

Data management system concerning both pollution monitoring and response operations during an oil spill: the Prestige experience

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ABSTRACT

In the case of the Prestige casualty, Le Cedre built up a database system about pollution itself as well as about the whole response operation that followed.

This allowed first to have an overview of the evolution of the pollution at sea and on shore in real time, to monitor the slicks at sea (oil slicks observations, oil slicks drift forecast, buoys drift) and to exploit the cleanup sites data at different levels of organization (cleanup operations, manpower resources, equipment requirements, collected waste, disposed waste, date of pollutant standings ...). This aimed at being able to define response strategies and to provide a user-friendly media communication support.

In a second time this system allowed us to create an archiving and synthesizing tool necessary to post incident analysis. Moreover the tool can be used as a possible support for cleanup cost claims.

The creation of this archiving tool and of the cleanup sites database implied the elaboration of an internet site. Indeed, given the data network architecture spreading on several different counties and given the sketch of the return of information, the internet is relevant because it allows to avoid numerous technical problems by gathering all the data on one "site" only.

So all the input data are integrated in the central database via the internet thanks to a user-friendly form. One person for each county is in charge of the inputting. The database can be questioned at distance. It enables the elaboration of "Excel" graphics about the evolution and about the amount of collected waste, the amount of manpower resources per day and the number of cleanup sites categorized by type etc... Maps are elaborated through Géomedia G.I.S (Intergraph) thanks to a transfer of data from the internet database directly to the Access database of the GIS. Maps are elaborated according to the situation of the operation sites at the level of the oiled areas and of the different involved counties. They represent the different operation sites, the kind of work, the amount and the origins of the manpower resources and the date of groundings ...

The building up of this system is described in this paper, regarding the difficulties encountered, the ideal architecture of a database network to be built in emergency cases as well as the limits and the interest of such a system.

1-DATA MANAGEMENT CONCERNING ACCIDENTAL POLLUTION

Data management concerning accidental pollution consists in collecting and organizing all the information about the pollution itself as well as all the following operations.

Daily data management, proves to be essential to inform and help decision makers, because it allows to assess the evolution of events.

In later studies, this system becomes essential to keep track of environmental such as the cleanup progress of a given site. It helps to evaluate the different impacts of the pollution or to draw an economical conclusion about the means of action (historic aspect).

According to the French organisation's ways, archive is under responsibility of authority in charge of pollution response, Maritime Prefect at sea, and Department Prefect on land (Polmar instruction – march 04 2002).

Data management homogenisation is one of the most basic needs. Considering the evolution of computer technologies, this homogenisation can't be achieved in crisis time without building up a computer tool for data management. Digitalisation (pre-established data base) will allow to format data and to exploit it quickly during the crisis. So, the Internet tool is necessary to assure the best and quickest use, transmission and publication of data.

2-PRECEDENTS

Exxon Valdez case (24/03/1989, USA)

During the Exxon Valdez Oil spill in Alaska, FOSC (Federal On Scene Coordinator) was in charge of information management, from the collect to the archiving. Many flexible and user-friendly computers tools were developed one after the other. The first one is CAMEO (Computer-Aided Management Of Emergency Operations)-Valdez developed by NOAA (National Oceanic and Atmospheric Administration) aiming at following the evolution of land operations. Exxon Valdez archives are now located in National Archives, with many documents gathered on CD-ROMs.

Sea Empress case (15/02/1996, Royaume-uni)

During the Sea Empress incident (Milford Haven), two systems were used to collect and dispatch information. SOCRATES (Shoreline Oil Clean-up, Recovery and Treatment Evaluation System), developed by BMT Marine Information Systems Ltd. and AEA Technology PLC, was adapted to the situation, according to a request from MPCU (Marine Pollution Control Unit). This operational tool is a GIS integrating environmental characteristic, access to the shoreline, cleanup operations, equipment. Diffusion of these informations was made by SERIS system (Sea Empress Response Information System) developed by BMT for the Maritime and Coastguard Agency, which allowed an user-friendly access to information for non-specialists.

Nakhodka Case (02/01/1997, Japon)

During the Nakhodka incident, diffusion of the information (pollution intensity, cleanup operation, tasks of volunteers ...) between the different organisations involved in pollution response and accident monitoring was made through the Internet : Web-GIS (Geographic Information System, internet access) and BBS (Bulletin Board System : display table on the internet).

Erika case (12/12/1999, France)

The team in charge of collecting and analysing information during Erika was confronted to many problems. The most important of them was that no organization was officially in charge of this activity, so there wasn't any data centralization (Poupon et al, 2001).

Erika archive was improvised. There wasn't any daily capture of information, (except for Morbihan department), so the archives, which began one year after the Erika were a very difficult work (crisis headquarters were closed, people in charge had changed ...).

Another problem was the paper form concerning cleanup sites, which was not standard and homogeneous. Many templates have been used, so information and accuracy of data are very different from one to another form. Many times information is very approximate.

Erika experience allowed us to assess the needs in this field : coordination between intervening people, homogenization and standardization of data (numerization and data format), centralization, exploitation and fast diffusion (databases, GIS, Internet). New tools are essential for this type of crisis.

