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A Review Analysis of International and Greek Databases Concerning Oil Spills: The Case of a New Greek Oil Spill Database

Nikolas P. Ventikos, Konstantinos P. Dilzas & Harilaos N. Psaraftis
Department of Naval Architecture & Marine Engineering, NTUA
Athens, Greece

ABSTRACT

In general, the problem of oil marine pollution is considered to be of extreme importance for the marine environment. It is a well-known fact, that detailed databases concerning oil spill incidents, are the necessary means for a realistic statistical analysis. In this paper, we will present the findings from a review analysis of databases, which include oil spill data. Then we will focus on the way that the Greek oil spill database was developed. We will conclude the description of the aforementioned database by defining some basic points of its statistical analysis and by exhibiting some corresponding indicative results.

KEY WORDS: oil spills, statistical analysis, strategic approach, risk assessment

INTRODUCTION

The problem of marine pollution and especially its part of oil marine pollution is a global disagreeable reality, that needs a continuous and effective confrontation. In this field, the exact meanings of terms such as "*effective confrontation*" or "satisfying clean-up operations" are characterized by a high degree of uncertainty and subjectivity. Moreover it is a known fact, that only the visible to the naked eye sea pollution is usually being cleaned-up effectively. It is also known, that the corresponding efforts - especially in case of cleaning-up large oil spills - are ruled exclusively by the public opinion and the consequent political cost. Finally, in some oil spill incidents, the need of immediate anti-pollution action has led to bigger catastrophes than oil spills themselves (*Amoco Cadiz* 1978).

In the context of a statistical analysis, the selection of the proper factors for the description of the theoretical distributions, is a really hard and complicated effort. For instance, the large fluctuation of oil spill sizes may distort the whole procedure and lead in many cases, to erroneous results. Moreover, according to the US Coast Guard, the average size of oil spills in the American territorial waters for the year 1982, was 2290 gallons. Despite of that, the 55% of the aforementioned registered oil spills were at least 20 times smaller than the average one. Additionally, the 61% of the total spilled oil came from only two oil spills that were recorded to be about 4000 times bigger than the average one (Psaraftis, 1987).

The structure of the paper is as follows. In the next two sections we review the relevant literature (databases) worldwide and for Greece, respectively. In the following section we provide a description of the newly introduced Greek database followed by another section where we present some indicative results based on it. The last section completes the paper with the conclusion and some remarks.

INTERNATIONAL OIL SPILL DATABASES

Statistical analysis of databases concerning oil spills is a very important means to help facing and preventing marine pollution, in the better possible manner. Taking advantage of the existing recorded experience is frequently necessary to use it for a successful time projection of the corresponding data, in a certain time period.

Thus, the Lloyd's Maritime Information System (LMIS) database is the first one presented in this paper (Psaraftis, Ventikos et al, 1999). It separates the analysis in two sections, one that focuses on the region of the North Sea and the other one that covers the accidents in a worldwide basis. Lloyd's gives the following definition of accident oil spills: "*An accident oil spill is the loss or leak of hazardous substances into the environment from the ship or ships that are involved in a marine accident*". The examined LMIS database covers the time period from 1978 to 1997 and concerns ships greater than 100 GRT. Totally, 18691 records of accidents were recorded, regardless of their polluting results.

The second database examined was the one created by the International Tanker Owners Pollution Federation (ITOPF). This version of the database covers the time period from 1974 to 1997 with almost 10000 oil spill records (Psaraftis, Ventikos et al, 1999). ITOPF have under observation approximately 6800 tanker ships, combined vessels and barges that total up to a capacity of 166000000 GRT, which is about the 98% of the corresponding worldwide capacity. This database deals with both accident and operational oil spills. Specifically, 83% of all records of the ITOPF database refer to small oil spills that have a size of less than 7 tons. In general, the size of the recorded oil spills can be divided into three main categories: the small ones (less than 7 tons), the medium ones (between 7 and 700 tons) and the large ones (bigger than 700 tons). The main disadvantage of this database is that the oil quantity that was burnt or remained into the foundered vessel is included in the recorded oil spill size.

