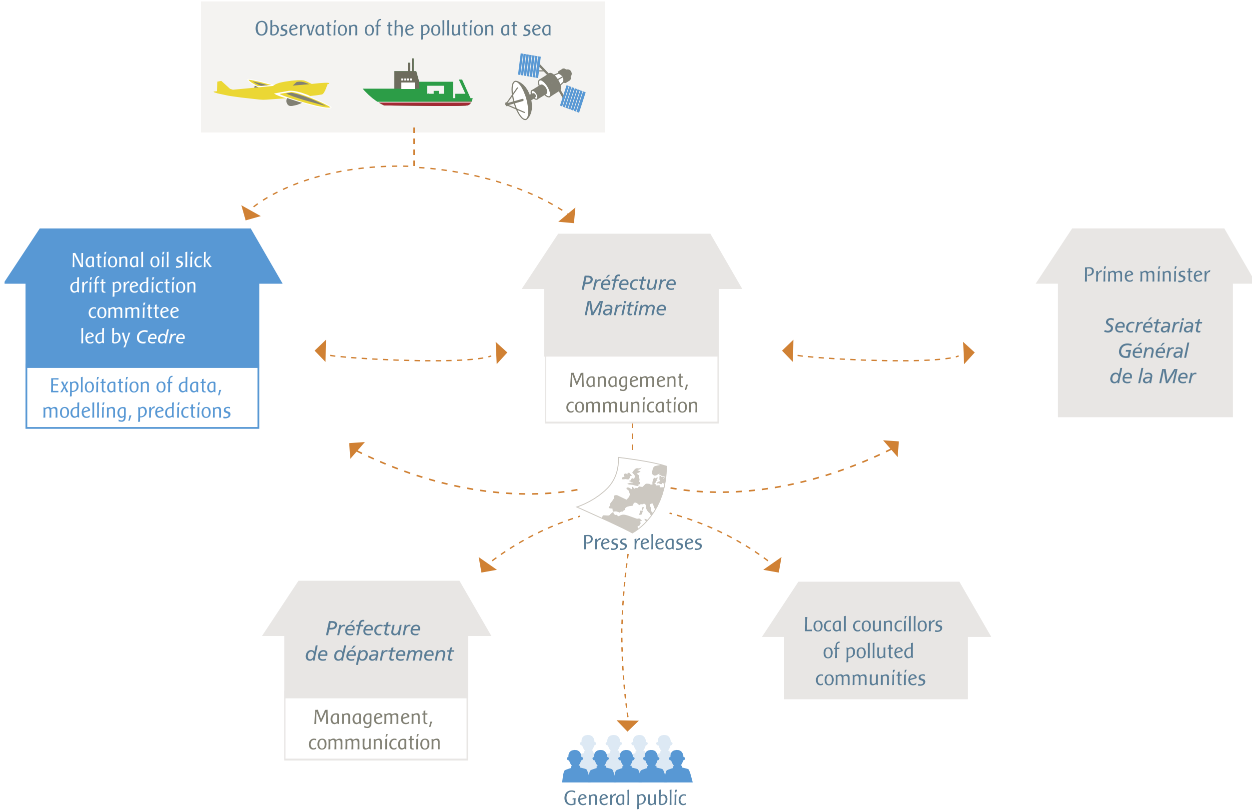
Specialised computer software exists which models the predicted drift of a slick taking into account the weather forecast and the currents; however the accuracy of these techniques is not perfect. They require, within a defined time period, accurate inputting of:

- the day's maritime and aerial observations (position of the pollution, comments on observations, flight plan, photos, imagery obtained by sensors...)
- data on seasonal or local currents provided by immersed drifting buoys (travelling below the surface) deployed in front of the pollution's edge.
- data provided by drifting buoys on the edges of the slicks.

This data is transmitted between operational services by email, to avoid the delays which would be caused by the transmission of paper copies and the risks of error through transmission by telephone.

As soon as the pollution hits the shoreline, reconnaissance should be carried out on land on a daily or twice daily basis. These reconnaissance efforts should be conducted according to rigorous procedures by specially trained personnel. They provide local response coordinators with accurate information on the operational characteristics of the site (accessibility, waste storage...) and on the characteristics of the pollution to be treated (impregnation of sediment with oil, alternate layers of polluted sediment and clean sediment, patches, patties•...). This information must also be transferred quickly and accurately from operators to decision-makers.

Information transmission in France during the *Prestige* accident



Prestige: a national slick drift prediction committee

The quality of slick drift predictions during the *Prestige* disaster was improved by the creation of a specialised slick drift prediction committee in France, which was based at *Cedre* and drew together all the competent organisations (French Navy, Météo France, Ifremer, SHOM). The resulting good quality of predictions facilitated decision making by the authorities in charge of response and their communication with local councillors and the general public.

Managing operations

Operations to combat a major oil spill• can require the mobilisation in a matter of days of tens of thousands of people from very varied backgrounds: civil and military servants of the State, civil servants and contract employees of the local authorities, personnel from private companies, volunteers from near and far, individually or in groups, and their management over a period of several weeks to several months. The vast majority of these participants have no previous experience in oil spill response. They must therefore not only be equipped, supervised, fed and given accommodation, but must also be trained in a few hours to play their role and to take precautions to avoid causing additional damage through poorly carried out response actions.

Training responders

Whatever the quality of the procedures laid out in contingency plans, it is difficult to avoid delays and inadequacies in the first few days when setting up operations. Negative images are promptly broadcast by the media, such as team leaders complaining about the lack of resources or the irritation of volunteers who feel useless and insufficiently supervised. Temporary disruptions can also occur, such as excessive collection of lightly oiled sand saturating the waste disposal and storage chain.

Clean-up worksite

Response to the *Erika* pollution

Response to the pollution from the *Erika* involved operations at sea and on land lasting for around 30 months, with an estimated total of around 400,000 man days of work. On the busiest days, the workforce reached some 15,000 people, not including volunteers, who were not recorded.

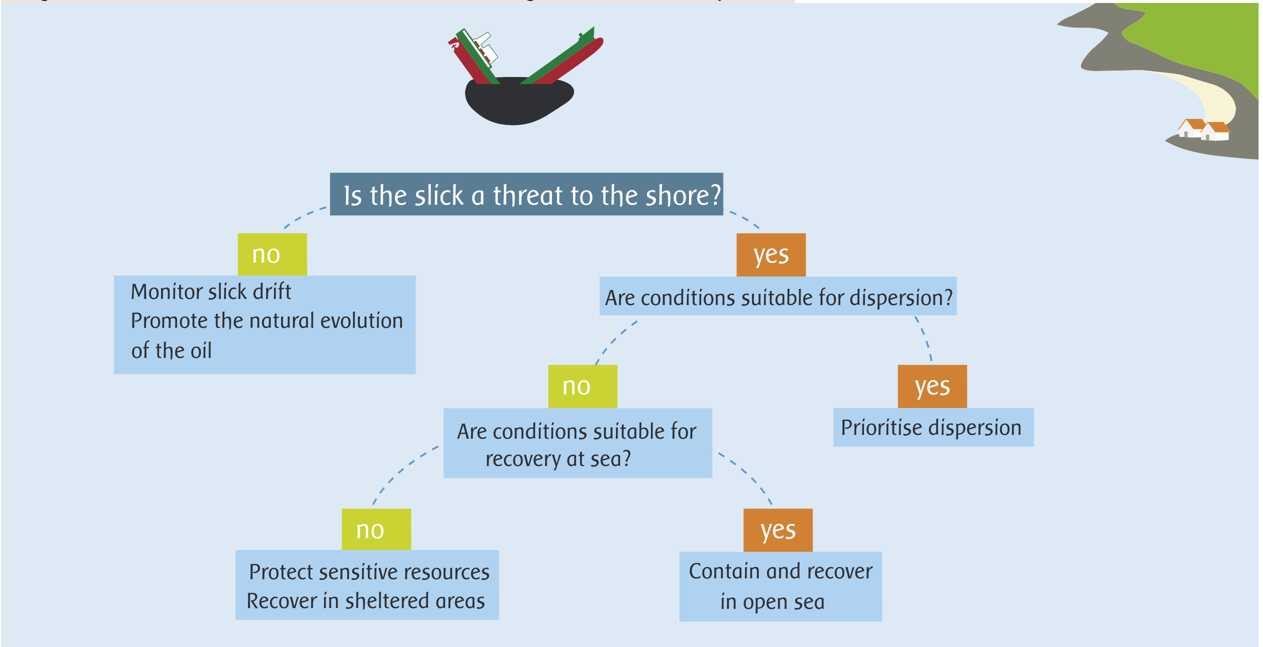
To manage the on-land side of operations, a zonal response centre, 4 departmental response centres (or permanent response centres) and 19 advanced response centres were set up, with interministerial coordination at the core.

Choice of response actions

This choice is in the hands of the response coordination unit, which is assisted by one or several scientific, technical and financial advisory groups.

Actions at the source	• Stop or reduce the spill • Make the vessel lighter (transfer contents into another vessel) • Contain or recover the pollutant • Disperse the pollutant • Burn the pollutant if this will not introduce new risks for humans and the environment
Response at sea	• Disperse in the water mass by spreading dispersants • Contain with booms and recover using pumps and skimmers • Trawl using skimming booms or vessels fitted with skimming arms • Spread sorbents on the slick and recover using surface trawlers
Response by the shoreline	• Act on slicks at sea close to the shoreline • Protect sensitive areas of the shore using booms • Direct drifting slicks towards areas of low sensitivity • Retain slicks in affected zones to avoid the extension of polluted areas • Contain and recover pollutant by the shoreline (same techniques as in the open sea) • Disperse carefully, by limited spreading of dispersants, under ecological control
Response onshore	• Set up clean-up worksites, with a good waste treatment chain • Limit response on very sensitive sites, such as marshes, to what is strictly necessary • Ban seafood sales and shoreline access where necessary • Evacuate and treat the recovered waste • When operations are complete, restore waste storage sites, altered access routes and soiled vegetation

Organisational flowchart to assist in decision-making in the event of a spill



Deploying an effective response may require several levels of actions, amongst which the allocation of responsibilities should be very clearly delineated. In France, three levels are generally distinguished:

- a general response unit: a single unit which coordinates the action
- zonal response units which manage response resources
- advanced response units which direct response teams and communicate information from the field.

The range of operational choices open to the response coordinator is restricted by a wide range of factors, including: the available timeframe during which response is possible, the sea conditions, the ecological characteristics of the area and the nature of the pollutant.

Possible response options can be categorised as follows: actions at the source, response at sea, response on slicks close to the shoreline and response onshore.

RESPONSE AT SEA

Lightering and burning

Recovery at sea and onshore is always difficult and very partial. Lightering, which involves transferring the cargo of oil from a stricken vessel into another vessel or a barge, is the best way of preventing or reducing pollution.

A slick on fire

For this, it may be necessary to call upon extra vessels or on extra equipment airlifted by helicopter onto the vessel in difficulty. Simple transfer pump units may be sufficient, however sometimes more complex systems incorporating safety devices, heating mechanisms and water injection, for viscous oils at ambient temperatures,may be necessary.

If a spill ignites during an incident, it will naturally reduce the amount of oil in the water. This phenomenon may occur naturally, when the accident results in an explosion, or when a spark produces a fire at the time of the spill. A form of spill response may involve controlling the fire without extinguishing it to reduce pollution. There have also occasionally been cases of slicks deliberately being set on fire when contained in fireproof booms (e.g. *Exxon Valdez* in 1989) and even of the vessel being set on fire (e.g. *Torrey Canyon* in 1967).

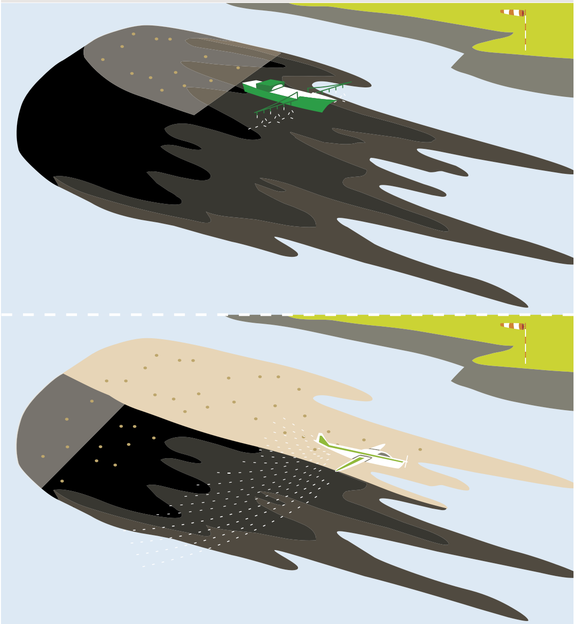
Deliberate burning remains, however, an exception. Technically, it can be applied to fresh oil before evaporation• of the volatile• parts and only in very particular conditions. The heat, combustion gases and soot released constitute other forms of pollution and tend to deter the decision to set the oil alight.

Dispersion

Dispersants• are agents which accelerate natural dispersion by wave action, facilitating the break up of slicks on the surface into a multitude of smaller droplets dispersed in the water column•. This facilitates the breakdown of the hydrocarbons• by bacteria which are naturally present in the water and reduces the local toxic effect.

However, the use of dispersants is limited by technical factors. They must be used in precise proportions and conditions. They remain inefficient on viscous or weathered oil. The decision to use dispersants in a particular situation cannot be put on hold, as dispersion is only an option in the first few hours or at the most the first few days. The decision to disperse the oil should be anticipated during the development of the contingency plan, depending on the characteristics of the zone. Most plans distinguish zones of free use of dispersants, zones of use in certain conditions and zones where the use of dispersants is prohibited.

Spreading dispersants by boat and by plane



In certain countries, dispersants undergo tests of their efficiency, toxicity and biodegradability. In France, these tests have been carried out by *Cedre* since 1978. The testing of a new product begins with the efficiency test, which determines whether or not the other tests are then carried out.

Spreading dispersants by boat and by plane

Dispersant toxicity

Dispersants• remain marred by a negative image. They have been accused of being more toxic than oil and of causing oil to sink to the seafloor, forming a deadly carpet of toxins.

These accusations are unfounded. Dispersants fragment oil into a multitude of droplets which spread out in the water mass, they do not drop to the bottom. Dispersing hydrocarbons• causes a temporary, local increase in their toxicity, while the dispersed oil spreads and dilutes through a vast volume of water to then become harmless.

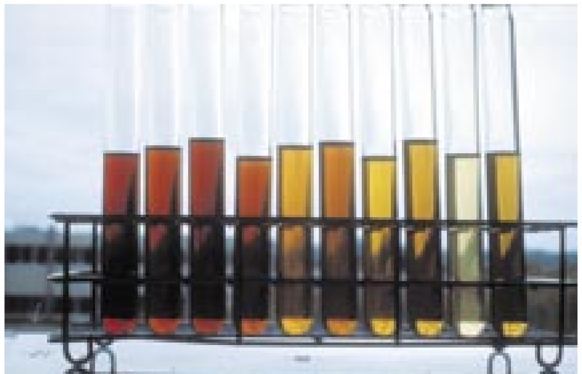
This effect implies a certain limitation concerning the use of dispersants near the shoreline and sensitive areas and/or when dilution conditions are low. However, recognised, modern, concentrated dispersants generally prove less toxic than dispersed hydrocarbons.

