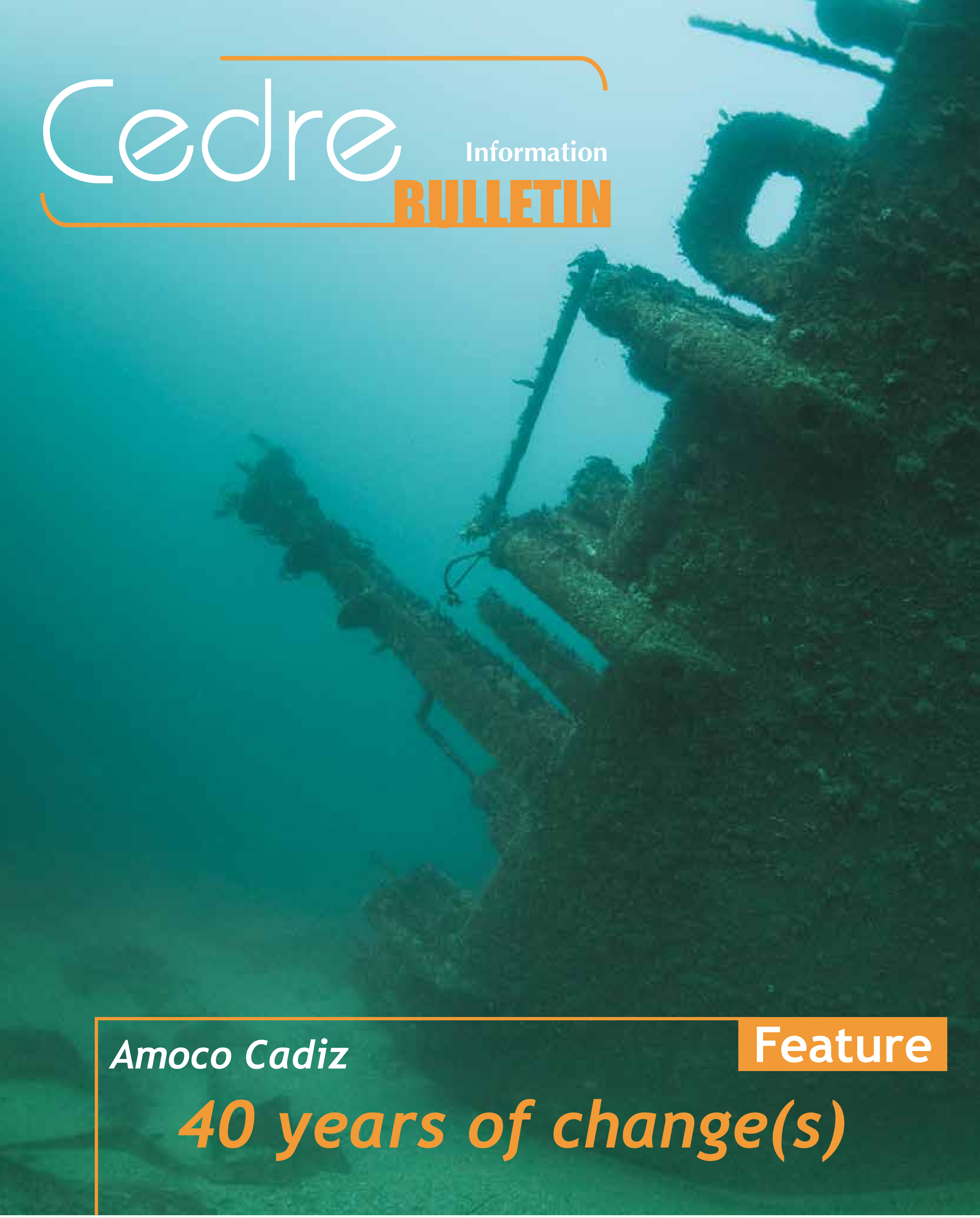

Cedre Information BULLETIN

Feature

Amoco Cadiz

40 years of change(s)

Special

Cedre turns 40

N° 37 - June 2018

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Cedre Information BULLETIN

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Major spills, but substantial advances

2017 was a key landmark in the history of oil spills, marking the 50th anniversary of the grounding of the *Torrey Canyon* oil tanker. This year we commemorate the 40th anniversary of the grounding of the *Amoco Cadiz* oil tanker off the coast of Brittany. These two disasters played a decisive role, as they attracted the whole world's attention to the catastrophic effects of major spills by oil tankers. More importantly, they brought about immediate, lasting changes which resulted in a subsequent clear drop in major ship-source oil spills.

While the *Torrey Canyon* directly led to the development of the International Convention for the Prevention of Pollution from Ships (MARPOL), the *Amoco Cadiz* triggered the adoption of the 1978 Protocol relating to this convention. These texts introduced substantial amendments and even tighter controls. They remain to this day the most important instruments in the prevention of ship-source pollution.

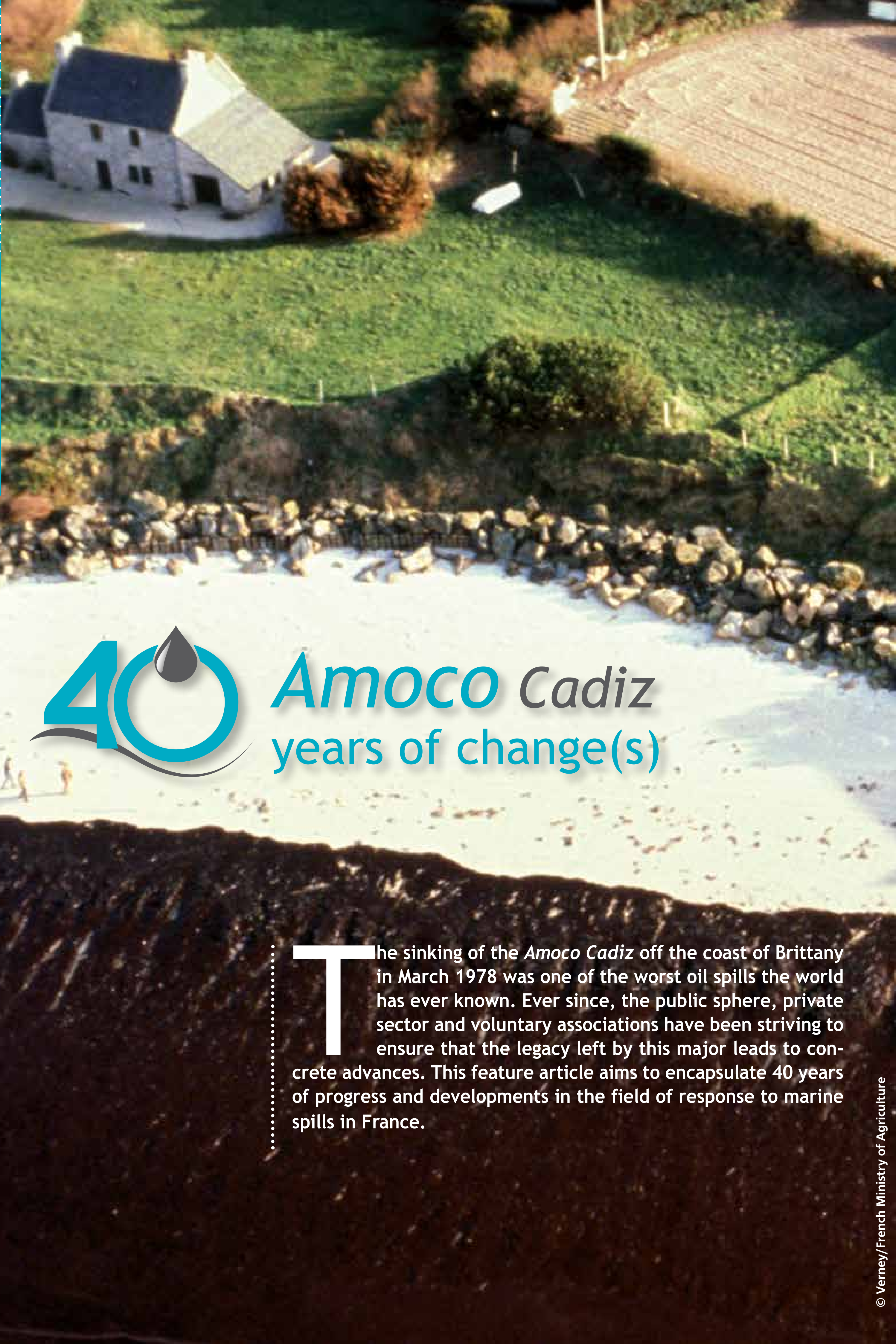
The *Torrey Canyon* disaster in 1967 and the work of the international community through IMO also gave rise to interesting developments on the questions of liability and compensation for oil spill damage, in particular with the adoption of the Civil Liability Convention (CLC 1969) and the 1971 Fund Convention. After the *Amoco Cadiz* ran aground, it only took IMO a few months to gather a sufficient number of ratifications. This process would probably have been delayed further had this spill not occurred. The experience of the *Amoco Cadiz* also contributed to the revision of the international regime in order to reinforce the protection of victims of oil pollution and encourage more States to participate in this movement. Another aftereffect of the *Amoco Cadiz* was the re-examination of international rules on salvage, finally giving rise to the IMO International Convention on Salvage in 1989.

Created in the aftermath of the *Amoco Cadiz* disaster, Cedre has proven to be a key stakeholder over the past 40 years through its R&D and its extensive field experience acquired during major spills. It has furthered our understanding of the behaviour and fate of oil and has produced outstanding tools and resources to respond to oil spills. In this complex field, Cedre is today a world renowned centre of expertise whose pioneering work continues to advance. Cedre strives to support the international maritime community by regularly providing its expertise and assistance to IMO at technical meetings and to other countries through capacity strengthening initiatives.

Demand for oil remains high and shipping continues to be the most efficient way of meeting this demand. The oil tankers sailing the oceans today are equipped with double hulls, double controls, segregated ballast tanks, inert gas systems and crude oil washing systems, as well as oily water separators which did not exist forty years ago. These innovations, together with the improvement of navigational aids and many other aspects relating to ship design, construction and technology, have led to far more demanding standards for the design and operation of ships. Meanwhile, proactive industry initiatives as well as IMO guidelines and conventions (safety, ship operation, vetting and reporting, ship management, crew training and certification) have all helped to shape a safer and cleaner world oil industry.

Thanks to all the measures implemented, oil tanker transport is now safer and cleaner than ever before and a solid mechanism exists to effectively respond to oil spills and cope with their financial consequences. The statistics clearly show that these efforts have met with resounding success: since the 1970s, the number of major oil spills has fallen 90% and the volume of oil spilt has been divided by 100.

Stefan Micaleff,
Director of the Marine Environment Division, International Maritime Organization



40 *Amoco* Cadiz years of change(s)

The sinking of the *Amoco Cadiz* off the coast of Brittany in March 1978 was one of the worst oil spills the world has ever known. Ever since, the public sphere, private sector and voluntary associations have been striving to ensure that the legacy left by this major leads to concrete advances. This feature article aims to encapsulate 40 years of progress and developments in the field of response to marine spills in France.

Oil tanker risk analysis

In order to assess the risk of marine oil spills, numerous factors must be taken into account, in particular:

- The evolution of the world economy and consequently of the oil market and the quantities of oil transported.
- The evolution of the fleet, in terms of the number, size, age and design of ships.
- Throw in human errors, adverse weather conditions, structural damage and you have the main parameters of the equation.

How has the situation evolved over the past four decades?

We have seen an overall expansion of the world fleet and increase in the goods transported. Oil has followed this trend. A share of refining activities has gradually shifted from the countries with high consumption to crude oil producing countries. The maritime transport of refined oil products, and in particular light fuels, has therefore greatly risen.

In terms of spills from oil tankers, an increase was recorded until the beginning of the 1980s, followed by a sharp drop with the renewal of the fleet, with the exception of the *Castillo de Bellver incident* (1983 in South Africa). A further rise in spills with the ageing of the fleet peaked in 1991 with the *Haven* spill (Italy). Since then, an ongoing gradual downward trend in oil tanker spills has been recorded.

