

Nr. 682

Theoretische Semesterarbeit für Herrn cand. ing. Yasin Akgün



## **Marea Negra-The daily danger of tanker disasters**

### **Barcelona 2008**

durchgeführt an der Universität Politècnica de Catalunya (UPC),  
Escola Tècnica Superior d'Enginyers Industrials de Barcelona (ETSEIB).

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Abgabe: 22.10.2003

## **Dedication**

Long since I believe the following:

- All I need to know does reveal to me.
- All I need comes to me.
- Everything is good in my world.

I feel big pleasure and happiness to gather here knowledge and to make it available to those walking on the same path.

I aim this dedication to all the people who showed me that what I know: to my parents, to my loves, to my friends, to my teachers, and the Divine and Infinite Intelligence, to channel through me that what the others need to know.

## Type of problem

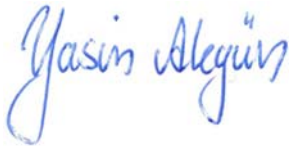
This work is designed to encourage safety improvements in the sea borne oil trade and bring about a change in the prevailing mentality, and also to examine various methods of cleaning and regenerating the seas following maritime disasters.

## Solemn affirmation

I hereby solemnly explain that I prepared the following work independently. Thoughts which are taken directly or indirectly from foreign sources are as such identified.

The work has previously been presented to another examination authority, the UPC.

Barcelona, the 30.09.2003



Yasin Akgün

## Abstract

Erika was a 25 year old product tanker with segregated ballast tanks carrying heavy fuel oil. Her statutory certification was in order and she had successfully completed a five year survey the year before the accident. An enhanced port State control inspection had been carried out in May and no deficiencies were found. She had undergone the charterer's inspection and had been found suitable for her trade. How, therefore, is it possible that the ship could have broken in two and caused such an environmental catastrophe?

Erika therefore poses a serious challenge to all concerned in the tanker industry. It clearly shows that action is necessary to look beyond the mere verification of certification and the conducting of superficial inspections if we are to prevent a repetition of such tanker accidents. Responsibility for ensuring that tankers meet the required safety and environmental standards lies with the owner and flag State. It is clear, though, that some States and owners are less conscientious than others. There is, moreover, a marked lack of transparency in this complex industry, often resulting in the identity of those persons responsible for an individual tanker being obscured behind the doors of "brass plate" companies in offshore locations. Because of this, there is a clear need for port States and responsible industry bodies to take a stronger line, particularly with respect to older tankers, to ensure that structural defects and substandard tonnage are identified well before they pose a threat to the environment. The fact that the average age of the world and EU tanker fleet is relatively high and still increasing is also of great concern. This trend has to be reversed by the introduction of newer, more environmentally friendly, tonnage.

What is needed all-in-all is a package of measures which will bring about a change in culture in the tanker industry. There should be stronger incentives for quality-minded carriers, charterers, classification societies and other key bodies. At the same time, the net should be tightened around those who seek short-term personal economic gain at the expense of safety and the marine environment.

The recent tanker disaster in the Atlantic made the reality clear, what the real effects of the "money first people later" attitude in the shipping and oil industry produces. The blame for the Prestige disaster is still to be ascertained, but the consequences of the oil spill and the long lasting effects on the environment and lives are clear. And what is becoming clearer is the constantly growing maritime traffic and the increasing pollution of

the oceans from numerous sources. For this reason, the importance of the protection of the sea is also increasing. The same disaster could happen anywhere in the world again.<sup>1</sup>

Apart from the entries of pollutants by air or rivers shipping is polluting the environment considerably, even if, compared with other transport systems, the ship is relatively environmentally friendly. Nevertheless shipping still represents a high risk. An ever increasing volume of traffic, overloaded and badly trained crews as well as old, insecure vessels are contributing to numerous ship disasters. Even if the quantity of tanker accidents decreased during the last years, maritime oil pollution through accidents still amounts to up to 5 %.<sup>2</sup>

For decades the oil and shipping industries have been permitted to control the way they operate. Money has always been at the forefront of decisions. Even when the European Union recognized that single hulled tankers are a threat to Europe's coastlines the interests of industrial commerce do take higher priority. A fifteen year breathing space for the industry was allowed. Having not enforced strict controls immediately has probably led to the Prestige disaster. It is much less likely that a double hulled tanker would have broken up and sunk.

The Prestige had about 70,000 tons of heavy oil on board, so plainly more than the 1989 running aground of the Exxon Valdez off Alaska, which destroyed a huge amount of unspoiled nature. The Prestige caused the biggest disaster in Spanish history. Galicia is now suffering from the consequences of this oil tanker disaster; the environment is suffering under the so called "Marea Negra"<sup>3</sup>, whilst families live under the threat from toxic waste on their doorstep. The ocean and the coast may be polluted for years. Not only many fish but also other marine animals have died. Experts estimate that more than 100.000 seabirds have already died and there are still many dying everyday. The livelihood of hundreds of fisherman is threatened. The worst is, that many people were and still are in frequent contact with the poisonous, carcinogenic residues fuel oil through cleaning the coast or only going for a swim to one of the numerous beaches.

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<sup>1</sup> The same day as the Prestige hit the main headlines two tankers were in flames on the coast of China. A further vessel sank in Asia, and another two collisions were reported.

<sup>2</sup> Compare Schlichting, Peter: Bekämpfung von Meeresverschmutzungen in den deutschen Küstengewässern, Kongressmesse SiTeRo, Symposium Verkehrssicherheit, Rostock, 25.10.2000, Kurzreferat p. 2.

<sup>3</sup> "Marea Negra" is the Spanish synonym for Black Tide and signifies the oil slick produced by the Prestige disaster

## **Abstract**

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There is a need for a vast overhaul of maritime safety across the whole industry. Old tankers, with inexperienced crews, or operated by unscrupulous owners or charters, cannot be allowed to transport such dangerous goods. A tanker may lose 70,000 tons of heavy oil. To some companies that is just a few million euros lost in their takings, while the future of the community affected will be changed for ever.

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## Abbreviations

<b>IMO</b>	International Maritime Organisation
<b>SOLAS</b>	Convention for the Safety of Life at Sea
<b>MARPOL</b>	International Convention for the Prevention of Pollution from ships
<b>ISM-Code</b>	International Safety Management Code
<b>LL 66</b>	International Convention on Load Lines
<b>STCW</b>	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
<b>COLREG</b>	Convention on the International Regulations for Preventing Collisions at Sea 1972
<b>FSI</b>	Flag State Implementation
<b>PSSA's</b>	Particularly Sensitive Sea Areas
<b>FOC</b>	Flags of Convenience
<b>CEDRE</b>	Centre de documentation de recherche et d'expérimentations sur les pollutions accidentelles des eaux
<b>CSIC</b>	Instituto de Investigaciones Químicas y Ambientales de Barcelona, Departamento de Química ambiental
<b>PAH's</b>	Polycyclic Aromatic Hydrocarbons

# 1 Introduction and target

Covering more than three fifths of the total surface of our "Blue Planet", oceans are as diverse as they are large. This ecosystem full of bizarre and fascinating creatures is so interesting and little understood. It is a self-containing world with a complex food chain and many organisms that have adapted to extreme and unusual conditions. The ocean is home to the smallest plankton and the largest creature on earth, the blue whale.

The entire water volume of the open oceans amounts to 1,3 billion cubic kilometres. With an average depth of 4000m covering a surface of approximately 325 million square kilometres.<sup>4</sup>

The sea not only regulates the climate and the weather of our earth, it also provides raw materials, serving as nutritional sources, and simultaneously forms important connections between the political economies. Its meaning is more important than ever before, because many answers to crucial future questions are to be found in the maritime areas. Undoubtedly the world is on its way to a maritime age, and the meaning of the seas will grow further. Two thirds of the world's population lives in coast areas and with a strong dependence on the sea. The oceans of the world will be a much greater source of economic wealth than they have been in the last centuries. Mankind's survival will be more and more dependent on the sea. Mankind's future, his survival on this planet is to be secured through continuing exploration and intelligent use of its natural resources.<sup>5</sup>

Everything we do has an effect on our planet and its resources. Our development, our welfare and our growth depend on natural raw materials. Therefore, environmental topics and the clever utilization of all sources should be a solid part of our daily work.

It must be our goal to work constantly on the improvement of the ecological domain, to preserve this, our planet for our descendants.

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<sup>4</sup> Compare Witthöft, Hans Jürgen: Das Jahr der Ozeane weist in die Zukunft, in Schiff & Haven, 1998, Nr 9, p. 5.

<sup>5</sup> Compare ibid.

### 1.1 Description of the problem

On 19 November 2002 the Prestige, a 26-year-old single hull oil tanker flying the flag of the Bahamas and carrying 77 000 tonnes of heavy fuel oil broke apart and sank 270 km off the Spanish coast. Thousands of tonnes of heavy fuel oil spilled into the sea, thereby creating the biggest ecological disaster in Spanish history. After polluting the Galician coastline, the pollution spread to the shores of Asturias, Cantabria and the Spanish Basque country. On 31 December 2002, it reached the French coast.

Maritime shipping is of great importance for the international movement of goods, totalling 95 % of overseas world trade. Maritime traffic is constantly growing. So the permanent threat of an ecological maritime shipping disaster is ever present.<sup>6</sup>

Of all basic products in the world, oil occupies the leading position in the transportation sector. The crude oil imports of the European Union represent about 27% of total world trade. Together with the United States the EU occupies the number one position in the petroleum products trade. According to predictions the use of oil tankers is expected to expand even further in the coming years. Nearly 90% of oil is transported by sea.

More than two third of oil tanker movements<sup>7</sup> in the EU are along the North sea and Atlantic coasts. For this reason these zones are the most vulnerable to oil spills as the Prestige accident shows. In addition, numerous oil tankers cross the waters of the Union without putting into port. This represents an additional volume of traffic, and therefore an additional danger. While the imported oil comes above all from the Middle East and North Africa the oil from the North Sea oilfields is exported mainly to destinations in North America.

Each year some 15 000 to 20 000 vessels ranging up to 200.000 or even more tonnes operate in the waters of the Union. Between 1992 and 1999 593 ships were lost worldwide, of which 77 were oil tankers. In 1999 the average age of vessels making up the world oil tanker fleet was 18 years. 41% of them were more than 20 years old,

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<sup>6</sup> Compare Bornemann/Harbrecht/Kaps: „Umweltfreundliches Schiff“, 1999, p. 1.

<sup>7</sup> Each year, 800 million tonnes of oil are transported to or from European Community ports.

representing 36% of the oil tanker tonnage.<sup>8</sup>

According to many international investigations shipping is no more one of the primary pollution sources of the ocean. It represents an environmentally friendly alternative to the transport systems by road or air. Maritime shipping has the lowest fuel consumption and with it the lowest emissions, above all of CO<sub>2</sub> and CO. To transport the same volume of load the energy requirement of train is approx. 2 times, that of HGV approx. 5 times and that of the airplane approx. 75 times higher.

It is generally known that transport pollutes the environment. The information about advantages of trains compared with road transports are accessible to the general public. The pro-shipping environment lobby of shipping is relatively small. This is easy to explain through some examples:

The wagon of a goods train contains on average 25 tonnes of load. Compared with a vessel like Prestige containing 77.000 tonnes of load this vessel has a capacity of 3080 train wagons. Concerning rail transport there is often a failure to notice that the generation of electricity also means environmental damage and threat. Besides, almost all waterways follow unchanged ancient commercial routes, while again and again countryside has to give way to the extension of land transport routes. Furthermore shipping does not entail bottlenecks or traffic jams.

The pollution of sea through oil as a result of maritime transport has fallen considerably over the course of time. In comparison to estimations at the start of the 80's a reduction from 1,47 to 0,57 million tonnes per year is detected. Annual pollution has decreased by about 60%. Nevertheless, according to the latest investigations 24% of the entire entry of oil into the seas is still from maritime transport.<sup>9</sup> Pollution of the oceans caused by accidents, especially from the oil of tanker accidents has clearly fallen. However this still represents a figure of 5% and each tanker disaster has fatal effects on coastal waters.<sup>10</sup>

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<sup>8</sup> Compare EU (publisher): Maritime safety: Erika I, online on WWW under URL: <http://europa.eu.int/scadplus/leg/en/lvb/l24230.htm> [06.06.03].

<sup>9</sup> See Table 2: Sources for oil entries into the seas p. 30.

<sup>10</sup> Compare Schlichting, Peter: Bekämpfung von Meeresverschmutzungen in den deutschen Küstengewässern, Kongressmesse SiTeRo, Symposium Verkehrssicherheit, Rostock, 25.10.2000, Kurzreferat p. 2.

However the majority of environmental pollution through maritime shipping is caused by intentional, illegal discharging of rubbish and operational residues as well as to a considerable degree through the emissions caused by normal ship operation. But this kind of pollution is not dealt with.<sup>11</sup>

### 1.2 Aim and procedure

Within the context of investigations of the “Escola Tècnica Superior d’Enginyers Industrials de Barcelona (ETSEIB)” of the “Universitat Politècnica de Catalunya (UPC)” about the Prestige accident there is a need for a study in the department of “Enginyeria Química” (Chemical Engineering) aiming to show the current situation of safety in the international maritime shipping and the examination of various methods of cleaning and regenerating the seas following the “Prestige” disaster.

In a similar way to the stringent regulations imposed on airlines an equally forceful code of conduct should be imposed on shipping. Robust maritime safety measures should be adopted at the international level, in the form of stricter navigation rules for ships carrying pollutant goods and more stringent controls on flag States. Routes should be outlined in such a way that petroleum products and other dangerous cargoes would be directed away from the coastline, whilst the same cargoes should not be allowed to be transported on vessels which do not fulfil the highest of standards. Even heavy dangerous loads on the roads require strict controls. However, shipping regulations do not impose such standards during the trans-global transfer of the same dangerous materials.

This thesis is designed to bring about a change in the prevailing mentality in the sea borne petroleum products trade. More powerful motivations are necessary in order to persuade the carriers, charterers, classification societies and other key bodies to place a greater emphasis on quality and safety in shipping. At the same time, the net should be tightened on those who pursue short-term personal financial gain at the expense of safety and the marine environment.

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<sup>11</sup> Bibliographical reference to other kind of pollution: Bornemann/Harbrecht/Kaps: “Umweltfreundliches Schiff“, 1999.

This study aims to answer following questions:

- What is the state of play of the sea borne oil products trade in international maritime shipping?
- How safe is international maritime shipping?
- How and to what extent does environmental damage through maritime shipping occur?
- What consequences does this have for the environment (plants, animals, human beings)?
- Which regeneration processes are natural and which are artificial?
- Which are the proposals to clean the oil spilt by the “Prestige”?
- What are the existing measures to ensure safety?
- What are the proposals for future action?
- Is the marine transport of mineral oils possible with sufficient safeguards from the point of view of environmental protection?

The available proposals should be understood as a starting point and an impetus for continuing development.

This thesis deals with universally applicable environmental aspects of maritime shipping in the case of ship disasters and accidents. Special cases like war, passenger, scientific research and Antarctic shipping are not recorded in this investigation.<sup>12</sup> Neither does it deal with varied environmental damage caused during raw material and energy extraction for ship construction, the construction of the ships themselves and their later break up, disposal or recycling.

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<sup>12</sup> Bibliographical reference to Antarctic shipping: Enß/Knoop/Brune/Kohnen, 1999.

## 2 Safety in the maritime shipping

### 2.1 International maritime shipping- Maritime law and ship safety law

The safety of the seas and with it also the protection of the maritime environment does not only depend on the condition and supervision of the international waters, it also depends on the density of shipping and the security in the operation of ships.

Maritime shipping has always been international, because ships of all nations are in operation worldwide.

Due to these conditions questions about maritime shipping and its security cannot be arranged effectively through only national law regulations. National regulations are meant for ships flying the flag of the nation concerned, but there is a limitation, if the ships are cruising in territorial waters of other countries. Furthermore, these national regulations would not be in force for ships flying a foreign flag, even if they are sailing the German bay or the Baltic Sea. Because in this respect the principles of the international laws of the liberty of the seas and the free thoroughfare of foreign territorial waters are in force.

Therefore maritime law and ship safety law are international laws. These laws are managed by the International Maritime Organisation (IMO), an organisation of the United Nations. The IMO looks into all maritime matters on an international level. In particular, the improvement of the safety of maritime traffic and maritime environmental protection. Its major function is to make shipping of all types safer, including tankers. The measures incorporated in the numerous safety conventions and recommendations apply to these as well as other ships - and the safer a ship is, the less likely it is to be involved in an accident. Over 150 states are members.

The basis of the safety regulations in maritime shipping is a large number of international agreements, which were worked out by the IMO and its committee. The most extensive of all treaties dealing with maritime safety is the International Convention for the Safety of Life at Sea (SOLAS) of 1974 and the International Convention for the Prevention of Pollution from Ships of 1973 (MARPOL). On the basis of these treaties are numerous points of law concerning various details, which are revised and adopted to the newest



insights.

Shipping safety is also concerning the European Union. There is a Commission sitting in as an observer on the work of the International Maritime Organization (IMO). Together with the Member States it seeks uniform interpretation and application of the international regulations throughout the European Community.

## 2.2 Safety in maritime shipping

### International Safety Management Code (ISM-Code)

The following aspects should be included in the consideration of the safety of ship operation:

- Structural security,
- the technical security of the equipment on board, in particular the fittings of alarms- and communication, anchor- and tow fittings, fire protection- and fire fighting equipment, leak combating devices, life rescue equipment and not least the technical equipment concerning the protection of the environment,
- the maintenance and inspection of security-technical equipment,
- the system of security and emergency management on board,
- the security/technical training of the ship's crew.

Investigations have revealed that as a rule it is not the lack of safety regulations which is the cause of tanker disasters. A large number of international regulations, perfected construction regulations and strict supervision by classification societies<sup>13</sup> reduces the risks clearly. The problem is rather that the safety regulations are not always followed and thus dangerous situations are created or favoured, which finally leads with statistic probability to disasters. The vast majority of ship disasters – about 70-80 per cent – are based on human error.<sup>14</sup>

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<sup>13</sup> Classification societies are highly specialised private organisations with extensive experience in the shipping sector, employing hundreds of technical staff and supported by powerful research and computer centres.

<sup>14</sup> Compare Bornemann/Harbrecht/Kaps: "Umweltfreundliches Schiff", 1999, p. 72.

To prevent this, since the 1st of July 1998 the **International Safety Management Code (ISM-Code)** was introduced. The ISM-Code is graduated to ship models and ship sizes. It is found in chapter IX of SOLAS and binding from the 1st of July 2002 for all ships.

Safety management is stipulated by chapter IX of SOLAS. This defines the time period within which varying ship models of varying sizes have to obtain a certificated safety management system. It refers to the ISM-Code, which is drawn up in resolution A.741(18). The SOLAS convention was ratified by nearly all IMO member states and is therefore a forced regulation for all maritime ship categories which are stipulated by SOLAS.

The **aim of the ISM-Code** is to ensure the safety of maritime shipping. In the first instance come the protection of human life, then the prevention of environmental damage and property damage. With regard to environmental protection the ISM-Code is limited to the prevention of environmental damage. The introduction of an environmental management system is not part of its minimal requirements.<sup>15</sup>

The ISM-Code supports the security management of the ship owners as well as on board for a safe ship operation. Part of this management is also the production of emergency plans. For that, Flag-state administrations have to produce certificates and check them constantly.

However the true reason for the cause of accidents through “human error” often lies more profoundly. Because of lower wage costs ship crews are recruited more and more often from all around the world. They do not always have an appropriate level of training and sense of responsibility for safety of ship operation. This safety is necessary and is to be expected. The multicultural composition of the ship’s crew could lead to difficulty in communication, which could be disastrous in situations of danger.

In addition there are further structural causes. The skipper is responsible for the safety of the ship and the crew. But he often has to take into consideration the economical interests of the ship owners and the owners of the cargo. In this conflict of interests the

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<sup>15</sup> Compare Germanischer Lloyd, online on WWW under URL:  
[http://www.gl-group.com/academy/e\\_information.html](http://www.gl-group.com/academy/e_information.html) [06.06.03].

relevant nautical safety considerations are often placed below economical considerations. In this case the relevant safety points could be probably be best strengthened by dictating a more clear liability on the ship owners or rather all the economical parties involved including their insurance companies – also for the environmental damage – and by more effectively monitoring the adherence to safety regulations.

### Particularly Sensitive Sea Areas (PSSA's)

Through Particularly Sensitive Sea Areas, area-specific rules can be matched to local needs and conditions to protect distinct areas of the marine environment that are particularly sensitive.

