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REGIONAL MARINE POLLUTION EMERGENCY RESPONSE CENTRE FOR THE MEDITERRANEAN SEA (REMPEC)

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MEDITERRANEAN ACTION PLAN

AERIAL AND SATELLITE SURVEILLANCE OF OPERATIONAL POLLUTION WITHIN THE ADRIATIC SEA: A COMPARATIVE ANALYSIS (AESOP)

REPORT

APRIL 2007

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I. Background

The AESOP (Aerial & Satellite surveillance of Operational Pollution in the Adriatic Sea) pilot project was launched in 2005 by REMPEC in collaboration with INFO/RAC (ex ERS/RAC), the EC - Joint Research Centre (JRC), the Italian Ministry of Environment, the Italian Coast Guard (ICG), the Faculty of Maritime Studies and Transport of the University of Ljubljana (Slovenia), the Central Institute for Marine Applied Research (ICRAM) and the Marche Region (DAMAC Project).

The project proposal addressed operational pollution at sea and was prepared following the Regional Workshop on "Prevention and Control of Operational Pollution in the Mediterranean region", organized by REMPEC in Ancona (Italy) in November 2004, where the Centre was requested by the Mediterranean coastal States to facilitate the promotion of satellite monitoring activities in the Mediterranean basin. The project is also in line with specific objective 6(c) of the Regional Strategy for Prevention of and Response to Marine Pollution from Ships, aimed at implementing the new Prevention and Emergency Protocol 2002.

The scope of the project was to assess the possibility of setting up an operational system based on the use of space-borne imagery, in order to support and integrate aerial surveillance for the detection of oil pollution as well as the monitoring of main shipping routes in the Mediterranean region. AESOP activities intended to test whether remote sensing observations can be a valuable tool for detecting the polluting ship and for prosecuting the offenders, and thus to discourage illicit discharges at sea.

The proposal was conceived taking into consideration all previous experience related to satellite monitoring in the Mediterranean region gained within the framework of different European projects such as RAMSES, GAIANET, VASCO and CLEOPATRA as well as studies performed by the EC-JRC in the field.

The Adriatic Sea was selected as the study area due to both its sensitivity to pollution and to the intense maritime traffic regularly crossing the basin. Besides its morphological characteristics and ecological heritage, the choice was also determined taking into consideration the different forms of cooperation already in place within the basin that could facilitate the implementation of the activities, such as the Sub Regional Contingency Plan between Italy, Croatia and Slovenia and the Adriatic Ionian initiative.

II. Activities

The project was divided in two different phases of work. During the first phase (August – September 2005), aimed at assessing the actual reliability of the system, the observations made by satellite and those taken by specially equipped aircrafts were expected to be compared and cross-validated. To this end, satellite image acquisitions and patrolling activities were planned in order to cover the same areas at the same time. Once the analyses of satellite images were carried out (not necessarily in Near Real Time - NRT) the relevant results were compared with data deriving from aerial observations. Remote sensing surveys were carried out through aero-photographic systems and Daedalus infrared/ultraviolet multispectral sensors.

The second phase (June – October 2006) was developed in order to assess the feasibility and capabilities of an operational system based on NRT use of space-borne observations aimed at providing early-warning to aerial means.

The project also aimed at collecting samples of the oil spill detected on the water surface, when possible, for further analysis.

An added value to the project was the use of AIS (Automatic Identification System) data, which were provided by the University of Ljubljana in order to integrate the relevant information with the identification of the polluting ship. This included the use of oil slick dispersion applications and meteo/oceanographic models.

III. Results

1. The first phase

For phase 1, ERS 2 Medium Resolution Image and RADARSAT full resolution products were used. The RADARSAT images were to be delivered in NRT mode, while for the ERS-2 products this additional service was not requested.

Satellite images of the Adriatic Sea were selected and purchased by INFO/RAC (RADARSAT) and EC-JRC (ERS 2) during summer 2005 taking into consideration the planned commitments of the ICG aircraft. It should be noted that due to the institutional tasks of the ICG aircraft, and in particular its Search And Rescue (SAR) duties, the necessary means were not always available for the project.

The five RADARSAT images, purchased by INFO/RAC in the period between 15 and 23 August 2005, did not reveal the presence of possible oil slicks (Tab. 1).

Table I. Cross validation of RADARSAT satellite data and aerial observations.

DATE	SATELLITE DETECTION	TIME	FLIGHT	RESULTS
15 AUG 2005	RADARSAT FRAME 6 NO POLLUTION FOUND		CANCELLED DUE TO BAD WEATHER FORECAST	N/A
16 AUG 2005	RADARSAT FRAME 7 NO POLLUTION FOUND		CANCELLED DUE TO BAD WEATHER FORECAST	N/A
22 AUG 2005	RADARSAT FRAME 9 NO POLLUTION FOUND RADARSAT FRAME 8 NO POLLUTION FOUND	5 h 30 ' 6 h	1 - 07:00 / 12:30 UTC 2 - 13:30 / 19:30 UTC	**OIL SLICK DETECTION** (42°16'05"N 015°48' 41" E)
23 AUG 2005	RADARSAT FRAME 10 NO POLLUTION FOUND	6 h	3 – 04:00 / 10:00 UTC	NO POLLUTION FOUND

The analyses of 69 medium resolution images of the ERS 2 satellite, performed by EC-JRC during summer 2005, identified 66 look-alike spills (Fig. 1), mostly concentrated in the Otranto Channel.

