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THE EUROPEAN CONTROLLING SYSTEM TO REDUCE OIL DISCHARGES IN THE SEA

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Abstract

Ship-origin operational discharges of oil mainly include the discharge of bilge water from motor rooms, fuel oil sludge and oily ballast water from fuel tanks. Also, various tankers can illegally discharge of tank-washing residues. Accidental discharges can appear when ship collide or come in distress at sea (e.g. engine breakdown, fire, explosion, pipeline breaks).

There is necessity of continuous inspection of marine shipping routes, especially in environmentally sensitive areas (e.g. whole Baltic Sea). If protection against oil pollution is considered - the coastal nations of the North Sea are formed in the Bonn Agreement, whereas coastal nations of the Baltic Sea are formed in the HELCOM convention. Both organizations carrying out the international aerial surveillances and manage international oil-combat systems. Unfortunately, air surveillance can operate mainly in good weather, good visibility and in daylight.

The surface of the whole world is observed independently on the time of day and weather by antennas of Synthetic Aperture Radars (SAR) of dozen military satellites with resolution of several meters. Some civil satellites equipped with SAR, supply every few days a set of signals which in ground-based centres are transformed to image of a define area of the sea surface. In these images, the shapes of places, which can be interpreted as polluted by an oil film, are shown. The system is introduced after EU directive and managed by European Maritime Safety Agency (EMSA). EMSA has developed the CleanSeaNet service - a satellite based monitoring system for marine oil spill detection.

Advantages and limitations of the SAR-methods are discussed in this study. Physical, meteorological and hydrological as well as organizational conditions for effective use of this system are considered.

***Keywords**: marine transport, oil pollution detection, satellite surveillance, CleanSeaNet*

1. Introduction

Oil residuals in the sea were recognized as an environmental problem in the middle of the last century. Replace marine coal engines for liquid fuel ones has resulted in appearance of a number of visible stains on sea surface - similar to the whale oil stains. Initially the sea was treated as an unlimited trash container. However, the inconveniences arising from the presence of oil stains resulted in modifications of the international law by including the rules for the protection of the seas and oceans against pollution by oil. In the field of protection of marine environment against oil pollution, major importance has the Marpol Convention, particularly Annex 1 [1], and the Helsinki Convention, particularly Annex 4 [2].

Above-mentioned “inconveniences” can be incidental or chronic. “Chronic” ones (arise as a result of frequent but almost unnoticed oil discharges which are unintentional - one can say “technological” or “operational”) - influence marine environment in a scale of a long term, whereas “incidental” ones (as a result unusual but substantial discharges, more than several litters) impacts environment rapidly, with visible results (oiled birds, denatured cultured and fishing marine organisms, dirty beaches) [3-5]. This type of discharges appears often as a result of intentional discharges or from the negligence, and must be quickly detected to identify who is guilty of environmental degradation and to address requests for compensation of financial losses and expenses of oil spill combating.

The most effective way to detect oil spill is a visual observation at different angles and the best way of documentation is a set of photographs at different heights and directions in relation to the Sun. Unfortunately there is low probability that the air inspector will be in the moment of oil spill over its surface. So observation devices have to be installed on the aircraft or satellites to collect information from a much larger area than the eye. These devices use ultraviolet and infrared light to produce images showing shape and thickness of the spill. These devices are able to operate only in a good weather conditions.

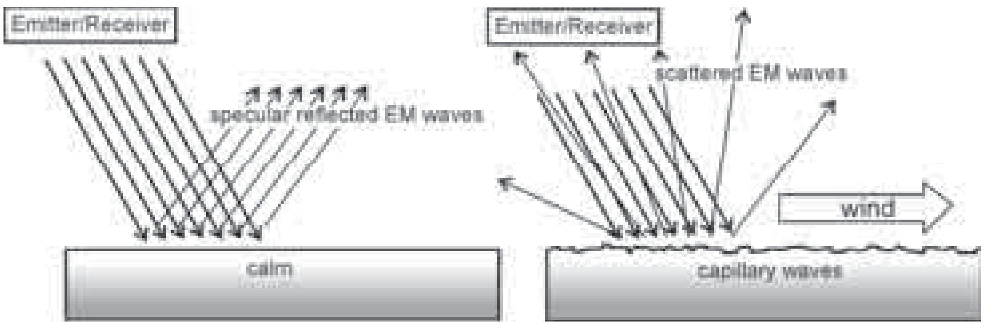

Fig. 1. Principle of capillary wives (roughness of the sea surface) detection using radar method