Why are oil tankers no longer the main source of spills?

Most likely because since the *Torrey Canyon* and the *Amoco Cadiz,* the prevention policy orchestrated by the International Maritime Organization in terms of shipbuilding, shipping regulations and controls, the creation of special zones and finally crew training has paid off.

Christophe Rousseau, Cedre

Oil study

Every spill sparks off a series of questions on the behaviour and fate of the crude oil, condensate or refined product released. When spilt at sea, they undergo various processes which alter their properties and which are collectively referred to as "weathering". Some of the main such processes are evaporation, emulsification, dispersion and photo-oxidation. These processes occur naturally due to sea surface agitation generated by the combined action of the wind, currents and waves, as well as to exposure of the oil to the sun's rays.

The specific chemical composition and physical properties of each oil thus evolve throughout the weathering process. Light fractions gradually evaporate, the density increases, part of the oil disperses throughout the water column while the share remaining at the water surface emulsifies and is photo-oxidised by the UV rays. The oil generally becomes increasingly viscous, thus forming a new pollutant which is more persistent in the environment. Its behaviour is often different to that of the product initially spilt. Understanding these transformations is a key element in assessing the potential impacts and optimising the response strategy in the event of a spill.

Nearer to the shoreline, interactions with the sediment load increase steadily and affect the behaviour of the pollutant. The product may adhere to sediment particles and gradually sink, ultimately settling on the seabed where it will remain if no clean-up operations are implemented. If the pollutant is washed up onto the shore, whether in the intertidal or supratidal zone, the same weathering processes as in the open sea, together with biodegradation, will gradually alter the composition of the stranded oil. Over the subsequent months and years, the initially sticky, liquid oil will become increasingly viscous to ultimately solidify to resemble a tar-like product. The intensity of the natural degradation processes will be greater on thin layers of pollutant, less than 5 mm thick. In such cases, natural clean-up of the environment could lead to the gradual disappearance of patches of pollutant. If the oil takes the form of deposits or crusts several dozen millimetres thick, it may persist for several decades, especially if it is trapped in riprap or buried under a layer of sediment.

Different experimental methods can be used to simulate these processes, which are necessarily complicated to reproduce as they occur simultaneously and influence each other. Laboratory-scale tests have the advantage of generating data which can be entered into weathering simulation software, thus providing supplementary information in addition to the product's initial characteristics. In the absence of such studies, such software programmes can nevertheless be used to predict these changes, in particular by approximating them with similar oil products available in their databases. Pilot-scale tests (for instance in Cedre's flume tank) performed on a few litres of product and by recreating offshore conditions prove to be more realistic. These tests tend to be more accurate in the case of products with a particularly low or inversely a very high viscosity, where laboratory tests hit their limits.

Julien Guyomarch
& Ronan Jézéquel, Cedre

Preparedness

On 18th March 1967, the *Torrey Canyon* ran aground near the Isles of Scilly and spilt 100,000 tonnes of crude oil into the Channel, opening Europe's eyes to the reality of a risk that had thus far lain dormant.

On 18th March 1967, the *Torrey Canyon* ran aground near the Isles of Scilly and spilt 100,000 tonnes of crude oil into the Channel, opening Europe's eyes to the reality of a risk that had thus far lain dormant. The French marine pollution contingency plan, dubbed 'POLMAR', saw the light of day a few years later following an interministerial instruction dated 23rd December 1970. The response and actions implemented by the authorities to manage the consequences of this spill lay the groundwork for the guiding principles of the French organisation.

> From hatching to fledgling

The first POLMAR onshore plans were developed. The plan for Finistère was activated in 1976 when the *Olympic Bravery* ran aground on Ushant Island. The Prime Minister was the sole person responsible for this plan, meaning that it was rather awkward to implement and hindering the execution of the preventive measures outlined. In 1978, in the ministerial instruction dated 12th October 1978, this overly centralised management was revised, placing the Maritime Prefect in charge of activating and implementing the POLMAR plan as well as of coordinating offshore response actions. This same text established the creation of Cedre and outlined its primary missions. The *Tanio* spill in 1980 was the opportunity to test the utility of this specialised organisation. France also acquired protective, recovery and shoreline clean-up equipment which was stored and maintained at POLMAR stockpiles.

In the 1980s, the POLMAR onshore and offshore plans were developed by the Prefects with active support from Cedre. Sensitivity atlases and shoreline protection plans were established, along with the reinforcement of POLMAR stockpiles.

> A shockwave

For nearly twenty years, no major spills came to remind us of the need to be well prepared. When the *Erika* sank in December 1999, the POLMAR onshore plans of three of the five departments affected were obsolete. New instructions drawing on the lessons learnt from the *Erika* were published in 2001 and 2002. Their main provisions included the definition of the pre- and post-spill missions of State services, reinforced coordination between the sea and shore, emphasis of the cooperation required between all players, mobilisation of expertise, such as that of Cedre, as well as reinforced preparedness with more frequent exercises (once a year for each coast; every 3 years for each department).

Boom deployment training

In 2006, the POLMAR texts were supplemented with the post-*Prestige* instruction,

after this oil tanker broke in two in November 2002 off the coast of Galicia, causing a major oil spill
in Spain and the worst ever to hit the Aquitaine coast. This instruction aimed to reduce requisitioning times by accelerating the establishment of public contracts for spill response (clean-up, waste treatment, etc.).

> Reaching maturity

With the post-*Erika* update of the POLMAR plan revision guide, produced by Cedre, a tremendous update effort was launched: 19 of the 25 shoreline departments in mainland France released their new POLMAR onshore plan, almost all of the POLMAR onshore and offshore plans for overseas France were updated and the three coasts (Channel, Atlantic and Mediterranean) totalled overhauled their plans. A reflection process supported by scientific studies led to the response strategy in sensitive tropical areas, such as mangroves and coral reefs, also being revised.

>Changes in the emergency response organisation

The civil protection reform between 2004 and 2005 led to a new emergency response 'ORSEC' system, which was integrated in the POLMAR plans. The fire brigade remained the Prefect's strong right arm in the emergency response phase. Final shoreline clean-up operations and waste treatment were handed over to private sector professionals.

To handle major maritime incidents, the instruction of 28th May 2009 emphasises the fact that ORSEC arrangements should be prepared in cooperation and implemented in close coordination to ensure the consistency of response operations across the whole zone potentially affected by the spill.

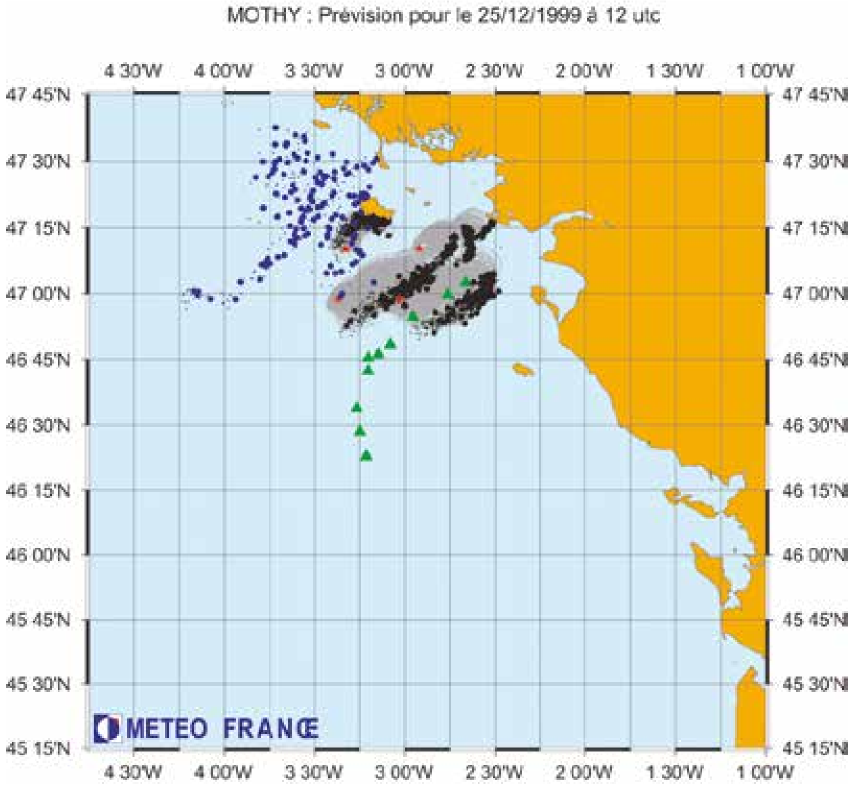
> Review of the POLMAR onshore preparedness arrangements

Fifteen years after the last major oil spill hit France, the French environment ministry – which implements a wide range of spill response measures (including purchasing, maintaining and storing response equipment), finances Cedre and provides technical support through Cerema (the French centre of studies and expertise on risks, environment, mobility and land-use planning) – commissioned a review of the POLMAR onshore organisation to assess its efficiency. The expert report was released on 23rd November 2017. It comprised twelve recommendations including the importance of revising the 2002 POLMAR instructions. In this context, Cedre provides ongoing assistance to the French authorities in the revision of their ORSEC/POLMAR onshore plan, as well as the running of exercises and training courses for decision-makers and field operators. For instance, in 2017, Cedre, alongside Cerema and in behalf of the relevant administrations, jointly ran 13 training courses for 12 departments (mainland and overseas France) and trained nearly 800 people.

> Inland waters

In the same way, the management of spills in inland waters (rivers, watercourses and lakes) was organised through specialised inland water contingency plans based on a circular from 1972, amended in 1985. Most of these plans are around twenty years old and are only updated in terms of resource preservation and the water supply to populations in the event of a spill affecting drinking water. A study conducted in 2008 for the French Directorate for Civil Protection aimed to compare shoreline and inland water issues. This study identified new challenges to be faced by the authorities, the relevant administrations and Cedre.

Natalie Monvoisin
& Emmanuelle Poupon, Cedre



Drift forecast map for the slicks identified during the *Erika* spill dated 25/12/1999

Pollutant drift and behaviour models are an integral component of the array of spill response tools. They can be used to predict the movement of the oil according to the metocean conditions. The increased accuracy of these forecasts and the observations from these data has played a considerable role in the evolution and reliability of drift models. Thanks to advances in this field, the geographical areas covered have been extended across France and around the world with an increasing resolution and an ever finer meshing.

The French national meteorological service Météo France began to work on this issue in the early 1970s, in the wake of the *Torrey Canyon* spill. A simple yet robust tool was successfully developed then used during the *Tanio* spill in 1980. In the 1980s, the subject lay dormant. Admittedly, no major spills hit the French coasts during this period. Work resumed in the early 1990s. Calculation methods had evolved and operational use of ocean models had become possible. The current slick drift model goes by the name of MOTHY and has been operational since February 1994.

In 1996, collaboration was instigated between Météo France and Cedre. An assistance agreement was concluded whereby Cedre is able to call on the services of Météo France under any circumstances to obtain weather forecasts for a given area and to activate the MOTHY model. This model can also be used for backtrack simulations, for instance to identify the origin of pollution hitting the shoreline, or in the case of containers fallen overboard. MOTHY is regularly upgraded by Météo France's engineers in Toulouse. It was used successfully during the *Erika* spill in 1999 and the *Prestige* spill in 2002.

From 2007, the accuracy and geographic scope of the MOTHY system have been improved with the inclusion of the currents analysed and forecast by operational oceanography systems such as MERCATOR and MFS.

In 2013, two new components were added to the services offered by MOTHY, namely probabilistic atmospheric forecasts and ocean multi-forcing which allows the uncertainty of environmental data (wind, current) to be integrated by overlaying the results of different models on the same map.

Since 2016, MOTHY has benefited from atmospheric forcing from the new fine mesh regional models AROME for overseas French territories and the high resolution ocean forcing of the new MERCATOR system.

In 2018, following a research contract with the French Naval Hydrographic and Oceanographic Service (SHOM) and work conducted by Institute of Research for Development (IRD) in Nouméa, a new very high resolution version of MOTHY for current calculation in New Caledonia's lagoon is set to be implemented.