Testing pollution response products

Oil spill• response often involves the use of chemicals which facilitate the breakdown or recovery of the pollutant. There are several families of response products: dispersants, surface washing agents•, sorbents•, gelling agents/solidifiers, emulsion breakers, bioremediation• agents, film-forming agents•...

These agents are used in the natural environment. It is therefore important that they undergo testing to ensure that they are harmless. Procedures which aim to approve or accredit these products have been set up in certain countries for some types of products. Lists of authorised or recommended products can then be drawn up based on the test results.

In France, the majority of test methods have been standardised by AFNOR (the French standardisation association), in particular the test procedures for marine dispersants, sorbents and rock washing agents. *Cedre* is responsible for testing these types of products, with assistance from a working group led by the French Ministry of Ecology and Sustainable Development and Planning, made up of representatives from ministries and research organisations. This group establishes the criteria and the acceptance levels which apply to the products tested.



Testing dispersants

Testing sheet sorbents

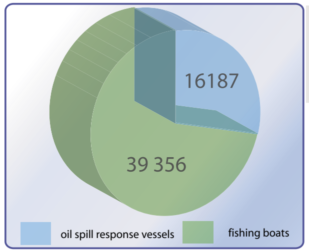
Containment and recovery

The aim of containment• and recovery operations is to remove the pollutant from the sea surface, at sea and near the coastline, before it hits the shore.

In the open sea, these operations are restricted by the sea conditions and the technical capacity of the available vessels. Specialised high sea oil recovery vessels are complex, very costly and are limited in their versatility. As the substance they recover contains several volumes of water for a volume of oil, these vessels must be able to store considerable quantities of oil-in-water emulsion• onboard. Emulsions can be treated using an emulsion breaker to separate the hydrocarbons• from the water and debris trapped in the emulsion, thus considerably reducing the extent of pumping operations and pollutant transfer. After settling•, the volume of oil which needs to be eliminated can be significantly reduced and the settled water can be released into the environment.

Near the coast, in sheltered bays and port areas, small barges, which can be transported by road or air, can be used. Their marine performance is relatively poor; however, their technical capacities of selective oil recovery (with a minimal amount of water) are good. They are often used in association with port storage barges or flexible tanks specifically designed for pollution response•, ensuring continuous recovery. These specialised vessels and barges are more effective on continuous thick slicks than on thin fragmented slicks. This method is often used on slicks which are contained by booms. The vessels are equipped with nets which can be used in dynamic mode (trawled by two boats) or in static mode (attached to fixed points).

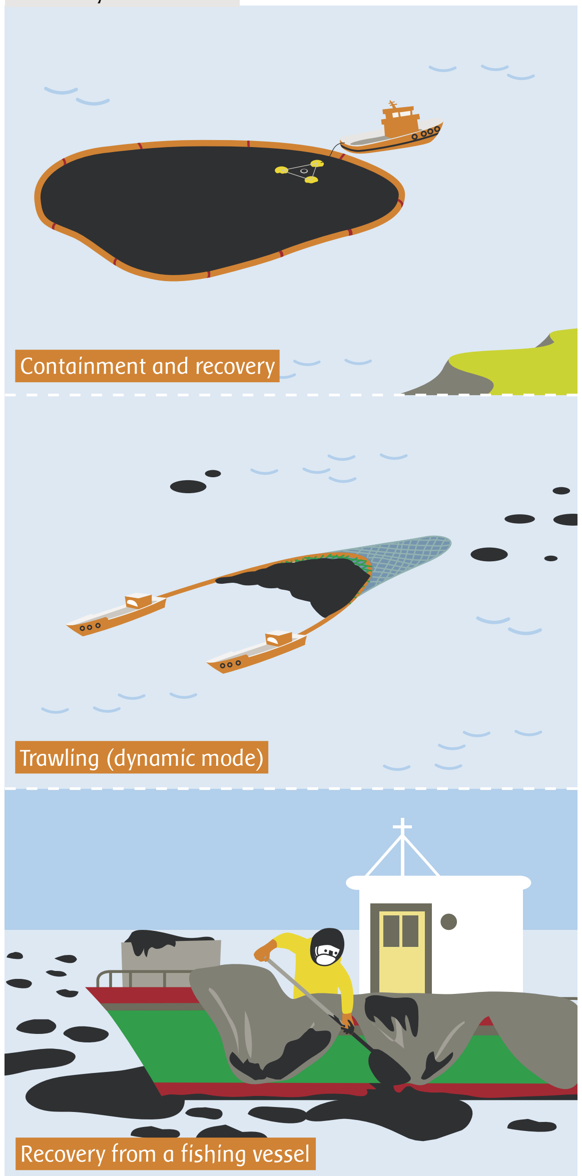
Experience of the *Prestige* pollution in the open sea, involving heavy fuel oil•, demonstrated the usefulness of fishing boats for the recovery of small dispersed slicks. These vessels, of which hundreds may be made available in an emergency, can cover far larger areas than the few dozen specialised response vessels and barges existing in Europe. Equipped with simple recovery means, similar to their usual work tools (nets, hand skimmers...), fishermen compensated for the low individual recovery capacity by their large number and motivation during response to the Prestige spill.



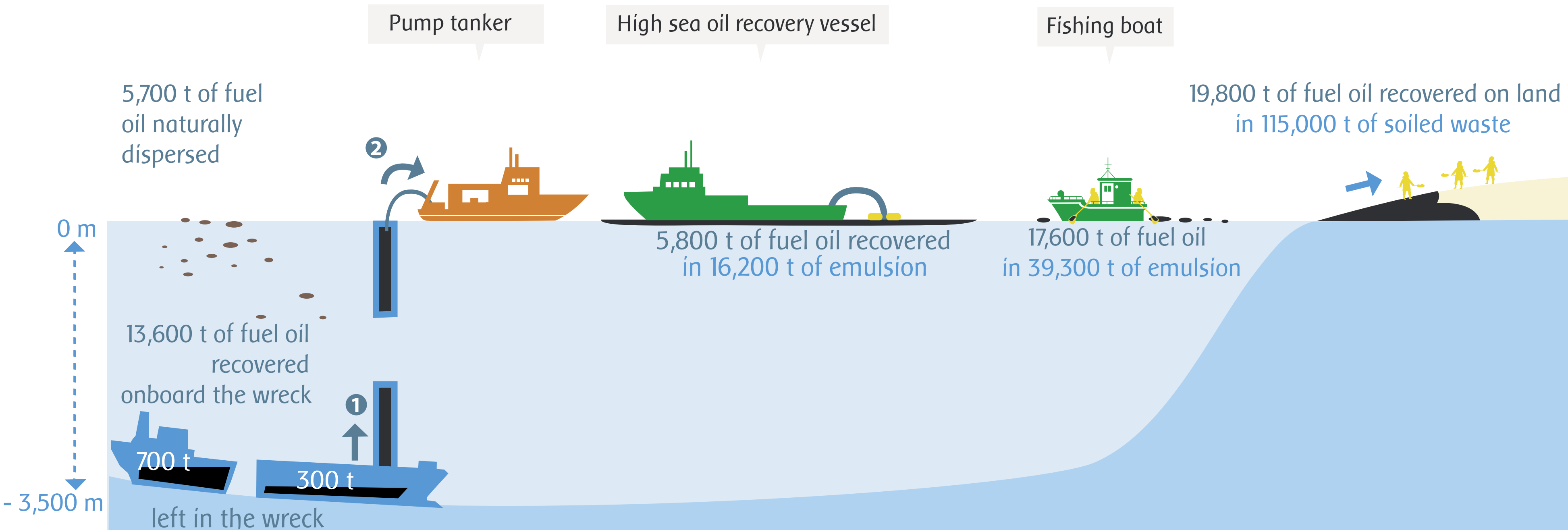
Polluted waste recovered during the *Prestige* disaster (tonnes)

Response means at sea: trawling a slick

Recovery at sea



Recovery of the fuel oil from the *Prestige*
Source: *Cedre*



An exceptional performance

Response at sea to the *Prestige* spill lasted 6 months, compared to only 11 days in the case of the *Erika* spill, before a storm pushed the slicks onto the shore. Thirteen oil spill response vessels and more than 1,200 fishing boats participated in the response, each crew with their own experience and tools. They recovered 55,500 tonnes of emulsion*, containing around 23,400 tonnes of fuel oil: an unprecedented performance in the history of oil spills*. The combination of specialised vessels, which were efficient on fresh slicks (thick and concentrated), and fishing boats (which intervened later by skimming* scattered patties* and patches), is illustrated by the above diagram.

Sorbents

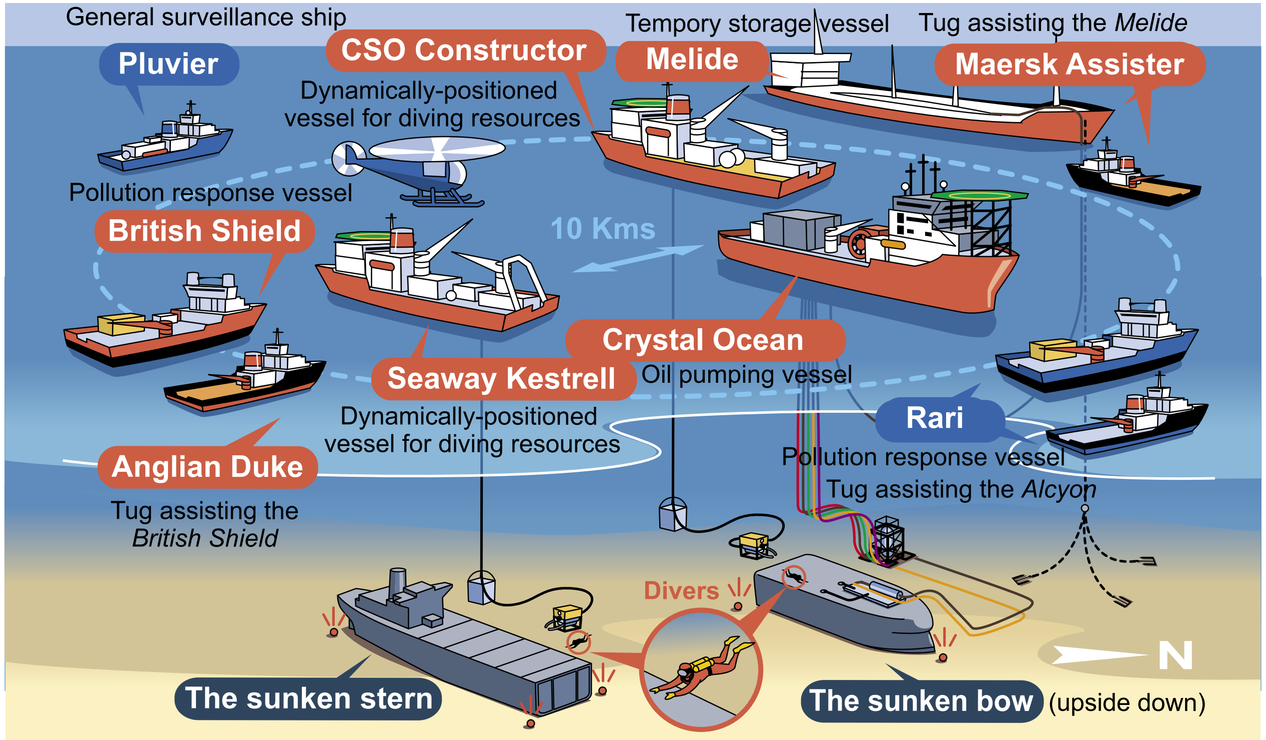
The use of floating sorbents• to retain and agglomerate oil or other pollutants in the event of an accident is a technique often used on calm water bodies and in ports to recover small spills. As a temporary measure, makeshift means can be used, such as straw or sawdust. These substances can be a good choice if they do not come into contact with water before or during the sorption process.

However, more suitable materials exist, in the form of low density products with the ability to prioritise sorption of the oil (oleophilic• property) rather than the water (hydrophobic property) and retain it in their pores.

These substances, known as sorbents, work due to two phenomena: adsorption• (whereby the pollutant accumulates on the surface of the sorbent) and absorption (whereby the pollutant diffuses into the mass of the sorbent). They are available in bulk•, in the form of powder, fibres, shavings, fine particles and conditioned, in the form of mats, sheets, rolls, booms...

There is no lack of sorbents or agglomerating products, from natural pine bark to the most complex synthetic compounds. However, more often than not, they are not used in the conditions which would maximise their efficiency.

Pumping the cargo out of the *Erika*
Source: Total



Treating the wreck

Despite all the operations which may be carried out at the source during a spill, if a vessel cannot be salvaged and sinks, significant quantities of pollutant may remain imprisoned in the wreck. This trapped pollutant is a potential future source of pollution.

For a long time, the prevailing principle was to do nothing, considering this risk of future pollution as a concern for future generations. Fortunately, this attitude has changed over the last few decades and it came to be established that a wreck should not be forgotten once response at sea is finished. Rather, it should be treated as soon as possible in order to reduce the risks of pollution to a minimum.

In 2000, 11,200 tonnes of fuel oil• were pumped out of the wreck of the *Erika*: a world record for the quantity recovered from a sunken vessel in the open sea. This record was later broken in 2004 by the 13,600 tonnes recovered from the wreck of the *Prestige*, in waters over 3,500 m deep.

RESPONSE ON LAND

Protective measures

Circumstances and timeframe permitting, certain measures should be taken before the arrival of the pollution on the shoreline, in a bid to facilitate the subsequent clean-up operations and limit the impact.

Collecting solid waste and natural debris onshore before the pollution arrives helps to reduce the amount of soiled material and facilitates clean-up operations. According to the extent of beachings, this collection can be carried out either manually or using public works machinery or specialised machinery such as sand screeners. Removal must of course be as selective and methodical as possible.

The apparent protection of bays, estuaries and inlets using booms can be somewhat illusory due to strong currents sweeping across their entrances. However, more limited areas can be protected. Contingency plans should define these areas and include suitable boom deployment plans, with pre-defined anchoring points.

Capture using a fine mesh net

Protection with filtering booms should also be anticipated for creeks, marsh creeks and water intakes in shellfish parks, fish farm basins, salt pans, thalassotherapy centres and other installations using seawater. The options vary according to the size of the sites needing protecting. The main resources available are gillnets, filtering barriers or dams made of earth and other materials. Some of these methods of protection combine the retention function of the dam and the sorption capacity of sorbents. The industry offers sorbent booms, suitable for relatively small quantities of fluid or finely divided substances. A net filled with straw can constitute a makeshift solution as long as the straw is changed often enough and correctly disposed of when soiled.

Filtering system made of oyster shells, feathers and pozzolana at the entrance to mud flats

The use of fine mesh nets attached to the foreshore at one end above the high tide mark is an effective method of catching clusters of oil beached at high tide. This technique is particularly productive on viscous, sticky pollutants, such as heavy fuel oil.

Adherence to a hard substrate can be reduced by spreading film-forming agents (biofilms) made from alginates which form a film on the substrate before the pollutant arrives. These substances are an effective way of reducing the adherence of oil to hard surfaces such as rocks, riprap and concrete walls. They facilitate clean-up and avoid the need to resort to high pressures or temperatures which may be harmful to the environment, as long as washing occurs at an early stage. They are not harmful to the flora and fauna present.