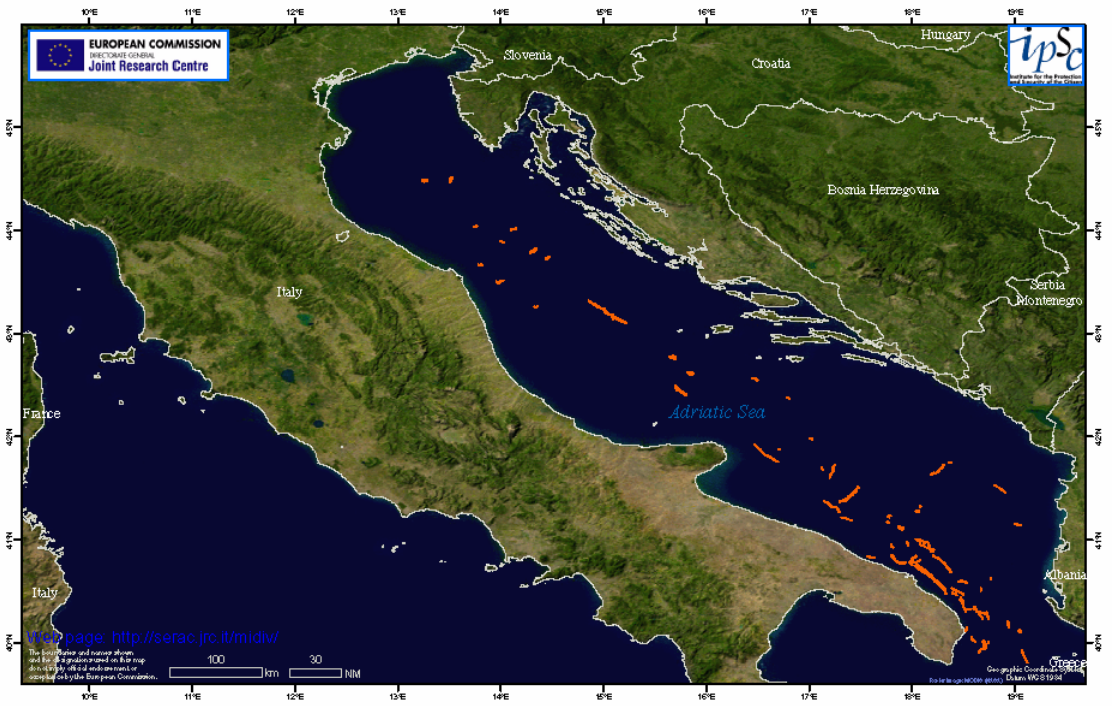

Fig. 1 Possible oil spills detected in the summer 2005 in the Adriatic Sea, 1st phase of the AESOP project.

The images acquired by the JRC were not supposed to be analysed and verified in real time. However 6 of these 69 images were delivered by the space provider unexpectedly within a short delay. This opportunity, even if not planned in advance, was used by JRC to inform the ICG of the possible oil spills detected in the satellite images. In one case, it was possible to verify the oil spills detected on 6 September by aerial surveillance (Tab. II & Fig.2).

Table II. Cross validation of ERS 2 satellite data and aerial observations.

DATE	SATELLITE DETECTION	TIME	FLIGHT	RESULTS
6 SEP 2005	ERS 2 SEVERAL OIL SPILLS DETECTED	2 h 05 '	1 – 14:15 / 16:20 UTC	**OIL SLICK DETECTION IN POS:** 43° 35' N – 014° 00' E 44° 05' N – 014° 07' E 43° 44' N – 013° 34' E 43° 57' N – 014° 02' E

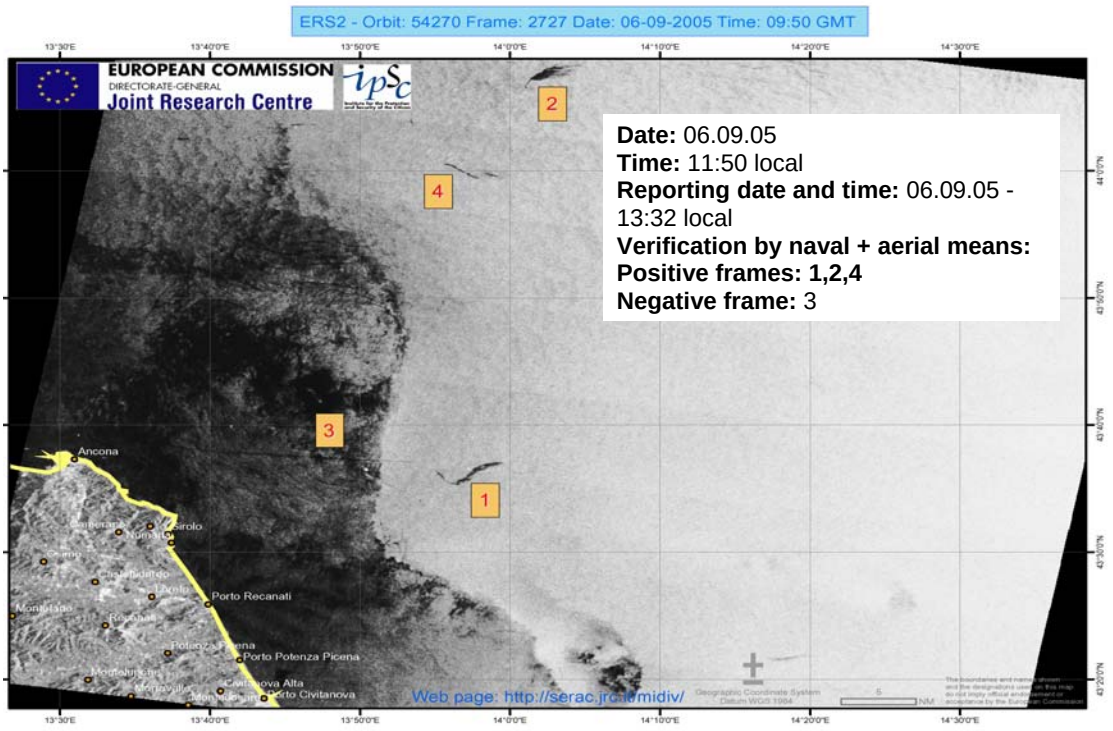

Fig. 2 Oil slicks detected by satellite offshore Ancona.