MOTHY is considered to be France's official operational model. Other commercial and institutional models exist and can be used for mainland and overseas France. In the event of a potential oil spill, it is strongly recommended that different models be run and the results compared.

Pierre Daniel, Météo France
& Vincent Gouriou, Cedre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Observation and remote sensing

When the *Amoco Cadiz* sank, Sweden was the only country to have an aerial surveillance programme which included remote sensing equipment: a plane equipped with side-looking airborne radar, another with infrared and ultraviolet sensors.

In France, LNE (the National Laboratory for Metrology and Testing) started an observation programme in 1978 with a *Cessna Caravan* equipped with an infrared sensor.

In the 1980s, this equipment became commonplace across Europe, at the initiative of each individual State and with technical support from the Bonn Agreement Working Group on Operational, Technical and Scientific Questions Concerning Counter-Pollution Activities (OTSOPA). This agreement between the 8 countries bordering the North Sea was signed in 1969, but was in fact not activated until after the *Ekofisk* rig blowout (in 1977) and the *Amoco Cadiz* spill. One of the issues addressed by the OTSOPA Working Group, to which Cedre contributes, is the aerial detection of marine pollution.

In France, it is Customs that are specifically in charge of aerial observation of marine pollution and, for this purpose, have specialised "POLMAR" *Cessna 406* planes fitted with remote sensing equipment. The French Navy aircraft conduct regular pollution detection and observation surveys, whether for spills or operational discharge, but have more limited detection equipment.

POLMAR planes currently use the conventional equipment available in most remote sensing aircraft, notably side-looking airborne radar and optical infra-red and ultraviolet sensors. The *Beechcraft King Air 350 ER* which are set to replace the *Cessna 406* shortly with be fitted with complementary equipment.

France does not only invest in equipment, the development of crews' skills is also essential. Since 1993, Cedre has been organising an aerial observation training course for the French Navy, customs and MRCCs (Maritime Rescue Coordination Centres). Cedre is also a member of the team of trainers in this field set up by the European Maritime Safety Agency (EMSA).

Cedre published a first operational guide on this issue in 1980. Several subsequent editions have been published, culminating in the guide being selected as a reference document by IMO.

While airborne oil detection equipment is widely understood and employed, considerable progress remains to be made in terms of the detection of other compounds, in particular those covered by Annex II (noxious liquid substances) and Annex IV (gases) of the MARPOL 73/78 Convention.

Many research projects are conducted in this field. Cedre has been working on chemicals since the 1980s ("Pollutmar" campaigns). Far more recently, we were partners in the POLLUPROOF project, funded by the French national research agency (ANR) and coordinated by the French aerospace lab ONERA. The results obtained through this project, which aimed to identify sensors able to detect and characterise chemicals, are promising. This project is now finished, but there is still a long way to go.

In terms of the detection of gases emitted by ships, a very interesting project, COMPMON, funded by the European Union and conducted by countries in northern Europe, again led to very encouraging conclusions.

Finally ranking among the major improvements since the sinking of the *Amoco Cadiz* is the CleanSeaNet Satellite Service, a programme set up by EMSA which collects radar images from several satellites, analyses them and transmits them to the Member States within 30 minutes. The system has been up and running since 2007 and is a valuable resource for rapidly obtaining images of vast areas, on which anomalies, potentially oil slicks, are identified. For France, this service is available for the mainland and the French West Indies.

Finally, EMSA has also acquired drones, still in trial phase, which may potentially be able to detect oil, HNS and gases.

Anne Le Roux, Cedre

In situ and laboratory-based analysis

The scientific literature published in the years following the *Amoco Cadiz* spill highlights the headway made in the field of analytical chemistry and the assessment of the impacts of such pollution on the quality of marine waters. For instance, the seminar held in Brest in November 1979 on the consequences of the *Amoco Cadiz* oil spill included reports of contaminant concentrations which are currently detected and quantified at thresholds 1000 times lower. This example cannot however be generalised, as the advances made vary greatly from one area to another.

In situ contamination measurements use fluorometric techniques, the basic principles of which have remained relatively unchanged. Similarly, measurements of dissolved aromatic compounds continue to be general determinations which do not provide concentration values for individual compounds. These techniques continue to be a valuable source of information in the hours and days following a spill. It is hence in the field of long term monitoring that advances have been the greatest.

The democratisation, beginning in the 1990s, of gas phase chromatography analysis systems coupled with mass spectrometry detection (GC-MS) considerably improved the accuracy of the diagnosis following an oil spill. These systems benefited from the combined progress of electronics and information technology, greatly expanding their use. The first application which comes to mind is the identification or confirmation of the origin of a spill, through comparison with a sample taken from the environment where there is a suspected source of contamination. Analytical techniques have little evolved since the early 2000s, but a major pan-European effort has been implemented, in particular through the Oil Spill Identification Network (OSINET) to define common criteria for interpreting analysis results. The results of such analyses can be used to confirm the type of contamination, by differentiating human inputs (anthropogenic) from natural background contamination (biogenic). It is even possible to distinguish accidental contamination caused by an oil spill from chronic contamination.

Above and beyond such qualitative or semi-qualitative approaches, considerable progress has been made since the 2000s in the determination of low concentrations of compounds associated with oil spills, in particular PAHs (Polycyclic Aromatic Hydrocarbons). Complex matrices such as biological tissues sometimes make it tricky to confirm the presence of target molecules, given the high number of interferences. More elaborate mass spectrometry techniques (high resolution or tandem mass spectrometry) can be used for instance to determine the concentration of bioaccumulated PAHs with greater certainty.

The field of water analysis has seen many developments to improve chemical water quality monitoring in the marine environment, in particular in relation to the Water Framework Directive. Micro-sample preparation systems (SBSE, SPME, SPE…) have greatly lowered the quantification thresholds, while allowing large-scale sampling thanks to the automation of extraction procedures. These solvent-free techniques are also a more environmentally-friendly solution.

Passive sampling systems can be left in the environment for several days and thus accumulate the pollution. The values measured are low and represent an average over several days.

All this progress should not however overshadow the phase that is sometimes wrongly considered to be less technical: the collection and preservation of a representative sample, without external contamination.

Julien Guyomarch, Cedre

Use of dispersants

The first chemical products analogous to dispersants and used in oil spill response were detergents. Responders used them in response to the *Torrey Canyon* spill in 1967 to clean oiled rocks as well as to fragment slicks drifting in inshore waters. However, the first assessments of these operations showed high mortality rates in certain populations of marine organisms, counteracting the benefit of their use despite their proven efficiency. The ecotoxicity studies launched highlighted the toxicity of the solvents contained in these detergents, mainly PAHs, which were held responsible for these mortalities. Based on the results observed in terms of shoreline clean-up, the UK authorities recognised the benefit of these products in oil spill response on the condition that their toxicity towards the marine ecosystem was reduced and, to this end, set up a research programme to optimise their formulation.

During the *Amoco Cadiz* spill, dispersants were applied, but only in an exploratory capacity to understand their potential for response. While their efficiency was again recognised, recommendations were rapidly made on the application techniques to be used and the storage of these products aboard response vessels. It appeared necessary to optimise spraying procedures to increase the surface area of slicks that could be treated in a single application and to reduce the number of trips back to base for restocking. Several research programmes were therefore initiated and one of the outcomes was the development of spraying arms fitted with special nozzles allowing the quantity of dispersant applied to be controlled by square metre of oil. The dispersant-oil ratio (DOR) was thus defined.

In the following years, over and above these purely practical aspects, the French government asked Cedre to define a dispersant test procedure to prevent the use of inappropriate and potentially toxic formulations on the market. Thus in 1988 the French procedure, still in force today, emerged. It includes the three following tests: an efficiency test (NF T 90-345), a toxicity test on the marine shrimp *Crangon crangon* (NF T 90-349) and a biodegradability test (NF T 90-346). Then in the 1990s, the limits for dispersant use on the French coastline were defined to prohibit their use in areas that may be potentially more sensitive to dispersed oil than floating oil or where their dilution in the water column is not optimal, in particular at an insufficient distance from the shoreline or in shallow waters. In terms of the intrinsic toxicity of dispersants, the chemical formulas currently on the market have successfully passed the toxicity tests for the marine environment and are not persistent as they are biodegradable.

Although dispersants were not used in France during the most recent oil spills, they are nevertheless an integral component in the array of oil spill response strategies.

Stéphane Le Floch, Cedre

In situ burning

In situ burning (ISB) is a response technique which consists in igniting an oil slick at the spill site. Although this technique appears attractive given its low cost, high yield, short oil elimination times and low quantity of waste generated, it has never been fully accepted in the range of "conventional" spill response techniques due to the difficulty involved in its deployment and the release of a large quantity of combustion products (gases, soot) into the atmosphere. This response technique has been a source of controversy since the late 1960s, when it was first tested (1967, *Torrey Canyon*) though unsuccessfully. Until 2010, the deliberate use of this technique to respond to a real spill was only reported once, during the *Exxon Valdez* spill (1989). Due to climate conditions and decision-making processes, only a 75-minute test burn was successfully performed, while the following attempts proved inefficient due to the emulsification of the oil.

Yet ISB has been the focus of numerous studies conducted both in the laboratory and during experiments, often in the Arctic, an environment particularly well suited to this technique. The low temperatures delay the oil weathering process by prolonging the presence of volatile compounds. Furthermore, the presence of blocks of ice at the water surface naturally contains slicks. The more recent *Deepwater Horizon* blow-out (2010, Gulf of Mexico) and the 400 burns organised during this spill provided extensive field experience, helping to improve scientific knowledge and optimise the equipment required. For certain States or decision-makers, ISB should now be promoted from its status as an alternative technique to that of a conventional technique for response at sea, to join ranks with dispersion and mechanical recovery.

Ronan Jézéquel, Cedre

In situ burning during the *Deepwater Horizon* spill (2010)

"In 40 years of research into bioremediation, a large number of laboratory-based and in situ experiments have been performed and have resulted in the production of numerous guides on this issue."

Bioremediation

Bioremediation covers all the techniques used to decontaminate an oiled site by accelerating the natural degradation of the pollutant by micro-organisms. This option is viewed relatively positively by the general public in comparison with other clean-up processes such as the excavation of sediments for treatment off-site. In the case of spill response, these operations should be implemented following final clean-up operations at the spill site, to avoid the major logistical implications of the transport of equipment, personnel and waste. During conventional bioremediation operations, populations of indigenous hydrocarbonoclastic bacteria develop in large numbers in the presence of oil and, as it is broken down, the populations decrease in number to return to their initial level. This process ultimately results in the production of biomass, carbon dioxide and water. Biostimulation, bioaugmentation and even phytoremediation techniques, although commonly used on contaminated soil in industrial areas, are not often applied in the natural environment in the event of oil spills.

In 40 years of research, a large number of laboratory-based and in situ experiments have been performed and have resulted in the production of numerous guides on this issue. Among the lessons learnt from the scientific studies, specialists now agree that bioaugmentation based on the seeding of a contaminated site with a specially developed bacterial consortium is not an effective solution given the immediate competition with indigenous bacteria, in favour of the latter populations. The biostimulation process is preferable for bioremediation operations in an open environment such as a shoreline. Today, many clearly identified biostimulation agents are available to increase the nutrient levels at the contaminated site in order to significantly enhance the biodegradation process and accelerate decontamination.

Ronan Jézéquel, Cedre

Containment and recovery at sea

Since the *Amoco Cadiz* spill, regulatory changes aimed at preventing oil tanker spills have contributed to the significant drop in major spills worldwide. In French waters, over the past 40 years, spills exceeding 1000 tonnes have been rare, and those under circumstances in which containment and recovery operations could be implemented at sea rarer still. The main spills offering interesting feedback in terms of the efficiency and limits of the techniques and equipment deployed and the identification of improvement opportunities are therefore those of the *Erika* oil tanker in 1999 (Bay of Biscay) and the *Prestige* oil tanker in 2002 (off Cape Finisterre). These improvement opportunities mainly concern the recovery of very viscous heavy fuel oil, which raises different issues to those of the major crude oil spills which had previously occurred in France or its neighbouring countries (*Braer* in 1993 and *Sea Empress* in 1996, both in the UK). In terms of mechanical recovery, the most significant changes triggered by past experience in France have mainly focused on enhancing the capacity to respond to spills of viscous substances, against the broader backdrop of numerous HFO spills across the globe (*Nakhodka* in Japan, 1997; *New Carissa* in the United States, 1999) and analysis of shipping trends, elements which have contributed to the improvement of appropriate technical solutions.