Finally, during recovery, measures should be taken to protect the soil and vegetation to diminish the impact of the pollution and of pedestrians and machinery. Heavy traffic on the shoreline without suitably adapted access can cause acute degradation of biotopes and contamination of the soil by machinery and soiled equipment.

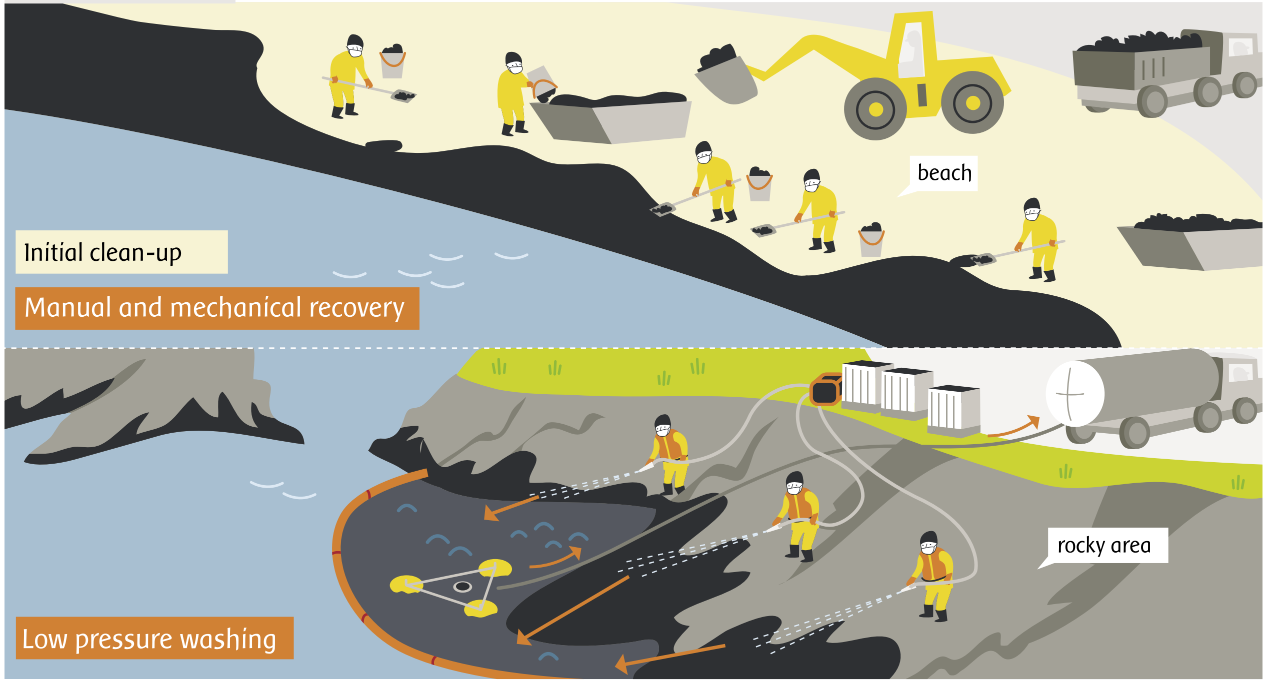
Initial clean-up

The first stage of shoreline clean-up aims to remove the maximum amount of pollutant from the shoreline to stop it being reclaimed by the sea, via waves and tides, and contaminating other sites. This first stage of clean-up requires different techniques depending on the pollutant and whether it is floating at the water's edge or has washed up onto the beach.

Skimming•, pumping and suction are the most common response options in the event of a major oil spill• by a fluid pollutant that has formed large accumulations. These operations can be carried out using agricultural pumps, slurry spreaders and sanitation trucks, as well as pumps and pump-tank units specifically designed for oil. This equipment can be complemented by surface scraping carried out by public works machinery or specially adapted scraper/ skimmer mechanisms.

On beaches, mechanical recovery using public works machinery or specially designed equipment (sand screeners•, rollers...) is a very productive method. It is however limited by the accessibility of sites to large or heavy machinery.

Recovery on land



Manual recovery

Manual recovery is systematically carried out whatever the pollutant, the site and the extent of the pollution. It is often the main, if not the only, means used in the event of small-scale or scattered pollution. It remains one of the most common options used to respond to a major spill. It is particularly well adapted to scattered beachings• in the form of freshly deposited tar balls• or patties•, before they are covered over or sink into the sediments. Manual recovery is the method used by default on sites where all other techniques are impossible, either through limited accessibility for equipment or because of the local environment's high level of sensitivity.

Public works and agricultural machinery, which is widely available and can be manoeuvred even on awkward sites, is often used for various tasks such as:

- scraping off thick layers of pollutant
- collecting and transferring offsite large quantities of pollutant and polluted materials
- clearing away clean sediments to uncover buried pollutant.

Selective sand screening equipment, which sieves sand to remove tar balls•, has been developed inspired by solid waste• screeners. These machines are well adapted to the recovery of tar balls and semi-solid patties on dry sand. The large machines are towed and the small ones self-propelled. Oleophilic• rollers are used to remove semi-liquid pollutant deposited on damp sand.

The use of a technique known as flushing•, involving washing using low pressure hoses, remobilises fresh clusters of pollutant deposited on the surface or trapped in the crevices of rocks in order to channel them to a collection point.

The technique of flooding•, the saturation of a beach with water, involves creating a flow from the upper part of the foreshore• to flood the area of sand that needs washing. This can be put in place using a perforated flexible pipe, parallel to the water's edge, that is supplied with seawater by a high flow pump. The flow sweeps away the freed pollutant with additional aid from hoses. Lighter pollutants float on the water, where they can be contained by a boom and recovered.

Surfwashing• involves moving polluted pebbles or sand down to the water's edge and depositing them in piles at low tide, to expose them to wave action. The waves free the pollutant trapped in the grains of sand or stuck to pebbles, ensuring natural washing by abrasion and collision. The waves disperse the piles and redistribute the sediments over the beach with the following tides. The freed pollutant is deposited on the surface, above the sediments. It can then be recovered by hand or caught using nets.

Initial clean-up worksites

Rock surface washing agents

There are two sorts of products which can be used to wash rocks depending on whether or not the pollutant is to be recovered below the area washed.

- If the pollutant is to be recovered, a non emulsifying washing agent• should be used. The pollutant can then be recovered using sorbents• or small skimmers.

- If the pollutant is not to be recovered, an emulsifying washing agent should be used. The pollutant should then be dispersed in the seawater. The use of this type of agent is necessarily restricted to small-scale pollution in areas of low ecological sensitivity.

As with all substances designed for use in the natural environment (effluent• discharge), these products should undergo tests to check that they are acceptable from an environmental point of view.

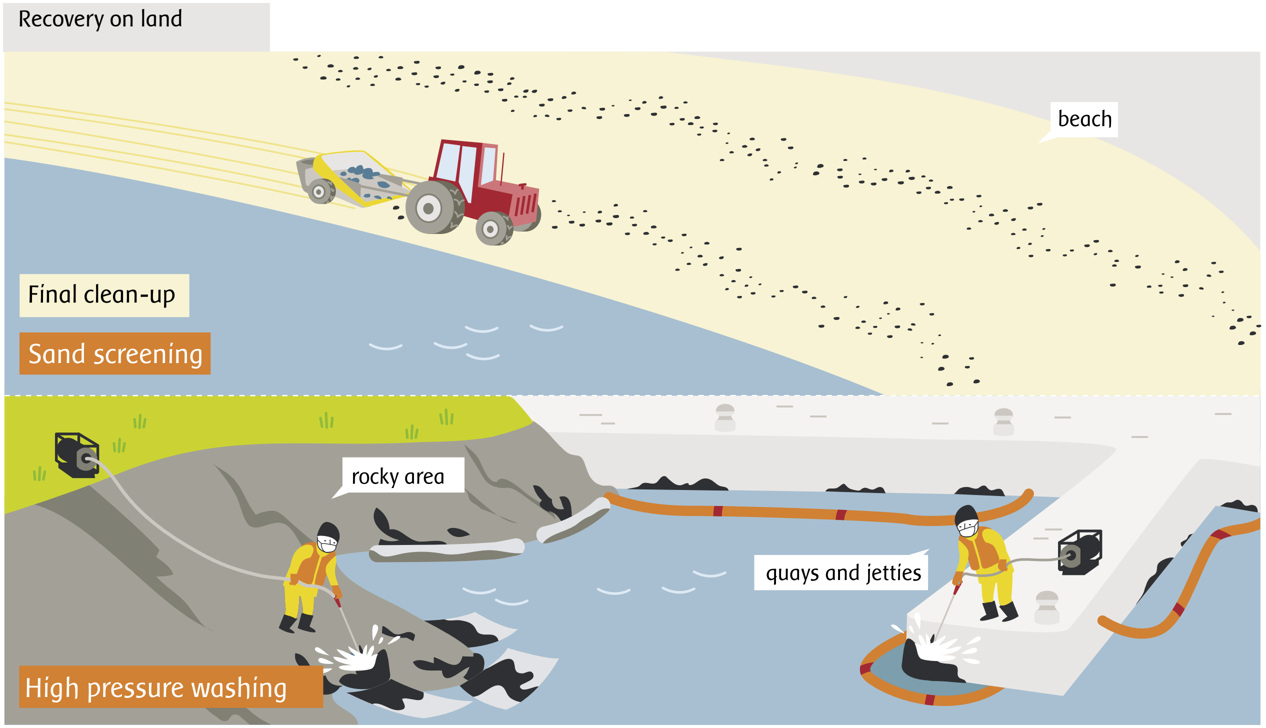
Final clean-up

Once the main part of the pollution has been cleared away and all risks of new arrivals of pollutant eliminated, the final clean-up phase can begin. Even if the sea naturally completes the operation, final clean-up by man is necessary when:

- the estimated timeframe for self-cleaning is incompatible with the economic or aesthetic constraints of the site (e.g. a popular tourist site during the pre-summer or summer season)
- the pollution may have a major impact on living, natural or cultivated resources or may become a source of chronic contamination.

The basic principle of final clean-up is to take advantage as far as possible of natural clean-up processes and only to recreate these processes where they prove to be of limited efficiency. The main mechanical, chemical and biological self-cleaning processes are:

- cleaning by wave action, the impact freeing fresh oil from surfaces as well as, on highly exposed sites, scouring the residues by abrasion of pebbles and rocks
- mixing polluted sediment by waves, separating the oil trapped in the sediment and placing it in suspension



- washing fluid oil through the sediment by forced percolation, with receding waves or the outgoing tide
- the effect of ultraviolet rays which destroy hydrocarbon films
- the activity of bacteria and micro-organisms which are capable of breaking down hydrocarbons.

A wide range of techniques is available and the choice depends on the site characteristics, the extent of the pollution, the nature of the pollutant and the required quality of clean-up. The determination of the techniques to be used, and the degree of cleanliness to be attained should take into account, amongst other factors, the ecological sensitivity of the site and its immediate surroundings.

As for rocks and port infrastructures, low pressure washing with cold water should be carried out on ecologically sensitive sites. High pressure washing, if necessary with hot water, can be used on non sensitive sites. Non toxic solvents can be used for port facilities. Sheet or bulk sorbents can be used on rocks and in shore pools. In the most exposed areas, the best solution is often to leave nature to do the job. As we will see later, the breakdown of hydrocarbons in this case is rapid and practically complete.

On stony beaches, after initial removal of oil, films of oil remaining on the surface should be washed using pressurised cold water and swept into recovery trenches on the lower foreshore. In the case of buried oil, either flooding can be carried out to free the pollutant and cause it to rise to the surface, or drains can be dug to accelerate natural washing, for example using the technique of surfwashing.

Stones can even be washed offsite, for instance in a drum adapted from a concrete mixer drum.

On sandy beaches, flushing, flooding, surfwashing and drainage techniques can be used. On dry sand, a second screening phase (possibly manual) can be carried out to complete initial clean-up. On damp sand, oleophilic rollers can be used. Finally, the technique of tilling frees fluid oil trapped in sediment and encourages natural break down. This technique can be used to complement screening operations.

Marshes and mudflats are areas in which oil tends to accumulate and cause serious ecological impact, through a toxic effect for light oils (chemical action) and by oiling and choking vegetation in the case of heavy oils (physical effect). Response in such cases is delicate due to difficult accessibility, low load-bearing capacity and limited circulation. Furthermore, it could have disastrous consequences for the ecosystem.

In very sheltered sites where clean-up operations would lead to additional damage due to the ecological fragility of the biotopes in question, not intervening can be a justifiable solution. Non-intervention should be a carefully considered and well argued decision in order to be justifiable in the face of public opinion and the media. This option does not consist of simply "doing nothing". It involves close monitoring of the site and of the evolution of the pollutant.

Once clean-up is finished, all or part of the polluted vegetation may be scythed or the crusts of weathered oil scarified to facilitate the reinstatement of vegetation. This must be carried out extremely carefully, under rigorous ecological control. Finally, all access routes created for the purposes of response and all waste storage facilities should be cleaned and restored to their original state.

Oleophilic roller pushed by a small caterpillar tracked vehicle (↑)
Clean-up by manual scything (↓)

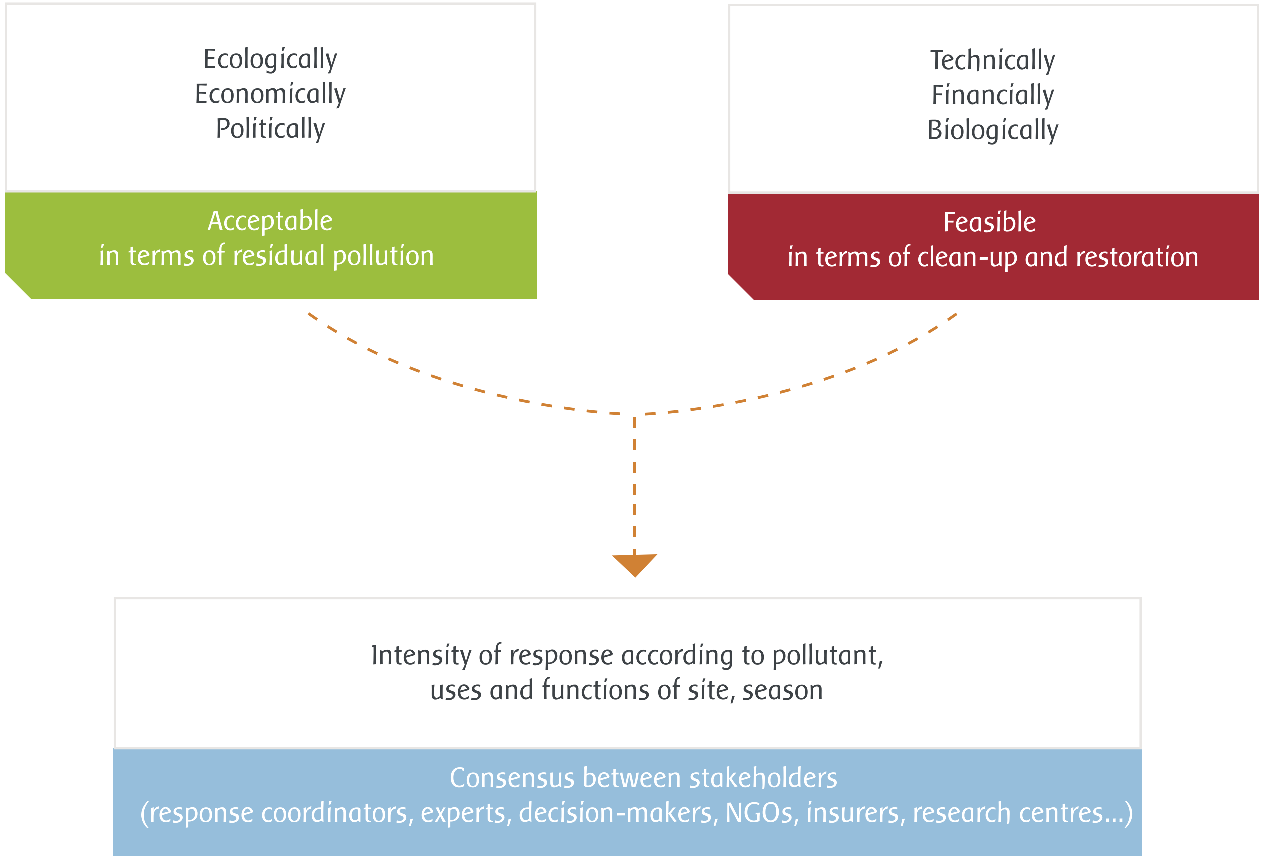
Botanical worksites

Sections of vegetation, in dunes or on rocks, may be polluted to a varying extent. Intervention in such areas is delicate and should be subject to a decision and specific recommendations made by expert botanists, who generally supervise the worksite. The term "botanical worksite" encompasses the sometimes extremely painstaking and time-consuming operations of scraping, brushing, scything, manual sand screening, suction and collection. The aim is to remove the maximum amount of pollutant without damaging the plant cover or the soil more than it is already damaged.

