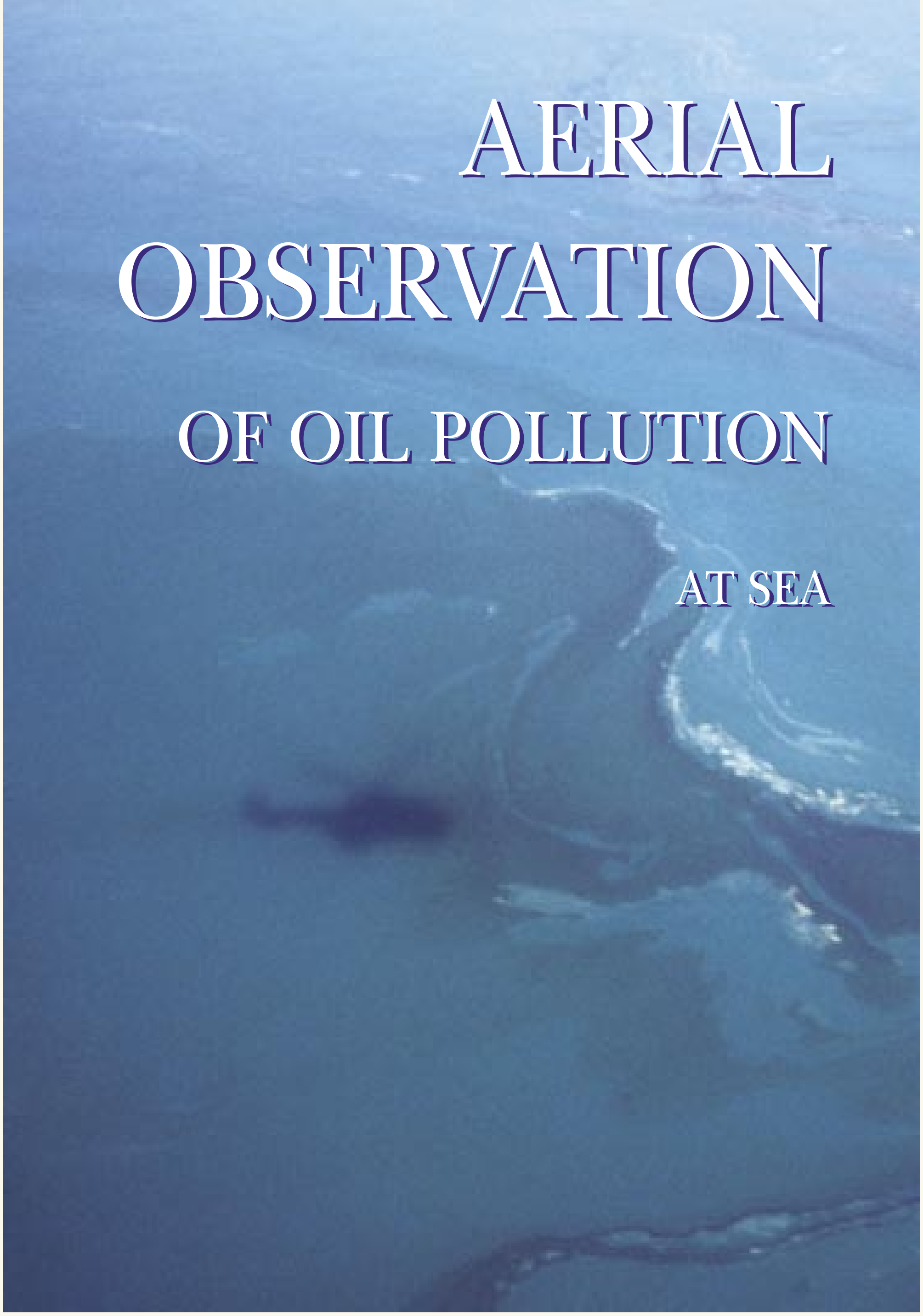
AERIAL OBSERVATION OF OIL POLLUTION AT SEA



OPERATIONAL GUIDE

Cedre

Cover photo: Aerial reconnaissance during the Exxon Valdez oil spill (Alaska, 1989)
Source: Cedre

AERIAL OBSERVATION

OF OIL POLLUTION

AT SEA

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This guide was written and produced by *Cedre*, the Centre of Documentation, Research and Experimentation on Accidental Water Pollution, as part of its technical program, with financial support from the French Navy, Total and the Ministry of Ecology and Sustainable Development.

The information contained in this guide is the result of *Cedre*'s research and experience.
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Translated by Sally Ferguson.

Purpose of this Guide

An important component of *Cedre*'s work involves designing operational guides which present the results of studies, of experimental work and experience feedback from accidents which have occurred.

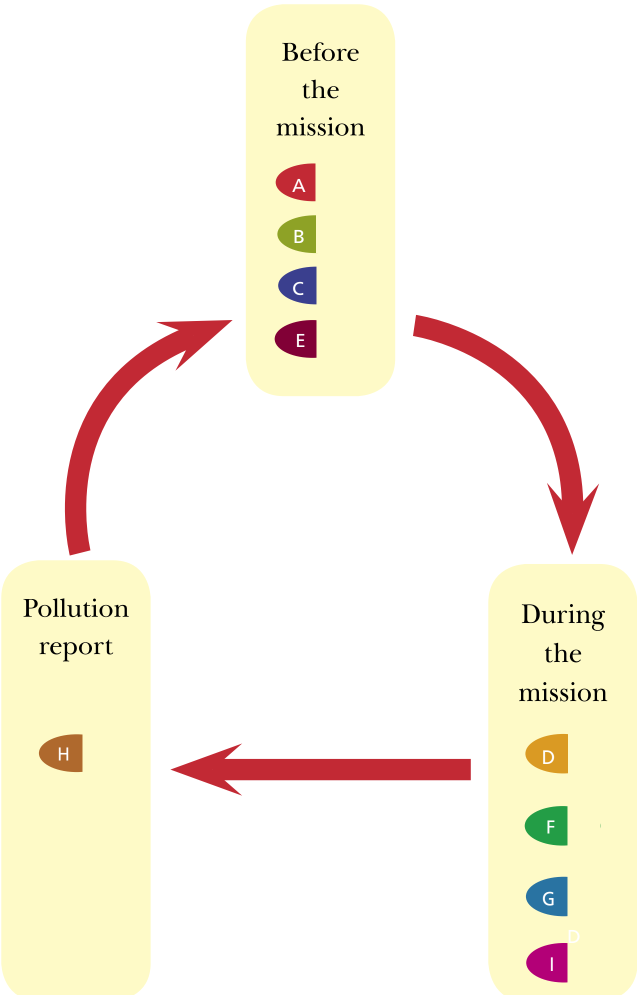
The original operational guide dedicated to aerial observation, published only in French, dated back to 1993. It therefore seemed necessary both to our experts and our partners (the French Navy, French Customs and Total) to update this guide, in light of the advances made in terms of practices and knowledge in this field.

The French Navy Air Force and French Customs (Aero-Maritime Surveillance Brigade) share their knowledge at bi-annual training courses organised by *Cedre*. Much of what is presented in this guide is a result of the work of these experienced observers. They will recognise their contributions, for which we are extremely grateful.

A number of important new points have been added to this edition, in particular the modelling of drift prediction (MOTHY model), the use of satellite-tracked drifting buoys and the Drift Prediction Committee, set up a few days after the shipwreck of the Prestige by the French General Secretariat for the Sea.

The first vocation of this operational guide is to be present onboard all aircraft likely to be involved in aerial observation of oil pollution at sea. However it is also a useful tool in pollution response centres and as a technical support for public relations personnel.

Operational Organisation



THE MISSION

The Aims of Reconnaissance Flights

A1

Aerial observation can be used for two distinct purposes.

First, it can be carried out routinely, to look for and suppress operational pollution by ships. In this case the aims are to:

- detect the pollution
- accurately locate and describe the pollution
- where possible, identify the polluter

in order to:

- assess the pollution (quantity and quality)
- anticipate the evolution of the situation
- prosecute the polluter via a pollution observation report

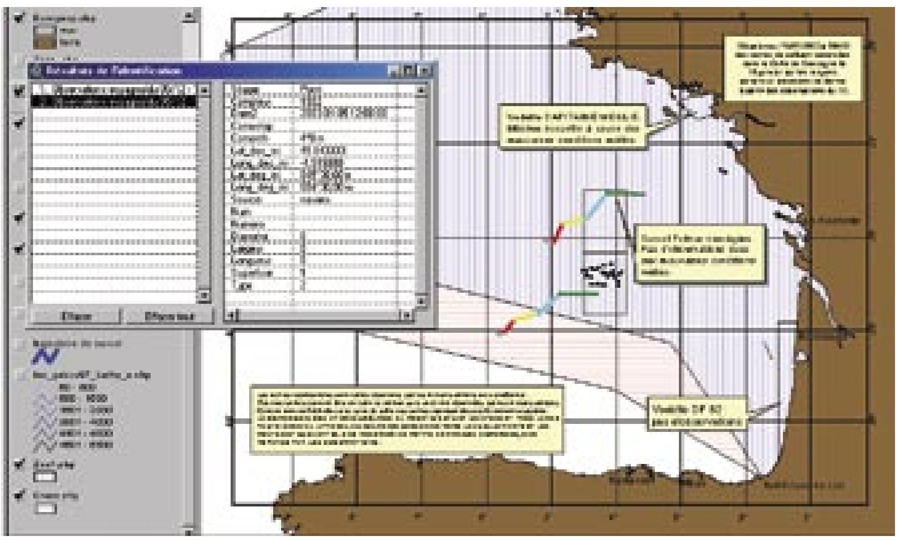
Secondly, aerial observation is used in the event of an accident, to assist in recovery and dispersion operations at sea. The aims of the observation missions are to:

- locate the slicks
- accurately describe the slicks
- map the pollution

in order to:

- monitor the pollution
- adjust drift models
- guide response operations that day
- prepare the response operations for the following days

In the event of an accident, aerial observation is the only means of obtaining a clear, realistic picture. It is the first link in a chain of important decisions.



The Prestige, an example of a GIS prediction map providing the details of a pollution observation

Preparing the Mission

All missions must be prepared. The aim here is to try to predict what is likely to be encountered, including the appearance, extent and location of the slicks.

In all cases:

- Prepare basic maps of the zone, on which the pollution can be mapped and observations noted during the flight. Clearly indicate on these maps the orientation, coastline, geographical co-ordinates, scale...

In the case of an accident:

- Gather as much information on the slick as possible:
  - nature of the pollutant: crude, refined, light or heavy oil (its density, viscosity, pour point, etc.). In the case of crude or light refined oil, beware of the risk of explosion (see A3) and make sure an explosimeter is available.
  - type of accident (sinking, grounding, explosion during operations ...).
  - type of spillage (isolated event, continuous flow, on surface, below surface).
  - last slick observation (date, appearance, location).
- Gather all the necessary data on the local conditions (weather since last observation, sea currents, sea state etc.).
- In the absence of specific instructions from a coordination centre, estimate the most probable location of the slick, by calculating its probable drift (see E1), either from the place of spillage or the last observed position.
- Investigate the possibility that other areas, so far unobserved, may be polluted. This should be carried out taking the prevailing local circumstances into consideration, for example the shipping route before the accident, a new leak in the wreck, other pollutant contributions due to slicks, previously having reached the shore, breaking away and drifting... (see example at foot of page).
- Identify the zone to be covered by the mission and establish a flight profile for maximum coverage (see A3).
- Forecast slick evolution according to the characteristics of the pollutant (estimate viscosity at ambient temperatures, assess tendency to form a reverse emulsion), or according to the available observation data, and anticipate any potential identification difficulties (e.g. low floatability of the pollutant, fragmented slicks...)
- Prepare and take onboard buoys which can be detected by satellite.

The example of the Erika

Before breaking in two, the *Erika* had already been leaking for many hours and the lost fuel oil arrived onshore without being observed at sea. This occurred due to a lack of specific research aimed at locating this loss, as it had not been reported by the ship's master.

Flight Profile

- As hydrocarbons tend to spread in bands parallel to the wind (see D3), the zone to be investigated should be covered flying cross wind, to increases the chances of detecting any slicks ("staggered sighting").

  - Mist and dazzle reflected from the sea surface often hamper visibility. Sometimes the best way to fly will be governed by the position of the sun.