”Particularly Sensitive Sea Areas (PSSA's) are areas of the seas and oceans that need special protection through action by the International Maritime Organisation (IMO) because of their ecological, economic, cultural or scientific significance, and their vulnerability to harmful impacts from shipping activities. PSSA's can benefit valuable ecosystems such as coral reefs, coastal wetlands and important habitats. They are also important for migrating birds, sea turtles, whales or other marine species, as well as feeding grounds for valuable fish stocks. In addition, they can benefit marine areas of particular importance for tourism, recreation, traditional subsistence, science or education. And if any of the above areas are close to shipping lanes, suffer from bad weather, have narrow passages, shallow depths or submerged reefs, or are otherwise sensitive to shipping impacts, then they may need PSSA assistance to protect them”.<sup>16</sup>

Through PSSA's coastal nations can prevent accidents and avoid habitat damage by regulating the passage of ships through or away from sensitive areas. PSSA's also serve to inform mariners of the need to take special care when approaching a sensitive area.

According to WWF Germany some of the measures available through the IMO to protect PSSA's include:

- **Areas to be avoided** to prohibit entry of tankers or other ships carrying hazardous cargoes,

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<sup>16</sup> Quotation from Gjerde, K.: Particularly Sensitive Sea Areas. Brochure, WWF UK, 1999

- **Traffic separation schemes** to require ships to stay within designated lanes,
- **Inshore traffic zones and deep water routes** to separate local traffic from transiting traffic,
- **Special discharge restrictions** under MARPOL 73/78 to ban the discharge of oily wastes, refuse and other harmful substances from ships,
- **Pilotage requirements** to ensure ships use local pilots who are expert local navigators,
- **Mandatory reporting requirements** to ensure two-way communication between ship and shore,
- **Vessel traffic management** service systems to help manage and control ships' passage,
- **Special innovative measures** may also be introduced to address specific local problems.<sup>17</sup>

PSSA's do not have to be restricted to national marine protected areas, they can also protect other ecologically, economically, or socially significant marine areas that are threatened from shipping.

### 2.3 Safety checks

All in all there are sufficient safety regulations; the problem is their obedience by ship owners and ship crews. Therefore monitoring of the obedience of safety regulations is of overriding importance. Such checks exist in the form of Flag State controls and Port State controls.

#### 2.3.1 Flag State Control

The **Flag State** is the state of the flag which the vessel flies, i.e. in whose register it is recorded. The Flag State has the responsibility to guarantee the effective application and supervision of the IMO-regulations, which it has previously accepted. In IMO Conventions, the flag state is sometimes referred to as the "Administration".

The following IMO Conventions – in the current valid version – are the most important

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<sup>17</sup> Compare WWF Deutschland, Project Team Pallas: Protection of the Wadden Sea from ship accidents through the establishment of a "PSSA Wadden Sea", 2000, p. 8.

for the Flag State Control:

- International Convention for the Safety of Life at Sea, 1974 (SOLAS 74),
- International Convention for the Prevention of Pollution from ships, 1973, with the amendments through the Protocol of 1978 (MARPOL 73/78),
- International Convention on Load Lines, 1966 (LL 66)
- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1995 (STCW<sup>18</sup>),
- Convention on the International Regulations for Preventing Collisions at Sea, 1972, (COLREG 72) and
- International Convention on Tonnage Measurement of Ships, 1969, (Tonnage 69).

IMO was established to adopt legislation. Governments are responsible for implementing it. In accepting an IMO Convention a government agrees to make it part of its own national law and to enforce it just like any other law, according to article 1 (b) of the SOLAS-Convention.<sup>19</sup>

“The problem with flag state implementation is that some countries lack the expertise, experience and resources necessary to do this properly.

IMO’s Technical co-operation programme is designed to assist governments which lack the technical knowledge and resources that are needed to operate a shipping industry successfully.

Meanwhile, IMO’s Sub-Committee on Flag State Implementation (FSI) was set up in 1992 to improve the performance of Governments. It also provides a forum where both flag and port States can meet and find solutions to issues relating to implementation.”<sup>20</sup>

The Flag State Implementation means, that the value of the vote of each state depends on the total tonnage of the fleet of the concerned state. That means that the ship owners can pick the flag state, which is most fitting to their wishes to avoid tax burden, social costs or

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<sup>18</sup> Compare Bornemann/Harbrecht/Kaps: “Umweltfreundliches Schiff“, 1999, p. 28.

<sup>19</sup> Compare Report “Havarie Pallas“, 2000, p. 44-46.

<sup>20</sup> Compare IMO online in WWW under URL: [http://www.imo.org/Safety/mainframe.asp?topic\\_id=156](http://www.imo.org/Safety/mainframe.asp?topic_id=156) [06.06.03].

costs to protect the environment. Thereupon, with the increased tonnage proportion, the chosen flag states gains more and more influence over the international safety regulations.

To make this clear, it is useful to imagine that one could choose the most appealing vehicle inspection organisation for an old car, which itself exerts an increasing influence on road safety regulations. It is easy to imagine in what this would result for road safety.

### 2.3.2 Port State Control (PSC)

Apart from the Flag State Control there is a safety control of vessels by the states, whose ports or territorial waters are used. PSC is the inspection of foreign ships in national ports to verify that the condition of the ship and its equipment comply with the requirements of international regulations and that the ship is manned and operated in compliance with these rules. With it the port State protects its territory from insecure ships which are running under foreign flags. It provides a “safety net” to catch substandard ships. The port state already has control over the ships under its own flag.

PSC was arranged uniformly Europe-wide in 1995 through the EU guide-line 95/21/EG<sup>21</sup>. It was completed in 1998, which means that the PSC is now responsible for observing the ISM-Code. In particular this defines that each member state has to control each year at least 25% of all ships putting into port, which, in Germany amounts to 1.500 ships. This quota is also reached by the other European member states. So Europe-wide a density of control of approx. 80% is reached.

This uniform arrangement is necessary because of competitive reasons. This prevents the insufficient control of the safety standards by individual EU-member states, so they can not save costs and obtain competitive benefits.

PSC is an effective tool. In case of defects which present a clear danger to safety, health or the environment, the ship is held in port until its defects are eliminated. This happens on average with 6% of the controlled vessels.<sup>22</sup> But PSC does not specifically focus on structural matters. As PSC is carried out during port calls, normally involving loading or

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<sup>21</sup> Compare EU: Maritime safety, online on WWW under URL <http://europa.eu.int/scadplus/leg/en/lvb/l24072.htm> [05.06.03].

<sup>22</sup> Compare Report “Havarie Pallas“, 2000, p. 46-47.

discharging operations, the ability to inspect the underwater hull structure is practically impossible and the inspection of cargo and ballast spaces is limited.

### 2.4 Safety education of the crews

The education of seaman is arranged worldwide through IMO in the “Standards of Training, Certification and Watchkeeping” in the version of 1995 (STCW<sup>23</sup>). In the opinion of the Pallas-Experts Committee there are existing worldwide standards because of these arrangements, however they are not as high as they should be. In many branches, for example, the safety of vessels they are vaguely composed. There are no concrete contents, only formulations of titles. These education standards were created to give a common ground between the highly industrialized traditional shipping nations and the developing countries. It was intended to enable an education also in the developing countries, where most of the low-paid seaman come from. Therefore, for example simulated training was not stipulated, with the exception of radar training.

The consequence for the IMO of the national putting into practice of the STCW<sup>24</sup> agreement was that those countries with a high education standard lowered their requirements for seafaring education. The changes in Germany were for example:

- The reduction of the highest qualification certificates for captains or directors of machine plants from 3 to 2 years.
- The non-continuation of periodical further education-courses in the field of ship safety; it is no longer stipulated that refresher courses must be taken as proof of qualification for lifeboat operators or competent fire combat, which previously had to be renewed every 10 years.

Safety education on a higher level in only a few countries would not be possible in practice because of the competitive point of view.

Although the requirements with regard to knowledge and ability have increased greatly in recent years, the basic education according to the “ship officer education order” (Schiffsoffizierausbildungsverordnung) in the field of safety has a relative low scale. There

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<sup>23</sup> Compare Bornemann/Harbrecht/Kaps: “Umweltfreundliches Schiff“, 1999, p. 28.

<sup>24</sup> Compare *ibid.*

is no longer a periodical further education, and importantly, there is no complete course in “emergency training of leadership personal in the maritime field”, where above all the necessary methodical specialist instruction should be taught as well as concrete practical training in mastery of imaginable emergencies.

Investigations concerning the theme of ship safety and the ISM-certifications through the Germanic Lloyd and the institute for Road Safety have concluded, that the complex field “Ship Safety” is currently suffering from a great lack of knowledge in the field of emergency mastery and emergency planning.

That affects in particular the basic knowledge of the leadership. Although captains and ship officers are revealing in their self estimation the motivation for informed instruction of the ships’ crew, the necessary specialized knowledge however was only available 40 %. But the basic knowledge must be available and retrievable immediately; because emergencies are happening suddenly.

There is also a lack of knowledge about effectiveness, productivity and the right action time of the defence technology. This technology is often deployed too late or without sufficient expert knowledge because of a lack of knowledge with regard to its possible consequences. For this reason the potential options which are available to effectively reduce the damage can not be taken advantage of. In the case of the “Pallas” ship accident, this concerned for example the late and insufficient deployment of the extinguishing equipment as well as the incomplete isolation of the fire at its source.

The causes of the disregard of safety education and further education are psychologically easy to explain. Emergencies seldom occur. For this reason the knowledge and behaviour to avoid and control these emergencies are considered consciously or unconsciously non-preferential, even if there are principally good intentions. The motivation of the crew in this field is an especially demanding task. They have to acquire expert knowledge and to train in manual skills, but use of these skills should not be required if possible. One has “learned and trained in vain”, if it is sailed without accident for many years. The necessary training in emergency management is still developed insufficiently and is not carried out properly. The effective training on board ships is for obvious reasons only practicable within limits. As experiences with accidents are fortunately very seldom for the individual seaman, he also can not gain these experience on normal board operation.



The mastery of a concrete emergency through immediate measures on board is very important, because help from the outside usually can not arrive fast enough. The first few minutes during an emergency often decide the consequences. To keep the possible harmful consequences of an emergency within justifiable limits, education and further education as well as training in this area have to be improved in future. At the same time it has to take into account the fast changes in shipping in order to make reliable and comprehensible decisions in accordance with the rules 5 to 8 of the ISM-Code.

Further education should furthermore, guarantee that all persons on shore who are directly responsible for the guarantee of ship security and environmental protection have the same level of knowledge as the ship's crew. This is an indispensable precondition for general effective support in overcoming danger on board as well as in the protection of the environment, and it is a demand of the ISM-Code.

Only a continuous further education in emergency management can contribute towards fulfilling the demands in complex and complicated processes during emergency situations. This also contributes towards avoidance of environmental damage due to ship disaster.<sup>25</sup>

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<sup>25</sup> Compare report "Haverie Pallas", 2000, p. 47-48.

### **3 Tanker disaster and the consequences for the environment**

#### **3.1 The threat of the maritime environment through tanker shipping**

Every year huge amounts of sea water-threatening goods are transported in international maritime traffic. In the years 1986 – 1999 on average each year approx. 1,6 billion tons of crude oil and mineral oil products were transported as cargo on maritime ships. This amount represents approximately 40 % of all transported goods on maritime ships in this period of time.<sup>26</sup>

The biggest potential threat is from tankers loaded with crude oil, chemicals or crude oil products, especially in areas such as Baltic- and the North sea or the Strait of Gibraltar for example. Besides mineral oil products chemicals as mass goods or in the packaged form as well as bulk goods are transported by maritime ships.

Most oil tankers nowadays are constructed with only one hull. In such ships, only a bottom and a side plate separates the oil in the cargo tanks from the seawater. Should this plate be damaged for example through a collision or stranding, the contents of the cargo tanks risk spilling into the sea. This risk could be avoided through a double hull design, where the cargo tanks are surrounded with a second internal plate which is at a sufficient distance from the external plate. This safeguards cargo tanks from damage and thus reduces the risk of pollution.

Furthermore on every trade ship a considerable amount of operating substances are carried, which present the same threat to maritime seawater as do oil products transported as goods. Thereupon one can not underestimate the considerable risk of big container ships. The bunkering capacities of these vessels exceed many times the transport capacities of small tanker ships. Besides a big proportion of dangerous goods of different danger classes loaded in containers these cargo vessels carry on board up to

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<sup>26</sup> Compare ISL (publisher): Shipping Statistics and Market Review, Executive Summary , online on WWW under URL: [https://www.isl.org/deutsch/veroeff/shortcommentno\\_12-2000d.html](https://www.isl.org/deutsch/veroeff/shortcommentno_12-2000d.html) [04.01.03];

note: commerce on the world seas 1999: 5,1 billion t, of it 37 % crude oil and mineral oil products.

8000 m<sup>3</sup> of heavy oil, diesel oil, hydraulic oil and lubricants for the operation of the ship.<sup>27</sup> Even small cargo vessels can so represent a relevant danger for the environment. Annually approx. 59 Mio. tonnes of mineral oil products are carried along on vessels as fuel.<sup>28</sup>

A special high risk involves the heavy traffic on the main shipping routes of the world. Years ago traffic separation areas were installed to increase lane safety. Nevertheless in these areas there still also remains a residual risk, especially in places such as crossing points of ferry shipping with the main routes of the cargo shipping for example.

An increasing amount of cargo is transported by bigger and faster vessels.

Another risk stems from inadequate crews, because of both their motivation and their qualifications. In experts' opinion many accidents and damage to the environment could have been avoided through better trained crews.<sup>29</sup>

### **Causes of accidents**

Between 1992 and 1999 the number of ships lost worldwide was in total 593, of which 77 were oil tankers. This corresponds to only 13% of the number of accidents but it nonetheless represents 31% of the lost tonnage.<sup>30</sup>

The reasons for ship disaster are mostly similar. The vessels are old and in bad conditions, sailing under so-called Flags of Convenience (FOC) with low security standards and unfortunately, these vessels are manoeuvred from badly trained, overburdened teams with bad informed pilots through ecologically sensitive areas (PSSA's). The fatal consequences are heavy oil accidents. Through 40 severe tanker disaster between 1983 and 1993,

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<sup>27</sup> Compare report "Havarie Pallas", 2000, p. 12.

<sup>28</sup> Compare Brand/Höth/Sachtleber: "MARION", 1999, p. 35.

<sup>29</sup> report "Havarie Pallas", 2000, p. 12-13.

<sup>30</sup> Compare EU (publisher): Maritime safety: Erika I, online on WWW under URL:  
<http://europa.eu.int/scadplus/leg/en/lvb/l24230.htm> [08.05.03].

approximately 3 million tons of crude oil entered in the oceans.<sup>31</sup>

### Flags of Convenience

One understands national registers by Flags of Convenience, so-called open registers, that frankly suit foreign ship owner, which gain cost reductions on this way through low dues and through prevention of the rules in the home country. States, that offer such open registers, with the aim to gain through these register, are e.g.: Liberia, Panama, Bahamas, Bermuda, Singapore Sri Lanka Vanuatu and within Europe: Greece, Malta and Cyprus. Every ship owner can let his ship register there and then it is subject of the local rules respecting crew, security requirements and minimum wages. Due to this, big advantages for the ship owner, the charterers and with it also for the large oil companies are resulting. The business and personnel costs of the ships are considerably worst. National and international safety regulations are not so strict, are not handled so strictly or can even be avoided partially. In the case of a catastrophe ship owner, charterers as well as freight owner are hardly liable through an ingenious network of international companies. They pay 30 % to 50 % less taxes and save up to two thirds for the personnel as well as the otherwise usual social benefits on labour costs.

From 1970 to 2000 the part of the world trade fleet registered in these states increased from 23 % to 52,3 % . At present, 52,2 % of all tankers drive under cheap open registers. Accordingly in bad conditions are most of these over 7000 tankers world-wide. 40,4 % (this corresponds to 1/3 of the entire world tonnage) is in service over 20 years.<sup>32</sup> The super-tankers over 350.000 tons are even 22 years old in average. Even the oil industry has the opinion, that one fifth of the large vessels are too old.<sup>33</sup> Many of them have considerable security lacks. Nevertheless, they remain as long as possible in operation: Every day on sea makes the owner gain approximately 38.000 thousand dollars.<sup>34</sup>

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<sup>31</sup> Compare Sesin, 2000, p. 22.

<sup>32</sup> Compare ISL (publisher): Shipping Statistics and Market Review, Executive Summary , online on WWW under URL: [https://www.isl.org/deutsch/veroeff/shortcommentno\\_12-2000d.html](https://www.isl.org/deutsch/veroeff/shortcommentno_12-2000d.html) [04.01.03].

<sup>33</sup> Compare Greenpeace (publisher): Die Gier nach Öl, 1993, p. 3.

<sup>34</sup> Compare Sesin, 2000, p. 20-22.

According to the EU the **causes of accidents** at sea can vary widely:

- “Accidents are often attributed to **human error** (navigation or pilotage error). Crew training and crew skills have been recognised as key elements in improving safety at sea. In addition, working conditions constitute an equally important factor, in particular since fatigue has come to be increasingly recognised as a growing cause of accidents at sea.
- There is a general correlation between the **age of the vessels** and the accidents that have occurred. Sixty of the 77 oil tankers lost between 1992 and 1999 were more than 20 years old.
- Problems associated with the **structure** (breach in the hull, corrosion, etc.), **fire** and **explosions** are among the other causes of accidents.
- The **chartering practices** peculiar to the oil trade also add to the complexity of the situation. Thus, the oil companies have largely lost control over their oil tanker fleet. In reality, they control only a quarter of the world fleet. What we are witnessing is a process of "atomisation" among the oil tanker owners. By dispersing their fleet among single-ship companies, often taking the form of dummy companies registered in offshore financial centres, the owners are able to reduce their financial risks. Consequently, it is often difficult to identify the real decision-makers and hence to determine where responsibility really lies.
- The oil trade and the charter market operate in a **highly competitive atmosphere**. Finding the cheapest oil tanker carrying capacity on the market is an essential part of the operation. The volatile nature of the market is also resulting in a move-away from long-term contracts between charterers and carriers towards short-term charters (the so-called “spot market”). Prices on this market are fiercely competitive. In reality, the age of the oil tanker plays little part in the decision-making process; often it is the cheapest available tonnage offered by the oldest ships that dictates prices. It is therefore difficult to create a situation where quality pays, so much so that small operators with low overheads are winning over parts of the market at the expense of companies with well established reputations. This phenomenon poses a risk to safety.”<sup>35</sup>

In Table 1 on the next page it is visible which are all potential causes of oil spill accidents at sea.

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<sup>35</sup> Compare EU (publisher): Maritime safety: Erika I, online on WWW under URL: <http://europa.eu.int/scadplus/leg/en/lvb/l24230.htm> [08.05.03].

**Table 1: Potential causes of accidents<sup>36</sup>**

<b>Technical failure</b>	<b>Human failure</b>	<b>Guidance system failure (risk culture)</b>	<b>Disturbances of the system's environment</b>
Machine breakdown	Navigational errors	Inadequate coordination of system elements	Inadequate coordination of system and system environment (interface problems)
Material fatigue like e.g. hull failure	Loading/discharging errors	Over complexity	Design errors of responsibility- and competence order
Information- and communication technique	Inadequate hazardous material treatment and danger routines	Inadequate structures of incentive, responsibility and control	
Security systems	Communication errors		
Foreign traffic participants	Other traffic participants		<b>Meteorological sphere (weather)</b>
Collision avoidance systems			
	Lack of motivation		
	Panic/stress		
	Ignorance		
	Negligence		
	Drug taking		
	Overtiredness		

### **3.2 Oil accidents**

Whether off the Breton coast, off the Shetland Islands or the Prince William Sound, Alaska, again and again spectacular tanker accidents occur, where ships burst into flames, become unmanoeuvrable, finally explode and spill their black cargo into the sea. So parts of the sea or whole coastal regions are polluted or their ecological balance is disturbed. Countless maritime creatures, e.g. cormorants, seals, eider ducks<sup>37</sup> and fish perish in agony in the sticky oil slick. Inhabitants of the coastal region living from fishing or tourism lose their livelihood. Between March 1999 and March 2000 alone over 28 ships sank.<sup>38</sup> Every ship accident, whether due to grounding, hull failure, collision, fire and explosion or sinking does not only mean danger or loss of human life or real value, but also considerable risk and great consequences for the marine environment.

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<sup>36</sup> Following Hassel, 1998, p. 31.

