Projects on Oil Spill Response in the Mediterranean Sea

George Zodiatis and George Kirkos

Abstract The Mediterranean Sea is an almost landlocked sea which constitutes just 0.7% of the global water surface. The intense shipping traffic and the recent boom of Oil and Gas exploration activities constitutes the Mediterranean amongst the seas facing the highest risk from oil spills in the world. The Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) and the oil spill response activities of the European Maritime Safety Agency (EMSA) spearhead a variety of initiatives to protect the Mediterranean against oil related pollution. The European Union has also funded a significant number of projects to support the oil spill response capacity and capabilities in the Mediterranean region focusing mainly on three pillars: monitoring of marine operations and detecting oil spills, developing oil spill dispersion models, strengthening the capacity of oil spill response authorities and developing innovative oil spill combating technologies. The successful implementation of such projects has significantly contributed to the protection of a valuable and sensitive ecosystem such as the Mediterranean Sea.

Keywords Eastern Mediterranean, Environmental impact, Legislation, oil spill, Oil spill response, Pollution, Satellite monitoring, oil spill modelling

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1 Introduction

The Mediterranean Sea is currently amongst the seas facing the highest risk from oil spills in the world. This risk comes largely due to the large number of shipping operations taking place within its waters and coasts; it is worth mentioning that more than 30% of all international sea-borne trade by volume originates from or directed to Mediterranean ports or passing through its waters, and nearly 25% of the world's sea-transported oil transits the Mediterranean Sea. Moreover, it is estimated that 2,000 merchant vessels of over 100 tons are at sea at any moment, with a total of 200,000 crossing the Mediterranean annually. This over activity of marine/shipping related operations has a seriously consequence to the Mediterranean Sea. The Mediterranean Sea constitutes 0.7% of the global water surface and it receives 17% of global marine oil pollution [1]. More specifically, it is estimated that every year between 100,000 and 150,000 tons of crude oil are deliberately released into the sea from shipping activities.

Nowadays, the risk of a big scale oil spill incident is greater than ever due to the deployment of a series of offshore installations across the Mediterranean Sea. According to a study made by the Mediterranean Oil Industry Group (MOIG), there are approximately 100 facilities handling oil in the Mediterranean Sea. Amongst them the 40% are refineries, 24% are ports, 26% are oil terminals and 10% are offshore platforms [2]. Accurate figures regarding the number of existing oil rigs are not easy to come by and reported numbers vary widely. More recent analyses of the Clarksons Database Data regarding the Mediterranean indicate the number of fixed offshore structures related to the oil and gas industry, in the Mediterranean to 367 and additional nine FPSOs located in the region [3]. These offshore facilities/installations pose a great risk to the sea and coastal environment and the consequences of a big scale incident can be devastating not only at local but at regional level as well, affecting the economies of many countries at Mediterranean Basin level.

2 The Roles of Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea and European Maritime Safety Agency in Oil Spill Response

In order to organize an efficient and coordinated oil spill response in the Mediterranean Sea, a number of instruments have been put in place, the most significant of which are administered by the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) and the oil spill response activities of the European Maritime Safety Agency (EMSA) [4].

2.1 The Role of Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea

One of the key bodies in dealing with oil spill response is the REMPEC which is administered by the International Maritime Organization (IMO) in cooperation with United Nations Environment Programme/Mediterranean Action Plan (UNEP/MAP). The objective of REMPEC is to contribute to preventing and reducing pollution from ships and combating pollution in case of emergency [5]. REMPEC assists countries in the prevention of pollution of the marine environment from ships and the development of preparedness for and response to accidental marine pollution and cooperation in case of emergency consisted by:

1. Strengthening the capacities of the coastal States in the region in oil spill response.
2. Developing regional cooperation in the field of the prevention of pollution of the marine environment from ships.
3. Assisting coastal States of the Mediterranean region which so request in the development of their own national capabilities for response to pollution incidents.
4. Providing a framework for the exchange of information on operational, technical, scientific, legal and financial matters between member countries.
5. Assisting coastal States of the region, which in cases of emergency so request, either directly or by obtaining assistance from the other Parties, or when possibilities for assistance do not exist within the region, in obtaining international assistance from outside the region.

Further details of the role of REMPEC are provided in a separate chapter in this volume [6].

2.2 The Role of European Maritime Safety Agency

Another important instrument for oil spill response is the EMSA. The Agency provides technical assistance and support to the European Commission and Member States in the development and implementation of EU legislation on maritime safety, pollution by ships and maritime security. It has also been given operational tasks in the field of oil pollution response, vessel monitoring and in long range identification and tracking of vessels.[1] Within EMSA, a marine pollution preparedness, detection and response capability has been established, including a European network of standby oil spill response vessels as well as a European satellite oil spill monitoring and vessel detection service (CleanSeaNet), both with the aim of contributing to an effective system for protecting EU coasts and waters from pollution by ships. Currently, seven EMSA contracted oil spill response vessels are stationed in the Mediterranean Sea.

Further details of the role of EMSA and its operational tasks are provided in a separate chapter in this volume [7].

3 Funding for Oil Spill Response

3.1 Funded Projects Overview

In order to support the oil spill response capacity and capabilities in the Mediterranean Region, a number of EU and national or international funded projects have been implemented over the years.

EU funded projects identified in this report can be broadly classified into three general categories:

1. Oil spill risk assessment, modelling and monitoring.
2. Oil spill response capacity building and training.
3. Oil spill response technological development.

Significant effort was put towards developing tools to monitor ship traffic and marine operations in areas with intense ship traffic as well as the detection of oil spills using moorings, drifters, ferry box and gliders networks (ARGOMARINE and PREMARPOL projects). Other projects developed oil spill dispersion models and platforms where different models could be integrated (MEDESS4MS, MOST, METANE, HAZARD, PRIMI and MEDSLIK-II projects) and others tried to strengthen the capacity of civil protection authorities through exercises and training tools (NEREIDS, TOSCA, RAOP-MED and Mediterranean Pollution Control projects). Then there are projects that develop innovative technological solutions to

[1] EMSA website [12].

assist oil spill response operations (KILLSPILL, EU-MOP, HOVERSPILL and URready4OS).