3-PRESTIGE INCIDENT

On 13 November, 2002, the oil tanker Prestige, flying the Bahamas flag vessel, with 77,000 tonnes of heavy fuel oil, broke in two, coordinates 42°15N and 12°08W, at about 130 nautical miles from the Spanish coasts west south-west of Cape Finisterre. At 12 o'clock, the stern sank into 3500 metres of water. The bow followed at about 4 pm. (Tiercelin and all, 2003)

Slick drift forecast and observations

As a consequence of the Erika experience (some unpredicted arrivals of submerged slicks on the shore proved the extreme importance of the oil slick prediction drifting models), many actions were taken in this field : oil slick position charts, drift forecast, weather forecast charts, buoy drift charts. Permanent exchanges of information between the concerned countries showed the efficiency of an international co-operation. On 13 November, 2002, *Cedre* activated the assistance agreement established with the help of Météo-France, the French national centre for weather forecast, with the idea to set up drift forecast charts for the police port authority of the Atlantic thanks to the Mothy model (Daniel and all, 2001). At the request of SASEMAR (Sociedad de Salvamento y Seguridad Marítima), *Cedre* was also preparing a daily position chart of the hydrocarbons observed at sea. On 18 November, 2002, a SASEMAR engineer joined the map-making unit situated in Brest for an urgent technology transfer. From this day, SASEMAR produced a position chart of the observed pollution every day. Following the directive of the "Secretariat General for the Sea", the settled unit (*Cedre*, Météo France, SASEMAR) was spread to SHOM (Hydrographic and Oceanographic Service of the French navy) and IFREMER and was called "drift committee". The committee met every day at *Cedre* to prepare a chart gathering the nautical and aerial observations of the pollution and a four-day drift forecast

available. This chart was accepted as an authority. It enabled to follow the route of the hydrocarbons, to anticipate the threat for the coasts and to guide the ships.

From December 2, 2002, the Portuguese Hydrographic Institute broadcasted a drift forecast chart every day. Finally AZTI, the Basque Country technology institute for fishing and food resources, broadcasted every day from December 8, 2002, a very comprehensive memorandum which covered the northern coast of Spain and gathered a report and weather forecast, the slick evolution and the French drift committee forecast, its own forecast and the drift of the buoys dropped by the institute in the midst of the main fuel accumulations observed at sea.

The location charts and the forecast were established from aerial observations made by planes and helicopters, from observations made by intervention ships and by the monitoring of the surface or subsurface buoys. These buoys have been implemented directly by SASEMAR, SHOM and AZTI or in the scope of SASEMAR/*Cedre*, AZTI/*Cedre* co-operations. For the slick location and the guiding of the vessels towards the intervention areas, the fishermen corporate bodies of the Basque Country used the method they usually use to locate fish beds. A plane covered the area by going back and forth perpendicularly to the coast and pointing out on the GPS system the observed hydrocarbon accumulations. Then the headquarters visualized on a same computer screen the different spots observed and the ship location on the scene of the action. Next, they only had to guide by satellite phone, ships which were the nearest of the work areas.

Shoreline clean-up

The first slicks reached the coasts of Galicia in the morning on 16 November, 2002 between La Coruña and the Cape Finisterre.

Operational headquarters were set up immediately at La Coruña. The oil combating shoreline operations were ensured by Tragsa (a Spanish company employed under contract to the Ministry of the Environment), volunteers and the army. The technical framework was provided by Tragsa, with the support of OSRL (Oil Spill Response Limited, an international oil organization fighting against pollution) and subsequently by the German and Belgian emergency services which came within the context of the European cooperation. During December, the northern coast of Spain was on its turn severely impacted from Asturias to the Spanish Basque Country. The first pollutant slicks impacted the Gijon area (Asturias) on the 4 December, 2002. Afterwards, the oncoming pollutants followed one another under the shape of tar balls or oil cakes from 5 to 20 centimetres in diameter, very viscous, coupled with a strong smell of hydrocarbons. At the beginning of January, the coast of Galicia was faced with a fourth massive pollutant oncoming whereas in Asturias, Cantabria and the Basque Country these phenomena remained relatively moderate only undergoing a sharp increase at the end of the month.

Despite a few organisation problems, numerous manual pickup sites were implemented. This was followed by the installation of water-jet cleaning sites and restoration operations. In Galicia, like on the northern coast, the increase in importance of the human means (contract workers, soldiers and volunteers) employed to fight against the shoreline pollution was made progressively to reach in December a maximum workforce of 10,000 people every day. This workforce fell back to 5,800 people in January.

The French coastline response was activated first all along the 600 km of coast of the 4 “départements” of the south-west defence area. And the first fragmented slicks arrived on 31 December, 2002 on the southern coasts where manual collection and mechanical means (screening machines and oleophilic rolls) as well as sufwashing and a series of protecting devices such as fine mesh nets, trawls, etc. were implemented. The beaches were closed by the authorities to the population on 31 January, 2003 up to 21 March 2003.

The slicks reached the northern part of the Gulf of Biscaye (Morbihan) on 20 January, 2003. Then, after a break up to mid march, the pollution continued to progress to the north and entered the English channel (western coast of the Cotentin peninsula) at the end of may. At that time, the means of aerial observation of slicks at sea were no more efficient and facing the huge length of impacted coastline, the authorities had to define the sites to be protected in priority. The scattered oil slicks were, in a great part, recovered by manual means.

4- BUILDING UP THE CARTOGRAPHIC TOOL

4.1 Cartography about pollution monitoring at sea

From the beginning of the pollution (19 November, 2002), Cedre published daily charts (week-ends and public holidays included) about the observed pollution at sea and drift prevision (Fig. 1). These charts became an efficient communication tool. They were sent to response teams on sites and to authorities every evening and to the public two days later (on the Internet in static form – jpeg format). These charts would progressively include complementary information : type of pollution, flight plans, MOTHY model forecast from Météo France, drift buoys progress, impacted shoreline (Fig. 2). From the beginning of the spill, «drift committee » met every evening to build up and discuss the charts, to validate and publish the data.