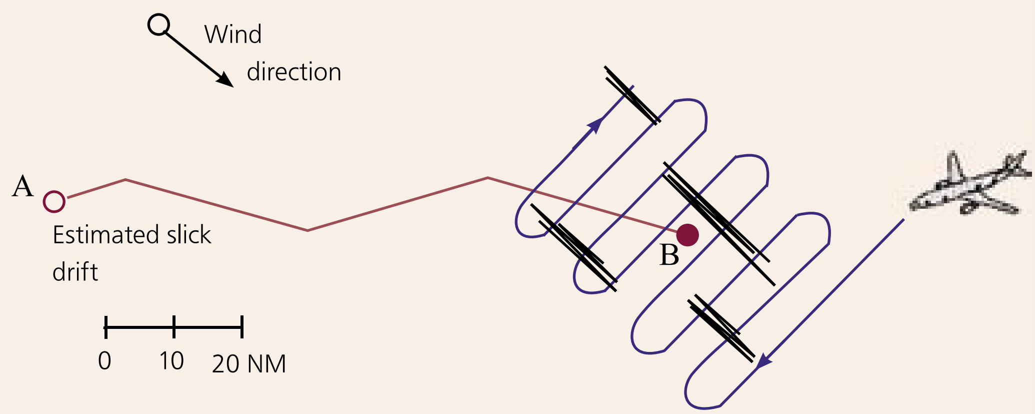
  - Flying altitude is determined by the size of the slicks to be located, the visibility and the sea state. It is important to ensure maximum sweep while conserving a good vision of all the details.

- First of all, look for the most polluted zones (thick patches or slicks, accumulation zones). Out at sea, follow thin patches or stripes (rainbow, sheen or metallic appearance) with the wind, in order to detect any possible thick patches leeward of the contaminated zone (see D3).

- If a new band of pollution or recent stripes are sighted, follow them in order to determine the source of pollution. This source will usually be located upwind, particularly if the spillage point is fixed, but also upcurrent (see D3).

- The use of polarised sunglasses facilitates observation.

- As far as possible, observations made using non-specialised planes (e.g. maritime patrol) should be confirmed by helicopter reconnaissance (which allows more precise observation), or by a plane fitted with specialised remote sensing equipment (IR, SLAR, FLIR, UV or possibly microwave).

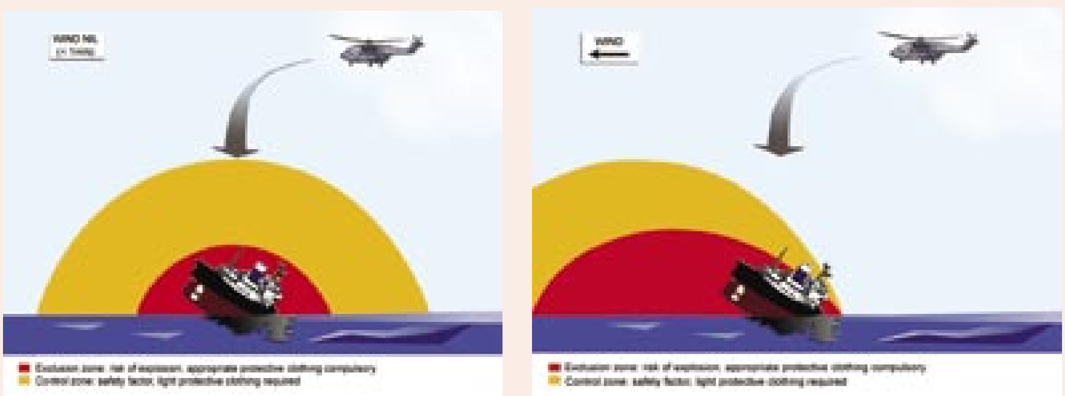


A: Last known slick position B: Probable current position of slick
NM: nautical miles

- In the event of a significant spill of light crude oil or a light refined product, a (toxic or explosive) gas cloud may form. In this case, the approach and overflights of the site must be carefully planned to avoid any possible risk for the crew. For helicopter reconnaissance missions, several recommendations should be followed. The approach to the spill area should be made cross wind or with the wind at the tail, at an altitude of at least 50 metres, to avoid entering the dangerous zone. The helicopter crew should be equipped with breathing masks, an explosimeter and optionally a toximeter, to detect the presence of toxic vapours in the air. A helicopter hovering over an inflammable slick should not lower to an altitude of less than 20 metres, or 30 metres in the case of a major spill of a highly inflammable product (a light hydrocarbon).

Warning: If the action of the currents is stronger than that of the wind, the slick may move upwind.

Helicopter approaching an oil tanker in difficulties



When no in-depth assessment of the situation can be immediately carried out, protect all responders, with protective clothing and masks, within a radius of at least 200 m.
The values quoted are purely to give an indication.
Each case must be assessed individually.

Different Types of Hydrocarbons

B

Oil and Oil Products

Hydrocarbons are complex associations of distinct chemical components. Their appearance, physical characteristics and behaviour depend on their composition. Spillage of petroleum products at sea concerns mainly three types of products with very different behaviour.

- **Light refined products** (petrol, white spirit, kerosene, diesel oil, domestic fuel oil...). These are colourless or only slightly coloured products with high fluidity and are made up of the lightest oil fractions.
- **Heavy refined products** (HFO, IFO, ship propulsion fuel, bilge discharge...). These products are black and often viscous, with no or few light fractions.
- **Crude oils** vary in colour from brown to black. They have widely varying characteristics, depending on their composition, in particular on the proportion of light or heavy fractions, resulting in their resemblance to either light or heavy refined products. After a certain length of time at sea, crude oils lose their light fractions through weathering (see C), resulting in similar characteristics and behaviour to heavy refined products.

The emulsions formed by these products vary in colour from dark brown to orange.

Type of oil	Persistance/Evaporation
Light refined products e.g. petrol, diesel, kerosene	Low or no persistence Rapid evaporation (in a few hours) Natural dispersion
Products with viscosity < 2 000 cSt. • Slightly weathered light and medium crude • Slightly weathered light and intermediate fuel oils	Low persistence High evaporation rate (around 40% in 24 hours)
Products with viscosity > 2 000 cSt. • Weathered light and medium crude oils • Heavy crude oil • Heavy fuel oil, operational residue e.g. Bunker C, HFO, IFO 380.	Average persistence Low evaporation rate (usually less than 10%)
Paraffinic crude oils with a pour point higher than the water temperature.	High persistence Solid or highly viscous liquid hydrocarbons Very low evaporation rate

Table summarising the properties of hydrocarbons

B2

Basic Physical Characteristics

A petroleum pollutant spilt at sea can be characterized by a certain number of physical parameters which inform those working on the site about its behaviour and weathering at a given point in its evolution. The principal physical characteristics are:

- **Density**

  The density of hydrocarbons is usually below 1, which means that they float on water. However, once spilt, and due to weathering phenomena (evaporation and particularly emulsification), the density increases progressively until values similar to those for sea water are reached, which makes buoyancy less probable in coastal and estuary areas.

- **Viscosity**

  The initial viscosity of hydrocarbons varies widely. Viscosity depends on temperature (see graph on next page). When spilt the viscosity of hydrocarbons progressively increases up to very high values (e.g. 105cSt), due to weathering phenomena (evaporation and emulsification, see C), which alters the pollutant's behaviour on the sea surface (see D1).

- **Pour point**

  The pour point of a petroleum product is the temperature at which it stops flowing in laboratory control conditions. This does not mean that below this temperature the hydrocarbon acts as a solid. The pour point is measured in the laboratory, in a narrow test tube. When spilled at sea, in an open area, hydrocarbons remain liquid at temperatures below their pour point.

  Two other characteristics are important: the flash point and the auto-ignition temperature. These factors are particularly important in the case of refined products, for which a thorough assessment of fire and explosion risks is necessary.

- **The toxicity of Volatile Organic Compounds (VOC)**

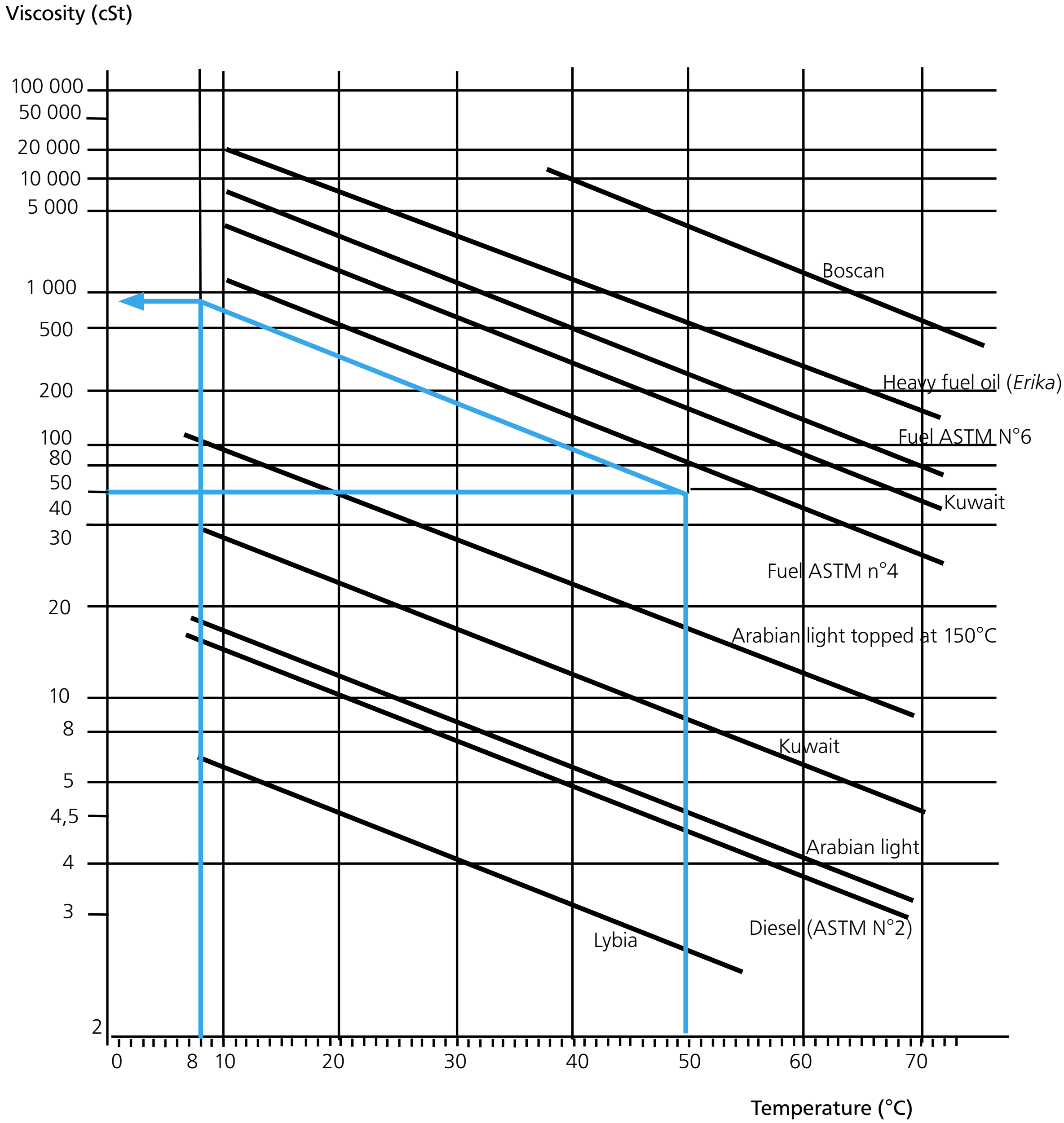
  At a concentration of 900 ppm (0.09%) VOCs lead to irritation of respiratory channels and eyes after about an hour.

- **Explosive range**

  The explosive range involves minimal values of gaseous hydrocarbons in the atmosphere, ranging from 2 to 11.5%.

DETERMINATION OF THE VISCOSITY OF A HYDROCARBON ACCORDING TO TEMPERATURE

! This diagram cannot be applied to highly emulsified hydrocarbons ("chocolate mousse"), nor to paraffinic hydrocarbons (pour point close to ambient temperatures).