> Chartering specialised oil spill response vessels (OSRVs) for HFO spills

The *Erika* spill in December 1999 confirmed the feasibility and merits of containment and recovery at sea. Despite severe sea and weather conditions, meaning that only 3 days of operations could be carried out in 3 weeks, and despite the very high viscosity of the fuel spilt, making pumping particularly difficult, over 1,100 tonnes of oil was recovered. This was not an insignificant result when considered in light of the duration and cost of operations to clean up the shoreline affected by the rest of the cargo. This result greatly benefited from the excellent cooperation between European countries which pooled their resources, in compliance with regional agreements activated following the *Sea Empress* spill for example. In the case of the *Prestige* spill in 2002, in which part of the oil drifted in the Bay of Biscay, over 20,000 tonnes of emulsion (i.e. around 25% of the spill) was recovered by the fleet of European OSRVs mobilised. This significant result was doubled thanks to the involvement of a fleet of vessels of opportunity (fishing vessels in this case) equipped with trawl nets and surface nets (in addition to some lighter tools). This response equipment, although rather "low tech", proved to be relatively well suited to the situation.

Since the 1990s, the majority of efforts to improve recovery capacities at sea, at least in Europe, have focused on chartering or purchasing multipurpose vessels fitted with response equipment suited to highly viscous substances (for recovery, storage, transfer and detection). In France, certain vessels have been adapted to improve their efficiency on HFO slicks. For instance, given the difficulties encountered during the *Erika* and *Prestige* spills, the French vessels *Alcyon* and *Ailette* were fitted with rigid sweeping arms, in addition to their Transrec weir skimmers and Hiwax skimming heads. The BSAD *Argonaute*, with a 1500 m^3 storage capacity, has been chartered by the French Navy since 2004.

However, in the field of OSRVs, a major initiative was introduced in Europe, through EMSA, and a significant budget was allocated to contracting private societies to maintain an operational European fleet of various vessels (supply vessels, cable ships, icebreakers, etc.) fitted with specialised spill response equipment. The specifications issued for these contracts took into account the lessons learnt from the most recent spills, including the *Erika* and the *Prestige*, and comprised a heavy fuel oil recovery capacity in rough seas. In addition to this fleet of vessels, EMSA also maintains two spill response equipment stockpiles, one for the Baltic Sea and the other the North Sea.

> R&D projects relating to ships capable of recovering heavy fuel

Despite investments made in OSRVs, research and development into new techniques have been relatively limited, except perhaps as concerns the use of remote sensing to guide ships. In France, a few days after the *Erika* spill, the Ministry of Industry launched a call for projects to improve the response capacity at sea under such circumstances. Four proposals for designing ORSVs were thus funded. Less than 3 years later, following the sinking of the *Prestige*, the two most promising of these were submitted to the European Commission in response to a similar call for projects. One of them (the Oil Spill Harvester or OSH project) was funded to develop a specialised catamaran. This project came to an end in 2008, concluding that the concept was feasible in terms of the recovery and storage of viscous products (even in rough seas), but was not economically viable. It also included the design and trial of a brush skimmer module.

> Increased mobilisation of vessels of opportunity

As mentioned above, the total quantity of fuel oil recovered at sea following the *Prestige* spill was doubled thanks to the involvement of numerous fishing vessels, equipped with unspecialised tools such as trawl nets, brailers, scoop nets, wire mesh spades, etc... which proved to be well suited to this type of pollution. Nevertheless, with the exception of surface trawl nets, few noteworthy improvements have been made to these systems.

> Development of new containment/recovery concepts

Over the past 40 years, while many European countries have been striving to develop stockpiles of equipment for response at sea, including pumping and skimming equipment, they are mainly restricted to the existing technologies and equipment available on the market as nearly no national initiatives exist to develop original at-sea recovery concepts. The market would appear to be too limited to encourage industry to fund significantly innovative research. Over the past 20 years, Japan was one of the few countries in which new pumping concepts for viscous substances have been developed and tested, based on the experience of the *Nakhodka* (1997), in particular a concept involving vapour jets and vacuum suction designed and tested by the Port and Airport Research Institute (PARI). In most cases, the developments proposed by the manufacturers are more improvements to existing systems or techniques than novel concepts.

> Testing and improving techniques and equipment

Pumps

In the field of pump technology, improvements have been made across the globe over the past 20 years, notably to Archimedes screw pumps, commonly used in oil spill response. These improvements have focused on optimising their performance on highly viscous substances. The benefits of the principle of annular water injection have been evaluated through tests conducted by various organisations located on either side of the Atlantic, for instance for the United States and Canadian Coast Guards (with specific programmes such as Joint Viscous Oil Pumping System (JVOPS), in Denmark at DESMI's facilities, in France at Cedre's facilities, in Finland at Larmor's facilities, etc. In France, this principle adapted from oil industry technologies was tested for application in oil recovery at sea by Cedre and IFP.

In the 2000s, vapour/hot water injection systems at the pump intake and annular water injection at the pump outfall ultimately led to a remarkable increase in the pump rate of viscous oil.

Mechanical skimmers

In terms of the recovery of highly viscous oil, many weir, belt and belt brush skimmers have been tested. Additional progress has been made through the use of belt or brush adapters fitted to weir skimmers, improving the overall recovery rate and selectivity. In Scandinavia in particular (for instance Norway and Sweden), evaluations have led to the production of offshore skimmers subsequently integrated in new offshore response units. In France, trials have been conducted at Cedre's facilities (above-mentioned European project OSH), as well as tests, at the request of the French authorities, to compare the performances of smaller systems.

Surface nets

In the early 1980s, surface trawl net systems were designed and tested in particular in France (Seynip systems), as well as in Japan, for the recovery of oil that has turned solid or highly viscous following prior application of sorbents on the slicks. Similar equipment has also been designed in Denmark (Scantrawl) and in the United

Containment and recovery during the *Prestige* spill

Recovering water-in-oil emulsion using a weir skimmer

Kingdom (Jackson Trawl Net), but the limitations relating to the application of sorbent in the open sea mean that these net systems were cast aside for over 15 years. They reappeared following the *Erika* spill for response inshore, where their potential for recovering extremely viscous floating products was confirmed. However, difficulties in handling and emptying/cleaning this type of trawl nets encouraged the appearance of disposable concepts (at least the cod-end). In France, after the *Erika*, the ECREPOL project (funded by the Ministry of Research and approved by RITMER) culminated in the development of such a system (Thomsea trawl net), which has since been purchased by several authorities, and other descendants of this concept, first invented some 40 years ago, have appeared.

Specialised storage reservoirs

Towable, flexible, floating storage tanks have been developed to increase the storage capacity for the emulsions recovered during operations at sea, but their capacity is generally too limited to avoid having to then transfer the oil to a larger storage facility. Closed models (e.g. bladders) can be towed to unloading sites at higher speeds, but are more difficult to empty, and manufacturers offer tanks with a removable cover to overcome this operational issue. Despite the improvements made to this type of equipment over the past four decades, and their presence in equipment stockpiles, they appear to be rarely used during real spills at sea, probably due to the risk of rupture during towing to shore.

Trial facilities

While standards have been established for the classification and evaluation of booms and skimmers for offshore response, there are few facilities worldwide at which they can be assessed in realistic conditions in order to determine and compare their performances. In the US, the most well-known such facility is without a doubt OHMSETT, built some 40 years ago, whose activity, which saw a slump in the 1980s, was rekindled following the *Exxon Valdez* spill. A wide range of equipment trials are conducted at OHMSETT, for instance on skimmers on the market or under development, according to US standard procedures for the needs of the private or public sector. In Europe, Norway (Norwegian Coastal Administration; Sintef) and France (Cedre) have specialised facilities that can be used to test skimmers using their respective standard protocols (AFNOR in France), pumps and other equipment.

Ivan Calvez, Cedre

Recovery vessel

A Seynip spill response trawl system being deployed by fishing boats

Use of sorbents

The use of floating hydrophobic sorbents is one of the commonly applied techniques to respond to oil spills.

In the 1980s, the first sorbents used were mainly loose sorbents of natural or synthetic origin, made from fibreglass (insulation), peat, perlite, cellulose, polyurethane powder, rubber (tyres), etc. Many products often came from industrial waste, either raw or processed and made into different formats to be applied to a slick.

Loose products were generally preferred for their low cost compared to the higher prices of sorbent pads or booms.

At this period, protocols designed to measure water and oil retention were implemented in Cedre's laboratory to define the performances of different sorbents in identical conditions and to determine the criteria to select the most efficient options. The reference oil used in these tests was ALC 110, an Arabian light crude similar to that of the *Amoco Cadiz* spill topped at 110°C to reduce its toxicity for the experimenter. Over the years, these protocols have evolved and have been adapted to different sorbent formats, resulting in standardised protocols published in 1990 which are still applied today for sorbent approval (AFNOR standard NF T 90-360).

The market for floating oil-only sorbent pads and booms for use on the water has developed, at the expense of loose sorbents. These products have become increasingly popular thanks to their simple usage. They are easier to recover and their application does not require any specialised equipment. Due to the scope of these markets and the competition between the many different manufacturers and distributors of these products mainly made from polypropylene from France, Belgium, the US, Turkey, China etc., the price of sorbent pads is now close to that of loose sorbents. Spill response operators now prefer polypropylene sorbents which hold a large market share. Sorbent booms remain more expensive but are nevertheless worthy of interest due to their two-fold role as both containment and recovery systems.

Pascale Le Guerroué, Cedre

"Spill response operators now prefer polypropylene sorbents which hold a large market share."

Sorbent booms laid to protect the shoreline during the *Deepwater Horizon* spill

Sorbent pads laid in a harbour

Protection of sensitive areas

Deploying a boom during a POLMAR onshore spill response exercise

Protecting sensitive shorelines is an ongoing concern of decision-makers involved in managing an oil spill. It almost always comprises the deployment of containment booms in front of the shore, which often represents the first visible stage in shoreline response for local populations and is therefore the first critical operation for the authorities in charge of conducting it. Floating booms made their first appearance in Europe and France following the *Torrey Canyon* spill, and saw considerable development in the wake of the *Amoco Cadiz*. In the 1980s and 1990s, a wide range of booms and accessories with a variety of characteristics and increasing intrinsic qualities were designed, drawing on newly discovered materials. Meanwhile, protection plans for sensitive coastal sites and related measures, as defined by the POLMAR circular of October 1978, became an important part of the French onshore marine pollution response mechanism comprising:

- oil sensitivity studies of the French coastline (which gradually led to the development of sensitivity atlases then to their current digital version in the form of geographical information systems (GIS), to provide decision-makers with a clearer overview of the environmental and economic factors of the shoreline at threat).
- the development of boom laying plans (including the best configuration according to the site's physical and hydrodynamic characteristics and the calculation of the tensile stress on the boom components and its moorings).
- the establishment of equipment stockpiles comprising complete containment systems (together with the necessary recovery and storage equipment)
- as well as the implementation of exercises to test and validate these boom laying plans. Since then, site protection efforts have not waned: selection of appropriate equipment at stockpiles, organisation of POLMAR exercises all along the coastline. In addition, studies and trials are conducted jointly by Cedre and Cerema (French centre of studies and expertise on risks, environment, mobility and land-use planning) in particular in areas of strong current or with high tidal ranges in order to obtain a better understanding of the limits of the available response equipment. Specialists and operational responders are now well aware of these hydrodynamic limits, which prevent full effective protection of all sensitive areas, meaning that booms should be concentrated on sites that can be effectively protected. Forty years on from the *Amoco Cadiz*, this situation still remains difficult for many stakeholders to accept. It is often challenging for technical advisers to convince decision-makers that boom deployment is not the most appropriate option and that in some cases it may be preferable to use alternative protection techniques (sorbents, nets, gabions, various filter systems, etc.) which proved successful during the *Erika* and *Prestige* spills. In all cases, initial clean-up actions on the most sensitive sections of shoreline must be planned and organised quickly.