Pollution observations:

A pollution report (POLREP) was elaborated by observers. These observations could be made by aircrafts, helicopters or antipollution vessels on site.

Spanish pollution reports were transmitted by fax or telephone by SASEMAR or directly by Cedre agents on site. Data exchanges between Cedre and Sasemar, were improved by liaison officers from each side.

French pollution reports were transmitted by the Navy, thanks to a Navy agent in the daily « drift committee » meeting.

Information was not digitalized and had to be put in the ACCESS database (Fig. 3: localisation: latitude / longitude, type of pollution and commentaries), then it was displayed in the GIS with shapes and color according to the type of the pollution. The input operation was a long and heavy task, especially when the pollution indicates hundreds of oil slicks observations.

Flight plans and vessel surveyed area:

Tracking oil slicks requires keeping all the pollution observations and flight plans in mind, since some oil slicks could drift out of surveyed area. Flight plans were generally included in the pollution report, and put in the GIS together with pollution observations. Some areas were regularly flown over, so the data input was made once in the GIS (Fig. 4).

MOTHY oil slick drift forecasts:

MOTHY oil slick drift forecasts were included in the charts on 25 November, 2003. The synthesis charts displays the oil slick drifting up to three days forecast, each 24 hours drifting forecast is displayed by colored line. (Fig. 4).

Tracking oil using drifting surface buoys:

When an oil spill occurs, the tracking of oil slicks by surface drifting is recommended in order to cross the information.

The prediction of the drift of slicks by computerized/modeling should always be validated by observation or by the mean of buoy-tracking satellite detection. Direct observation in good conditions is not always possible due to the weather conditions (visibility, ceiling). A reliable remote sensing of buoy is very helpful to track the slicks and guide aerial surveillance aircraft.

In remote areas at sea which cannot be reached quickly by boat, slicks can be marked using aircraft. Buoys have to be adapted to be usable in these conditions.

During the Prestige incident, Cedre enabled the French Navy, SASEMAR and AZTI (Basque Oceanographic foundation) to have access to the positions of some surface buoys drift tracked by satellite, already tested in December 1999 during the Erika Incident.

Some buoys were dropped by the Portuguese Oceanographic Institute and by Sasemar above the Prestige's wreck in February 2003, none entered the Bay of Biscay. Others were dropped at the extremity of an oil slick and entered the bay of Biscay in December 2002, one of them went up to the Archachon bay and even up to Brittany's head (Fig. 5).

Buoys signals were received and processed by ARGOS satellite (low-earth orbit), positions were then made available on the Internet. Buoys emitted approximately every two hours depending on the satellite position. Satellite information was then processed and transmitted approximately ½ hour to 3 hours after acquisition. "Elsa" software was used to display buoys' trajectories to be added in the GIS. Buoys lifetime ranges between 2 and 3 months.

4.2 Cartography about land operation monitoring

From the Prestige incident, Cedre built up a Data Management System on POLMAR activities. It manages in real time at different information levels, cleanup sites' data, operational objectives, and aims at defining the response strategy. In differed time, it provides a synthetic, technical and statistic archive tool.

Since the first groundings, we gathered data on operations on land, and set up a data flow input process in order to avoid information losses. We received some help from private companies (Atlantide and Nasca both from Brest).

Building up the tool:

In a first time, input tool of clean up sites data (workers, waste, technical means and cleaning strategy information) was set up using Access software (Microsoft) and tested on the Arcachon area from January 26, 2003. This test phase validated the tool's efficiency and data transmission by e-mail (from January 26 to 29, 2003). Cedre took benefit from this phase to test the process and the management (graphics and charts) of data received from Arcachon's Crisis centre.

In a second time, input operation on Internet improves and simplifies Cedre's management of the database (Fig. 6) and avoids technical problems (data input, update, archive, exploitation, diffusion).

Once in the database, the input data were displayed on Excel graphs (Microsoft) showing the evolution of collected waste, daily manpower types by category of origin (firemen, military, district agents...) number of cleanup sites operations etc... The maps were displayed thanks to Géomédia (Intergraph) through a data transfer from the Internet site.

Response centres (thanks to a password) had access to raw information on cleanup sites through the Internet. Different information levels about a cleanup site between two dates were also available. These data could be handled on Excel or into a GIS. This exploitation required a good knowledge of these tools (Fig. 7).

Data capture organisation

ZDSO (South West Civil Defence Zone) coordinated shoreline response in Charente Maritime, Gironde, Landes and Pyrénées Atlantiques départements. In each Department, one Cedre agent was in charge of inputting operations and at the same time following cleanup sites progresses. Data input took approximately 20 % of a working day. Guidelines were dispatched on cleanup sites in order to get a homogenised input. The Internet site included drop-down lists with the same goal.

Another Cedre agent was based in Bordeaux (ZDSO Headquarter) in April, 2003 to coordinate the transmission of data and to publish weekly charts.

Because of the success of the system deployed in ZDSO, the same organisation was set up in ZDO (West Civil Defence Zone) one month after the first shoreline oiling (on 15 June, 2003). ZDO coordinated shoreline cleanup in *Manche, Ile et Vilaine, Côtes d'Armor, Finistère, Morbihan, Vendée* départements. In the same way, one Cedre agent was located in Rennes to coordinate information transmission and data gathering.

Data management

Data management purpose is to display the evolution of cleanup operations on land. These charts were delivered each week to responders, authorities. They displayed different information level (national, civil defence area, departmental).