Sufficient data about oil spills were also found in the data files of the UK P&I Club (Psaraftis, Ventikos et al, 1999). The analysis that has been done is focused not only on the number of the accidents that led to

marine pollution, but also on the total amount of compensation that was endorsed for each accident. Grounding (drifting & powered) is presented to be the most costly cause, with 20% of claims from marine pollution incidents. For the time period from 1987 to 1996, the 50% of the relative compensations was charged to grounding whilst in the time period from 1987 to 1992, this percentage was at 40%.

The next database examined was the database for accidents of the Institution of Chemical Engineers (IChemE). The examined database contains numerous of records covering the time period from 1911 to the October of 1997 (Psaraftis, Ventikos et al, 1999). Some of those records are referred to marine accidents that led to sea pollution and have a detailed description of their consequences to the marine environment as well as to the human health generally.

It is of great importance to define the way that this database was structured. The consequences to the environment after an accident are divided into the four following categories:

I) Oil spills,
II) General pollution,
III) Ecological destruction and
IV) Dangerous gas releases.

From the 540 sea and 86 river incidents of possible marine pollution that are included in the IChemE database, the 48% and 73% respectively, are responsible for very serious environmental damages. The oil spills are responsible, according to this database for the 2/3 of the marine accidents that led to ecological consequences.

Then it was examined the database created in the context of the European research program SAFECO II with the contribution of the Norwegian Register DNV (Det Norske Veritas). This database contains 433 records relative to marine pollution from vessels, with 387 of them referring to oil pollution (Psaraftis, Ventikos et al, 1999). It is worth mentioned that the database from SAFECO II contains exclusively pollution incidents resulting from naval accidents and not from other causes (e.g. loading/discharging, bunkering etc).

Another database is the one that was structured by the CUTTER INFORMATION CORP. The examined version of the database covers the time period from 1960 to 1995 and contains data for about 1720 oil spills over 10000 gallons (Psaraftis, Ventikos et al, 1999). The main disadvantage of this database is that it covers mainly the region of the USA.

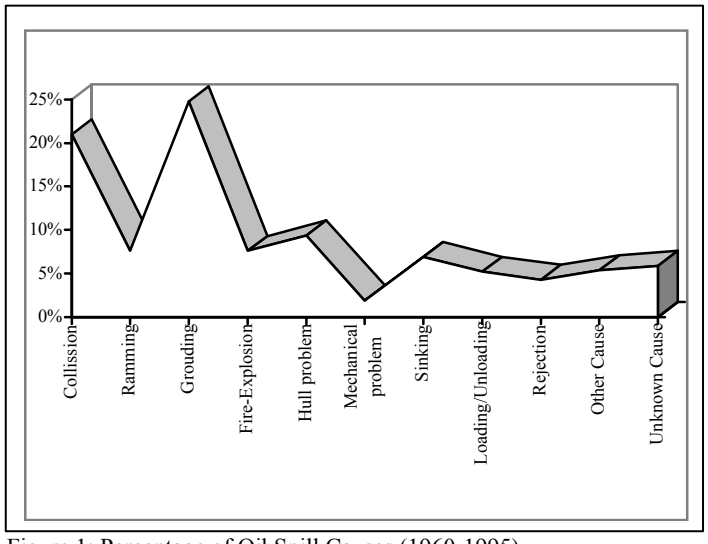


Figure 1: Percentage of Oil Spill Causes (1960-1995)

Figure 1 depicts the magnitude (percentages) of various causes concerning sea oil pollution. As it seems Grounding and Collision are the most common causes that lead to the formation of oil spills.

The database that was created under the umbrella of the European research project SAFECO I was examined. This database has to do only with marine accidents that happened in the year 1994 (Psaraftis, Ventikos et al, 1999). From the 2049 records of the database, only 377 (18%) had simply a confirmed answer to the question: "Has the marine accident led to a pollution or not?" Due to lack of further data the above percentage is very small and not enough to establish this database as a very useful one for the certain study

Next follows a brief description of the SPILLASE database (international part). The SPILLASE database was based on the REMPEC database, which covered the Mediterranean Sea for the time period of 1978 to 1995 (Psaraftis, Ventikos et al, 1999). The analysis of the SPILLASE database coped mainly with the quantities of oil that leaked into the sea and its results were confirmed from the international bibliography (Ventikos, Psaraftis et al, 1998). Table 1 is an indicative example of those results.