When to stop cleaning

The level of clean-up required and the urgency of completing it are dictated by the ecological sensitivity of the site, its uses and the season. Some members of the general public will always demand that the site be cleaned of the last trace of pollutant. However, this "spotless" cleaning, although satisfying, can cause more damage to the environment than the pollution itself. It is therefore necessary to assess the advantages and disadvantages of the available techniques and not to dismiss the option of natural completion.

In practice, any pollutant which may be remobilised, and constitutes a potential source of recontamination, should first be removed wherever possible. Once this risk has been eliminated, we must then question the utility of further intervention. Except in particular cases, such as popular tourist beaches, the aim is not to remove all traces of oil, but rather to provide the environment with the most favourable conditions for rapid reinstatement of populations and restoration of socio-economic activities, ensuring that the remaining pollutant is not harmful to the ecological niche or the site's uses.



Assessment of the level of clean-up to be attained

Bioremediation

Bioremediation consists of using biological processes to accelerate the decontamination of a site. Amongst the possible biorestoration techniques, biostimulation accelerates the development of bacteria naturally present in the environment and capable of breaking down hydrocarbons. This acceleration can occur by optimising the environmental conditions necessary for bacteria, in particular the presence of nutritional elements and the availability of oxygen. This is a finishing technique, which can be used in situ, whilst respecting the ecosystem, or on sediments transported offsite. Various members of the industry have greatly invested in this field, by participating in international research programmes on bioremediation techniques and developing products designed to accelerate the biodegradation of oil.

Offsite biorestoration is a technique whereby operational techniques for industrial treatment of contaminated soil are applied to some of the waste from the site. It is currently used for soiled sediments collected on beaches, in general through landfarming, i.e. spreading and tilling small quantities of soiled sediments on agricultural land, in the presence of natural biorestoration accelerating agents. Research has shown that cultivated plants in these conditions do not contain a single trace of hydrocarbons during the breakdown process in the soil.

In situ biorestoration was used on a large scale in the accident involving the oil tanker the *Exxon Valdez* in Alaska (1989), in a bid to provoke major acceleration of the elimination of biodegradable hydrocarbons through the provision of nitrogen and phosphorous.


Ploughing to encourage biodegradation


In situ biorestoration experiment


Wharf of the *Exxon Valdez* (Alaska, USA)

Cleaning birds and mammals

When an oil spill• occurs, the cleaning of birds and mammals is an important issue which attracts a lot of media attention. For a long time, this was more of a remedy for people's consciences than an operation of real ecological value, as few subjects survived for more than a few days after the stress and damage caused by the oiling, intoxication by ingestion of hydrocarbons• and cleaning.

However, cleaning techniques and products have been considerably improved and refined over the last twenty years. Today, there are specialised teams which can intervene very quickly in any part of the world, with products which have been specially adapted to their needs. Animals are no longer released as soon as they have been cleaned but rather are placed in feeding and swimming rehabilitation basins. These specialised clinics manage to save up to two thirds of the oiled organisms which are brought in.

Recent studies cast a shadow over this positive picture, highlighting the abnormally high mortality rate in cleaned animals during the months following their release into the natural environment. Affected by the pollution, their capture, cleaning and the biological and physiological effects of inhalation and ingestion of oil, some of the individuals rescued no longer have the defence mechanisms necessary to survive in the natural environment. Researchers are currently working to accurately monitor the fate of rescued organisms and to develop more effective and less stressful procedures, products and tools.

However, by far the most effective solution is to move as many birds and mammals as possible away from the polluted areas. This can be achieved by the movement of people and boats, and the noise of engines and flares.

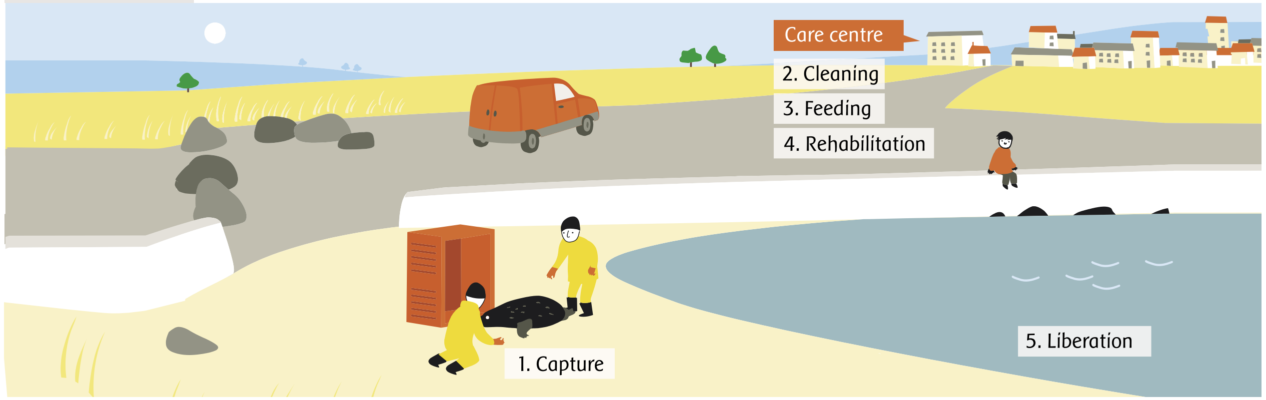
Bird scaring buoys, which can be launched from boats and emit several dozen different sounds in sequences of 20 to 50 seconds, have been successfully tested, without the birds becoming accustomed to the devices as quickly as with other techniques. They emit sounds which keep away 85% of seabirds within a radius of 800 metres for 3 consecutive days. They are autonomous buoys which can drift within an oil slick or can be anchored in front of a contaminated shore. They can also be used as a preventative means where there is a risk of a spill which may contaminate birds, such as on offshore oil platforms. ■

More information

The Yves Rocher laboratories, the CHENE Association (*Centre d'Hébergement et d'Étude sur la Nature et l'Environnement*) and the French oil industry have developed a bird cleaning machine and a mild shampoo.

This system treats animals more quickly than by hand washing and is therefore thought by certain care centres to noticeably reduce the stress generated by cleaning operations.

Animal rescue



WASTE DISPOSAL

Storage

Oil recovered at sea or arriving on the shoreline in the form of "chocolate mousse•" can contain up to 4 or 5 times its weight in water. This mousse soils sediments, seaweed, plant debris and often solid waste•, which are then collected with the pollutant in proportions of up to 20 times that of the oil. The pollutant and polluted materials recovered in response to an oil spill• therefore end up representing far greater quantities than that of the spill.

The recovered pollutant and polluted materials are not all waste in the technical sense of the term: certain parts can be extracted and recycled. However, it is common to merge them all in the expression "oil spill waste".

This waste can be in the form of liquids, pastes or solids. It can contain highly variable quantities of oil and water. It can comprise solid objects which make it unsuitable for pumping. Its transportation, storage and disposal make use of very different solutions depending on their characteristics.

Storage facilities are necessary at all levels of the recovery chain. Primary storage for a period of a few hours to a few days is unavoidable on the recovery site or nearby, as an intermediate between the collection and evacuation chains. It is generally accompanied by straining• off liquids and pastes to avoid clogging up the pumps, using filter baskets placed over storage tanks. Emulsions• which were not broken during pumping should be broken at this stage to avoid the storage of large quantities of water.

Intermediate storage facilities act as the link between evacuation and treatment chains. They are sometimes located on the coast, other times on the treatment site, and should be carefully prepared and made watertight to avoid polluting the substrate• and ground water.

When the quantities in question surpass the treatment capacities of existing plants, a final storage site may be necessary to store waste until a specific treatment plant is built.

Storage skip

It takes a considerable amount of work to install, secure, manage, dismantle and restore these different storage facilities. They also require a complete control and transport chain.

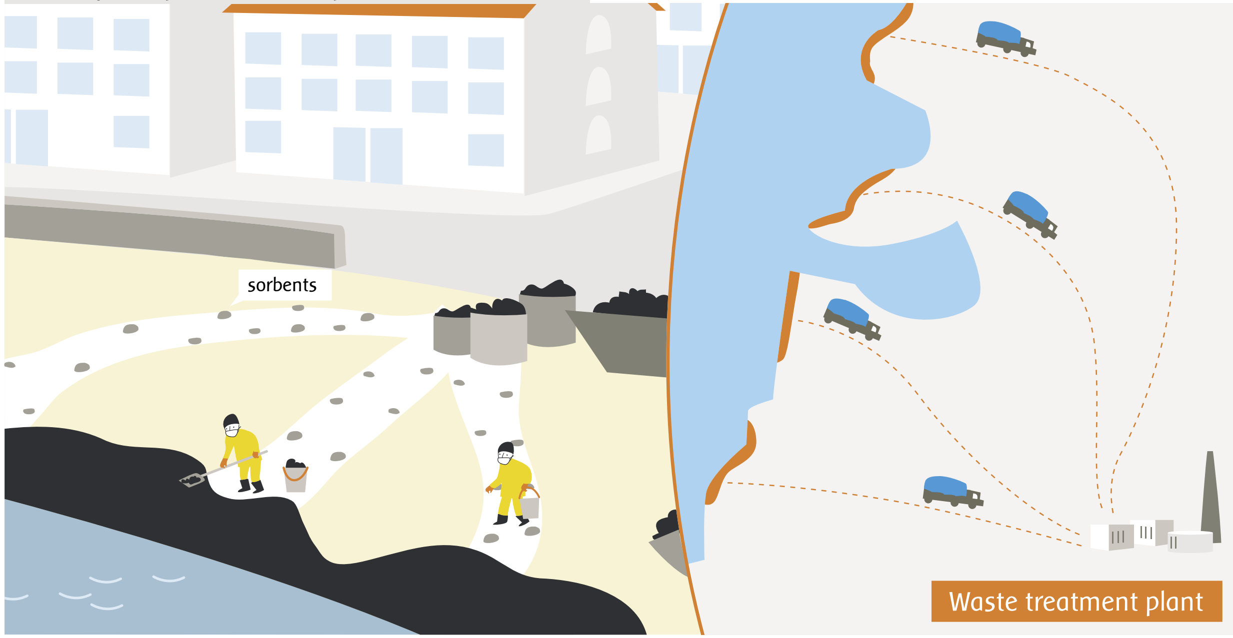
Waste collection

Transportation

The first stages of transportation can be ensured by the collection equipment itself: slurry spreaders, loaders, skimming• vessels, sanitation trucks... It can also be carried out by pumps, tank trucks, skip trucks and trailers. This equipment is used on the polluted site and does not necessarily need to be 100% watertight, but should be well adapted to the particular conditions of use. On the other hand, transportation from intermediate storage facilities, by road, rail or sea, requires receptacles which avoid all risk of spreading the pollutant during the journey and, if necessary, may involve washing the tyres and sills of the vehicles in a decontamination area before leaving the storage facility.

Waste transportation by truck

Recovery, transportation and disposal of collected waste



Specific treatment plant for industrial waste, Gironde, France

More information

The complex issue of storage, transportation and treatment of pollutants and polluted waste from oil spills is explored in a practical guide, which can be downloaded from the website www.cedre.fr, in the publications section.

Zierbena, port of Bilbao (Spain), final storage site for waste from the *Prestige* spill

Treatment

The treatment of liquid or solid waste with high hydrocarbon• content (over 15%) can be undertaken by recycling it in deballasting stations• or by incineration in hazardous waste collection centres, cement works, or even, subject to specific derogation, in household waste incineration units. Emulsion• recovered at sea, only soiled by small quantities of solid waste•, is a typical example of materials which can be recycled. Thick patties• collected on the beach using shovels, with varying quantities of seaweed, sand and solid waste, can be recycled or incinerated.

Forgotten storage sites

During the *Erika* disaster, the French media highlighted the persistence of a few waste storage sites from previous oil spills. These were "definitive" storage facilities which had sunk into oblivion. In France, this previously used concept of definitive oil spill waste storage centres is no longer part of national contingency plans. All that is removed from intermediate storage sites must now be sent, after sorting into categories of materials:

- either directly to treatment plants accredited by the law in force (e.g. incineration of bird corpses)
- or, if this is not possible, to final storage sites from which point these products should then be treated.

Treatment is carried out at intermediate storage sites for certain products and after being sorted, is sent to specialised treatment plants for others. This treatment aims to recycle or destroy as much waste as possible and to transform the rest into ultimate waste in the strict sense of the legislation in force, i.e. all that cannot be recycled or destroyed. Ultimate waste is then sent to specialised storage centres.

Forgotten storage site from the *Torrey Canyon*, 1980

Materials with low hydrocarbon content should undergo lime stabilisation in pits at intermediate storage sites, in power plants or on platforms. Building companies and public works then use the stabilised materials to build roads and embankments. However, this method is not exempt from criticism on the duration of stability obtained. Biological treatments (bioremediation and landfarming) are very effective but very long processes.

Ultimate waste, inert substances or substances presenting only slight traces of oil should be definitively stored in conditions whereby there is no risk of polluting surface or underground waters. This requires specially prepared sites and rigorous controls. The return of sand to the beaches where it came from is sometimes appealed for. This request is however generally dismissed, as it is practically impossible when an oil spill occurs, to treat the sand from each beach separately and even less conceivable to return sand from various origins to the relevant beaches. ■

Destruction of aquacultural produce

The experience of several recent oil spills highlighted the fact that the development of shoreline aquaculture has generated a new type of waste: tainted aquacultural produce which is destroyed due to a decision made in the name of consumer protection. The quantities at stake can be very high: nearly 9,000 tonnes of shellfish in the *Aegean Sea* accident in Spain (1992) and over 5,000 tonnes of salmon in the *Braer* accident in the Shetland Islands in Great Britain (1993).
Due to the lack of regulation, the disposal solutions put in place were specific to each case, from reuse as animal feed (for mink breeding, their flesh not being consumed by humans) to burying on landfill sites after lime treatment (www.ipieca.org).


