REPORT OF THE ENQUIRY INTO THE SINKING OF THE **ERIKA** OFF THE COASTS OF BRITTANY ON 12 DECEMBER 1999

This report was drafted according to the terms of the decree of 20/01/81 relative to technical and administrative commissions of enquiry following accidents at sea and its decree of enforcement dated 16/12/97 by which the Maritime investigation office (Bureau – enquêtes-accidents / mer or BEA / mer) and a permanent commission of enquiry into accidents at sea (Commission permanente d'enquête sur les événements de mer or CPEM) were set up, on the one hand, and in compliance with the terms of IMO Resolutions No. A849(20) of 27/11/97 and No. A.884(21) of 25/11/99 for the Investigation of Marine Casualties and Incidents and of the International convention of the law of the sea of 1982, on the other hand. These texts enable States to conduct technical enquiries into incidents in international waters which place their coasts at risk or damage them and where it is clearly in their interest to discover the cause thereof.

As the **ERIKA** was operated by Italian nationals, manned by a master and crew of Indian nationality and sailed under the Maltese flag, the necessary contacts were made with the MALTA MARITIME AUTHORITY (MMA) and relevant information exchanged with the authorities responsible for the investigation of marine casualties according to the provisions of the above mentioned IMO resolutions, in each country concerned (Malta, India, Italy). This report will be submitted to the IMO as required by the above resolutions.

This report will also be transmitted to the French authorities responsible for the legal consequences of the casualty.

In order to investigate the causes of the sinking of the **ERIKA** the CPEM comprised the following members :

- **Co-chairmen**
- Administrator general of Maritime Administration **Georges Tourret** Director of BEA/mer
- Administrator general of Maritime Administration **Jean-Louis Guibert** secretary general of the French Institute of Navigation

- **Experts**
- **Daniel DREVET** Chief engineer, BEA/mer engines expert
- **Bernard PARIZOT** Naval architect, BEA/mer hull expert
- Captain **Yves HALNA DU FRETAY** Director of operations for the company LES ABEILLES INTERNATIONAL

Other experts were consulted as required - tanker captains, naval architects, shipbuilding engineers, hydrodynamicists and metallurgists.

Furthermore, the following organizations also participated in the report : the Directorate for Research and Scientific and Technical Action (Direction de la Recherche et de l'Action Scientifique et Technique – DRAST) of the ministry of transport, the Central Laboratory of the Civil Engineering Department (Laboratoire Central des Ponts et Chausées – LCPC) and the Research Institute for Shipbuilding (Institut de Recherche de la Construction Navale – IRCN).

The findings of the Commission were transcribed by **Mr Bernard LION**, secretary general of BEA/mer

This translation is the work of Mr ***David Keating****, lecturer in Maritime English at the Ecole Nationale de la Marine Marchande of Nantes* .

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This document, as published, reports the findings of the CPEM on the circumstances and causes of the sinking of the ERIKA.

The Commission encountered much difficulty in gathering the information necessary for writing this report.

Should any new elements come to light, the Commission reserves the right to modify its conclusions.

In accordance with the provisions of IMO Resolutions No. A849(20) of 27/11/97 and No. A884(21) of 25/11/99 as well the decree of 20/01/81 concerning commissions of enquiry into marine casualties and incidents, this report does not seek to apportion blame, or determine civil or criminal liability.

Its only aim is precautionary and seeks to avoid a repeat occurrence of the same type of casualty.

Consequently, the use of this report for purposes other than prevention could lead to mistaken interpretations.

1* A brief review of the circumstances in which the Erika sank.

In the early afternoon of the 11th. December 1999, while on passage from Dunkirk to Leghorn (Italy), laden with a cargo of 30,884 tonnes of No.2 heavy oil, the Malta registered oil tanker Erika experienced a structural failure as she was crossing the Bay of Biscay in heavy weather. The vessel first began to list heavily and then, after the list was corrected, broke her back several hours later. Following this major failure the vessel foundered some 30 nautical miles south of the Pointe de Penmarc'h in Brittany. Both sections of the vessel eventually sank in about 120 metres of water in a position fairly close to where the vessel broke in two, following an unsuccessful attempt to tow the stern section further out to sea.

The entire crew was rescued without injury after a rescue operation carried out by the French navy with the CROSSA in Etel acting as MRCC. As a result of the sinking a large proportion of the vessel's cargo and bunkers spilled into the sea. It was very difficult to contain this pollution because of the type of cargo being carried and because of the severe weather conditions and it eventually soiled several hundred kilometres of coastline from Brittany down to the Ile de Ré.

The BEA/mer put its technical enquiry in hand on the morning of 12th December 1999 upon receiving confirmation of the sinking from the MRCC Etel.

On 13th December the Maltese maritime authorities were contacted and they, in turn, set up a commission of enquiry. The IMO was informed of the situation by the BEA/mer on the same day. This report will be made available to the maritime authorities of Malta, Italy and India in compliance with the terms of the IMO Code for the investigation of marine casualties and incidents, owing to the nationality of the crew and of the persons or entities implicated in the ownership and classification of the vessel as well as in her management and/or certification.

The judicial authorities were informed of the opening of this enquiry.

Finally, following the sinking of the Erika, the commission noted the work of the Parliamentary Commission of enquiry into the practices of international merchant shipping concerning safety and of the Senate work group whose brief was to examine the overall impact of the oil spill resulting from the sinking of the Erika, to propose how to improve existing rules applicable in such cases and to define what measures are necessary to prevent such mishaps from happening. At the request of this commission and of the work group the CPEM immediately made known and commented on its findings. A similar task was undertaken by the economic and social Council with a similar follow-up.

2* Operation/management of the vessel

When she sank the Erika was undertaking a voyage which involved two sets of commercial entities, as is the case when any ship is chartered ; these were the owners on the one hand and the charterers on the other. It was far easier to identify the latter than the former.

Indeed the operation of the Erika, like many other tramp ships, whether carrying dry cargo or oil under open registry flag, brought into play a large number of different entities on a primary or secondary basis :

- the owners who fix their company's strategy (choice of subcontractors/suppliers, allocation of maintenance resources and equipment, financial management) ;
  in the case of the Erika the owners were a Maltese company under the control of two Liberian companies the capital of which was held by individual or legal entities whom it has not been able to identify with absolute certainty.

- lawyers’ cabinets giving legal existence in the interested countries (Malta/Liberia) to the individual or legal entities who were directly or indirectly the owners of the vessel and who were responsible for dealings with the flag state ;

- a shipmanager in Italy responsible for the overall technical management of the vessel and also appointed, on the basis of his qualifications, to act as designated person ashore responsible for implementing the safety management system Code (ISM) for which he was remunerated by the owners ;

- a classification society remunerated by the owners and whose task was to assign class to the vessel and certify her on behalf of the flag state, notably within the framework of the ISM code (the vessel and the shipmanager’s head office) ;

- an Indian crewing agency commissioned to provide, on short term contracts, the master, officers and crew (ratings) having the necessary qualifications as required by the STCW convention ;

- a time charterer registered in the Bahamas but operating out of Switzerland ; he had hired the vessel from the owners and was offering her services on voyage charters and as such was the person apparently responsible for the vessel, or its disponent owner ; the importance of his rôle diminishes as soon as the vessel is taken off hire ;

- a maritime agent located in Switzerland and sub-contracted by the owners to be responsible for giving the ship her sailing orders as well as organizing the vessel’s commercial and technical calls and stopovers ;

- an insurance company insuring the owners against the total loss of their vessel ;

- a London P&I club, albeit registered in Bermuda, insuring, with limited liability, against any damage caused by the ship or her crew to the environment or to a third party ;

- two freight brokers, one in Venice, the other in London, acting respectively on behalf of the disponent owner and the charterer ;

- a voyage charterer, namely a French oil group which both produced and owned the cargo which was sold through its subsidiaries upon arrival at its destination ; the group had its own vetting service for inspecting vessels before hire and had hired the vessel at current market prices ;

- a consignee, in this case, an Italian electricity company who in no way influenced the organization of the voyage except to decide on the port of destination.

The commission considers that - although the above arrangement is far from unusual when it comes to transporting bulk cargo by sea – it was highly complex and did not make it easy to apprehend the precise responsibilities of each one of the interested parties.

The commission also noted that the Erika, like many product-carriers of her age, was used for the transport of black products (heavy fuels, tar), that it to say the most polluting but the least demanding in terms of cargo tank quality and tank cleaning between voyages. White products (diesel oil, petrol, kerosene, naphtha), because of their inflammability, are more immediately dangerous but they pollute less, precisely because they are so volatile. Moreover, such products are demanding as regards cargo tank cleanliness. They are generally carried by the more recent products tankers with effective cargo tank coatings. Those vessels which are mainly used to transport black products are, statistically, the most likely to be involved in accidents.Their cargo tanks are protected against corrosion, naturally, by the very nature of the cargo they carry. The same cannot be said for the ballast tanks.

There is no alternative but to conclude that the most polluting oil products are carried by the least safe ships, but that the behaviour of the Erika's charterers was little different from that of the other major oil groups and rather better than that of the traders who do not generally possess their own vetting services.

The commission further noted that the majority of the ships used by the major European operators for trading black products were between 17 and 25 years old as against 10 to 18 years old for ships carrying crude oil or white products. For black products 49% of the ships were more than 20 years old. This does not mean that they are all unacceptable but that there is simply a greater risk of finding sub-standard ships in this age group.

3* The ship

3.1* General information – History

The ship was built in Japan in 1975 at the Kudamatsu shipyard of the Kasado Dock Co. Ltd (hull No.284). Originally designed as a products/crude carrier, she had 13 cargo tanks with two sets of cargo lines and two slop tanks. The main characteristics of the vessel were as follows :

- Length overall : 184.03 m
- Length between perpendiculars : 174.00 m
- Moulded breadth : 28.05 m
- Summer draught : 11.027 m
- Depth : 14.99 m
- Summer deadweight : 37,283 t
- Winter deadweight : 36,285 t
- Speed during trials : 16.4 kts
- Service speed : 15.2 kts

She was fitted with

- Segregated ballast tanks
- Inert gas system (except in ballast tanks)
- Cargo heating system (up to 70°C)
- IHI Sulzer 8RND68 diesel engine producing 9715 kW at 150 rpm
- 2 Daihatsu 6PSHTM diesel alternators producing 500 kW
- an IHI ADM325 16 bar oil-fired boiler
- an IHI ADM 2800 7 bar waste heat boiler

In view of her date of building (1975), this vessel was considered to be « pre-Marpol ». She was of single hull design without segregated ballast tanks. However, in 1990, for the sake of convenience but more especially because she was not fitted with a COW (crude oil washing) system, four of her tanks – Nos 2 and 4 lateral ballast tanks– were first converted into clean ballast tanks(CBT). In 1993 the No.2 CBT's were transformed into dedicated sea water ballast tanks, thereby becoming segregated ballast tanks (SBT). No.4 centre CBT was not assigned the same usage until 1997 and was eventually replaced by No.4 lateral tanks following the work carried out in Bijela in 1998 (this would explain why the No.4 ballast tanks were subsequently found to be in better condition than the No.2 ballast tanks).

In her final arrangement with defensive segregated ballast tanks, in accordance with MARPOL Annex 1 regulation 13, the Erika had 9 cargo tanks, 4 lateral ballast tanks and 2 slop tanks. The forepeak and aftpeak were used as independent ballast tanks (See table below).

Cargo tanks (COT)

Volume and distribution

Cargo tanks	**Frames**	3
1 COT centre	74 82	4 841.83
–	–	
–	–	
–	–	
–	–	
–	–	
–	–	
–	–	800.62
3 COT starboard	58 66	3800.62
Slop tank port	50 2	897.83
Slop tank starboard	50 2	897.83
Total		

Segregated ballast tanks (SBT)

Volume and distribution

SBT	**Frames**	**Volume in m³**
2 SBT port	– 74	3 798.28
– starboard	66 –	3 798.28
4 SBT –	52 58	
4 SBT starboard	– 58	2 829.55
	82 fore end	
Aftpeak	11 –	201.11
Total		**15 288.49**

The total volume of the segregated ballast tanks was 15 288 m which represents 43% of the total volume of the cargo tanks.

The Erika was not automated (UMS). A permanent watch was therefore kept

atements collected by the commission, the vessel seemed to be well maintained and her equipment complied with regulations. She was

capable of calculating and printing out the bending moments and shearing stresses.

were manually operated. There were high level alarms.

Other testimonies allude to a generally unsatisfactory condition, with very dirty, -saving appliances for the

The overall impression gained by the commission is one of an old, apparently seaworthy ship which had, for a long time, been maintained and equipped to minimum requirements. The visible elements of her hull had aged rather better than her structural elements which, to all evidence, were far more difficult to inspect on a continuous basis.

The commission noted that, since 1975, the vessel had sailed under three different flags (all open registry – Panama, Liberia and Malta) with 8 different names (which would seem to indicate changes in ownership) ; that she had been assigned class by 4 classification societies (all members of IACS : International association of classification societies) and that she had been managed by 4 different shipmanagers, with the possible risk of discontinuity in the maintenance of the vessel.