Arnaud Guéna, Cedre

Custom-made straw barrier

Shoreline clean-up operations following the *Amoco Cadiz* spill came to completion after 3 months of intensive efforts. The first to take action were the local population (residents, fire fighters, local authority staff, fishermen, farmers, etc.) who made do with the tools and clothing at hand. For some, these tasks were familiar, as they had carried them out 12 years earlier during the *Torrey Canyon* spill. Very soon, back-up arrived in the shape of organised forces: fire fighters and military, mainly composed of conscripts. Spill response equipment stockpiles did not yet exist and specialised equipment (booms, skimmers) was not widely available: only a few units and prototypes arrived at the beaches. The fluid oil continued to flow and spread everywhere. Pumping was therefore the number one priority: pumping the oil, but also pumping water to supply hoses to wash oiled substrates. The equipment used mainly consisted of slurry spreaders and high flow pumps equipped with manifolds. Soon after came pressure washers: still uncommon at the time, they became a centrepiece of shoreline clean-up thanks to the quick reaction of the local private sector which provided autonomous, mobile units. Response operations and the associated logistics, both on and offshore, were masterminded by the equipment directorates. Fleets of public works machinery grumbled across the beaches and surrounding areas, dipping into the thick slicks at the water's edge or scraping those already washed up on the beach, removing bins filled by hand on the rocks, digging pits in the ground to store the substances pumped and stripping away heavily oiled layers of sediment. Driven by the pressing need to remove the oil from the beaches, or even purely out of concern for efficiency, clean-up operations were sometimes rushed, causing further damage to the environment. At the many protests held against the oil spill at the time, signs cropped up criticising the operations which were claimed to be devastating: Messages such as "No detergents" and "Save our dunes" were evidence of the environmental conscience already deeply rooted in part of the local population.

In the 1980s, Cedre, justly newly created, naturally focused on improving its knowledge of pollutants and response equipment. Certain technical aspects which were deficient or lacking during the *Amoco Cadiz* spill were therefore given particular attention. The development of tools to recover oil from beaches, in cooperation with national or local manufacturers, was a key concern during the early years. However the low frequency with which these prototypes were used put an end to their industrial development and Cedre turned away from this line of activity. The only such equipment designed at Cedre and which has prospered is a simple, efficient, cost-effective system: a hose for underwater agitation which was tested on certain beaches in Finistère which still had pockets of oil trapped in their depths. Cedre then turned its focus to the assessment of available response products and equipment liable to be used at sea or on the shoreline. The purpose of such assessments was to determine the real performance and optimal conditions of use of equipment (in terms of efficiency and potential ecological impact) and to recommend effective equipment to national authorities in addition to that already available in the POLMAR stockpiles (equipment purchased during the *Amoco Cadiz*). From the 1990s, the oil industry began to take an interest in this activity and support it.

Meanwhile, Cedre drafted practical guides to shoreline response for the French ports and maritime shipping directorate, the European Economic Commission and IMO. It also took a close interest in the potential environmental impact of the different response techniques. For some 15 years, experiments were conducted on the shoreline, with or without real oil, to monitor the possible effects of techniques on the flora and fauna, in association with the universities of Brest and Rennes which were in charge of ecological monitoring. Several related techniques or actions were scrutinised: rock washing with agents; washing of marsh vegetation; chemical dispersion of stranded slicks; underwater agitation on sandy beaches: scything of marsh vegetation; the application of film-forming agents to protect substrates; the use of heavy vehicles on beaches...

The 1990s were marked by a series of major oil spills overseas, for many of which Cedre was called upon. Feedback from these real incidents and the comparison of post-*Amoco Cadiz* experience with practices used abroad helped to improve shoreline

Pressure washing riprap

response and to reduce ecological impacts. Less environmentally aggressive techniques, for example underwater mixing and surfwashing, were tested then recommended, in particular to reduce the removal of sediment from beaches to a minimum. During these years, environmental concerns were epitomised by the American post-*Exxon Valdez* notion of "How clean is clean?" which encapsulated an approach which was in fact already well ingrained in Europe and in France. The associated definition of a clean beach, based only on visual observation, to determine when to stop clean-up operations is a trickier, or even illusory, concept, as illustrated by the limits of the "white sock" test in the US, or the white towel test during the *Erika* in France.

Faced with the inadequacy of visual observation alone, another approach was adopted during the *Erika* spill to determine when to stop clean-up. This system consisted in setting up an environmental unit composed of representatives of all the stakeholders involved which jointly defined the response aims and clean-up techniques prior to starting operations according to the site's environmental and economic specificities. At the end of operations, the same unit decided whether or not the clean-up site could be closed down based on the initially established endpoint criteria.

The response to the *Erika* also saw other major changes. First, new stakeholders became involved, including the owner of the cargo transported by the polluting ship, who voluntarily declared their involvement in the response, bearing in mind that this was the country's main oil company (REPSOL did the same in Spain during the *Prestige* spill). Having spontaneously chosen to play an active part in clean-up operations, Total was assigned some of the most technically complicated sites to clean. This involvement, in addition to the financial windfall it represented, changed the game in terms of previous internationally accepted clean-up standards. This was the case, for instance, of clean-up operations conducted on cliffs which were entirely unprecedented. Total, then the French shoreline pollution framework POLMAR, contracted professional climbers to provide access in order to remove oil from steep-sided creeks and to clean oiled cliffs. Meanwhile, particular attention was given to avoiding the spread of oil from clean-up sites to unoiled sites and to preventing deterioration to access points and the ground. All these innovations are now integral elements of clean-up operations, both in France and abroad, just as much as personal protective equipment for instance. Another new feature was the involvement of environmental experts to identify species and habitats at risk and to coordinate their clean-up, as well as to provide advice on the response timeline according to the species' presence and life cycles. Surfwashing was another technique that also enjoyed its hour of glory. Although the basic principle was already established, it was greatly improved by using synthetic nets to more effectively capture the oil released, a technique which has since been frequently implemented.

Another major change initiated during the *Erika* marked the 2000s in France: the sharp drop in the involvement of the public sector in response, in favour of the private sector. Private response companies – newcomers on the scene – began to be called upon to clean up the shoreline, replacing the contingents that had previously made up the majority of the troops. Military forces, still very present during the *Erika* (for the first 6 months), were no longer or scarcely present (with the exception of civil protection units) during the *Prestige* spill: with the end of military conscription, the previously ample supply of field operators had dwindled. In terms of fire fighters, another key source of labour, their mobilisation was restricted to an emergency context and could not be extended longer term. This was further exacerbated by the cutback in the number of civil servants assigned to the State services customarily in charge of the response organisation and management. To compensate for this reduced workforce and to facilitate management of the response, the private sector began to be called in. Public contracting, an innovation during the *Erika*, went on to become the norm. From this point on, contracts were concluded with private service providers for each geographical zone in order to be able to launch operations or source equipment as quickly as possible in the event of a spill.

In 1978, it took 3 and a half months to clean up the 230,000-tonne *Amoco Cadiz* spill. To clean up the 20,000 tonnes released from the *Erika*, operations continued intermittently for more than 2 years. After the *Amoco Cadiz* spill, the population returned to the beaches without great concern, with the summer season beginning 3 months

Manual oil recovery

Inshore flushing

Shoreline clean-up site

Collecting solid waste from riprap

after the spill. In the case of the *Erika*, it took 6 months of efforts to obtain authorisation to officially reopen only some of the most popular beaches to the public. The general public's tolerance level of contamination has greatly lowered, contrary to pressure on State services in terms of health precautions.

The final stakeholder to have entered the scene in the 2000s was the health inspector, tasked with authorising the reopening of beaches to the general public. Given the radical progress in terms of the personal protection of responders – sometimes even to an exaggerated extent – the odds are that in the case of a new spill of a highly volatile, light substance (similar to that of the *Amoco Cadiz*, for instance, even on a smaller scale), the health inspector would be called in from the onset of operations to decide whether or not personnel could be sent onto the beaches, and, if so, with specific, duly supported, recommendations on the personal protective equipment to be worn, working hours and other procedures to be respected. This would evidently affect the organisation, duration and cost of the response. Without a shadow of a doubt, a disaster on the scale of that of the *Amoco Cadiz* would not be remediated in 3 months and a few days.

Loïc Kerambrun, Cedre

Volunteer management

Every oil spill triggers an influx of volunteers. The accepted definition of a volunteer is a person who accomplishes a task without being required or paid to do so. Oil spill volunteers fall into two main categories: regular volunteers who have specific emergency response skills and occasional volunteers, moved by the disaster, who freely decide to offer their services, in the hope that they will be included in the response organisation.

The major spills caused by the *Amoco Cadiz* and the *Erika* mobilised 9,000 and 5,000 volunteers respectively, many of whom were occasional. However when the *Prestige* spill occurred, the mobilisation of professional units composed of personnel from the equipment directorate, civil protection and military personnel, together with the private companies contracted, meant that the response workforce was organised quickly without having to call upon large numbers of occasional volunteers.

Before 2006, the French marine pollution 'POLMAR' regulations encouraged the use of volunteers, but post-*Prestige* regulations addressed this aspect differently. Only the members of community reserves, civil protection associations or nature protection associations, with prior training and appropriate insurance, are destined to be included in spill response as occasional responders reporting to the municipality's technical services and under the responsibility of the mayor.

The regulations in force recommend including in contingency plans lists of tasks for each response phase, which could be proposed to volunteers, as well as to the relevant associations and professional organisations. It is also recommended to use volunteers from established volunteering organisations rather than individual volunteers. In France, to be mobilised in the event of a spill, associations must prove their response capabilities and should preferably request a civil protection accreditation from the Prefect. Unless absolutely necessary, untrained individual volunteers should be referred to community reserves or accredited associations.

Mélusine Gaillard, Cedre

Briefing volunteers

In 1978, when the *Amoco Cadiz* sank, academics sprang into action to conduct an initial survey of intertidal zones just before the oil slicks hit the shore, with a view to post-spill impact assessment. Scientists were then called upon to assess the impacts for the subsequent legal proceedings. During clean-up operations, a number of consultations were held in relation to response strategies, in particular on dispersant use and the sensitivities of marine resources, as well as the collection and rehabilitation of oiled wildlife carried out by associations. The spontaneous and unsolicited involvement of academics and associations opened the way to a more formal participation of environmental specialists in response operations. Furthermore, the pressure inflicted by the public works machinery mobilised to recover 250,000 tonnes of solid substances from the shores remained engraved in memories as environmental impact which could have been partially avoided, hence the need to take better account of the sensitivity of environments during clean-up operations.

To follow through the lessons learnt from the response to the *Amoco Cadiz*, regulations on contingency plans were amended in October 1978 and henceforth recommended obtaining expert advice. At a central level, it was stated that the incident command should include representatives of all the relevant ministerial departments, competent technical and scientific organisations as well as, where appropriate, all qualified experts. Cedre's expertise was highlighted in relation to response techniques. Similarly, at a departmental scale, the Prefect, as

"During the Tanio *spill (1980), Cedre, just newly created, provided its expertise, yet it was during the* Erika *spill that the use of environmental expertise took on a new dimension."*

commander of spill response operations, was placed in charge of leading and coordinating the action of decentralised Government services and departmental services and could call upon the same expert organisations as well as any other person he considered necessary. The paragraphs relating to response preparedness also stipulate that the operations must be conducted in cooperation with the administrations, councillors, nature protection associations, marine environment professionals and marine environment user associations, and, if necessary, with advice from the previously mentioned expert organisations as well as any relevant marine environment research units.