In two other cases, the slicks identified within the satellite images were verified by patrol boats. In one particular case, namely on the 25th of August, the analysis of the satellite image (Fig. 3 & Tab. III), offshore San Cataldo Point in Puglia (South Adriatic), was reported to the ICG. Oil pollution was identified and a response operation to collect the oil at sea, both in little hydrocarbon agglomerates and unbroken wakes of 5/6 mm of thickness, was activated and coordinated by the ICG. The operations were ended on 27 August.

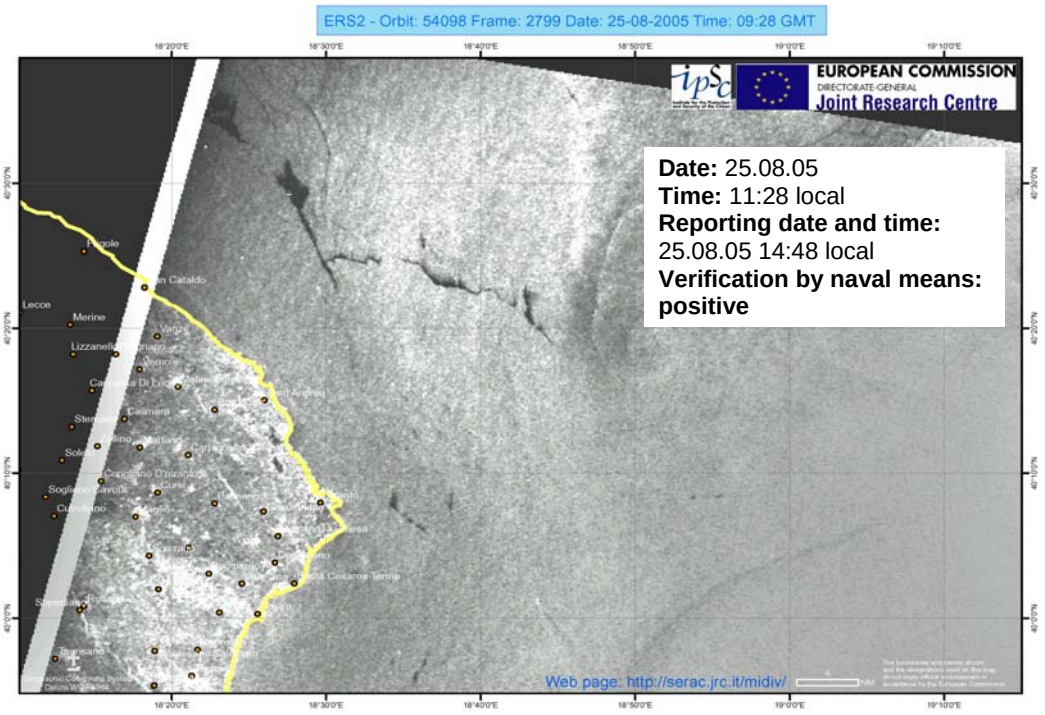

Fig. 3 Oil slicks detected by satellite offshore S. Cataldo Point (Lecce).

Table III. Satellite images which were validated by patrol boats.

DATE	SATELLITE DETECTION	POSITION	NAVAL UNIT AIRCRAFT	RESULTS
15 AUG 2005	ERS 2 20:58:41 TWO OIL SLICKS DETECTED	OFFSHORE OTRANTO CHANNEL (10 NM)	PATROL BOAT CP809 ANTIPOLLUTION VESSEL	POLLUTION NOT FOUND AS FAR AS 20 NM OFF THE COAST
25 AUG 2005	ERS 2 09:29 SEVERAL OIL SLICKS DETECTED	OFFSHORE S.CATALDO POINT (LECCE) S.FOCA MELENDUGNO	PATROL BOAT CP 314 PATROL BOAT CG 246 PATROL BOAT CP 518 PATROL BOAT 809 PATROL BOAT CG 150 ANTIPOLLUTION VESSEL “VISONE” “ECO 880” ROAD PATROL UNITS	**OIL SLICKS DETECTED** oil slick 200 x 500 m pos. 40°17.4’ n-18°30.0’e (hydrocarbon agglomerates) several oil slicks 5 nm from the coast pos. 40°21.6’n-018°29.7’e oil slick (unbroken wake) 30m wide 1 nm long hydrocarbon agglomerates- 5/6 mm thick pos. 40°17.6’n-018°28.8’e broken oil slick in the sea area facing the Salento shore from torre specchia ruggeri to capo d’otranto 5 nm from the shore in the coastal zone of marina s.foca melendugno oil slick 100 m wide ashore

Unfortunately, there were no AIS data available for the area offshore S. Cataldo Point on the 25th of August. The available Slovenian AIS receiver is barely covering the northern part of the Adriatic (north of Ancona) (Fig. 4).

Nevertheless the satellite image dated 25th August was utilized as a test for validation of PISCES oil spill drifting application (Delgado *et al.* 2005) and ADRICOSM meteo/oceanographic source. The meteo/oceanographic parameters were transmitted in the GIS system of the PISCES application in which the satellite image was also integrated. The slick was located from the picture and its spreading simulated. As the location of beaching corresponded to the real condition which occurred in the following days, the simulation tools were considered satisfactory.