BIOLOGICAL IMPACTS OF OIL POLLUTION: FISHERIES

Erika, Prestige: exceptional treatment plants

To ensure the final treatment of the 270,000 tonnes of soiled waste produced by the polluted shoreline clean-up in the wake of the *Erika* disaster, the Total group set up a pilot scheme and then a plant specially adapted to the treatment needs on the site of the Donges refinery (France). The development of techniques and the construction of the plant took 8 months, from September 2000 to April 2001. The plant functioned for 19 months, and was then dismantled. In Galicia, Spain, a similar but smaller plant treated the 70,000 tonnes of soiled waste produced by the *Prestige* pollution.

Rehabilitation

How does the restoration process work?

- Public concerns
- Fate of oil
- Regaining a natural balance
- Resuming activities
- Future prospects

PUBLIC CONCERNS

A few weeks or months after an accident occurs, or a little over a year in the worst of cases, clean-up operations are completed and response teams demobilised. There is no longer any visible pollution, except on sites where the decision was made not to intervene and to leave nature to do the work (natural clean-up). However, some ecological, epidemiological, financial and legal questions may remain unanswered. What happens to the oil which is not recovered? Is it a long term danger? Will the affected species, ecosystems and the local economy fully recover or will any damages persist? Who will pay compensation, when, to whom and how much?

Providing precise and swift answers to these questions is of paramount importance. Otherwise, facts and realities may be quickly submerged by fears and speculations from which the general public will draw their own conclusions. In the aftermath of a major spill, feelings run high. It has been known for demonstrators to flood onto the streets bearing placards and banners such as: "the polluter must pay!" and "never again!".

Even in the early days of a spill, scientists and economists will be getting to work on assessing the actual short and long term impacts. However they need time to provide objective answers and it can take months or years to publish the results. Until then all manner of speculation is possible, including, of course, the more extreme interpretations favoured by some media. Such speculations, whilst they are inevitable, do cause concern to all stakeholders.

The Impact of the Sea Empress spill

Press headlines at the time of the spill:

World Wildlife Fund update, a few months after: "...impacts (...) will not be fully known for months or even years. Some estimates for full recovery of the ecosystem - if it can fully recover - are as long as 30 years." The Sea Empress, an ecological disaster, 1996

Scientific community assessment, 2 years after: "The main impacts all occurred at the time of the spill or shortly afterwards, and there appear to have been few major longer term effects. Indeed, several of the affected species seem to have substantially recovered." The Environmental Impact of the Sea Empress Oil Spill, 1998

However, each party involved has particular priorities according to the nature of their interest in the sea and the shore. Ecologists are concerned by the return of the affected species, of the natural balance of ecosystems and by the maintenance of biodiversity. Hotel and restaurant owners and shopkeepers worry about the image of the region and the return of customers. Fishermen and seafood breeders are preoccupied by being able to market their produce again and find customers. Consumers question the quality of the water, the beaches and sea produce. Answers have to be provided to each of these legitimate concerns. This requires hard work and time.

Naturally, the same information may be seen in many different ways by the different stakeholder groups, who may use it to demonstrate different points. Some environmental campaigners may want to demonstrate extensive harmful effects of even the most minimal damages to make the incident unforgettable and use the subsequent furore to catalyse drastic decisions about maritime transport. Some economic operators may want to show a maximum amount of damages to obtain the maximum levels of compensation. Other economic operators may have an interest in showing the impacted areas to be not so badly damaged after all in order to win back the trust of users and consumers.

The answers to the different questions asked depend on the type of oil, the characteristics of the sites affected, the species concerned, the circumstances surrounding the spill and the effectiveness of response. They are not always simple. They require time-consuming, delicate and costly effort.

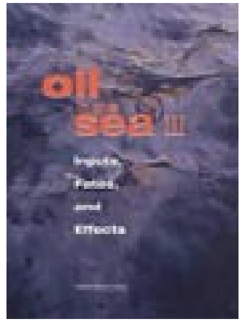
The best way to address the concerns of the public after a spill is to develop and transmit clear and complete information in a timely fashion. The fate of the oil remaining at sea must be studied, the evolution of the affected stocks and ecosystems must be analysed and, most important of all, environmental and economic damages must be assessed.

The way in which these two types of damage will be compensated are different. In most parts of the world, economic losses will be compensated through an international compensation fund, calculated through estimated loss of profit sustained by the claimant where this can be satisfactorily demonstrated. Also, in most parts of the world, environmental damage is compensated rather through restoration actions than in money.

Sealed oil samples from the *Prestige* pollution

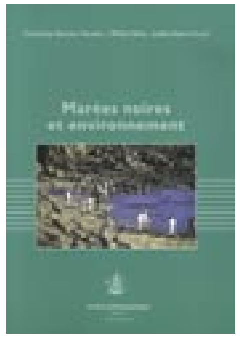
More information

A key reference work which explores the question of the impacts of oil spilled at sea is a study entitled *Oil in the Sea III: Inputs, Fates, and Effects*. This study is in fact part of a larger project which dates back to the early 1970s, when scientists began to realise that a considerable amount of pollutants were being discharged into the marine environment. In 1973, the US National Research Council organised a workshop to address this issue, which culminated in the publication of the NRC report entitled *Petroleum in the Marine Environment*. This report highlighted the lack of quantitative data on the subject.



This work was later updated to include significant new quantitative data, upon the request of the US Coast Guard, to produce *Oil in the Sea: Inputs, Fates and Effects*, published in 1985. Since this date, a vast quantity of data has been accumulated and new computational analysis techniques have been developed. Therefore, in 2003 an updated and improved 265 page report was published: *Oil in the Sea III: Inputs, Fates, and Effects*. This study was compiled by the 'Committee on Oil in the Sea: Inputs, Fates, and Effects', a committee of fourteen engineers and scientists from a wide range of technical backgrounds. The resulting work is a systematic and comprehensive approach to the discharge of petroleum• into the world's oceans.

Not all decision-makers in every country are fully fluent in English and the lack of a reference book in the national language has been recognised in some countries. This was the case for France in the aftermath of the *Erika* incident, giving rise to the production of a key reference work in French, in the form of an unprecedented study: a comparative analysis of 17 oil spills• throughout the world over the previous 35 years. It addresses the highly contentious issue of the long term harmful impacts of an oil spill on human health and the marine environment.



This project, carried out upon the request of the French Ministry of Ecology and Sustainable Development and entitled *Marées noires et environnement* (black tides and the environment), was defined, supervised and assessed by a steering committee made up of representatives of the Ministry and distinguished scientists from diverse backgrounds. It was published jointly by the *Institut océanographique de Paris*, the Ministry and *Cedre* in 2004.

FATE OF OIL

Oil in the environment

The elements which evaporate during the first few hours and are photo-oxidised or biodegraded before and during operations represent between 30 and 50% of a crude oil* spill.

Containment* and recovery operations at sea and onshore help recover around 20% of the remaining pollutant, or 40% at the very best.

It can be deduced therefore that at least a third and in some cases up to half, of the volume of crude oil spilled subsists in the environment. It does so in three forms: dissolved for a small part made up of the soluble compounds, settled on the seafloor and adsorbed by the sediments for the heavy compounds, and in the form of particles for the rest.

This oil which is missing from response calculations is therefore not in the form of a large, thick, continuous slick drifting under the surface and threatening the shoreline. Rather, the initial slicks are scattered by the swell, wind and currents.

At this stage, natural and chemical dispersion has begun its work. The oil, freed of its evaporable and rapidly photo-oxidisable and biodegradable components, is fragmented into scattered patties, tar balls* and particles.

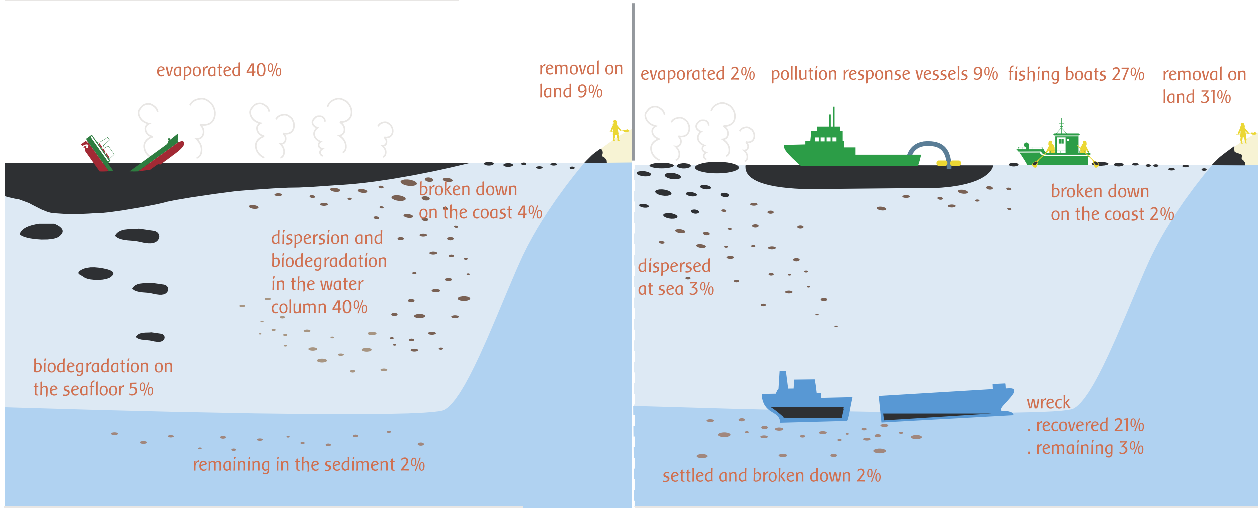
Certain slicks drift in the open sea, out of reach of recovery operations at sea. Others are beached, covered by sediment or forgotten, deliberately or otherwise, by shoreline clean-up operators. In this case, the oil is weathered, semi-solid to solid and mainly made up of asphaltenes - non toxic, long-chain hydrocarbons*.

This weathered oil interferes with species and ecosystems by a simple mechanical effect, like asphalt debris from roads being swept away by a flood and dispersed in the natural environment.

In large quantities in the sand on a beach, or the mud of a marsh, weathered oil can affect seasonal beach growth and depletion cycles, causing localised effects on the wildlife.

The dissolved fraction, droplets adsorbed by the sediments, as well as particles in suspension can still contain perceptible proportions of aromatic compounds, with non negligible toxicity. It is these elements in particular which could contaminate organisms in the long term, by breaking down respiratory and digestive cells, in particular in organisms which filter the water or sediments. If hydrocarbons in suspension subsist in large quantities, they can prolong abnormal concentrations in shellfish, causing their collection to be banned.

Summary of fate of oil calculated by mass



Amoco Cadiz: light oil, high level of evaporation*

Prestige: heavy fuel oil, high level of recovery at sea and in the wreck

Persistence of heavy fuel oil on the shoreline

One of the general public's main concerns in the aftermath of the *Erika* was the persistence of fuel oil• which had not been removed from the shoreline. As it was a substance with very low biodegradability, there was a risk of finding it years later. The subject was therefore broached in the follow-up programme of ecological and ecotoxicological consequences of the oil spill• (www.suivi-erika.info).

Studies showed that 3 years after the incident residual fuel oil remained on rocks in the form of thin layers, broken down on average by 66%, and in the form of patties and crusts, on average 55% broken down, with noticeable variations in the environment. Within riprap where the fuel oil was sheltered from light, it remained viscous, broken down by less than 20 %.

The break down of the fuel oil, as expected, was very low. However, there was significant photo-degradation where the oil was exposed to solar rays, in particular in fine layers.

It would have been far different if the *Erika* had been carrying a light product: little to no pollution would have remained on the shoreline after 1 year.

Oiled slabs of granite for a study of oil persistence on rocky substrates• (↑)
Residual fuel oil from the *Erika* on a bed of vegetated stones (↓)

Public fears

Dramatic media representation of spills can fuel public worries about the risk of contamination of organisms in the long run:

- fear of alterations in behaviour, metabolism, growth and reproductive faculties of plants and animals which come into contact with the oil
- fear of bioaccumulation• of certain hydrocarbons, causing an amplifying effect in the food chain, eventually reaching consumers of sea produce
- fear of development of benign or malignant tumours in the organisms affected and their descendants
- fear of potential chromosomal aberrations liable to affect future generations
- fear of long term impact on the health of operators participating in shoreline clean-up and bird rescue.

Scientific compilations like those on page 95 provide objective answers to those worries, but they do so in words more suitable for scientists that for the general public. During the crisis, that information must be translated into easily understandable answers, specially adapted to the incident concerned and provide in real time. Whenever there is a recognised risk, in-depth studies should subsequently be implemented.

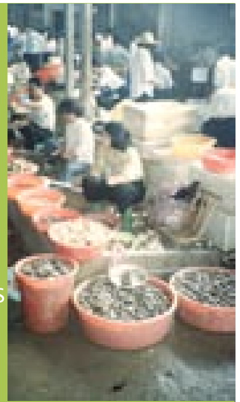
Oil in organisms

Many scientific studies on the fate of oil in organisms have been carried out. They have shown that certain hydrocarbons• can provoke abnormal cellular proliferation (tumours) when they are injected or implanted in the flesh. Repeated contact with these substances can provoke lesions or necrosis, in particular in the eyes and nose, as well as chromosomal alternations in reproductive cells. After some oil spills•, various mutagenic, carcinogenic, pathological or metabolic effects have been observed in the long term on diverse aquatic species.

However, the direct link between the pollution and these effects has never been clearly demonstrated, as many other factors of natural or human origin interfere in the lives of species. As a consequence, claims for long term damage to ecosystems are often rejected due to insufficient evidence to support the causal link between the pollution and the perceived impacts.

The tainting• of taste and odour in the flesh of certain species is however perfectly observable and measurable. This "oil-like" taste can form in a few hours to a few days in contaminated water. It then disappears in a few weeks when the contamination ceases. This alteration assumes particular importance for the species which are depended upon for fishing or other aquacultural activities, which can cause them to become temporarily unfit for sale. This necessitates quick decisions to ban fishing or selling sea produce. These bans, based on analysis of flesh or organoleptic tests, are an indisputable precautionary measure. Decisions to resume activities are not easy

Organoleptic testing



Shellfish marketing in China (Source: Ifremer)

Each country manages bans on marketing sea produce according to their own regulations, thus assuring consumers of the level of protection they are entitled to, without banning beyond reasonable limits or excessively destroying stocks.
This is neither easy to establish nor to put into effect. The results of tests carried out on samples can be interpreted in very different ways according to the nature and severity of the selected criteria.