3.1.1 Kill Spill Project

General Information

- *Title:* Integrated Biotechnological Solutions for Combating Marine Oil Spills (Kill Spill)
- *Project Period:* 2013–2016
- *Geographical Scope:* Even though the main testing of the project results will be carried out in the Mediterranean, North and Norwegian Seas, the project will develop knowledge and tools that are applicable worldwide
- *Funding Program:* 7th Framework Programme for Research and Technological Development under the Grant Agreement no. 312139 within the theme Food, Agriculture and Fisheries and Biotechnology
- *Website:* http://www.killspill.eu/

Background

Oil spills can result in significant releases of oil in the marine environment. Oil spill response is a resource intensive, timely and costly process which on average results in only 10% of the oil released in a marine oil spill to be captured. Weathering processes and biodegradation further reduce this amount, but the project considers that a lot more could be achieved by enhancing these processes.

Main Objectives

The project's main objective was to develop highly efficient, economically and environmentally viable biotechnological solutions for the cleanup of oil spills caused by maritime transport or offshore oil exploration and related processes.[2]

These new developments include biosensors to monitor hydrocarbon degradation, novel environmentally friendly dispersants and adsorbents, combined microbial and additives formulations, multifunctional bioremediation agents and tools for sediments decontamination. The impact and toxicity of these newly developed products will be evaluated; and they will be validated in mesocosms and on real oil spills.

Additional objectives include the development of appropriate tools for:

[2]KILLSPILL project website [13].

- First response,
- Follow-up and
- Longer-term actions, specifically tailored to a broad range of different kinds of oil spills.

Main Results

The Kill Spill project has not been concluded by the time of the writing of this report but significant work has been carried out in the following activities:

- Development of biodegrading booms for small oil spills.
- Development of novel oil spill dispersants such as specialized biological surface-active compounds (biosurfactants, biodispersants and bioemulsifiers) and other suitable mineral dispersants and sorbent materials to accelerate oil dispersion, emulsification, sorption and ultimately hydrocarbon bioavailability to microbial degradation leading to complete mineralization.
- Development of (bio)monitoring methods such as biosensors, transcriptomics, stable isotope ratios and diagnostic isomer ratios to verify biodegradation processes in spill events and to better characterize the microbes involved.
- Development of novel or improved technologies, which accelerate the biodegradation of hydrocarbons in contaminated sediments.
- Development of multifunctional remediation agents for oil spills.

3.1.2 EU-MOP Project

General Information

- *Title:* Elimination Units for Marine Oil Pollution (EU-MOP)
- *Project Period:* 2005–2008
- *Geographical Scope:* The project targets the European Waters and specifically the Baltic and the Mediterranean Seas
- *Funding Program:* The project is funded by the EU Commission under the 6th Frame Work Programme (DG-RTD)
- *Website:* http://www.transport-research.info/project/elimination-units-marine-oil-pollution

Background

Oil pollution either from marine accidents or from routine ship operations is one of the major problems that threatens the marine environment. Efforts in protecting the environment after an oil spill could cost billions of euros in cleanup and subsequent damage costs, often producing questionable results. The key factor for efficient

cleanup operations is to develop an adequate structure focusing on the confrontation of oil when is into the sea and diminish the impact on nearby coasts.

Main Objectives

The EU-MOP project proposes the design and proof of concept of autonomous EU-MOPs, capable of mitigating and eliminating the threat arising from oil spill incidents. The EU-MOPs were expected to be low-cost, possibly recyclable, autonomous vessels/drones that would be released in the oil spill area and would use sensors to identify the spill and combat it locally. The concept was to release a swarm of these units to confront the whole profile of the spill.[3]

Additional objectives were to establish:

- Innovative concepts in oil spill management;
- Novel devices for oil spill confrontation;
- An integrated framework for oil spill management and
- An advanced structure for the dissemination of oil pollution response policies.

Main Results

During the EU-MOP project, a new concept for oil spill response featuring autonomous unmanned robot vessels that operate as a swarm in order to efficiently collect the spilled oil was developed.

An EU-wide anti-pollution equipment inventory identified existing gaps in the anti-pollution arsenal, in order to target the recorded weaknesses. The project resulted in the development of two EU-MOP designs in the form of a Catamaran and a Monocat, designs that featured distinctive advantages.

The project carried out tank tests for these designs to estimate their resistance.

A simulation framework was developed to assess the preferred sensor configurations and control systems of the EU-MOPs which simulated both the robots and the oil slick. Furthermore, several swarm strategies were developed, in the process of identifying the most efficient ones. In the validation of the swarm behaviour, the main objective was to demonstrate physically the swarm behaviour via studying mobile land-based robots to collect "oil" which was projected onto the floor with the help of a video projector. Three separate simulation modules were developed and integrated: the oil fate, robot and visualization programs. A model was developed addressing the strategic planning of stockpiling EU-MOP units in candidate (port) facilities, so as to optimally respond to potential oil spill incidents in a nearby risk area.

[3]EU-MOP: Transport research and innovation portal [14].

3.1.3 HoverSpill Project

General Information

- *Title:* Development of a small hovercraft vehicle for fast response at difficult access or ecologically sensitive oiled sites (HOVERSPILL)
- *Project Period:* 2009–2013
- *Geographical Scope:* Even though the main testing of the project results was carried out in the Mediterranean, the project will develop knowledge and tools that are applicable worldwide
- *Funding Program:* 7th Framework Programme for Research and Technological Development
- *Website:* http://www.cedre.fr/en/Our-resources/Research/Response-equipment-and-products/HOVERSPILL-2009-2013

Background

On the market, there is a lack of amphibious vehicles dedicated to fast oil spill response operations in difficult-to-access areas such as estuarine or river in shallow waters. The lack of such tools renders the response to oil spills in the above mentioned environments difficult resulting in increased response times and poor effectiveness.