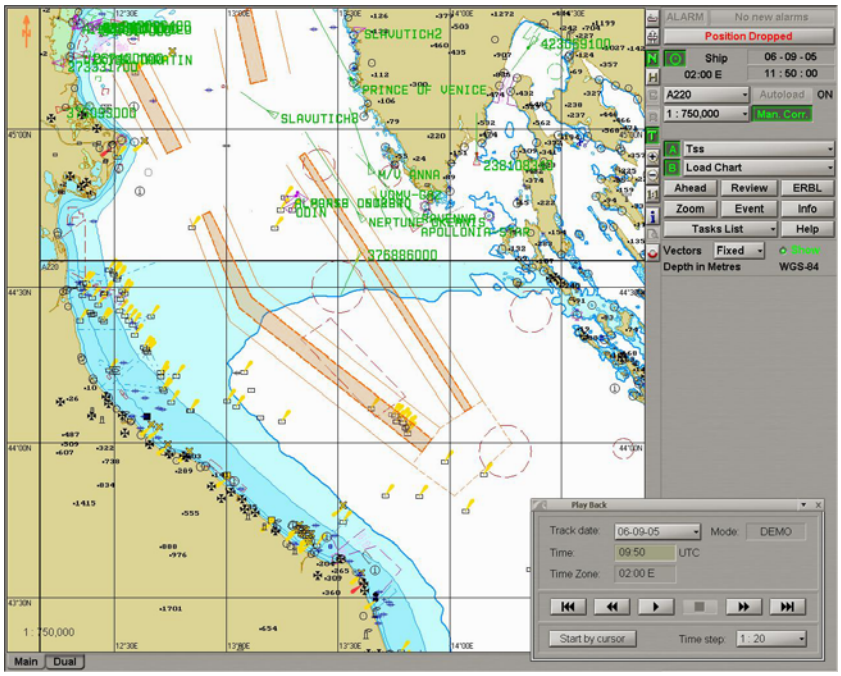

Fig. 4 AIS data of 06/09/05 for the area in front of Ancona.

As for the spills detected in the satellite image of Fig.2 (area in front of Ancona), attempts were made to reconstruct the spilling scenario by integrating satellite images, data on weather conditions, AIS traffic archives and mathematic tools for 'hindcast' simulations of the oil spill. For two slicks (n.2 and n.4), out of four, potential polluters were identified. Moreover, the analysis of AIS archives related to slick number 3, which was the only one not validated by aircraft, led to the conclusion that the signature detected on the satellite image could be caused by the wake of a high speed vessel rather than an oil slick, and probably the fast ferry Ancona-Split.

2. The second phase

The second phase of the AESOP project was launched in summer 2006.

ERS 2 medium resolution satellite images of the Adriatic Sea were purchased by EC-JRC for the period between 20 June and 15 October 2006 and analysed in NRT in order to deliver the necessary information to specially equipped aircrafts within one hour from satellite data acquisition. The images were mostly concentrated on the Otranto Channel, as the results of the first phase of activities highlighted numerous cases of operational pollution in the area.

All delivered images were interpreted carefully through visual inspection. Each identified spill was registered in a database, together with information concerning its geographic position, the date and time of detection, the spilled area and a vector describing its shape. The JRC implemented for this phase a data exchange server so that all partners were able to download the analysed images in average 40 minutes after the spill report was sent.

For the period between 20 June and 25 July 2006, a total of 33 satellite images were acquired and analysed by JRC (23 ERS 2 and 10 ENVISAT/ASAR images).

The analysis of 23 ERS 2 images led to the detection of 18 possible oil spills. The analysis of 10 ENVISAT/ASAR images (18 July – 25 July), delivered in non NRT, identified 10 oil spill candidates in the Adriatic Sea. Due to both the numerous institutional duties of the aircraft and the lack of funding for additional flights, the relevant aerial surveys could not be performed and the presence of oil at sea was verified mainly by patrol boats. Action was taken only when satellite images highlighting oil spills with high confidence were processed and analysed in NRT. In one verified case, out of five, the detected pollution resulted to be a discharge from a ship (Tab. IV).

Table IV. Actions taken by the ICG following the detection of possible oil spills by satellite.

DATE	SATELLITE DETECTION	TIME	FLIGHT – PATROL BOAT OR ACTIONS TAKEN	RESULTS
23 JUNE 2006	ERS 2 PRESUMED OIL SLICK	3h 30’	PATROL BOAT CP 281	POLLUTION FOUND
26 JUNE 2006	ERS 2 PRESUMED OIL SLICK		INVESTIGATED SHIPS IN TRANSIT BY ARES SYSTEM	POLLUTION NOT FOUND

29 JUNE 2006	ERS 2 PRESUMED OIL SLICK	2h 30'	PATROL BOAT CP 885	POLLUTION NOT FOUND
02 JULY 2006	ERS 2 PRESUMED OIL SLICK	3h 30'	PATROL BOAT CP 2098 INVESTIGATED SHIPS BY AIS SYSTEM (ANCONA)	POLLUTION NOT FOUND
06 JULY 2006	ERS 2 PRESUMED OIL SLICK	4h	PATROL BOAT CP 314 INVESTIGATED SHIPS IN TRANSIT BY ARES SYSTEM ADRIATIC TRAFFIC	POLLUTION NOT FOUND

For the image dated 26th June (Fig. 5), the potential offender was identified through fully automatic integration of SAR image, AIS archive data, oceanographic data and oil spill application running backwards.