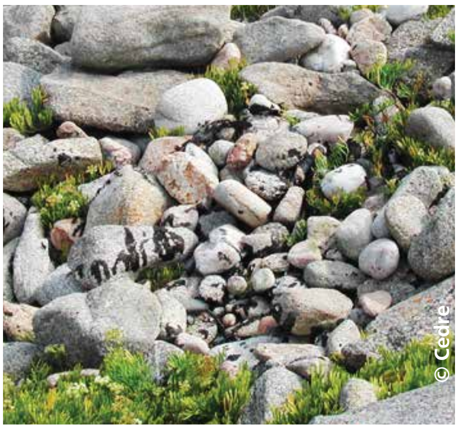
During the *Tanio* spill (1980), Cedre, just newly created, provided its expertise, yet it was during the *Erika* spill that the use of environmental expertise took on a new dimension. The regional delegations of the Environment Ministry mobilised experts who were organised into environmental assessment units:

- around 20 specialists (academics, associations, specialised structures taking part in reporting meetings with field teams and in meetings required to develop recommendations),
- including a team of around 10 people working directly in the field (botanists, geomorphologists, biologists, naturalists, representatives of services) to establish recommendations for environmentally-friendly cleaning and to advise operational teams from the launch to the completion of operations. On certain sites, botanists even led clean-up operations on vegetation (referred to as "botanical worksites"), which was particularly affected during this spill.

This field expertise was improvised at the time of the emergency. The number of experts who could be mobilised at short notice and for a long period limited the number of people involved. Mobilisation was indeed difficult to organise (agreements, requisitions, etc.) as was the coverage of mission expenses, in the absence of payment.

In addition to environmental assessment units, specialised expert groups composed of scientists, administrations, local authorities and professionals addressed specific issues such as the protection of and water supply to salt marshes.

This system was implemented again and considered successful during the *Prestige* and *Tricolor* spills. It became a permanent feature and was included in the POLMAR regulations in 2002. The expected contribution of experts is detailed in these regula-



Residual oil from the *Erika* on a rocky platform and stones interspersed with vegetation

Botanical follow-up after the *Erika* spill tions and relates to a variety of aspects: the evolution of the pollution, health aspects for responders and the population, the optimisation of response equipment and techniques, the assessment of long term consequences for the environment, fisheries, shellfish farming, knowledge of the affected environments and assessment of initial impacts, the proposal of indicators and methodologies to monitor impacts. Environmental support for clean-up operations at field command posts is also mentioned. In terms of response preparedness, the 2002 texts provide for the establishment of lists of experts appended to the POLMAR plans.

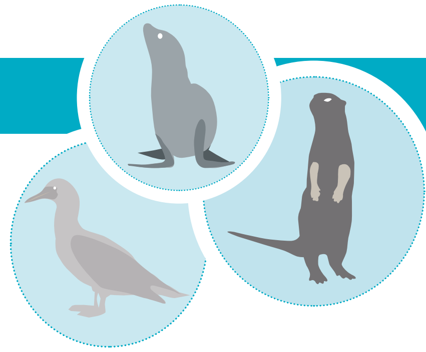
When these contingency plans are revised, commissions meet to identify, contact and list regional experts and key contacts in the various above-mentioned fields. Certain regional environment agencies occasionally organise training and discussion days to organise networks of experts and to encourage experts and the services and organisations in charge of spill response to get to know each other, making for smoother, more effective cooperation.

Among the lessons learn from the *Amoco* experience, from 1978, the involvement of different scientific and environmental resources liable to be mobilised in the event of a spill (expert organisations, universities, associations, etc.) has been included in legislative texts, with palpable results during the *Erika* and subsequent spills. Certain difficulties identified following past spills are however still experienced today, in particular in terms of the definition of the conditions and procedures for mobilising experts, operational collaboration with government services and local authorities as well as the question of expert availability, which remains one of the primary obstacles.

Florence Poncet, Cedre

Botanical follow-up on the banks of the Loire river

Oiled wildlife rehabilitation



On 20th March 1978, a meeting chaired by a representative of the French Environment Ministry was held in Brest. It was decided that the collection and rehabilitation of oiled birds would be carried out by SEPNB in Finistère and LPO (*Ligue pour la protection des oiseaux*) in Côtes-d'Armor. Some 30 rescue centres worked in the affected area.

An attempt was made to repopulate the Sept-Îles archipelago with puffin chicks imported from the Faroe Islands, like after the *Torrey Canyon* spill in 1967, at the initiative of LPO, and in particular Colonel Milon, its president at the time.

Very soon, the need for permanent structures to handle future spills became apparent. This meant not only having premises, equipment and staff ready and able to handle such an incident, but also capitalising on past experience, or even conducting research.

The nature rescue centre CHENE was established in 1980, its museum in 1981, and the Ile Grande bird centre and its rescue centre (jointly funded by the French Environment Ministry and donations received following in the *Amoco Cadiz* spill) were inaugurated in 1984. In 1985, CVFSE (veterinary centre for wildlife and ecosystems) was created.

In Brittany in the 1970s, marine mammals (grey seals) were cleaned and rehabilitated mainly by SEPNB volunteers on the premises of the faculty of science in Brest. In 1989, this rescue centre was transferred to the new premises of Océanopolis and was run by their employees. In 2016, an umbrella association was created – the rescue and conservation centre for aquatic wildlife of Brittany – uniting Océanopolis, the *Groupe Mammalogique Breton*, the LPO and *Bretagne Vivante* (formerly SEPNB). The centre continued to be based at Océanopolis.

The CESTM turtle centre at the La Rochelle Aquarium has been monitoring sea turtles along the Channel and Atlantic coasts of France (coordination of the French Mediterranean sea turtle network RTMAE) and taking in stranded turtles in distress at its rescue centre since 1988.

The personnel from these organisations first trained abroad with experienced colleagues, then each centre ultimately developed its own protocols and skills.

Other centres, whether temporary or permanent (Hegalaldia and Alca Torda), were also set up during some of the major incidents of the 2000s, or later, such as "Volée de Piafs".

Today, a dozen or so rescue centres with skilled staff exist for oiled wildlife in mainland France, to rehabilitate birds, mammals and turtles.

In addition, mobile rehabilitation units, or rather rescue and first aid units, exist and can be deployed in an emergency to handle the first birds discovered or to supplement an existing rehabilitation centre.

In overseas French territories, however, few such structures specialised in the rescue of marine species affected by oil spills exist.

Ever since their creation, there have been regular technical exchanges, through their experiences, between these centres as well as contacts with foreign counterparts. They take part in conferences and some are involved in cooperation with industry. All these efforts help to improve the animal care and veterinary protocols for washing and rehabilitating oiled wildlife. Contrary to other fields of spill response, technological developments have been few and far between.

One noteworthy exception to this rule however is the bird washing machine. Developed in the 1990s by CHENE, this system was designed in order to quickly and effectively wash birds, thus reducing handling time and interactions with humans, thereby potentially reducing the stress for the bird. Criticised by some, frequently used (with very positive results) by others, these machines have unfortunately never been produced in sufficient quantities to make them a reliable option or to ensure easy maintenance.

In terms of marine mammals, one of the main developments since the 2000s is the reinforcement of health protection (health monitoring, improvement of knowledge relating to pathologies and zootechnics).

For birds, through the experience accumulated, many adjustments (medical stabilisation protocol, replacement of litter with screens, washing temperatures, etc.) have improved the level of care provided and increased their chances of survival.

International organisations have also developed. One such example is the International Fund for Animal Welfare (IFAW), which can set up an emergency response team in the event of a spill, in order to advise on-site operators. On a different note, the Sea Alarm foundation works on a European level to reinforce States' preparedness, contingency planning and response capacities, mainly via the publication of good practice documents and the organisation of workshops bringing together experts, administrations and industry. Sea Alarm can also respond in an emergency with a group of experts to organise oiled wildlife rescue in the case of a large-scale spill, in particular to assist in setting up structures.

In France, marine pollution shoreline response plans include a section on wildlife response. Rehabilitation centres and certain wildlife protection associations are involved in the working groups that draft these documents.

In January 2018, Cedre published an operational guide on the issue of oiled wildlife response.

Anne Le Roux, Cedre

Waste management

When the *Amoco Cadiz* sank in 1978, France had already been faced with the issue of oil spill waste management and disposal. Previously, the waste collected during spill response operations carried out in 1967 following the *Torrey Canyon* spill and in 1976 following the *Olympic Bravery* and the *Boehlen* was mainly simply buried onshore. The 1970 POLMAR instruction glossed over this issue, the authorities being required to "organise the storage and destruction of residues recovered at sea" and to "store, evacuate and destroy the residues recovered on land".

In 1978, the majority of the 250,000 tonnes of waste generated by recovery and clean-up operations following the *Amoco Cadiz* spill was treated. Admittedly, there were a few exceptions: 5,000 tonnes of untreated solid waste was deposited at a controlled landfill site in Donges and certain sites still contain waste from the *Amoco Cadiz*, as reported by the French geographical survey BRGM in its inventory of oil spill waste storage sites conducted in 1994 then updated in 2012 and 2015. An island in Brittany, Ile d'Er (Côtes-d'Armor), was thus rehabilitated through Government funding in 2011. However it is worth remembering that over 220,000 tonnes of oil washed up on the shoreline and during the first days of the response more than 1,500 m³ of waste was transported to the port of Brest on a daily basis. The waste was initially stored at intermediate (today referred to as "primary") storage sites, before being transferred to deballasting stations, in the case of liquid waste, while solid waste was taken to "temporary" (today known as "intermediate") storage sites such as those set up in Brest's port area, pending treatment. In a report drafted by Cedre's first Director, Pierre Bellier, at the request of the Ministry of Transport and published in 1979, it is stated that: "In the past, the disposal of solid waste has raised serious issues. Attention therefore naturally turned to a radical form of disposal: incineration. Its cost together with the fact that it was not the most appropriate solution for oiled waste meant that other treatment methods were sought, based on chemistry or material coating techniques". Different studies and experiments were therefore performed to identify the most technically and financially viable options.

Waste in bags at an intermediate storage area during the *Erika* spill

The main technique chosen was ultimately the application of quicklime.

"Previously, the waste collected during spill response operations carried out in 1967 following the Torrey Canyon *spill and in 1976 following the* Olympic Bravery *and the* Boehlen *was mainly simply buried onshore"*

In its report submitted to the Senate in June 1978, the parliamentary investigation commission identified, in addition to waste treatment options, two other major diffi-

Transferring and recovering waste using a crane during the *Erika* spill culties relating to waste management: the apparent absence of a prior study listing the sensitive areas where primary storage sites must not be set up and the high quantities of waste. The report indicated that there was a shortage of equipment with a sufficient capacity to transport waste from storage sites to treatment sites.

In October 1978, the POLMAR legislation was amended. The associated circular specified that each departmental response plan must include:

> the inventory of temporary storage sites for recovered waste, certain of which should be acquired and prepared as a precautionary measure (...);

> the inventory of treatment centres for products liable to be recovered with their technical characteristics (...), their treatment capacity, their operating cost, etc.

Cedre immediately began to tackle this issue: in 1979, a first report was published on a study into identifying and designing intermediate storage sites for oiled waste.

When the *Erika* spill occurred in 1999, the question of waste was insufficiently addressed in the plans, as highlighted in the report by the Inspectorate General for the Environment providing feedback on the operation of the POLMAR plan. Furthermore, during this spill, the quantity and composition of the waste were such that Total, which had agreed to support the Government by managing waste treatment, had to build from scratch a unit capable of treating the 270,000 tonnes of waste collected. While the prototype was being developed, the waste was stored at "long-term" storage sites, on land belonging to the port of Nantes Saint-Nazaire and to Donges refinery. A classified facilities authorisation was issued for each site, but no prior public enquiry was carried out given the emergency situation. Physical and chemical treatment by washing with diesel and water followed by extraction ended in December 2003.

The 2002 legislation specified that the storage and treatment of the "polluted and polluting materials" recovered must be fully developed in the POLMAR plans. It distinguished three types of sites – primary, intermediate and long-term – the last two of which were governed by legislation on industrial facilities.