Main Objectives

The main objective of the HoverSpill project was to develop an autonomous system capable of working at difficult access and ecologically sensitive sites using air cushion vehicle (or hovercraft) technology. The hovercraft was to be designed to comply with certain operational and environment requirements[4]:

- To consist of an autonomous and multipurpose platform capable of providing enough room to operate safely and supplying the required power for implementing oil spill response devices;
- To be light and small in size, suitable for road transport and for easy and fast implementation and launch in various ways;
- To be easy to use and handle in restricted areas;
- To be easy to maintain and to repair in the field and
- To be environmentally friendly (minimum impact on ground).

[4]HOVERSPILL: CEDRE website [15].

Main Results

During the duration of the project, an oil spill literature and experience assessment was carried out that identified possible difficult-to-access areas where an oil spill could occur and the necessary capabilities that an oil spill response vehicle should possess. Based on this assessment, the project conceptualized, designed and developed the HoverSpill, an innovative System based on a hovercraft specialized for high speed Oil Spill emergency response and remediation. Its independent power generator and oil separation device cleans up coasts, beaches and shoals where vessels/land devices cannot operate. Its amphibian performances and compactness makes it easy on road or vessel transportation and beach based operation.

The HoverSpill is a hovercraft with unsinkable and shock proof soft hull, lateral skirt protection, oil resistant skirts and a Flapton System that allows for maximum manoeuvrability. HoverSpill's simple construction from parts commonly available in industrial market makes for ultra-simplified maintenance and low cost. The vehicle can also be used in other situations such as in flooding, firefighting or police operations. It could also serve in conservation activities. The project also resulted in the development of a diphasic oil–water separator, deployed during skimming operations on floating slicks, and assembled together with the recovery system (skimmer + pump).

3.1.4 METANE Project

General Information

- *Title:* Development of a modelling tool to study oil behaviour in the event of a deep sea leak (METANE)
- *Project Period:* 2011–2014
- *Geographical Scope:* French Mediterranean waters
- *Funding Program:* Single Inter-ministerial Fund of the Regional Council of Brittany
- *Website:* http://wwz.cedre.fr/en/Our-resources/Research/Response-equipment-and-products/METANE-2011-2014

Background

For many years, Oil and Gas industry stakeholders have clearly expressed their need for tools to predict and model oil and gas leaks. The accident involving the Deepwater Horizon platform in the Gulf of Mexico in April 2010 confirmed the importance of fully understanding these underwater phenomena and their consequences at the sea surface [8].

Main Objectives

The METANE project's (Modelling underwater gas/oil blowout and LNG leak) long-term aim is to obtain a comprehensive IT system to describe the behaviour of gas or oil in the marine environment in the event of accidental discharge. The aim of this project is to improve both the safety of personnel on-board offshore Oil & Gas installations and the pollution response to limit the impact on the marine environment [8].

The first objective of the METANE project is to develop a decision support tool for the implementation of contingency plans for industrial risks related to oil and gas leaks at sea.

The second objective of the project involves conducting pilot-scale trials to test the observations made on a smaller scale and to provide input for scientific research and debates on the mathematical equations describing these phenomena.

Main Results

The work of the project led to development of a tool featuring scientific modelling of the dynamics of a gas and/or oil plume when rising in the water column, taking account of the specific characteristics of the deep ocean. Calibrating and validating the chosen numerical models were carried out using Cedre and EMA technical resources (5-m column, pressurized column, high-frequency camera, etc.).

The METANE tool is made up of a computing code which is reachable through a graphical user interface (GUI) providing access to the initialization of the computation process and to the post-treatment and visualization of the results. Results from the simulation are directly exploitable in the quantitative view: displaying plume slices or a cut view, picking points in the plume to obtain information about oil/natural gas concentration and velocity, and 2D plot outputs are also available, giving extra information on surface pollutant concentration, or fountain elevation with radius [8].

The METANE tool provided answers to operational questions: where and at what rate does the plume surface and how concentrated is it? Adopting a "serious game" approach, the results of the tool are presented in a 3D scenario and thus offer a realistic view of the accident for intervention team training.

3.1.5 MOST Project

General Information

- *Title:* Development of a tool to analyse and predict the evolution of drifting oil slicks (MOST)
- *Project Period:* 2012–2013

- *Geographical Scope:* The project is related to the French waters of the Mediterranean Sea
- *Funding Program:* Collaborative & Innovative Technology Program in Exploration and Production of Hydrocarbons (CITEPH)
- *Website:* http://wwz.cedre.fr/en/Our-resources/Research/Response-equipment-and-products/MOST-2012-2013/

Background

Oil spill response efficiency is currently held at low levels which means that only a small portion of released oil is actually collected and removed by oil spill combating units and equipment. In order to implement oil spill response equipment in a more efficient way, the following parameters are necessary:

– Prediction of the slick formation;
– Prediction of the spill drift;
– Prediction of the evolution of oil at the surface, i.e. whether it will fragment or not; and
– Estimation of the quantities of drifting oil in order to determine the resources required for response operations at sea and/or on the shoreline.

Main Objectives

The aim of the MOST project (Mapping Oil Spill Drift) is to improve decision support for the definition of the response strategy to be implemented, by significantly improving the processing technique for images obtained by remote sensing in the field.[5] The idea is to develop an IT tool to analyse these images based on a new protocol designed to:

- Accurately outline drifting slicks and provide more accurate information on their shape and therefore their surface area;
- Geolocate oil spills on a map environment and
- Estimate the oil spill thickness to the greatest extent possible.

The information collected through the developed tool will be sent to Météo France for use as input data for the MOTHY drift model.