Weekly civil defence area maps : municipality involved in cleanup sites, waste volume, origin of workers (Fig. 8) output based on Department and civil Defence Zone level

Weekly departmental maps : (Fig. 9)

Weekly departmental graphs (Fig. 10)

Weekly waste maps (Fig. 11)

Weekly shoreline impacted (Fig. 12)

Many others maps or graphics could be elaborated on request. For example: waste by category and by department, total waste by department and by contamination rate ...

(Fig. 13).

5 - Encountered difficulties and discussion:

Data gathering and information transits were the most difficult challenges when building up the sea charts. For example, all pollution reports were sent to Cedre by fax or telephone, that implied a huge work of digitalisation before mapping. This task could be avoided

through a direct digitalisation achieved on the data source (for example, in the aircraft or just after aircraft landing). This would avoid possible interpretation mistakes and loss of time. A special transmission data provider with predefined format data is essential.

A first version of the GIS tool, displaying the situation at sea, was built up in a hurry as soon as the Prestige accident occurred.

Concerning land operations, we immediately took benefit from the Erika's experience, but no computer tool was yet completed when the Prestige sank. It was still only a project. Cedre had to build up this tool in only a few weeks' time whereas many months would normally be needed.

Once the tools set up, the main difficulty was the input phase. It is a constraining and difficult work, which takes a minimum of 2 hours a day per department. Agents need an easy and user-friendly access and a graphical and chart exploitation use of the database. This would allow them to visualize their work in almost real time on the Internet. The difficulty of the inputting was more significant in ZDO where the people in charge of the capture for each department were district employees and not Polmar ones. This complexity sometimes slowed down the process due to the lack of available data.

Another problem met during the cleanup site data exploitation phase concerned cleanup techniques (which is not systematically taken into account or mentioned on the site form), waste (values on the forms are visual estimations), cleanup area and volumes (data not always provided), name of the cleanup site (different spellings, same name for different sites). All these factors made data management difficult.

As far as possible, data has to be validated by experienced people before this exploitation. The only interpretation of the site form does not always correspond to reality.

Cedre has to continually adapt graphics and charts' output according to special requests, critics ... For example the charts on land pollution were modified many times, due to many misunderstandings.

The input tool was adapted many times too. For example, some fields had to be added to allow the input of new cleanup techniques (net deployment). This shows the necessity to have a quite flexible tool allowing quick and easy modifications.

Improvements realized or to come:

Concerning shoreline response monitoring, the building of this system was really fast when the Prestige accident occurred, and obviously, can still be improved. Returns on experiences will allow us later to get more prepared to make available the needed tools to handle the transmission of data as soon as an accident occurs, thanks to pre-established procedures.

Concerning the monitoring of pollution at sea, it is absolutely necessary to improve the transmission networks in a format suiting all the different actors. So we have to foresee the creation of a secured website on which each contributor (Préfectures Maritimes, customs, CEPPOL, Météo-France...) will share the common data useful to create an information network more efficient than today's means of transmission.

These data will then be automatically or semi-automatically integrated into a GIS.

At Cedre, the GIS progressively became an operational decision-helping tool. Soon it would be used by all members of Intervention service of the Cedre. Thus, thanks to ACCESS (Microsoft), EXCEL (Microsoft) and Géomédia (Intergraph), we created simplified interfaces accessible even to non specialists.

A previous work on data collection was carried out: shoreline, bathymetry, administrative and juridical limits, sensitive areas, and geomorphology. These data were bought or got through special conventions with data providers. Ifremer helped us with these proceedings. Ifremer has got a geographic data server (SEXTANT) with the aim of centralizing and spreading geographic data to all Ifremer stations in the World via Intranet. Ifremer placed geographic data¹ with access limitation at Cedre's disposal on SEXTANT. Ifremer server allows Cedre to extract geographic data for a specific area and in a specific format. The server is open 24 hours a day, operational in case of emergency and by this way Cedre is able to avoid paperwork and updating procedures.

The paper atlas on dispersion limits was digitalized and integrated into the GIS. Cedre and Météo-France have worked on their data transmission and exchange. Today, Météo France is able now to send us a half hour after the drift forecast request, a text file (with Mothy results) by e-mail which can be automatically integrated in our GIS. Since the Prestige accident we have been working accident, with Météo France's collaboration, on the Mothy representation in GIS. The stick representation can lead to a lack of information, so we are still looking for a new representation, now still on study.

A user-friendly form on Access allows the capture of pollution position observations with associated comments, from one position it is possible to run a very basic (3% of the wind and 100% of the current) oil slick drift forecast software. All this information will be displayed on the GIS with many other operational data (location of the spill, comments, Mothy forecast, signals emitted by Argos buoys etc ...) and other geographic data (*bathymetry, shoreline, dispersion limits, sensitive areas, orthophotoplans etc ...*) (Fig. 13).

During the Prestige, charts were published in a static format (jpeg or pdf). Cedre intends to provide a dynamic access to geographic information through the Internet (with a password). Cedre built up a server with Géomédia WebMap Server which allows geographic information diffusion with all GIS functions (zoom, request, and selection of display data ...). This server will be soon operational at Cedre.

Concerning cleanup operations monitoring, predefined organization of data transmission from the field to the authorities has to be improved. The quick setting up of an operational tool at the beginning of the event has to be improved too.