Vessel Size	SINK	GR	FIRE-EXP	MECH	HULL	COLL	OTH	TOT
Very Small	1.0	1.0	0.0	0.0	0.0	1.0	1.0	4.0
Small	0.5	3.5	1.0	0.0	0.5	2.0	3.5	10.9
Medium	1.0	1.5	1.5	0.0	0.0	5.0	5.4	14.4
Big	0.0	3.0	0.5	0.0	1.5	1.5	6.4	12.9
Very Big	0.0	0.0	0.5	0.0	0.5	0.5	3.0	4.5
Not known	1.5	1.0	0.5	0.0	0.0	1.5	6.9	11.4

Table 1: Pollution Possibilities per Accident Type (per 100 vessels)
Source: (Ventikos, Psaraftis et al, 1998)

GREEK OIL SPILL DATABASES

The starting point is the analysis of the SPILLASE database (Greek seas), which has been based on data from REMPEC (Ventikos, Psaraftis et al, 1998). Thus, from the initial analysis of the SPILLASE's raw data, the oil pollution in the Greek seas was examined in association with the oil pollution of other Mediterranean countries. An indicative result is shown in Figure 2. It clearly shows that the majority of the recorded oil spills in the Mediterranean Sea concern mostly the Greek and the Italian seas. Nevertheless, from such an analysis, it is not difficult to arrive to erroneous conclusions as far as the Mediterranean countries' venturousness is concerned (Ventikos, Psaraftis et al, 1998). Furthermore, this kind of analysis is not quite suitable for realistic comparative procedures. It ignores consequently the fact, that the number of oil spills in one country may differ from the corresponding number in another country, due to several reasons, such as different size of shoreline, different geographical morphology etc.

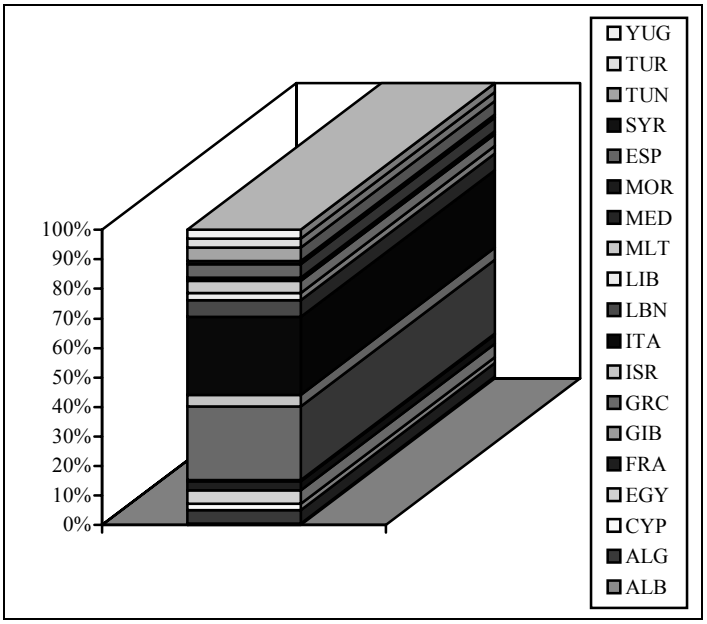


Figure 2: Allocation of Oil Spills in the Mediterranean Sea

The next database examined was the LIMENAR3 database, which includes oil spills that formulated exclusively in the Gulf of Saronikos. The corresponding data came from the Hellenic Mercantile Marine Ministry and from the various local port authorities. The total record number of this database (195 records) can be considered as sufficient enough for the covered time period (1990 to 1995), since the corresponding analysis for the Mediterranean Sea was based on a database of only 200 records. Of course comparing to other international spill databases - e.g. the one of the US Coast Guard with 10000 entries for the time period 1970-1972 (Ventikos, Psaraftis et al, 1998) - the specific number of records can be considered as small. This fact stresses out the disadvantages of the spill recording system in the Mediterranean Sea in general, and more specifically in the Greek seas.