[5]CEDRE 2016 [16].

Main Results

The MOST project resulted in the development of a software tool, which can be used to accurately describe the shape and geometry of a drifting slick from a remote-sensing image.

3.1.6 MEDESS-4MS Project

General Information

- *Title:* Mediterranean decision support system for marine safety (MEDESS-4MS)
- *Project Period:* 2012–2015
- *Geographical Scope:* The project is relevant to the whole Mediterranean Sea region
- *Funding Program:* Financed by the European Regional Development Fund within the Med Programme for Strategic Projects
- *Website:* http://www.medess4ms.eu/

Background

One of the permanent risks from an incident in the Mediterranean is associated with the heavy traffic of maritime transport and with the coastal and offshore installations related to oil industry. Such a dense activity imposes on the coastal countries the need for preparing an operational response in cases of major incident. The use of oil spill models is a significant part of oil spill response activities and Member States agencies have been using a number of well-established oil spill models during real oil spill incidents within the Mediterranean for years. On the other hand during the last decade, the GMES marine core service (nowadays the Copernicus marine service) and the associated national ocean forecasting systems developed. However, there was a distinct lack of coupling these forecasts with oil models and more importantly there was a lack of common services which would harmonize and integrate the existing systems in order to improve the efficiency of oil spill response.

Main Objectives

The MEDESS-4MS project is an ambitious project aiming at improving capacities in preventing and mitigating maritime risks deriving from oil spills through the use of forecasting and support decision tools. The project would deliver an integrated operational multi-model oil spill drift prediction service connected to existing monitoring platforms (EMSA-CSN, REMPEC and AIS), using the well-established

oil spill modelling systems, the data from the Copernicus MED-MFC marine service and the associated national ocean forecasting systems [9].

The project's overall objectives are:

- To implement an integrated real-time multi-model oil spill forecasting system;
- To implement an interconnected network of data repositories that will archive and provide in operational way the access to all available environmental and oil spill data;
- To test the service functionalities with key end users: REMPEC, EMSA and national agencies responsible for combating oil spills and
- To develop the integrated system with a unique access web portal with different services and user profiles, multi-model data access and interactive capabilities.

The reasoning of the project is to set up an integrated real-time operational oil spill forecasting service for the Mediterranean for national response agencies, REMPEC and EMSA, that will give these response agencies the capability to use real-time information about position of the oil slick, and interface it with oil spill models capable to forecast the movement of the pollution providing tailored products to oil spill crisis management users, contributing substantially to maritime risks prevention and maritime safety. This capability will allow for significant decrease in response times to oil spill incidences and since oil spills are like fires, where fighting them when still small makes all the difference, MEDESS-4MS developed the most effective tool for initiating the appropriate response when disaster occurs at sea.

Main Results

The MEDESS-4MS project has resulted in a large number of deliverables and activities relevant to oil spill response. A large number of studies and reports were produced regarding oil spills modelling and oil spill response in the Mediterranean sea[6]:

- Development of Socio-economic Vulnerability Maps from Oil Spills for the Mediterranean;
- Analysis of ship traffic and ship density in the Mediterranean;
- Analysis of oil transport and
- Analysis of historical accident data in the Mediterranean region.

Furthermore, a large number of research papers were produced as part of the project and the project was represented in various relevant conferences.

One of the most important outcomes of the project is the MEDESS-4MS Web Portal that provides comprehensive information and data regarding oil spills and oil spill response in the Mediterranean Sea. The web portal also serves as a data

[6]Medess-4MS project website [17].

repository backed by database that is linked to data contained in ENI database developed in the MEDSTAR project as well as other databases.

The main service delivered by MEDESS-4MS is an integrated real-time operational oil spill forecasting service for the Mediterranean for national response agencies, REMPEC and EMSA.

The multi-model oil spill forecasting system is composed of environmental information from the Copernicus MED-MFC marine service and the national ocean forecasting systems interfaced with oil slick data from existing monitoring platforms from EMSA-CSN, as well with AIS data. It uses the real-time information about position of the oil slick, and interfaces it with oil spill models capable to forecast the movement of the pollution providing tailored products to oil spill crisis management users, contributing substantially to maritime risks prevention and maritime safety.

The service is accessible through a User Interface that is basically the web portal on which the MEDESS-4MS services are made available. The system is accessed by different users' categories and thus implements authentication services, profiling, management of customized contents and centralized administration. Users have the possibility to choose the MEDESS-4MS oil spill model that best satisfies their local or subregional needs, and select the necessary forcing data from the output of local, subregional and regional ocean and meteo-forecasting systems.

The MEDESS-4MS services are delivered through three service scenarios (SS), in order to assist operational response agencies:

SS1 – Real-time interactive oil spill predictions by the end-user request. It is an automatic system that runs after an oil spill alert from satellite data. It is a scenario used by selected authorized users (i.e. official agencies of Member States).

SS2 – Delayed mode simulations by end-user request. In this solution, intended for the use of REMPEC and generic users, the UI provides the means to access monitoring component, environmental data and model outputs and receive integrated remote/in situ data. The User queries the NDR Service to consult historical data, for study or statistical purposes and possibly query the NDR to back trace data with the aim of identifying possible polluting ships.

SS3 – Decision support system (DSS) to manage emergency operations. These services consist of a DSS operational tool proposing to the users a set of possible scenarios, developed according to the foreseeable meteo-marine conditions and to the possible on-site interventions. The DSS is then used for oil spill crisis management and built upon a set of simulation functionalities, launched by the UI to support the work of operational decision makers.