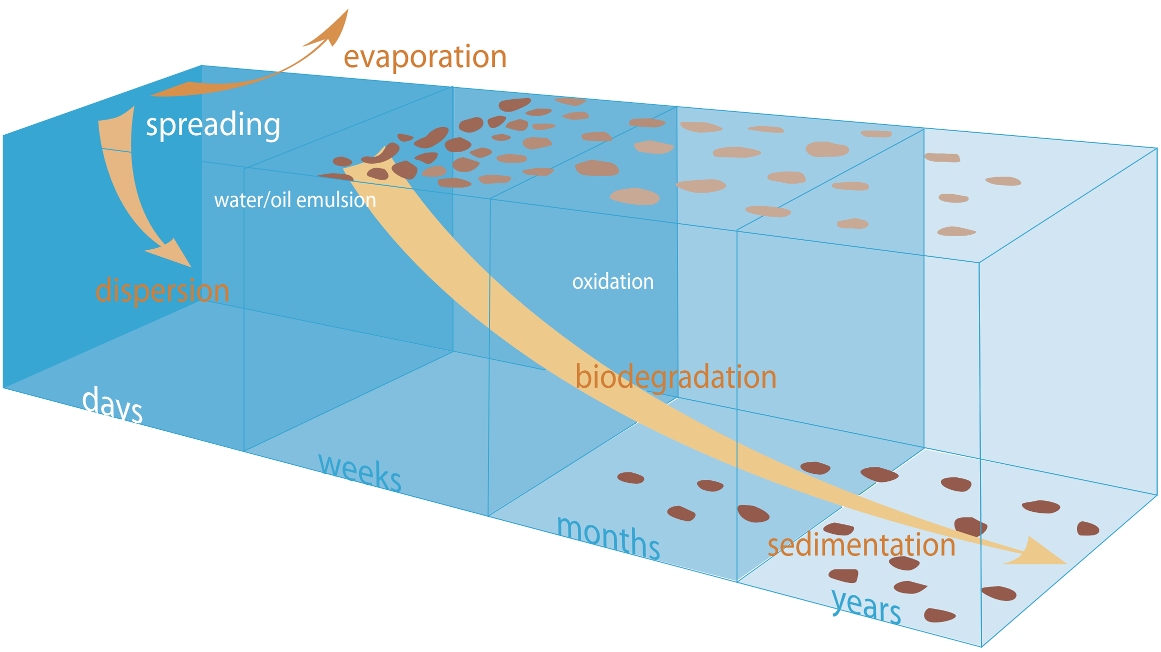


Example of use of this diagram: the blue line shows that the viscosity at 8°C of a fuel which measures 50 cSt at 50°C is 800 cSt

Evolution of Oil at Sea

C

Over time, oil spilt at sea gradually changes in appearance and behaviour.



The natural weathering of hydrocarbons spilt in water

The First Few Days

Warning: Chemicals with a high vapour pressure, such as petrol, are dangerous if inhaled and can explode or ignite (even with a low concentration in the air).

Over the first few days, the oil spilt at sea undergoes the following processes.

- Spreading into a film which may be very thin (a few microns). Thus a small quantity can cover a very large surface area (1 km² for 1000 litres). However the spreading is irregular.
- Evaporation of the lighter fractions. Crude oils, condensates and refined products begin to evaporate immediately after a spill, and can continue to do so for a long time if the meteorological conditions are favourable. The rate of evaporation depends first on the volatility of the various components of the spill mixture but also on factors such as the quantity spilt, the water and air temperature, water turbulence, wind and rate of spreading of the slick.
    - When petrol at 20°C is spilled, approximately 50% evaporates in the 7 to 8 minutes following the spill. Petrols, kerosene and light fuel fractions (volatile compounds with a boiling point of 200°C) disappear almost completely after 24 hours at 20°C.
    - The proportion lost through evaporation is lower for heavy fuels. For domestic fuel oil (DFO), 30 to 50% evaporates in a day.
    - The heaviest fractions such as Bunker C scarcely evaporate at all. Loss through evaporation is estimated at a maximum of 10% of their weight.
- Dispersion: The percentage of natural dispersion is essentially related to the nature of the product and to the sea state. The waves and turbulence of the sea surface act on the slick and induce the formation of oil droplets of varying sizes. The smaller droplets stay in suspension in the water column, the others either coalesce with other droplets or spread into a thin layer. Coalescence of droplets in suspension is most prevalent when the sea is calm, however in this case aerial observation is made easier.
- Emulsification occurs mainly with crude oils or black refined products, after a few days, or even a few hours if the sea is rough. The emulsion formed varies in colour from dark brown to orange. This phenomenon increases the apparent volume of pollutant, reduces spreading (by forming thick patches) and eventually increases the apparent density of the pollutant until it is almost equal to that of seawater. It may therefore remain below the surface, or even sink, especially in coastal or estuary areas, due to the presence of substances in suspension and the reduced salinity.

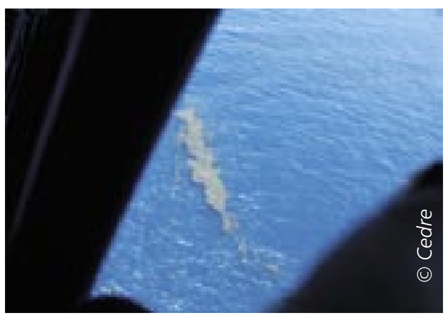
Photographic Imagery of the Evolution of Oil at Sea

Recent spillage (a few hours old): the fresh pollutant spreads widely to form a film with scattered thicker patches

With weathering, brick red patches of reverse emulsion may form in the centre of thinner layers (rainbow, sheen or metallic) and thicker patches (2 to 8 days after the spill).

Over time, the slick fragments and the thickest patches are increasingly noticeable compared to the thin layers (rainbow, sheen or metallic), from a few hours to 1 day after the spill.

C2



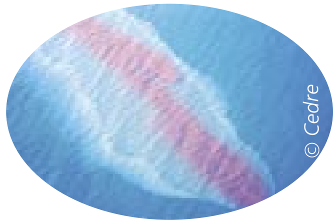
Subsequently, the films (rainbow, sheen or metallic) gradually disappear and eventually only patches or stripes of emulsion may remain (a few days after the spill), especially in a rough sea. Iridescences can however reappear later, even several weeks or months after the spillage, if the sea is very calm and the sun is warming up the spill.

Appearance of Oil Slicks

With a small angle of incidence, usually only sheen or a rainbow or metallic film is visible

General Overview

*Crude oil slick (*Nassia *accident, Bosphorus, Turkey, 1994)*



D1

Light refined products

- Spread rapidly over very large surface areas in a fairly homogeneous, thin film.
- Substantial evaporation and natural dispersion causing disappearance in two or three days, or even a few hours.
- Colourless or only slightly coloured products, mainly visible with a small angle of incidence. The slicks show up as shiny patches.

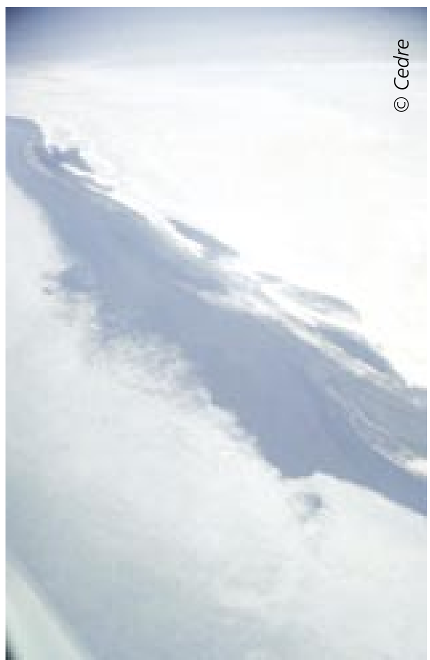
Slick of light refined product rapidly spreading into a thin film

The colour of thick patches and stripes may vary depending on the luminosity, the colour of the sky and the observer's position in relation to the sun.

Heavy refined products or crude oil

- Irregular spreading, rapidly forming thick patches or stripes, which are black or dark browny black (or possibly greenish) surrounded by a dark, unbroken thin film.
- Over time (and after the loss by evaporation of the light fractions of the pollutant), the tendency to spread increases. The patches thicken and pile up (several millimetres thick), turning brown/orangey brown, while the unbroken film becomes thinner and eventually transforms into a rainbow or metallic film. Within a few days, the thin layers eventually disappear altogether. However in calm, sunny conditions iridescences may reappear.
- Thin, unbroken films are clearly visible with a small angle of incidence (shiny patch) whereas thick patches are best seen with a large angle of incidence.

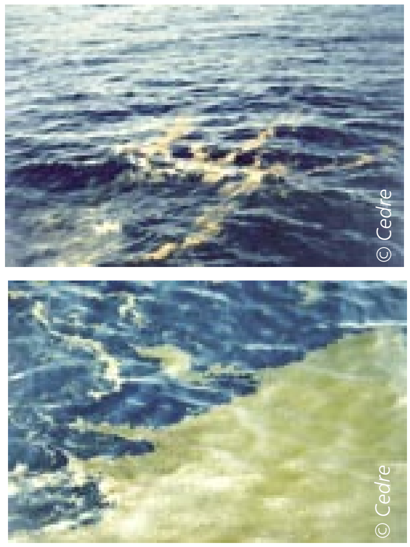
Crude oil slick (Gulf War, 1991)



Special Cases

- Oil treated with dispersant: the dispersed oil appears as an orange to light brown (or sometimes dark brown) cloud, just below the surface of the water.
- Congealed petroleum products at seawater temperature (mainly concerns products containing heavy paraffins): formation of thick or lumpy patches possibly surrounded by thin rainbow or metallic layers.
- Product forming little or no reverse emulsion, case of a light hydrocarbon (crude oil or refined product): only thin films remain, which gradually break up and disappear.

Oil treated with dispersant



Congealed paraffinic oil: close up, the patches can be seen to be made up of lumps.

Oily film in the process of becoming completely dispersed

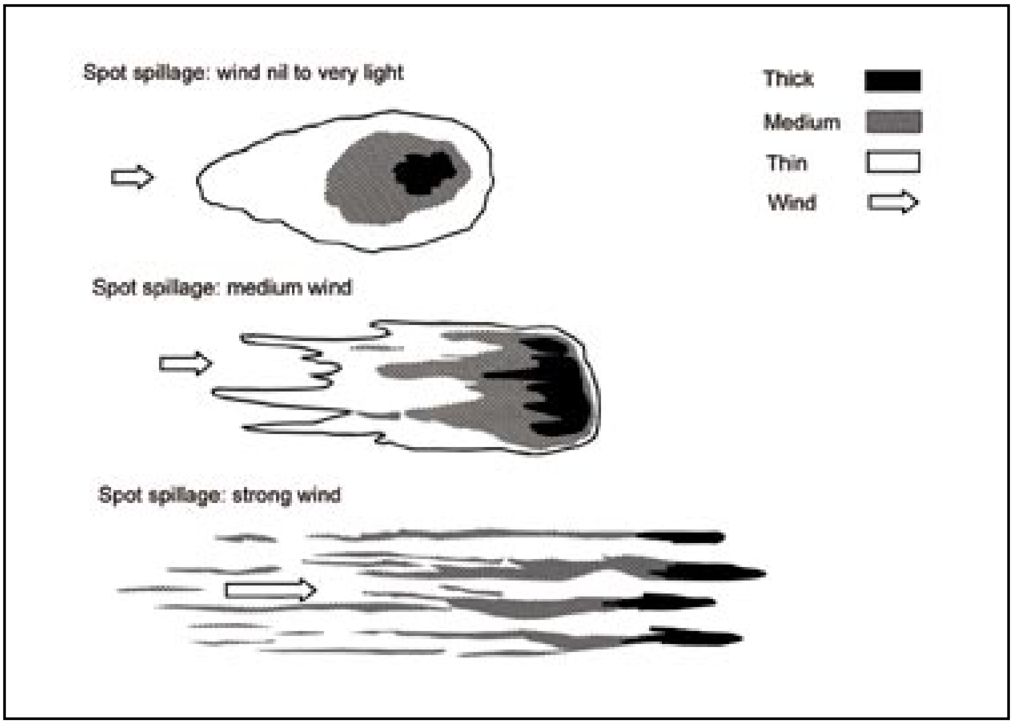
Topography of Oil Slicks at Sea

- **For fairly fresh slicks** (several hours to a few days old), the shape and thickness distribution (thick, medium, thin) depend mainly on the wind.

  The wind spreads and elongates the slicks, eventually cutting them up into windrows and then fragmenting them.

The thickest patches lie furthest downwind.

When the wind is very strong, the iridescent zones (sheen - rainbow - metallic) tend to disappear.