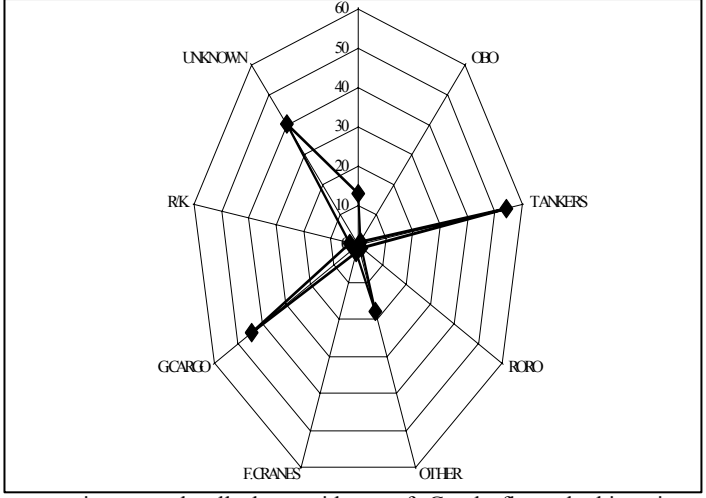
Figure 3 illustrates how the oil pollution in the Gulf of Saronikos is allocated per ship type for the chosen time period (1990 to 1995).
Figure 3: Analysis per Ship Type Responsible for Oil Pollution in Saronikos Gulf

Next, it was decided that some interesting statistical factors concerning the medium sized oil spills (1-99 tons) should be presented in Table 2. This oil spill category is the most frequent one in the LIMENAR3 database for the time period from 1990 to 1995.

STATISTICAL FACTORS	**VALUES** (tons)
AVERAGE VALUE	~12
STANDARD DEVIATION	~19
VARIANCE	~359,6
MOST FREQUENT VALUE	2,97

Table 2: Statistical Quantities for Medium Sized Oil Spills (1990-1995)
Source: (Ventikos, 2000)

The next examined database coping with oil pollution in the Greek seas was the accident database from the Hellenic Mercantile Marine Ministry. It must be noted that the specific version of this database



covers in general, all the accidents of Greek flagged ships, in a worldwide basis. The total number of records registered in the database is 1354. Unfortunately, the quality and density of these records from a marine pollution point-of-view are very small, so it is very difficult to conclude to any realistic and credible result.

DEVELOPMENT OF THE HELLENIC OIL SPILL (HELLIOS) DATA BASE

The Hellenic Oil Spill database (HELLIOS) is the new Greek database that was developed in the context of oil spill prevention and confrontation (Ventikos, 2000). One part of this database, under the name of HELLAS-SPILL, includes records of oil pollution incidents that cover all the Greek seas. The number of these records adds up to 251 covering the time period from 1979 to 1999. An important factor is that a very big portion of them (about 85%) seems to cover the years from 1990 to 1995. Another part of the HELLIOS database, under the name of BAY-SPILL, contains all the confirmed records for marine pollution in the Gulf of Saronikos. This version of the database adds up to 229 records and covers the time period from 1980 to 1999. Once more a large portion of them (about 91%) seems to cover the six-year time period from 1990 to 1995. Figure 4 schematically shows the procedure that was followed in order to collect and develop both of the fragments of the HELLIOS database. Hence, the only criterion that was used in the separation of the two aforementioned parts (for Greece and solely for the Saronikos Gulf) is the accurate geographical boundaries of the examined areas.