The data capture tool has been developed on the Internet but all the data exploitation was carried out on a local computer. In the future, Cedre foresees to exploit data directly on the Internet, together with the validation phase. This will improve data diffusion and access for all intervening people. Charts layout and specific requests would have to be defined before the creation of the tool. Automatisations functions will be developed to reduce the delay of exploitation, but the system would have to remain flexible to answer the different requests. During data capture, some fields were useless, others have to be added to take new cleanup means into consideration, so database and capture forms will have to be restructured.

¹ Only for data that Cedre bought or got through special conventions.
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Some GPS systems compatible with GIS could be deployed on the field to help site location and pollution surveys.

Conclusion:

During the Prestige, the building up of the data management system concerning both pollution monitoring and response operations was really fast, but can obviously, still can be improved. Returns on Prestige experiences will allow us later to get prepared to dispose immediately of operational tools and to develop data network between each contributor (Préfectures Maritimes, Douanes, CEPPOL, Météo-France...) with the aim of facilitating the transmission and exploitation of data as soon as an accident occurs.

The main difficulty in data management comes from the fact that so many actors involved as data producers or contributors, users (operational people, decision makers, media...) already use many different exploitation systems. So instead of creating a new system common to all, it seems better for a start to adapt existing systems in order to make them compatible with each other.

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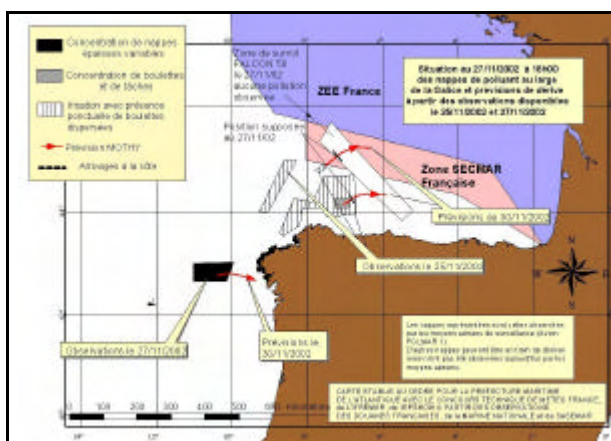


Fig. 1 position charts of the observed pollution

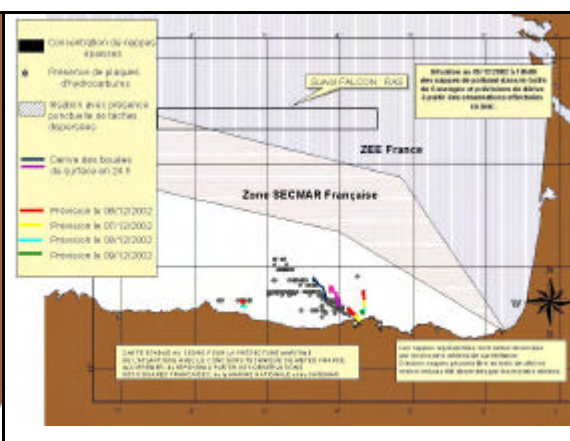


Fig. 2 position charts of the observed pollution

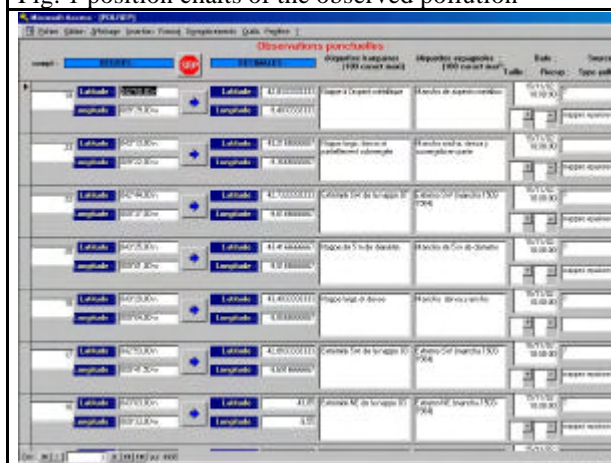


Fig. 3 access input positions

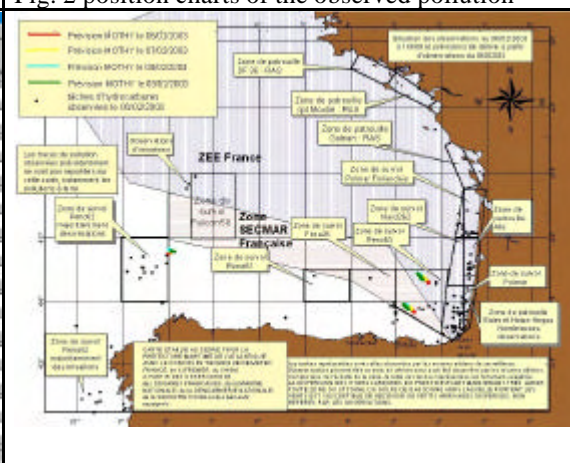


Fig. 4 position charts of the observed pollution

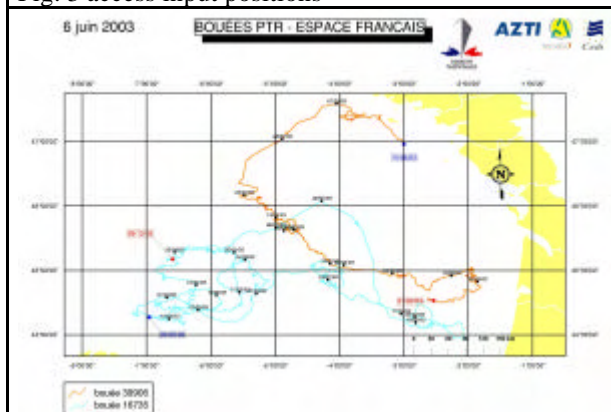
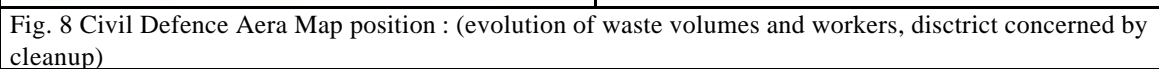
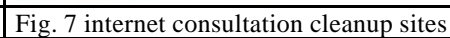
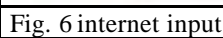