<sup>37</sup> Any of several large sea ducks, having soft, commercially valuable down and predominantly black and white plumage in the male.

<sup>38</sup> Compare: Schiffsuntergänge März 1999 bis März 2000 – eine Auswahl, in : Greenpeace Magazin 3/2000

### 3.2.1 Sources for oil in the marine environment

Oil can reach into the sea through different ways. The main source for oil entries are:

**Table 2: Sources for oil entries into the seas<sup>39</sup>**

<p><b>Transport: 555.000 t/a</b></p> <ul style="list-style-type: none"> <li>• tanker, normal operation</li> <li>• tanker accidents</li> <li>• bilge oil and fuel</li> <li>• ship repairs</li> <li>• accidents (non tanker)</li> </ul>	<p><b>Plants: 180.000 t/a</b></p> <ul style="list-style-type: none"> <li>• coastal refinery</li> <li>• offshore installations</li> <li>• oil ports</li> </ul>
<p><b>Other sources: 1.380.000 t/a</b></p> <ul style="list-style-type: none"> <li>• local waste water</li> <li>• industrial waste water</li> <li>• surface drainage (cities)</li> <li>• entry through river</li> <li>• atmospheric entry</li> </ul>	<p><b>Natural sources: 250.000 t/a</b></p>

Bilge Water is water that collects in the lowest inner part of a ship’s hull. Bilge water is frequently contaminated with oil (bilge oil) and other lubricants from the engine room. Under various national and international standards, discharged bilge water must not exceed a certain maximum oil concentration (for example, 15 parts per million). Almost half of the oil entries caused through transport can be assigned to the category “Bilge oil and fuel” (252.000 of 555.000 t/a). The estimated annual total of the above-mentioned sources is 2,365 Mio. tons<sup>40</sup>

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<sup>39</sup> Table from GAUSS (publisher): Entölertechnik an Bord von Seeschiffen, online on WWW under URL: <http://www.gauss.org/> [03.05.03].

<sup>40</sup> Compare ibid.

### 3.2.2 Numbers and amounts spilt

The two major sources of information on accidental oil spills are a commercial US news bulletin, Oil Spill Intelligence Report (OSIR), and the International Tanker Owners Pollution Federation (ITOPF), a technical adviser, which has maintained a database of accidental oil spills on a worldwide scale since 1974, except those oil spills resulting from acts of war.

“The database contains information on both the vessel involved and the spill itself (amount and type of oil spilt, location and cause), and the vessel involved. For historical reasons, spills are categorised by size (<7 tonnes, 7-700 tonnes and >700 tonnes) although the actual amount spilt is also recorded. Information is now held on nearly 10,000 incidents, the vast majority of which (85%) fall into smallest category i.e. <7 tonnes.

Information is gathered from both published sources, such as the shipping press and other specialist publications, and also from vessel owners and their insurers. Not surprisingly, information from published sources generally relates to large spills, often resulting from collisions, groundings, structural damage, fires and explosions, whereas the majority of individual reports relate to small operational spillages. Complete reporting of this latter type of spill is clearly to achieve.

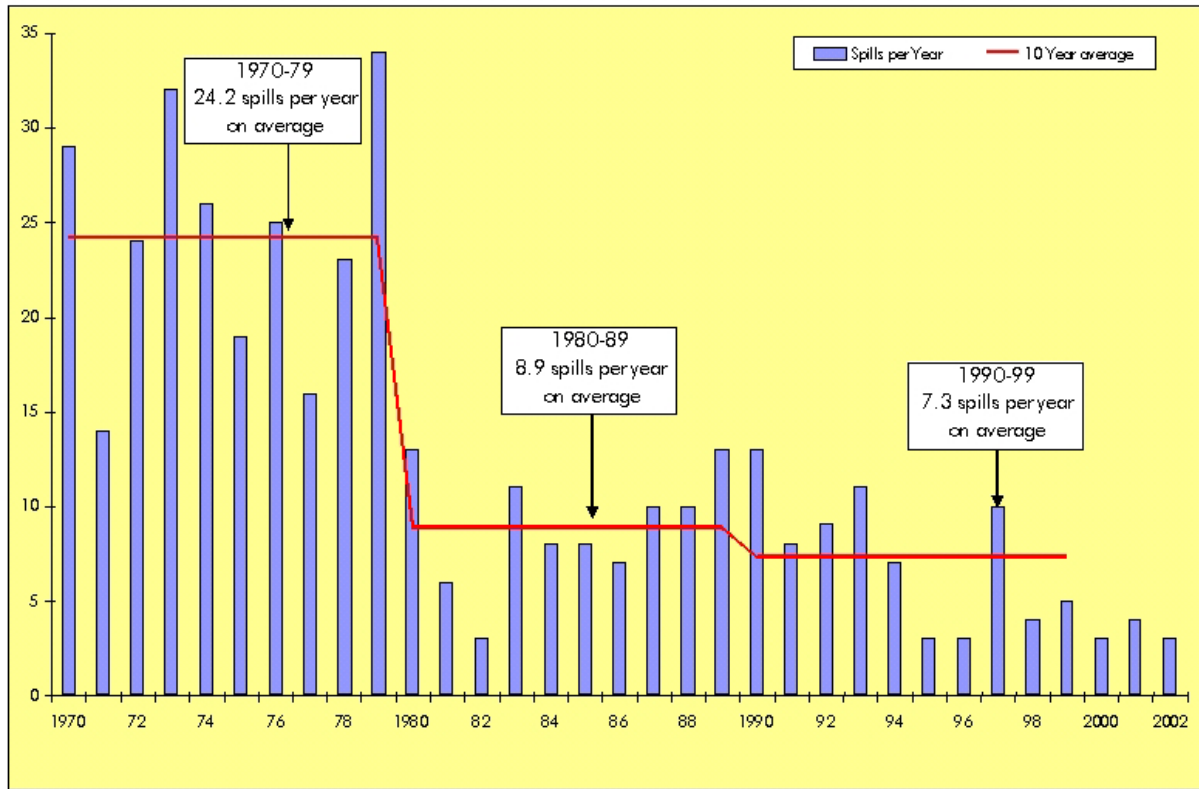
It should be noted that the figures for amount of oil spilt in an incident include all oil lost to the environment, including that which is burnt or remains in a sunken vessel. There is considerable annual variation in both the incidence of oil spills and the amounts of oil lost and so the figures in the following tables, and any average derived from them, should be viewed with caution.”<sup>41</sup>

The amount of oil spilt annually in the sea varies tremendously because of the small number of big oil disasters. It is apparent from figure 1 below, that the amount of big oil accidents (>700 tonnes) has decreased considerably in the past thirty years. In the nineties it was only a third of the incidents in the seventies.

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<sup>41</sup> Quotation from: ITOPF (publisher): Tanker oil spill statistics, online on WWW under URL: <http://www.itopf.com/stats.html> [03.04.03].





**Figure 1: Number of spills over 700 tonnes, 1970 - 2002<sup>42</sup>**

The vast majority (85 %) of spills are small (<7 tonnes) and make a relatively small contribution to the total annual quantity of oil spilled into the marine environment. Only incomplete data on numbers and amounts is available.

Reliable data on spills of over 7 tonnes is available and portrayed in Figure 5 at p. 35.

<sup>42</sup> Figure from ITOPF (publisher): Tanker oil spill statistics, online on WWW under URL: <http://www.itopf.com/stats.html> [03.08.03].

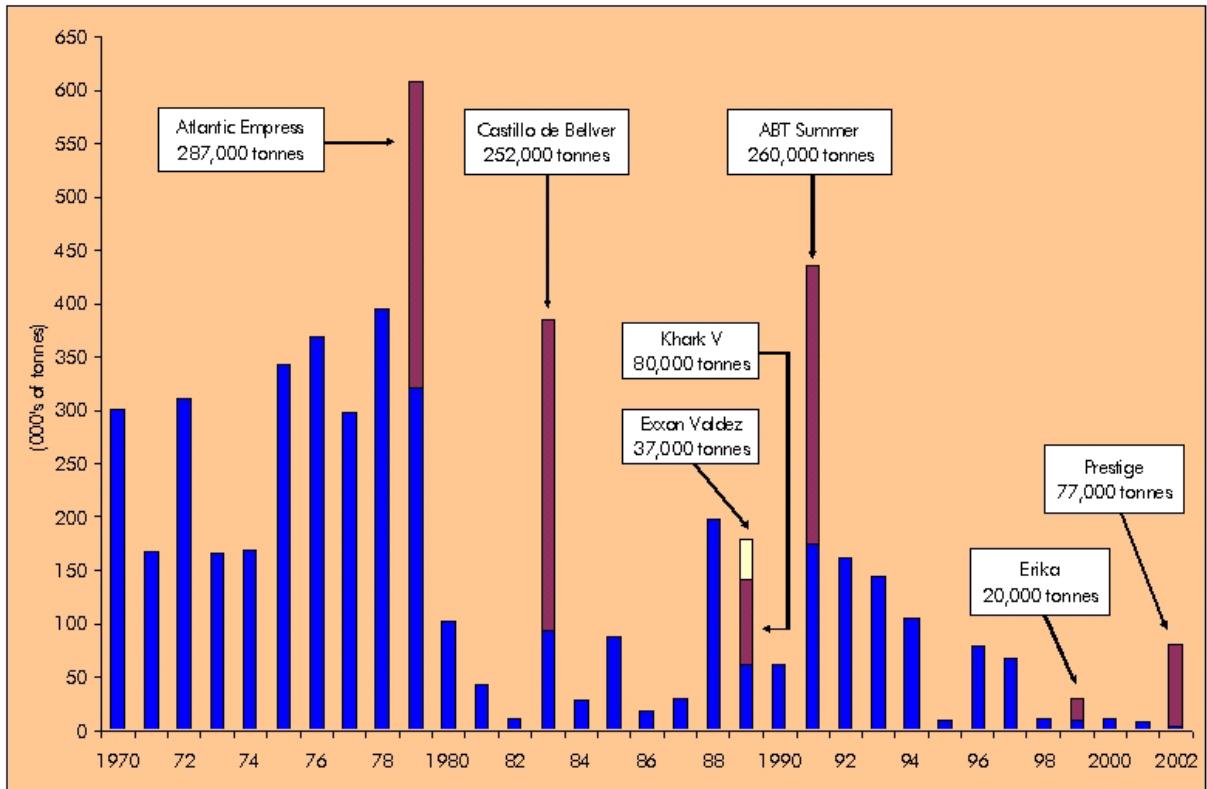


Figure 2: Quantities of oil spilt, 1970 - 2002<sup>43</sup>

It is notable that a few large oil disasters are responsible for the high percentage of the oil spilt. For example in the decade 1990-1999 there were 346 oil accidents over 7 tonnes, totalling 1096 thousand tonnes, but 830 tonnes (75 %) of this were spilt in the marine environment in only 10 incidents (just over 1 %).<sup>44</sup>

### 3.2.3 Incidence of spills by cause

Most incidents are the result of a combination of actions and circumstances contributing in varying degrees to the total outcome. The following analysis explores the incidence of spills according to the following causes:

<sup>43</sup> Compare *ibid.*

<sup>44</sup> A listing of big tanker accidents from 1967-1999 see Table 4 p. 46.

Table 3: Incidence of spills by cause, 1974-2002<sup>45</sup>

	< 7 tonnes	7-700 tonnes	> 700 tonnes	Total
<b>OPERATIONS</b>				
Loading/discharging	2772	301	17	3090
Bunkering	542	25	0	567
Other operations	1167	47	0	1214
<b>ACCIDENTS</b>				
Collisions	164	260	87	511
Groundings	222	203	107	532
Hull failures	563	77	44	684
Fires & explosions	150	16	19	185
OTHER/Unknown	2221	165	38	2424
<b>Total</b>	<b>7801</b>	<b>1094</b>	<b>312</b>	<b>9207</b>

Operations, accidents and other (these are incidents where important information is missing/lacking or it was not possible to classify in one of the two other rubrics).

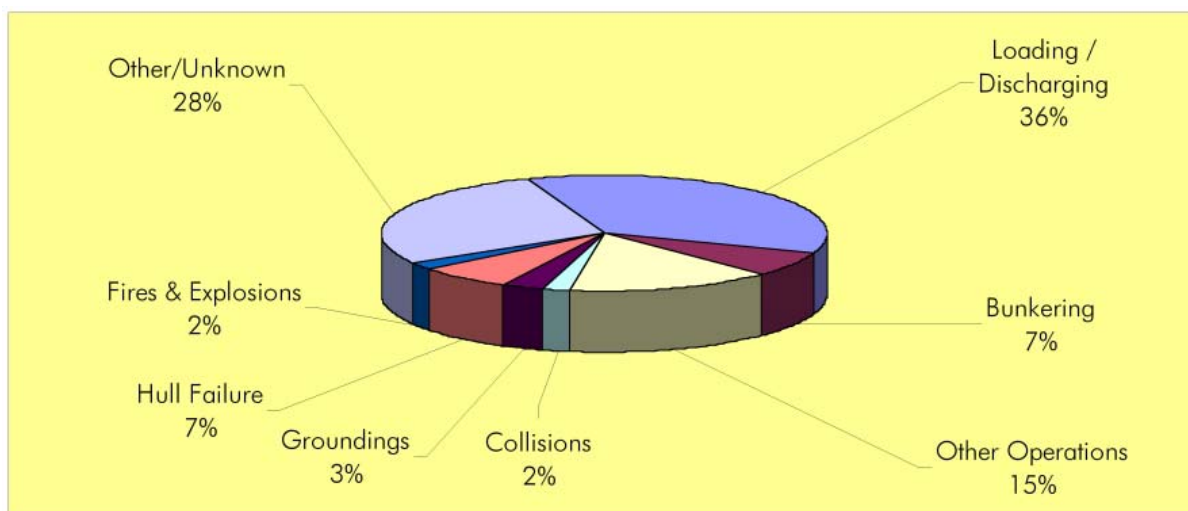


Figure 3: Incidence of Spills < 7 Tonnes by Cause, 1974-2002<sup>46</sup>

<sup>45</sup> Table from ITOPF (publisher): Tanker oil spill statistics, online on WWW under URL: <http://www.itopf.com/stats.html> [03.08.03].

<sup>46</sup> Figure from ibid.

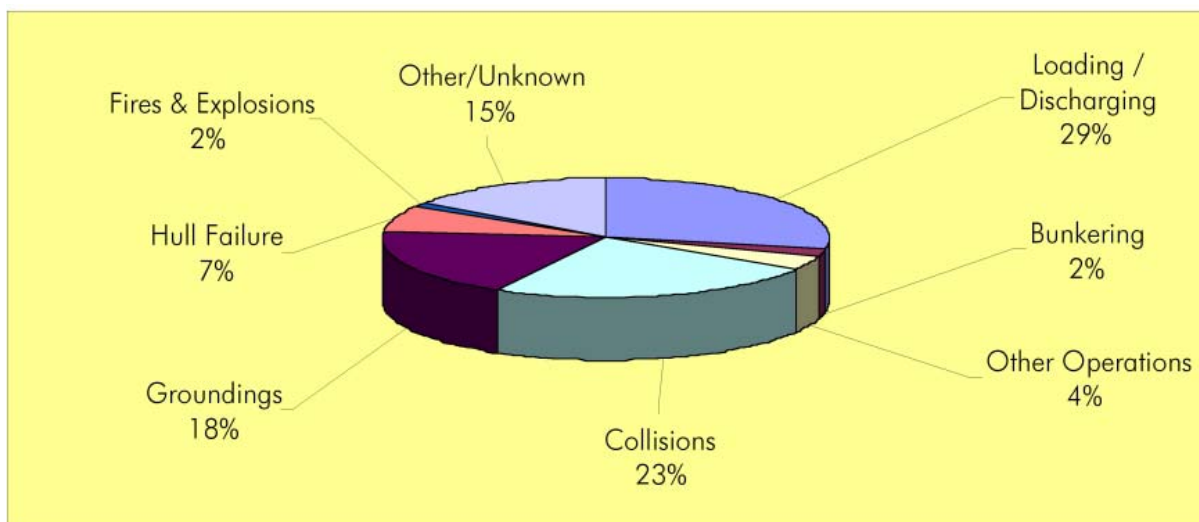


Figure 4: Incidence of Spills 7-700 Tonnes by Cause, 1974-2002<sup>47</sup>

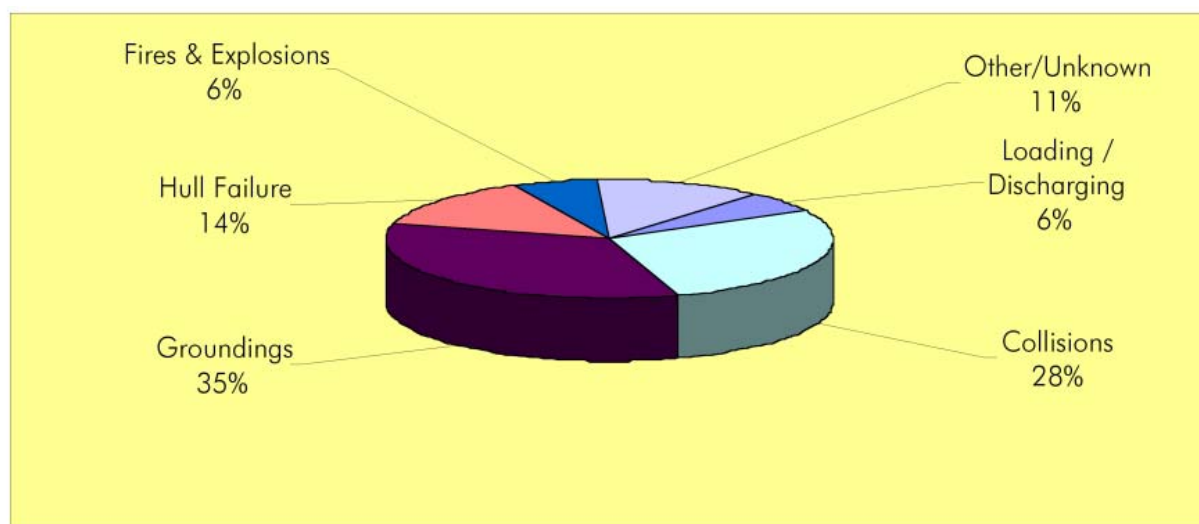


Figure 5: Incidence of Spills >700 Tonnes by Cause, 1974-2002<sup>48</sup>

It is apparent from Table 3, p. 34 that:

- most spills from tankers result from routine operations such as loading, discharging and bunkering which normally happen in ports or at oil terminals;
- the majority of these operational spills are relatively small, with some 92% involving quantities of less than 7 tonnes;
- the biggest part of much larger spills with 7-700 and more tonnes is attributed to accidents like collisions and groundings.

<sup>47</sup> Compare *ibid.*

<sup>48</sup> Compare *ibid.*

### 3.3 Weathering processes in case of spilt oil at sea

The term **“oil”** describes generally any persistent hydrocarbon mineral oil such as crude oil, fuel oil, heavy diesel oil and lubricating oil, whether carried on board a ship as cargo or in the bunkers of such a ship. The difference in composition determines the quality of any particular oil. Petroleum is a complex mixture of hydrocarbons, but it can be fractionated into aromatics, aliphatics, asphaltenes and a small portion of non-hydrocarbon compounds.<sup>49</sup>

**“Crude oil”** shall mean any liquid hydrocarbon mixture occurring naturally in the earth whether or not treated to render it suitable for transportation. “There are several hundred individual components in every (type of) crude oil, and the composition of each crude oil varies with its origin”.<sup>50</sup> Certain distillate fractions could have been removed (“topped crudes”) or certain distillate fractions could have been added (“reconstituted” crudes). Crude oils contain a wide spectrum of hydrocarbon compounds including very light, volatile components like propane as well as complex, heavy components, like bitumen, resins and waxes. Refined products, petrol or other fuels and fuel oils are composed of smaller, more specific fields of these hydrocarbons.

The term **“fuel oil”** describes residues or heavy distillates from crude oil or blends of such materials intended for use as a fuel for the production of heat or power.

**“Heavy fuel oil”** is among the most contaminating types of oil. In view of its comparatively small risk of fire or explosion and relatively low commercial value, it is frequently transported in older tankers nearing the end of their economic lives, and which present the greatest safety risks. Heavy fuel oil, heavy crude oil, waste oils, bitumen and tar are all in the category of heavy fuel oils. (see also p. 53)

Once oil reaches the water it will normally be dispersed and spread out in the marine environment in time. This results from various chemical and physical processes. These

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<sup>49</sup> Atlas, R.M.; Bartha, R. *Microbial Ecology: Fundamentals and Applications*. 3rd ed. Reading, Ma: Addison-Wesley publishing Company; 1993, p. 394

<sup>50</sup> Compare *ibid.*

processes are generally known as weathering resulting in changes to the substance properties. Some of these weathering processes like natural dispersion in water ensure that parts of the oil leave the water surface, whilst others like evaporation or water-in-oil emulsification (formation of emulsions) cause the oil to remain on the water surface and become tough.