Method in which oil spillage can be detected even at night and in bad weather, is the radar method. In this method, electromagnetic wave reflected from sea surface is received. Naturally, the transmitter and receiver are placed in the same point (installed for example on the underside of the aircraft). Therefore, the receiver records the waves that are spread out from the sea surface being scattered on the rippled surface. Dimensions of surface irregularities must be similar to the length of electromagnetic waves (several centimetres). In this case, the electromagnetic waves are scattered is the most efficient, therefore the strongest signal reaches the receiver (Fig. 1). Surface waves with lengths of several centimetres are formed during movement of air masses along the water surface. In this case, following the adhesive strength of particles of water and air particles, the friction of air and the natural heterogeneity of the air density air pressure fluctuations occur at the interface of air-water. Following this phenomenon, the water surface is wrinkled. This kind of waves is called capillary waves.

In a presence of oil film, capillary waves are dumped, therefore radar signals from area polluted by an oil film decreased.

2. Radars operationally used for oil spill detection

2.1. Side-Looking Airborne Radar

The Side-Looking Airborne Radar system (SLAR) is a radar system mounted on aircrafts receiving electromagnetic waves perpendicular to the direction of flight. Ships, land, ice, oil spills, wind speed (and direction), currents, tides or even internal waves or upwellings radar echoes can be visible up to several dozen kilometres to both sides of the aircraft.

Side-Looking Airborne Radar is used as one of devices for aerial surveillance. The operator located on the board of the aircraft watches the surface of the sea displayed on the monitor screen, where for various reasons disappeared capillary waves. One reason for the disappearance of capillary waves may be an oil film.

2.2. Synthetic Aperture Radar

Synthetic-aperture radar (SAR) is an advanced form of above mentioned the side-looking airborne radar (SLAR). SAR is usually implemented on a moving platform such as an aircraft or spacecraft (satellites), a single beam-forming antenna from which a target scene is repeatedly illuminated with pulses of electromagnetic waves at wavelengths from several dozen centimetres down to millimetres. The reflected-scattered waves received successively at the different antenna positions are coherently detected and transmitted to ground station for further processing to produce an image of the target region. SAR images have wide applications in remote sensing and mapping of the surfaces of the Earth. Greatest of SAR satellite applications are military ones. A little part of SAR images are purchased for environmental applications. In Europe, and also in the Baltic region the European Maritime Safety Agency (EMSA) [6] buys a certain number of images of marine areas created by SAR technique.

In the field of satellite detection of oil spots, only radar technology has far developed stage, reaching full operational level. The satellite flew over the supervised area sends a set of data that in the ground station is processed and displayed with gradation of gray showing the state of the sea surface roughness, but only in form of capillary waves. Gravitational waves are not visible. In these pictures, degree of intensity of capillary waves exhibit a variety of phenomena, such as internal waves, upwelling, plankton bloom, ocean currents, and - of course - the wind-wake zones. Because oil spills in radar images have characteristic contours, and often are associated with the ship discharging oil (silhouettes of ships manifest themselves in white), therefore using special algorithmic criteria can be automatically "captured".

Several dozen satellites are equipped with SAR technology. Most applications of this technique refer to the economic and military issues. Currently, the use of "favours" of this technique is possible only in countries with its own satellites with SAR equipment. An example is Germany, which, thanks to civil satellite TerraSAR-X (2007) and 5 military satellite systems SAR-Lupe (2008), being able to continuously monitor an area almost the whole globe (sea & land). At the present, only a few satellites with SAR equipment are used in oil spill detection. They are:

– RADARSAT 1 (from 4 November 1995, Canadian Space Agency),
– RADARSAT 2 (from 14 December 2007, Canadian Space Agency),
– ERS 1 (from 25 July 1991, European Space Agency) - from 10 March 2000 not working,
– ERS 2 (April 21, 1995, European Space Agency) - to 2011,
– Envisat (March 1, 2002, the European Space Agency),
– COSMO-Skymed (Italian Space Agency ASI, a constellation of four satellites).