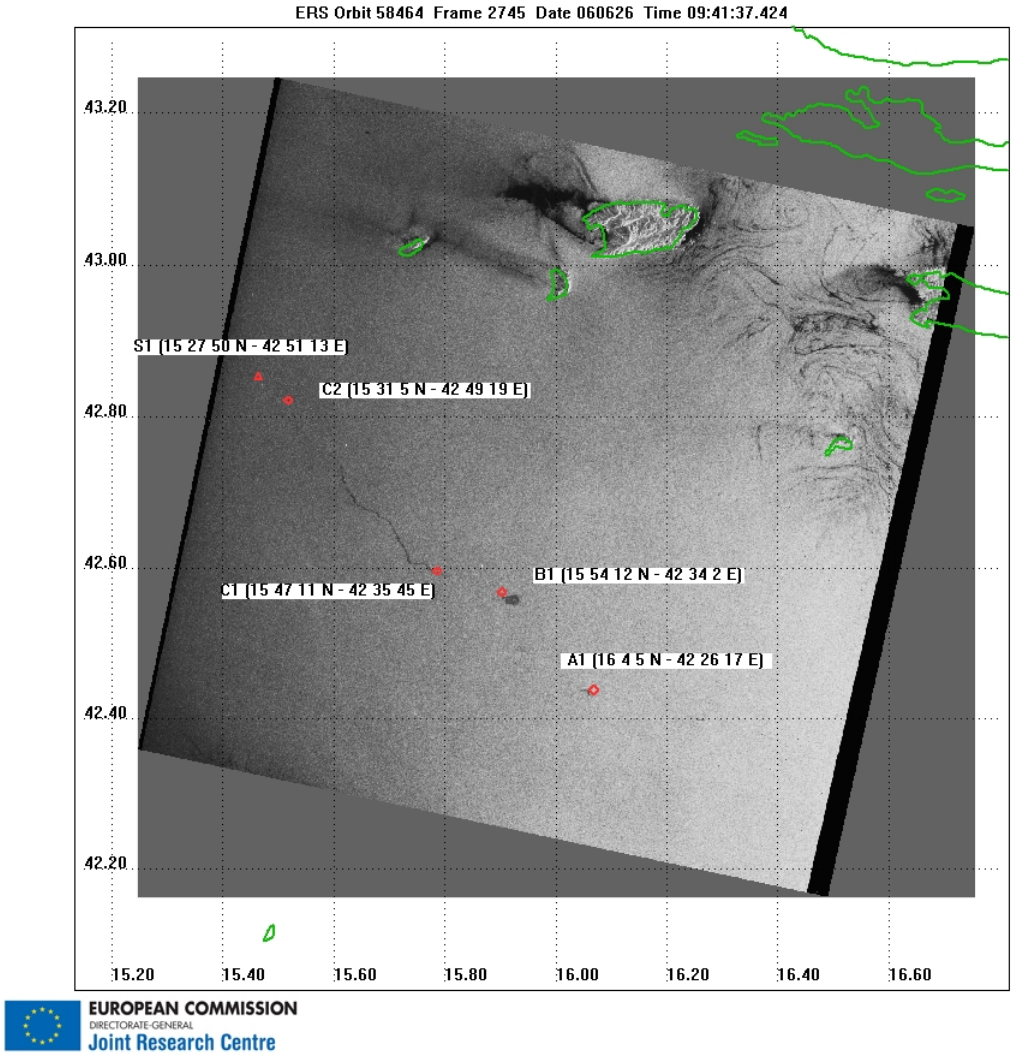

Fig. 5 Oil spill detected in the satellite images dated 26th June 2006 at 9:41 (local time).

As regards to the satellite image dated 6th July 2006 (Fig. 6), the University of Ljubljana was able to clearly identify, through ADRICOSM traffic report (ADRIREP), the polluter which was then investigated by the ICG within the Port of Venice. The ADRIREP is a special report which all ships carrying dangerous goods are obliged to send via VHF to Coast Guard stations along the Adriatic coast, containing the following data: name of ship, IMO number, ship flag, speed, course, position, departure port, destination and cargo on board. It appeared that the tanker was partly loaded with vegetable oil which was the cause of the detected spill.