• 1975 : SHINSEI MARU Japan	NK
• 1975 : GLORY OCEAN Panama	NK
• 1977 : INTERMAR PROSPERITY Liberia Berwick Shipping Ltd / Intermarine	NK
• 1980 : INTERMAR PROSPERITY Liberia South Energy Shipping Company / Wallem Shipmanagement	ABS
• 1985 : SOUTH ENERGY Liberia South Energy Shipping Company / Wallem Shipmanagement	ABS
• 1985 : SOUTH ENERGY Gaymont Inc. Monrovia Liberia	ABS
• 1986 : JAHRE ENERGY Liberia	
• 1990 : PRIME NOBLE Desert Peace Ship Co. Ltd. Malta Sapha Maritime Enterprise – Polembros Group (Nicosia)	ABS
• 1993 : PRIME NOBLES Malta	BV
• 1994 : NOBLESS Tevere Shipping Co. Ltd. MALTA Drytank – Cardiff / Starship Management	BV
• 1996 : ERIKA . MALTA	BV
• 1998 : ERIKA Tevere Shipping Co. Ltd. MALTA Panship Management	RINA

3.2* Classification

been built. She subsequently transferred to ABS from 1980 until 1993, then to BV

to 1998 and finally to RINA.

The commission noted that during the period in which they were responsible

1993, followed by a general survey (afloat) in November 1993. The

certificate was issued on 04/06/93 and was valid until 04/06/98. Intermediate surveys of the hull were carried out in 1995 and 1996 while an occasional survey was

n the

in 1977 and 1985 on the Orinocco (Venezuela), occurred at low speeds and on sand

On the eve of a fur

decided to transfer class to RINA on 23/06/98. According to the TOCA or Transfer of

society must accept the recommenda

and must report back to the latter.

transfer to RINA and had asked them to conduct a detailed pre entry survey of the

as carried out while the vessel was in the Turkish port of Aliaga

mentions many deficiencies concerning practically every point examined (structure,

equipment). The impression gained from reading this

structure are concerned. The surveyor in charge of the survey considered the vessel

RINA unless major repairs were undertaken (the final

On **13/05/98,** the owners asked for an extension of class so that the vessel could proceed to a shipyard for repairs. The survey for granting this extension was conducted in Naples on the 02 and 03/06/98 and a provisional certificate of classification was issued with a validity of a few days to enable the vessel to proceed in ballast to the Bijela repair yard in Montenegro where she was due to arrive on 23/06/98. This certificate mentions, amongst other things, the deformation diagram of bulkhead 58 between No. 4 centre and No. 5 centre cargo tanks. The transfer to Rina was made on 24/06/98.

The vessel's last dry docking thus took place in the above shipyard in August 1998 (the next one being planned for 2001) ; at this time RINA carried out a special survey, the most stringent one, which covers the structural aspect in particular. Subsequently RINA conducted a two part annual survey in Genoa on 17/08/99 and in Augusta on 22/11/99 (the ballast tanks were inspected in the presence of a representative of the shipmanager).

The vessel was assigned RINA's highest class : **100 – A.1.1 – Nav. 1L ; Cst(oil) ESP.**

In general, the commission has observed that the successive surveys and inspections carried out on the Erika by the classification societies since 1997 showed her to be sometimes in poor condition and sometimes in acceptable condition.

3.3* Certification – ISM

As is most often the case with open registry states, the certification of the vessel, namely the issuing of the relevant international safety certificates required by various IMO conventions (SOLAS, Load lines, Marpol), was delegated by the state of Malta to the classification societies assigning class to the vessel, in this case BV then RINA.

The certification relative to the international safety management code or IMS which corresponds in part to a maritime quality insurance and involves making an audit of the vessel and her owners (Panship shipmanagement in this case) was, the commission observed , once again issued by RINA – after an audit made in June 1998.

The commission also observed that in keeping with the other certifications, the auditor was remunerated by the owners.

3.4 * Flag state surveys

The commission noted that a flag state survey was carried out on 08/05/99 at Porto-Torres at the same time as a PSC inspection. The survey report was not made available to this commission. The survey was conducted by a service company which was paid by the owners.

In fact, when a flag state confers on a classification society the right to certify ships flying its flag, flag state inspections seem to be little more than the very occasional verification of the competency of the classification society surveyors to whom it has delegated its authority for issuing certificates.

Thus, in the case of a Maltese ship which was the object of numerous recommendations within the framework of a PSC inspection, the MMA reminded the classification society that they were issuing the ISM certificate under MMA's authority.

3.5* Port state control (PSC) inspections

the vessel underwent a number of PSC inspections especially within the framework of the Paris memorandum :

- on 17/04/96 at Milazzo (Italy) : a deficiency with the lifeboats ;
- on 05/07/96 in Gdynia (Poland) : vessel detained for several deficiencies, mostly in the engine room due to the fact that it was poorly maintained at that time ;

- on 22/08/96 in Punta Delgada (Portugal) : engine deficiencies some of which were recurrent, deficiency of winches and windlass ;
- on 16/01/97 in New Orleans : deficiencies mainly concerning the fire fighting system ;

-
- on 11/12/97 in Rotterdam : vessel detained because of several deficiencies including corrosion of a bulkhead in the accommodation. The vessel's classification society (BV) were informed for repairs. The vessel was detained for 24 hours ;
- on 20/05/98 in Stavanger (Norway) : numerous deficiencies (11) including three for the fire fighting equipment and electrical installations, one deficiency mentioned hull corrosion (this did not give rise to the vessel's being detained). The target factor [1] here would have been 40 ;
- on 08/05/99 in Porto-Torres (Sardinia) : although this inspection was described as « extended » it only concerned the vessel's certificates and thus no deficiencies were reported. The upshot of this was to cancel the inspection priority which the Norwegian authorities had requested and to reduce the target factor ;
- on 12/11/99 in Novorossiysk (Russia) : four deficiencies concerning unpainted freeboard marks, immersion suits, lifebuoys and firemen's outfits.

In substance the commission noted that :

- the vessel was inspected every year (at least once) under Port state control ;
- she was detained twice, once for corrosion ;
- corrosion was observed twice (hull and accommodation bulkhead) – no details were given ;
- the final inspection, just one month before she sank, was limited to an examination of the ships papers and equipment.

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[1] This is calculated by taking into account :

a generic factor : flag and/or vessel targeted, classification society, age of vessel, ratification or otherwise of international conventions, flag and class above or below average ;
a historical factor : detentions, deficiencies etc..

- the vessel’s target factor which takes into account a number of critical parameters (flag, previous history etc.) and which is set by those agents approved for PSC, was no higher than 12.

As a matter of fact there was never a thorough inspection under PSC of the vessel’s internal structure. The reason for this is that such inspections are usually conducted while the ship is in port and carrying out cargo operations which makes it very difficult for inspectors to enter the tanks, even the dedicated ballast tanks. Both the December 1997 inspection (Rotterdam) and the May 1998 one in Stavanger make no mention of the vessel’s ISM status.

3.6* Vetting Inspections

Prior to chartering one of the 12,000 or so tanker ships in their common database, most of the major oil companies carry out inspections of the vessels likely to interest them.

Such inspections are called vetting and are conducted by their own inspectors (usually ship repair technicians or merchant marine officers) who draw up a standard report (to which they may add their own comments). This document is then included in the SIRE (Ship Inspection Report) database which is jointly run and organized by a number of oil companies such as EXXON, MOBIL, SHELL, BP, TOTAL, ELF (but not REPSOL). Most of the oil majors do not question the reliability of the other companies’ vetting procedures, but their final decisions are taken using their own criteria which are not necessarily limited to vetting inspection reports but can include other criteria (age, classification, flag … etc) taken together or individually.

These reports comprise 14 topics : general information , documents and certification, crew, aids to navigation, ISM, pollution prevention, STRUCTURE, cargo handling equipment and ballasting, inerting of cargo tanks, ground tackle, engines and steering gear, general aspect, possibility of transferring cargo ship to ship.

The commission noted that, during this type of inspection too, the tanks, even dedicated ballast tanks are rarely inspected because of cargo operations. The « inspection » in this respect is therefore mainly document based. The crew, on the other hand, must try to inspect the ballast tanks every three months. The commission noted that these inspections had been carried out and that the vessel's successive masters had noted the presence of corrosion notably in the No.2 ballast tanks.

After a satisfactory inspection or one giving rise to recommendations which the owner confirms having carried out, the charterer agrees to charter the vessel on a time charter basis according to her age :

- 0 – 10 years : 24 months
- 10 – 20 years : 18 months
- more than 20 years : 12 months, or, more usually, on a voyage charter basis.

The Erika was only chartered on voyage charters. One of the reasons for this was that she had no emergency generating set, only one oil-fired boiler and no back-up compressor. This equipment , although not obligatory at the time she was built, makes a considerable contribution to the overall efficiency of commercial operations. Moreover, Total has indicated that they charter ships more than 15 years old on a voyage basis only, that is to say for periods of a few days or a few weeks,. Applying Total's standards to the Erika, she could never have been chartered on time charter, that is to say for periods of several months or even several years.
Such was the context in which the Erika was inspected **seven** times during her final year of operation.

On 21/11/98 in Mellilli for TOTAL ;

- the tanks and ballast tanks were not inspected, but the tanks were supposedly coated with epoxy and there were reported to be anodes in the ballast tanks ;
- the coatings of the forepeak and the wing ballast tanks were in poor condition ;
- the deck plating at section 1 and the wing ballast tanks were repaired.

On 25/01/99 in Thessalonika for SHELL (Stasco)

- the original coatings of the ballast tanks, which were not inspected, were apparently in relatively good condition ;
- there was no cathodic protection ;
- there was corrosion and lack of watertight integrity below the forecastle deck (rectified) ;
- the vessel was acceptable, subject to inspection every year, for loading at a Shell terminal but not for charter by SHELL(too old).

On 03/04/99 at Porto Torres (Sardinia) for TEXACO :

- there was no internal inspection.

On 20/11/99 at Termini Imerese (Italy) for TEXACO :

- there was no internal inspection, but the terms of the report echo those of the master who had been able to inspect the tanks at a previous port of call ;
  - the tanks and ballast tanks were partially coated (epoxy) but only at the top and bottom ;
  - the coatings were in more or less good condition ;
  - there were no anodes in the cargo tanks, only in the ballast tanks ;
  - the anodes had lost 25% of their volume ;
  - there were no visible cracks ;
  - the piping was in good condition ;
  - there were no indications of leaks.

On 23/11/99 in Augusta (Sicily) for EXXON :

- a number of drawings required for the IACS transfer of class procedure were missing ;
- other documents required by the flag state and by RINA were also missing ;

- the ballast tank coatings were apparently in poor condition … a RINA surveyor inspected them the following day and found « nothing out of the ordinary …. or which could affect the assignment of class » ;
- the loading calculator only calculated (and printed) the shearing stresses and bending moments, not the stability.
- the general condition of the hull was good and the deck was well painted ;
- the report does mention, however, a number of deficiencies especially regarding the aids to navigation. Consequently preliminary approval was refused and it became necessary for Exxon to have a complete new inspection made should they subsequently wish to charter the vessel.

On 23/11/99 in Augusta (Sicily) for BP AMOCO :

- the vessel had undergone a change of ownership in March 1997 ;
- she had arrived from Novorossyk ;
- it was the master's first voyage on this vessel (and the first mate's first voyage as first mate) ;
- the hand-over from one master to the other had gone quite normally and the new master had previous experience of this type of ship ;
- there were numerous deficiencies concerning the navigation equipment, pollution prevention, the state of the engine and the cleanliness of the accommodation ;
- the vessel looked her age and the deck was deeply pitted in several places but the overall condition of the hull seemed good ;
- The ballast tanks were not inspected but the report mentions :
    - the thickness measurements carried out in June 1998 which showed a decrease in thickness of up to 26% in the No.2 ballast tanks,
    - the RINA report of 16/12/98 which mentions "poor coating",
    - the " vessel particular questioning " which notes 25% wastage of the anodes (*which was what the master of the Erika was saying when he spoke, as did his predecessor, about the fact that the bulkheads of the ballast tanks were corroded with extensive rust, patches of which were breaking off, and about the particularly alarming state of No.2 starboard ballast tank with a 26% thickness diminution)*;

- the report concludes by refusing approval unless the deficiencies were rectified. BP moreover stated that after reaching the age of 25 years the vessel had to comply with rule 13G of Marpol.

On 03/12/99 the vessel was inspected for REPSOL in Corunna but the report was not transmitted to SIRE as REPSOL does not subscribe to SIRE. REPSOL nevertheless considered the vessel to be worthy of hire without restriction. The inspector, however, observed that there was no specialist officer on board responsible for communications in case of emergency. The commission noted that this final inspection was not conducted before the vessel was chartered but after unloading.