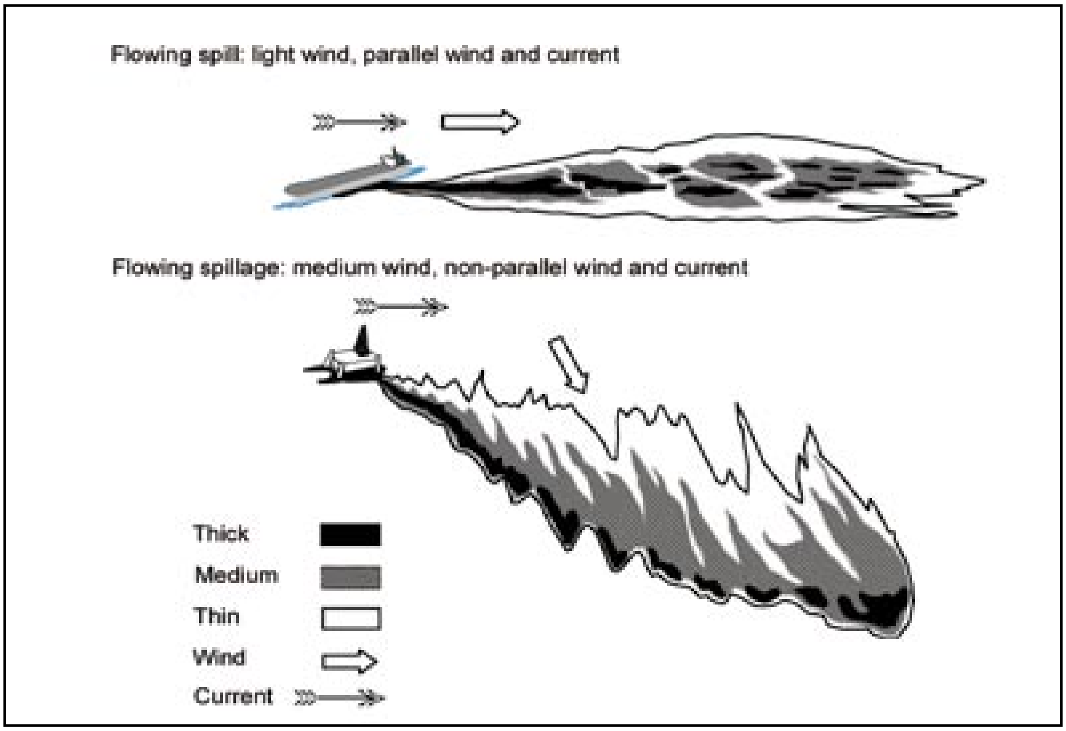


- **For weathered slicks** (several days old or more), sheen and rainbow or metallic films gradually disappear. Only very thick, highly emulsified patches remain, barely floating on the surface.

  In the case of violent storms, even extensive slicks may not be visible, but may reappear when the conditions become calmer.

Breaking waves may also fragment these patches so that eventually they become scattered lumps which are increasingly difficult to observe.

The oldest slicks often become mixed with floating debris.



Arrival of Oil on the Coast

1 Slicks or floating patches accumulate in coastal areas open to the wind (coves, bays, inlets...).

2 Pollutant is deposited in accumulation zones, with the ebb and flow of the tides. The pollutant usually forms stripes, fragmented to varying degrees, along the high tide line.

3 The pollutant is often mixed with varying quantities of floating debris and, in particular, seaweed.

4 The pollutant may be carried away if the wind or currents change direction.

Small quantities of oil or fragmented slicks which arrive on the coast are difficult to identify from aircraft, especially in rocky areas.

1. Arrival of weathered emulsion on the coast, from the Erika*'s cargo of heavy fuel oil (Le Croisic, Loire-Atlantique, France, December 1999)*

2. Arrival of an emulsion of heavy fuel oil on the coast from the shipwreck of the oil tanker the Tanio *(off the coast of Brittany, March 1980)*

3.Arrival of an emulsion of fuel from the wreck of the Prestige *on the coast, combined with seaweed (Galicia, November 2002)*

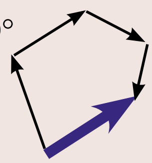
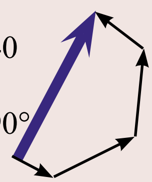
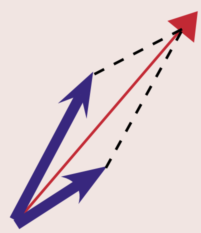
4. Remobilisation of fuel from the Erika *which was trapped in rocks in the Loire-Atlantique region: lumpy browny-red emulsion, containing debris (Le Pouliguen, France, September 2000)*

Drift of Oil Slicks

Calculation of Drift

Oil slicks drift on the water at 3 – 4% of the wind speed and 100% of the speed of the current. The actual route covered by a slick (or "course made good") can be determined graphically by vectorial addition of the speed of the current and 3 - 4% that of the wind, established

	Current	Wind	Drift
1st hour	1.5 knots at 340°	12 knots at 285°	
2nd hour	1.5 knots at 60°	30 knots at 240	
3rd hour	1 knot at 110°	25 knots at 190°	
4th hour	1 knot at 190	20 knots at 25°	

Calculation of drift over 4 hours
The black arrows show the successive effects of the current (100%) and the wind (3%) on the slick each hour. The blue arrows show the resultant after 4 hours. The red arrow shows the overall resultant.

Slick movement and drift models: computer software exists for calculating the drift of oil slicks and can be useful in preparing a mission. The MOTHY model, designed and run by Météo France in Toulouse, is the program used by *Cedre* (see E3).

Information and Data Transmission

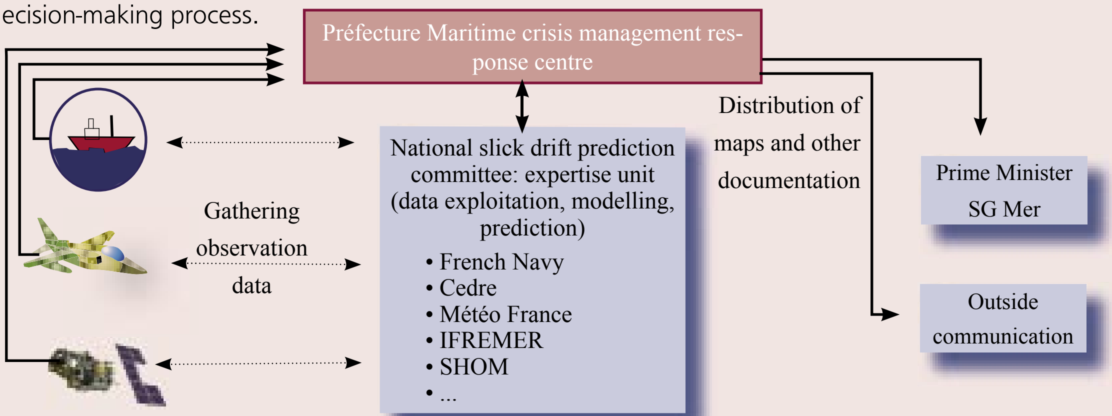
In pollution management, many factors must be taken into consideration, including aerial observation data (position of the pollution, remarks about the observation, flight plans, photos, remote sensing imagery...), drift prediction and signals sent by buoys launched at sea (see E4). This information is exchanged between responders by various means (fax, telephone, email, internet). To optimise transmission and exploitation of the data, computer-based methods should be given priority (e.g. pollution reports in an Excel document, the use of digital cameras or a different system coupled with GPS). Transmission via the internet should eventually become standard practice.

It is important to:
- computerise as much information as possible
- use digital photographic equipment
- prioritise real-time transmission of information by using the internet

Thanks to experience from the *Erika* disaster, as soon as the *Prestige* spill occurred, a committee of experts was appointed by the French General Secretariat for the Sea, in order to provide information about the drift of oils slicks for the responders. The Météo France – *Cedre* unit, set up the day after the accident, rapidly expanded to form a Drift Prediction Committee, led by *Cedre*, which included representatives from the Préfecture Maritime, Météo France, IFREMER and SHOM. The main aims of the committee were to:

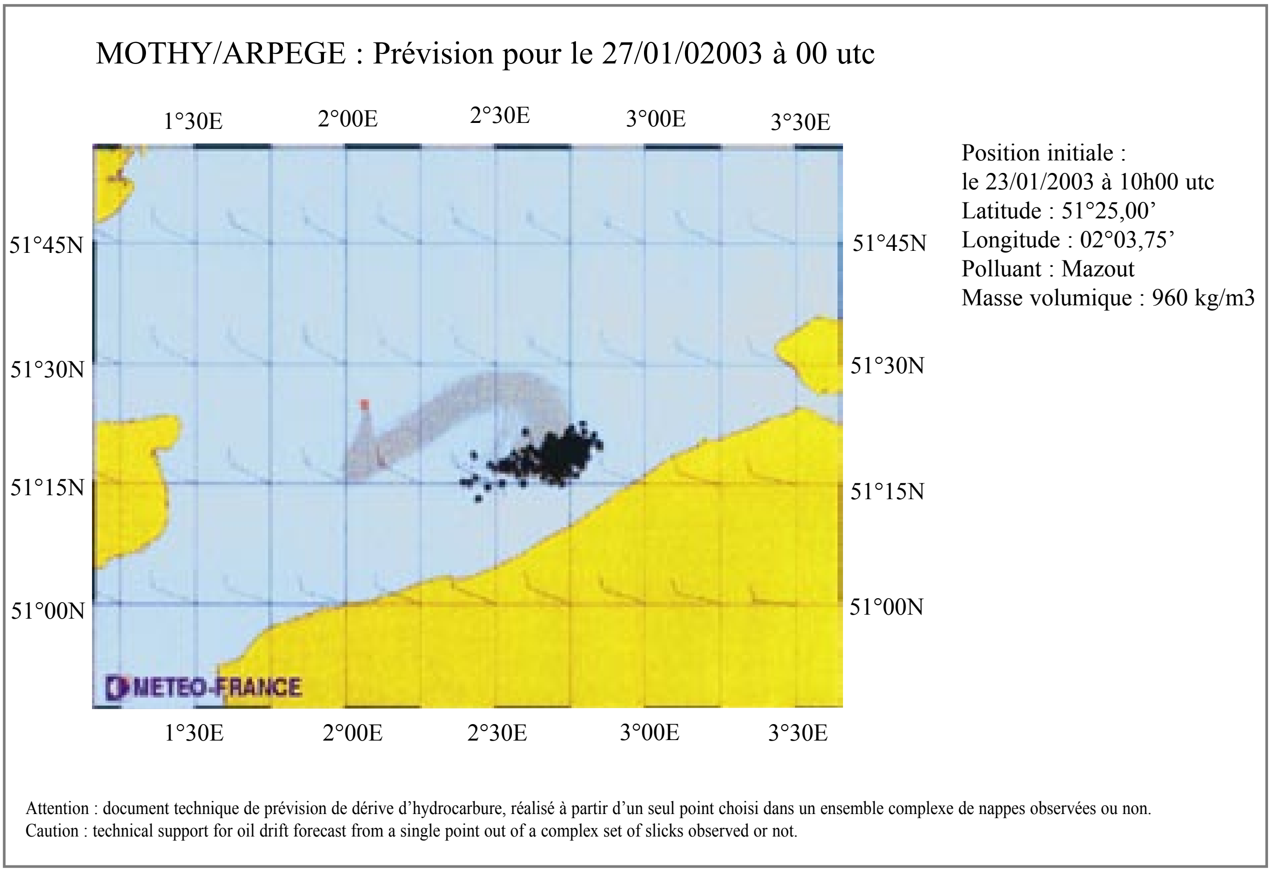
- analyse the observation data (aerial, nautical and satellite observation) and transmit it to Météo France's specialist in charge of MOTHY
- provide advice for future observation flights
- update the location map daily and send it to the responders
- propose study and experimentation programs which could help reinforce predictions

This committee was a valuable innovation in the field of information and communication. It contributed to a marked improvement in the quality of predictions and facilitated the authorities' decision-making process.