Specialised industrial waste treatment centre in Bassens

During the *Prestige* spill, the quantity of waste collected in France meant that a just-in-time management strategy could be implemented: no long-term storage sites were used, treatment units were requisitioned prior to specific public contracts being concluded for the geographical zone. Just over 20,000 tonnes of waste in the form of pastes and solids recovered at sea and on the shore was incinerated in Aquitaine. The post-*Prestige* POLMAR instruction published in 2006 this time focused on waste recovered at sea and the need to identify the potential unloading/storage options at a port site when it cannot be unloaded at oil facilities. In 2010, to prevent all risks of storage sites being forgotten, legislation on industrial facilities was tightened: all temporary transit facilities for waste generated by spills at sea or in rivers or waste from natural disasters with a capacity of at least 100 m^3 was henceforth required to be declared. The declarative system took into account the urgent nature and short turnaround times required in such incidents.

This timeline shows that since the 1970s, waste treatment techniques have diversified, while the supervision and preparation of this aspect of spill response have been further tightened after each major spill. Currently, concerns over the selectivity of collection and sorting should ensure better management of the treatment processes, however the sudden influx of waste, its diverse nature and the costs involved will continue to remain a major challenge to be tackled in the event of a new spill.

Florence Poncet
& Emmanuelle Poupon, Cedre

Assessment of ecological and economic damages

Forty years on from the *Amoco Cadiz*, where do we stand in terms of liability and compensation for oil spill damage? With hindsight, the *Amoco Cadiz* disaster was a real baptism by fire for the international CLC/IOPC Funds system applied today in terms of liability and compensation for oil spill damage.

At the time, only the first of the two IMO conventions which now lay the groundwork for this system applied: the 1969 International Convention on Civil Liability for Oil Pollution Damage (CLC). The 1971 Fund Convention did not enter into force until October 1978.

The victims of this pollution, unlike those affected by the *Torrey Canyon* spill 12 years earlier, were able to file compensation claims within a specific framework for the damage suffered, what's more on an amicable basis without having to prove the responsibility of any party. Yet the Breton victims vetoed this option and chose, as we know, to take the case before a US court of justice.

Different factors justified this bold move. While the aim was mainly to draw attention to the circumstances surrounding the incident, so as to sentence the responsible parties, the hope was that the compensation received would exceed the maximum limit of several million euros (less than 40 million in current value) defined by the 1969 Civil Liability Convention, for liability in the absence of fault by the owner of the ship which was registered in Liberia.

The Breton victims therefore decided to take on the American parent company of the Amoco group, Standard Oil Co., whose financial strength was considerably greater, in the hope that an American judge would offer a broader interpretation of repairable damages, in particular in terms of immaterial damages, as well as the amounts recognised.

Oiled marshland in Bourgneuf Bay during the *Erika* spill

This was a lengthy legal battle for the parties involved and although the amounts obtained by the claimants were far lower than the sum of the damages suffered by the victims, the compensation granted was far higher (just under 200 million euros in current value) than that initially provided for under the international regime.

The various decisions rendered by the US court, in 1984 in terms of liability and in 1992 in terms of damages, left their mark on the evolution of the international regime.

A major amendment was made to the CLC and IOPC Fund conventions in 1992, and a subsequent protocol was adopted in 2003 following the *Erika* and *Prestige* spills. While all these changes significantly upped the compensation limit for future oil spills (just under 900 million euros in current value per disaster), they greatly curb the possibility of victims taking legal action against any party other than the shipowner (designated as the sole party with civil liability by the international conventions) and make it very difficult for the compensation process to take place outside of the international framework and to uncap this limit. These changes also reinforce the affirmation that only material damages are covered by the system, by not recognising either the ecological damages and the individual and collective moral damages that the victims of the *Amoco Cadiz* had claimed for, with however somewhat limited success.

Faced with these limits, the victims of the *Erika* and the *Prestige* also initiated legal proceedings which led to unprecedented decisions in several respects. In 2012, the supreme court took an original interpretation of the international texts and their application, by recognising, over and above the civil liability of the shipowner, the criminal liability of the oil group Total, cargo owner and charterer of the *Erika* tanker. In the same way, the court went beyond the notion of damage caused by the pollution as laid out in the CLC and IOPC Fund conventions by recognising the moral damages claimed by certain parties and, for the first time ever, the ecological damages incurred. In the case of the *Prestige*, a decision rendered in November 2017 by the court of A Coruña prevented the shipowner and insurer from invoking the compensation limits set out in the 1992 CLC convention and thus granted considerably higher sums to the affected parties than the amounts defined by the international regime.

While these rulings were a welcome reward, they nevertheless entailed a great amount of effort by the victims, who finally received compensation a dozen years after the spill. These decisions are worth highlighting as they bring to the fore the barriers that continue to exist today, preventing victims from rapidly obtaining full compensation for oil spill damages. Through these rulings, we obtain a glimpse of the progress still to be made in terms of the revision of the international CLC/IOPC Fund system to achieve full compensation for damages, a legitimate goal which was already called for forty years ago by the victims of the *Amoco Cadiz* spill.

Julien Hay [1] & Yann Rabuteau [2]

[1]Lecturer and researcher in economics at the University of Brest, UMR 6308 AMURE.
[2]Expert in maritime law in the Allegans network, associate member of UMR 6308 AMURE

Media communication

Thanks to its associational status, its recognised technical skills and its neutrality, Cedre is a valuable source of information for journalists, in particular when a major spill occurs. In such cases, Cedre respects a number of fundamental communication rules: a single, identified spokesperson and no information disclosed on the operations conducted by the authorities.

With its limited means, Cedre, as a technical adviser, strives to carefully answer, in real time, the many questions it is posed, often demystifying preconceived ideas.

During a major spill, Cedre is very frequently contacted. At the height of the *Erika* disaster, up to 45 interviews a day were given for print media, radio and television. Oil spills tend to trigger a great amount of emotion and we received frequent threats following our television interviews.

The *Erika* spill marked a turning point in spill crisis communication, mainly due to the emergence of the internet as a communication tool. We provided a lot of information via our newly created website in 4 languages: French, English, Spanish and Galician. Yet, like other response stakeholders, "traditional" media communication has gradually been overshadowed by so-called direct communication. A citizen or group of citizens takes photos of the shoreline pollution directly on site, gives an opinion and broadcasts it to the general public and the authorities via the internet without the filter or sounding board of the media.

This phenomenon is further amplified today by the development of social media and the sources of information available online 24/7.

Christophe Rousseau, Cedre

SPECIAL

Cedre turns 40

Although Cedre was originally created to focus on the question of marine oil spills, over the years the team has gained experience and developed expertise in other fields: hazardous and noxious substances, containers, litter, microplastics, inland waters, spills in ports, deep-water oil production, response in extreme environments... This diversification has led to a noteworthy shift in Cedre's activities over the past 40 years.

40 years of response

Cedre's duty service and emergency response component was an integral component of Cedre from day one, even although it did not appear on the organisational chart at the time. In 1979, the "Resource organisation and use" department was in charge of "orchestrating Cedre's actions when advising the authorities in charge of the response to a spill".

From that very year, Cedre was involved in the field response to several spills, in France (*Sea Valiant*, *Gino*, *Peter Sif*…), but also abroad (*Ixtoc 1* well blowout in the Gulf of Mexico...). The young team was called upon in relation to hazardous substances, when tanks of aluminium alkyls were lost by a car ferry at the entrance to the Casquets traffic separation scheme.

In 1980, Cedre's team was heavily involved in its first major spill, that of the *Tanio*, while continuing to be called out abroad.

In 1981, when Cedre moved premises to the CNEXO (today Ifremer) site, its first response room was set up.

In 1985, Cedre's organisational chart first featured a "Response and training coordination" department, which later became the "Response coordination and plan and guide preparation" department.

In the 1980s and 1990s, the team developed its skills through a wide range of cases, some involving oil, others chemicals (or detonators) transported in containers. It also worked on a number of unusual spills, such as that of the *Fénès*, in 1996, whose cargo of wheat fermented, producing hydrogen sulphide which presented a risk for responders.

In 1993, a major change took place: given that the emergency response activity was becoming increasingly complex, in terms of the type and origin of requests, Cedre's management decided to create a specific team (previously all technical staff had been involved in this duty service on a rota). The "Emergency Response" department was composed of 4 engineers in 1993.

The early 2000s emphasised the importance of the duty and response missions, with a series of spills: *Erika* and *Dolly* (1999), *Ievoli Sun* (2000), *Prestige* (2002), *Adamandas* and *Tricolor* (2003).

The number of duty engineers rose to 5 in 2000, 6 in 2002, 7 in 2014 then 8 in 2015. Some of these staff belonged to the Emergency Response Department while others came from other teams.

Studying nautical charts

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In 2014, the Emergency Response Department was abolished and the operational duty service was reorganised.

As has been the case since the onset, all technical personnel may be sent into the field. During the *Erika* and *Prestige* spills for instance, our offices were practically empty.

Alongside the assistance provided to the French authorities (public service mission), Cedre soon began to be mobilised by other parties:

- foreign authorities
- industry
- international organisations.

While some of these mobilisations were one-off, the idea soon emerged of signing assistance agreements with certain oil companies, shipping companies, etc. The first such agreements were signed in 1991.

Cedre was also mobilised under the European Task Force for the first time in 1988 for the incident involving the *Cason* chemical tanker in Spain, then very regularly until this Task Force disappeared in 2002 with the creation of EMSA.

In 2018, nine duty engineers were tasked with first line response, an activity which was becoming increasingly specialised. The Director and his deputies run a less technical, duty management rota.

In addition to its public service mission, the team has around 15 assistance agreements with both industry and States (e.g. the Maritime and Port Authority of Singapore).

Cedre is also the French focal point for the ICE network (onshore chemical spill response network) and the single contact point for the European network MAR-ICE (Marine Intervention in Chemical Emergencies Network).

We have a technical cooperation agreement with SASEMAR (Spain) which is regularly activated.

We can also be mobilised by REMPEC as part of the Mediterranean Assistance Unit. Thus in autumn 2017, we provided technical support to the Greek authorities following the sinking of the *Agia Zoni II* in the Port of Piraeus.

This international activity, which never detracts from our primary mission - assistance to the French authorities -, was rewarded in 2015 by a Green Star Award, attributed by the United Nations Development Programme (UNDP), the United Nations Office for the Coordination of Humanitarian affairs (OCHA) and Green Cross International. This award came in recognition of several assistance operations conducted around the globe.

Cedre receives a Green Star Award

The response activity naturally draws on Cedre's full range of know-how, whether it be research, equipment testing, documentation, technology intelligence or analysis and knowledge of pollutant and response products. Our duty officers also hold regular discussions with technical partners such as CEPPOL (French Navy's Centre of Practical Expertise in Pollution Response), LASEM (French Navy laboratory), Cerema (French centre of studies and expertise on risks, environment, mobility and land-use planning), Météo France (French meteorological service) and INERIS (French national institute for the industrial environment and risks).

The duty team handles 100 to 150 calls a year, relating to oil or chemical spills at sea or in inland waters... pending the next "major" incident. If the (completely subjective) "11 year-rule" applies once again, the current lull should last a few more years. After the *Torrey Canyon* in 1967, the *Amoco Cadiz* in 1978, the *Exxon Valdez* in 1989, the *Erika* in late 1999, *Deepwater Horizon* in 2010, the next spill with a significant impact on international regulations and technological advances can be expected in 2021. Until then, we must keep up our guard...

Anne Le Roux, Cedre

Cedre's response centre


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40 years of preparedness

Cedre's experience in terms of spill risk analysis, crisis management and response techniques led it to contribute, from the start, to the drafting of contingency plans for the government and industry, as well as to the training of both decision-makers and operational personnel. Through these activities, Cedre has developed its presence across France, Europe and the whole world and has not ceased to expand its horizons.

> Contingency planning

In addition to its vocation to provide support to the French authorities in terms of spill preparedness, Cedre has, since its very creation, always been involved in drawing up contingency plans for foreign authorities, ports and the petrochemical industry.