In substance :

- The Erika effectively underwent a large number of inspections, the more so as, during the last few years, she was more often than not chartered on a voyage basis ;
- the inspections seem to have been carried out by competent, conscientious officers : their many additional commentaries as well as the length of time spent on board (10 hours or more) bear witness to this ;
- but, on the occasion of these inspections no inspection of the structure was ever made, especially in the ballast tanks for which the reports did no more than reiterate the comments of the vessel's masters (it is worthy of note that the last captain who joined the ship on 21/10/99 in Sevastopol, made the same comments as his predecessor).

It is to be noted that following all these inspections the vessel had received the following « letters of approval » :

- REPSOL : from 03/12/99 until 02/05/00
- TEXACO : from 20/11/99 until 20/08/00
- EXXON : from 10/12/99 until 22/11/00
- SHELL : from 25/01/99 until 24/01/00 But not for a Shell chartering

The commission noted that some of these letters included serious reservations. A few companies did consider that the Erika could be accepted at their port terminals but also considered that her age would sooner or later make her unacceptable for transporting their own cargo.

It should also be noted that practically none of the above oil groups (whether or not they subscribed to the SIRE system) chartered the Erika for any of her last forty voyages, that is, from September 1996 onwards. The only exceptions were SHELL (December 1997) and REPSOL (November 1999) both of whom chartered her for one voyage each, lasting only a few days. TOTAL chartered the vessel four times in 1999. The three previous voyages made by the Erika on behalf of TOTAL involved carrying crude oil from Algeria and Russia to Varna in Bulgaria.

The commission noted that, as was the case for the PSC inspections, none of the vetting inspectors mentions the structural condition of the vessel, no doubt because they had been unable to check it themselves.

The commission also concluded, from statements made by the crew, that the corrosion of the upper and lower parts of the bulkheads between the ballast tanks and the cargo tanks, with abundant rust and patches of rust breaking away, was a first sign of a weakening of the structure.

3.7* Inspections carried out before June 1998

3.7.1* Occasional survey at Ravenna in April 1997

The vessel was classed with BV at this time.

No.4 lateral tanks were found to be in acceptable condition (they were used as cargo tanks). On the other hand, the condition of No.2 lateral ballast tanks was considered to be unacceptable. The upper parts of the transverse webs in way of frames 68, 69, and 70 in No.2 port ballast tank and in way of frames 69 and 70 in No.2 starboard ballast tank showed severe deterioration and had to be replaced. Moreover, the BV survey report on this inspection confirms the worsening of the corrosion in the No.2 lateral ballast tanks in which a reduction of scantlings of more than 10% and up to 19% was observed, and to a lesser extent that in No.4 lateral tanks. As early as April 1993, thickness measurements taken during the special survey revealed extensive corrosion with a diminution of thickness of 10% or more on vital structural elements.

The reports on this survey also mention the absence of interior coatings and of cathodic protection.

3.7.2* Pre-entry survey

This survey took place in Aliaga (Turkey) in February 1998 and lasted two days. It consisted of an inventory or audit preliminary to the vessel's being accepted by RINA for a transfer of class between classification societies. During this survey it was not possible to inspect the cargo tanks as the vessel was carrying out cargo operations. The main deck, the forecastle, the forepeak tank, No.2 port ballast tank and the engine figure prominently among the elements examined. It was not possible to inspect No.2 starboard ballast tank. The survey report (see annex) mentioned severe deterioration and corrosion and especially :

- extensive corrosion of the main deck plating (with pitting and rust patches) with a diminution of thickness varying between 18% and 68%, holes between frames 80 and 82 and very severe corrosion of the plate welds in certain areas ;

- substantial deterioration of the entire fore part of the vessel and the equipment there as well as the piping on the main deck ;

- the extremely bad condition, at first sight, of the No.2 port and starboard lateral ballast tanks, which were contaminated by oil residues (which in theory should never have been there), had cracked web frames, showed heavy corrosion of the stiffeners, and whose access ladders were so corroded as to make inspecting the tanks a very difficult undertaking ;

- considerable deterioration of the fore peak tank with corrosion and cracks on the collision bulkhead, the stringers, the vertical stiffeners and the bottom longitudinals ;

- the lack of coatings in the No.2 lateral ballast tanks and the fore peak tank.

The engine room was the only part of the ship which called for few observations.

Following this survey and taking into account the deficiencies found, the vessel was not considered to be acceptable for classification with RINA. Her classification became dependent on further inspections of the scantlings being carried out and on the necessary work being done ; a preliminary list of work to be done was drawn up contingent on a complete set of thickness measurements of plating and other structural elements being made. This work was to be carried out on the forepeak tank, the No.2 port and starboard lateral ballast tanks, the access ladders to the tanks, the forecastle and the piping as well as the aft superstructure.

In light of this report the shipmanager decided not to have the vessel classified in March 1998 (during a planned dry-docking) as had originally been contemplated when the pre-entry inspection had been requested.

3.8* The June 1998 special survey

This survey is required by international and IACS regulations which require a special survey of the vessel to be carried out every five years in line with the directives of IMO Resolution A.744(18) concerning the Enhanced Survey Program (ESP) for oil tankers.

The survey was conducted between 23 June and 15 August 1998 during the Erika’s stay at the Bijela shipyard. It served as a first entry survey under the IACS TOCA procedure for the transfer of class from BV to RINA.

During the survey the following points were inspected :

- the hull ;
- all cargo and ballast tanks ;
- the main engine ;
- the boiler ;
- the auxiliary engines ;
- the pumps ;
- the ballast and cargo tank piping systems ;
- the inert gas system.

A thickness gauging was carried out by a RINA approved company according to the procedure defined in the ESP program and to instructions issued to the surveyors.

About 7000 points were gauged including 250 on the main deck.

The results of these measurements showed :

- an overall reduction in scantlings of some 10% in the longitudinal elements (bottom, bulkheads and side shell):
  - bottom and side plating (10 to 13%);
  - longitudinal bulkheads (10 to 12%) ;
- an average diminution of the deck plating (plating and longitudinals) of 14 to 16% reaching 25 to 26 % in places especially in the forward half of the vessel.

As far as the lateral ballast tanks in section No.2 are concerned, analysis of the thickness measurements of the transverse structure resulted in the following table .

Diminution of thickness in %

Frame	% diminution in deck transverse elements	% diminution in bottom transverse elements
67	25 – 26	9 –11
68	Port 9 / starboard 24 – 27	10 – 12
69	9 –11	11 – 12
70	9 –11	10 –12
71	23 –27	10
72	24 –26	9 –12
73	24 –26	8 - 10

There was therefore substantial corrosion in these compartments and that of the upper parts contributed to the weakening of the deck plating forward of the midships section of the ship girder.

The Commission considers that the number of measurements made was not sufficient on account of the vessel's size.

The almost total disappearance of the coating in what just a few years previously had been cargo tanks, sea water ballasting and condensation due to the presence of heated products in the adjacent tanks were the main causes of this deterioration.

3.9* Inspections carried out after the special survey

Subsequently RINA carried out an annual survey in 1999. As the Erika had terminated her special survey on 15 August 1998, according to IACS regulations, the vessel was required to undergo an annual hull and engine survey between 15 May and 15 November 1999, using ESP criteria.

The survey took place in two stages, first in Genoa, then in Augusta.

A) Genoa from 16/08/99 to 17/08/99

The survey took in only the engine and the inert gas system. The hull survey and more particularly the inspection of the ballast tanks was not carried out under ESP rules.

It was noted that the survey report mentions the following documents as missing :

- hydrostatic curves ;
- load calculator user manual
- SOPEP.

B) Augusta from 22/11/99 to 24/11/99

This survey completed the one begun in Genoa. It was carried out in the presence of a representative of the ship manager. The ballast tanks were inspected and the poor condition of the internal coating confirmed.

No.2 lateral ballast tanks : a diminution of thickness was observed in the deck longitudinals. The thicknesses of the affected areas were not measured. A diminution of thickness in the upper part of the access ladder was also observed.

<u>Forepeak tank : collision bulkhead</u>

First flat below main deck : corrosion and diminution of plate scantlings over a length of about 4 metres forward of the collision bulkhead.

Corrosion and diminution of thickness of longitudinal face plates I, II, III and IV starting from port side plating and starboard side plating.

Corrosion and diminution of thickness of brackets between side longitudinals and collision bulkhead.

Corrosion and diminution of thickness of connecting brackets between deck plating and collision bulkhead.

First stringer : corrosion and diminution of thickness of plating.

Following this survey the following recommendations were made :

- before January 2000, conduct a further inspection of the deck longitudinals and make thickness measurements of the affected areas in No.2 port and starboard ballast tanks ;
- repair the upper portion of the access ladder ;
- make new thickness measurements in the fore peak tank and make the necessary repairs.

According to normal procedures, such recommendations do not fall within the scope of a simple annual survey. This can only make them more worrying.

The owners are thought to have intended these thickness measurements to be made at the vessel’s following port of call, Cartagena. A company is said to have attended the vessel to effect them, but after inspecting the parts to be reinforced, put off the work as certain items of equipment were not at hand. At the following ports of call, Corunna and Dunkirk, no companies attended the vessel to undertake the work.

3.10* Recapitulation and structural state of the vessel for her last voyage

Second in a series of 8 oil tankers built in Japan between 1974 and 1976 , the Erika was used to carry crude oil but above all heated black products. She sailed under several names – and thus had several owners – and several flags, generally open registry flags. She was always assigned class by classification societies who were members of IACS.

If some of her sister ships experienced serious structural problems during their lives (two of them were scrapped, see § 6.2.3), the problems which beset the Erika were apparently caused by her conversion to segregated ballast tanks which began in 1990 (CBT) and was only completed in 1998 (SBT 4 and 2).

Neither the infrequent flag state surveys, nor the port state and vetting inspections seem have picked up this fact.

The only people who were aware of this were the crew (but they had little opportunity for expert assessment) and, of course, the classification societies whose scope for action is undoubtedly limited by the socio-economic context inherent in the operation of this type of vessel.

The various reports and opinions voiced make it abundantly clear that after the August 1998 special survey the corrosion of the No.2 port and starboard ballast tanks had developed apace so weakening their structure that what followed became inevitable.

4* The crew

The Erika's crew totalled 26 officers and ratings, corresponding to the normal complement of a non-automated vessel with a permanent watch in the engine room.

The entire crew was of Indian nationality and had been recruited by HERALD MARITIME SERVICES of Bombay acting on behalf of PANSHIP, who managed the ship. The lengths of the contracts offered were as follows :

- 5 – 7 months for the officers
- 9 months for the ratings
- 11 months for the cadets.

The following table shows in detail the length of service in the company, the seniority in rank, the time spent on tankers and finally the time on board the Erika, for the officers, as of 12/12/99 :

	Company service	**Seniority in rank**	**Tanker experience**	**Time on board**
Master	2 months	3 years	6 years	2 months
First Mate	1 month	1 year	3 years	3 months
Second Mate	1 year	1 year	1 year	5 months
Third Mate	1 month	1year	1 month	1 month
Chief engineer	2 years	2 years	3 years	2 months
Second engineer	8 months	2 ½ years	10 years	2 months
Third engineer			,	1 month
Fourth engineer	1 year	Less than 1 year	2 years	5 months

The commission noted that several of the officers had already sailed on the Erika, but that others had only been on board for a short time and had therefore perhaps not had sufficient time to become completely familiar with the vessel's characteristics. However, all had a good knowledge of oil transport and had experience of this type of work. As for the master, he had spent 48 hours in Ravenna at the PANSHIP offices before joining the Erika and had had a four-day handover period with his predecessor in Sevastopol during which he had inspected as many of the accessible spaces as possible, including the ballast tanks.

It is to be noted that the crew was well-assorted and seemed capable of working efficiently together as is evidenced by the way in which they managed to launch a lifeboat in very severe weather. The commission noted that the master in particular, a 35 year old, well trained mariner with 15 years sea-going experience, acted properly and made the right decisions in view of the information available to him. He was the last person to leave his ship and took important ship's documents with him.

The commission was also interested in ascertaining whether there was a common working language on board on account of the many different languages spoken in India. The officers used English as their everyday working language and all the ship's documents were kept in English. It is not clear whether this linguistic competency could be extended to the ratings.

5* Voyage history

5.1* General

The voyage history is based mainly on examination of the vessel's logbook (a copy of which was received from the Maltese authorities) for the final few days, on messages exchanged between the ship and the shore, on interviews and hearings and on cross-checking the various items of information.

A) The vessel's logbook

If the final pages of the logbook were obviously of great interest, it also appeared worthwhile to examine the entire document to gain an overall impression.

The logbook started on 1st October 1999 at Varna in Bulgaria and was well kept throughout, in English, right up to one hour before the sinking.

- all the courses were recorded, with comparison made of the different compass readings, except, of course, for those followed « on the master's orders and on pilot's advice » ;
- the positions, on the other hand, were given by GPS rather than by bearing, mark and distance (the transit of the Bosphorus, for instance, can generally be « read » by following the various course alterations) ;
- weather observations were regularly recorded and relevant commentaries on how these affected the ship were appended as necessary ;
- watches kept on the various items of GMDSS radio equipment were systematically noted ;

- it was noted that a number of safety drills, including fire drills and abandon ship drills were carried out over a two and a half month period ;
- Basic information pertaining to commercial operations was also present (tank inspections, ullage measurements, sampling …) but any details in this regard, which were normally contained in the cargo record book were lost with the ship.