Slick Drift Modelling

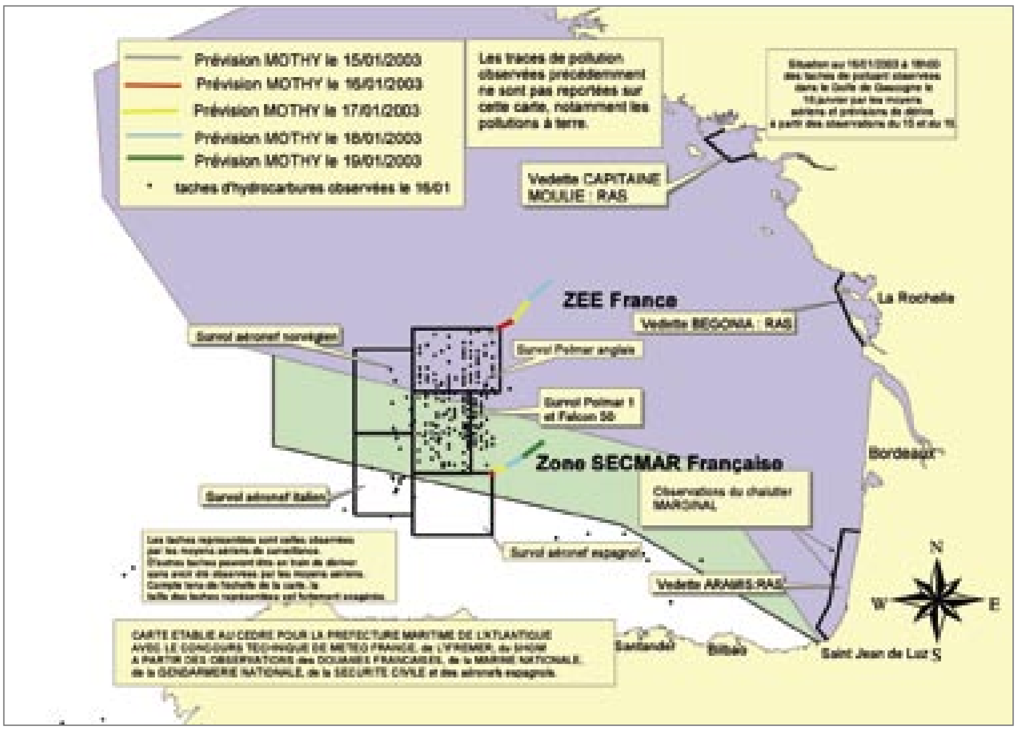
Météo France is responsible for surface drift prediction modelling (for slicks, containers, barrels...) for the French authorities (MOTHY model).



Example of slick drift calculated using the MOTHY model

The input for the MOTHY model is based on pollution observation data (usually from aerial observation), for which the appearance (degree of fragmentation, floatability), the dimensions, the position and the time have been recorded. The model must be regularly updated by observation data. Buoys can be launched on the slicks to help to locate the slick in relation to predictions (see E4). The reliability of meteorological data allows routine forecast for 3 to 4 days ahead and drift backtracking for up to 3 days.

In the event of a major pollution incident which affects a vast sea area, drift model output, such as the example on the previous page, is used to design maps which draw together all the observation data for that day and the drift predictions for the coming 3 days. The observations are accompanied by indications of the overflight zones of the different aircraft, showing which areas have been explored and those which have not. The maps are drawn up in relation to the points which the Drift Prediction Committee considers to be the most threatening for the coast.



Pollution from the Prestige*: observation of pollution and slick drift prediction*

Use of Drifting Buoys

In the event of pollution, it is important to be aware of the slicks' drift patterns and to be able to anticipate their movements, in order to guide pollution response vessels at sea and to inform the onshore response authorities as soon as the pollutant threatens to arrive onshore. In addition to aerial observation and satellite images, satellite-tracked drifting buoys can be deployed.

Experience of past pollution incidents (e.g. major incidents, illicit discharge, wrecks) has shown that drifting buoys launched by aircraft or by boat have a number of advantages.

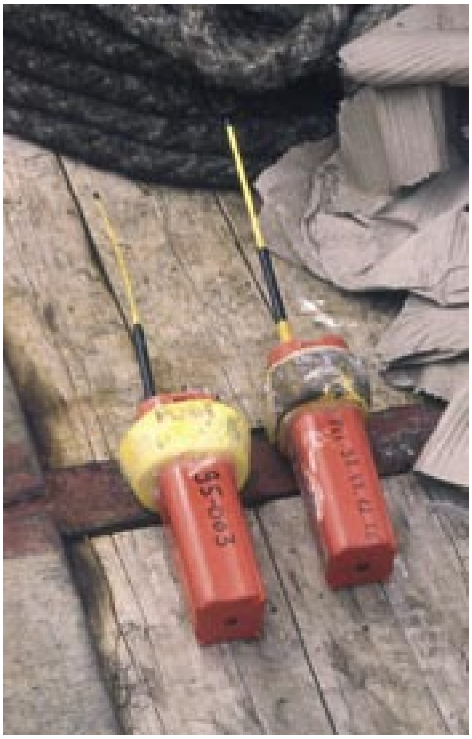
- The drift can be followed from a distance (useful when poor conditions prevent overflights and observation operations).
- If slicks disappear from view they are not lost.
- The grounding location of small amounts of pollution from illicit discharges can be identified.
- Information can be provided about the fate of potential pollution from wrecks.

The *Prestige*

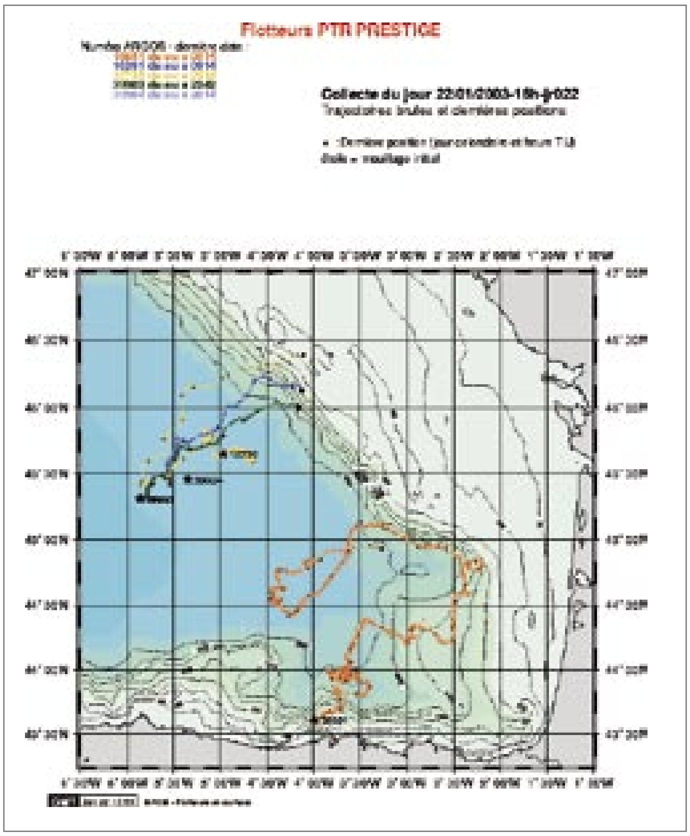
Drogued satellite-tracked drifting buoys (submerged 15.50 m or more below the surface) were deployed by SHOM (the Naval Hydrographic and Oceanographic Service) to measure the seasonal current, known as the "Navidad" current, which was believed by some to be likely to pull the slicks along like a river. The drifting buoys showed that the current was not developed and that the drift of the slicks was mainly dictated by the wind.

Cedre provided surface drifting buoys for use by the French Navy, SASEMAR (the Spanish Maritime Rescue and Safety Association in charge of response at sea in Spain) and AZTI (the Basque Oceanographic Foundation). These drifting buoys were tested by *Cedre* (a series of tests starting in 1996) and their drift was almost identical to that of oil slicks. Some of these buoys were used in December 1999 during the *Erika* pollution. It was in this way that the drift movements of the slicks in the Bay of Biscay could be tracked in the medium term. A drifting buoy which was launched at the beginning of February 2003 off the coast from the Arcachon Basin was found three months later at the tip of Brittany.

The Portuguese Oceanographic Institute and then SASEMAR, in collaboration with *Cedre*, also placed surface drifting buoys above the wreck of the *Prestige* on a monthly basis, as of the 23 February 2003. None of the buoys entered the Bay of Biscay in the following 12 months, highlighting the fact that the risk was higher for the Portuguese and Moroccan coasts than the French coasts in the event of a leak from the wreck of the *Prestige*.



IESM-PTR buoys: independent, floating ARGOS buoys, which can be launched from aircraft



Cartography of tracking buoys drawn up by SHOM

Oil Spill Observation

F

Observation Criteria

The observation criteria for oil spills are:

- **The degree of coverage** (see H3) and the dimensions of the slicks or patches, which provide information about the overall extent of the spill.
- **The position and time** of observation.
- **The appearance**: shape, colour and organisation, which provide information about the type of pollutant and its degree of weathering.

The appearance may be one of the following:

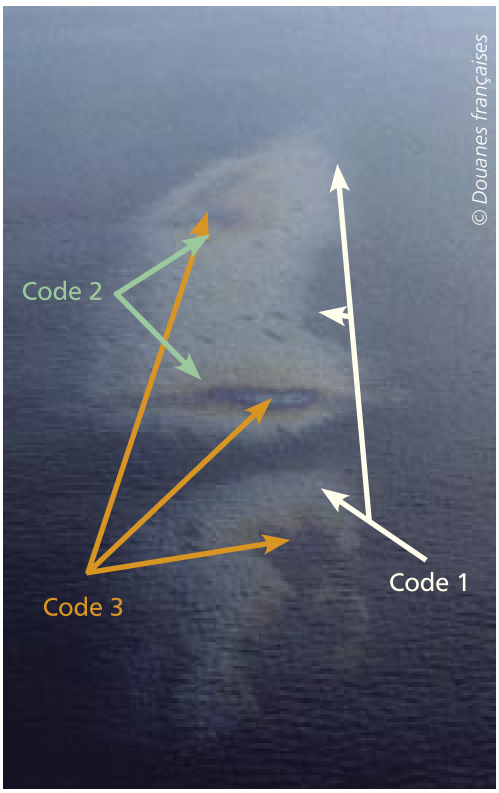
- **Thin films** (sheen, rainbow or metallic) which are silvery and/or coloured (in the case of light refined products or small widely-spread pollution), with a thickness of a few microns (< 50 l/ha).
- Slicks of **varying thicknesses with discontinuous colour** (black or brown depending on the hydrocarbon), often surrounded by thin films (sheen, rainbow or metallic), depending on the degree of weathering.
  - Black slick and thin film: recent pollution, little weathering.
  - Brown to red slick with gradual disappearance of thin films: emulsion weathered by several days at sea – thickness of 50 to 200 µm, 0.5 to 2 t/ha.
- **Thick patches** with clear coloured borders, usually dark brown to orange in colour and sometimes surrounded by thin films (patches of emulsion well weathered by a week or more at sea), substantial in thickness, 0.2 to 3 cm and more, i.e. 20 to 300 t/ha, or more in the case of extremely viscous hydrocarbons or emulsions.
- **Tarballs of emulsion** resulting from the fragmentation of thick patches into smaller elements, which are then increasingly difficult to detect.
- **Brown and orange** (or sometimes black) **cloud-like patches** can sometimes be seen below the surface of the water, indicating that oil has dispersed after treatment with dispersant.

Discontinuous true colour (see F2) is caused by the appearance of thicker slicks edge to edge with thinner (metallic) slicks. It is an effect created more by the combination of two appearances than of one specific appearance.
The colour of the slicks, patches and stripes will vary according to the luminosity, the colour of the sky and the observer's position in relation to the sun.
Oil slicks may adopt various random behaviour patterns or lie in windrows, parallel to the wind direction.

Bonn Agreement Oil Appearance Code

The Oil Appearance Code is the result of a scientific program, aiming to determine the quantities of hydrocarbon spilt using visual aerial observation. Recent studies carried out in conjunction with the Bonn Agreement led to the adoption of a new Appearance Code, to replace the former Colour Code. This code should be used for preference rather than the other existing codes such as that of the Paris Memorandum of Understanding.

Appearance	Layer Thickness Interval (µm)	Litres per km^2
1. Sheen (silvery/grey)	0.04 - 0.30	40 - 300
2. Rainbow	0.30 - 5	300 - 5 000
3. Metallic	5 - 50	5 000 - 50 000
4. Discontinuous True Colour	50 - 200	50 000 - 200 000
5. Continuous True Colour	> 200	> 200 000



This code allows thin layers to be characterised and the extent of spills to be assessed.

F2

Source: Bonn Agreement Aerial Surveillance Handbook (www.bonnagreement.org)

Code 1 - Sheen (< 0.3 µm)

The very thin films of oil reflect the incoming white light slightly more effectively than the surrounding water and will therefore be observed as a silvery or grey sheen. The oil film is too thin for any actual colour to be observed. All oils will appear the same if they are present in these extremely thin layers. Oil films below approximately 0.04-µm thickness are invisible. In poor viewing conditions even thicker films may not be observed. Above a certain height or angle of view the observed film may disappear.

Code 2 - Rainbow (0.3 µm - 5 µm)

Rainbow oil appearance represents a range of colours: yellow, pink, purple, green, blue, red, copper and orange. This is caused by an optical effect which is independent of the type of hydrocarbon involved. The colours will range from pale to highly luminous according to the angle of view and the thickness of the layer. Oil films with thicknesses near the wavelength of different coloured light, 0.2 µm – 1.5 µm, (blue 0.4 µm, red 0.7 µm) exhibit the most distinct rainbow effect. This effect will occur up to a layer thickness of 5 µm. Poor light conditions can lead to reduced appearance of colours. A level layer of oil in the rainbow region will show different colours through the slick because of the change in angle of view.