Fig. 5 buoys drifts



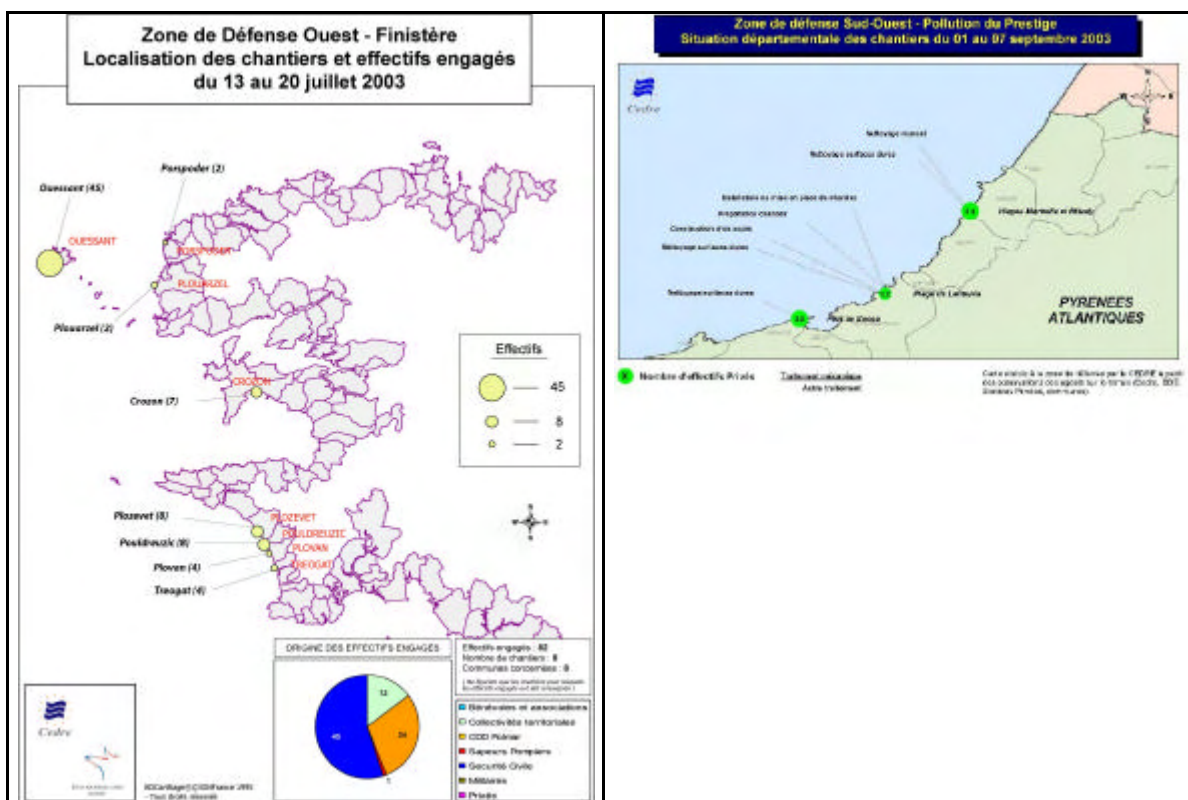


Fig. 9 Department map position (cleanup sites and number of workers)