B) Messages exchanged

These consist mainly of telex messages transmitted via INMARSAT C between :

- the vessel and the MRCC ;
- the vessel and her shipmanager (PANSHIP) ;
- the vessel and her charterer (TOTAL) ;
- and vice versa.

Only a few voice communications were transmitted by MHF or VHF radio. Some of these were recorded by the MRCC although this was not compulsory.

Communications between the various shore authorities such as PREMAR, MRCC and the autonomous port of St Nazaire were made by telephone. Some of these were recorded while others were noted down on the notepads of the radio operators.

Attention is drawn to the fact that the MRCCs are generally responsible for communications with ships at sea. They have the onus of informing the naval centre of operations (COM) where a naval officer (usually a general staff duty officer or OSEM) keeps a permanent watch notably on behalf of the maritime prefect (PREMAR) for incidents which fall within his jurisdiction (these include search and rescue, surveillance of navigation and preventing and fighting pollution).

Attention is also drawn to the fact that, for technical reasons, the MRCC Corsen is better able to receive messages from ships in the MRCC Etel's area of responsibility and who are in fact trying to contact MRCC Etel.

Unless otherwise stated the times used in this voyage history are local time, that is to say, UTC +1 or Alpha Time.

5.2* The voyages preceding the last voyage but one.

During these voyages, which took place in the Black Sea and the Mediterranean, the Erika carried crude oil or fuel oil. (see annex)

They yield a certain amount of information, especially about the weather conditions which ranged from rather poor to severe.

October

Varna	01-02	Unloading crude oil
Varna – Tuapse	03-05	Course E - wind E.5 – sea state 4
Tuapse	05-07	Loading FO
Tuapse – Beirut	08-13	Course WSW - wind NW7 – sea state 6
		Bosphorus
	-	Course E - wind E 6/7 - sea state 7/8
Beirut	14-15	Unloading
Beirut – Sevastopol 4/5	16-21	Course WbyNW – wind NW5/6 – sea state
	20	Bosphorus. Bunkering FO & DO at Instanbul
	-	Course NE - wind N 6/7 - sea state 6
Sevastopol	22-23	Loading crude oil
		Captain MATHUR joined ship
Sevastopol – Varna	24-25	Course WSW - wind N 6 – sea state 6
Varna	25-26	Unloading
		Stand by

November

Varna	06	RINA – Freeboard
Varna – Novorossiysk	07-10	Course ENE - wind NE 4/8 – sea state 4/8
		Port closed
Novorossiysk	11-13	Loading FO
	12	Vetting inspection
Novorossiysk – T.Imerese	13-18	Course WSW – wind SW 5/7 – sea state 5/6 Bosphorus
	15/18	Course W – wind SW 7/8 – sea state 5/6
Termini Imerese	19-21	Partial unloading
Termini – Augusta	21-22	
Augusta	22-24	Unloading completed
	22	Vetting inspection
		RINA survey. Bunkering (FO & DO)
Augusta – Cartagena	24-27	Course W - wind NW to SW 4/5 - sea state 4/5
Cartagena	27-29	Loading FO
Cartagena – Corunna	29-02	Gibraltar – Course WNW - wind E 6/7 - sea state 7

December

		Cape St. Vincent – Course N – wind NE 6/8 – sea state 5/7
Corunna	03-04	Unloading
		REPSOL vetting inspection.

5.3* The last voyage but one : Corunna to Dunkirk

The vessel set sail from Corunna on 05/12 in ballast ; this was estimated to be 10,000 tonnes distributed between the forepeak tank and Nos. 2 and 4 lateral ballast tanks. Following a course of N by NE she experienced :

- a force 5/6 NNE wind which later backed WSW force 8
- a sea state between 6 and 8.

- Having passed Ushant on 06/12, the vessel proceeded up the English Channel with a force 8 west wind and a sea state of 7.

5.4* The stopover in Dunkirk

5.4.1* Cargo operations

The Erika arrived in Dunkirk on 7 December 1999, in ballast. As she had partially deballasted, her forward draught was then 3.5 metres and her aft draught 6.5 metres.

The pilot went on board on 07/12 at 1630 hours. The ship appeared completely normal to him.

On 07/12 at 2042 hours the vessel berthed starboard side alongside the Total Fina oil terminal at the Mardyck oil refinery.

Loading of No.2 fuel oil (FO2) commenced the same day at 2330 hours and was completed at 1554 hours on 08/12. It was carried out by the Chief Mate following the ship's normal practices with the master's approval. (see § 6.1.3)

5.4.2* The cargo

According to the Erika's transport documents, the cargo to be carried was No.2 heavy fuel oil. An analysis report of the substance provided by Total's Flanders refinery is appended.

The commission considered that it was worthwhile to compare the characteristics of the heavy fuel carried by the Erika with those of the heavy fuels (which are residual fuels) commonly used as bunkers by ships and burnt by them in their engines or boilers.

	ERIKA	ISO standard 8217 for RMK 45 Marine fuel	Sulzer specification for RND engine
per dm^3	1.0025	1.010	0.991* to 1.010
(cSt)		45	45* -
Pour point °C	3		30
Conradson % weight		22	20* -
Water % weight	0.05		1
Ash		0.2	0.1 –
-	2.28	5	
Aluminium ppm	36		30
Nickel ppm		-	-
	10.8	-	
Vanadium ppm	82.7		600
Flash point °C		60° minimum	60° minimum
	3.78	-	-

* -

fuel carried by the Erika was as good or even better than that of some marine residual fuels ; for the most part its characteristics were well within the limits set by ISO standard 8217 and by the

This means that, provided that the fuel was sufficiently heated (140°C) to obtain

could easily have been used to propel the ship or heat her cargo.

5.4.3* Bunker reserves on leaving Dunkirk

The amount of bunkers on board (FO – DO) as measured on arrival on 07/12/99 and on departure from Dunkirk on 08/12/99 were as follows :

Arrival at Dunkirk (vessel trimmed 3 metres by the stern)

- FO : 232 tonnes
- DO : 133 tonnes

Departure from Dunkirk (vessel on even keel)

- FO : 227 tonnes
- DO : 130 tonnes

In comparison, a different set of figures was obtained from the telexes which the ship sent to AMARSHIP on 07/12 and to PANSHIP on 08/12, namely :

- on arrival at Dunkirk : FO : 189 tonnes – DO : 113 tonnes
- on departure from Dunkirk : FO : 197 tonnes – DO : 108 tonnes.

The differences in the figures can be explained by the fact that the latter set only takes into account the quantity of fuel remaining in the bunker tanks and probably does not include the amounts in the settling tanks and daily tanks.

When she left Dunkirk the vessel would therefore have been carrying 227 tonnes of FO and 130 tonnes of DO (corresponding to approximately 10% of her maximum bunker capacity for FO and about 60% for DO). After deducting about 10% of unpumpable products, this would have left her with 204 tonnes of FO and 118 tonnes of DO.

The vessel was scheduled to call at Algeciras for bunkering, representing a distance of 1282 miles from Dunkirk.

The fuel consumption figures recorded in the ships documents report a total daily consumption of 44 to 48 tonnes of FO (27 to 31 tonnes for propulsion purposes and 17 tonnes for heating the cargo) and 2.8 tonnes of DO. The consumption figures depend on the ship's speed, on her displacement, on the weather conditions and on the temperature at which the cargo has to be maintained.

On Friday 10 December the bunkers remaining on board as recorded in the log book were as follows : 165.9 tonnes of FO and 104.9 tonnes of DO, which would represent a daily consumption of some 42 tonnes of FO[2] and 2.4 tonnes of DO at an average speed of 8 knots. In this case , the ship only had a four day reserve of FO. As her ETA at Algeciras was some time in the afternoon of 14 December, she would probably have had to cut back on cargo heating or, if necessary, used DO, of which there was plenty, for propulsion purposes in order to increase her range.

In case of absolute necessity, she could have put in at Corunna or a Portuguese port for bunkers.

Generally speaking, as the vessel was hired on a voyage charter, it was not in her interest to have too large a reserve of fuel.

5.5* The final voyage

It is to be noted that the radiocommunications equipment on board the Erika met GMDSS (Global Maritime Distress and Safety System) requirements for A3 coverage (satellite coverage). The vessel's INMARSAT A station (telephony) was in a room situated beneath the bridge and only worked in a sporadic manner. For this reason most of the ship's communications were made by telex from the INMARSAT C station on the bridge.

The vessel set sail on an even keel with a draught of 10.5 metres at 1945 hours on 8 December bound for Milazzo. The pilot left the ship at 2334 hours. In his report, he mentioned that the vessel's general condition was good, adding that « she didn't look her age » (15-20 years old rather than 24) and noted the correct working of the engine and manoeuvring equipment as well as the competency of the crew.

2 This figure seems excessive. Fuel consumption recorded during the previous voyages hardly exceeded 26 tonnes per day.

The vessel encountered heavy weather all the way down the English Channel with force 7/8 (30 – 35 knots) W/SW winds and 3 – 4 metre waves.

The vessel reported to VTS Jobourg at 2301 hours on 09 December, as required, when passing Cherbourg (wind : W/SW force 7 – rough sea).

The vessel reported to VTS Corsen at 1312 hours on 10 December, as required, on passing Ushant, as she entered the area covered by this VTS centre (wind : SW force 8 – rough sea). No mention was made of any particular problem. On account of the sea conditions her speed between Jobourg and Corsen was 7.9 knots at 107.9 rpm (instead of her normal 12.5 knots at 120 rpm).

On leaving the Ushant traffic separation scheme the vessel altered course to 210° for Cape Finisterre in north west Spain (see charts annexed) at a planned average speed of 7 knots. Her new destination was Leghorn.

The Erika then proceeded until 1418 hours on 11 December in very heavy weather : wind was SW force 8/9 (more than 40 – 45 knots), there was a heavy swell from the west and the sea was very rough (waves of more than 6 metres). The vessel was pitching and pounding heavily into the troughs (the wave period was 8 – 10 seconds for a length of 100 – 155 metres, swell period was 10 – 12 seconds for a length of 125 – 225 metres) ; heavy seas continuously broke over and swept the deck.

From 1240 hours onwards on 11 December the vessel was noticed to be progressively taking on a starboard list ; the master estimated it to be about 15°.

The master had the No.4 ballast tanks sounded and no differences were found in the ullages. They were, therefore still half full.

At 1408 hours the master sent a distress call by IMARSAT C (telex). The message was received, via France Telecom, by the MRCC Etel. It indicated that the ship’s position was 46°29’N 07°20’W. This placed her more than 300 kilometres from Brest (and from Lanvéoc-Poulmic where the heavy SAR helicopters are based ; their radius of action is no more than 220 kms and they cannot take off in more than 45 knots of wind), 355 kilometres from Corunna and 400 kilometres from Donges. Her speed was 6 knots. The message did not indicate why the call was made.

At 1411 hours the MRCC acknowledged the message on INMARSAT C and tried unsuccessfully to make contact with the vessel by radiotelephony.

At 1415 hours the master of Erika made contact with a nearby container ship, the Nautic, (probably by VHF) asking her to stand to give assistance , if necessary, and to relay a message by INMARSAT A (radiotelephony) to the ship's owners in Ravenna. The Nautic informed the Erika that she was unable to make contact with her owners and that she had relayed the request to other ships in the vicinity.

At 1418 hours as the list was partially corrected (residual list 5°), the master decided to run before the sea (course 030°) so that ullage measurements could be taken and an inspection made of the deck without exposing the crew to the seas which were continuously being shipped.

It was then observed that No.2 starboard ballast tank which should have been almost empty was in fact half full and that the level in No.3 centre cargo tank, which should have been full with an ullage of 1.49 metres, "has dropped significantly." The master concluded that all or part of the oil cargo of No.3 centre cargo tank had leaked into No.2 starboard ballast tank. He then ordered No.4 starboard ballast tank which had been half full of seawater up until then, to be deballasted. This operation lasted from 1340 hours until 1530 hours.

At 1430 hours the Chief Mate informed the master that he had found, in the deck plating forward of No.2 starboard ballast tank :

- 3 cracks
  - one transverse one 1.5 metres long and 1 to 2 cms wide,
  - one diagonal one about 2.4 metres long and 5 cms wide,
  - one longitudinal one about 1.5 metres long and 1 to 2 cms wide ;
- 3 folds due to buckling, 2 to 3.5 metres long, 7 cms high and about 60 cms apart.

At 1434 hours the master ordered the defects in the deck plating to be kept under observation. He reduced the engine speed from 105 to 90 rpm and then to 75 rpm. At that moment he considered that he no longer required assistance and cancelled his distress message changing it into a safety message (Mayday into Securité). He informed the MRCC of this by answering their 1411 message, stating that the vessel had had a heavy list but that he had managed to bring the situation under control.

At 1438 hours the watch officer responsible for SAR (SMC) at the MRCC Etel called the General Staff duty officer (OSEM) at the naval centre of operations (COM) in Brest and informed him of the Erika's situation.