3.1.7 TOSCA Project

General Information

- *Title:* Tracking Oil Spills & Coastal Awareness network (TOSCA)
- *Project Period:* 2010–2013
- *Geographical Scope:* The project is relevant to the whole Mediterranean Sea region
- *Funding Program:* Financed by the European Regional Development Fund within the framework of the Med Programme
- *Website:* http://www.tosca-med.eu/

Background

The increasing importance of Eastern Mediterranean ports and the traffic density concentrated around Western and Central Mediterranean ports are constantly raising the risk of an important marine incident. For these reasons, Med partners need to work together on a stronger current monitoring system and on effective action plans in case of maritime accidents in order to reduce the risks and the impacts caused by a maritime accident.

Main Objectives

The TOSCA project aims to improve the quality, speed and effectiveness of decision-making process in case of marine accidents in the Mediterranean concerning oil spill pollution and search and rescue (SAR) operations.

More specific objectives include[7]:

- Provision of real-time observations and forecasts of the marine environmental conditions in the Western and Eastern part of the Mediterranean Sea through the construction of an observational network, based on state-of-the-art technology (HF radars and drifters);
- Development of a decision support tool for authorities in charge of marine emergency response and
- Set up a sustainable network of local authorities, policy makers and scientists in the Mediterranean.

The network will be used to implement action plans in collaboration with local authorities, as well as to set a common scientific strategy in cooperation with policy makers to provide immediate response, mitigation and long-term management of oil spill pollution and SAR operations in case of marine accidents.

[7]TOSCA project website [18].

Main Results

The main result of the TOSCA project was its contribution in the development of new and updated knowledge on surface currents and noticeable progress in the monitoring of oil slick drift. The added precisions and data collection from this project could now help authorities choose the right strategy for the deployment of drifters to track oil spills.

The TOSCA project has developed an innovative approach using HF radars and drifter measurements to provide crucial and complementary information to predict oil spill dispersion and trajectory more accurately. To provide real-time observations and forecasts, an observational network, based on state-of-the-art technology (HF radars, drifters and ocean modelling systems), was installed and assessed in five sites of the Mediterranean sea, on the coastal areas near the outlets of major existing or planned oil pipelines and on high traffic areas.

The major results of the analysis of the data set obtained during the experimental campaigns prove:

- The benefit of HF radars as a powerful tool to provide satisfactory estimation of transport and to improve our response to oil spill and SAR emergencies;
- The benefit of an optimal drifter deployment strategy to be used to correct radar intrinsic errors or enhance models and to get direct information on oil spill transport and dispersion and
- The benefit of the TOSCA strategy to enhance numerical models and provide more accurate forecasts of the trajectory of oil spill, a wreckage or a lost person.

3.1.8 NEREIDS Project

General Information

- *Title:* NEREIDS
- *Project Period:* 2013–2015
- *Geographical Scope:* The project is relevant to the Eastern Mediterranean Sea region
- *Funding Program:* Financed by the Humanitarian Aid & Civil Protection, in the area of preparedness in Civil Protection and Marine Pollution
- *Website:* http://www.nereids.eu/

Background

Oil spills in a cross-border environment increases the operational challenges of civil protection and other authority's in combating the spill. There is a need for development of a high level of communication, cooperation and training capacity

between cross-border oil spill response authorities to improve the effectiveness of the response.

Main Objectives

The NEREIDs project aims to increase preparedness and collaboration in civil protection and marine pollution amongst Greece and Cyprus, building on international standards, best practices and innovative Information and Communication Technologies.[8]

Additional objectives of the NEREIDs project include:

- The advancement of cross-border civil protection and marine pollution cooperation for direct response to disasters;
- Increasing the preparedness for the mitigation of oil spill impacts on the coastal environment;
- Increasing the coordination between various oil spill response authorities in Greece and Cyprus as well as the capacity to receive foreign assistance;
- Development and implementation of e-learning tools based on innovative concepts of online games, mobile technologies (m-learning), crowd sourcing and web applications to train civil protection and marine pollution professionals, volunteers and other related stakeholders as well as for increasing awareness, knowledge and skills and
- Limiting the consequences of emergencies through sharing experiences and best practices on developing and making use of situational reports.

Main Results

- The project succeeded in improving the collaboration of Greece's and Cyprus's oil spill response stakeholders through common trainings, working meetings and two full-scale tabletop exercises for oil spill response where realistic scenarios that included the request of assistance from the EU host nation support mechanism.
- Additionally, the project developed tools to allow for the availability of crucial information to the response authorities specifically, an online Incident Report Database was developed to collect, evaluate and verify information on incidents in a standardized user friendly format (see http://www.nereids.eu/site/incidents_view/admin/debr-list.php). Statistical analysis and evaluation of the incidents report database containing historical accidents and oils spills for the last 50 years was carried out to identify accident and response patterns.

[8]NEREIDs project website [19].

- Based on seafloor and near-coast morphology data, oil spills coastline susceptibility maps were developed to assist authorities to better develop response plans.
- A variety of training and informative tools have been developed such as a web-based learning game, educational material to train civil protection and marine pollution professionals, volunteers and other related stakeholders and E-training courses based on ICT Technologies to deliver high-quality learning experience to remote professionals, volunteers and other related stakeholders.
- An e-learning portal in the field of civil protection and marine pollution for spreading knowledge with the appropriate content to reach a broader audience has been developed as well as a mobile learning (m-learning) application to be used as a tool for educating the appropriate personnel.

3.1.9 PREMARPOL Project

General Information

- *Title:* Prevention and Combating of Marine Pollution in Ports and Marinas (PREMARPOL)
- *Project Period:* 2011–2014
- *Geographical Scope:* The project is relevant to the Eastern Mediterranean Sea region
- *Funding Program:* Financed by Greece–Cyprus 2007–2013 Interreg Cross-border program
- *Website:* http://www.oceanography.ucy.ac.cy/pages/premarpol/

Background

Pollution phenomena such as oil pollution, increased concentrations of suspended particles in water, foul smells and other contaminants are common within and in adjacent port facilities. However, such pollution is incurring negative impacts both on the physical environment as well as the further growth of close-to-port areas. There is a distinct necessity for the prevention of any port related pollution but also for the development of the necessary mechanisms to timely detect and mitigate any pollution caused. The necessity for the implementation of such a system is now becoming imperative, since most international organizations and the EU institutions impose strict penalties on environmental unreliable port operators.