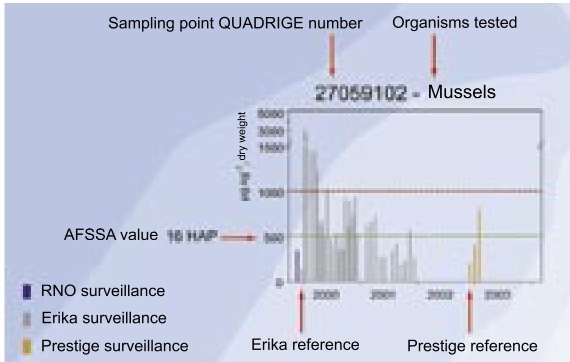
During the *Aegean Sea* pollution in Galicia, the Spanish authorities chose organoleptic testing as a point of reference, with the destruction of contaminated sea produce.

In the case of the *Erika* in France, the French food safety agency chose to analyse the content of "packages" of 16 known carcinogenic polycyclic aromatic hydrocarbons, without destroying stocks (except for oiled mussels).

matters as consumers may have difficulty in accepting seafood which was tainted by oil even once its taste has returned to normal.

It is out of the question to have consumers take the slightest risk. They must be reassured as to the quality of the produce, which may have been declared irremediably contaminated during the days immediately following the disaster. On the other hand, the additional negative economic impact on certain industries of an excessive ruling on these matters is also a cause for concern and should be avoided.

In practice, as it is materially impossible to know which wild fish and crustaceans have been contaminated, fishing is reauthorised as soon as repeated chemical or organoleptic tests ensure that there is no more contamination in the whole area. As for fish and shellfish farms, stocks are sometimes destroyed before recommencing sales, in order to guarantee irreproachable produce for consumers.



Mussel contamination follow-up during the *Erika* and *Prestige* disasters
(Source: Ifremer)

Impact studies

Oil spill• impact studies tend to come up against a number of problems, for which no satisfactory solutions have been found. Knowledge of the situation before the pollution is always very incomplete: despite the proliferation of marine environment surveillance databses, scientific information on the permanent state of populations and their seasonal variations remain more qualitative than quantitative.

Creating networks specific to oil spill damage assessment needs for the whole shoreline would be excessively costly. In most cases, therefore, we have to resort to emergency sampling from in front of the edge of the pollution, which requires rapid mobilisation.

The organisation and contracting of complete impact studies of sufficient duration are rarely allowed for in response plans. A pilot committee should be set up. The preparation of calls for tenders and the allocation of contracts require an irreducible timeframe. By the time studies begin, sampling from the edge of the pollution is often no longer possible and the vital information is lost.

The financing and supervision of such studies is a matter of - at times heated - debate. Should they be negotiated and undertaken on public funds, with no contribution and no possible interference of the polluter, his insurers or the international compensation system? Or should these parties be invited to participate in financing and decision-making as, at the end of the day, they will be asked to reimburse the expenses? The preferred option varies from country to country.

There are also differences of opinion on technical aspects. Impact studies can call upon large teams for several years. At what point should they be ceased? When no more serious effects are found or when no single trace of a localised effect can be identified? Budgetary considerations often weigh heavily in these decisions.

Another major question is that of the dissemination of results. Information on the studies undertaken and the results obtained must be communicated to the public. But should they be made known at the end, once all results are available, or in real time with the risk that incomplete results may be misleading? Whatever the route taken, the internet is nowadays a key tool for diffusing results. ■

More information

Oil spill impact on the Internet

• *Exxon Valdez*, Alaska - USA, 1989
The official *Exxon Valdez* Oil Spill Trustee Council website: http://www.evostc.state.ak.us/
A comprehensive site on the *Exxon Valdez* spill: http://library.thinkquest.org/10867/?tqskip1= 1&tqtime=0218

• *Sea Empress*, Wales - Great Britain, 1996
The website of Swansea University: http://www.swan.ac.uk/empress/empress.htm
The site of the British Marine Life Study Society with a copy of the *Sea Empress* environmental impact assessment committee: http://www.glaucus.org.uk/Empress.htm

• *Erika*, Brittany - France, 1999:
The official site of the *Erika* spill follow-up programme: www.suivi-erika.info (in French)

• *Prestige, Galicia* - Spain, 2002:
Access to the report on bird impact by the Galician society of ornithology: www.sgosgo.org/archivos/informe3anosprestige.pdf (in Spanish)

REGAINING A NATURAL BALANCE

Natural recolonisation

By the time clean-up operations are complete, the wildlife populations will very likely have been altered, sometimes locally eradicated, by the effects of the oil and clean-up. The affected sites may be partially depopulated and become newly habitable areas for other species. First, colonising species settle in them, then over time populations similar to the original species return. However, this colonisation sequence may be threatened by the existence of abnormally high quantities of hydrocarbons• in the water and sediments for months or even years after the spill. Scientific follow-up can be set up to determine whether the original balance has been regained and the timeframes involved.

Studies have shown that the areas seriously impacted by a major oil spill• would typically regain a balance comparable to that of surrounding areas in the following timeframes:

- 2 to 6 years for low sensitivity areas (rocky points and other areas beaten by waves)
- 5 to 15 years for moderate sensitivity areas (beaches and other areas of moderate hydrodynamic activity)
- 10 to 25 years for high sensitivity areas (coastal marshes and other areas of very low hydrodynamic activity).

These timeframes cited here as typical for species/population recovery rates after a major oil spill are not much higher than those required in similar environments following a natural disaster, such as a major flood, a large mudslide or a volcanic eruption.

Human support for nature

Faced with the considerable time periods needed for the most sensitive areas to regain their balance, humans began to wonder whether they could help speed up nature, by conducting repopulation operations, in the same way as replanting trees after forest fires, or, more simply, by facilitating natural growth of shoreline vegetation and recolonisation of the foreshore• by animals, through protective measures.

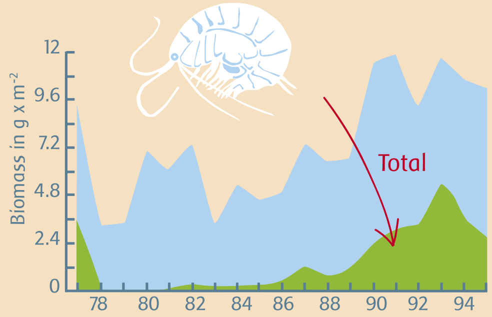
Today, facilitation of growth by protective measures is a common practice for sites which have been trampled by shoreline clean-up operators or degraded by vehicles or temporary storage. The simple measure of protecting these sites using barriers, stopping people and vehicles passing, is often enough to encourage recolonisation.

Actual repopulation on the foreshore and at sea poses further problems. Technical knowledge of repopulation and the reintroduction of marine species remains far behind this knowledge on land environments. What we do know is restricted to a small number of species, which are only a minor part of natural populations and are often high in the food chain (predators), when repopulation operations should logically start with plants and animals low in the food chain (herbivorous).

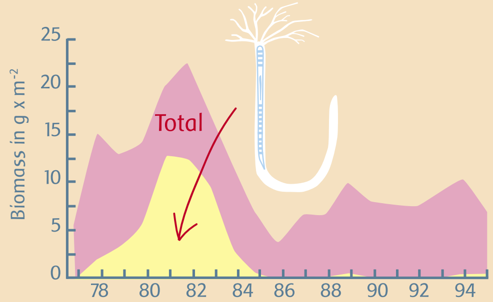
As a consequence, apart from a few exceptions, reseeding techniques for marine life are today either non-existent or embryonic. There are therefore few recommendable operational solutions. Those which do exist concern a small number of species in specific environments.

Impact of the Amoco Cadiz in France

An example of the problem of assessing impact
(Source: DAUVIN J.C. *Surveillance du milieu marin : travaux du RNO de la qualité du milieu marin*, 1996 Edition)



Ampelisca: fine sand at Pierre Noire



Lanice : muddy sand in the river of Morlaix

The graphs showing the evolution of the biomass of populations in the bay of Morlaix (Brittany, France) after the *Amoco Cadiz* spill (1978) seem to contradict each other if we only consider the overall quantities. We must look at individual species, or groups of species, to understand what really occurred.

In fine-grain sand, Ampelisca (type of amphipod), a sensitive species, practically disappeared for two years and only returned to its normal level some 14 to 15 years after the disaster. In muddy sand, Lanice (segmented worms) developed abnormally and became abundant the year of the disaster and for the following 7 years, before returning to the former modest numbers.

Recovery of the ecological environment

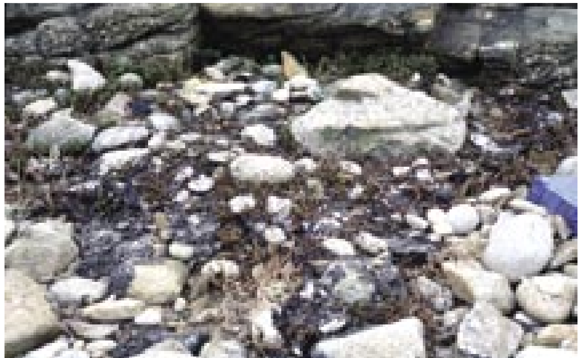
The areas of the Breton coastline which were successively hit by the pollution from the *Torrey Canyon* (1967), the *Amoco Cadiz* (1978) and the *Tanio* (1980) suffered two major disruptions to ecosystems in recovery phase. Today, the vast majority of their populations have regained a balance similar to that of surrounding areas, however traces of overabundances of opportunist species or abnormally low levels of sensitive species still remain measurable in certain environments.

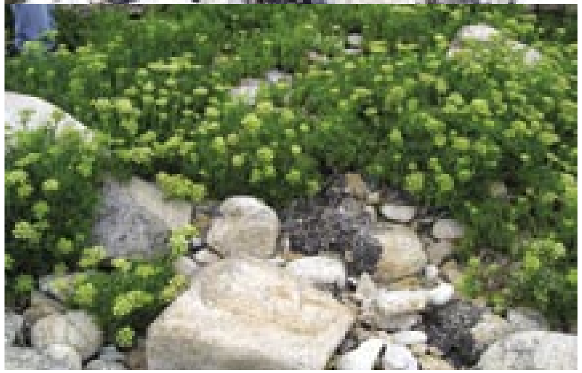
At temperate latitudes, a period of 6 to 7 years is generally enough to see all traces of a major oil spill• disappear. However this is not always the case. Some highly protected environments, such as maritime marshes and mudflats, where arrivals of oil from the Amoco Cadiz were widespread, were still polluted 13 years after the vessels grounded.

Techniques exist for reconstructing coral reefs, generally used to repair damage caused by vessels grounding, which can be adapted to the context of oil pollution. There are also propagation techniques for submarine plants (sea grass in the Mediterranean environment) and marsh plants (mangrove trees in swamps) by taking cuttings, which have undergone trial testing and could be widely applied to future accidents. There is no doubt that other propositions will surface in the future.

All these techniques put together will, in the long run, open up a new part of oil spill response: human assistance in the repair of environmental damages, once clean-up operations have been completed.

Restoration goes in line with strengthened preventative measures to ensure against restoration efforts being set back halfway through by another spill.





Natural recolonisation:
situation in December 1999 (top left)
situation in summer 2003 (bottom left)

Botanical restoration (top right)

Environmental restoration

Approaches to repairing environmental damages varies from country to country. Some countries, such as Italy, have legislation on environmental damages while others, such as France, do not. In the US, compensation for damages to natural resources can add significantly to the total spill clean-up costs. Other countries focus on replacement processes, which consists of financing the protection of a natural site to compensate for an equivalent degraded site elsewhere. The pros and cons of the different approaches to compensating environmental damages will not be explored here.

Member States of the International Oil Pollution Compensation Funds (IOPC Funds) can obtain reimbursement for environmental impact studies and, where possible, environmental restoration using established techniques and implemented at a reasonable cost, with respect to the extent of the pollution and the damages caused.

RESUMING ACTIVITIES

Revival of the local economy

Following an oil spill, the local economy in the surrounding area may be affected in several ways.

• Activities may be physically interrupted. This could be the case, for example, for maritime transporters or fishermen whose boats are soiled in port or blocked by a protective boom.

• Activities may be affected by bans. This could be the case, for example, for fishermen or sea produce breeders whose produce is no longer allowed to be sold.

• Activities may be affected by the total or partial loss of customers. This could be the case for industrial ice suppliers who find themselves with no fishermen to deliver to or campsite owners who have lost part of their clientele.

Activities can also suffer in a more complex manner from economic damages induced by unfounded public fears. This could be the case, for example, for salt cultivators who see their customers turning down their produce, unaware that it comes from previous years' harvests. More complex still, damage to fishing resources can cause a decrease in catches years later, due to a certain age group being most heavily hit.

To address these various scenarios, action must be taken. Support for affected productive sectors and assistance in refloating the economy are today well established components of oil spill response. Insurance companies and the international compensation system are naturally unavoidable contacts. However, other entities may intervene, in particular the European Commission and various United Nations programmes, through donations, subsidised loans or financing of redevelopment projects.

Transitional financial aid, directed towards economic operators whose activity is interrupted (fishermen, shellfish breeders, tourist industry personnel), takes most often the form of the payment of daily sums based on the minimum guaranteed revenue of the sector. This unemployment benefit acts as vital support for the operators affected, deprived of resources during the period when waiting to resume their activities. Monthly payments can sometimes be deferred and bank guarantees allocated, to free those committed from the burden of paying back loans which they cannot face in the circumstances.

Professional organisations can benefit from assistance to regain their place on the market. Mostly, this consists of financing advertising campaigns aiming to restore the image of the region and its produce. These campaigns are often complemented by the promotion of companies which had to stop work during the incident.

Technical, financial, strategic and legal aid can be necessary to allow economic operators to accurately assess their situation and relaunch their production in the best possible way. This is of particular importance for fish farms which have to start again from scratch, if their livestock has been entirely destroyed. The financing of that aid is usually taken care of by State and regional authorities. In Europe, European community relief funds can be called upon. The same applies to federal funds in the US.

Compensation of damages

In 1978, the French State, the Breton communes and the economic operators affected by the *Amoco Cadiz* pollution had no other alternative than to embark upon legal proceedings in the United States against the shipowner, as the international conventions and national rules in force at the time made it impossible to obtain satisfactory compensation in a straightforward manner from a French court.

Considerable progress has been made since in favour of those affected. Whether he is responsible for the spill or not, the owner of a tanker is liable for the damages caused up to a certain limit. The International Oil Pollution Compensation Funds (IOPC Funds)

"From Galicia, and so fresh"

This Spanish advertising poster with the slogan "From Galicia, and so fresh" explains that after the *Aegean Sea* oil spill in Galicia (Spain), only 100 km out of 1,350 km of shoreline were affected and boasts of the quality of the waters and produce from this province's sea.

can be approached for supplementary compensation, in excess of the tanker owner's limit of liability. The assessment of damages is determined by the law of the affected country, within the limits of the international convention governing the funds.

Compensation is subject to strict rules, in order to avoid abuse. The use of theoretical mathematical models to assess global damages is not accepted and each claimant has to individually demonstrate his loss. This can be disconcerting for claimants, who find themselves having to show their account books to international experts and to prove the relationship between the pollution and their damages, when they might have expected the polluter to come with a cheque in hand. However, representatives from the IOPC Funds are pro-active in assisting local claimants to understand how to make a successful claim. This approach can also provoke criticism from scientists and economists who are used to assessing the evolution of ecosystems and the economy of usable resources using mathematical models.