Taking into account:

- that the vessel no longer required assistance,
- that the master said he had the situation under control,
- that the Erika was in the middle of the Bay of Biscay half way between Ushant and Cape Finisterre in Spain,
- that the only SAR resources in the area capable of rescuing the crew (if necessary) were merchant ships,

the two officers agreed to call each other if there were new developments in the situation. The Search and Rescue services were kept on standby (a Breguet ATLANTIC and a SUPER FRELON on 1 hour's notice).

At 1442 hours, the master of the Erika informed PANSHIP that, in heavy weather, he had had a heavy list to starboard, that he could see FO on the deck forward of the manifold, that fuel oil had leaked from No.3 centre cargo tank into No.2 starboard ballast tank which was now full of fuel oil (causing the list) and that there were several cracks in the deck plating on the starboard side.

The inaccuracy of this first message should be noted, especially as regards the FO on the deck, no trace of which was found after a detailed inspection of the deck.

At 1448 hours, in reply to a VHF call from a British warship – the FORT-GEORGE – he confirmed the list and the inspection of the cracks but added that assistance was not required as he had the situation under control. The French authorities did not become aware of this communication until 11 January 2000, a month later.

At 1455 hours, voice contact was finally established on 2182 kHz between the MRCC and the master of the Erika. The latter confirmed what he had said in his previous message. He reported that everything on board was in order, that the starboard list was under control and confirmed that he no longer required assistance. During this conversation there was no mention of the cracks seen in the deck, although whether this was due to oversight or omission is not clear … This was the only voice communication between the master of the Erika and the MRCC.

At 1500 hours, the engines were ordered half-ahead.

At 1510 hours, the master of the Erika made contact with another merchant vessel, the SEA CRUSADER, still with a view to possible assistance but also to ask them to contact the owners in Ravenna by satellite radiotelephony. The vessel advised the Erika that she had managed to contact the « designated person » (in the ISM meaning of the word) at PANSHIP headquarters.

At 1514 hours, the Erika’s master sent a message to the MRCC saying that he had the situation under control, that he was changing his distress message (MAYDAY) into a safety message (SECURITE) and that the crew was safe.

At 1530 hours, after the deballasting of No.4 starboard ballast tank stopped, the ship was trimmed 0.6 metres by the head. The ullage of No.3 centre cargo tank was thought to have risen significantly and that of No.2 starboard ballast tank to have been 5 metres. The connections between No.2 port and starboard ballast tanks were, it is believed, opened to equalise their levels. The vessel had a slight list to port and the stresses she experienced remained within the permissible limits as the ship’s load master indicated.

At 1547 hours, the Erika's master confirmed to PANSHIP that he had cancelled his request for assistance, that he had the situation under control and that he had put his vessel on a reciprocal heading (030°).

At 1612 hours, the master called the « designated person » at PANSHIP by radiotelephony (via Monaco Radio) and told him that the vessel had listed following a leakage of fuel oil from No.3 centre cargo tank into No.2 starboard ballast tank. He also said that he had altered course and was heading for the safest port of refuge. He spoke about the cracks and said that apart from No.3 centre tank all the cargo tanks were full. He did not say anything about fuel oil in the sea.

At 1627 hours on 11 December the master of the Erika set a course of 085°, engines still half ahead, to seek shelter at Donges. Using the addresses communicated by PANSHIP, the master got in touch with TOTAL's Parisian head office, then with PANSHIP's French agent –Agence Maritime Pommé – in Port-de-Bouc who, in turn, designated the STOCKALOIRE agency in Donges to organize this unscheduled stopover. Her new course brought the Erika closer to land and shelter but also exposed her to heavier swells as she neared the continental shelf ; this would have been the case too, if she had headed towards Brest.

At 1725 hours on 11 December, The Erika's master informed the MRCC of the course alteration he had made at 1418 hours (course 030°) and cancelled the safety message (SECURITE) which was itself the result of his cancelling the distress message (MAYDAY). He added that he was heading for a port of refuge.

At 1728 hours the MRCC informed the maritime Prefecture of everything it knew about the vessel's situation in a SITREP type message with copies to all the relevant authorities (including the BEA/mer and the St Nazaire harbour master). As it had not yet been informed about the defects in the deck , the MRCC could obviously not mention them in this message. As the safety message (SECURITE) had been cancelled, there was every reason to believe that the situation on board was perfectly under control.

At about 1730 hours, in order to prevent the fuel in No.1 starboard cargo tank from leaking if the cracks in the deck plating of this tank got any worse, the master of the ERIKA had the oil cargo transferred from this tank into No.1 centre cargo tank (both tanks were partially full). This meant that No.1 centre cargo tank was full while No.1 starboard cargo tank was now only half full (ullage : 7 metres).

At 1744 hours The MRCC asked the Erika's master to specify the port of refuge mentioned in his 1725 message.

At 1808 hours the Erika stated that she was bound for Donges with an ETA of 1800 hours on 12 December.

At 1830 hours, the No.2 lateral ballast tanks were equalized with an ullage of 10 metres. The cross-over connecting the two tanks was closed.

At 1834 hours, the TOTAL maritime and environmental safety committee in Paris received a message informing them of the vessel's problems with the exception of the cracks.

They were then told that that POMME/STOCKALOIRE has been designated as agent in St Nazaire. After that, right up to the time that the Erika sank, PANSHIP made no further contact with TOTAL.

At 1917 hours, the master of the Erika advised PANSHIP :

- that he had made TOTAL aware of the situation,
- that he was proceeding to Donges,

and asked them to get in touch with the insurers, the P & I club and the classification society. He added that the cracks had not worsened.

At 1946 hours, The Erika's master confirmed to Total what he had said to them in his 1834 message and told them what steps had been taken.

At 2040 hours, STOCKALOIRE, representing PANSHIP sent the Erika instructions for contacting the MRCC in Etel.

At 2115 hours, the St Nazaire harbour master told the MRCC that the Erika's shipmanagers had designated STOCKALOIRE to represent them and that the latter had got in touch with him. He mentioned that the agency's representative had told him that the vessel was listing heavily and that, as far as he knew, the leaks had been stopped. **The commission notes that this was the first time the problem of the cracks had been made known to the French maritime authorities**. The harbour master answered that he would allow the Erika to berth at Donges even if she was listing but that he could not allow her to do so if any oil was leaking into the sea as it was impossible to set up barriers on the Loire because of the currents. He mooted the idea of re-routeing the vessel to Brest.

At 2120 hours, The MRCC asked the Erika's master to give a detailed account of the leakages between the tanks so that the port of St Nazaire could be notified.

At 2120 hours the MRCC reported the latest developments in the Erika's situation to the maritime Prefecture.

At 2227 hours the master of the Erika sent a SURNAV message to the MRCC giving the ship's position as 46° 55'N 006° 04'W, her course as 090°, her speed as 9 knots, her destination as Donges, her ETA as 1430 hours on 12 December, her predicted draught on arrival as 11.9 metres forward and 10.5 metres aft and her cargo as 30,884 tonnes of fuel oil. This message also mentions the fact that cracks had developed in the deck plating forward of No.2 starboard ballast tank.

At 2250 hours, the master of the Erika sent the MRCC a synopsis of the situation from the moment when the vessel began listing at 1418 hours and mentioning the cracks in the deck plating for the first time.

At 2330 hours, the MRCC made the maritime Prefecture aware of the latest developments in the Erika's situation. Copies of all the messages exchanged with the Erika's master were included in this detailed account.

At 0010 hours on 12 December, the wind was SW force 9/10. The sea was very rough. The vessel began listing again, 3 or 4° to starboard. The ullage of No.2

starboard ballast tank which had been 10 metres decreased to 5 or 6 metres. The master had the ballast tank continuously pumped out. This went on until approximately 0300 hours. The vessel was trimmed 0.6 metres by the head.

At 0100 hours the master of the Erika altered course to 050° until 0410 hours in order to alleviate the stresses acting on the vessel.

From 0300 hours onwards the cracks widened. The vessel, with a speed of 5 knots, was becoming increasingly difficult to steer. The engines were kept at 75 rpm. The ullage of No.3 starboard oil tank increased.

At 0330 hours No.3 starboard cargo tank was seen to be leaking ; its ullage had increased from 1.5 metres to 4 metres. Course was set to 085° to reach Donges as soon as possible. Some oil was seen to be leaking into the sea.

At 0330, 0340 and 0350 hours, the MRCC unsuccessfully attempted to contact the master of the Erika on the 2182 kHz distress frequency. Finally, the MRCC asked the Erika for her position by telex message.

At 0405 hours, the MRCC received a message from the Erika's master giving her position as 47°11'N 04°54'W, her course as 095° and her speed as 9 knots (it was, in fact, 8.3 knots).

At 0554 hours, the master of the Erika reported a breach in the hull with a resulting ingress of water. He transmitted a new distress alert and asked for his crew to be rescued from the ship. The maritime Prefecture was informed of the situation and the MRCC took command of search and rescue.

At 0612 hours, the master of the Erika informed PANSHIP that the side shell plating of No.2 starboard ballast tank had opened over half its length, had flipped over on to the deck and then sunk. The ship could not be steered.

At 0620 hours, the vessel reported to TOTAL that the side shell plating continued to be torn from the ship.

At 0655 hours the vessel gave her final position : 47°12’N 004°36’W.

At 0737 hours the airborne rescue services which had been on stand-by up until then, were brought into operation.

At 0808 hours, the ship began to break her back.

At 0821 hours, the bow and stern sections broke apart from each other.

From the moment when the side shell plating of No.2 starboard ballast tank was torn off (0600 hours) until the ship broke in two (0820 hours), the detachment of the plating spread along the bottom plating in section No.2. The vessel bent, as if her deck were hinged.

At 0810 hours, the rescue helicopter began to winch the crew off the vessel.

At 1043 hours, the last of the 26 man crew was rescued. All were safe and well.

The bow section of the vessel (about 80 metres long) first floated in a vertical position with her forecastle above the water, thanks to the buoyancy of the forepeak tank and the No.1 tanks. It sank during the night of 13 – 14 December.

The stern section (104.45 metres long) sank in 120 metres of water at 1445 hours on 14 December after an unsuccessful attempt at towing by the tug ABEILLE FLANDRE.

During the towing operations, it was possible to inspect the Erika’s navigation bridge. The inspection took place at 1420 hours on 13 December. Everything appeared to be in good order but neither the charts nor the logbook which has been kept right up to the time of the 0554 Mayday and which the master had taken with him on abandoning the ship, were in the wheelhouse. The radar was still working and the helm was not amidships.

5.6* Commentary

However « tiring » the Erika's voyages over the last three months of her existence may have been due to the unfavourable weather conditions, they did not, for all that, have any harmful effects on the vessel.

The cargo was practically always the same – mainly FO2 heated to 65°C – for relatively short voyages in the Black Sea, the Mediterranean and for the two final ones, the north east Atlantic.

Although sea conditions in the Atlantic were somewhat different from those encountered in the Mediterranean, they could not be considered to be « extreme » for a well-found ship nor for the Indian crew who had faced the perils of most of the world's oceans including such difficult areas as the Indian Ocean and the seas of south east Asia during the monsoon or typhoon season, not to mention the Pacific Ocean.

6* Technical factors contributing to the sinking

6.1* Factual analysis

6.1.1* Work carried out at Bijela

Following the classification pre-entry survey and on the basis of the recommendations made by BV, the owners drew up a work list and chose the repair yard at Bijela to carry out the work. Generally speaking the choice of a repair yard takes the following elements into account :

- terms offered by the yard
- the yard's reputation
- availability of the dry dock
- geographical situation (distance from last unloading port and to next probable loading port).

The Bijela repair yard regularly carries out work on vessels classed by various classification societies. It is intended to have it certified ISO 9002 by the BUREAU VERITAS.

The Erika arrived at the Bijela yard on 18 June 1998 from Naples. She remained in dry dock from 19 June until 7 July. She left the Bijela yard on 15 August 1998.

Concerning the structure of the vessel, the work mainly consisted of replacing a number of structural reinforcing elements and deck plating (see annex for details). This included :

- 14 panels of deck plating above :
  - No.1 port cargo tank (58 m^2) and No.1 starboard cargo tank (66 m^2) ;
  - No.1 centre cargo tank (12 m^2) ;
  - No.2 port ballast tank (15 m^2) and No.2 starboard ballast tank (19 m^2) ;
  - No.3 port cargo tank (43 m^2) and No.3 starboard cargo tank (37 m^2) ;
  - No.4 starboard ballast tank (22 m^2) ;
  - The FO daily tank (3 m^2) ;

representing a total of 275 m^2 according to the yard's invoice (316 m^2 according to RINA's report) or some 8 to 9% of the total surface area of the deck.

- as well as some plating on the forecastle deck,
- half of the deck longitudinals (one in two) in No.2 port and starboard ballast tanks between frames 66 – 70 and 70 – 74 ;
- the upper parts of the transverse webs in No.2 port ballast tank (in way of frames 67, 70,71,72 and 73) and No.2 starboard ballast tank (in way of frames 67, 68, 70,71 and 73) ;
- 2 plates and one transverse on the longitudinal bulkhead between No.3 centre cargo tank and No.2 starboard ballast tank as well as one plate on the longitudinal bulkhead between No.5 centre cargo tank and No.4 starboard ballast tank ;

- plates and stiffeners on the watertight transverse bulkheads of No.2 port and starboard ballast tanks in way of frame 66.