Weathering of oil depends on its properties, particularly how dense it is. Light products, like for example kerosene, evaporate and part quickly and in a natural way/naturally. In comparison heavy oils like many crude oils part only slowly. In case of these oils purge measures are absolutely necessary. The oil's physical properties like density, viscosity and Pour Point (the temperature, where the oil stops to flow influence its behaviour. In addition it depends on various other factors. The amount and the type of spilt oil, the weather conditions and in addition, whether the oil remains in the water or is washed ashore have a considerable influence on the weathering period. Of significance therefore, is the evaporation and with it the change in the properties of the oil up to the point of solidification as well as the drifting of the oil due to wind.<sup>51</sup>

The eight main processes leading to the weathering of oil are portrayed in Figure 6.

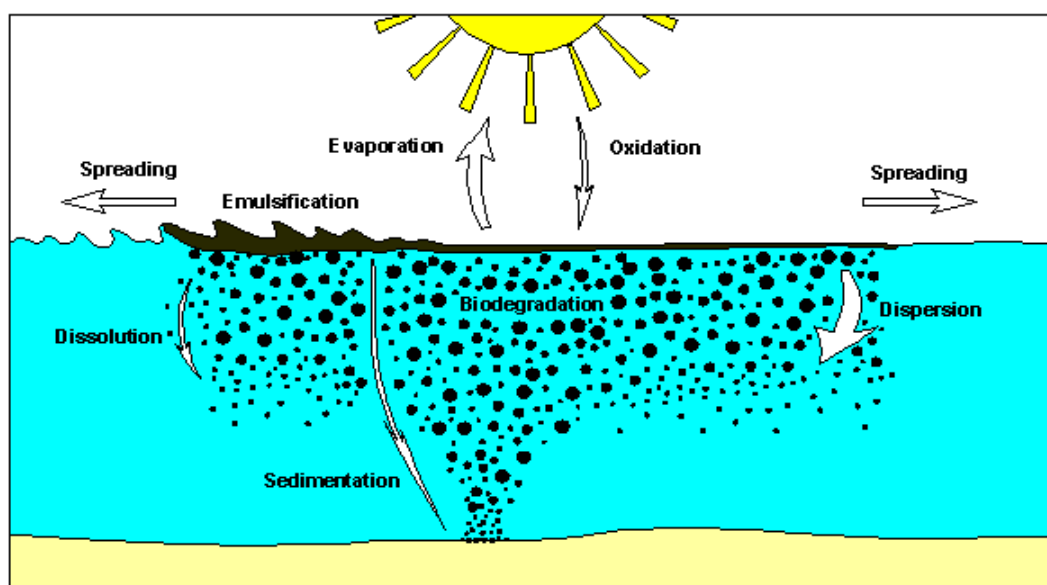


Figure 6: Main weathering processes of oil spilled at sea<sup>52</sup>

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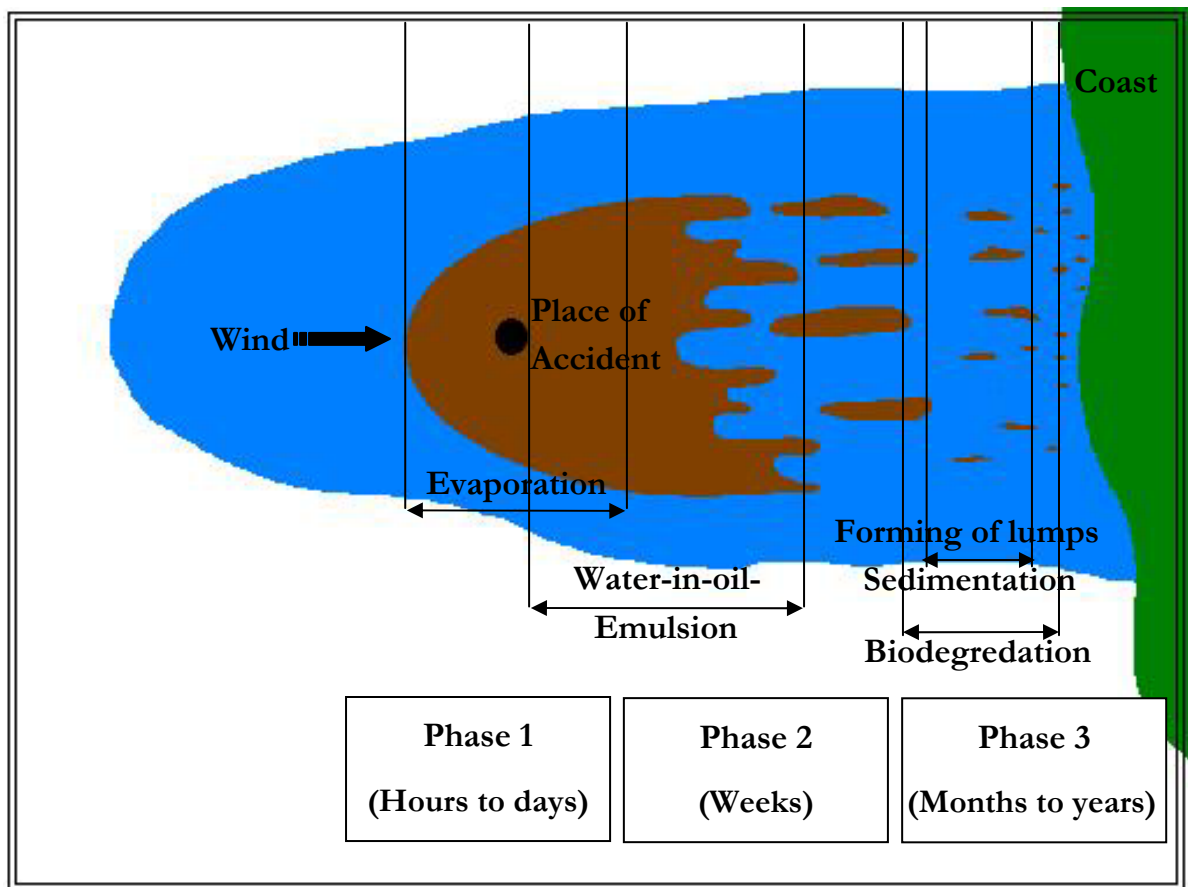
<sup>51</sup> Compare ITOPF (publisher): Fate of Marine Oil Spills, online on WWW under URL: <http://www.itopf.com/fate.html> [04.05.03].

<sup>52</sup> Compare *ibid.*

The processes of spreading, evaporation, dispersion, emulsification and dissolution are most important during the early stages of a spill whilst oxidation, sedimentation and biodegradation are more important later on and determine the ultimate fate of the oil.

**Spreading**

Differing from accidents on land, oil spreads out rapidly over big surfaces, initially as an oil spill. Spreading takes place in three phases (see Figure 7). Only in the first phase is an effective combating of the oil possible and with it the avoidance of further spreading, and the stemming of ecological damage.<sup>53</sup> Therefore the fast combating of oil at sea must have absolute priority over the extremely difficult cleaning of the coastal area. The spreading speed depends for the most part on the oil's viscosity. Liquid oils with less viscosity spread faster than oils with a high viscosity. After some hours the spill begins to break open because of wind and wave as well as water turbulence. So the spreading speed depends on the prevailing conditions such as temperature, water- and tide current and wind speeds. The more unfavourable these conditions the faster the oil spreads.



**Figure 7: Reaction/behaviour of spilt oil at sea<sup>54</sup>**

<sup>53</sup> Compare BMV (publisher): Ölnfallbekämpfung, 1989, p. 6.

<sup>54</sup> Figure following of BMV (publisher): Ölnfallbekämpfung, 1989, p. 7.

### Evaporation

Light components of oil evaporate in the atmosphere. Dimension and speed of this process depends on the oil's volatility. An oil with lighter, more volatile compounds will evaporate more than one with greater parts of heavy compounds. For example, petrol, kerosene and diesel evaporate almost completely within a few days, compared with the only slight evaporation of heavy oil.<sup>55</sup> The evaporation can rise with increased spreading because of the enlarged surface. Rough sea, high wind speeds and high temperatures favour the process.

### Dispersion

Waves and turbulence on the water surface lead to the slick breaking up in fragments and small droplets of different sizes, which are mixed in the area of the water close to the surface. Some of the smaller droplets remain behind in the water, while the bigger ones reach the surface, where they join an oil slick or continue spreading as a thin film of oil. The remaining droplets in the water have a bigger surface and due to this, undergo other processes such as dissolution, biodegradation and sedimentation. In the same way that they influence spreading and evaporation, the properties of the oil and the state of sea influence the process of dispersion. This occurs the most quickly with light oil with a lower viscosity, and rough sea. The addition of dispersants accelerates the natural process.

### Emulsification

The term emulsification refers to two insoluble liquids being finely mixed. In case of oil emulsion seawater droplets mix themselves with the oil caused through turbulence on the water surface. Such emulsions are very glutinous and more persistent than the original oil. They increase the dimensions of the pollution about 3 to 4 times and slow down decomposition processes. Oils with an asphalt content of more than 0,5 % form stable emulsions, still existing many months after the oil accident. Only if the emulsion is heated by the sun washed on to the coast is it separated again to oil and water.

### Dissolution

Oil components which are soluble in water dissolve in the surrounding water. This depends on the state of the oil and occurs most quickly if the oil is already dispersed finely in water. Components most susceptible to dissolution in water are light aromatic hydrocarbon compounds like benzene<sup>56</sup> and toluene<sup>57</sup>. But such compounds are also

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<sup>55</sup> Generally oil compounds with a boiling point below 200 °C evaporate within the first 24 hours.

<sup>56</sup> A colourless, flammable, liquid aromatic hydrocarbon, C<sub>6</sub>H<sub>6</sub>, derived from petroleum and used in or to



those which evaporate first and up to 10 to 100 times faster. For this reason and because oils mostly contain few of these compounds dissolution is one of the most unimportant processes.

### **Oxidation**

Oil reacts chemically with oxygen either through breaking down into soluble products or through forming lasting, heavy compounds of high viscosity, called tars. This process is caused by sunlight and depends on the nature of the oil and how it is exposed to the sun. However this process is very slow. Even under strong sunlight a fine film of oil decomposes only around 0,1 % each day.

### **Sedimentation/Sinking**

Some heavy, refined products have a higher density than 1 t/m<sup>3</sup> and for this reason sink in fresh or brack water. Sea water has a density of about 1,025 t/m<sup>3</sup> and only a few crude oils have a large enough density or are sufficiently weathered to sink to the bottom of the sea/ into the marine environment. This occurs especially in flat stretches of water, due to the high proportion of floating sediments or organic particles, which offer excellent conditions for sedimentation because of the adhesion of these particles with the oil. Oil which has been mixed with sand or other sediments on the beach and has been washed back into the sea also sinks. Likewise the remains resulting from oil fire can lead to sedimentation.

### **Biodegradation**

Over the last 20 years complex chemical equations have been derived to describe the metabolic pathways in which oil is broken down. All of these pathways will result in the oxidation of at least part of the original hydrocarbon molecule. The content of a particular petroleum mixture will also influence how each hydrocarbon will degrade and the type and size of each hydrocarbon molecule will determine the susceptibility to biodegradation.<sup>58</sup>

Sea water contains a large number of micro organisms who can split up oil partly or fully

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manufacture a wide variety of chemical products, including DDT, detergents, insecticides, and motor fuels. Also called benzine, benzol.

<sup>57</sup> A colorless flammable liquid, CH<sub>3</sub>C<sub>6</sub>H<sub>5</sub>, obtained from coal tar or petroleum and used in aviation fuel and other high-octane fuels, explosives, and as a solvent for gums and lacquers. Also called methylbenzene.

<sup>58</sup> Compare Atlas, R.M.; Bartha, R. *Microbial Ecology: Fundamentals and Applications*. 3rd ed. Reading, Ma: Addison-Wesley publishing Company; 1993, p. 394.

into water soluble compounds and possibly into carbon dioxide and water. However some oils are partially or totally resistant towards such biological decomposition. The main factors determining the efficiency of biodegradation are the content of nutrients (nitrogen and phosphorus) in the water, the temperature and the oxygen content. The development of oil droplets through natural or chemical dispersion and with it the enlargement of the oil surface also supports biodegradation.<sup>59</sup>

### 3.4 Technical cleaning methods in case of spilt oil

The regeneration of areas contaminated by fuel or oil has two different phases. The first is the elimination of as much oil as is possible to collect by mechanical methods. The second phase requires the cleaning of areas where the mechanical methods are not efficient enough. Normally with the passing of time nature does its work, but this work could be accelerated significantly if it was tackled with determined simple strategies favouring the degrading action of micro organisms in the affected zone: **Bioremediation**.

We can split up into physical, chemical and biological, the methods to clean the oil slick. They should not be used without a careful consideration of the environmental effects, which could sometimes be worse than that of the oil spill itself. Actually in remote areas of fast natural recovery or in ecologically sensitive areas it is preferable that the oil slick, once arrived at the coasts, cleans itself by natural mechanisms (see: 3.3: Weathering processes in case of spilt oil at sea).

The **physical methods** could be:

- The collection of the oil in the sea by vacuum, centrifugation or by using absorbing fibres, known as skimming ladles.

This method is environmentally the most harmless, but it eliminates only a small part of the oil spill.

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<sup>59</sup> Compare ITOPF (publisher): Fate of Marine Oil Spills, online on WWW under URL: <http://www.itopf.com/fate.html> [04.05.03].



**Figure 8: Collection by vacuum**

Spanish soldiers cleaning up a beach on the Galician coast after the tanker *Prestige* spilled oil on 13 November 2002.

© WWF / Raúl García

- Collection on land through mechanical methods.

The clean-up on land is realized through collection by hand. This method could be used to collect the biggest oil accumulations. It is particularly efficient immediately after the oil has arrived the beach or rocks and in the form of globules before being surrounded by sand or before it has penetrated between sediments. The collection by hand could be used in all types of area but it is used in general where there are no other possible methods available, the place is difficult to access or is very sensitive. Viscose oil is picked up easier by hand than more fluid oils. This method always has to be attempted first method before using for example biological methods, because biological methods are not efficient enough to remove the whole contaminant. Unfortunately this manual method, which is very mild for the environment, is extremely dependent on a large number of personnel and a great deal of time and could also be very difficult. The most important equipment is the protection suit which the personnel have to use. Other equipment such as sacks, buckets, shovels and scrubbing brushes are also necessary.



**Figure 9: Spanish sailors help shovel sludge off an oil-stained beach** © ITOFF

## Tanker disaster and the consequences for the environment

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- Washing with cold or hot water under high pressure.  
Two types of high pressure are used,  $P = 10 \text{ kg/mm}^2$  or  $P \leq 4 \text{ kg/mm}^2$ . This is used for the removal of oil in places with difficult access. It uses water as a cleaning element but misuse or bad application could damage the ecosystem. Application zones are rocky surfaces and all types of rocks in higher levels of sea.



Figure 10: Hot water washing of oiled rocks, © ITO PF



Figure 11: High Pressure washing



Figure 12: High pressure washing of tidal zones with hot water, © ITO PF

- Mixing and dispersion of the oil with sand from the coast (see Figure 13, p. 44)  
This method produces big amounts of hazardous waste and loss of sand.



**Figure 13: Collection of sand-oil lumps by hand in San Sebastian/Donostia,** by Akgün

The last three methods could cause erosion problems and contamination of deep layers of the soil, besides the damaging of coastal flora and fauna.

The **chemical methods** consist principally of the use of dispersant agents, similar to detergents, which, like the name indicates, facilitate the dispersion of the oil before it arrives at the coast, split into small drops. So it facilitates its chemical and biological degradation. The concentration of the oil is reduced and so therefore are its toxic effects. They are recommended for small slicks, with dispersants of low toxicity.

### **Bioremediation**

The most effective method to clean spilt oil seems to be **Bioremediation**, which favours natural processes of biodegradation mentioned before (p. 40). Basically it involves increasing degradation bacterium's at the affected coasts through addition of bacterium's, or the stimulation of the reproduction of the native bacterium's by providing them with nutrients and/or creating better environmental conditions for their action, called Bio-stimulation or Nutrient Enrichment (see page 71).

Bioremediation is a cheap and generally an effective method, although it is slow (months to years). It is based on natural biodegradation and is free of possible environmental impacts or the poisonous effects of some secondary degradation products.

## **Tanker disaster and the consequences for the environment**

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The application in case of light to medium crude oils and fuel oils (asphaltenes tend to inhibit rapid biodegradation) is most effective. It is less effective where oil residues are thick and not considered for gasoline spills, which evaporate rapidly.

More information is available in part Bioremediation: bio technical approaches to regenerate the contaminated areas by the oil slick of the Prestige at page 68.

### 3.5 Sad dates in history: Big tanker catastrophes

In 1978 “AMOCO CADIZ” lost 223.000 tonnes of crude oil off the coast of France. In 1989 the “EXXON VALDEZ” polluted the coast of Alaska with 37.000 tonnes. The following table shows that there have been tanker accidents with even more considerable oil amounts.

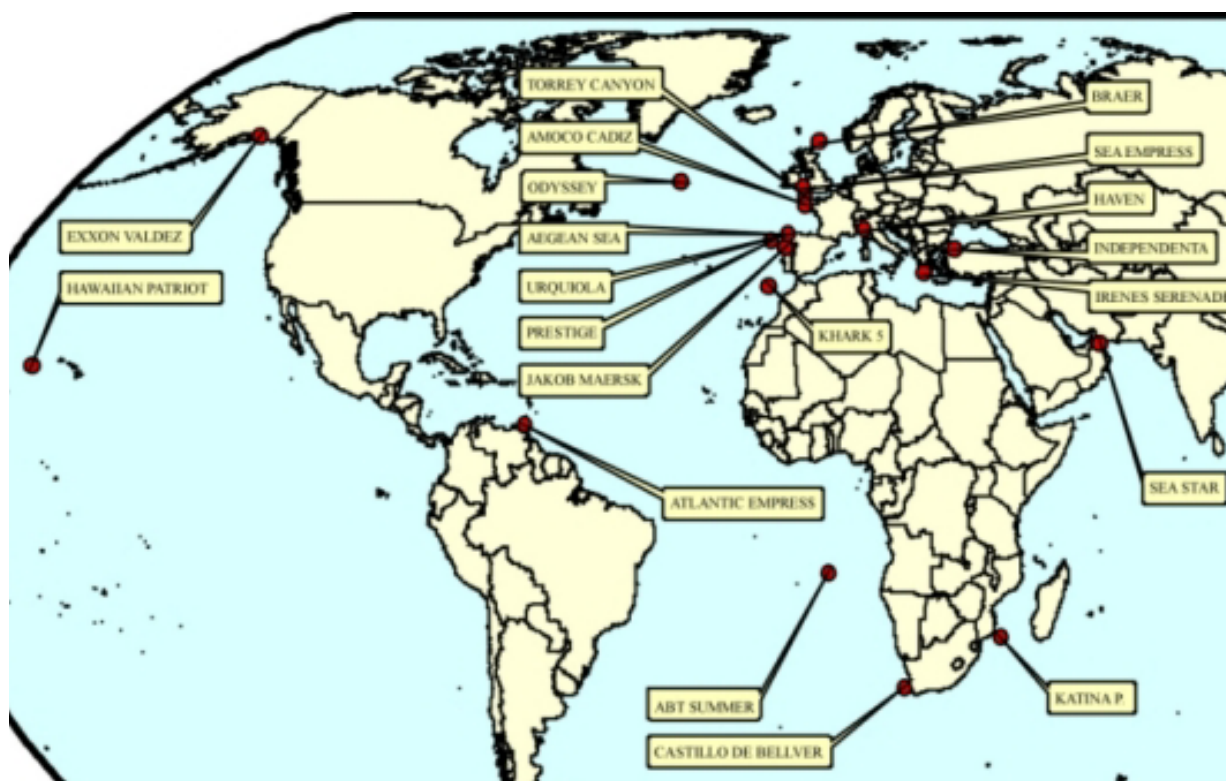
**Table 4: Big tanker catastrophes<sup>60</sup>**

Year	Tanker	Place	Oil amount (t)
1967	<b>Torrey Canyon</b>	Scilly Isles, UK	119.000
1971	<b>Wafra</b>	off Cape Agulhas , South Africa	40.000
1974	<b>Metula</b>	Magellan Straits, Chile	50.000
1975	<b>Jakob Maersk</b>	Porto, Portugal	88.000
1976	<b>Urquiola</b>	La Coruña, Spain	100.000
1977	<b>Hawaiian Patriot</b>	300 nautical. miles off Hononulu	95.000
1978	<b>Amoco Cadiz</b>	off Brittany, France	223.000
1979	<b>Atlantic Empress</b>	off Tobago, West Indies	287.000
1979	<b>Independenta</b>	Bosphorus, Turkey	95.000
1983	<b>Castillo de Bellver</b>	off Saldanha Bay, South Africa	252.000
1983	<b>Assimi</b>	55 nautical. Miles off Muscat, Oman	53.000
1985	<b>Nova</b>	Iran	70.000
1988	<b>Odyssey</b>	700 nautical. miles off Nova Scotia, Canada	132.000
1989	<b>Khark 5</b>	120 nautical. miles off coast of Morocco	80.000
1989	<b>Exxon Valdez</b>	Prince William Sound, Alaska, USA	37.000
1991	<b>ABT Summer</b>	700 nautical. miles off Angola	260.000
1991	<b>Haven</b>	Genoa, Italy	144.000
1992	<b>Aegean Sea</b>	La Coruña, Spain	74.000
1992	<b>Katina P</b>	off Maputo, Mozambique	72.000
1993	<b>Braer</b>	Shetland Islands, UK	85.000
1996	<b>Sea Empress</b>	Milford Haven, UK	72.000
1997	<b>Nachodka</b>	Japanese Sea, Japan	20.000
1999	<b>Erika</b>	off Brittany, France	20.000
2002	<b>Prestige</b>	La Coruña, Spain	77.000

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<sup>60</sup> Figure from ITOPF (publisher): Tanker oil spill statistics, online on WWW under URL: <http://www.itopf.com/stats.html> [03.08.03].