Aware of the importance of preparedness in limiting the environmental, technical and financial impacts of a spill, the key private sector stakeholders no longer content themselves with developing simple reflex sheets annexed to their internal contingency plan, but rather they work together with Cedre to develop crisis management tools based on a tested method and international standards. Current contingency plans, delivered in both printed and electronic form (a website available offline), can include: map data, results of deterministic or stochastic modelling, strategy flowcharts, tactical cards, response and assignment sheets, inventories of mobilisable equipment and results of the analysis of potential pollutants whose characteristics and weathering can be analysed in our laboratory, flume tank or at sea.

"After the sinking of the Amoco Cadiz, *then the* Tanio, *France put great effort into training the personnel involved in spill response."*

To complete this emergency planning effort, Cedre regularly organises and runs training courses and tabletop or field-based exercises. These are crucial stages in the overall preparedness, testing and update process for these documents which must, above all, be operational.

> Training

After the sinking of the *Amoco Cadiz*, then the *Tanio*, France put great effort into training the personnel involved in spill response. From 1979, Cedre was called up by the French Equipment Ministry to contribute to this effort, making training one of the pillars of its activity.

Initially conducted outside of Cedre's premises and clearly geared towards oiled shoreline clean-up, the training activity has been constantly evolving with, first and foremost, the creation between 1985 and 1995 of one-of-a-kind technical facilities unrivalled in size and and offering trainees the opportunity to train in near-real conditions through hands-on exercises with real oil.

Since then, Cedre has become a training provider, has obtained several accreditations (both national and international) and has designed innovative training tools and materials, some of which have been translated into several languages. For the past 15 years or so, Cedre has also considerably expanded the range of training courses it offers both in France and abroad, by covering inland waters, chemical spills and, naturally, moving towards digitalisation and e-learning.

> Our facilities

In 1979, the first training actions were carried out at external facilities at the request of government training centres or schools. The conference room was only able to accommodate small groups and did not have simultaneous translation facilities. In 1980, when Cedre was called upon to help run the third international seminar INFOPOL, organised by the French ministry in charge of the sea, the lecture theatre at Ifremer was used for the 40 participants. From 1981, Cedre had use of a 15,000 m^3 pit in Brest's port area, with one sloping side covered in sand and a concrete structure simulating rocks. These facilities were able to cater for practical exercises from 1985. The same year, driven by a training request

Response demonstration on drums of chemicals at Cedre's facilities

from the Total group, Cedre set up trainee reception facilities. In 1986, the installation work in the port area continued with the establishment of oil product storage facilities, the development of a washing area, the redevelopment of the area surrounding the water body and the sanitary block. In 1993 and 1994, a major development programme involved the second hand acquisition of a prefabricated building for organising practical training courses, the purchase of new spill response and handling equipment, the restoration of the water body and beach, the digging of a new deep-water tank and the construction of an equipment storage hall. With the State-Region plan signed in 1995, the development of the deep-water tank could be completed and response equipment was purchased to diversify the practical exercises on offer. In 1998, the construction of the main building, which Cedre has occupied since 1999, began. This building comprises a conference room equipped with all the latest teaching facilities, as well as modular classrooms and dining rooms. In 2009, a subsidy from the region of Brittany was used to improve safety around the outdoor test tank and water body and to treat the polluted sand on the man-made beach. Finally, in 2016-2017, in the run-up to its 40th anniversary, Cedre was revamped through various development projects, this time self-funded:

- the creation of a hall for vehicles,
- the renovation (replacement of doors, windows and cladding) of the warehouses, workshops and prefab used for training,
- the renovation and extension of the equipment showroom in order to house additional and more recent equipment exhibited by suppliers and manufacturers in the oil and chemical spill industry,
- the renovation of the main conference room and the acquisition of a very large touch screen display.

> Preparedness today entails:

- over 60 specialised trainers (half from Cedre) who give lectures in their field
- over 70 training actions a year, including over 20 organised by us at our facilities
- 10 different standard courses, including one in English, run 1 to 4 times a year
- a record year in 2017 with over 1,900 people trained and some 19,300 trainee-hours, i.e. around 900 hours of lectures delivered
- plus a few other figures: training of representatives of 60 countries across 5 continents, in 4 languages (French, English, Spanish and Greek), and last but not least a 6000 m^2 man-made beach and a 2,000 m^2 test tank!

Natalie Monvoisin, Cedre

40 years of research and experimentation

When Cedre was created, research and experimentation were identified as core focuses and given pride of place in the acronym (Centre of Documentation, Research and Experimentation on Accidental Water Pollution) to highlight their importance in the improvement of spill response. The characteristics of a spill are never identical from one case to another and therefore require a response adapted to suit the given context and the specificities of the spill. In concrete terms, responding to a spill often calls for adaptation and imagination, based on a foundation of knowledge which should be as well supported as possible. Two different phases of research are conducted:

- first, prior to a spill, with the production and acquisition of scientific knowledge relating both to the fate of products spilt in the marine environment, including their potential impact on flora and fauna, and to the efficiency of response techniques that may be deployed,
- second, during the post-spill analysis phase with the input of an expert assessment, which may include experimental work, and will comprise knowledge of the specificities of the spill.

During the response to the *Amoco Cadiz* spill, several technical innovations were invented and are still currently undergoing research to improve their performance.

In the 1980s, research into accidental marine pollution mainly focused on deepening knowledge of the behaviour and fate of oil products. It later expanded its scope with the increasing diversity of types of spills which raised new response challenges. For instance, following the *Fénès* incident (1996), the question of cargoes of foodstuffs transported in bulk arose, and in particular the risks associated with their fate when spilt at sea (fermentation and production of hydrogen sulphide). Then, with the *Allegra* spill in 1997, the issue of vegetable oil was addressed through a study of its fate (floating versus settling in the water column) and response equipment which can be deployed (containment and recovery versus trawling). With the *Ievoli Sun* (2000) and the *Ece* (2006), the theme of HNS spills took front stage with research covering aspects such as the fate of HNS cargoes, possible response techniques (recovery by pumping versus controlled release in the water column) as well as their potential impact on living organisms, in particular on seafood products (fish, crustaceans and bivalves) and, by extension, on humans through the food chain. This issue was particularly under the spotlight given that over the past years, one by one States were ratifying the 2000 OPRC-HNS Protocol on Preparedness, Response and Co-operation to pollution Incidents by Hazardous and Noxious Substances. More recently, on the sidelines of the two major research themes of oil and chemicals, Cedre has begun to address the issue of shoreline pollution by micro-plastics and litter. Both on a national and international scale, the need to identify, characterise and treat this emerging form of pollution is present. Research must provide pragmatic answers both in relation to their potential environmental impact, recovery, and even preventive methods to be implemented.

Addressing these research topics necessarily involves the development of new work protocols which, at Cedre, has resulted in

> *"The characteristics of a spill are never identical from one case to another and therefore require a response adapted to suit the given context and the specificities of the spill."*

Oil weathering trial in the Arctic

Assessing radar and optical sensors for detecting and characterising hazardous liquid substances in Cedre's outdoor test tank

the definition and construction of original experimental tools. Thanks to these facilities, Cedre has been able to provide valuable information during spills, but also for prevention by producing experimental data which is used in contingency plans and specialised databases. This also led to the production of reflex action cards describing the risks associated with the transport of specific products and, just as importantly, the update of training courses delivered by Cedre on spill response. The clearest illustration of these innovative protocols is the flume tank designed in 1997 which is used to study the fate of a cargo (liquid or solid bulk) when released at the water surface, in different prevailing environmental conditions (water agitation, temperature, sun). The studies conducted using this tank, in addition to providing very pragmatic information on the persistence of a product at the water surface and its physical and chemical evolution, to help to define the most appropriate response technique to be deployed, i.e. either applying dispersants or containing and recovering the slick. Other original tools developed at Cedre include:

- the Cedre experimentation column which is designed to study two-phase flows to determine the fate of a substance (oil, chemical or gas) in a seawater column as it rises or sinks,
- the burn test bench which is used to determine the rate at which a fire consumes oil as well as to understand its potential impact on the environment,
- the chemistry test bench which characterises the competition between the evaporation kinetics and dissolution kinetics of a given substance.

Forty years after its creation, Cedre still maintains a high level of research. Its overarching aim is to improve knowledge of pollutants and response techniques and to provide the response authorities with information to support decision-making in terms of the most appropriate strategic options for the situation in hand.

Sophie Chataing-Pariaud
& Stéphane Le Floch, Cedre

40 years of documentary resources

From the onset, the collection and dissemination of quality information in the field of accidental water pollution were one of Cedre's clearly stated, primary duties. It was not until 2001 however that a specific team was assigned to this mission. The team combines various skills: documentation, audiovisual, image processing, desktop publishing (DTP), website management and, more recently, geomatics, social media and press relations. This multidisciplinary team is hence able to promote Cedre's expertise and experience both nationally and internationally.

> Collecting and organising

Cedre began its documentary collection in its early days. When the organisation moved to new, more spacious premises in 1981, it gained a functional archive room and a more user-friendly resource centre. In 1989, computing made its debut at the resource centre with the acquisition of a microcomputer and the first documentary management software programme. While the documentary collection grew, an increasing number of photos were also being taken. To index them, a slide library with nearly 2,500 references was set up in 1992.

In 1999, Cedre entered brand new premises in the port area of Brest which feature a large resource centre. In 2001, a photo management software programme was implemented to simplify the management of both analogue and digital images, the new standard in photography. In late 2010, a new documentary management software programme was adopted, providing external access to the bibliographical references.

> Summarising and disseminating

In 1980 the first external communication effort was implemented with the launch of the Cedre Information Bulletin.

Cedre's publications began to take off with plans to produce an operational guide on aerial observation. In 1987, a collection of mini chemical response guides was launched, comprising first line information in case of spills into water. Three years later, this collection totalled 61 guides.

Under the impetus of the newly composed Strategy Committee, 1995 saw the release of the monthly newsletter and the first Information Day was held in Paris.

With the digital revolution, the first version of Cedre's website went live in 1998. This shift towards communication with a broader audience also gave rise to the publication of a learning guide on oil spills. Late 1999 was marked by the *Erika* disaster during which Cedre regularly published information on its website in real time to provide answers to the concerns of the media and the general public.

To preserve a record of the documents produced or collected during the *Erika*, *Ievoli Sun* and *Prestige* spills, multimedia CD-Roms were produced. In 2004, a new collection of chemical response guides was launched. These guides include data obtained from

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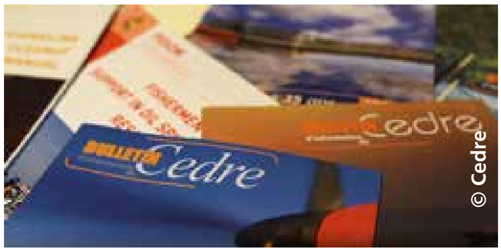
modelling software and information on spill response.

From 2000, our Newsletter subscribers could opt for a printed or electronic version, and in 2007 it went exclusively digital. In the same way, all our guides were published on the Cedre website. From 2006, the majority of our publications were translated into English. Two educational websites, one on marine oil spills and the other marine chemical spills, were launched in 2006 and 2012. Between 2010 and 2018, many other operational guides were produced. A wide variety of issues are covered, but always addressing major concerns: guidance for local authorities, custom-made barriers, manufactured booms, volunteer management, containers and packages lost at sea, response in mangroves, involvement of sea professionals, skimmers, chemical spills, wildlife rehabilitation...

The internet continued to play a growing role in information dissemination. After four major redesigns in 2002, 2009, 2015 and 2017, the website cedre.fr now has over 60,000 visitors a year from across the globe. With the rise in the use of online mapping tools, different types of data became represented in map form, offering a more user-friendly output. Today the Newsletter is sent to 2,300 subscribers both in France and abroad. The online press review, launched in 2013, topped 5,500 views in 2017. On social media Cedre has a community of 450 LinkedIn contacts, 560 Twitter followers and 445 Facebook group members. The YouTube channel is also gaining ground with a rising number of videos.

Mélusine Gaillard, Cedre



Multichannel approach to communication: meetings, printed publications and web content

Cedre

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