It should be noticed that satellite technologies other than radar techniques are not operationally used in the detection of oil pollution in the sea.

3. CleanSeaNet system

European Directive from 2005 year (No. 2005/33/EC) "... on ship-source pollution and on the introduction of penalties and refringements" have resulted in establishing the European agency for safety at sea, the European Maritime Safety Agency - EMSA, based in Lisbon. This agency has led to a decentralized institution called CleanSeaNet [8], which organizes and manages a system to detect oil spills at sea throughout Europe, and the rapid distribution of information on the likely spillages and to verify truthfulness of alarms.

CleanSeaNet has steering group that is the European Group of Experts on Satellite Monitoring of Sea-based Oil Pollution (EGEMP). In the Polish case, Maritime Offices are users of CleanSeaNet. The system is available for SAR image editing schedule different areas of Europe and the image from archival database. Each edition is an image associated with the diagnosis for the identification of oil-contaminated areas with an evaluation of credibility in the three-step scale. Among the information on a given edition is the original image area. An example is shown in Fig. 2. In a magnified part of this area, there are two black spots that could be areas covered with an oil film (Fig. 3).

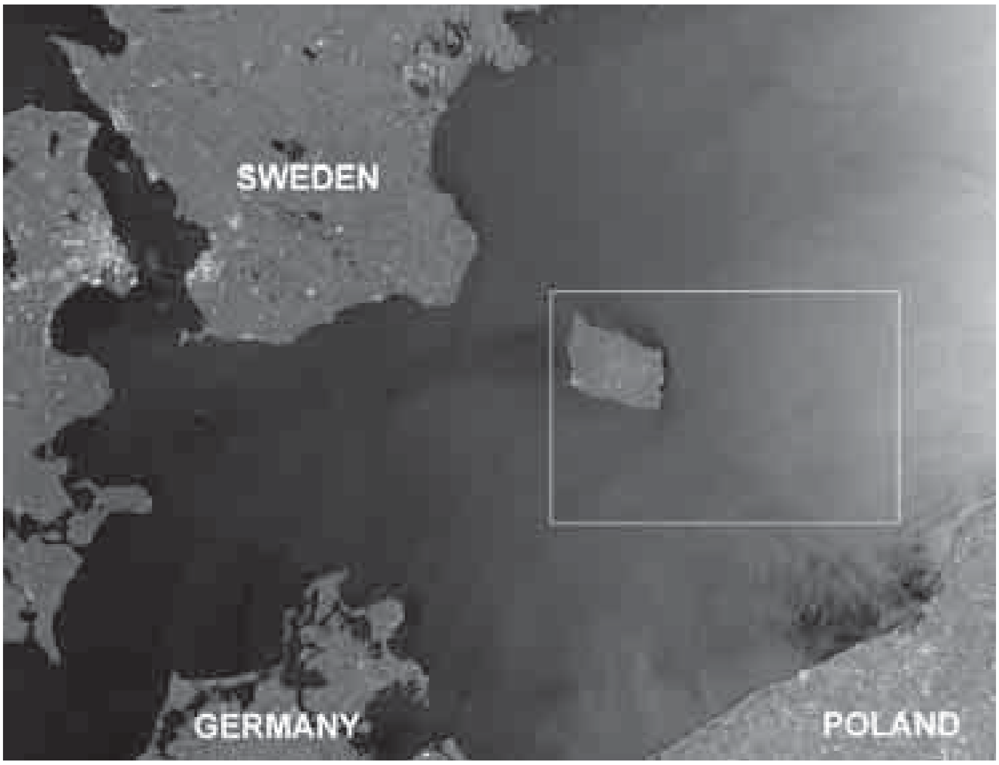

Fig. 2. Exemplary SAR-image for Southern Baltic Sea. Image obtained from CleanSeaNet [7] and processed by the author (contrast adjusted to the area near the Polish coast). Several other oenological phenomena like upwelling and oscillations of atmospheric pressure close to seashore in the lower part of the picture are visible