In the forepeak tank some plating and stiffeners were replaced on the collision bulkhead on the port side and on the starboard side ; other repairs were carried out on the swash plates and the chain lockers.

All in all, the quantity of steel replaced would have been only 100 tonnes.

Other work was done on :

- the means of access to the tanks ;
- the mooring equipment (windlass, mooring winches) ;
- the cargo and ballast tank pipelines, the cargo heating steam circuit ;
- the boiler ;
- the main and auxiliary engines, the pumps ;
- the propeller blades (permanent repairs);
- the emergency towing arrangements ;
- the inert gas system ;
- the transformation of No.4 port and starboard ballast tanks into segregated ballast tanks.

The deck above the cargo tanks was sandblasted and repainted. For technical reasons, openings 1 metre long and 1 metre high were made in the bilges of the No.2 port (3 openings) and starboard (5 openings) ballast tanks so that the tanks could be cleaned. These openings were made without obtaining preliminary approval from Rina a few days after the ship had entered the dry dock. The cut out pieces of plating were re-installed after the tanks had been cleaned according to instructions given by the RINA class surveyor. It was not necessary, however, to make special openings to put new sections of the structural elements – notably longitudinals and transverse webs - into the ballast tanks as the main deck plating had been removed for replacement. The new deck longitudinals were butt-welded on to the old longitudinals which had been cut about 200 to 300 mm from the bulkheads. Insert plates were welded between the deck longitudinals on the transverse bulkhead

between No.1 port cargo tank and No.2 port ballast tank and between No.1 starboard
No.2 starboard ballast tank in way of frame 74.

The work was carried out under the supervision of the PANSHIP inspector and the RINA surveyor ; the checks carried out by the latter mainly concerned the preparation of the edges of the plates to be welded,
electrodes and the qualifications of the welders as well as the welding sequences and inspection of the welds themselves.

As is usual in such cases, Rina did not give any instructions ; all orders and instructions concerni

to assign class to the vessel as she stood.

The Commission noted, however, that there were differences between the
wo
invoice of the shipyard
and the work which was actually invoiced. For instance, the replacement of the upper part o
not mentioned in the invoice.

The Commission also noted that some panels of deck plating with original scantlings of 16 mm were replaced by new plating which was only 14, or in
cases, 12 mm thick. It is thought that, due to the unavailability of 16 mm plating, the shipyard suggested that 14 mm plating be used. This offer was supposedly accepted
:

- the 2 mm difference in thickness was within the 25 % tolerance ;
  the thickness of the adjacent plates was approximately 13.9 mm ; the plate thicknesses therefore remained homogeneous ; the 13.7 mm plates which were visually unsatisfactory were changed.

The commission considers that such practices are not in keeping with the code of normal practices in ship repairing.

The fitting of insert plates between the deck longitudinals on the transverse bulkhead in way of frame 74 needs to be done with the greatest care otherwise cracks may form with subsequent structural failure.

The commission further noted that non-destructive testing of the welds went no further than kerosene testing and watertightness testing with hosepipes.

No X-ray or ultrasonic checks were carried out on the welds even in such sensitive areas as the bilges.

The commission also noted :

-the poor preparation of the special survey

-the paucity of information supplied to the RINA head office by the class surveyor. The thickness measurements, for instance, were sent for technical analysis only in September, that is to say, after the vessel had resumed commercial operations.

-the lack of documentation on the work done

Segregated ballast tanks

The conversion of cargo tanks into segregated ballast tanks is a well-known weak spot in tanker ships of the Erika’s type and age. As these tanks are poorly, slightly, not at all or no longer protected by an internal coating (such as epoxy), the alternance of sea water and a « saline atmosphere » encourages corrosion to develop especially in the « nooks and crannies » made by the longitudinals where they meet the bulkhead plates and the shell plating they strengthen. Furthermore, the heating of the cargo tanks produces condensation in the adjacent ballast tanks which is also conducive to corrosion. The parts which suffer most in this respect are the deck longitudinals and plating which contribute to the solidity of the ship girder (see drawing). To this must be added the thermal stresses due to the differences in temperature of the various bulkheads. Cathodic protection alone is generally insufficient to prevent corrosion, the more so if the ballast tank is only partly filled.

Moreover, the conversion of cargo tanks into segregated ballast tanks may lead to a redistribution of the overall stresses acting on a structure, and certain elements like bulkheads may have to withstand greater stresses.

The ballast tank bulkheads, for example, are subjected to the **hydrostatic pressure** of the adjacent tanks. Such was the case of the longitudinal bulkhead between No.2 starboard ballast tank (empty) and No.3 centre cargo tank (full). It should be noted that when the vessel is in ballast, the pressure is exerted in the opposite direction.

Finally mention should be made of the movements of the surface of the liquid cargo in the tanks. In bad weather, the movements of the ship form waves in the tanks which crash violently into the bulkheads setting up dynamic forces ; this is known as *sloshing*. However, the small *ullage* in No.3 centre cargo tank would have prevented this phenomenon from developing to any great extent.

We should recall that *corrosion* is the final stage of a process that begins with rust. However, contrary to rust which *protects* metal to a certain extent when it is spread evenly over a piece of metal, corrosion develops in an irregular manner. Corrosion « concentrates » on a certain area, proliferates and burgeons until layers are formed which then flake off as a result of the movements of water and vibrations in the ballast tanks.

As the corroded metal breaks off from the metal « clean » metal appears underneath which is even more likely to be attacked by « active corrosion ». This process results in pitting and holes in the metal which may become the starting point of cracks or in a reduction in thickness of metal surfaces which may lead to failures in less than six months.

Loading in Dunkirk

a) General

On tanker ships like the Erika, as well as on bulk carriers moreover, the loading sequence and the distribution of cargo weight must be carefully calculated to limit the stresses caused by the unequal distribution of the weight of the various elements making up the ship and the upward forces exerted by sea water along the ship's longitudinal axis:

- shearing stress : shear force between 2 adjacent tanks of differing weight (e.g. one empty and the other full).
- bending moment : according to whether the loaded tanks are at the ends of the ship (hogging) or amidships (sagging), there will be alternate tensile and compressive stresses on the deck and bottom.
- torsional stresses : these could occur if, for example, the forward starboard tanks and the aft port tanks were loaded.

Furthermore, in oil tankers care must be taken to reduce the movement of liquids against the internal structural elements of the tanks (sloshing). Restrictions are sometimes imposed on the partial filling of tanks in order to limit the stresses caused by these movements of liquid.

It is also important with heated oil products to avoid thermal stresses.

In order to calculate and thus limit these stresses, loading must be planned and checked on the vessel's load calculator which enables the officer responsible for loading to be sure that the allowable values for bending moments and shearing stresses are not exceeded. Before commencing commercial operations, the ship and the shore agree on the loading rates to be followed at the beginning and at the end of the loading operations. Once the vessel's loading lines have been connected to the shore – by means of two flexible cargo hoses connected to the manifold (a cargo distribution system usually placed amidships) – the onus is then on the crew to distribute the cargo to the various tanks, monitoring the values given by the load calculator so that the maximum allowable values for stresses are never exceeded.

b) Quantity – Freeboard

The vessel's charter party did not mention a precise tonnage to be carried but stipulated a minimum load of 30,000 tonnes. It also stated that the vessel would make the decision as to when to stop loading.

To keep her freeboard in compliance with the minimum winter freeboard figure, the vessel's draught could not be greater than 10.798 metres corresponding to a deadweight of 36,285 tonnes.

Taking into account the weight of her supplies which amounted to some 1000 tonnes, the vessel could not load more than 35,000 tonnes.

In fact, loading stopped when some 30,882 tonnes had been taken on board with a corresponding draught of 10.55 metres, bearing in mind that there were also about 3000 tonnes of ballast on board and a sagging condition of 5cms.

c) Loading

It was unfortunately not possible to examine the plan giving details of the Erika's *loading sequence*. It was left in the cargo operations room at main deck level. It is to be noted that, unlike the usual practice when dangerous cargoes are loaded, the « shore » does not receive a copy of such a document.

According to the master, loading commenced by No.4 centre cargo tank (as mentioned in the bridge log book), while according to the Chief Mate, the loading sequence was as follows : Nos. 1, 3 and 5 centre cargo tanks followed by Nos. 2 and 4 centre tanks and finally Nos. 1 and 3 port and starboard cargo tanks.

d) Cargo distribution - Stresses – Trim

The cargo was distributed among all the cargo tanks which were filled to between 95 and 98% of their capacity except for the three tanks in section No.1 which were equipped with swash bulkheads and were filled to 78%of their capacity.

It is noteworthy that, without remote sounding and with manual operation of the cargo valves, it would have been difficult to obtain a better result.

The loading rate of 1957 m^3 per hour was lower than the expected 3000 m^3 per hour which was the vessel's nominal loading rate.

The shearing stresses and bending moments were within the allowable limits : the shearing stress was 40% of the maximum at frame 66 while the bending moment was 75% of the maximum at frames 61 and 62 (see annex).

With this load, in order to be on an even keel, the vessel ballasted 1500 tonnes in each of the No.4 ballast tanks which were thus half full.

e) Temperature

The temperature of the fuel loaded was between 64 and 69° C. Paragraph 5.4.5 of Section B. Part II of RINA's 1998 rules states that calculations of stresses due to temperature gradients must be made for ships carrying products the temperature of which exceeds that of seawater by 75° C, the sea water temperature being considered to be 0°C. This rule is meant for new buildings , but the ship had been built for carrying heated cargo (70°) and was presented as such .

Concerning recommandation 7.6.14 of the *International Safety Guide For Oil Tankers & Terminals* (ISGOTT) according to which owners should be informed when cargoes of more than 60° are loaded, the Commission noted that it was a normal practice for the ship and its owners could not ignore it .

The differences in temperature between the different tanks were less than 5° C (see table).

Distribution of cargo on leaving Dunkirk

Tank	**Final ullage (m)**	**Volume (m3)**	**Temperature (°C)**	**Tank capacity (m3)**	**Filled (%)**
1 C	4.10	3804.04	69	4842	78.57
2 C	1.13	2443.48	66.8	2492	98.05
3 C	1.49	4769.27	66.5	4984	95.69
4 C	1.31	2414.06	66.6	2492	96.87
5 C	1.03	4915.3	67	4984	98.62
1 Port	4.02	2403.23	64.5	3076	78.13
1 Starboard	4	2407.5	64.5	3076	78.26
3 Port	1.75	3588.47	66.5	3800	94.45
3 Starboard	1.75	3588.47	66.2	3800	94.45
Sloptank Port 5	1.15	883.15	65.5	898	98.34
Sloptank Starboard 5	1.07	888.11	64.4	898	98.89
TOTAL		**32,105.08**	**66.1 (average)**	**35,342**	

Cargo : FO No.2 **Specific gravity at 15° C : 1.0025**	**Vessel**	
Shore's figures : 30,884.47 tonnes Ship's figures : 30,946.54 tonnes	Draught Forward : 10.5 metres Aft : 10.5 metres	Trim : 0 List : 0

In **conclusion,** considering that :

- the freeboard was greater than the allowable minimum,
- upon cargo loading, the vessel's load lines were normal,
- the stresses acting on the ship girder were within the permitted limits,
- the cargo was well stowed,
- the vessel almost always carried the same quantity (from 30,000 to 32,000 tonnes) of the same type of cargo at the same temperature with a similar distribution of the cargo among the cargo tanks,
- the ship's officers all had previous experience of tanker work and had loaded and carried two similar cargoes on the Erika since joining her,

the Commission considers that there is no reason to believe that the loading of the vessel was a contributory factor to her sinking.

6.1.4* Conditions of navigation

a) Weather

The weather report for the period from 8 to 12 December (see annex) mentions an unsettled weather situation with mostly westerly winds veering north west at times or backing south west at others, force 6 or 7 on the Beaufort scale reaching gale force 8 or 9 on Sunday 12 December. The sea was rough with waves 5 to 6 metres high. The swell was from west, of the same height, but with a period of 10 to 12 seconds corresponding to a length of 125 to 200 metres.

Such conditions are not uncommon in the Bay of Biscay at this time of the year and they do not prevent ocean-going ships having the classification societies' highest class from navigating without restriction.

The figures given by METEO-FRANCE were slightly lower than those recorded in the Erika's log book but this is not unusual in this context.

The Erika proceeded down the English Channel from the evening of Wednesday 08 December until the afternoon of Friday 10 December in force 6 to 7 westerly winds with 3 to 5 metre waves and a swell period of about 10 seconds. After passing Ushant and entering the Bay of Biscay in the afternoon of 10 December, the vessel encountered force 7 to 8 south west winds with 5 to 6 metre waves and a westerly swell with a period of 10 to 12 seconds until 1240 hours on 11 December.