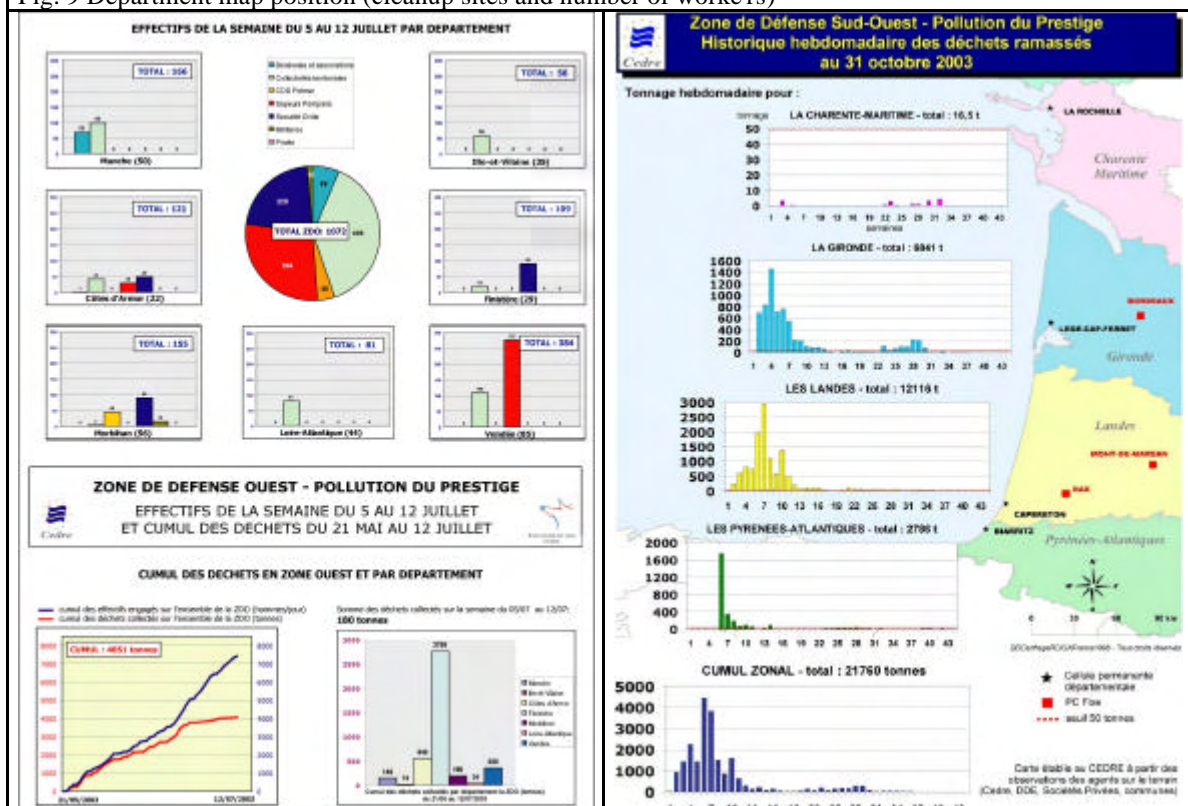


Fig. 10 Detailed graphs (total workers evolution and workers categorize by origin)

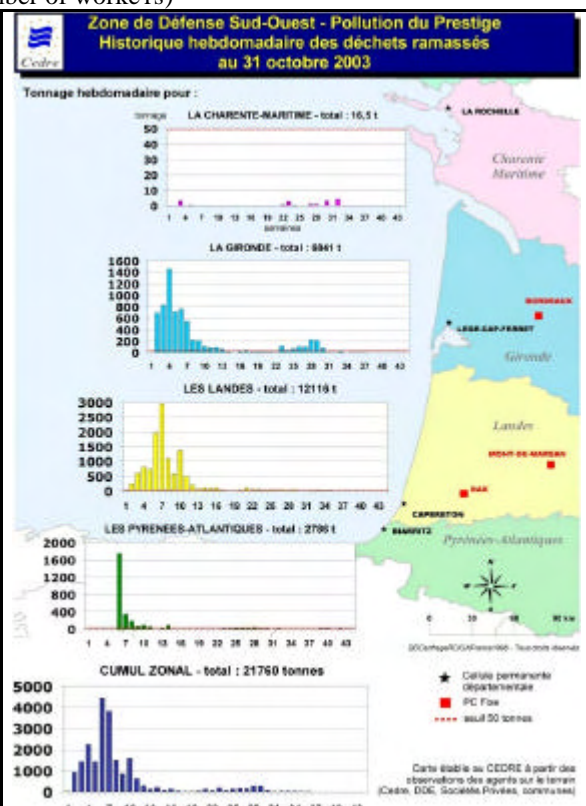


Fig. 11 waste evolution by department

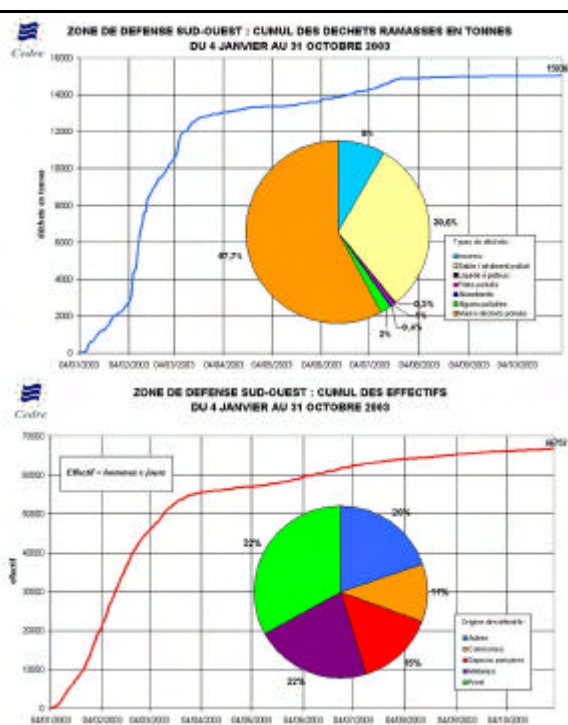
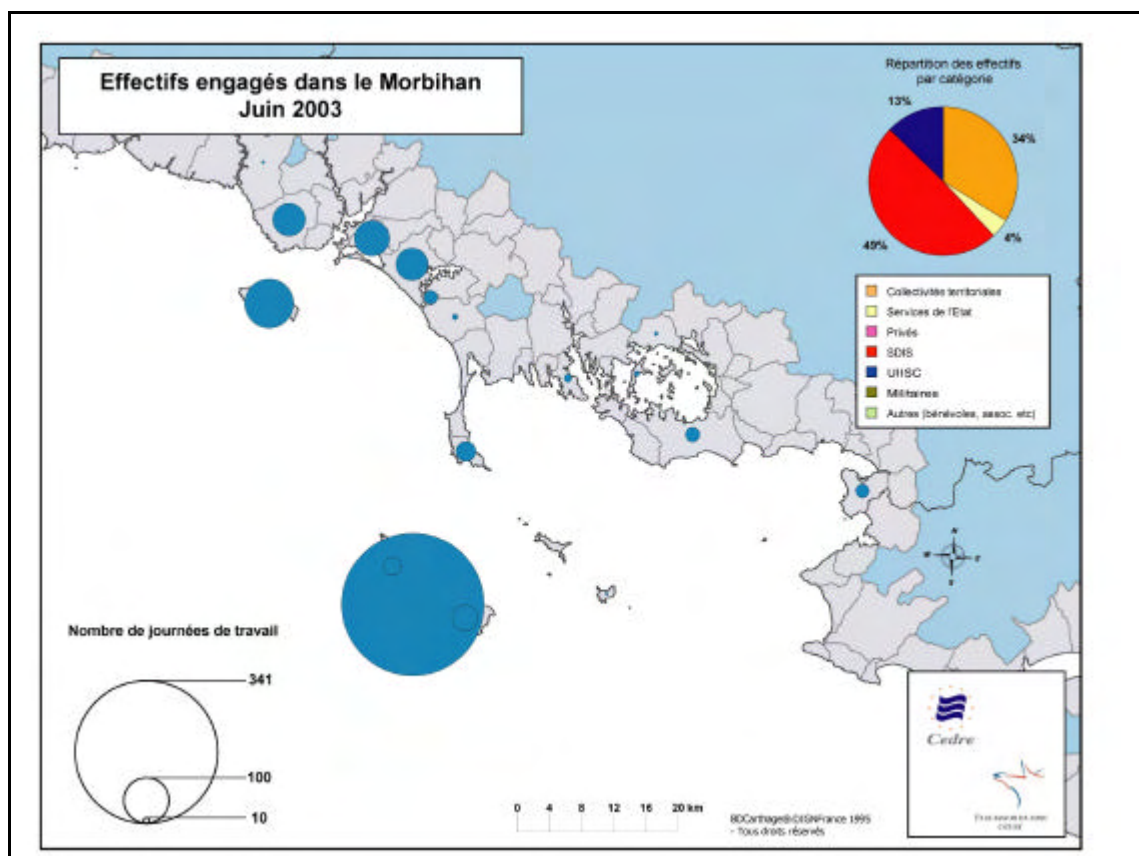