Figure 14: Location of Selected Spills<sup>61</sup>



March 18, 1967, TORREY CANYON

The Liberian tanker, chartered by the union Oil Company of California, loaded with 119.000 tons of crude oil, runs aground between the Scilly Isles and the British coast. Numerous oil slicks drift, touching the British and the French coast. It is later found out that some of the means of dispersants used for the struggle were more toxic than the oil itself. This accident makes Europe discover a risk that had been disregarded and initialises the first elements of French, British and European policies of prevention and combating of big oil spills.

March 16, 1978, THE AMOCO CADIZ

The Liberian tanker transporting 223.000 tons of crude oil from the Persian Gulf towards Rotterdam drifts in a strong storm towards the Breton coast. The manoeuvres with a German tugboat coming to rescue it are difficult. The first attempt fails. In spite of the efforts, the ship runs aground off the small port of Portsall. Over two weeks, the cargo flows into the sea and pollutes more than 300 km of coast.

April 10, 1991, AGIP ABRUZZO AND HAVEN

<sup>61</sup> Figure from *ibid.*



## **Tanker disaster and the consequences for the environment**

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The oil tanker Agip Abruzzo collides in fog with the ferry Moby Prince. A gigantic fire breaks out. It lasts 7 days and 143 victims lose their lives. 130 km of coast are polluted.

The following day, the Cypriot oil tanker Haven, lying at anchor at the Genua, catches fire, explodes and breaks into three parts. It is transporting 144.000 tonnes of crude oil, a part of which flows out immediately, the remainder later.

December 3, 1992, AEGEAN SEA

While trying to enter in the port of La Coruña because of bad weather, the Greek tanker runs aground, breaks and burns during 24 hours. It has on board 74.000 tons of crude oil.

January 5, 1993, BRAER

The Liberian tanker, on the way from Norway to Canada, runs aground at the southern tip of the Shetland Islands. After a strong storm it is shipwrecked and 85.000 tons of crude oil spills into the North sea. It mainly damages local fish-farms and sea bird populations. Because of favourable winds causing rough sea, the spilt oil disperses in a few days.

February 15, 1996, SEA EMPRESS

The Liberian tanker, loaded with 130.000 tons of crude oil, runs aground on the reefs near the port of Milford Haven. It is set free 5 days later, after having lost more than half of its load.

Following, I would like to explain the Prestige-disaster in more detail to describe the enormous extents of a catastrophe.

## 4 The « Prestige » accident

### 4.1 Conditions of Prestige

On 13 November 2002, the Prestige, a Bahamas-flagged single-hulled tanker loaded with 77 000 tonnes of heavy fuel oil, ran into difficulties in heavy seas off the west coast of Galicia. During the next few days the tanker lost parts of its poisonous cargo. The tanker was towed out to open sea, but while discussions were taking place concerning a suitable safe haven to transfer its cargo to another ship, the on board situation deteriorated. On 19<sup>th</sup> November, the vessel could no longer withstand the forces of the sea. A large crack in the starboard side of the hull caused the ship to break off into two parts and sink to some 3600 metres below sea level. This took place some 100 miles off the Spanish and Portuguese coast, 234 kilometres off the Cíes Islands, including the national park of the Atlantic Islands. A large quantity of fuel oil was released into the sea, with further oil spillage observed for a considerable time afterwards. The pollution has affected, and is still affecting, the coastlines of Spain, Portugal and even France. It is calculated that approximately 40 000 tonnes of fuel oil has leaked out of the tanker until now.<sup>62</sup>

### 4.2 Chronology of the catastrophe-The shipwreck history of the “Prestige”

**November 13<sup>th</sup> 2002.** At 15:15 an SOS call arrives from the Prestige. The oil tanker with a crew of 27 is located 50 km from Fisterra. The first spill occurs.

**November 14<sup>th</sup>.** It is decided to tow the vessel as far away from the coast as possible. An oil spill of nine km surrounds the ship.

**November 15<sup>th</sup>.** The Prestige is escorted 120 miles out to sea by the Armada. It is prohibited to dock in any Spanish harbour. An oil spill of 3.000 tons is already very near to the “Costa da Morte” (Coast of Death). Manuel Fraga, the president of the Xunta de Galicia<sup>63</sup> declares: “The biggest danger has already passed”.

**November 16<sup>th</sup>.** The first oil slick arrives at the “Costa da Morte”. Miguel A. Arias,

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<sup>62</sup> Compare EU, online on WWW under URL:

[http://europa.eu.int/comm/transport/themes/maritime/prestige/com\\_2003\\_0105\\_en.pdf](http://europa.eu.int/comm/transport/themes/maritime/prestige/com_2003_0105_en.pdf) [03.07.03].

<sup>63</sup> The Xunta de Galicia appears in the Statute of Autonomy defined as the collegiate body of the Government of Galicia.

## The « Prestige » accident

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minister of agriculture, fishing and feeding, confirms: “Fortunately the fast intervention of the Spanish authorities taking the ship away from the coast means that, we neither have an ecological catastrophe nor big problems for fishing”.

**November 17<sup>th</sup>.** The slick already affects 190 km of coastal area and reaches La Coruña. The delegate of the Galician government explains: “We can not speak of a black tide, but rather individual and isolated patches of oil.”

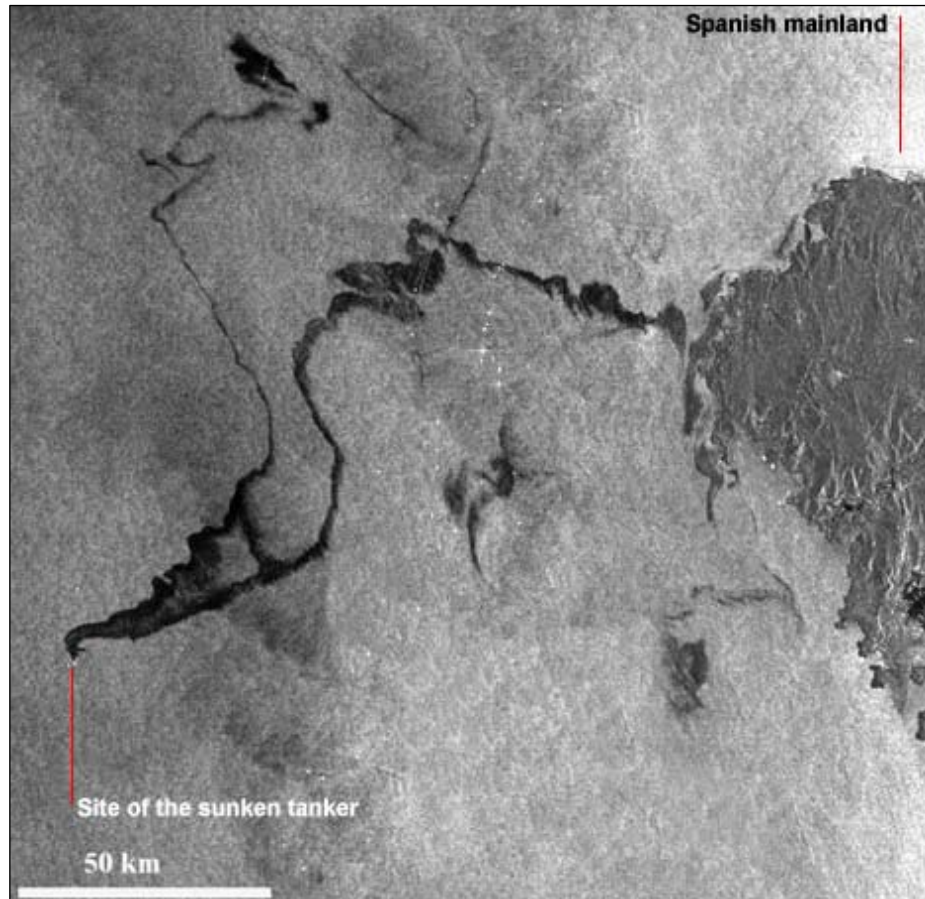


Figure 15: Envisat's ASAR wide-swath image acquired 17 November 2003

**November 18<sup>th</sup>.** The crack in Prestige's single hull leaves another big oil slick off Corrubedo. The minister Cañete assures: “There is no black tide, but rather a spillage which has unequally affected certain parts and not all of the coastline.

**November 23<sup>th</sup>.**

- Estimated 12,000 of original 77,000 tonnes has leaked so far
- The boat is resting in an underwater channel that separates the Galician Bank from the continental shelf.

## The « Prestige » accident

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- This area is a seamount - an underwater mountain - and has very high biodiversity, much of which has not yet been identified<sup>64</sup>
- Species affected include: porpoises, guillemots, gannets, some species of sheerwater, black legged kittiwakes, European shag
- Ship facts<sup>65</sup>: Bahamas flagged Tanker; deadweight tonnage of 81,564 tonnes; 243.50 meters in length; 34.40 meters in width; built in 1976; Owner is Mare shipping, Liberia; Ship operators is Laurel Sea Transport, Athens, Greece

**November 19<sup>th</sup>.** Finally the Prestige's stern sinks at around 12.00 GMT and the bow at around 16.00 GMT, 234 km from Fisterra above the Cíes Islands. The Wind and waves push a slick of 10.000 tonnes of heavy fuel oil towards the coast.

The damaged tanker was towed during 6 days, covering 243 miles (437 kilometres) in total.

### **December 19<sup>th</sup>.**

- 15 holes counted in the sunken wreck
- From 30 to 40 tonnes of oil leaking from the wreck each day
- Oil takes around 1 day to reach the surface
- Leaking could continue for up to 3 years
- 90,000 livelihoods affected

### **January 28<sup>th</sup> 2003.**

- 654 out of 1064 beaches have been affected at various levels on the Spanish Atlantic coast
- Total number of birds affected during the first two months of the Prestige oil spill was between 65,000 and 130,000. The most affected species continue to be Guillemot (5,691 live and dead), Razorbill (2,248 live and dead) and Puffin (1,877 live and dead)<sup>66</sup>

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<sup>64</sup> More details online on WWW under URL: <http://www.panda.org/downloads/marine/galiciabank1.pdf> [03.07.03].

<sup>65</sup> Compare SMIT, online on WWW under URL <http://www.smit-international.com/> [23.06.03].

<sup>66</sup> Compare online on WWW under URL: [http://www.panda.org/news\\_facts/crisis/spain\\_oil\\_spill/latest\\_facts.cfm](http://www.panda.org/news_facts/crisis/spain_oil_spill/latest_facts.cfm) [03.07.03].

### 4.3 Causes for the disaster

The tanker “PRESTIGE” sailed under the flag of the Bahamas. The ship’s operator was established in Greece and the classification society in charge of the periodical safety inspections was the American Bureau of Shipping. The precise cause of the accident cannot be assessed with certainty at this moment. The Commission services have written to the UK, Greece, Latvia and Russia to enquire about Port State inspections during recent calls of the ship to ports under the jurisdiction of these countries. The crew at some point reported that the ship would have collided with a floating object. However, this is difficult to verify. What is known is that the “PRESTIGE” was a 26-year old single hull tanker constructed in Japan. On the basis of the double hull regulation, adopted by the Council and the European Parliament following the ERIKA incident, this ship was to terminate its operation by 15 March 2005 at the latest. (The same rule was adopted at an international level and therefore applies world-wide, see section 6.2) The ship was thus clearly approaching the end of its life cycle.

The last Special Survey No. 5 was conducted in Guangzhou China, May 2001. 362 tonnes of steel was replaced, the major operations took place at tank n° 3. The last annual survey was in Dubai, UAE between may 15<sup>th</sup> 2002 and may 25<sup>th</sup>. Hereby, the ship’s hull, machinery, automation and inert gas system, alarm and detection system was inspected.

The last port state controls took place in<sup>67</sup>

- Port Hawksbury, November 28<sup>th</sup> 1998, no detentions, no deficiencies,
- Long Island (US), April 15<sup>th</sup> 1999, no detentions, no deficiencies,
- New York, April 19<sup>th</sup> 1999 with one deficiency in the navigation system. No detentions.
- Long Island (US), May 19<sup>th</sup> 1999, no detentions, no deficiencies,
- Baltimore (US), June 25<sup>th</sup> 1999, , no deficiencies,
- Rotterdam (Netherlands), September 1<sup>st</sup> 1999. It was find three deficiencies, no detentions.

There is certainly a problem in that many of the world’s ship yards have been closed down. Therefore there are a limited number of places where new double-hull vessels can be built. There are also concerns about building vessels too fast and compromising design

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<sup>67</sup> Compare online on WWW under URL: <http://www.eagle.org/news/press/nov202002.html> [03.06.03].

standards. The point design standards is highly relevant as it appears that design standards may have been a factor in the Erika and Prestige oil spills. It seems that in the mid-70s in Japanese ship yards, a lot of tankers were produced very quickly and, for some at least, their hulls seem to be “thin”. This itself doesn’t appear to be a problem until repairs are carried out which include welding. There isn’t a good deal of supporting information, but it appears that in the case of the Prestige and the Erika, the structural failures occurred some months after welding repairs on their hulls, suggesting this could be a factor in the structural failure of these hulls. But nothing, so far, is proven.

### 4.4 The properties of the oil

The type of oil carried by the “Prestige” is very persistent and difficult to clean. It is similar to the oil that was carried by “Erika”, however “Erika” was a smaller ship carrying 35,000 tonnes, of which 20,000 tonnes were spilled. It is not yet clear how much oil has been spilled into the sea, but the first estimations by experts indicate that it might be some 15,000 tonnes. According to the investigations of the French environmental organisation CEDRE<sup>68</sup> and CSIC<sup>69</sup> the oil carried by the super-tanker “Prestige” consists of more than one third carcinogenic substances, which threaten the health of the citizens and the volunteers working in the affected areas. It is a residual oil that corresponds to oil Nr. 2 in the French scale and to oil Nr. 6 (also known as bunker oil C) in English and international terminology. It is basically used as a fuel in industrial installations.<sup>70</sup>

#### Composition

Residual oils remain as thick remains after the refinery of crude oil to petrol, diesel and light fuel oil. They are used above all/primarily as cheap ship fuel. They contain complex mixtures of components with a relatively high molecular weight. They contain compounds of Polycyclic Aromatic Hydrocarbons (PAH’s) the most toxic and with the potential to provoke cancer. In a smaller amount they also contain less heavy aromatic hydrocarbons like e.g. toluene. Furthermore the residual oil carried by the “Prestige” contains a high amount of heavy metals. For more information about the oil’s composition see section 5.2.2.

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<sup>68</sup> Centre de documentation de recherche et d’expérimentations sur les pollutions accidentelles des eaux.

<sup>69</sup> Instituto de Investigaciones Químicas y Ambientales de Barcelona, Departamento de Química ambiental

<sup>70</sup> Compare online on WWW under URL: [http://www.le-cedre.fr/fr/prestige/fichiers/baert29\\_11es.pdf](http://www.le-cedre.fr/fr/prestige/fichiers/baert29_11es.pdf) [13.06.03].

### Characteristics of residual oils:

- Low solubility in water
- The coastal area is very difficult to clean because of its viscosity and adhesiveness  
This difficulty increases with time
- Slow degradation
- Less dispersion capacity
- Long term contamination of sediments
- High contamination in tidal zones

### Toxicity

This type of fuel is less volatile- it is estimated that it evaporates between 5-10%- because of the high content of (elevated) macro molecules<sup>71</sup>, like poly-cyclic hydrocarbons. This confers less toxicity upon it in the short term than the other types of oils which have a higher content of less macro aromatic hydrocarbons like benzol.

The direct mortality rates of aquatic birds and sea-mammals could be increased, especially when there are concentrated populations living in small areas, as is seen during bird migrations.

However the high presence of heavy poly-cyclic hydrocarbons gives the polluted soils, sediments and waters a risk of toxicity in the long term, with carcinogenic, mutagenic effects and alteration of the endocrine system. This can cause an alteration of the immune and reproductive system. In addition it should be considered that these pollutants have a potential of accumulation in the biosphere.

The aromatic hydrocarbons could enter organisms by three means:

- the respiratory tract,
- the skin
- and the digestive system.

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<sup>71</sup> molecules with high molecular mass

The way through the respiratory tract seems now to be the most complicated. In the long term it would be necessary to supervise the accumulation of these hydrocarbons in living organisms.

Not least of all the residual oil contains a high quantity of composition of sulphur, which can liberate itself and could be very toxic, causing different effects like irritations in the eyes, skin and the respiratory tract, as well as head aches, nausea and insomnia.

### 4.5 The fatal consequences of oil

Known as “black gold” oil gives off a dirty shimmer, smells unpleasant and above all is poisonous.

Almost all oils float on the sea surface because of their specific weight. It follows that there is a particular threat to birds. Birds are one of the groups of creatures most affected by oil pollution, as small amounts of oil can destroy large bird stocks under unfavourable circumstances, and because many bird species have a small reproduction potential. The species affected first and foremost are those which spend much time floating on/diving into the water. Even after small accidents long lasting consequences for bird populations are expected, above all, if there are a large amount of birds present during the accident period, as in the case of breeding areas, in rest and moult areas as well as in winter accommodations areas.

“Plankton is a term applied to floating plants and animals carried passively by water currents in the upper layers of the sea. Their sensitivity to oil pollution has been demonstrated experimentally. In the open sea, the rapid dilution of naturally dispersed oil and its soluble components, as well as the high natural mortality and patchy, irregular distribution of plankton, make significant effects unlikely.

In coastal areas some marine mammals and reptiles, such as turtles, may be particularly vulnerable to adverse effects from oil contamination because of their need to surface to breathe and to leave the water to breed. Adult fish living in near shore waters and juveniles in shallow water nursery grounds may be at greater risk to exposure from dispersed or dissolved oil.

The risk of surface oil slicks affecting the sea bed in offshore waters is minimal. However, restrictions on the use of dispersants may be necessary near spawning grounds or in some sheltered, near shore waters where the dilution capacity is poor.



The impact of oil on shorelines may be particularly great where large areas of rocks, sand and mud are uncovered at low tide. The amenity value of beaches and rocky shores may require the use of rapid and effective clean-up techniques, which may not be compatible with the survival of plants and animals.