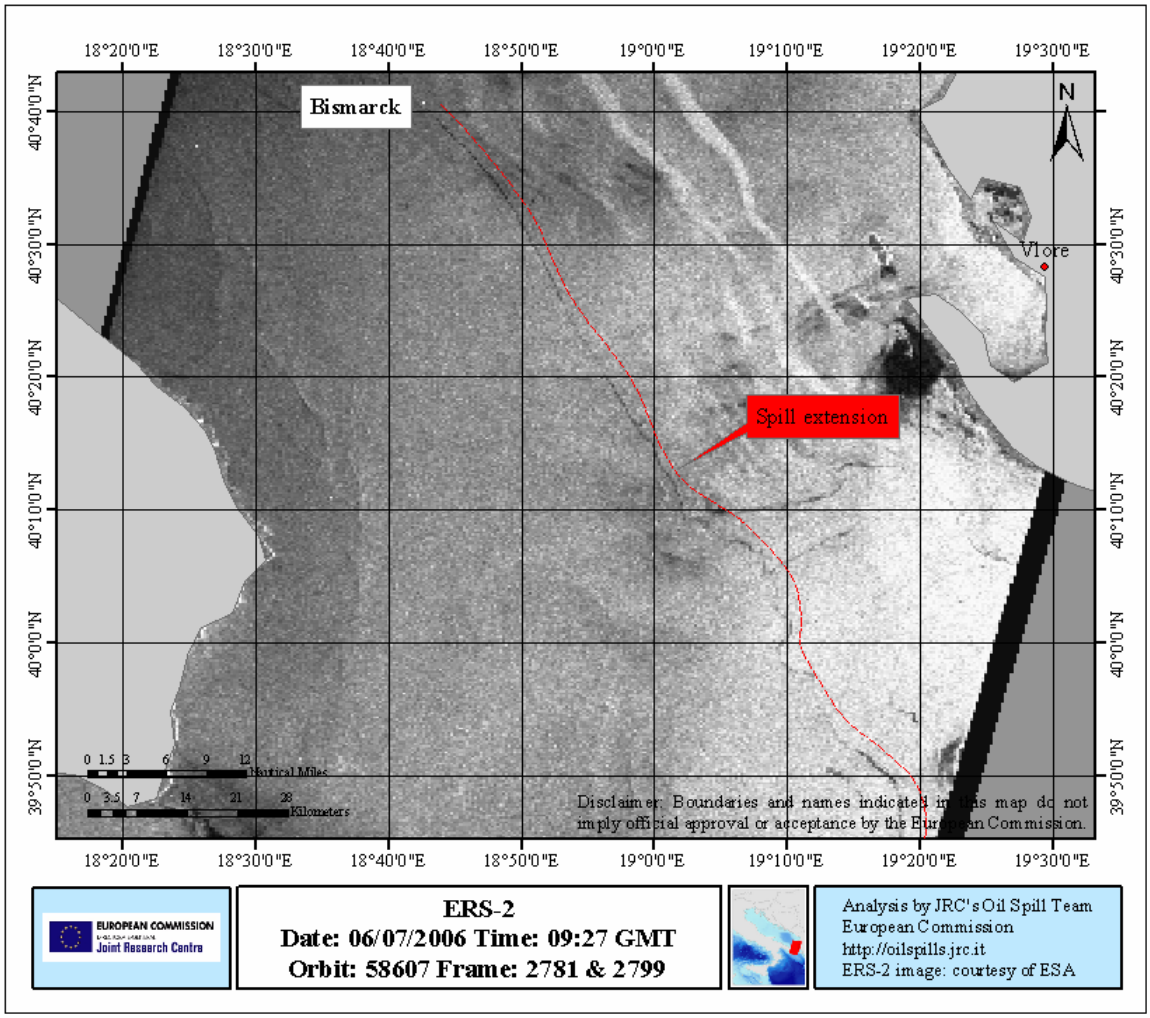

Fig. 6 Oil spill detected in the satellite images dated 6th July 2006 at 11:27 (local time).

Four oil spill candidates were detected after the analysis of the ENVISAT/ASAR images dated 21st July 11:26 (local time; Fig. 7), offshore Ancona (Central Adriatic). The detections were not reported because of the non NRT status of the satellite images. One ship of interest was located close to a large spill. The vessel was identified by AIS as Asso Diciannove, an offshore supply ship (Fig. 7). The 24h

analysis of the AIS information for the 21st July adduced that the vessel was more ore less on the same position all day long (orange dots in Fig. 6). The alignment with the digital nautical chart (Fig. 8) shows for the same position an offshore platform called Daria A/B, which is located on the AGIP Dira field.

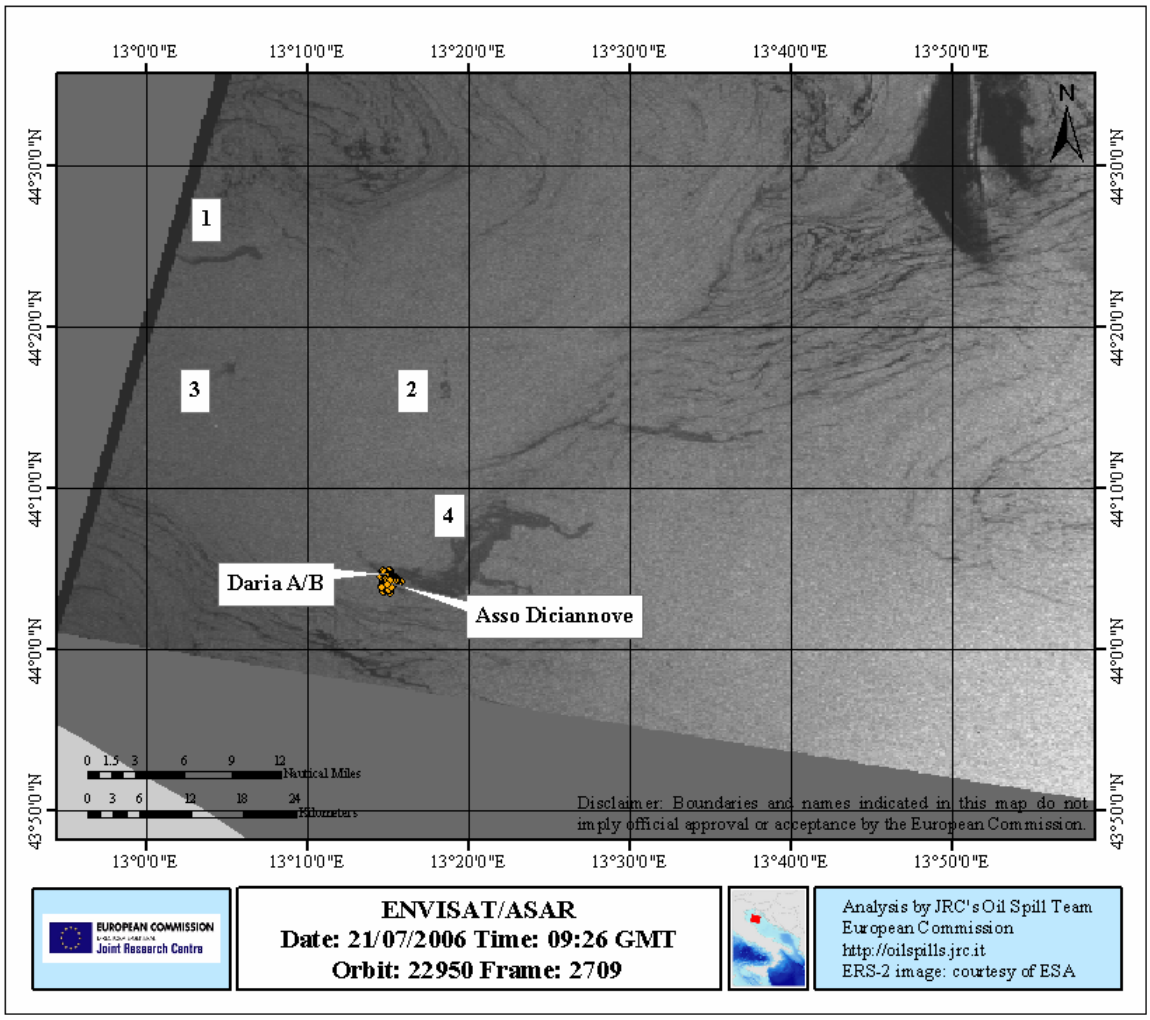

Fig. 7 Oil spill (4) detected close to the offshore platform Daria A/B and the supply vessel Asso Diciannove in the satellite image dated 21st July at 11:26 (local time).