Main Objectives

The PREMARPOL project aims to assist the competent authorities to prevent and fight marine pollution in ports, in order to protect the health of neighbouring populations, i.e. port workers, port clients and local residences. Additionally, the

project aims at the protection of the physical environment within and adjacent ports from any kind of port related pollution.[9]

Project objectives include the installation of modern pollutants detection sensors in the ports of Cyprus, Rhodes and Samos, as well as the adjacent water bodies and the development of an integrated information system which would collect and process the acquired data in order to assist competent bodies to implement timely pollution prevention and mitigation measures.

Main Results

The project has developed and implemented a series of multisensor instruments within ports for real-time data on water quality status of the port basin water as well as water bodies adjacent to the port area. The sensor readings were presented on an online web portal that is open to the public.

3.1.10 Mediterranean Pollution Control Project

General Information

- *Title:* Oil Pollution Management Project for the Southwest Mediterranean Sea
- *Project Period:* 1992–2000
- *Geographical Scope:* The project is relevant to the Eastern Mediterranean Sea region
- *Funding Program:* Financed by the World Bank global environment trust fund
- *Website:* http://projects.inweh.unu.edu/inweh/index.php

Main Objectives

The primary objectives of the project were to reduce the quantity of petroleum hydrocarbons entering the international waters of the Mediterranean and to comply with MARPOL7 3/78 Convention requirements [26].

The project also achieved the development of a comprehensive and integrated system for the management of oil pollution caused by marine sources, thus ensuring commonality of approaches and methodologies, promoting exchange of information and coordination, enhancing monitoring capability amongst the countries in the region (Algeria, Morocco and Tunisia) for preventing and combating oil pollution and improving the quality of the marine environment.

Additional objectives include:

[9] PREMARPOL project website [20].

- Utilization of national data sets to assess long-term regional trends in marine pollution, both for national coastal waters and for adjacent international waters;
- Enhancement of the national monitoring capability of the three countries and
- Development of a coastal environmental management framework.

Main Results

A major institutional outcome of the project has been the development of a framework for a comprehensive national and regional management of oil pollution, the drafting of a regional contingency plan (RCP) and the purchase of standardized equipment to combat pollution. Furthermore, the project also initiated cost recovery system at the port level through an adequate tariff structure, and at the national level through creation of an environmental fund, enactment of a law regarding fees and penalties and enactment of polluter-pay rules [26].

3.1.11 ARGOMARINE Project

General Information

- *Title:* Automatic Oil spill Recognition and Geo-positioning integrated in a Marine Monitoring Network (ARGOMARINE)
- *Project Period:* 2009–2012
- *Geographical Scope:* The project is relevant to the whole Mediterranean Sea region
- *Funding Program:* Financed by the European Commission under the Transport Theme of the 7th Framework Programme for Research and Technological Development
- *Website:* http://www.argomarine.eu/

Background

The Mediterranean Sea is amongst the world's busiest waterways accounting for 15% of global shipping activity by vessel deadweight (DWT). Ship traffic through Mediterranean basin daily consists of 2,000 ferries, 1,500 freight ships and 2,000 commercial crafts, and 300 of them are tankers (20% of the world amount of oil sea traffic), carrying more than 350M oil tons per year (8M barrel per day). The high ship traffic combined with the difficult, in many places, navigation routes constitutes the Mediterranean Sea as one amongst those facing the highest risk of oil pollution. Additionally, the recent developments in Eastern Mediterranean for exploration and exploitation of offshore Petroleum Hydrocarbons increase the threat to Eastern Mediterranean States.

Thus, decision makers in this region have a strong need for an efficient pollution monitoring and forecasting system, to support them in planning and conducting preventive and emergency interventions.

Main Objectives

The scope of the proposed ARGOMARINE project is to develop and test an integrated system for monitoring of the marine traffic and pollution events due to carriers/commercial ships as well as recreational boats through environmental-sensitive sea areas.

Main Results

A methodology and tool was developed to identify and analyse oil spills from SAR images coming from satellite-hosted platforms. This monitoring is implemented by means of electronic, geo-positioning and tools for transmitting ship navigation data through a high speed communication network. Environmental data from different sensors (SAR, hyperspectral sensor and thermal sensors) on satellites, aircraft, vessels, in situ anchored buoys and AUVs are collected and sent by telemetric links to a central server for map processing. Therefore, to monitor marine pollution, data from both satellite and airborne remote sensors and in situ sensors on vessels and buoys are integrated to derive information about water quality and spread of hydrocarbons/oil slicks over large areas.

External data such as weather station data, weather operational models and large-scale hydrodynamic and wave models are gathered and placed in a 3D hydrodynamic model a wave model and an oil spill model.[10]

All the data and the information obtained are merged and elaborated in a Marine Information System (MIS), i.e. an information system where all collected data are stored and tools for data retrieval, data manipulation and analysis, as well as for presentation, are available through a common interface. The ARGOMARINE platform guarantees a better management of sea and coastal areas and a reduction in the burden of continuous visits all over the territory in the traditional surveillance modalities. These factors will reduce the cost of the environmental conservation system and simultaneously improve the quality and efficiency of agencies that are in charge of control services.

[10]ARGOMARINE project website [21].