Code 3 - Metallic (5 µm - 50 µm)

The appearance of the oil in this region cannot be described as a general colour, as it will depend on the type of hydrocarbon as well as oil film thickness. Where a range of colours can be observed within a rainbow area, metallic will appear as a quite homogeneous colour that can be blue, brown, purple or another colour. The 'metallic' appearance is the common factor and has been identified as a mirror effect, dependent on light and sky conditions. For example blue can be observed in blue sky.

Code 4 - Discontinuous true colours (50 µm - 200

For oil films thicker than 50 µm the true colour of the oil will gradually dominate the colour that is observed. Brown oils will appear brown, black oils will appear black. The broken nature of the colour, due to thinner areas within the slick, is described as discontinuous. This is caused by the spreading behaviour under the effects of wind and current. 'Discontinuous' should not be mistaken for 'coverage'. Discontinuous implies colour variations and not non-polluted areas.

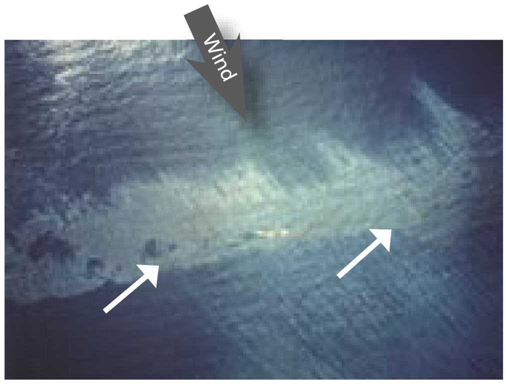
Code 5 - Continuous true colours (> 200 µm)

The true colour of the specific oil is the dominant effect in this category. A more homogenous colour can be observed with no discontinuity as described in code 4. This category is strongly oil type dependent and colours may be more diffuse in overcast conditions.

Appearance at Sea

Sheen - rainbow

Fresh slick spread widely into a thin film



As the slick weathers, thicker zones appear (downwind of the slick)

First thick patches of emulsion begin to appear

After a few days, the thin layers have been dispersed and only the patches of emulsion remain

F3

The patches of emulsion fragment and form small tarballs which are only visible close up

The wind slices the slicks into windrows. If the wind is strong, iridescences may disappear.

Weathered emulsion arranged in parallel stripes by the wind

Partly dispersed oil slick

Onshore Observation

For onshore observation procedures, refer to the guide entitled "Surveying Sites Polluted by Oil" (Cedre 2006).

It is important to:
- specify the surface area of accumulations
- indicate whether the pollution is floating or has settled (observe attenuation of the height and breaking of waves to get an idea of the thickness of the pollutant, which may be as much as several centimetres)
- describe the morphological characteristics of the type of coast affected, a factor which will determine the response techniques.

Arrival of an emulsion of weathered fuel oil on the coast, from the oil tanker the Prestige*, Galicia, 2002*

Photographic and Video Imagery

In certain countries, photographic and video imagery acts as evidence for the repression of illicit discharge. Ideally, all the necessary information can be provided in three complementary shots:

- a detailed shot of the slick, taken almost vertically, from an altitude of less than 300 metres with the sun at the photographer's back
- an overall, long range shot of the ship and the slick, showing that the oil came from the ship in question
- a detailed shot of the ship for identification purposes (colour of the hull and of funnels, name...).

In practice, a series of photos should be taken, showing the ship and her polluted wake, the extent of the wake (without discontinuity), the name of the ship, and finally the surroundings (in particular, if possible, other ships with "clean" wakes for comparison) to clearly show that it is the ship in question that is responsible for the pollution. A shot showing where the discharge seems to have originated can also be added, even if this could potentially lead to confusion. Whatever the case may be, do not claim definitively that it is the discharged pollutant that is visible in the photograph. It is important to remember that ships can also discharge non-pollutant liquids (e.g. cooling water).

For preference, a polarising filter should be used, which allows more selective visualisation of thin films and thick layers than the naked eye. If the aircraft is equipped with remote sensing equipment, include SLAR and infrared imagery.

F5

Photo of ship and her wake: the surrounding area is clean

Circle: close-up of a wake

Note - The above photos are given as an example of possible shots. They concern three different cases and do not allow identification of the vessels in question.

Photo of ship: her characteristics can begin to be distinguished at this distance

AERIAL PHOTOGRAPHY: TECHNICAL SPECIFICATIONS

FILM PHOTOGRAPHY

Camera: Single lens reflex, manual or shutter speed priority
Lens: 28 mm, 35 mm, 50 mm, 55 mm. Focus set to infinity.
Accessories: motor (if the reflex camera is not fitted with a motor drive system), lens hood, filters (skylight, polarising, anti-UV).
Film: from 200 to 400 ISO, or even 800 ISO (ideal for foggy or overcast conditions, the quality remains good and retains a fine grain).
Shutter speed: from 1/500° to 1/2000° (highest possible shutter speed to avoid blurring).
Aperture: from f/8 to f/16 for a maximum depth of field.

DIGITAL PHOTOGRAPHY

In order to obtain images of a similar quality to silver film, cameras able to capture at least 5 million pixels are required (professional quality). However 3 million pixels can provide acceptable photography if taken in 17.34 cm × 13 cm format (2,048 x 1,536 pixels), with a resolution of 300 DPI.

The real limitations concern the delay between the pressing the shutter-release and when the photo is actually taken, as well as the recovery time between two shots. In the first case, if the delay is one second, the aircraft will already have travelled some 50 metres. Professional cameras have short, if not negligible, delays.

HELPFUL HINTS

- Do not lean against the inner wall of the aircraft, or lean the camera against the cabin window (to avoid vibrations).
- Place the camera very close to the window (about 1 cm away) and parallel to its surface to avoid any reflections.
- Pay attention to the position in relation to the sun, as well as the colours of the sea and sky which may be difficult to distinguish.
- If possible, take photographs around midday (solar time), avoid dawn and dusk (when the light may affect the colours).
- Take the tides into account for photographs of the coast.
- For best results fly at low altitude.

Remote Sensing

Remote sensing is a possible complementary method of observation, in addition to observation by the human eye. A number of different sensing systems are able to detect and map the presence of hydrocarbons on the sea surface in certain conditions.

This observation method has the following advantages over visual observation:

- detection can be carried out from a distance (SLAR: 15 to 20 nautical miles on each side)
- slicks can be accurately plotted on charts/ maps
- imagery from sensors can be recorded
- visualisation is possible outside of the visible spectrum.

In the case of aerial surveillance missions at sea for illicit discharge, this technique also allows nocturnal surveillance. If a very low light level camera is available, it is possible to read the name of the vessel at night, in good weather conditions. If no colour photos are available, the report must include an SLAR image, infrared thermography of the wake and a photo showing the name of the vessel. This type of evidence implies that lawyers and judges must be specially trained.

Active sensors transmit a signal and receive another signal in return. Passive sensors do not transmit a signal but simply use the signal transmitted by the sea surface.

Infrared image of a vessel illicitly discharging oil

F6

Remote sensing system	Active/ Passive	Sensing means	Range	Layer thickness interval detected	Limitations
Side-Looking Airborne Radar (SLAR)	Active	Detects dampening by wind and oil of capillary waves generated by the wind.	During reconnaissance flights (from 1,500 to 4,000 feet), SLAR can detect oil 15 to 20 NM away, on either side of the plane, except in a "blind spot" directly under the plane, which is equal in width to the altitude of the plane. This gap can be covered by an infrared scanner.	Over 3 to 5 µm (to produce a dampening effect on capillary waves)	Penetrates the cloud layer. If the sea is too calm (0 to 1 on the Beaufort scale), the waves created by the wind are not high enough. On the other hand, if the sea is too rough (over 7 or 8 on the Beaufort scale), the oil layer will not dampen the capillary waves. The results must always be confirmed by visual observation and/ or IR-UV scanning.
Infrared Line Scanner (IR)	Passive	Detects thermal radiation with a wavelength in the band of 8 to 12 µm.	Zone scanned is equal to twice the altitude of the plane. Compensates for the "blind spot" of the SLAR. In practice, scanning should be carried out at 1,500 feet and 160 knots, allowing a width of approximately1,000 m.	Over 10 µm. Slicks appear black or white on the screen depending on their thickness and temperature.	Thickness of slicks
Ultra Violet Line Scanner (UV)	Passive	Detects the ultraviolet component of light from the sun reflected by oily liquids.	Zone scanned is equal to twice the altitude of the plane. Compensates for the SLAR "blind spot". In practice, scanning should be carried out at 1,500 feet and 160 knots, allowing a width of approximately1,000 m.	From 1 µm	Cannot distinguish between different thicknesses.
Microwave Radiometer	Passive	Similar to IR Line Scanner. Has the advantage of being able to measure the thickness, and therefore volume, of slicks detected.		From 100 µm	Calibration necessary to determine volumes. For thick slicks and emulsions, the surface area of the slick can be calculated, but the thickness must be determined using other methods, such as by ships involved in response operations.
Forward-Looking Infrared Scanner (FLIR)	Passive	Detects thermal radiation with a wavelength in the band of 8 to 12 µm.	Depends on the altitude of the plane and the field of view selected by the operator, as well as the hygrometry.	From code 2 or 3	FLIR detects zones of different temperatures, but cannot be used as a principal pollution research sensor. FLIR recordings can be used as a complementary method in addition to visual observation.

Guiding Response Operations

Guiding a Pollution Response Vessel

As the vessels cannot easily detect pollution on the water surface, they have to be guided in order to be effective in treating and recovering the pollutant.

The best method involves providing detailed (map-based) descriptions of the pollution in the zone where the vessel or fleet are to operate. This means that it is not necessary to have a guidance aircraft permanently in operation.

Basic guidance involves directing the vessel to the thickest parts of the slicks by indicating the azimuth angle/distance.
E.g. A slick 20 m wide by 200 m long is situated 30° right at 200 m.

- The plane or preferably helicopter, in the area, must inform the vessels of the location and shapes of the slicks, indicating the thick zones (or patches) on which pollution response operations should focus.
- Guidance can be carried out directly via indications transmitted by radio.
- When flying time in the area is limited, it is preferable to transmit to the vessel an exact description of the slick(s) and their position.
- Guidance can be improved by indicating the position of marker buoys or smoke floats in relation to the slick.

G1

French Customs performing aerial guidance to direct the French response vessel the Ailette *(pollution from the* Prestige*, Galicia, 2002)*

An Example of Guidance during the *Prestige* Response

GUIDING SPANISH BASQUE FISHING BOATS

The Spanish Basque fishermen were very involved in the operations at sea to recover the fuel oil from the oil tanker the *Prestige*. Their efforts came in addition to the pollution response vessels, when the pollution had become too geographically dispersed for these operations to be efficient enough. The fishing boats therefore had to be guided to the accumulations of fuel as soon as they were spotted.

Basque fishing boat involved in response operations for the Prestige *pollution.*

A plane belonging to the regional authorities conducted flights over the zone, flying perpendicular to the coast. As soon as the plane was close enough to land, the positions of the slicks (taken using GPS) and estimations of their surface area or their volume were transmitted to AZTI, the Basque Oceanographic Foundation, by mobile phone. A database, developed by AZTI, was used to reference all the vessels involved in response operations, the coordinates of their positions, and the number of people onboard (real-time transmission of information by satellite radio).

The AZTI operator was then able to determine which vessels were closest to the identified slick and whether or not the vessel had enough space to store the pollution. He then informed them of the positions of the slicks by VHF (almost real-time transmission).

These boats then recovered the pollution and once the recovery was completed the skipper of each boat contacted the AZTI response centre by VHF to inform them of the tonnage recovered. The vessel then continued on to another slick or headed into the harbour. This system was set up very rapidly, thanks to the routine cooperation of the Basque fishermen and of AZTI during the fishing season.

Reconnaissance Report

Mapping Pollution

All the observations made during a reconnaissance mission must be recorded on one or several map(s). This operation should be carried out carefully, either during the flight or afterwards, depending on what is possible for each case. Mapping should be standardised so that the various observations made during a series of flights can be easily interpreted. Particular attention should be paid to marking the most polluted zones (thick patches or slicks, pollutant accumulation zones), so that the extent of pollution can be estimated (see H2) and response operations directed.

The method proposed in this chapter is directly derived from the internationally adopted method for observing icebergs in the polar areas.