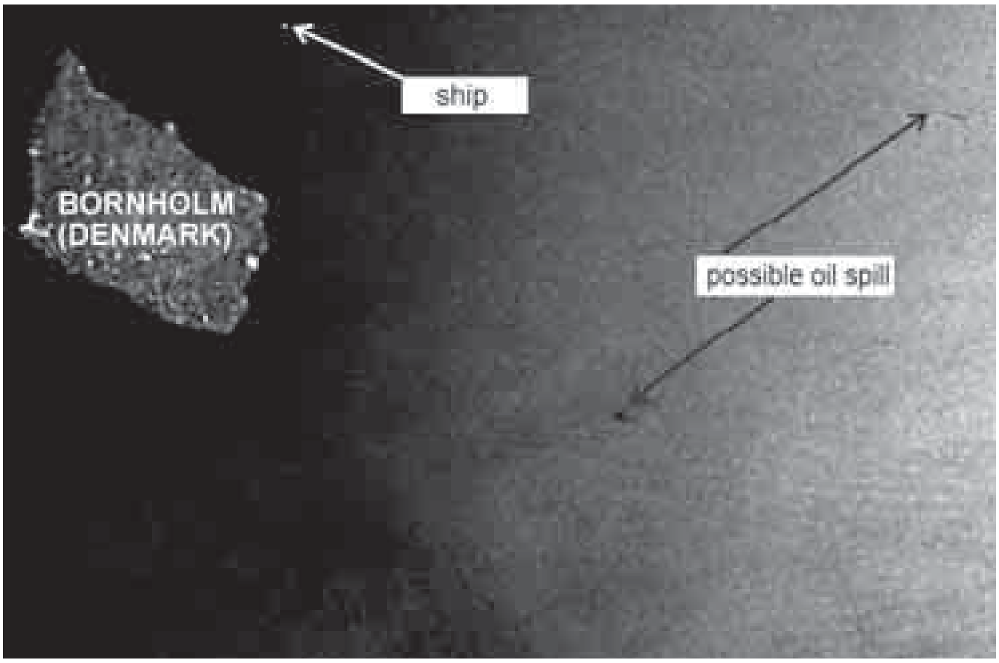

Fig. 3. Enlarged and contrasted part of an image at Fig. 2

4. Oil spill informative system

After the CleanSeaNet alarm which informing that define area can be polluted by oil, starts the procedure to confirm the reality of the oil spill. Oil spill can be confirmed by aerial or marine patrol as well as by units passing near the spill at the moment - at the present there is full possibility of tracking all vessel in the world-ocean in the real-time. Baltic Sea area is divided into responsibility zones between all Baltic countries. In case of Poland, three Maritime Offices (Gdynia, Slupsk, Szczecin) have possibility of immediate voice communication with all vessels in the Polish marine areas.

If the alarm appears to be real and indicates large extent of oil spill as well as the risk to the marine environment, the procedure leading to the decision on the use of measures to combat the oil spill begins. Also, the procedure for the preservation of samples for chemical analysis and the procedure to determine the source of the contamination begins. If it is suspected that it is a define vessel, samples from all installation are collected.

Possibility of determining if define vessel is guilty of discharging of oil, thanks to modern technology and organizational systems, is very real. Especially useful are two following systems: the SeaTrack Web (for prediction of movement of the spill route at the time of both forward and backward) [8] and the real-time vessel traffic and positions service based on Automatic Identification System (AIS) [9]. Both services are available only for governmental institutions; in Polish case only above-mentioned Maritime Offices and Maritime Search and Rescue Service (at Gdynia, Poland [10]) are designed to this activity.

The SeaTrack Web delivers various services including spill trajectory tracking (Fig. 4). It is possible thanks ongoing replenishment data on weather and marine currents - the most useful is the ability to determine where there was a spill at different times. This, in connection with history of nearest ships positions, gives information which ship is a source of oil pollution.