3.1.12 HAZADR Project

General Information

- *Title:* Strengthening common reaction capacity to fight sea pollution of oil, toxic and hazardous substances in the Adriatic Sea (HAZADR)
- *Project Period:* 2012–2015
- *Geographical Scope:* The project is relevant to the Adriatic Sea region
- *Funding Program:* Financed by the IPA Adriatic Cross-Border Cooperation Operational Programme
- *Website:* http://www.hazadr.eu/

Background

The Mediterranean is one of the most crowded seas in the world in terms of traffic. Even if it covers only 0.7% of the total seawater surface in the world, it hosts 30% of the overall international maritime traffic. Sea pollution by oil, hazardous and noxious substances can happen at any time and in any place, especially along the main maritime routes due to technological and natural hazards and during the loading and unloading vessels' operation in the sea terminals, where the likelihood of marine environment pollution is the highest. The Adriatic Sea is no exception, especially since it represents a narrow and shallow basin across which petroleum transport is directed towards transit ports mainly situated in the northern part of the Adriatic.

Main Objectives

The main objective of the project is the establishment of a cross-border network for the prevention of risks and the management of emergencies, in order to reduce the risk of pollution and contamination of the Adriatic Sea and strengthen a common reaction capacity of the communities belonging to the Adriatic region against environmental and technological hazards due to collisions, shipwrecking and spillage of oil and toxic material into the sea.[11]

Main Results

The project's results include:

[11]HAZARD project website [22].

- An assessment of the legal and administrative framework on oil spill response of the countries of the Adriatic region has been carried out.
- A statistical analysis of maritime incidents, from 1970 to 2014, considering all the events recorded in the main international databases was completed.
- Coastal vulnerability maps were developed in order to provide the decision maker with the most accurate knowledge of the area that might be impacted by the spill.
- Oil spill risk assessment for the Adriatic region has been carried out.
- The AdriaCOAST forecasting system was developed to run autonomously every day and produce a 72-h forecast to predict the oil dynamics (direction, speed and impact) on the sea surface and its possible stranding is GNOME (General NOAA Operational Modelling Environment).
- A common database on the state of readiness and spatial distribution of pollution preventing equipment along the Adriatic coasts as well as the improvement of the operational instruments to cope with the environmental and technological hazards was developed.
- A joint radar monitoring program based on a set of radar systems and VHF devices was developed.

3.1.13 RAOP-MED Project

General Information

- *Title:* Risk Assessment Analysis on Offshore Platforms in South East Mediterranean (RAOP-MED)
- *Project Period:* 2013–2015
- *Geographical Scope:* The project is relevant to the South East Mediterranean region
- *Funding Program:* Financed by the Cross-Border Cooperation within the European Neighbourhood and Partnership Instrument (ENPI) Mediterranean Sea Basin Joint Operational Programme
- *Website:* http://www.raop.eu/

Background

In recent few years, the Mediterranean Sea is increasingly becoming a field of oil and gas exploration and production due to a series of deep sea deposits found especially in the Eastern Mediterranean region. According to a recent study made by the MOIG, there are approximately 100 facilities handling oil in the Mediterranean Sea with increasing trend.

Main Objectives

RAOP-MED project aims to offer a holistic study on the risks associated with the exploitation and exploration of the continental shelf and seabed that includes prevention, early detection and control of the oil spill, reorganization and redistribution of the resources available for efficient and accurate combat of the oil spill at the early stages and, furthermore, to raise awareness of the possible consequences of such an incident in financial, environmental and social level.

Therefore, RAOP-MED specific objective is the development of a comprehensive Risk Management Plan that evaluates the risk of an oil spill incident caused by offshore platform in the Mediterranean Sea and propose all the necessary structural and institutional changes and suggest possible response mechanisms that need to be taken into account in order to minimize the response time and improve the overall performance of competent authorities and relevant stakeholders to an oil spill combat.

Main Results

The project has resulted in a number of significant results to improve the oil spill response capabilities of the South-Eastern Mediterranean countries[12]:

- An analysis of maritime traffic through the Automated Identification System (AIS) in conjunction with the oil transport data was carried out that resulted in vessel traffic and density maps and the identification of High Risk areas for Oil Spill incidents/releases.
- The probability of occurrence of an oil spill due to a ship–oil platform collision was carried out by assessing the traffic density in relation to the location of the offshore structure. Additionally, an oil spill evaluation was carried out to assess the probable size and type of oil spill release.
- Development of integrated sensitivity maps for the Southern Eastern Mediterranean area that can provide a very valuable tool for the risk assessment of any area in the Southern Eastern Mediterranean sea was carried out.
- A comprehensive Impact Damage Assessment was developed based on the predictions of the well established MEDSLIK oil spill model, to assess the consequences of any possible Oil Spill release in the South East Mediterranean.
- An assessment of the technical capacity of each country (Cyprus, Egypt, Israel, Lebanon, Syria, Turkey and Greece) to respond effectively to oil spill incidences within it territorial waters was carried out. Additionally, the status of enforcement of the various International and Regional Conventions and Protocols for Prevention Control and Combating Oil Pollution by the South-Eastern Mediterranean countries was carried out showing that the East Med region is

[12]RAOP-MED project website [23].

characterized by heterogeneous level of preparedness and response due to the partial fulfilment of the relevant country's obligations derived as signatory Parties to the existing treaties or even more because they have not ratified yet a number of them.

The strategic impact of the project is that it developed knowledge and tools that can allow the participating countries to: (a) redraft their Emergency Contingency Planning on Oil Spills to include risks from Offshore Structures; (b) increase awareness to Institutional and Operational Stakeholders and (c) to improve distribution of oil response equipment.

3.1.14 PRIMI Project

General Information

- *Title:* Pilot marine pollution by hydrocarbons (PRIMI)
- *Project Period:* 2007–2010
- *Geographical Scope:* The project is relevant to the Mediterranean region
- *Funding Program:* Funded by ASI (Italian Space Agency)
- *Website:* http://spatial.telespazio.it/plone3.0/Primi/

Background

Marine pollution by oil is a threat that increasingly threatens the ecosystem complex sea/coastal areas. Earth observation systems are an effective way to monitor and combat oil spills and have an increasing application by authorities. However, observation systems had some obvious gaps between requirements and performances such as: the necessity for high revisit times, wide spatial coverage, indication of the spills fate, composition, age, quantities and system reliability.