HELLAS-SPILL and BAY-SPILL databases (the two components of the HELLIOS database) contain the following major information fields (Ventikos, 2000):

- **DATE:**
Month, Year.
- **INVOLVED SHIPS:**
Ship Type 1-2, Ship Flag 1-2, Destination Port 1-2 etc.
- **GEOGRAPHICAL REGION:**
Geographical Longitude and Latitude, Port Authority, Region, Country.
- **CASE:**
Cause 1, Cause2, Cause 3, Responsibility etc.
- **POLLUTION:**
Quantity, Type of Polluting Oil etc.
- **POLLUTION MAGNITUDE:**
Length of the Coast, Fishes' Mortality, Recovering Time etc.
- **ECONOMICAL FACTORS:**
Property Loss, Damages to Third Parties, Total Cost etc

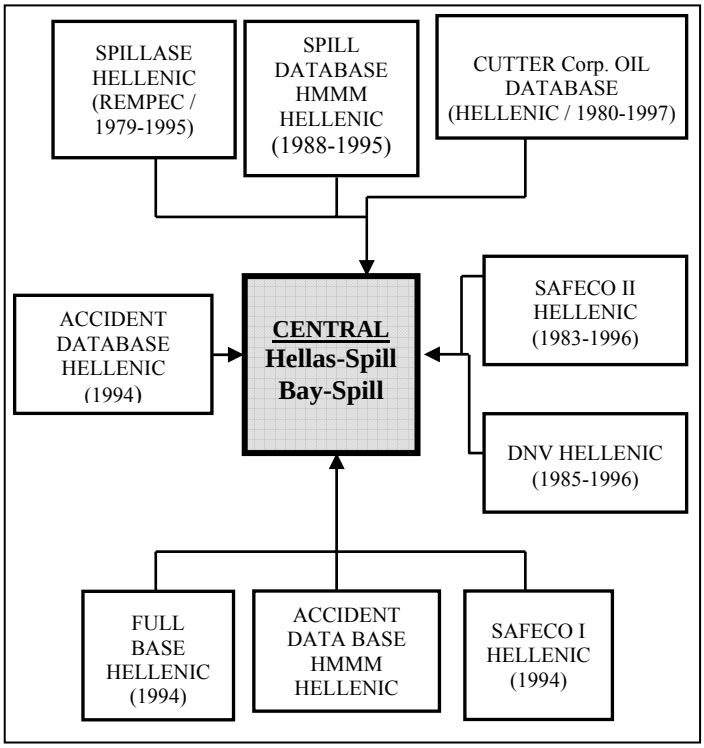


Figure 4: Development of the HELLIOS Database (HELLAS-SPILL & BAY-SPILL)

The specific Greek database can be found and examined in the following forms:

1) with records of oil spills generated from all types of ships in Greek seas,
2) with records of oil spills generated only from tanker vessels in Greek seas,
3) with records of oil spills generated from all types of ships exclusively in the Gulf of Saronikos and
4) with records of oil spills generated only from tanker vessels exclusively in the Gulf of Saronikos.

Moreover, the statistical effort and method was similar for all the above four versions of the examined HELLIOS database, in order to reach to some solid, comparable and realistic results.

The implemented (statistical) analysis combines the examination of the number of the recorded polluting incidents with the corresponding leaked quantity of oil. Thus, it can be noted that this amount of leaked oil may be able to give a first impression of the real environmental significance for each oil spill (even as a gross estimation). Furthermore, the aforementioned implementation of the simultaneous examination of the number and quantity for oil spill incidents can provide the necessary means to formulate a certain strategic approach in relative matters. In this way, oil marine pollution can be studied in the context of a joined effort from a preventive and strategic point-of-view. In accordance with this outline, all oil spills are being analyzed through the introduced magnitudes of the "*statistical venturousness*" and the "*pollution potential*". Nevertheless, the presentation of these two factors is not in the scope of this paper.

RESULTS FROM THE ANALYSIS OF THE HELLENIC OIL SPILL (HELLIOS) DATABASE

The presentation of the chosen indicative results begin with the analysis of the type of vessels involved in cases of oil marine pollution.