Fig. 12 shoreline impacted and district concerned

Fig. 13 evolution and categorization of waste and workers



Fig. 13 shoreline impacted (left) and waste collected and contamination rate (right)



Number of workers in June 2003 by district area (Morbihan department)

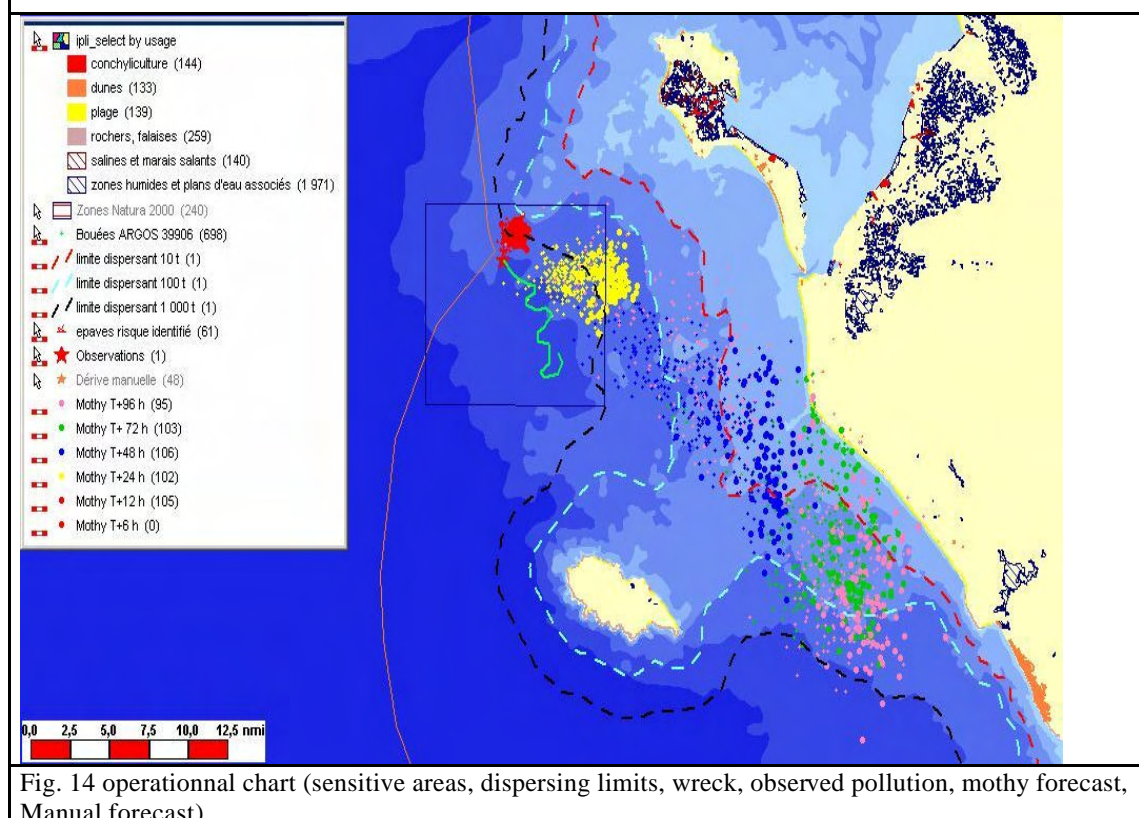


Fig. 14 operational chart (sensitive areas, dispersing limits, wreck, observed pollution, mothy forecast, Manual forecast)