It is therefore not surprising that compensation is an extremely controversial subject. Once duplications in claims and saved expenses have been deducted, payment offers are often considerably lower than the claimed amounts. Most claimants recognise the logic of the system and accept amicable settlements. However, some do not and decide to challenge the rules in force in the national courts of the country affected. As a result, most large oil spills of the last few decades have failed to avoid a major lawsuit. Some such lawsuits end up being terminated after some years by an out-of-court settlement, while others have extended for more than a decade.

Who pays?

In the more than one hundred countries party to the Civil Liability Convention, developed under the aegis of the International Maritime Organization (IMO), an oil tanker which spills part of its cargo or bunker fuel at sea, for whatever reason, is obliged to pay compensation of victims, up to a certain limit. Beyond this limit, supplementary compensation is available from the IOPC Funds, managed by the member States and financed by mandatory levies from oil importers.

It is therefore the tanker owner, through his insurance premiums, and the oil importer, through a contribution per tonne imported, who finance the protection of those affected. This mutual system functions without a bonus-malus system: it insures against risks but does not encourage shipowners and importers to reduce accident occurrence. In the case of large spills where the total compensation funds available are not sufficient to face all damages, it is usually the national government which bridges the gap with national solidarity funds.

The USA is the only major country not party to the IOPC Funds system: it has opted for a national compensation fund under its own rule: the Oil Pollution Act, 1990. The US fund functions in a similar way to the international regime with one major difference: it accepts the compensability of environmental damage. Canada has opted for an intermediary arrangement: a national fund with rules comparable to those of the US fund plus adhesion to the IOPC Funds system, towards which the national fund reverts after payment for reimbursement.

IOPC Funds compensation limit

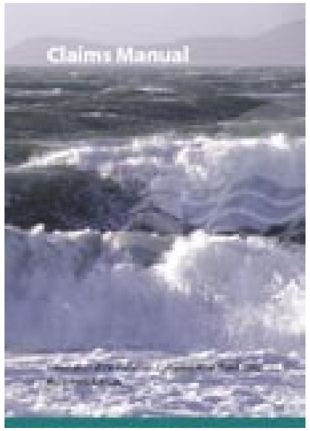
The rules of IOPC Funds stipulate an overall maximum amount payable per disaster. In the event of damages being estimated at a value above this limit, payments to victims are reduced in proportion to the maximum available amount and the total of recognised damages.

This limit has proved to be far too low when faced with a major heavy oil fuel spill. For all the economic operators affected by the *Erika* pollution to receive complete compensation, the French State and the Total group had to voluntarily choose not to claim their expenses. Similarly, at the time of writing, payments for the *Prestige* pollution are restricted to only 30% of damages taken into account. A post-*Prestige* European initiative led to the creation of a complementary third-tier fund, which is now in effect for its signatory countries. If this fund had existed at the time of the Prestige accident, current payments could have bordered on 90% of accepted damages.

A joint IPIECA/ITOPF guide available on the IPIECA website provides detailed information on compensation issues.

Exerting one's rights

To assist compensation claimants, the IOPC Funds• publishes a practical guide to the rules governing the system. In the event of a major incident, a claims office is often established near the scene by the vessel's insurer and the IOPC Funds to assist claimants. Claimants have a period of 3 years after the spill has taken place to make their claim and come to an amicable agreement. Beyond this period, they can only conserve their rights by filing a lawsuit.



IOPC compensation rules

Any expense/loss must actually have been incurred.

Any expense must relate to measures which are deemed reasonable and justifiable.

A claimant's expense/loss or damage is admissible only if and to the extent that it can be considered as caused by contamination.

There must be a link of causation between the expense/loss or damage covered by the claim and the contamination caused by the spill.

A claimant is entitled to compensation only if he has suffered a quantifiable economic loss.

A claimant has to prove the amount of his loss or damage by producing appropriate documents or other evidence.

The problematic link

A turbot breeder is affected by an oil spill and loses a large part of his stock in the second year. However, he manages to save the majority of his stock from the first year by improvising a semi-closed water circulation system. The rest of his stock from the second year is unfit for consumption and is destroyed a few months later as a result of an administrative decision. The breeder continues to maintain and feed his stock from the first year, which seems to have suffered little.

The following year, these fish are seriously affected by a common illness on fish farms, which can usually be treated without any major damage. Other fish farms in the region which were unaffected by the pollution the previous year suffer only minimal losses. The breeder is convinced that his losses are due to medium term effects of the oil, which made his animals fragile. But how can he prove, a year on, the link between the losses suffered and the past oil spill?

There is no obvious solution to this type of problem and it can often require court arbitration to resolve such cases.

Case studies

Amoco Cadiz (16/03/1978, France)
According to the regulations in force at the time of the accident, the shipowner's liability was limited to 77 million French Francs (the equivalent of 33 million Euros today). Rather than attempting to establish that the shipowner was at fault in French courts in order to lift his limit of liability, the French authorities and victims turned to the shipowner's parent company, which they litigated in American courts during a 14 year long lawsuit.

Tanio (07/03/1980, France)
This was the first major oil spill that the IOPC Funds were to handle. The shipowner's limit of liability was 11.8 million French Francs and the IOPC Funds' 2,447 million French Francs (in total 84 million Euros today). Compensation from the IOPC Funds was settled amicably, five years after the incident. The French State and the IOPC Funds jointly embarked upon a lawsuit in the court of Brest (Brittany, France) against the insurer, the shipowner, the naval shipyard which carried out the last repairs and several other stakeholders. In 1997, an out-of-court settlement allowed the IOPC Funds to recover part of its payments and allowed the French State to complete compensation payouts.

Aegean Sea (03/12/1992, Spain)
The shipowner's liability was limited to 1,121 million Pesetas and the IOPC Funds' intervention to 9,513 million Pesetas (a total of 59.2 million Euros today). After a long process of amicable compensation claims to the IOPC Funds and simultaneously recourse to Spanish courts with penal then civil judgements, an overall agreement between the Spanish Government and the IOPC Funds was signed in 2002 to settle all the remaining disagreements.

Braer (05/01/1993, Great Britain)
The shipowner's liability was limited to £4.9 million and the IOPC Funds' intervention to £50.6 million (in total 97.4 million Euros today). Amicable settlements rapidly progressed until the third year following the incident, when legal action before Scottish courts led to an interruption in payments. In 2000, the withdrawal of a claim from the UK Government, for response expenses, allowed payments to be resumed and the case was closed by the end of 2002.

Sea Empress (15/02/1996, Great Britain)
The shipowner's limit of liability was £7.5 million at the time, and that of the contribution of the IOPC Funds was £51 million (in total, 90 million Euros today). Like the *Braer*, all the amicable settlements had not been completed three years after the incident and thus legal action was taken by the claimants against the shipowner, the insurer and the IOPC Funds. The liability of the Milford Haven port authorities was also questioned, concerning the competency of the pilot in charge of assisting the vessel. By the end of 2004, a total of £36.8 million of compensation had been paid by the insurer and the IOPC Funds, while procedures continued.

FUTURE PROSPECTS

Myths and realities

As legitimate and understandable as it may be, the appeal "never again!" which follows every major oil spill has about as much of a chance of being fulfilled as the "no more accidents!" appealed for after an air or rail disaster. The failures which occurred must be analysed and prevention reinforced as a consequence. However, zero risk does not exist. Whatever the efforts made, other spills will inevitably occur. "Never again!" is sadly a deceptive illusion.

"Never again like that!" is, on the other hand, quite realistic. Every major spill has led to the reinforcement of prevention and response preparedness. Even although the bucket and spade remain the essential tools of oil spill response, much progress has been made. The frequency of accidents has considerably decreased. Recovery of heavy fuel oil at sea has been made possible. The foreshore can now be cleaned without exacerbating damages, including using machinery. Tight flow waste management has become possible.

In all these fields, feedback from real-life experience has allowed progress to be made. However, the increase in maritime traffic and in the number of vessels circulating in the world's oceans, as well as the diversification of cargos, has generated new risks, which will have to be dealt with. At the same time, public demand for more rapid and environmentally friendly clean-up and restoration increase with every new accident. In all fields, more must be done to fulfil demands.

The European *Erika* "packages"

The *Erika* oil spill triggered a series of European initiatives, in the form of sets of measures known as the "Erika packages". These packages contain pollution prevention measures and measures which extend well beyond this issue. They were in the process of being negotiated at the time of the *Prestige* spill. They were largely driven by the emotion that this new oil spill stirred up.

The "Erika 1" package came completely into force in July 2003. It includes three main measures:

- reinforcement of the control of the flag State, with the publishing of a blacklist of damaged vessels
- setting up of control procedures for vessel classification societies
- an agreement with the International Maritime Organization to speed up the removal of single hull tankers from the worldwide fleet.

The "Erika 2" package, which is partially in force at the time of writing, is also made up of three main measures:

- the creation of the European Maritime Safety Agency (EMSA), which became functional in spring 2003
- an agreement for the International Oil Pollution Compensation Funds (IOPC Funds) on tier 3 compensation funds (COPE, the Compensation for Oil Pollution in European waters fund), which came into force in March 2005, increasing the maximum possible amount of compensation in member States to one billon Euros
- the creation of a European maritime traffic control and monitoring system in the zones under the authority of member States.

A third package of measures, aiming to reinforce the competitiveness of European flags, compliance with rules in force, prevention of pollution and international cooperation, was proposed in 2005. It should come in effect in 2007.

Prevention

Those who have experienced a major oil spill and seen the extent of its ecological and economic consequences will unhesitatingly agree that no effort to help prevent another spill should be overlooked. However, every effort has a price tag, which must be contrasted with the progress expected. There is no miraculous cure-all solution. Double hulls, for example, are effective in the event of scraping against a rock, a wreck or another vessel. However this measure does not protect against collisions at full speed, nor structural damage in bad weather conditions.

Risk reduction requires a sound combination of different measures: traffic separation schemes, traffic surveillance systems; double hulls or other comparable systems; checks carried out on vessels by the flag State and the port State; reinforcement of safety procedures onboard vessels, in pipelines, on platforms; high sea tugs permanently on standby, etc. The relative efficiency of these different measures varies from one case to another and the best choices are not always the same in every situation.

Implementing best choice options requires considerable determination. Accidents, through the emotion they generate, can offer the possibility of obtaining together the necessary budget and political will to generate new measures. Sustaining the momentum to see through major changes in the years after an incident, when emotions have subsided, is a challenge. The *Erika* packages are a demonstration of that dynamic: their eventual implementation was catalysed by the *Prestige* incident.

Rerouting a vessel suspected of illicit discharge off the coast of Brittany (France)

Aluminium shuttle used to remove the remaining cargo of fuel oil from the wrecks of the *Prestige*

Beyond oil spills

Prevention reinforcement measures triggered by oil pollution can stretch beyond accidental spills. Response to operational discharge in France is a striking example of this situation.

After the *Erika* oil spill, permanent surveillance of the wreck for possible seeps increased awareness of the high level of illicit discharge in the Bay of Biscay. Furthermore, it appeared that some passing vessels took advantage of this accidental pollution to release their waste waters in the zone around the wreck.

At that time, French legislation relating to research and repression of pollution at sea required samples to be taken from the sea and from the suspected vessel. Thanks to the evolution of photographic technology, these regulations underwent a fundamental modification. As of July 2002, it was no longer necessary to take samples. This opened the door to seeing photographs and videos accepted as evidence of pollution. Meanwhile, specialised courts were also created to judge cases of illicit discharge at sea.

Vessels suspected of polluting French territorial waters and the French EEZ are now rerouted to a French port. These vessels have to answer a legal inquiry and deposit a bank guarantee to ensure payment of the fine, before being allowed to continue their journey. Previously, convictions were rare and fines never paid. Since the *Erika* (1999), convictions have become frequent and fines severe.

To take another example, Canada has recently consolidated zero tolerance national Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals, with a view to eliminating deliberate, negligent and accidental discharge of pollutants from ships into Canadian waters.

Updating organisational frameworks

Continuous improvement of preparedness and response capability is of paramount importance. It requires up-to-date contingency plans, adapted response stockpiles• and well-trained personnel. Response capacity is not directly dependent on the size of stocks of dispersants•, booms, pumps, nor the number of people having followed a specialised training course as part of their job. Rather, it requires properly maintained, suitable equipment, handled by trained personnel, who can be rapidly mobilised and are capable of properly supervising response personnel recruited during the crisis.

To use these resources in the best possible way, it is necessary to have a high data collection, transmission and handing capacity, for many different data elements: observation at sea, oil slick drift prediction modelling, observation and quantification of arrivals onshore, predictions of requirements of personnel and equipment, performance of shoreline clean-up, information of the authorities and the general public.

The combination of stocks and teams from public and private sectors with modern means of rapid transportation of equipment from one site to another increase efficiency with limited stockpiles and teams. Oil spill• response has today passed the stage of discovery and approximation.

Faced with less frequent accidents, this field has become an organised sector, within the framework of a worldwide strategy, aiming at the highest cost-effectiveness. On top of operational leaders' own means, they should ideally belong to a network of partners able to very rapidly provide human and/or material support where necessary.

It is important not to let efforts ease off. Each major spill has pulled up the level of performance to be attained. Today, it is no longer simply a question of being efficient in the action taken to organise response. Response should also involve the ability to communicate information in real time on what is being done and what is going to be done, and to explain, or even justify, these choices.

The fight against oil spills is no longer only a fight against the pollutant, but also a fight on the information front.

Rock clean-up training

Oil industry preparedness

The Global Response Network (GRN) formalises collaboration between oil industry funded, non-profit making oil spill• response organisations. These organisations collaborate and share human and material resources, in order to maximise the effectiveness of response operations in the event of a disaster. Today the GRN brings together organisations with regional and world-wide scope, which are based all over the globe. The members of the GRN are Alaska Clean Seas, Australian Marine Oil Spill Centre, Clean Caribbean Americas, East Canada Response Corporation, Western Canada Marine Response Corporation, Marine Spill Response Corporation (US), Oil Spill Response Limited (UK) and East Asia Response Limited (Singapore).

Global Response Network

Tendencies

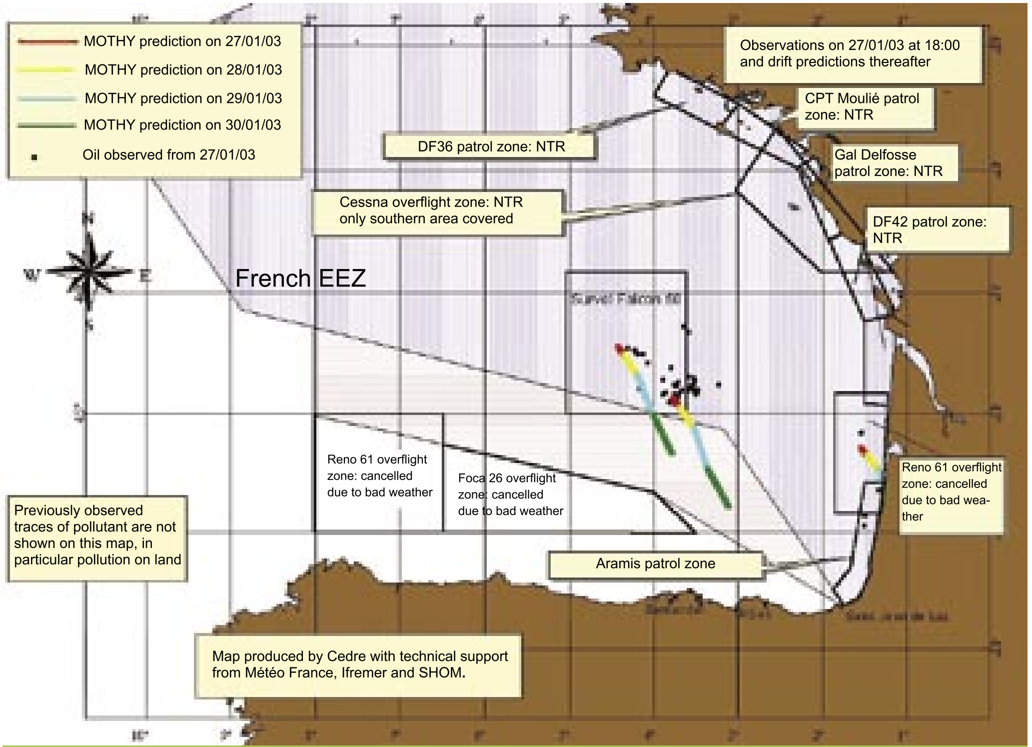
Attempting to predict what oil spill• response will be like in the future runs the risk, as with all predictions, of being proven wrong. However, several tendencies can be identified.