Marsh vegetation shows greater sensitivity to fresh light crude or light refined products whilst weathered oils cause relatively little damage. Oiling of the lower portion of plants and their root systems can be lethal whereas even a severe coating on leaves may be of little consequence especially if it occurs outside the growing season. In tropical regions, mangrove forests are widely distributed and replace salt marshes on sheltered coasts and in estuaries. Mangrove trees have complex breathing roots above the surface of the organically rich and oxygen-depleted mud in which they live. Oil may block the openings of the air breathing roots of mangroves or interfere with the trees' salt balance, causing leaves to drop and the trees to die. The root systems can be damaged by fresh oil entering nearby animal burrows and the effect may persist for some time inhibiting recolonisation by mangrove seedlings. Protection of wetlands, by responding to an oil spill at sea, should be a high priority since physical removal of oil from a marsh or from within a mangrove forest is extremely difficult.<sup>72</sup>

Birds and sea mammals die of exposure or drown after their sticky fur or feathers have lost their insulating, water repellent properties and thus also the effectiveness in terms of buoyancy. Many animals fall victim to the chronically after effects of oil pollution. By trying to clean their plumage, poisonous and corrosive components penetrate into the digestive tract – months later they die of lung damage, stomach or intestinal ulcers. An oiled sea bird can die even if the oil polluted part of their body has the size of a coin with a diameter of 3 cm.<sup>73</sup> Several of the oil's elements store themselves in the fatty tissue of the victims and damage the genetic make-up. The offspring fails to develop or is born deformed. Fish and benthos (animals and plants living on or within the substrate of a water body) are also threatened by oil accidents. Animals like mussels, snails and crayfish as well as plankton are destroyed - the beginning of the marine food chain is ruined. Nobody knows at present what the combination of the numerous substances in the oil with other materials will cause in the future. Even today, 14 years after the disaster of "Exxon Valdez" in Alaska experts are reporting the lasting consequences of the oil

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<sup>72</sup> Quotation from ITOPE, online on WWW under URL: <http://www.itopf.com/effects.html> [04.06.03].

<sup>73</sup> Compare Greenpeace (publisher): Die Gier nach Öl, 1993, p. 4.

pollution: crippled fish and brain damaged seals, infertile birds and dead killer whales.<sup>74</sup>

In tropical regions mangrove forests at low river mouths and sea bays, influenced by the tide, are very widespread. These mangrove forests live on organically rich but oxygen deficient mud seabed. Therefore they have complex respiratory roots rising up out of the water surface. If these forests are polluted by oil, the oil closes the respiration openings of the roots. This disturbs the supply of oxygen and nutritional salts. The leaves fall off and the trees die.

Coral reefs with their rich fauna and flora can also be badly damaged by oil pollution. Consequences of oil in the reef are influenced above all by the proportion of toxic compounds, by the duration the reef is influenced by the oil and by other stress factors. Once the living corals are destroyed the remains of the dead coral colonies are exposed to wave erosion.<sup>75</sup> The constant regeneration process and the growth of the reefs are no more guaranteed. A habitat dies.

The salt meadows are the most endangered by oil spills compared with different coastal ecosystems. Oil is reduced very slowly and for this reason stays in the soil a long time. The regeneration ability of salt meadows after oil accidents depends highly on the season, the affected plant species, the kind of oil and other factors. Observations after some oil accidents verify that oil pollution of salt meadows evoked heavy long term damage.<sup>76</sup>

It is not to forget that human cleaning action itself and with it the physical damage to the living spaces has also a detrimental affect on maritime life.

## 4.6 The effects of the Prestige oil upon the environment

On January 28<sup>th</sup> 2003 654 out of 1064 beaches have been affected at various levels on the

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<sup>74</sup> Compare *ibid.*

<sup>75</sup> Compare ITOPF (publisher): Fate of Marine Oil Spills, online on WWW under URL: <http://www.itopf.com/effects.html> [04.05.03].

<sup>76</sup> Compare Bericht “Havarie Pallas”, 2000, p. 52-53.

Spanish Atlantic coast.<sup>77</sup> The black tide spreads not only on the surface but also on the sea bed. Oil slicks spread because of different factors: the speed and direction of the current and the wind, and also the effect of the wave system.

The impact of this disaster on the marine ecosystems will last for decades and it will cause short, medium and long-term consequences. These consequences will result in economic, social and cultural costs.

The short-term effects are, on the one hand, the toxicity of the oil and the effects of the deposited oil on the substratum, and on the other hand the lack of light penetration in the marine medium. This lack of light in the marine medium because of the oil slick will inhibit photosynthesis of producers (alga, phytoplankton<sup>78</sup> and some phanerogams<sup>79</sup>) and, in consequence, they will not free oxygen in the marine ecosystem. Furthermore, the toxic spill will pollute or even kill the plankton, which is composed of lots of small organisms living near the surface. They are the basis of the whole food chain in the marine environment.

The long-term effects related to the structure alteration and dynamic of the ecosystem are caused by, amongst other factors, the accumulation of oil components (bio accumulative and persistent) in the trophic chains over many generations.

It will be difficult for the landscape to recover totally (the British coast has not yet recovered the from the Erika oil spill, three years ago) because while the ecosystem returns to normality, species will grow that will be different from the original ones and will modify the original characteristics of the ecosystem.

The whole marine food chain will be affected by the oil slick, from the base, where phytoplankton and alga will not be able to photosynthesise because of a lack of light, which means less quantity of oxygen and of food, up to the peak of the chain, where the

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<sup>77</sup> Compare online on WWW under URL: [http://www.panda.org/news\\_facts/crisis/spain\\_oil\\_spill/latest\\_facts.cfm](http://www.panda.org/news_facts/crisis/spain_oil_spill/latest_facts.cfm) [28.01.03].

<sup>78</sup> small, free-floating aquatic plants

<sup>79</sup> plants producing seeds

third consumers will suffer the lack of food and the direct effects of the oil.

According to the report made by the Research Group for fishing and natural resources economy of the University of Santiago de Compostela, it is faced a period of economic and environmental recovery that will last longer than 10 years and in some species could even last 25 years.

The researchers underline the multiplying effect of the spill because of the importance of the fishing sector in this area. So, the effects will lead to changes in production which will transfer from one sector to another: the destruction of the marine ecosystem will modify fishing and seafood activities but also the sectors that depend on these activities (like e.g. transport sector, trade, tourism).

The Prestige sank near the so-called Galician's Banc, an area of great biodiversity, located 200 km from the Galician coast. It is a marine mountain 5000 metres deep and separated from the continental platform by a valley of 2000 metres. The species that live there do not have a commercial value but they contribute to an exceptional marine wealth. Amongst other organisms to highlight: 90 different fish species, 11 species of shark and numerous sponge, star and coral species.

### **4.6.1 Effects on birds**

The birds arriving at the Atlantic Coast to spend the winter have also suffered directly from the effects of the slick.

From the sky, the patches of oil look like rocks or small islands and, therefore, the birds land on them and become trapped. As their feathers get soaked in oil they break and loose their impermeability to water and also their isolating and thermoregulatory properties. As a consequence the birds suffer from dehydration and their vulnerability to extreme temperatures increases, which can cause their death by overheating. In addition to this they lose their ability to fly, which limits their capacity to feed and escape from predators.

Furthermore the direct contact of a bird with the chemical components of the oil can produce burns and lead to the absorption of toxic chemical elements through its skin.

## The « Prestige » accident

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When the bird tries to clean itself with its beak, it will ingest the toxic components. The most vulnerable species are the divers like cormorants and seagulls.

These internal effects, although more difficult to see by eye are often the more difficult to treat:

Pneumonia, alteration of the hepatic functions, anaemia or intestinal irritations, that increase dehydration and the metabolic imbalance...

Just two months after the Prestige disaster, this is already the second worst mortality of marine birds by oil spillage registered in the European Atlantic. The largest number of bird deaths was caused by the Erika disaster, which injured and killed many birds on the Atlantic coast. And only a small amount of these affected birds could be recovered while the great majority continued their migration, harmed by the oil, to die in the open sea far away from the polluted area.



**Figure 16: A bird lies covered in oil on a beach** © TIME

During the first two months following the sinking of the Prestige:

Of 13221 birds of 62 different species, collected from the Spanish, Portuguese and French coast, 3873 survived and 9348 died.

On January 28<sup>th</sup> 2003 the estimated number of birds highly affected by the oil is between 65000 and 130000. The most affected species continue to be Guillemot (5,691 live and

dead), Razorbill (2,248 live and dead) and Puffin (1,877 live and dead).<sup>80</sup>

Galicia is one the key zones of the north-east Atlantic for the reproduction, migration, and hibernation of nearly 40 marine species. In autumn its importance is crucial, as an important part of the species that reproduce in other latitudes pass through the Galician waters or hibernate there.<sup>81</sup>

The strategic importance of this area for the marine bird population increases the possibility that the impact of the Prestige oil spill (it began to lose oil in November 2002) will be of great magnitude. This situation will surely continue for years and will continue affecting the marine birds and their habitat in this area.

### 4.6.2 Impact of oil on fisheries and mariculture

“An oil spill can directly damage the boats and gear used for catching or cultivating marine species. Floating equipment and fixed traps extending above the sea surface are more likely to become contaminated by floating oil whereas submerged nets, pots, lines and bottom trawls are usually well protected, provided they are not lifted through an oily sea surface. Experience from major spills has shown that the possibility of long-term effects on wild fish stocks is remote because the normal over-production of eggs provides a reservoir to compensate for any localised losses.

Cultivated stocks are more at risk from an oil spill: natural avoidance mechanisms may be prevented in the case of captive species, and the oiling of cultivation equipment may provide a source for prolonged input of oil components and contamination of the organisms. The use of dispersants very close to mariculture facilities is ill-advised since tainting by the chemical or by the dispersed oil droplets may result.”<sup>82</sup>

The Prestige oil spill caused loss of market confidence since the public is unwilling to purchase marine products from the region irrespective of whether the seafood is actually tainted. Bans on the fishing and harvesting of marine products were imposed, both to maintain market confidence and to protect fishing gear and catches from contamination.

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<sup>80</sup> Compare *ibid.*

<sup>81</sup> More details online on WWW under URL:<http://www.panda.org/downloads/marine/galiciabank1.pdf> [03.07.03].

<sup>82</sup> Quotation from ITOPF (publisher): Fate of Marine Oil Spills, online on WWW under URL:<http://www.itopf.com/effects.html> [04.05.03].

## 5 Proposal to clean the affected area by the “Prestige”

The recent Prestige tanker accident in front of the Galician costs is unfortunately not an uncommon event in the annals of catastrophic aggressions to the environment caused by oil spills. In the last 28 years the Galician ecosystems suffered the following 7 incidents, three of them in close vicinity of the North-west corner of Spain, locally known as the “Death Coast” or “Costa da Morte”:

**Table 5: Oil catastrophes in close vicinity since 1976**

Year	Tanker	Place	Oil amount (t)
1975	Jakob Maersk	Porto, Portugal	88.000
1978	Amoco Cádiz	off Brittany, France	223.000
1976	Urquiola	La Coruña, Spain	100.000
1989	Khark 5	off Morocco	80.000
1992	Aegean Sea	La Coruña, Spain	74.000
1999	Erika	off Brittany, France	20.000
2002	Prestige	La Coruña, Spain	77.000

Occupying is, apart from the oil spillage of 15.000 tons until now, the sinking of the oil tanker and the continuous leak of oil at the bottom. In these moments the vessels stern is located in the position 42°12.6 N, 12°03.0 W in a depth of 3.800 m and the bow 42°10.8 N, 12°0.6W at 3.600m. It is considered that the bow contains some 37.900 tons of oil while the stern contains some 25.900 tons. <sup>83</sup>

### 5.1 Preparatory work<sup>84</sup>

Generally it suits to clarify that the existing techniques that counteract in little time the heavy effects on the ecosystem of a spill like that of the Prestige, depend on the use of cleaning ships, of physical barriers and also of the addition of detergents or additives helping to disperse the oil slick or to submerge them to great depth. Regrettably, there was not any biological technology that could counter act in a short time the sharp effects

<sup>83</sup> Compare SMIT, online on WWW under URL <http://www.smit-international.com/> [23.06.03].

<sup>84</sup> Compare Bioremediation and its Application to Exxon Valdez Oil Spill in Alaska, Ray Gordon, 1994 available online on WWW under: <http://www.geocities.com/CapeCanaveral/Lab/2094/bioremed.html>[03.08.03].

on the ecosystem of this type of spill.

An investigation of quality is the base for a reliable oceanic prediction and for an effective coordination of the fight means against the contamination directed towards the minimization of the impacts on the marine environment and the coast.

At the beginning the following tasks should be done:

- It is indispensable and urgent to know the **physical properties** (like density, viscosity, thermal conductivity) of the remaining oil in the deposit tanks in a wide range of pressure and temperature to predict and to describe the temporary reaction at the bottom of the ocean.
- It is necessary to determine the **detailed chemical composition** of the spilled oil to:

Diagnose the origin of slicks in the future and eventual the presence of oil products in the area through other sources (for example the washing of the oil tankers tanks).

Evaluate the toxicity and the risk of their manipulation.

Monitor the oils weathering processes in the sea and their consequences in degradation and toxicity.

- Furthermore it is important to know the **oceanographic conditions** in the sinking area with the aim of being able to stabilize the situation if the remaining oil reaches the water surface or if it interactions with the ocean currents at this depth.
- The **oil's flow temperature** should also be quantified to estimate the buoyancy speed.

The main objectives from the geologic point of view would be the following ones:

- Specification of the **morphology of the marine bottom** of the area where the ship is located more precisely to be able to know the elements of potential risks in relation to the structures stability.
- Identification of **petrography aspects of the seabed** and stability affecting the ship and its load, like for example: gradients, earthquake activity, current flaws, sediment texture, porosity, permeability, content of gas in the sediment, bottom currents,..).
- Evaluation of the **thickness and distribution of the sediment type** which can affect any natural posterior action of the ship, like for example erosion excess,



petrographical discontinuities in the immediate seabed.

Within the sphere of actions to adopt in the medium and long term, a **study of the corrosion of the ships hull** is suggested in temperature and pressure conditions of the Prestige’s current location (350 atm, 2.5°C). These studies would allow a prediction of its long term behaviour. Information on the types of materials used in the hull and their technical specifications would be required to carry out this work:

- welded unions (types and localizations of the welding),
- design (if there is corrosion because of a crack, differential ailing, etc.),
- protection mechanisms against the corrosion (cathode protection, painting, etc.).

It would also be necessary to know the current state of the ship and the filling level of the deposits. In this sense, the french submarine Nautilus will be able to provide information and even samples of the hull.

On the other hand the **characterization of the environment** is necessary:

- type of water,
- mainly the content in chlorides and oxygen.

(Water could be extracted with bottles in the vicinity of the sinking area (3.600 m, 2.5°C).) So pertinent experiments with natural water could be carried out, not simulated. It would be able to predict the speed of the hulls corrosion and to characterize the products of corrosion.

Another proposal is the **pursuit and operational simulation of the trajectories** of the oil slick in the area of the sinking.

Furthermore a structure of operational oceanography at national level should be created, a structure that integrates the collection of data and the assimilation of the same ones in **numeric models of prediction**. Herby specifying what objectives would

- provide in an operational way the positions, size and evolution in the focus of contamination of different space scales with the aim of being able to evaluate in real time the correct strategies of action to minimize the effects on the coast.
- provide in an operational way the meteorological conditions and the marine climate to plan the activities of the crafts operating in open sea.

- provide in an operational way the **conditions of waves, currents, tide and wind in the coast** to plan the activities of cleaning in beaches and cliffs and the coast.
- to provide information of waves, currents, tide and necessary wind in coastal areas (estuaries, creeks, ports, etc.) for the correct location of mechanical measures of protection, such as barriers, especially in the entrance of creeks, estuaries and swamps in the affected areas. With this information, numerous decisions will be taken: placing, order and more appropriate protection system (total closure, floating barriers...); study of combined systems of protection or determination of sacrifice areas if necessary; the effective strength will be determined of the barriers with the purpose of improving their efficiency and reliability.

## **5.2 Study of the environmental behaviour and cleaning of the spilled fuel-oil**

An oil product spilled to the sea suffers a series of:<sup>85</sup>

- physical processes (for example break-up, evaporation and emulsion),
- chemical processes ( for example photo oxidation)
- and biological processes (for example degradation).

These processes drive its distribution between the different compartments of the marine medium and to its ulterior accumulation and/or degradation.

These processes are sequential in time and they affect in a different way the different components of the oil. Although each spill has different dynamics, depending on the product type and the environmental conditions (latitude, station, etc.), generally it can be pointed out that the physical processes happens from the first moment of the spill until the first weeks. The photo-oxidative processes becomes evident after several weeks. Finally, the biodegradation has effects for several months.

On the other hand, the compounds of lower molecular weight (<10 atoms of carbon) are susceptible of being evaporated and dissolved at a certain speed and, therefore, disappear in the first days of the affected area. The aromatic compounds will be the main ones

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<sup>85</sup> For detailed information see section 3.3 Weathering processes in case of spilt oil at sea, p. 36 ff.

affected by the chemical photo-oxidation that leads to the formation of oxygenated compounds of more toxicity and, being of a radical type, also to the forming of condensation products (resins and asphaltenes) more persistent in the water. Besides, the aerobic bacterium in the marine medium, mainly *Pseudomonas* and *Aero-monas*, will use the aliphatic hydrocarbons as an energy source, transforming them into CO<sub>2</sub> and H<sub>2</sub>O( and, also as co-metabolics for the degradation of aromatic rings). These processes take place in a timescales of several months or years. In any case, oil is a natural, organic product that will be recycled at a natural speed.

The knowledge of the environmental dynamics of spilled oil, through the study of the evolution of its chemical composition, is fundamental in order to evaluate its impact in the medium, its extension and duration and the form of accelerating the natural processes of restoration. The following tasks to clean the affected area should be investigated:

- Levels of hydrocarbons in the column of water and plankton
- Levels of hydrocarbons in the marine sedimentation
- Photochemical and microbiological degradation processes
- Investigation on new cleaning methods of beaches and of the coast

Following the last two tasks will be explained closer

### **5.2.1 Photochemical and microbiological degradation processes**

The main objective of this task is to evaluate the effect of the environmental conditions in the behaviour and persistence of the oil in the abiotic medium. The work carried out soon after the accident of the *Aegean* showed that after two years the hydrocarbons coming from the oil slick had disappeared and the initial levels were recovered. However, in that occasion, the spilled oil was light crude oil, while presently it is heavy fuel oil. Therefore, it is necessary, continuing from a similar point of view, to investigate the evolution of the oil of the *Prestige* in the coastal area and to guide the tasks of cleaning and the ecotoxicological studies on the species of commercial interest.

The field studies should be supplemented with laboratory studies, to simulate or to confirm the observed processes. The field studies deal about the collection of samples of the oil slick and sediments, selected in function of the characteristics of the area, and their characterization. These samples will be taken over a period of three years, with variable rhythm, in function of the results.

### **5.2.2 Investigation on new cleaning methods of beaches and the coast**

The Prestige oil spill is a complex mixture of hydrocarbons whose composed by 22% in saturated hydrocarbons, 50% in aromatic hydrocarbons and 28% in asphaltenes and resins. The fraction of aromatic hydrocarbons is constituted fundamentally by naphthalene<sup>86</sup> (C<sub>10</sub>H<sub>8</sub>) henanthrene<sup>87</sup>( C<sub>14</sub>H<sub>10</sub>) and its derived alkylics, and the fraction of saturated lineal and recurrent hydrocarbons of different chain longitude. These fractions are susceptible to biodegradation, by aerobic organisms in good mixed waters and superficial layers of sandy and rocky beaches, as well as by anaerobic micro organisms that eliminate these compounds in sediments through the sinking of the oil to deeper layers of the beaches sand. On the other hand fractions of asphaltenes and resins are, in general resistant to the action of living things. However, they are susceptible to photo-oxidation processes that produce hydrocarbons, which themselves are assimilable by living things. Nevertheless the biological remediation can take a lot of time, in particular in areas with higher contamination. This natural process can be accelerated if the areas to be treated are fertilized by using compounds that facilitate Biodegradation.

For example in case of the Amoco Cádiz incident it was calculated that the recuperation of the contaminated areas took more than 20 years. In case of the Torrey Canyon accident, it was calculated that the remediation took between 2 and 10 years. In case of the Exxon Valdez in Alaska it is considered that the majority of the biological elimination happened in a period of four years, although in this case the biodegradation was only operative in summer periods, when the temperature surpassed 10 degrees centigrade.

Calculations of the remediation time cannot be made due to the complexity and variability of the present compositions, the orography of the area and the climatologic conditions. Some studies demonstrate, the time of recovery can be very different in geographical areas within close proximity. However, since the area is relatively changeable and rough, the mechanical dispersion and formation of emulsions is bigger than in areas with less wave action. Additionally, the average temperature is higher than 10 centigrade throughout the year which makes it possible for that action of the micro organisms to happen continuously throughout the year. Any biodegradation program should consider

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<sup>86</sup> A white crystalline compound, derived from coal tar or petroleum and used in manufacturing dyes, moth repellents, and explosives and as a solvent. Also called tar camphor.