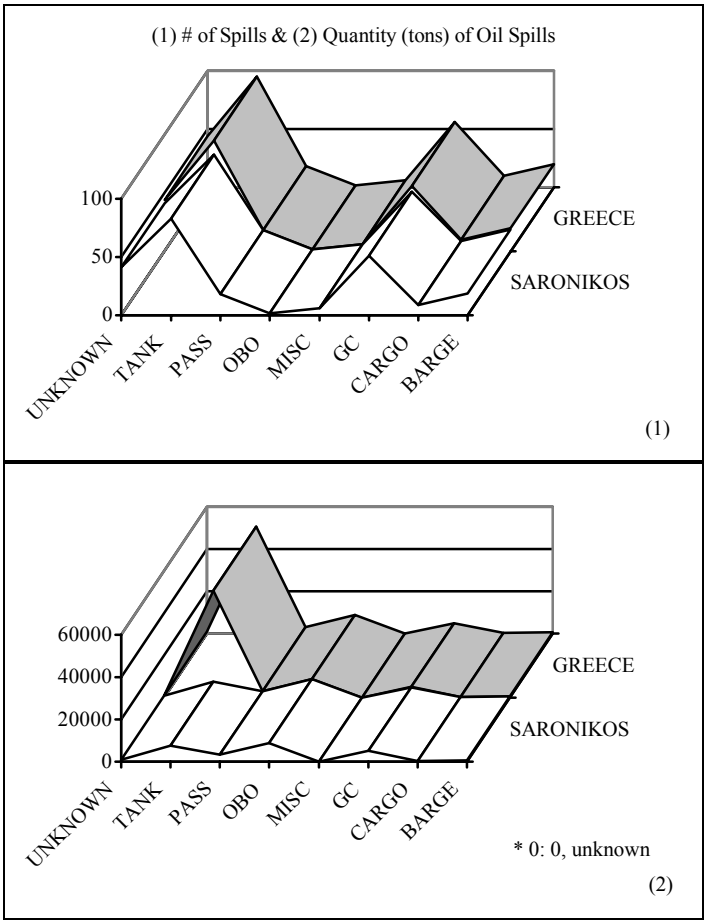


Figure 5: Comparative Results for Oil Marine Pollution per Ship Type (1979-1999)

It is clearly shown from Figure 5, that tanker vessels are the most common and important ones from oil marine pollution point-of-view. But taking into consideration solely the quantity of the leaked oil in all those cases, the situation seems to change, especially for the Gulf of Saronikos. Thus, tankers can be characterized as the most important marine pollution sources when taking into account the oil quantities that pollute all of the Greek seas. The results are presented quite different when the Gulf of Saronikos is individually examined. In this case, the category of the combined vessels (e.g OBOs) seems to be the most responsible one for oil marine pollution leaving tankers in the second place.

	GREECE (tons)
Linear Prediction for Marine Pollution (Greek Ships – 2000)	3067
Confirmed Linear Projection	49%

TABLE 3: Linear Prediction for Marine Pollution in Greece from Greek Ships
Source: (Ventikos, 2000)

Table 3 illustrates the quantitative prediction of the pollution magnitude caused by Greek flagged ships operating in Greek seas. In this case, the predicted pollution magnitude reaches up to 3067 tons of spilled oil for the year 2000, regardless of the actual type of the involved ships. However experience shows that until now, the certain approach gives a confirmation percentage of about 49%.