Map Identification

In a corner of the map, the following should be recorded:

1 The date and times of the flight
2 The zone overflown
3 The map number (where several maps are produced during the flight)
4 The name of the observer and of the organisation to which he belongs
5 The type of aircraft used
6 The meteorological conditions: cloud cover, colour of the sky and the sea, the sea state.

Observation Log

On a basic map prepared prior to the mission (see A2), the contours of each polluted zone observed should be marked with a continuous line, giving indications on the nature of the slick for each zone according to the criteria explained on the following page (use the given abbreviations). The plane’s route should be marked with a dotted line.

This log will contribute to the report to be completed at the end of the mission. Notes taken during the flight can be adapted to the circumstances and the practices of the observer.

Description of the pollution	**Abreviation**
Colour/appearance (see F2)	
1 Sheen	code 1
2 Rainbow	code 2
3 Metallic	code 3
4 Discontinuous true colour	code 4
5 Continuous true colour	code 5
For 4 and 5, indicate colour:	
Black	bl
Brown	br
Orange	or
Type	
• Slick (Ø or L > 30 m)	sl
• Patch (5 cm < Ø ou L < 30 m)	ptc
• Patty (10 cm < Ø 50 cm)	ptt
• Tarball (Ø indiscernable)	tb
State of pollutant	
• Fresh oil	fo
• Dispersed oil	disp
• Emulsion	emul
Arrangement	
• Random	•
• Parallel stripes	//
Debris	deb

Degree of coverage

The degree of coverage is indicated as a percentage, in connection with the reference plates (H3). If coverage is by thick patches and thin layers (sheen, rainbow, metallic), if possible, specify their respective coverage (e.g. 5% pat – 30% code 3).

Slick Dimensions

The average dimensions for patches of emulsion (or potentially for slicks of fresh oil) are expressed in metres.

The information about the slick is reported as a list in the following order:

- Type and arrangement
- Coverage
- Dimensions

Example of notation: pollution in the form of rainbow stripes, covering 40% of the sea surface, combined with patches covering 3% of the sea surface, average size of the patches: 10 m.

- ptc + code 2 //
- 40% code 3 – 3% ptc
- 10 metres

For clarity, these indications can be recorded on the edge of the map, taking care to show, using arrows, to which point on the map they refer.

If the same description applies to several different zones, the descriptive criteria should be recorded in a corner of the map with an identification by letter, and this letter noted in each of the zones concerned (for an example, see map, next page).

When a slick spreads beyond the horizon, the limit of visibility should be shown using a dotted line.

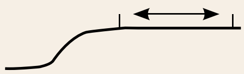
Other indications

- Show the route followed using dashes and crosses

  e.g. - + - + - + -

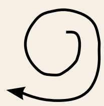
- Show the parts of the coast affected

  e.g.



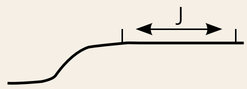
- Also give the points at which the oil surfaces (in the case of a pipeline leak or a sunken wreck)

  e.g.

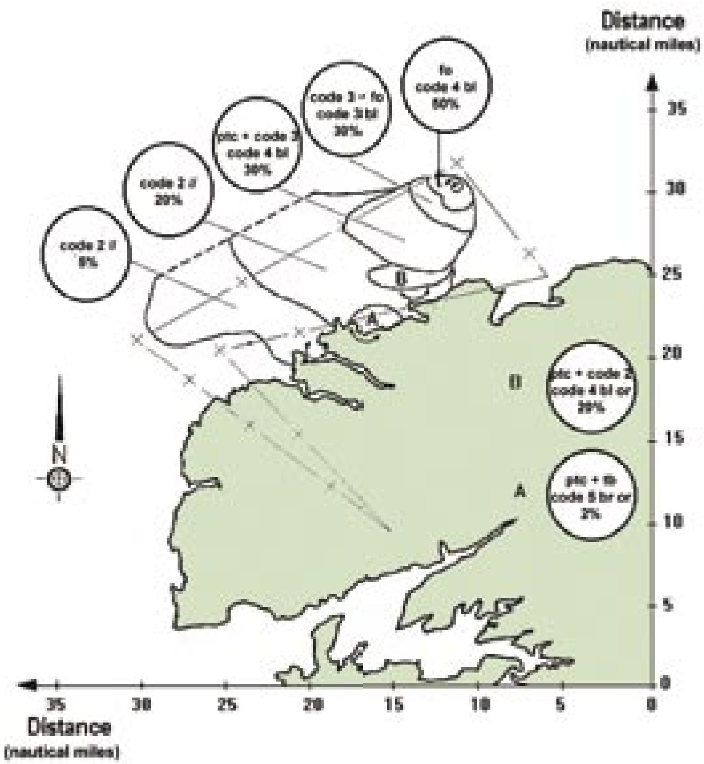


- Various remarks and observations may be noted on the edge of the map or on an attached sheet, making sure that the place they refer to is clearly identified on the map by a letter at the appropriate point

  e.g.



J = polluted pebbles at the top of beach



Example of a summarising map using the above mentioned abreviations

Estimating the Quantity of Pollutant

Although estimating the quantity of pollutant is no easy task, it is nevertheless a necessary one. Estimations are made using maps, taking into consideration the polluted surface and the thickness of the slicks.

Estimation at Sea

- Surface

  Only thick patches should be considered and accumulations which represent the main part of the volume of the slick, excluding iridescent zones (thin layers).

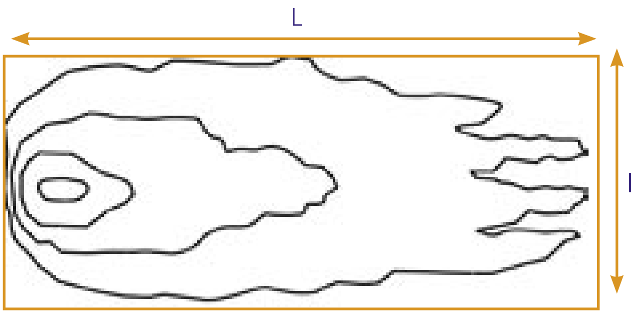
  The surface area is obtained by multiplying the overall surface area of each zone by its degree of coverage (thick patches).

- Thickness

  For a major oil spill, as a first estimation and in the absence of indications to the contrary, take the lower value of the appearance code bracket for the pollution observed.

- Calculation of the quantity of pollutant

  The surface area of a slick or an accumulation of oil droplets can be calculated directly using an onboard GPS system.



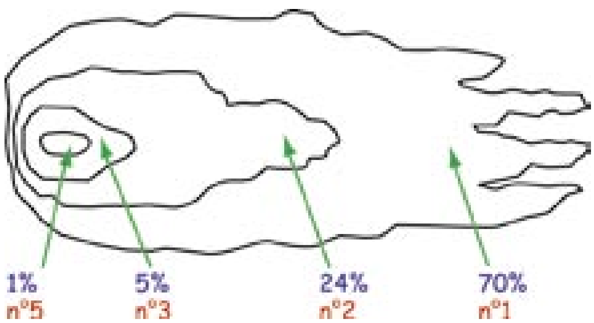
Example of estimation using the Bonn Agreement Oil Appearance Code

L = 12 km / l = 2 km

Total surface area = 24 km^2

Coverage = 80%

Surface area covered: 24 x 80% = 19.20 km^2

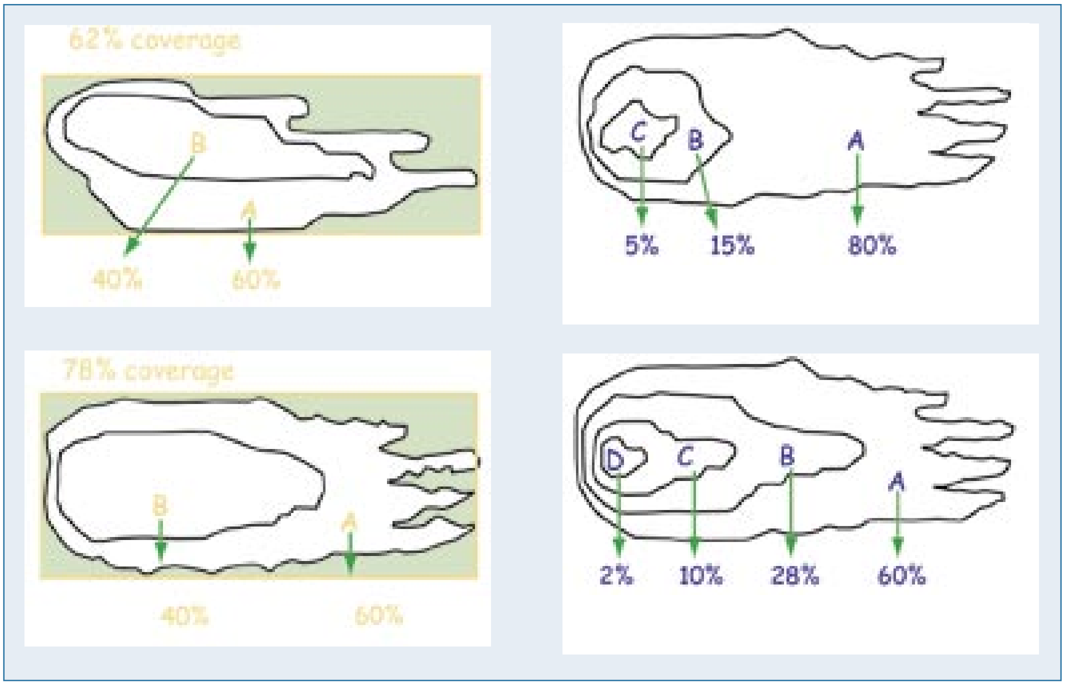


N° 1 (sheen) 0.04 / 0.3 µm
N° 2 (rainbow) 0.3 / 5.0 µm
N° 3 (metallic) 5.0 / 50 µm
N° 5 (continuous true colour) over 200 µm

Minimum estimation	Maximum estimation
N° 1 19 x 70% x 0.04 = 0.532 m^3	x 0.3 = 3.99 m^3
N° 2 19 x 24% x 0.3 = 1.368 m^3	x 5.0 = 22.8 m^3
N° 3 19 x 5% x 5.0 = 4.750 m^3	x 50 = 47.5 m^3
N° 5 19 x 1% x 200 = 38 m^3	38 m^3
TOTAL 44.65 m^3	TOTAL 112.29 m^3

As the thickness may be considerable and cannot be determined by plane, the minimum thickness should be taken.

H2



Other examples of estimations on different shapes of slicks (Designed by J-P Castanier, French Customs. Calculation method by Alun Lewis, Consultant)

Onshore estimation

Although the surface area of pollution can be estimated fairly quickly (stretch of the coastline affected multiplied by width of the zone covered), the thickness varies widely (from a few millimetres to several decimetres).

Moreover, on the coast, the risk of error and confusion is increased by the presence of other factors such as debris, seaweed, etc. (see D4).

For greater accuracy, the assessment of coastal pollution requires on-land reconnaissance.

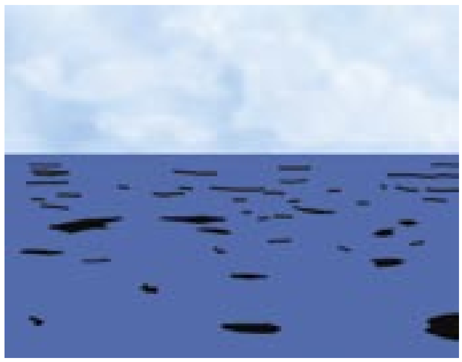
Arrival of an emulsion of heavy fuel on the coast from the oil tanker the Erika *(Le Pouliguen, Loire-Atlantique, France, December 1999)*

Evaluation based on aerial observations can only provide an order of magnitude. Uncertainties about the true thickness of slicks can lead to estimations of volume that vary up to a factor of ten. Nevertheless, minimal estimations should be considered a reliable source of information in determining the minimum quantity that was spilt in reality.

Degree of Coverage: Reference Plates

1%

5%



20%

See Appearance Code (F2).

POLREP

Source: UK Ministry of Defence Acquisition Management System.

INITIAL POLREP-SIGNAL MESSAGE FORMAT

Addressee for action: relevant MRCC.

Addressee for information: relevant authorities

Title/subject: POLREP

A – Classification of report:

Doubtful – probable – confirmed

B – Date and time pollution observed/ reported

C – Position and extent of pollution

If possible, state range and bearing of some prominent land mark or Decca position, and estimated amount of pollution (i.e. size of polluted area, number of tons spilled, or number of containers, drums lost). Where appropriate, give position of observer relative to pollution.