<sup>87</sup> A colorless crystalline hydrocarbon, obtained by fractional distillation of coal-tar oils and used in dyes, drugs, and explosives.

the aspects of the possible impact of the treatment and should be accompanied by the following monitoring parameters to evaluate the grade of recovery of the ecosystem:<sup>88</sup>

- nitrogen and phosphorous nutrients
- total hexane-extractable hydrocarbons in the water column
- plankton chlorophyll
- total aromatic hydrocarbons bio accumulated in mussels (held in cages at the low tide zone of the fertilized shorelines)
- water sample toxicity using a standard effluent toxicity test program. (This test is designed to detect any general toxicity associated with the nutrient addition operation.)

If monitoring results demonstrate any adverse environmental effect, the application of the fertilizer should be terminated immediately.

### **Bioremediation: bio technical approaches to regenerate the contaminated areas by the oil slick of the Prestige**

Basic principles that form a base for the recommended approach:

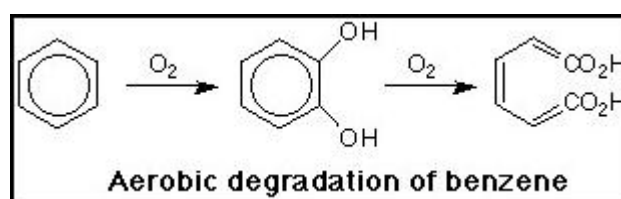
The available information indicates that the oil spilled by the Prestige is “heavy”, formed mainly by hydrocarbons of high molecular weight with a high percentage of aromatic and saturated compounds and with sulphur. A lot of information exists regarding the capacity of diverse micro organisms to degrade - to metabolize - this type of oil fractions and to transform them into CO<sub>2</sub> and H<sub>2</sub>O. These micro organisms are quite frequent and ubiquitous, as much in the sea as on the mainland. In other similar cases, especially in the accident of the tanker Exxon Valdez it has been proven that the number of these hydrocarbon degrading micro organisms increases in a spontaneous way in several orders of magnitude in the polluted areas the first few weeks of the accident. This growth goes accompanied by the degradation of many (although not all) of the present hydrocarbons( and it is greatly facilitated by the fact that most of these micro organisms produce different surfactants, surface-active substances helping to dissolve the fuel).

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<sup>88</sup> Compare Bioremediation of Exxon Valdez Oil Spill, United States Environmental Protection Agency press release, 1989, online on WWW under URL: <http://www.epa.gov/history/topics/valdez/01.htm> [03.08.03].

However, there are several existing factors that could hinder or limit the biodegradation process. The main one is that the oil contains a lot of carbon and there is enough sulphur in assimilable forms for the micro organisms, but it has very little nitrogen and phosphorus, what limits the microbial growth. Several investigators have reported that concentrations of available nitrogen and phosphorous in seawater are severely limiting to microbial hydrocarbon degradation. When the available sources of nitrogen and phosphorus are drained, the micro organisms stop to grow, although there is a lot of hydrocarbons available. Therefore, the hydrocarbons cannot be metabolized efficiently unless adequate nitrogen and phosphorus sources are given. There exist numerous experimental tests about the addition of these nutrients. However their effectiveness depends on how they are applied. In the case of the Exxon Valdez for example it was observed that the granulated fertilizers favoured the biodegradation in sandy beaches, while the oleophilic<sup>89</sup> fertilizers (which adheres to the oil residue on the surface) favoured the biodegradation on rocky beaches. It is also important to provide iron, since many of the enzymes that oxidize hydrocarbons use iron as cofactor.<sup>90</sup>

Another important factor is the availability of oxygen. The biodegradation of oil in polluted soils is relatively efficient in superficial layers, where oxygen there is enough oxygen, but it is slower in areas where the oxygen is scarce, like for example in the subsoil or in marine sediments. Micro organisms do exist that are able to degrade hydrocarbons in absence of oxygen (anaerobic) but this process is less effective and the growth a lot slower than that of the micro organisms using oxygen (aerobic) to metabolize the hydrocarbons. The aerobic degradation of benzene is illustrated in Figure 12:



**Figure 17: Aerobic Degradation of Benzene.**<sup>91</sup>

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<sup>89</sup> Any of a class of unsaturated open-chain hydrocarbons such as ethylene, having the general formula  $C_nH_{2n}$ ; an alkene with only one carbon-carbon double bond.

<sup>90</sup> Compare Tabak et al. 1991, p.581, online on WWW under URL : <http://www.geocities.com/CapeCanaveral/Lab/2094/bioremed.html> [09.07.03].

<sup>91</sup> Image Source: Brauner, J. and Killingstad, M. 1998. In situ Bioremediation of Petroleum Aromatic Hydrocarbons, online on WWW under URL: <http://www.cc.vt.edu/enviro/gwprimer/btexpbio.html> [09.07.03].

The limiting factors that may inhibit the rate of degradation are the concentrations of available oxygen, nitrogen and phosphorous. The oxygen functions as the electron acceptor when the carbon source is metabolized by the bacteria. In this case, the soil is porous and shallow, so there may be an adequate supply of oxygen and it may not be necessary to inject additional oxygen, such as hydrogen peroxide. It would be viable to add surface nutrients of nitrogen and phosphorous in the form of a soluble fertilizer.

The final result is that the growth of degradation (autochthonous) micro organisms is favoured. It is important to highlight that this method is simple and has already demonstrated to be efficient and does not require adding degradation micro organisms obtained in the laboratory or somewhere else. Usually the addition of exogenous micro organisms does not give good results, probably because the obtained micro organisms cannot be competitive when they are inoculated in another different environment.

To conclude, it is feasible to exploit the microbial capacity to metabolize hydrocarbons to clean soils or waters contaminated by oil and other substances derived from petroleum. Although it is not essential to add exogenous micro organisms to the polluted area, the appropriate supply of nutritious (nitrogen, phosphorus and iron) to stimulate the growth of the micro organisms inhabiting the area is very beneficial. The available data indicates that the addition of these nutrients accelerates the regeneration of the polluted areas up to 3 times faster. As it has been discussed for years, the stimulative effect is very significant. (Instead of one year without external help it is able to reduce the contamination in only about four months.) Finally, it is necessary to indicate that the generated biomass of micro organisms will be diluted and will fall in the moment in that the oil, constituting its finished food.

This type of bioremediation treatments should begin when the maximum amount of oil has been eliminated by mechanical methods. In this context the following stages are proposed.

**First stage: exploratory program to evaluate in a laboratory scale the potential of different biological strategies for the acceleration of the recovery of the affected ecosystems (approximately 3 months).**

Fundamentally, quick stabilization should be tried if in the affected beaches the number

of degradation micro organisms has increased compared to non polluted areas and to determine if the elimination of the present compounds in the fuel mixtures is mineralised “to fertilize” the waters or sands by addition of different nitrogen sources and/or phosphorus, together with small amounts of iron. A very important aspect would be to improve the screening procedures of (heavy oil dispersing) micro organisms able to disperse heavy oil, independently of its biodegradable capacity.<sup>92</sup>

### **Second phase/stage: Pilot program of Bioremediation in selected parcels through Bio stimulation (approximately 1 year).**

After the parcelation of the selected areas, mixtures of water-soluble nutrients with phosphorus, nitrogen and iron should be applied by a spray irrigation, if the nutrients are a limiting factor (as measured using the interstitial pore water). They should be applied daily if maximum bio stimulation is desired and if the impacted area gets completely submerged by tides and waves. The quantity of nutrients to add is important: it should be enough, but not excessive so that it could cause damage the marine environment. The studies carried out in the case of the Exxon Valdez indicated that it is not suitable to surpass the quantities of nitrogen and phosphorus in the marine. Oleophilic fertilizer or slow-release granular or encapsulated nutrients should require less frequent addition, but (frequent) monitoring of interstitial pore water nutrient levels is needed to ensure that target levels are being maintained and that the eutrophication<sup>93</sup> of the treated waters or beaches does not take place. Based on the results obtained in the previous stages, the adoption of bio stimulation protocols to a greater extent should be proceeded.<sup>94</sup>

The use of ammonia-based fertilizers at highly elevated concentrations should be avoided because un-ionised ammonia is toxic to aquatic life. Nitrate is an equally good nitrogen source. Sodium-tripoly-phosphate is a better phosphorus source than orthophosphates because it is more soluble in seawater. Only nutrient additives proven to be non-toxic and effective should be used in the environment.<sup>95</sup>

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<sup>92</sup> Compare Chianelli et al. 1991, p.550, online on WWW under URL :

<http://www.geocities.com/CapeCanaveral/Lab/2094/bioremed.html> [09.07.03].

<sup>93</sup> Having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the extinction of other organisms.

<sup>94</sup> Compare Bioremediation of Exxon Valdez Oil Spill, United States Environmental Protection Agency press release, 1989, online on WWW under URL: <http://www.epa.gov/history/topics/valdez/01.htm> [03.08.03].

<sup>95</sup> Compare Nutrient Enrichment online on WWW under URL:

<http://response.restoration.noaa.gov/oilaidis/response/pdfs/methods/nutrient.pdf> [09.07.03].



An environmental effect that could be the damaging to shoreline is from foot or vehicle traffic caused by workers applying nutrients (unless nutrients are sprayed from a vessel or aircraft).<sup>96</sup>

**Third stage. Execution of an extensive plan of Bioremediation (approximately 3 years).**

Once the best form of acting according to the accumulated experience has been determined, the authorities will have in their hands the possibility to materialize a plan of fertilization of the affected areas with the help of more appropriate formulations of nutrients. Depending on the available information, the possibility to add degradation micro organisms of various origins(, specially producers of surfactants can also be considered). In this sense (en ester sent do) it is better to receive professional help from people with experience in other bioremediation projects that have taken place.

The estimated time for Bioremediation performances to show effect could be about 3 years. No biological technology exists that is able to remediate the problem in a shorter time. Because of this, the technique is more appropriate for the regeneration of rocky coastal areas which cannot be cleaned in another way. Anyway, it is advisable not to applicate employment of chemical detergents or synthetic solvents. They can gloss over the visual impact but they increase the problem due to their impact in the ecosystem.

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<sup>96</sup> Compare *ibid.*

## 6 Measures to avoid tanker accidents

### 6.1 The existing measures

Following some very serious oil spills caused by tanker accidents, several strict measures were taken at international level to improve safety standards. A number of conventions like the International MARPOL Convention or the International Safety Management Code (ISM), have already been drawn up under the patronage of the International Maritime Organisation (see section 2). Their aim was to combat unforeseen events like accidental pollution and operational pollution such as the cleaning of tanks with seawater. They also provide for continuous improvement in management skills of personnel, especially in safety and response to emergencies. Other measures have also been taken. For example, Traffic Separation Schemes (TSS's) have been adopted in high-density shipping areas like e.g. the Strait of Dover. An important measure are PSSA's (see section 2.2). They can help avoid habitat damage and stop intentional pollution by regulating the passage of ships through or away from sensitive areas. Additionally, navigation equipment is much more reliable and more precise than it was some decades before.<sup>97</sup>

However it should be recognized that action on maritime safety under the patronage of the IMO falls short of what is needed to tackle the causes of such disasters effectively. There is an absence of adequate control mechanisms governing the way the rules are applied throughout the world. That handicaps action by the IMO. For this reason, IMO regulations are not applied everywhere with the same strictness. The evolution of maritime transport over the last decades, in particular, the emergence of “flags of convenience”<sup>98</sup>, some of which fail to live up to their obligations under the international conventions, have a tendency to worsen this phenomenon.<sup>99</sup>

Therefore, due to the shortcomings of IMO, the European Council called on the Commission, following the 1978 Amoco Cadiz disaster, to come forward with proposals

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<sup>97</sup> Satellite navigation technology provides a greater degree of precision and reliability, in particular, the GALILEO system.

<sup>98</sup> registration of vessels in foreign countries, see Flags of Convenience on p. 27.

<sup>99</sup> Compare EU (publisher): Maritime safety: Erika I, online on WWW under URL: <http://europa.eu.int/scadplus/leg/en/lvb/l24230.htm>.

to improve shipping safety. After the Erika disaster, when the ship ran aground on 12 December 1999 polluting almost 400 km of the French coastline, the European Union considerably reinforced its legislative arsenal to combat flags of convenience and give Europe better protection against the risks of accidental oil spills. It worked out the Erika I package (March 2000) and the Erika II package (December 2000). This was a major step towards putting effective rules into place to increase maritime safety and to counter the risks of oil spills. Thanks to these measures substandard ships should disappear from international waters within the next years.

### 6.2 Measures adopted in the EU following the Erika accident

The Erika disaster demonstrates, firstly, the risk presented by old ships and, secondly, the need to tighten up the existing Community regulatory framework - which, incidentally, Member States are not applying properly, particularly as regards the number of inspections in ports - beyond the level of the IMO standards. This was also the tendency in the USA, where the regulatory framework was tightened up at federal level following the Exxon Valdez catastrophe.

The **Erika I package** deals with the most serious lacks in the maritime safety rules revealed by the Erika disaster:

“First, it **strengthens the existing Directive on port State control**. The number of thorough inspections of ships in EU ports has been greatly increased. Over 4,000 vessels considered to represent particular risks will be subject to mandatory structural inspections each year. Ships repeatedly found to be in a bad condition will be black-listed, and refused access to EU ports.

Second, it **strengthens the existing Directive governing the activities of classification societies**, which conduct structural safety checks of ships on behalf of flag States. The quality requirements for classification societies have been raised. Approval to operate within the EU will be conditional on continued meeting of these requirements and the performance of the classification societies will be strictly monitored. Failure to meet the standards will result in temporary or permanent withdrawal of the Community approval to operate on behalf of EU Member States.

Third, it **brought forward the timetable for the worldwide phasing out of single hull oil tankers**. Double hull tankers offer better protection for the environment in case of an accident. Because of this, IMO had decided that only double hull oil tankers should be constructed as from 1996. However, the gradual replacement of single hulls

by double hulls was spread over a very long period ending in 2026. The EU insisted to accelerate this process, which the maritime world accepted after tough negotiations. The industry has followed quickly and double hull tankers now represent almost half of the world tonnage. The last single hull tankers will be banned from EU waters by 2015<sup>100</sup> according to the new international and EU standards.”<sup>101</sup>

The Erika I steps up controls in ports, monitors the activities of classification societies and speeds up the timetable for eliminating single-hull tankers. These three measures were adopted by the European Parliament and the Council in December 2001. The EU Member States must incorporate the measures in their national legislation by mid-2003 at the latest. The only exception is the port of Rotterdam, which has obtained a six-month extension regarding stricter checks in ports.

The **Erika II** measures provide the practical solutions to support the **Erika I** measures:

“First, with the creation of a **European Agency of Maritime Safety** (EMSA) to monitor the effectiveness of EU maritime safety rules. Member States and candidate countries are under increasing pressure to apply a number of new safety requirements, and to harmonise their inspection and control procedures. The new agency will support their efforts by collecting information, maintaining a maritime safety database, auditing classification societies, and organising port state control inspections in the Member States. It will also facilitate exchanges of good practice between Member States and provide technical assistance to the Commission in all fields relating to maritime safety and the prevention of marine pollution. Pending a decision by the European Council on the location of the agency, the Commission will provisionally host it in its own premises in Brussels.

Second, with a Directive which establishes a notification system for improved **monitoring of traffic** in, or passing through, European waters. Member States will be given strengthened powers to intervene when there is a threat of accident or pollution. Ships in EU waters will be required to fit automatic identification systems for the

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<sup>100</sup> According to the statistics provided by Intertanko, the proportion of double hull oil tankers rose from 39% in 2000 to 51% at the end of 2002. Intertanko estimates that by 2007 around 75% of oil tankers will be double hull vessels, online on WWW under URL: <http://www.intertanko.com/> [04.04.03].

<sup>101</sup> Quotation online on WWW under URL: [http://www.europa.eu.int/comm/energy\\_transport/mm\\_dg/newsletter/nlSEPREstige-2002-11-20\\_en.html](http://www.europa.eu.int/comm/energy_transport/mm_dg/newsletter/nlSEPREstige-2002-11-20_en.html) [23.05.03].

automatic communication with coastal authorities and voyage data recorders (black boxes) to facilitate accident investigation. The Directive will improve procedures for the shared use of data about dangerous cargoes, and allow ports to prevent the departure of ships in extreme weather conditions. It will also require each maritime Member State to establish places of refuge for ships in distress.

Third, by drawing attention to **payment of compensation to victims of oil spills** and proposing to improve the current international mechanism in this area. The Commission proposed to raise the upper limits on the amounts payable in the event of major spills in European waters (up to EUR 1 billion from the current ceilings of EUR 200 million), and to ensure that adequate penalties are imposed on those who cause pollution damage by negligent behaviour.”<sup>102</sup>

The first two measures were adopted by the Parliament and the Council in June 2002. The Regulation establishing the European Maritime Safety Agency entered into force in August 2002. The Commission has already put in place the appropriate administrative mechanisms for the Agency to be operational in 2003. The Member States have to incorporate the Directive on the monitoring of maritime traffic by February 2004. However, the proposal on compensation for victims of oil spills was not adopted by the Council.

### 6.3 European Commission proposals following the Prestige accident

The Prestige accident, coming less than three years after the Erika disaster, has highlighted the urgent need for rigorous action to protect Europe’s coasts and citizens against such catastrophes. The loss of the Prestige verifies that the Erika I and Erika II packages are well founded. However, these measures did not/will not begin to enter into force until 1 January 2003 (when the first single hull oil tankers were taken out of service), 22 July 2003 (Directives on port State control and classification societies) and 5 February 2004 (Directive on vessel traffic monitoring). While there is no need for numerous new proposals, the fast and effective application of the existing proposals must be the priority. The best outcome would be if they were applied worldwide, and not only in the EU.

Aware of the urgency of the situation, the Commission has not been waiting for these dates to implement the Erika I and Erika II packages. In response to the Prestige disaster,

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<sup>102</sup> Quotation from *ibid.*

it is intended to tighten up and speed up certain points in the existing legislation. Finally, it expects the Member States and parties concerned to show the same determination to apply these measures.

In response to the **Prestige** accident, the European Commission

- published an **indicative “black list”** of substandard vessels which would be prohibited if the provisions of the Erika I package were in force at the time.<sup>103</sup> The publication of this list is intended to send a clear, strong message to the ship owners and flag States concerned to remedy the identified shortcomings before the new provisions of the Port State Control Directive enter into force,
- **established a trans-European data exchange network** for vessel traffic monitoring, in application of the Erika II package,
- mobilised all its forces to enable an **earlier establishment of the European Maritime Safety Agency**,
- speeded up preparations of the plans to accommodate vessels in **places of refuge**.

In addition, the Commission submitted to the European Parliament and the Council a **proposal for a Regulation** aimed at:

- speeding up the **timetable for phasing out** single-hull oil tankers adopted in the framework of Erika I. The Regulation is applicable as of 1 January 2003.
- **banning the transport of heavy fuel oil in single-hull tankers** bound for or leaving EU ports,

A provision requiring that, from now on, heavy oils must only be carried by double-hull tankers. Heavy fuel oil is among the most polluting types of oil. In view of its relatively low commercial value and comparatively small risk of fire or explosion, it is regularly carried in older tankers nearing the end of their economic lives, i.e. ships posing the greatest safety risks. The Commission has therefore proposed banning the transport of heavy oils in single hull tankers bound for or leaving the ports of EU Member States.

Furthermore the Commission requested the Member States

- to recruit a sufficient number of **port State control inspectors**,

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<sup>103</sup> The Prestige would have been taken out of service two months before the disaster.

- to take the measures necessary to achieve a **sufficient level of inspections** at all ports and anchorage areas in the European Union to prevent them from becoming veritable “ports of convenience”
- to ratify the convention creating a **third level of compensation for damage** (with a ceiling of EUR 1 billion, instead of the current EUR 200 million) to complement the IOPC Fund.

“To defend the Union’s interests at international level, the Community needs to be able to make its voice properly heard in the relevant international bodies, in particular the International Maritime Organisation (IMO). The EU merely has observer status in this institution, which in no way reflects the extent of its powers in the field of maritime safety nor its role as a driving force within the IMO.