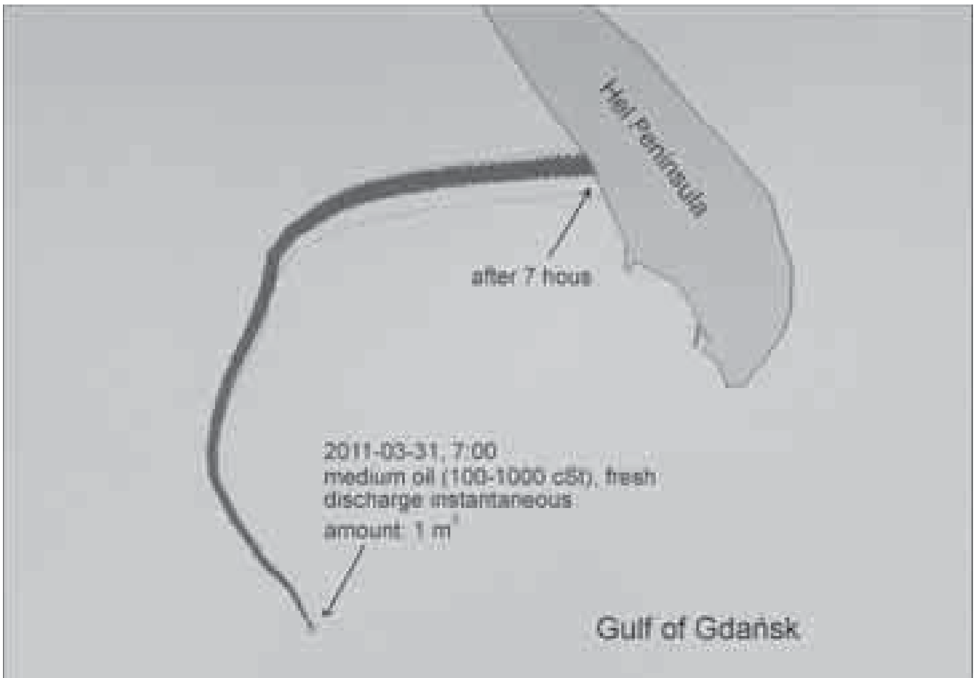

Fig. 4. An example of oil spill track scenario created by SeaTrack Web. Oil spill is hypothetical, whereas currents and wind velocities – real (by courtesy of Dr. C. Ambjörn, from SMHI [8])

Summing, the European organizational system for reducing oil spillages in marine areas consists of several entities, namely: decentralized organization the CleanSeaNet [7] operates under auspices of the European Maritime Safety Agency [6], SeaTrack Web maintained at the Swedish Meteorological and Hydrological Institute, Automatic Identification System (AIS) operating under Regulation 19 of International Convention for the Safety of Life at Sea (SOLAS) and domestic institutions (depending on country: Maritime Offices, Coast Guards).