Main Objectives

PRIMI was a Research and Development project aiming to address the identified gaps in the oil spill earth observation systems and increase the use of satellite data in support to environmental protection. The main goals were to [10]:

- Increase the frequency of monitoring through the use of SAR and Optical data and the use of multiple sensor bands and polarizations.
- Provide slick forecasts for the 72 h after detection in support to remediation actions.
- Supply estimates of parameters such as spill volume, wind and wave conditions, etc., extremely useful during intervention planning.
- Provide data to end users via WEB–GIS technologies.

Main Results

The PRIMI project has developed a modular system able to detect polluted areas both in SAR and in optical imagery, ensuring a wide coverage and a frequent revisit time, to provide a forecast of the observed slicks, using numerical models, meteorological and marine data products and to present all the relevant information to the system end users via a user friendly WEB–GIS portal.

3.1.15 URready4OS Project

General Information

- *Title:* Underwater Robotics Ready For Oil Spills (URready4OS)
- *Project Period:* 2014–2016
- *Geographical Scope:* The project is relevant to the Mediterranean region
- *Funding Program:* The project is financed by the Directorate-General Humanitarian Aid and Civil Protection of the European Commission
- *Website:* http://www.upct.es/urready4os/

Background

Surface oil is not the only effect of oil spills. Underwater oil plumes can come from bottom leaks and from surface patches forming subsurface plumes as recently been brought into the public eye during the 2010 Deepwater Horizon incident. The existing capacity in combating underwater oil plumes is not as developed as surface oil plumes.

Main Objectives

The project's aim is to develop a fleet of autonomous underwater vehicles (AUVs), unmanned aerial vehicles (UAVs) and unmanned surface vehicles (USVs) with operational capability to intervene against oil spills in European Seas using new cooperative multivehicle robotic technologies [11, 25].

Main Results

The project has successfully developed a fleet of unmanned vehicles that are equipped with relatively low-cost standard sonar and oil-in-water sensors to detect and monitor underwater oil plumes. Three different kinds of vehicles are involved: (a) AUVs, (b) USVs and (c) UAVs. The URready4OS is completed by two separate

pieces of software: (a) NEPTUS – a command and control console and data visualization tool and (b) MEDSLIK – an oil spill tracking and fate forecasting model.

While the AUVs measure the oil in water, the USVs and UAVs increase the AUVs operational range acting as gateways for communication between the vehicles and the base station, either on land or ship, where near real-time data are received. Using the data from the vehicles, the system is able to build up a highly accurate and dynamic image of the spill. Ultimately, this cooperating multivehicle robotic technology allows a cheap, flexible, expandable, precise and rapid DSS for Civil Protection decision makers by optimizing the response time before the oil reach the coast [25].

3.1.16 MEDSLIK-II Project

General Information

- *Title:* Oil spill model code MEDSLIK-II
- *Project Period:* 2011–2016
- *Geographical Scope:* The project is relevant to the Mediterranean region
- *Funding Program:* The development of the MEDSLIK-II model is supported by a formal agreement signed by the following institutions: Istituto Nazionale di Geofisica e Vulcanologia, Centro Euro-Mediterraneo sui Cambiamenti Climatici, Consiglio Nazionaledelle Ricerche – Istituto per lo Studio dell' Ambiente Marino Costiero, Alma Mater Studiorum – University of Bologna and the developers of the MEDSLIK oil spill model
- *Website:* http://medslikii.bo.ingv.it/

Background

Oil particles are dispersed by turbulent fluctuation components that are parameterized with a random walk scheme. In addition to advective and diffusive displacements, the oil spill particles change due to various physical and chemical processes that transform the oil (evaporation, emulsification, dispersion in water column and adhesion to coast).[13] Understanding of the behaviour of oil particles in the water column is essential for effective oil spill response.

Main Objectives

The aim of the model is to act as a tool to allow for improved oil spill response planning as well as oil spill combating.

[13]MEDSLIK-II model [24].

Main Results

MEDSLIK-II is a model based on MEDSLIK, that simulates the transport of surface slicks by the sea currents and by the wind. MEDSLIK-II includes high-frequency currents and wind fields in the advective components of the lagrangian trajectory model, the introduction of the Stokes drift velocity and the coupling with the remote-sensing data.

MEDSLIK-II requires as input the oil spill data, the wind field, the sea surface temperature and the three-dimensional sea currents collected from several different sources. The oil spill data required to define a numerical oil spill initial condition are: location, time and area of the spill, as well as the age of the oil spill from initial arrival in the sea. This information can be easily provided to MEDSLIK-II by satellite monitoring systems.

Using the required input parameters, the model produces as output the oil properties evolution and the position, every hour and for the next days, of the surface, dispersed oil and of the oil arrived on the coasts.

4 Conclusions

In this report, 16 European projects relevant to oil spill prevention and mitigation in the Mediterranean Sea have been presented, the majority of which have been completed within the last 10 years. This shows that the EU is actively pursuing and investing in the protection of the Mediterranean from Oil Spills. The implementation of these projects has yielded valuable information that allowed for the improvement of the capacity of the Mediterranean countries to protect the Mediterranean against oil pollution. The main benefits arising from these projects include:

1. Bringing together the academic and operational aspects of oil spill response to identify better solutions.
2. Strengthening the relations between oil spill response authorities in the various Mediterranean countries and facilitating the exchange of expertise.
3. Developing better understanding of the behaviour of oil spills.
4. Assessing the risk of oil spills and their impacts and identifying hot spots or sensitive areas to protect. This allows for better allocation of resources to achieve more effective oil spill response.
5. Developing and implementing powerful and sophisticated models and tools to predict oil spill dispersion and behaviour.
6. Developing new, more efficient, cost effective and environmentally friendly solutions for the cleanup of oil spills.

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