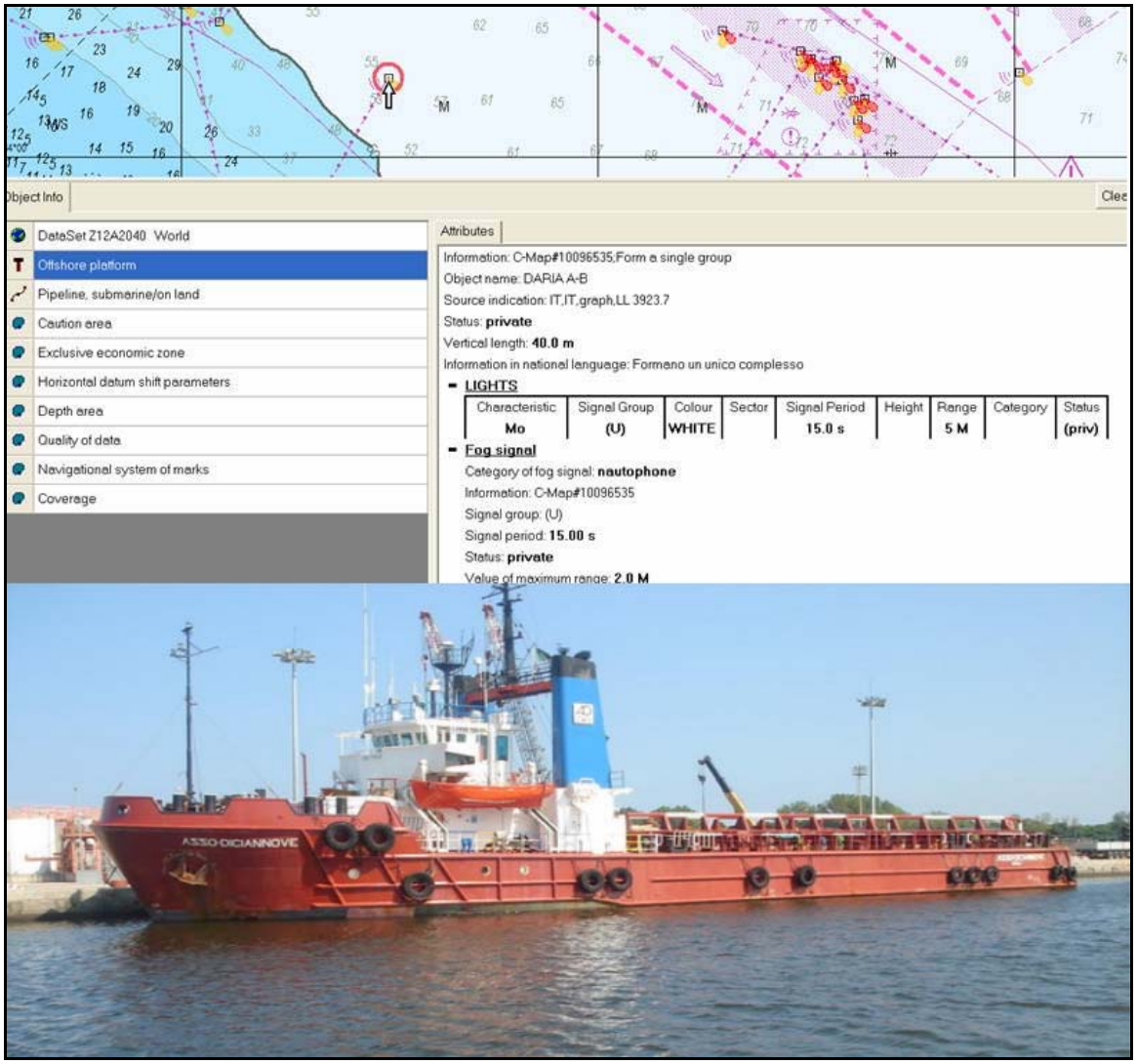

Fig. 8 Digital nautical chart information regarding the offshore platform Daria A/B and picture of the Asso Diciannove.

The analysis of forty-nine ERS 2 images referring to the period 3 July – 15 October 2006 led to the detection of 30 possible oil spills. In this period, gaps of image acquisition were registered between 25 July - 3 August and 29 August - 20 September.

Conclusion: The analysis of 82 images delivered during the second phase of AESOP revealed the detection of 58 oil spill candidates in the Adriatic Sea (North of Capo Santa Maria di Leuca – Fig. 9).