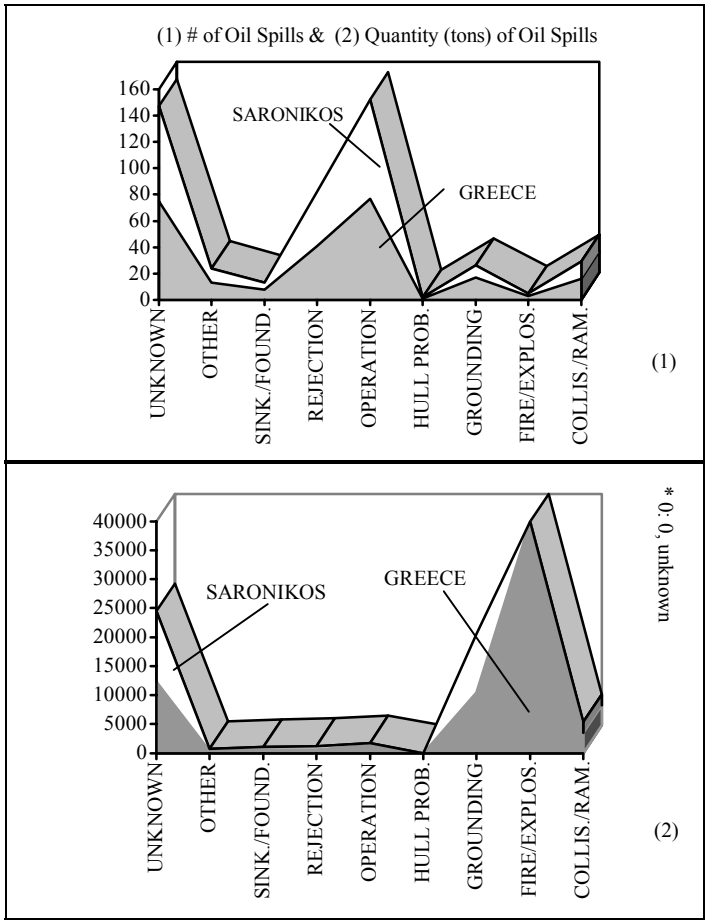


Figure 6: Comparative Results for Oil Pollution per Cause of Incident (1979-1999)

The results of the above mentioned analysis (Figure 6) are characterized by the high number of the unknown causes for oil marine pollution incidents, both for the number of oil spills and for the quantity of leaked oil. Emphasis is also given to the fact that there is an already known inconsistency between the separate implementation of the number of oil pollution cases as an analysis element and the respective quantities of leaked oil. This inconsistency becomes more obvious in some accidents (e.g. collision fire/explosion, grounding etc), where although the total number of accidents is small, the quantitative contribution of them to the marine pollution is extremely high. On the contrary, incident categories such as "Rejection" or "Port Procedures" present a large number of confirmed spills, but a low corresponding quantitative contribution to marine pollution. Moreover, Tables 4 and 5 depicts clearly the different attributes that can and must be spotted between accident and operational marine oil spills.

STATISTICAL FACTORS	GREECE	SARONIKOS
Average Value (tons)	6854	2112
Standard Deviation (tons)	13851	3942
Confidence Interval 95% for the Aver. Value (tons)	9598	3155
Skewness	2,5	2,3

Table 4: Analysis – Results for Accident Oil Spills (1979-1998)
Source: (Ventikos, 2000)

STATISTICAL FACTORS	GREECE	SARONIKOS
Average Value (tons)	406	206
Standard Deviation (tons)	413	271
Confidence Interval 95% for the Aver. Value (tons)	362	237
Skewness	0,65	1,0

Table 5: Analysis – Results for Operational Oil Spills (1979-1998)
Source: (Ventikos, 2000)

Some very important comments can be extracted from Tables 4 and 5. In this paper though, the attention is only focused on the fact, that the rate of quantities between the two aforementioned types of oil spills (accident and operational) varies from about 5,9% for all the Greek seas to 9,5% when the Gulf of Saronikos is exclusively examined.

CONCLUSIONS - REMARKS

It is a well-known fact that a statistical analysis can yield some realistic and logical results only if it is grounded upon a credible and an updated relative database. Furthermore, the newly introduced spill database HELLIOS was the product of an extensive and cautious merger coming from several information sources. The purpose of this task was to create a complete and truly updated oil spill database, in order to permit the implementation of a thorough statistical approach. To the best of the knowledge of the authors of this paper, this is the first time that such an effort is being held exclusively for Greek waters. The corresponding combined analysis that is based upon both the number of oil spills and their quantitative magnitude can come up with some really interesting results that can help to pinpoint some basic factors concerning oil marine pollution field.

However, closing this paper, it must be noted that from all the necessary research that was needed for the development of the HELLIOS database one fact was made clear to the authors. The monitoring and recording system of oil marine pollution generally for the Mediterranean Sea and more specifically for the Greek seas, have numerous disadvantages that they should be dealt with as soon as possible. Depending almost exclusively on the pilots of a specific airline and of the Hellenic Air Force to report a possible spill site is certainly not the proper way to advance in the 21st century. The problem can be even bigger in case of operational spills, where either the incident is never even recorded or it is in such a way, that is clearly underestimated. So it is obvious that actions and measures must be taken now, in order to protect the famous worldwide Greek marine environment.

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