It is essential that this driving force be fully recognised in future and that the **EU become a full member of the IMO**. The enlarged Union, with 25 members, will thus bring its effective weight to bear on the organisation’s decisions, avoiding dissipation of effort. The Commission recently asked the Council for a negotiating mandate to this end, and hopes that the Member States will understand how important this accession will be in enabling the EU to steer the IMO towards greater safety and better prevention of marine pollution.”<sup>104</sup>

### 6.4 Proposals for future action

Before proposing new measures for future action attention must be drawn to the fact that several of the measures already adopted have still not been correctly implemented. Some of the measures already adopted by the European Community have either not been transposed or are not being properly applied by most of the member states. The result is that there are infringements in several cases.

Furthermore, while deploring the widespread recourse to flags of convenience, the Commission also points out that most of the ships controlled by European companies have been flagged out to third countries for tax reasons. The Commission also considers that one of the conditions of accession negotiations with Cyprus and Malta should be that these countries apply the existing Community legislation on maritime safety as soon as

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<sup>104</sup>Quotation online on WWW under URL:

[http://www.europa.eu.int/comm/transport/themes/maritime/prestige/2003\\_01\\_08\\_memo\\_en.pdf](http://www.europa.eu.int/comm/transport/themes/maritime/prestige/2003_01_08_memo_en.pdf) [23.05.03].

possible and certainly no later than the date of their accession.

### **Vessel manning conditions**

According to the international conference on seafarers in the European Union, held in Dublin in December 1996, the number of Community seafarers employed on Community flagged cargo vessels had fallen by 37% between 1985 to 1995. To exclude the possibility of unfair competition states and shipping companies must guarantee third-country nationals employed on board their ships the same terms and conditions of employment applied to European Community seafarers.

These terms and conditions of employment should cover the following subjects<sup>105</sup>:

- maximum work periods and minimum rest periods;
- minimum number of days of paid annual leave;
- minimum rates of pay;
- health, safety and hygiene at work;
- terms and conditions of employment for pregnant women, children and young people;
- equality of treatment for men and women;
- measures for the repatriation of seafarers and payment of wages in the event of the insolvency of their employer.

### **Establishing a network of PSSA's**

Depending on both the maritime and the environmental requirements for a PSSA, more should be designated, especially in areas with high marine traffic. To illustrate this, the number of shipping journeys in the Wadden Sea is 260,000 a year. This makes this area and its surroundings one of the most frequented sea areas worldwide. But it is still not designated as a PSSA. In 1999 171.5 million tons of cargo were transferred alone in the German North Sea ports.<sup>106</sup> Theoretically, every single ship entering the southern part of the North Sea can be a threat to the Wadden Sea. Five out of eight designated special areas under Annex 1 of MARPOL 73/78 have become effective. These are:

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<sup>105</sup> According to the international conference on seafarers in the European Union, held in Dublin in December 1996

<sup>106</sup> Compare WWF Deutschland, Project Team Pallas: Protection of the Wadden Sea from ship accidents through the establishment of a "PSSA Wadden Sea", 2000, p. 10



- the Baltic Sea area,
- the North-West European waters,
- the Antarctic area,
- the Mediterranean Sea area,
- the Black Sea area.

As the Prestige disaster shows, it is necessary to declare the Galician coast as a Particularly Sensitive Sea Area. Galicia is more affected by oil spills (five oil spills in 20 years) than any other region in Europe. The number of shipping movements of seawater threatening goods less than 50 miles from the Galician coast amounts to more than 6000 annually.<sup>107</sup>

### **PSSA Control Centres and Marine Operation Coordination Group**

An important measure would be the creation of PSSA Control Centres with a Marine Operation Coordination Group (MOCG) where all the information regarding ship traffic is gathered. The MOCG would decide whether ships could enter or leave harbours depending upon the traffic situation and following a set of defined, public decision-making criteria. If necessary it would decide on appropriate safety measures under close consultation with the local Vessel Traffic Centres.

The control centre must be manned at all times by highly qualified staff. The “Prestige” accident has highlighted that political decision-makers should not interfere in the management of an intervention. It would be absolutely necessary to keep the existing local Vessel Traffic Centres, as they inform ships about the current traffic situation, the conditions of the shipping routes as well as disturbances, accidents, water levels, the weather and the tides.

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<sup>107</sup> Compare Greenpeace, online on WWW under URL:

<http://www.greenpeace.es/gp2/informes/Escrito%20Universidade1.pdf> [23.05.03].

The tasks of the PSSA Control Centre are:<sup>108</sup>

- general illustration and coordination of the entire ship traffic in the surveillance area,
- coordination of ship traffic through the intervention area,
- organisation of interventions.

### Increased transparency

While various bodies collect a great amount of information relating to the safety and quality performance of ships and their operators there is still a lack of availability of this information. It is often difficult to access and scattered in many different places. Consequently, the European Commission, in cooperation with the maritime administration of France, has initiated the creation of a new ship safety database, EQUASIS. It is collecting information on matters of relevance to ship safety and make it easily accessible on the Internet since May 2000 ([www.equasis.org](http://www.equasis.org)).

Additionally the WWF has suggested an information log file that has to be developed to increase the transparency in PSSA's. Data would be collected regarding all ships sailing in the surveillance area and would be updated continuously. The data would be accessed via a password at any time by all authorities, organisations and companies responsible for the protection. An important basis for the information log file would be the EQUASIS database.

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<sup>108</sup> Compare WWF Deutschland, Project Team Pallas: Protection of the Wadden Sea from ship accidents through the establishment of a "PSSA Wadden Sea", 2000, p. 15.

**Table 6: Comparison of the suggested PSSA information log file with the EQUASIS database<sup>109</sup>**

PSSA information log file	Found in EQUASIS
IMO number, call sign and name of ship	Yes
Main dimensions, type	Yes
Cargo	No
Special features e.g. Single/Double-Hull, Lightweight construction	No
Additional sources of information e.g. construction shipyard/construction plans/emergency plans/fire prevention plans	No
Results/Claims of port state controls	Yes
Particular events	No
Contact e.g. owner*, operator* (=ship owner), insurance*, owner of cargo, charterer, agent, classification society*	Partly (only those marked with *)

Through this system, the ship owner would be able to prove the reliability of his ship to potential customers. This measure would enhance ship traffic safety near the PSSA.

### Surveillance of shipping

It is proposed improved surveillance of shipping particularly relating the uncertainties to oil spills of less than 7 tonnes (legal or illegal). They could be reduced by further developing the indicator on aerial surveillance, especially in those areas where oil tanker traffic is most dense.

Aerial observations of oil slicks, like for example in the North Sea are conducted by

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<sup>109</sup> Table from WWF Deutschland, Project Team Pallas: Protection of the Wadden Sea from ship accidents through the establishment of a “PSSA Wadden Sea”, 2000, p. 17.

European countries. Other countries should be encouraged to operate in the same way to complete the information on other seas, such as the Black Sea and Mediterranean Sea. But through aircraft surveillance detection rates are low because the ocean is a big place

“Space observation offers an alternative solution and early warning when a slick threatens a coastline. ERS-1 and 2, Envisat’s predecessors, have already demonstrated their effectiveness at detecting oil slicks. Oil over water has the effect of dampening out wave motion. Because ERS’s SAR radar sensor basically measures surface texture, this means oil slicks show up very well, as black smears on a grey background.

Envisat’s ASAR radar looks at much more of the ocean at once than ERS, observing a 400-km strip in its wide swath mode, compared to just 100 km for the earlier spacecraft. The imaging spectrometer MERIS can also be used in conjunction with ASAR to gain more data on a slick. Using Envisat in conjunction with other radar satellites - which can peer down through cloud and darkness - tankers can no longer pollute with impunity and countries are able to mount much faster cleanup operations. In 1997 in Singapore, one ship’s captain was jailed by evidence from ERS-1 - more will certainly be jailed by Envisat.”<sup>110</sup>

### **Liability and compensation**

Certain aspects of the international regime for liability and compensation for oil pollution should be revised as there is no balance between the responsibility of the players involved in the maritime oil transport and their exposure to liability. There is also a need for stricter application of the “polluter pays” principle. The right of ship owners to limit their financial liability is to be restricted if the accident is due to their actual fault and the de facto immunity of other key players, in particular the operator, charterer or manager of the ship should be removed from compensation claims.

Moreover, there is a need for adequate compensation for damage to the environment to fund ecological restoration.

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<sup>110</sup> Quotation online on WWW under URL : [http://www.esa.int/export/esaSA/ESA1XRVTYWC\\_earth\\_0.html](http://www.esa.int/export/esaSA/ESA1XRVTYWC_earth_0.html) [26.07.03].

### **Penal sanctions**

To complete the measures in the area of liability and compensation described above, penal sanctions should be taken against any person (including legal persons) who, through grossly negligent behaviour, causes marine pollution, whether deliberate or accidental.

A measure of this kind was already included among the Erika II proposals (payment of compensation to victims of oil spills, p. 85), but was not adopted by the European Council.

### **Acceptance of Pilotage in PSSA's**

An important safety component in the protection of PSSA's is the presence of a pilot on board when vessels have to be navigated through difficult i.e. narrow, highly frequented, shallow or continuously changing waters. The pilot assists the captain with his knowledge of the area during the passage. However, the pilot only can advise the captain, with the latter still remaining responsible for the ship.

Pilotage should be made compulsory for difficult and sensitive areas. The obligation to accept pilotage will affect both the ships entering and leaving PSSA harbours and ships just passing through the PSSA area.

The benefit of such a measure is, that the pilot on board can support the captain's accident management and operations management in case of an accident with his knowledge. Therefore he can ensure that suitable actions are initiated and carried out in time. However the staff for the pilotage must be qualified and motivated.

### **Escorting**

Another measure to improve the safety of ship traffic is that all vessels with a high risk potential must be escorted either actively or passively<sup>111</sup>. Criteria determining if and how far the ship is to be escorted are: the size of the ship; cargo; the width of the shipping channel or the sea area; technical equipment (redundant drive and rudder unit, emergency

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<sup>111</sup> During passive escorting a tug accompanies a ship without, unlike active escorting, a towing connection between the two ships.

towing arrangement, take-home drive); speed; unusual features; and also direction and strength of the wind.

The basis of judgement for the danger potential, apart from to the type and amount of cargo and other factors, is the suggested information log file.

In some US areas like the Prince William Sound in Alaska active escorting of tankers is already compulsory through the “Oil Pollution Act” of 1990. Unfortunately tugs, which can be used for active escorting, like the special ships that operate in Alaska and other oil ports, are not available yet in the needed areas.

### **Emergency towing arrangement**

All ships sailing PSSA’s must be suitably equipped so that they can be towed away quickly in the case of an emergency. An emergency towing arrangement significantly facilitates the establishing of a towing connection. According to the international SOLAS regulations 3-4 tankers with a minimum of 20,000 tdw at bow and stern must be equipped with an emergency towing arrangement since 1<sup>st</sup> January 1999. However, non-tankers are excluded from this regulation. As there is also a threat for the maritime environment from non-tankers (bunkering) this regulation should be expanded to all ships cruising in PSSA’s.

### **Establishing a network of Safe Havens**

A “Safe Haven” is a port where damaged ships carrying dangerous cargo can be moored to existing equipment and subsequently decontaminated.

Ships will always have accidents, and when they do, they need outside help because it is usually very difficult to solve the problem on the high seas. It is a tough decision to allow a damaged ship to come closer to a sensitive coastline or into a port. The “Erika” and “Prestige” incidents have both shown how sensitive this issue is. In both cases the urgent requests to port authorities of Nantes-St.-Nazaire or La Coruña to enter the port were denied on the grounds of potential danger of oil pollution. Ships in distress must have the option of a port of refuge. At least one port in the close vicinity of the main shipping routes, must be set up as a Safe Haven for damaged vessels of any size and cargo type.

According to WWF Germany the following operational, constructional and technical requirements have to be considered when choosing a “Safe Haven”:

- “Access with enough draught for seagoing vessels,
- Existing fire fighting appliances with the necessary supply and means of disposal. The water and foam, used in extinguishing the fire,
- Existing equipment for protection and disposal as well as according logistics,
- Greatest possible distance from residential and industrial areas,
- Convenient traffic network (e.g. roads, railway nearby),
- Not situated in ecologically sensitive areas,
- Possibly situated directly on the coast.”<sup>112</sup>

### **Emergency Towing and Emergency Response Vessels**

To guarantee sufficient resources in case of emergency, in 1994, a working group called “Working Group for Emergency towing” (ETOW) of the contracting parties of the Bonn Agreement defined the tasks of “Emergency Towing Vessels” (ETV’s) as follows:

#### **“Role of Emergency Towing Vessels (ETV’s)**

The primary role of any ETV is prevention of pollution or environmental damage occurring as a result of vessel breakdown or mechanical failure. The prime example may be quoted as a disabled laden tanker driving ashore in bad weather and subsequently losing part or all its cargo. Secondary Roles may be defined and delegated by individual Contracting Parties, and may include all or some of the following responsibilities.

#### **Suggested secondary roles:**

- a) Counter Pollution Duties
- b) Search and Rescue Duties
- c) Guardship Duties
- d) Surveillance and TSS Identification Duties
- e) Customs/Police/Fishing/Law Enforcement/Military

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<sup>112</sup>Quotation from WWF Deutschland, Project Team Pallas: Protection of the Wadden Sea from ship accidents through the establishment of a “PSSA Wadden Sea”, 2000, p. 27

f) Assistance to other Governmental maritime authorities”<sup>113</sup>

Some European countries like for example the Netherlands, Germany or France already use a small number of either salvage tugs or anchor handling tugs as ETV's. But the ETV's differ widely because none of the existing ETV's were designed or built for this task. Existing ships were modified accordingly for this type of operation. The multi-purpose vessel “Neuwerk” is currently the newest and modern ETV. It was developed and put into service in 1998 by the German Water and Shipping Authority. It is specialised in responding to accidents involving harmful substances.

There is also a need to develop a new type of ship, called “**Emergency Response Vessel**” (ERV). ERV's should allow an exchange of entire ship crews and individual crew members in case of an incident. Moreover, ERV's could be used for replacement in case of maintenance work or repairs, as a supplement if one of the other ERV's is involved in an emergency operation and for training purposes.

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<sup>113</sup> Quotation from WWF Deutschland, Project Team Pallas: Protection of the Wadden Sea from ship accidents through the establishment of a “PSSA Wadden Sea”, 2000, p. 29



## **7 Conclusion: The “Hydrogen revolution”**

The available proposals how to clean the affected area (section 5) and the proposals for future action in the security of maritime shipping (section 6.4) should be understood as a starting point and an impetus for continuing development. Despite the fact that the measures proposed in section 6.4 would significantly reduce the risk of oil spills, it seems impossible to avoid spills completely. There would not be so many oil tankers sailing the seas if the consumption of oil and petroleum derivatives are not increasing in an alarming way. In order to minimise the risk of oil pollution in our seas, we must reduce our excessive dependence on oil. This can be achieved by approaching the end of the fossil fuels era.

Experts have been saying that there is another 40 years or so of cheap recoverable crude oil left. Now, however, some of the world’s leading petroleum geologists are suggesting that global oil production could peak and begin a steep decline much sooner, as early as the end of the year 2010. This would send oil prices through the roof and a never before seen oil crisis would appear. Most of the remaining oil reserves are in the control of politically unstable states in the Middle East. The tensions between the western and the Islamic states could endanger additionally the access to these oil reserves.

Hydrogen has the potential to finish the world-wide dependence on oil importations and with it also the dangerous power games of Islamic extremists and western nations. As Hoffman writes in his book, *Tomorrow’s Energy: Hydrogen, Fuel Cells and the Prospects for a Cleaner Planet*<sup>114</sup>, hydrogen can “propel airplanes, cars, trains and ships, run plants, and heat homes, offices, hospitals and schools....As a gas, hydrogen can transport energy over long distances, in pipelines, as cheaply as electricity (under some circumstances, perhaps even more efficiently), drive fuel cells or other power-generating machinery for the end consumer to produce electricity and water. As a chemical fuel, hydrogen can be used in a much wider range of energy applications than electricity.”

In a new energy economy based on hydrogen each human being can produce energy through fuel cells and feed it into the hydrogen energy web. There is for the first time a possibility to introduce a democratic energy supply.

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<sup>114</sup> Compare Peter Hoffmann: *Tomorrow’s Energy: Hydrogen, Fuel Cells, and the Prospects for a Cleaner Planet* Cambridge, Massachusetts: MIT Press, 2001.

## **Conclusion: The “Hydrogen revolution”**

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The changeover to the hydrogen economy could be arranged within one decade. The internet and the World Wide Web grew also in a short time, at least in the developed world, and it changed the way of communication and business fundamentally. Numerous renovated economy newspapers believe that hydrogen energy and the formation of a World-Wide Energy Web is the next big revolution of business life. But the realization of these prognoses need the inside willingness of economy, society and a practical vision how the way into the hydrogen future should look like. The first time in mankind's history, an energy for the eternity is in sight. Hydrogen could become as affordable as personal computers and mobile phones, and then, nothing more hinders a real democratic energy, that is available to all human beings on the planet.<sup>115</sup>

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<sup>115</sup> Bibliographical reference: Jeremy Rifkin, *The Hydrogen Economy: The Creation of the World-Wide Energy Web and the Redistribution of Power on Earth*, J. P. Tarcher, 2002.

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## Annex

### **PRESTIGE - Update, 30th April, 2003<sup>116</sup>**

#### **Clean-up Operations**

Spanish government authorities report that there have been no observations of black oil surfacing from the PRESTIGE since late February, although thin sheen has occasionally been reported.

Offshore operations using specialised anti-pollution vessels ceased to be effective once the oil had been at sea for a few weeks. As the oil emulsified and weathered on the sea surface it became increasingly difficult and finally impossible to pump and even most of the heavy-duty oil recovery equipment failed. By the beginning of January, only a handful of the vessels were able to successfully recover any significant quantities of oil. In addition to increasing viscosity, floating oil fragmented into countless patches of ever-decreasing size. This caused problems with detection from the air and hence the guidance of vessels to locate recoverable oil. As mentioned in earlier reports, offshore tuna boats and trawlers, mussel farming vessels with grabs and small fishing boats were also used along different parts of the Spanish and French coasts.

Early in the response, shoreline cleanup was primarily undertaken manually by military units, fishery associations and civilian volunteers. A number of pumping stations using portable pumps and vacuum trucks were put in operation on the foreshore where bulk oil had collected in accessible points. As the oil weathered, pumping became increasingly difficult. As an alternative, various ways of mechanical recovery using bucket grabs and front end loaders were used to collect thick oil accumulations immediately near shore in addition to the numerous small fishing vessels offshore.

Later in the response, beach cleaning machines were used when small fragments of oil and tarballs repeatedly stranded on long stretches of sandy shorelines along the northern coast of Spain and the French Aquitaine region. In other places sand was sieved through screens to remove oil fragments. Natural cleaning through the scouring action of the sea during winter storms has also taken place and its effects can only now begin to be judged as the weather improves. However secondary cleaning is already being undertaken by means of pressure washing in affected areas that are accessible to the public.

In France, most of the shorelines affected are composed of relatively hard-packed sand, which are relatively easy to clean, both manually and mechanically.

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<sup>116</sup> Compare ITOPF, online on WWW under URL: <http://www.itopf.com/news.html#tasmanspirit> [02.05.03].



### **Impact of the Spill**

Most of the fishing bans have now been lifted. In Galicia, the worst affected region, fisheries exclusion zones were put in place shortly after the incident banning virtually all fishing along about 90% of the coastline and extending 8 miles offshore. These bans have caused widespread economic impact to some 13 000 shellfish harvesters and the owners of some 6 000 inshore fishing vessels. The fishing bans did not cover aquaculture, even though this sector has also been affected by pollution. A number of important fish farms are located in heavily polluted areas, although most took measures to prevent oil entering the rearing tanks so that they could continue to operate. However, despite these efforts stocks were destroyed at one of the smaller farms on the order of the health authorities.

The major aquaculture activity in Galicia is the rearing of mussels on rafts. However, no mussel rafts in the main cultivation areas appear to have been directly affected by oil.

The rearing of molluscs in intertidal areas is not subject to closures, but some areas have been physically oiled and owners have reported that depuration plants are refusing to accept their products.

A number of depuration plants and aquariums, which rely on a regular supply of clean seawater, have closed either as result of actual or perceived contamination of their intakes or due to limited supplies of marine products arising from the fishing bans.

### **Waste**

As in most large incidents, the volume of waste for storage and disposal far exceeds the quantities of oil actually spilled. In Spain to date, some 54,000 tonnes of liquid waste (oil/water mixtures) has been collected offshore and 63,000 tonnes of solid waste has been collected onshore.

In France about 1,500 tonnes of liquid waste was recovered by fishing vessels, whilst some 15,000 tonnes of solid waste has been collected from the shorelines.