During the night of 11 to 12 December the wind was reported to have veered west then north west force 8 to 10 with 5 to 6 metre waves and a swell from the west with a period of 10 to 12 seconds.

b) Course and speed

- Courses followed in the English Channel

From Dunkirk to Ushant, the vessel followed the normal courses using the Dover Straits, Casquets and Ushant traffic separation schemes (TSS).

With a nominal speed of 12.5 knots at 125 rpm main engine speed, she made 7.5 knots average at 107 rpm main engine speed.

- Courses followed in the Bay of Biscay

Having passed Ushant at 1700 hours on 10 December, the Erika altered course to 210° heading for the downbound lane of the Finisterre TSS in Spain.

Her average made good between Ushant and the position where she began listing at 1240 hours on 11 December was 7.1 knots. The vessel was rolling and pitching and shipping green water on the deck from the starboard bow. She also suffered from the fact that with a swell period of about 10 seconds, she was alternately supported first on one crest then on two (see drawing in annex).

Calculations of the strength of the ship girder (see calculations in annex) show that whether her speed was nil or 6.8 knots the stresses to which the vessel was subjected remained approximately the same and well within the acceptable limits.

When the vessel started listing at 1240 hours, the master's first reaction was to correct the list, or at least sufficiently so, that he could turn the ship on to a reciprocal course and thus be able to inspect the deck of his vessel.

This explains why he continued to hold course on 210° until 1418 hours when he altered course to port and put his vessel on a new heading of 030°.

He then carried out a certain number of checks and inspections and decided that he could no longer continue on to Italy but that it was necessary to seek a port of refuge where he could lighten or even unload his vessel.

He could have gone to Corunna, but it was already 1630 hours and since he had turned back, he had moved further away from that port. Moreover, the course would have been 195°, which was very similar to that being followed when the vessel began to list.

Another possibility was Brest.

The idea of proceeding to Brest was based on the notion of running before the sea. However, as the course of 210° was not really head on to the sea because the ship was taking the sea and swell on her starboard shoulder (see sketch of position at 1408 hours), the course of 030° would not really have enabled the ship to run before the sea.

Moreover, calculations show that the stresses on the ship girder would have remained almost the same, and , if the starboard side of the ship had been protected from the elements then the port side would have been exposed to these same elements, which was hardly an improvement.

Finally, it was observed that if she had followed this course and taking account of the subsequent developments in the weather situation, by 0800 hours on 12 December, the Erika would have been taking the sea and swell from abeam ; this would have resulted in heavy rolling which could have accelerated the ongoing deterioration of the ship's structural integrity (see § 6.3.3).

- The course towards DONGES

After considering La Rochelle, the master, in agreement with his shipmanagers, decided to seek refuge in Donges. As Donges is an oil terminal, he would have been able to find there any lightering or unloading facilities which may have been necessary.

He therefore altered course to 085° at 1627 hours on 11 December with the engine at 75 rpm.

It must be stated that, globally speaking, the vessel was proceeding with a following sea (see diagrams on course, speed and weather conditions).

The speed made good between 0000 hours and 0500 hours was 8.07 knots ; it would not have been possible to reduce it to any great extent for reasons of maintaining manoeuvrability in such conditions with a following sea.

Calculations have shown, moreover, that although a vessel’s axial movements are decreased in a following sea, there is little effect on the stresses acting on the ship girder which remain largely the same.

Course, Vessel's speed and main engine rpm.

	Time	**True Course**	**Wind**	**Sea state(1)**	**Rpm**	**Speed (2)**	**Propeller slip**	**Remarks**
Wed 08/12	23.26	270	SW 7	7	107			Full away
Thurs 09/12	03.22	236	SW 7	7				
	12.00					7.02	43%	
	13.00	255	SW 8/9	8				
Fri 10/12	01.00	231	SW 8	8				
	12.00	231	SW 8	8	107[9]	8.33	33%	
	17.00	210	WSW 8	8				Passed Ushant
	23.00	210	WSW 8	8		7.8		
Sat 11/12	06.00	210	WSW 8/9	8/9				
	12.40	210						Progressive list
	13.41							Began deballasting 4 Stbd
	14.10							MAYDAY
	14.18	030	SW 9	8		6.46		
	14.30							FO in 2 Stbd +
	15.02							Cracks on deck
	16.24							MAYDAY ? SECURITE
	16.27	085			75			Cancelled SECURITE
	18.30							Proceeding to DONGES
	20.00	085	SW 9	9				Finished deballasting 4 Stbd
Sun 12/12	00.10							Ullage in 2Stbd decreased
	01.00	050						
	02.30							
	03.00	050	SW 9/10	9		8.7		200 m depth line
	04.00	085				8.3		cracks widen
	05.00	085				7.3		
	06.04							FO in sea
	06.12		SW 9/10	9		3.8		Side shell plating detached and bent
	08.20							MAYDAY
								Side shell plating torn away
								Vessel breaks in two

(1) sea state – (2) made good between GPS fixes Compiled by BEAmer

c) Engine settings

The Erika was fitted with an IHI SULZER 8 RND68 engine having a maximum continuous rating of 9715 kW at 150 rpm. Her nominal service power was 8743 kW at 144.8 rpm.

At 107 rpm the engine-propeller work diagram, according to the « propeller curve » , gives a corresponding power of about 40% of the normal service power. This is a theoretical value.

In the absence of information about the engine parameters (load indicator ,torque, exhaust gas temperatures, turbocharging air pressure) it was not possible to calculate the load on the engine precisely.

The propeller slip values (43% and 33%) are high and are indicative of a loss of propulsive efficiency due to the severe weather conditions which the vessel met.

Fouling of the hull and the propeller blades must also be taken into account.

The propeller slip values recorded in the log book on the previous voyages were between 6 and 13 % (vessel in ballast) and between 7 and 17.5% (vessel loaded).

These values must therefore be treated with caution and do not allow us to state categorically that the vessel was using excessive engine power.

d) Dangers to navigation

It has been suggested that there were drifting logs in the area where the Erika went down.

A NAVAREA safety message No.333/99 broadcast on 4 November 1999 … some five weeks previously, did mention that floating logs had been reported in the easternmost up bound lane of the Ushant TSS.

6.1.5* The initial list taken by the Erika on 11 December 1999

At 1240 hours on 11 December, the master "observed a heavy, progressive list to starboard ".

The list is described as heavy because it was, of course, unusual, but also because the vessel was rolling between 10 to 12 ° to starboard and 2° to port, and then later, between 12 to 15° to starboard without coming back to the upright position.

The list is described as progressive because its development was felt and observed to be due to the constant, inexorable movement of weight over a period of something less than hour.

The list could have been caused by :

- a shift of cargo,
- ingress of water through the cracks on the deck (see § 6.1.3),
- ingress of water through a crack in the side shell plating,
- or a combination of the above causes,

with the proviso that, at the beginning at least, No.2 starboard ballast tank was the only one affected.

a) Accidental shift of cargo

There can be no question about the fact that there was a shift of cargo from No.3 centre cargo tank into No.2 starboard ballast tank; this is corroborated by the fact that :

- the ullage of No.3 centre tank increased,
- the ullage of No.2 starboard tank decreased,
- oil was found in No.2 starboard tank.

This cargo shift was caused by the breaching of the longitudinal bulkhead between No.3 centre cargo tank and No.2 starboard ballast tank. The gap opened could only widen under the effect of the hydrostatic pressure coupled with the free surface effect, however small. It may have run over only a part of the bulkhead or over its the whole length.The origin of the breach was certainly to be found in the severe corrosion mentioned in § 3.6* to 3.9* above.There are two possible explanations for the shift of cargo :

- A TOTAL BUT PROGRESSIVE SHIFT of the cargo resulting from propagation of the initial breach and progressive collapse of the bulkhead, would lead to some 2010 tonnes of fuel being transferred from No.3 centre cargo tank into No.2 starboard ballast tank, which could, according to later calculations, have been sufficient to cause both the mean 7.5° list, allowance being made for the free surface effect, and the 5 metre ullage of No.2 starboard ballast tank as subsequently measured.
- A PARTIAL SHIFT OF CARGO would have corresponded to an increase in the ullage of No.3 centre cargo tank from 1.49 metres to 3.5 metres.

Attention is drawn to the fact that this “measurement” was not mentioned in the first hearings. The Chief Mate had first reported “a substantial increase in the ullage of No.3 centre cargo tank”.

Certain misgivings may also be voiced about the accuracy of such measurements made in the prevailing conditions : flexible tape soundings with both the ship and the liquid surfaces in movement.

It was noted that, subsequently, no further mention was made of the ullage of No.3 centre cargo tank.

All things considered, if the ullage measurement of 3.5 metres is retained, there can only have been a partial shift of cargo, amounting to about 650 tonnes of oil, a quantity insufficient to have caused such a severe list.

The hypothesis of an oil shift between No.3 centre cargo tank and No.2 starboard ballast tank via the ballast line was also considered. For this to be possible the valve in No.2 starboard ballast tank would have had to be open and the line in No.3 centre cargo tank holed, or alternatively the ballast line would have to have been holed in No.3 centre cargo tank and No.2 starboard ballast tank.

The commission considered this hypothesis to be highly unlikely.

b) Ingress of water through the cracks on deck (see § 6.1.6*)

Whether it happened at the same time as the cargo shift or not, the ingress of water via the deck and/or the side shell is beyond doubt, if only because the ullage of No.2 starboard ballast tank which was 10 metres at 1830 hours after No.2 port and starboard ballast tanks had been equalised, had decreased to 5 metres by 0010 hours on 12 December corresponding to the ingress of 2500 tonnes, 1250 tonnes of which were “new” water.

However, the ingress of the 1360 tonnes of water, which added to the 650 tonnes of oil were necessary to cause a 7.5° list, could not have taken place “progressively”.

Indeed :

- either the ingress of water had been taking place since the cracks were formed – supposedly on 9 or 10 December – in which case the list would have been observed much earlier,
- or it took place at the same time as the cargo shift which meant that the rate of ingress had to be compatible with the known facts.

Now the water which could have entered the ship via the deck came from the seas which were shipped on deck and which, because of :

- their relative speed,
- the movements of the vessel,
- the fact that, on these vessels, stanchions had replaced bulwarks with freeing ports,
- the vessel’s marked camber accentuated by the rounded sheerstrake,

did not remain on deck for very long. There was no permanent layer of water with a constant height and thus load, there was only a “film” of water to drain into the cracks which themselves ran in different directions.

The theoretical calculation in § 6.1.6* would seem to indicate that an ingress of 1360 tonnes of water would take about three hours with a permanent 10 cm layer of water on deck , at least covering the cracks.

c) Ingress of water through a crack in the side shell plating

It could be surmised that a crack in the side shell plating could have been initiated by the weakening of transverse webs following the breach which appeared in the longitudinal bulkhead separating No.3 centre cargo tank from No.2 starboard ballast tank.

The existence of this crack is beyond doubt; it was the cause of the breaking and subsequent detachment of the side shell plating. On the other hand, its size was not sufficient, at this point, to allow as much water to enter No.2 starboard ballast tank as was needed to cause a steadily increasing severe list.

As stated elsewhere, the breach in the longitudinal bulkhead between No.3 centre cargo tank and No.2 starboard ballast tank and its deterioration was almost certainly spread to the hull by the progressive breaking apart of the structure of No.2 starboard ballast tank.

Generally speaking, the vessel's list is more likely to be due to a shift of cargo; the ingress of water becomes more significant only at the end of 11 December : the decreasing ullage of No.2 starboard ballast tank and the widening of the cracks on deck heralded the break up of the side shell plating which began at 0330 hours when No.2 starboard ballast tank and No.3 starboard cargo tank became open to the sea.

6.1.6* The cracks and buckling in the deck plating

At 1430 hours on 12 December, the Chief Mate discovered, as we may recall, cracks and folds or buckling in the deck plating on the starboard side forward of No.2 starboard ballast tank which were described as follows :

- 1 transverse crack 1.5 metres long and 1 to 2 cms wide;
- 1 diagonal crack 2.4 metres long and 5 cms wide;
- 1 longitudinal crack 1.5 metres long and 1 to 2 cms wide;
- 3 folds due to buckling 2 to 3.5 metres long, 7 cms high and about 60 cms apart.

These defects, located more or less in way of frames 72/73, well forward of the midship section, can be interpreted :

- either as a “simple “ buckling of the deck plating which, no longer being able to count on its stiffeners (because of corrosion), had to withstand the weight of the seas crashing down on that particular spot of the main deck,
- or, as seems far more likely, as a phenomenon of progressive deterioration resulting in the deck plating’s “sliding”.

It was thus possible for sea water to enter No.2 starboard ballast tank through these cracks :

The average surface area of the cracks was :

- 1.5 m x 0.015 m = 0.0225 m^2
- 2.4 m x 0.05 m = 0.120 m^2
- 1.5 m x 0.015 m = 0.0225 m^2
- amounting to a total of S = 0.1650 m^2

If we assume, for the sake of argument, that the deck was permanently covered by a 10 cm layer of water, then the amount of water which could enter No.2 starboard ballast tank through the cracks, can be found using the formula :

Quantity (Q) in m^3 per hour : $Q = S \times 0.6 \times 3600\sqrt{2g\,h}$

substituting

$Q = 0.165 \times 0.6 \times 3600\sqrt{2 \times 9.81 \times 0.1}$

Q = 500 m^3 per hour

= 512 tonnes of sea water per hour.