The public authority in charge of maritime security and pollution response• in a coastal State should know at all times the exact situation involving a vessel in difficulty. Whether by using beacons, planes, helicopters or satellite data, it is required to be able to see and understand what is happening, in order to decide, if necessary, to intervene in time.

It is essential to be able to strike hard and fast at sea, without sparing resources, even if it means reducing them later. Response to the *Prestige* pollution clearly showed that response at sea can be far more than simply a symbolic front, as long as the circumstances grant it some time. Response at sea to a major pollution incident is a great expectation of shoreline economic operators and the general public. It can still provoke difficulties in terms of compensation of expenses incurred.

Reliable pollution follow-up and movement predictions are necessary. Onshore response leaders, politicians and the general public expect modern technology to be able to accurately state where, when and in what form drifting slicks will hit the shore. This is in order to have enough time to protect the sites which may be hit and to be able to enlist the available response means and workforce rapidly and efficiently.

Those in charge of response should not hesitate, where necessary, to temporarily close access to beaches or stop fishing, ban the sale of produce from marine cultures, or even destroy stocks of this produce. Based on the precautionary principle, society expects authorities to take all possible measures to protect users, professionals and consumers from all health risks.



Drift prediction map of the fuel oil from the *Prestige*, 27 January 2003, Bay of Biscay

Clean-up cannot be restricted to the spilt pollutant. Subsequently, environmental damages caused by the pollution and response operations should be repaired as far as possible. This applies to sites, to the flora and fauna and enters into the field of costs which may be reimbursed, as long as the work carried out remains reasonable in view of the damage suffered.

Wrecks need to be treated if the pollutant trapped inside represents a future risk, even if these wrecks are far from the coast and the risks several decades away, for the sake of future generations.

Oily waste and polluted debris collected during clean-up operations must be completely treated in suitable facilities without generating further pollution. Old temporary deposits should be cleaned and the areas restored without leaving oil or polluted debris anywhere. All access paths to the cleaned areas should be restored to their original state.

The words marked by • in the text are defined here. They are either words which are specific to the vocabulary of the oil industry or pollution response, or words used in a particular sense, different from their general meaning.

A

Accidental pollution: pollution which results from a sudden event, independently of human will.

Adsorption: physicochemical phenomenon in which a chemical accumulates on the surface of a solid (at its interface with air, water...) or any other liquid or gaseous fluid.

Anti-adherent: agent designed to stop a pollutant from sticking in the areas where it is applied before the pollution arrives.

Aromatic: property of a compound which contains one or more benzene rings, which give it a particular smell, an "aroma" (e.g. hydrocarbons).

Asphalt: a sticky, black, highly viscous liquid or semi-solid composed almost entirely of bitumen, used for surfacing roads and for waterproofing.

B

Ballast: compartment of a vessel which can be filled, or partially filled, with water to stabilise the vessel.

Barrel: unit of measurement (volume) used for petroleum and its products (around 159 litres).

Beach depletion: according to the sedimentary cycle of the shore, at the beginning of winter, the sand moves down the beach. This process is known as beach depletion.

Beach growth: according to the sedimentary cycle of the shore, before summer the sand migrates up the beach. This process is known as beach growth.

Beaching: deliberate action of landing a vessel for repairs.

Bioaccumulation: capacity of organisms to accumulate chemicals through the food chain, reaching concentrations far higher than those normally present in the environment.

Biodegradation: decomposition of certain substances (in particular hydrocarbons) by living organisms.

Biogenic hydrocarbon: aromatic oils and essences present in many plant and animal species.

Bioremediation: involves promoting/accelerating natural break down processes by micro-organisms. Also known as biorestoration.

Bitumen: the residual fraction obtained from the fractional distillation of crude oil. It is the heaviest fraction and the one with the highest boiling point.

Black tide: see "oil spill"

Bulk: cargo which is not packaged and does not need stowed.

Bunker: compartments used to store engine fuel.

Byssus: bundle of threads secreted by certain shellfish (for example mussels) to attach themselves definitively or temporarily.

C

Charterer: a person who hires (charters) a vessel.

Chocolate mousse: expression used to describe emulsified oil.

Chronic pollution: permanent pollution caused by human activities.

Classification society: an NGO which provides safety standards for construction and maintenance (vessels' hulls and engines) and is responsible for the inspection of vessels to ensure the enforcement of these standards.

Containment: stopping the migration of solid or liquid, polluted substances out of a particular area using a boom.

Crude oil: a naturally occurring, unrefined, mineral liquid composed principally of hydrocarbon, which accumulates in reservoirs beneath the Earth's surface and is used as a source of energy.

D

Deadweight: maximum weight of the goods that a vessel is authorised to transport according to the ship's papers, expressed in tons.

Deballasting: operation which involves emptying a ballast tank of its contents.

Deballasting station: facilities where oil tankers can berth and unload their washing waters from their tanks. These waters are then treated in the deballasting station by settling.

Degassing: ventilation of tanks to eliminate hydrocarbon vapours to allow access for inspection or repair work.

Dispersant: liquid used to place oil in suspension in the water mass and promote its dispersal, in order to accelerate break down by the natural environment, at sea or in fresh water.

Dissolution: process of a solid (or gas) forming a solution in a liquid (e.g. sugar dissolving in water).

Double hull: watertight compartment surrounding the shell or part of the vessel to protect it in the event of a leak in the hull.

Drilling rig: structure consisting of a raised, flat, horizontal surface used to exploit submarine oil reservoirs.

Dry dock: basin which can be closed by gates and drained once the vessel is inside in order to carry out maintenance work or painting for example.

DWT (deadweight ton): capacity in long tons (2,240 pounds) which can be transported by a vessel (cargo and bunkers). See "deadweight".

E

Ecotoxicology: science which studies the ecological consequences of pollution and chemical and radioactive contamination.

EEZ: Exclusive Economic Zone, intermediate maritime area between the territorial sea and the high sea, where the coastal State possesses sovereign rights in terms of exploration and exploitation of the sea's and seafloor's resources.

Effluent: waste waters or liquid waste discharged into the water during clean-up operations in pollution response.

Emulsification: dispersion of a liquid into very fine particles in another liquid, forming an extremely heterogeneous liquid.

Emulsion: mixture of two non miscible substances (i.e. which do not normally mix), such as water and oil.

Emulsion breaker: liquid used to break down emulsions in the form of pastes made of oil in water, which are recovered onshore or at sea.

Epithelium: tissue made up of juxtaposed cells arranged in one or several layers lining the inner surface of organs.

Equipment: action of equipping a vessel and supplying it with all the resources needed for navigation.

Evaporation: gradual change of state of a liquid into a gas.

F

Film-forming agent: substance which can form a thin layer (a film), used to reduce the adhesion of oil on hard surfaces such as rocks, riprap and concrete walls, to facilitate cleaning. It is applied before the pollutant arrives.

Final clean-up: this is the second stage of clean-up. It involves allowing sites to recover their former uses and return to normal ecological functioning.

Flag: nationality of a ship.

Flag of convenience: registration of a ship in a country which grants its flag without assuming its responsibilities in terms of safety checks.

Flooding: saturation of a beach with water.

Flushing: clean-up technique involving the remobilisation of fresh pollution using low pressure hoses in order to channel it to a collection point.

Foreshore: the part of the shore between the high and low water levels (= intertidal zone).

Fuel oil: residue from the distillation of oil, formed from a mixture of solid and liquid carbides. In appearance it is a thick, brown liquid used as combustion fuel.

G

Gasoline: American term for petrol.

Genotoxic: agent which increases the appearance of genetic mutations.

Gross tonnage: the volume of all the compartments located below deck onboard a vessel. It is expressed in register tons, equivalent of 100 cubic feet or 2.83 cubic metres, (old system) or in units (new convention).

Grounding: when a vessel accidentally hits the ground, causing it to need to be refloated.

H

High tide mark: the highest point on the foreshore reached by the high tide.

Hydrocarbon: compound containing only carbon and hydrogen, forming the main component of oil.

I

Initial clean-up: the first stage of clean-up operations. The aim is to remove large accumulations of pollutant and heavily polluted materials as quickly as possible in order to limit expansion of the pollution and ecological impact.

Intertidal zone: part of the shore between the furthest limits reached by the tides (= foreshore).

IOPC Funds: the International Oil Pollution Compensation Funds.

K

Kerosene: fuel obtained by distilling crude oil and used as fuel for jet engines in planes.

L

Landfarming: technique involving breaking down the pollutant by setting up a system to create bacterial action on polluted soil.

Lightering: operation which involves emptying part of the cargo of a vessel into another vessel.

Lime stabilisation: the addition of quick lime to materials polluted by oil in order to obtain more stable chemical compounds.

O

Oil cut: mixture of hydrocarbons defined by the interval of their boiling points or by the number of atoms of carbon in their compositions (e.g. heavy petrol: 100-180°C, C7-C10).

Oil fraction: See "oil cut"

Oil spill: sudden, localised release of petroleum into the environment. In the case of major spillages, the quantities greatly exceed what the local environment is able to assimilate without resulting in damages.

Oil tanker: vessel designed to transport liquid hydrocarbons (crude oil or refined products) in bulk in its tanks.

Oil well: perforation through the Earth's surface designed to extract oil.

Oleophilic: property of presenting an affinity for oils, absorbing them selectively.

Operational discharge: release at sea of waste waters containing a certain quantity of hydrocarbons. Release linked to the routine activity of a vessel.

Outcrop: an area of rock emerging at the ground surface.

Oxidation: chemical reaction in which a compound combines with one or more atoms of oxygen, with the loss of one or more electrons.

P

PAH: Polycyclic Aromatic Hydrocarbon = hydrocarbon formed by the fusion of a variable number of benzene rings (C6H6); the most simple PAH is naphthalene (C10H8).

Patty: a deposit of pollution roughly between 10 cm and 1 m in diameter. In the classification of pollution, it is considered smaller than a patch but larger than a tar ball.

Percolation: circulation of water through the sand, due to gravity.

Petrochemistry: industrial chemistry of petroleum derivatives.

Petrol: a petroleum-derived, volatile mixture of flammable liquid hydrocarbons used as fuel in internal combustion engines (e.g. cars). Also known as gasoline.

Petroleum: See "crude oil"

Photo-oxidation: phenomenon of oxidation of a pollutant facilitated or provoked by sunlight.

Pipeline: a large pipe or tube used to transport certain liquids over a long distance, especially liquid fuels such as hydrocarbons, natural gas etc.

Place of refuge: area, usually a port, where a vessel in difficulty can be taken to stabilise the situation, to minimise the impact on the environment.

Polludrome: a unique tool belonging to *Cedre*, in the form of a flume tank used to simulate the weathering of oil at sea.

Pollution reponse: all efforts made to minimise the impact of a pollution incident.

Port of refuge: see "place of refuge".

Pozzolana: volcanic earth, brown to grey in colour.

Ppm: Parts per million, i.e. a concentration (mg/l, g/t) of one millionth (1/1 000 000, 10^{-6}).

Protection and Indemnity club (P&I club): insurance covering the responsibility of the shipowner.

R

Reference condition: initial state of the natural environment in a localised area before being polluted.

Refined product: petroleum product obtained from crude oil by refinery according to the proportions and quality required: propane, butane, petrol, kerosene, diesel, bitumen, fuel oils.

Refinery: 1) operation or series of operations through which a (homogenous or heterogeneous) mixture of substances is separated into one or more pure bodies or one or more mixtures with well defined properties. 2) Industrial plant where this process is carried out.

Remote sensing: science and technique of detection at a distance (satellite, aircraft).

S

Sand screener: machine which picks up a layer of sand 5 to 20 cm thick and passes it along a vibrating wire conveyor belt, acting as a screen, to recover the solid waste (tar balls).

Sedimentation: natural settling of particles with a higher density than water, caused by gravity.

Separator: device which separates the different components in a mixture, in this case they separate oil from water.

Settling: deliberate separation of matters in suspension by leaving them to fall to the bottom of a recipient.

Sheen: production of the colours of the rainbow by the fractioning of light caused by thin films of silvery hydrocarbons a few microns thick.

Shipowner: the person in control of a vessel, who is responsible for its operation, maintenance and running.

Shipping lane: channel or route that ships must follow near certain coasts.

Skimming: recovery of hydrocarbons on the water surface.

Slop tank: tank into which residues are pumped and left to settle onboard oil tankers.

Sludge: fuel residue in the form of an agglomerate of solid and liquid materials with a tendency to form a deposit.

Solid waste: all types of various forms of waste, either of human or natural origin, floating at sea or deposited onshore.

Sorbent: all products designed to absorb and/or adsorb liquid spilled in the environment, in order to facilitate their recovery.

Stockpile: a reserve where materials and equipment are stored for future use.

Straining: initial phase of purification of polluted water, which involves eliminating solid waste and large particles.

Substrate: nature of surface sediments.

Surfwashing: beach clean-up technique which involves moving sediments down the beach to the area where the waves are breaking in order to expose them to wave energy.

T

Tainting: alteration of taste and smell of sea produce to acquire an oil-like taste when an oil spill occurs.

Tank: compartment onboard a vessel used to store cargo or ballast waters.

Tar: coal-coloured derivative of oil. By-product of the distillation of coal in the fabrication of petroleum coke. It is highly viscous or can even be solid.

Tar ball: small ball of weathered oil

Terminal: industrial facility where oil tankers load and offload their cargo.

Tour d'Horizon: a yearly reconnaissance flight carried out within the framework of the Bonn Agreement, mainly along offshore installations, covering at least 600 nautical miles, roughly between 52 north and 63 north.

Traffic separation scheme: see "shipping lane".

Tug: a strong, powerful boat used for towing other vessels.

V

Vetting: evaluation by a charterer of whether the risk presented by the use of a tanker is acceptable in terms of his standards.

Viscosity: resistance of a liquid to flow.

Volatile: which easily or spontaneously changes into a gas.

W

Washing agent: product which helps remove oil which is stuck to rocks.

Water column: a volume of water in a real or imaginary vertical tube.

Wharf: a platform built on pilings, alongside which a vessel can berth.

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