D – Tide, wind speed and direction

E – Meteorological conditions and sea state

F – Characteristics of pollution

Give type of pollution, e.g. oil (crude or otherwise), packaged or bulk chemicals, sewage. For chemicals give proper name or United Nations number if known. For all, give also appearance, e.g. liquid, floating solid, liquid oil, semi-liquid sludge, tarry lumps, weathered oil, discolouration of sea, visible vapour. Any markings on drums, containers etc. should be given.

G – Source and cause of pollution

E.g. from vessel or other undertaking. If from vessel, say whether as a result of a deliberate discharge or a casualty. If the latter, give brief description. Where possible, give name, type, size, nationality and port of registry of polluting vessel. If vessel is proceeding on its way, give course, speed and destination.

H – Details of vessels in the area

To be given if the polluter cannot be identified, and the spill is considered to be of recent origin.

I – Whether photographs have been taken, and/or samples for analysis.

J – Remedial action taken or intended, to deal with the spillage.

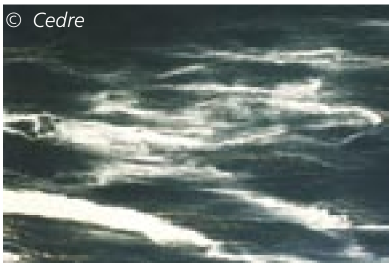
K – Forecast of likely effect of pollution (eg arrival on beach) with estimated timing.

L – Names of other States and organisations informed.

M – Any other relevant information (eg names of other witnesses, reference to other instances of pollution pointing to source).

Other Products

Images of various chemicals and food products spilled at sea can be confused with images of oils slicks. It is therefore useful to have a number of reference images to avoid interpretation errors. Vegetable oil and certain chemicals also show up on remote sensing equipment.

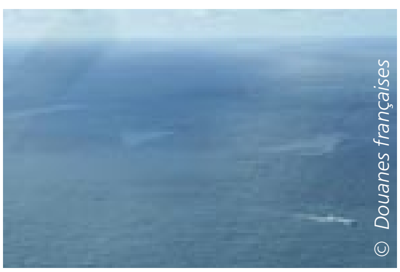


*Emulsion of palm oil in the form of white patches (*Allegra *accident, Western Channel, October 1997)*

*Styrene slick observed by a French Customs plane (*Ievoli Sun *accident, Les Casquets, France, October 2000)*

Palmor I experimentation: castor oil slick

Palmor I experimentation: soya bean oil slick



Palmor I experimentation: from left to right, soya bean oil, fuel oil, palm oil

Natural Phenomena

For example photos see following page.

Various floating objects and other phenomena can be mistaken for oil slicks. For instance, the following have already given rise to confusion:

- Shadows of clouds making darker zones on the surface of the water.
- When the sea is relatively calm, surface currents or convergence of cold and warm water can, with a small angle of incidence, give the appearance of a film (sheen, rainbow, metallic).
- Muddy water at river mouths, in bays or simply near to the coast, can catch the eye because of their beige appearance in comparison to the surrounding water (coloured water without any sign of a film – sheen/ rainbow/metallic – on the surface cannot be an oil slick).
- Floating algae or phytoplankton blooms or pollen stripes may look like coloured slicks.
- Shoals which look like dark slicks.
- Calm areas.

IF IN ANY DOUBT, OBSERVE THE AREA FROM A CLOSER DISTANCE TO CONFIRM OR DISMISS THE PRESENCE OF OIL.

For observation by helicopter, check for the presence of an oil slick when in doubt by hovering low. If the sighting is in fact an oil slick, the turbulence made by the rotor will make it drift away.

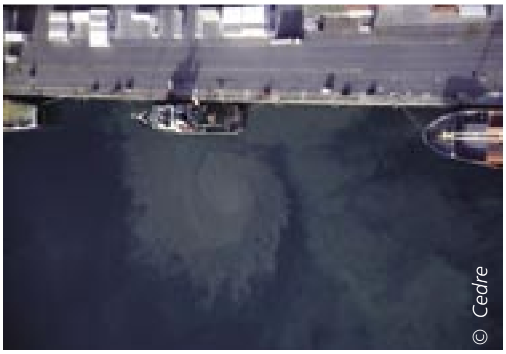
Wherever possible, observations carried out by plane should be ultimately confirmed by helicopter reconnaissance (allowing closer observation), or by a plane fitted with special remote sensing equipment (IR, SLAR, FLIR...). If still in doubt, samples can be taken to remove all uncertainty, if the weather conditions and techniques available allow it. In this case, samples should be taken as quickly as possible and exclusively from the slick observed. The aim is to prove that the substance spilt at sea is indeed a hydrocarbon. It is, however, difficult to take samples at sea from an aircraft. Studies are currently being carried out on the subject, in particular in Sweden (see below).

Sampling Buoys

The Swedish Coast Guard recently designed sampling buoys which can be launched directly from an aircraft onto a slick. They contain a piece of teflon material, which can absorb hydrocarbons for subsequent analysis. The buoys can be identified by a light and a radio signal. So far, only one case has been taken to court in which samples taken by sampling buoys played a decisive role in obtaining a guilty verdict. The crew denied having discharged hydrocarbons.

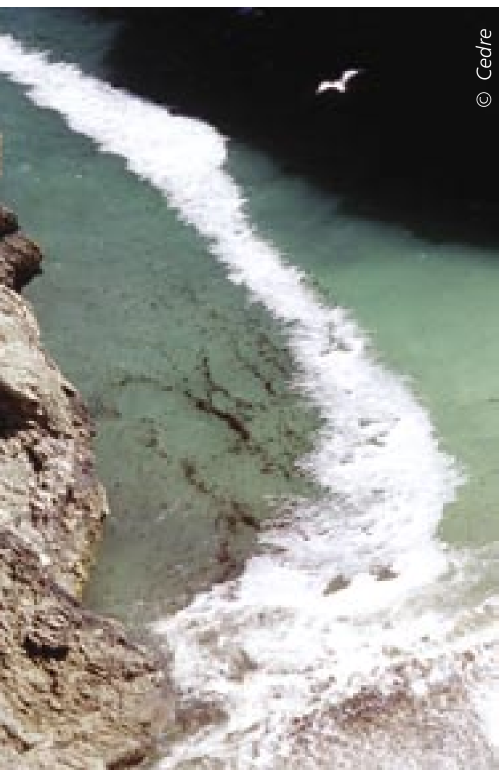
Slick-like effect made by the shadows of clouds

Surface effect due to the presence of two water masses having different temperatures



Muddy water near the coast. Silt from the seabed becomes suspended in the water due to the movement of the propellers.

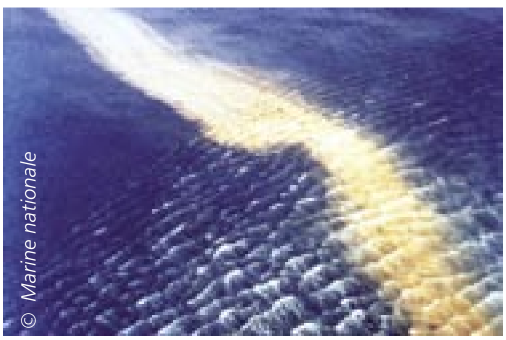
Peat on the water surface



Seaweed near the coast
Clumps of seaweed drifting at sea (long shot and close-up)

Slick-like effects due to the presence of sand banks, seaweed, coral reefs etc.

Calm patches can be confused with a thin film of oil



Coloured stripes due to the development of phytoplankton (observation made from a hovering helicopter, note the effect of the wind made by the rotor which shows that in this case it is not an oil slick)

GLOSSARY

Auto-ignition temperature	Minimum temperature at which vapours spontaneously igniteSpanish Basque
AZTI	Oceanographic Foundation, involved in the social and economic development of several aspects of the fishing and food industry, as well as the protection of the marine environment and fishing resources.
Cedre	Centre of Documentation, Research and Experimentation on Accidental Water Pollution
Density	Quotient of the volumic mass of a substance and the volumic mass of water for a liquid or of air for a gas.
Dispersant	Product containing a solvent, used to condition active matter and to diffuse it in the water. A mixture of surfactants ensures the dispersal of oil into small droplets in the marine environment.
Dispersion	Formation of oil droplets of varying sizes, due to wave action and turbulence on the sea surface. These droplets either stay in suspension in the water column, or resurface to form another slick. This natural process can be encouraged by the use of dispersants, depending on the viscosity of the product and on whether the geographical and bathymetric situation makes their use possible.
Emulsification	Emulsification refers to the formation of a "water-in-oil" reverse emulsion. This emulsion may be made up of a large proportion of water (often 60%, can be up to 80%). It varies in colour from brown to orange and is often referred to as "chocolate mousse", which gives an indication of its consistency.
Evaporation	Transformation of a liquid into a vapour via its free surface, at a particular temperature. The rate of evaporation of oil depends mainly on the proportion of volatile products and the combination of hydrocarbons, as well as other factors such as the wind speed, the water and air temperature, the roughness of the sea surface and extent of spreading. The lightest fractions evaporate first, and the least volatile fractions form a residue, with a higher density and viscosity than the original product.
Explosimeter	Appliance used to measure the concentration of inflammable gas in the atmosphere.
Flash point	Lowest temperature at which the concentration of vapours emitted is high enough to produce a flash when in contact with a flame, a spark or a hot spot, but too low to produce combustion in the absence of a pilot flame. A substance with a flash point of less than 0°C is described as extremely inflammable, between 0 and 21°C easily inflammable, and between 21 and 55°C inflammable.
FLIR	Forward-Looking Infrared. Infrared sensor used for remote sensing of oil slicks. In optimal atmospheric conditions, it can detect a slick approximately 20 nautical miles from the aircraft when flying at 3,500 feet. It can detect Bonn Agreement code 2 (rainbow) slicks, and has no upper thickness limit. It can also be used to read the name of a vessel at night.
GIS	Geographical Information System
GPS	Global Positioning System
Ifremer	French Research Institute for Exploitation of the Sea

Microwave radiometer	Sensor used for remote sensing of oil slicks. The detection method makes it an all-weather sensor. It can also determine the thickness of slicks.
MOTHY	Météo France's Oceanic Oil Transport Model, a drift prediction model for oils slicks and objects at sea.
MRCC	Marine Rescue Coordination Centre
Phytoplankton bloom	Vigorous proliferation of plankton
POLREP	POLlution REPort
Pour point	Temperature below which a hydrocarbon stops flowing. If a substance's pour point is above room temperature, it is less fluid. Pour points are measured in laboratory conditions and are not an accurate representation of the behaviour of a particular hydrocarbon in an open environment.
Remobilisation	Remobilisation is the process in which the sea reclaims grounded or beached pollutant, or pollutant buried or trapped in sediment near the coast.
Remote sensing	Collection of techniques used to detect and identify phenomena from a certain distance, either through human capacities or special sensors. In the case of aerial observation of oil pollution, remote sensing relies on the use of detection systems, including SLAR, FLIR, infrared and ultraviolet scanners and microwave radiometers.
SASEMAR	"Sociedad de Salvamento y Seguridad Marítima" (Spanish Maritime Rescue and Safety Association). Spanish organisation in charge of research and rescue services at sea, as well as pollution response for the Spanish state, within its responsibility zone which covers approximately 1,500,000 km2.
SG Mer	French General Secretariat for the Sea
SHOM	French Naval Hydrographic and Oceanographic Service
SLAR	Side-Looking Airborne Radar, used to detect oil slicks
Surfactant	A wetting agent which can increase spreading of a liquid (which is dependent on surface tension).
UV	Ultraviolet
Viscosity	Property of resistance to uniform pouring without shaking a substance, inherent in the mass of a substance.

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Centre of Documentation, Research and Experimentation on Accidental Water Pollution (*Cedre*): http//www.cedre.fr, "Discharge at sea" section.

Community Information System: http://europa.eu.int/comm/environment/civil/marpol-cis/index.htm, European Union's website explaining the national organisation for response to accidental marine pollution and means available for each member state.

Helsinki Commission, aerial surveillance: http://www.helcom.fi/shipping/waste/en_GB/surveilance.

International Tanker Owners Pollution Federation (ITOPF): http://www.itopf.com/aerial.html.

National Oceanic and Atmospheric Administration (United States) : http://www.noaa.gov,
- section "Ocean"
- subsection "Oil and chemical spills"
- subsection "Emergency response", "Responding to oil spills"
- documents "Open-Water Oil Identification Job Aid for Aerial Observation" and "Dispersant Application Observer Job Aid".

International Maritime Organisation: www.imo.org, "Marine environment" section.

Operational Guide: Aerial Observation of Oil Pollution at Sea

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