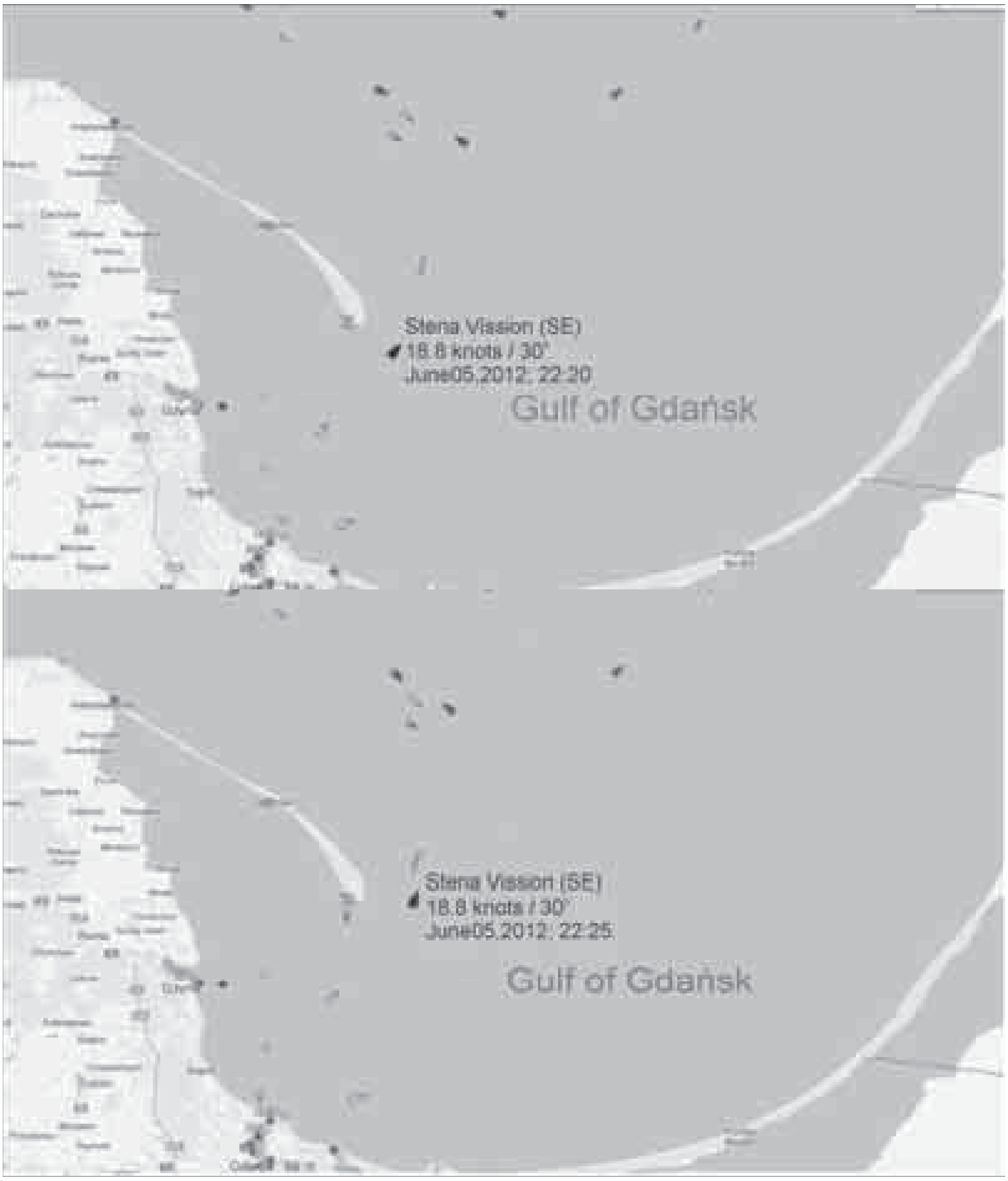

Fig. 5. Visual example of present possibilities of vessel traffic tracking (the Gulf of Gdansk in June 05, 2012 from 22:20 to 22.25). Modified after „Live Ships Maps – VTS – Vessel Traffic and Positions"[10]

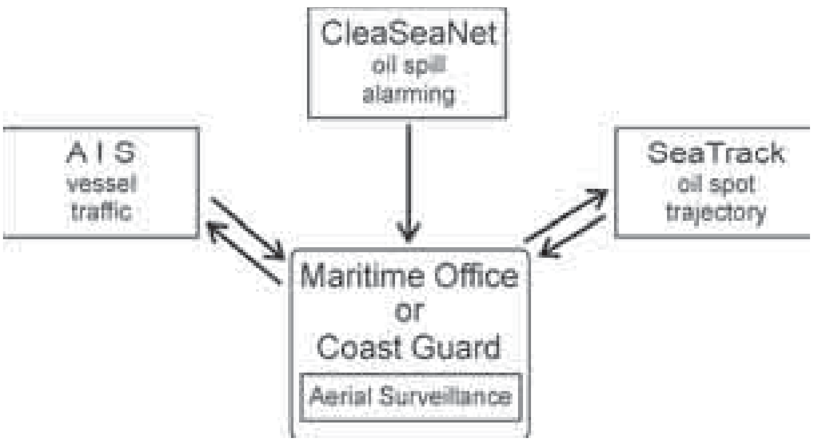

Fig. 6. The Baltic operational system for oil spill detection and source identification

5. Final remarks

In define day the (civil) SAR technique covers only small part of the world's ocean and watching define marine area is possible only every few days. On the other hand, the multispectral technique predicts a slight chance of automatic detection of spillages and is not used continuously. Only the combination of SAR techniques and multispectral images could improve the effective tracking the size and extent of oil spill, and improve the precision of tracking the route of his movement.

Theoretically it is possible to cover completely marine areas by satellite detection in SAR technique (even with the current technical potential), but it appears to be viable (in terms of gradation needs - military-intelligence tasks are priority). Therefore, the current operational satellite detection systems are to serve as a more deterrent and preventive than a real controlling system. Perhaps this feature will soon also be disputable due to availability of information on where and when the satellite holding the detection system passes.

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