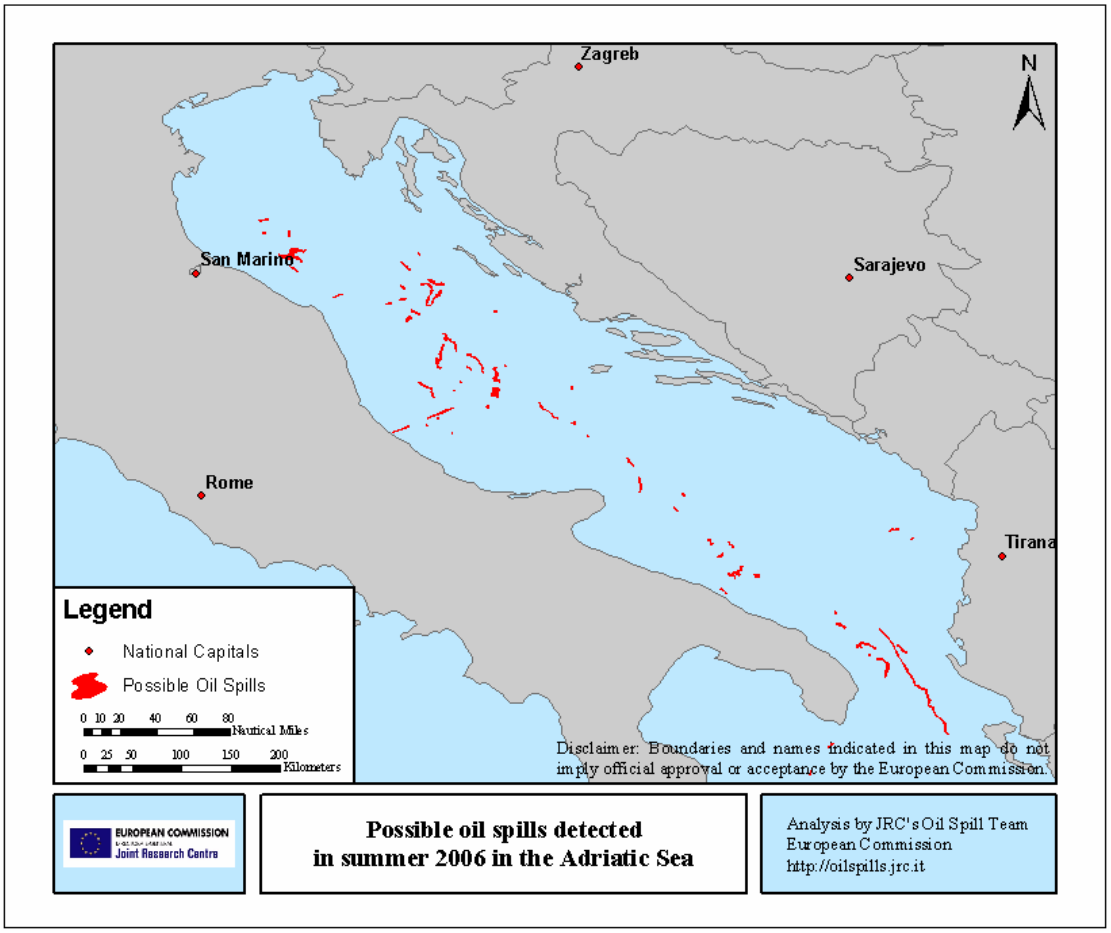

Fig.9 Possible oil spills detected in the summer 2006 in the Adriatic Sea, 2nd phase of the AESOP project.

IV. Discussion and conclusions

The results obtained during the AESOP pilot project represent an encouraging step towards the prevention and monitoring of illicit discharges in the Mediterranean Sea and highlight the need to continue the exercise of fine-tuning the operational procedure leading to the prosecution of offenders.

When evaluating its relevant outcomes, one should take into account the fact that the project was implemented without specific funding and that all activities were carried out by Partners at their own expenses. As a consequence, planned activities, particularly aerial surveillance, were sometimes compromised and alternative solutions were provided by all Partners to reach the objectives. In particular, during the first phase, oil slicks detected with high confidence by satellite were validated subject to aircraft and/or patrol boats available in the area. Furthermore, validation activities led to the activation of antipollution measures and to the collection of evidence for prosecuting the offender.

The outcome of the second phase of the project confirmed the fundamental need of verifying the pollution suspicion by aerial surveillance. Indeed, according to previous experience on the use of satellite imagery, it is extremely difficult to confirm illicit discharges by vessels, mainly because of the lapse of time which is necessary to reach the polluted site (only major pollution events may represent an exception). Bearing this in mind, a possible reason why presumed oil slicks detected by satellite during the project could not be validated is that the slicks moved to a different position and/or were dispersed by the time the patrol boat arrived on site. In such cases, the use of models able to predict the movement of the spill could be essential.
Finally, it should be noted that the AIS system proved to a very useful tool for identifying the polluting ship.

Although AESOP was drafted as a pilot project of limited duration and commitment, the results achieved by the project demonstrated that there is a room for future developments in the field.

It is now clear that one of the main limits of the project was the unavailability of the aircraft, which obliged the ICG to rely on patrol boats for the relevant operations. Future exercises should take advantage of the experience gained through AESOP and ensure the availability of the necessary aerial means to carry out the activities. Knowing also that the ICG has recently equipped one of its aircrafts with a Side Looking Airborne Radar (SLAR), which was not available during the AESOP project, it may be envisaged to carry out another campaign in order to further investigate the reliability of the system. This would give the opportunity to cross-validate data of the same nature (radar images) but deriving from different sources (satellite and aircraft).
Finally, with a view to strengthening the capacity of all coastal States in combating operational pollution at sea, it is recommended to develop similar activities in the Mediterranean region.

Reference:

Ferraro, G., Bernardini, A., Matej, D., Meyer-Roux S., Muellenhoff, O., Perkovic, M., Tarchi, D., Topouzelis, K., 2007. Towards an operational use of space imagery for oil pollution monitoring in the Mediterranean basin: A demonstration in the Adriatic Sea, Marine Pollution Bulletin, 2007, in press.

Delgado, L., Kumzerova, E., Martynov, M., Mirnyj, K., Shepelev, P., 2005. Dynamic simulation of marine oil spills and response operations. In; Brebbia, C.A., de Conceicao Cunha, M. (Eds.), Coastal Engineering VII. Modelling, Measurements, Engineering and Management of Seas and Coastal Regions. WIT Press, pp.123-133.