This amount would be 723 tonnes per hour with a permanent layer of water 20 cms high … and so on.

However, it is not known when the cracks and buckling first appeared. All that can be said is that they were not noticed during the last inspection of the deck which the weather conditions permitted on 09 December 1999.

6.1.7* Weight transfers

These consist of :

- the 2010 tonnes which flooded No.2 starboard ballast tank;
- the deballasting of 1400 tonnes from No.4 starboard ballast tank;
- the equalising of No.2 starboard ballast tank/No.3 centre cargo tank/No.2 port ballast tank with 1400 tonnes, 1812 tonnes and 1400 tonnes respectively;
- and finally the transfer from No.1 starboard cargo tank to No.1 centre cargo tank (1491 tonnes/4512 tonnes).

Calculations show , and this is confirmed by the master's statement that he had checked them on the load master, that these weight transfers were compatible with the hull girder strength criteria and that they even reduced the shearing stresses and bending moments at the midship section and at frame 71, reducing the bending moment at the midship section in particular from 73% to 40% of the allowable still water bending moment.

As a consequence of these weight transfers, the vessel became trimmed by the head (estimated at 1.92 metres) with the result, among other things, that the bow was not so well protected, and all the more so if she had maintained her course of 210°.

6.1.8* Detachment of the side shell plating

The detachment of the side shell plating of No.2 starboard ballast tank and of part of No.3 starboard cargo tank was a consequence of the decay of No.2 starboard ballast tank which began after the total or partial collapse of the longitudinal bulkhead between No.3 centre cargo tank and No.2 starboard ballast tank had itself caused the dislocation of the transverse webs and the collapse of the remaining stringers and longitudinals. The fragment of one of the stiffeners still attached to the piece of side shell plating which sank 4.8 nautical miles from the spot where the vessel sank is proof in this respect.

6.1.9* The ship’s breaking in two

Calculations have shown that, right up to the moment when the side shell plating was torn away from the side of the vessel, she was able to resist the bad weather and the internal stresses. If the hull failure had been limited to the opening of No.2 starboard ballast tank to the sea she would also have been able to withstand it. Calculations further show, however, that the opening of another tank to the sea, specifically No.3 centre cargo tank following the collapse of the longitudinal bulkhead – not to mention the opening of No.3 starboard cargo tank to the sea – led to the allowable bending moment for the midship section being exceeded by more than 65%. The detachment (as was also the case with a bulk carrier) of the side shell plating of tanks Nos. 2 and 3 starboard and the interconnection between No.2 starboard tank and No.3 centre tank resulted in the ship breaking in two some two hours later.

It is noteworthy that this sequence of events is not incompatible with a progressive opening of No.2 starboard ballast tank to the sea prior to the breaching of the longitudinal bulkhead between No.2 starboard and No.3 centre tanks at 1240 hours on 11 December, as it was only after the interconnection between these two tanks that the bending moment which led to the ship’s breaking exceeded the allowable limit by 60%.

However, if the hypothesis of an overall opening to the sea is accepted, one can only speculate as to how the vessel could have survived for the following 20 hours.

6.2* Observations and technical analysis

6.2.1* Observations of the wreck

Reconnaissance operations and examination of the wreck began on 30 December 1999.

They were carried out partly by the ABEILLE SUPPORTER and partly by the CSO MARIANOS using surface-controlled robots (ROVs).

The examination of the wreck, both fore and stern sections, especially the appearance of the fractures and the structural elements, took place in co-operation with TOTAL while they were checking the wreck and stopping the leaks as part of the work being carried out preliminary to pumping operations.

The first stage which lasted from 31 December 1999 until 19 January 2000 and was effected by the ABEILLE SUPPORTER, comprised an overall inspection of the fore and stern sections of the wreck by the ABYSSUB, ACHILLE TRAVOCEAN and TRITON XL18 COFLEXIP ROVs as well as work on closing the gaps.

The next two stages enabled a more detailed video inspection and a cartographic survey of the wreck to be made (see annexes).

- between 04 and 13 February 2000 : the fore section and part of the stern section.
- between 17 and 21 February 2000 : the stern section and two other fragments of the wreck, one of which was located 150 metres east of the stern section, the other being 5.8 miles from the fore section at 47° 14.3'N 4° 31'W.

A further inspection took place between 15 and 22 September 2000 after pumping out of the fore and stern sections was completed. It was carried out by divers and a ROV.

During these underwater investigations, debris and fragments of the Erika's structure were picked up by the ABEILLE SUPPORTER's ROV and the hydrographic survey vessel LA PEROUSE while pumping operations were taking place during the mission carried out by the Service hydrographique et océanographique de la marine (SHOM) on 03 February 2000.

The various pieces were measured for thickness and analysed by a laboratory.

6.2.1.1* Examination of the fore section

- Position : 47° 14' 24.0718" N / 004° 22' 21.8871" W
- Orientation : 045°
- List : 4 – 5° to starboard
- Depth : 114.2 metres
- Bottom : sand and shells
- Bottom temperature : 11° C
- Bottom visibility at time of observations : 5 – 6 metres
- The wreck had not made a bed in the bottom.

The fore section of the wreck was upside down. The deck was lying on the bottom at a depth of 114.2 metres. The inspection took place between 0730 hours and 2110 hours on 05 February 2000.

The following observations were made :

- the bow was severely staved in with a break in way of the curve between the bulbous bow and the stem.
- No.2 starboard ballast tank (on the left side of the wreck) had completely disappeared with the exception of part of the bottom plating near the bilge keel and the round of bilge.
- The break was clean and uninterrupted in way of the after bulkhead of No.1 starboard wing cargo tank (frame 74). A breach was visible in the bulkhead between No.1 starboard and No.2 starboard tanks 3 metres from the bottom.

- Only a small section of the longitudinal bulkhead between No.2 starboard wing tank and No.2 centre tank remained; it could be seen with its longitudinals.
- No.2 port wing tank (on the right side of the wreck) was buckled between frames 69 and 70. Several longitudinals from the detached side shell were still in place.
- There was a longitudinal fold due to buckling in the bottom of No.2 starboard wing tank from frame 74.
- In the round of bilge of No.2 port wing tank, near the bilge keel, two welded panels were observed which could correspond to the openings made in the Bijela shipyard for cleaning the tank.
- The hull had a “hammered” aspect (bottom, round of bilge, side shell, boot topping) and exhibited numerous traces of corrosion.
- The bottom plating had been torn away in way of the round of bilge and the portside bilge keel was hanging free.
- The bottom plating of No.2 starboard ballast tank, of the whole of No.2 centre cargo tank and of a great part of No.3 centre cargo tank had been folded back 90° from frame 74 forming a vertical wall as high as the wreck itself (15 metres), the bottom plating being folded back on to the sandy bottom (see diagram and sketch made on board “CSO MARIANOS” after the observations).
- The bottom plug of No.2 centre tank was at a depth of 107 metres (the keel was at a depth of 99 metres) confirming that this tank had been crushed, while the structure of No.3 centre tank had also been crushed (below the bottom plating).
  - No plating or any other structural element from the wreck was found on the bottom within 150 metres of the wreck during subsequent inspections.
  - The robot’s camera showed what appeared to be a transverse web in way of frame 73 in No.2 port wing tank.
- Examination of the bottom plating to find the bottom plugs showed plating apparently in better condition in way of No.1 starboard tank
- Sand and decreasing visibility, however, made it impossible to be absolutely certain of this.

Thickness measurements were made on the bottom plating of the tanks :

- No.1 starboard : 14.9 mm – 15.2 mm
- No.1 centre : 17.6 mm – 18.3 mm
- No.1 port : 14.7 mm – 16.7 mm
- No.2 centre : 17.6 mm – 22.7 mm

6.2.1.2* Examination of the stern section

Inspection of the stern section which began on 12 February 2000 had to be interrupted due to unfavourable weather conditions.

The inspection took place after the operations to stop the leaks from the fore section, the checking of the geographical positions and a sonar and visual inspection of an area 50 metres around the fore section of the wreck.

- Position : 47°09'25.4464" N / 004°15'47.327" W
- Orientation : 011°
- List : 0.8° to port
- Trim : +0.5 metres
- Depth : 129 metres
- Bottom : Hard sand – small rocks to port of the wreck
- Bottom temperature : 11°
- Bottom visibility at time of inspection : 2 to 3 metres
- The wreck had not made a bed in the bottom

The initial inspection of the break of the stern section was made using the ROV TIGER 807 between 0850 hours and 0935 hours on 12 February 2000.

It consisted in following the break on the port side in way of frame 66 (abaft No.2 port ballast tank) downwards.

The following things were observed :

- There were the remains of twisted longitudinals level with the break, the bulkhead between No.2 starboard and No.3 starboard tanks being about 50 cms abaft the gap in the side shell then flush with the gap as far as the diamond-shaped painted mark (tug pushing point) at right angles to the bulkhead;
- There was a relatively clean break in the port side plating (only three panels of the No.2 port ballast tank plating, and small ones at that, remained in place);
- The deck stringers were flat bars;
- The bottom plating of No.2 port tank was folded up vertically to a height of 2 metres above the bottom;
- The port side plating was dented in way of frame 50;
- On the port side of the deck in way of No.4 port ballast tank near frames 33- 34, there was a crack running north east for 5 to 6 metres from the derrick at the side of the vessel.

Thickness measurements were made of the deck plating :

- Starboard sloptank : 11.6 mm
- No.5 tank : 14.8 – 16.8 mm to starboard of the piping ;
  : 15.3 – 16.4 mm to port of the piping
- No.4 starboard ballast tank : 12.1 mm
- Port sloptank : 11.5 – 15.2 mm
- No.4 centre cargo tank : 17.3 mm
- No.4 port ballast tank : 11.9 mm

The inspection of the area within 150 metres of the wreck on 18 February 2000 revealed the presence of debris (starboard lifeboat, satellite aerial dome) and of a 15 by 3 metre fragment 150 metres to the east of the wreck which was apparently part of the upper deck (it was painted green).

- The inspection was interrupted after the ROV cable parted and recovery of the robot. Sea and weather conditions did not permit the inspection and work on the plugging of the leaks to start again before 19 February 2000.

After the starboard side shell had been examined, the break in way of frame 66 was inspected over a two hour period between 1330 hours and 1530 hours on 19 February 2000.

- The starboard deck storeroom which straddled Nos. 2 and 3 wing tanks showed a fissure in its lower part which ran along the transverse bulkhead to a point approximately 3 metres from the deck line. This fissure continued into the plating of No.3 starboard wing tank on to a point 7 metres above the round of bilge and then followed the transverse bulkhead once more to the 1st stringer 5.1 metres above the bottom.
- The transverse bulkhead between Nos. 2 and 3 starboard tanks did not seem to have suffered any damage except for a fissure near the plating in the area of the opening in No.3 starboard tank mentioned above (see attached diagram made on board following the observations).
- In the gap in No.3 starboard tank plating, the longitudinals could be seen and most of them, with the exception of those near the intermediate stringer, were broken off flush with the bulkhead.
- The vertical stiffeners of the No.2 starboard / No.3 starboard bulkhead (8) were intact with the exception of those corresponding to the fracture.
- On the starboard side of bulkhead 66 the two horizontal stringers look as they had been in part torn off .
- The deck stiffeners of which there were 10 and 6 of which were located below the deck storehouse had been cut flush with the deckhouse close to the transverse bulkheads.
- The same facts were observed for the portside part of the transverse bulkhead from No.2 port wing tank to No.2 starboard wing tank.

- The bottom plating and stringers had folded upwards to a height of 4 metres across the whole breadth of the vessel.
- The deck plating above the centre tanks had folded downwards as far as the bottom plating; the fracture had occurred on either side of the deck plating.
- It corresponded to the forward part of No.3 centre tank (two valve handwheels - the suction and stripping valves of No.2 centre tank – could be seen).
- The ROV TIGER then passed behind the vertical wall formed by the main deck and through the central transverse web of frame 66. Heating pipes could be seen as well as the ladder and tank hatch of No.3 centre tank.

To summarize, the path of the fracture can be described as follows : roughly speaking, in its upper part the fracture crossed the deck, except for a strip of deck which was folded down towards the bottom.

It went along the bulkhead, round the starboard deckhouse store, to the starboard side shell running at right angles to frame 66. From there it continued on down the starboard sideshell plating.

6.2.1.3* Examination of the fragment located 150 metres east of the stern section

- Position : 47° 09’ 28” N / 004° 15’ 38” W
- Depth : 135 metres
- Bottom visibility at time of inspection: 2 metres

This fragment was examined after the operations to stop leaks – which took place from 20 February 2000 to 21 February 2000 – were completed.

The fragment was approximately 15 metres by 3 metres in dimension, was painted green and comprised a tank hatch as well as part of a bulkhead perpendicular to the main deck.

It was part of the deck plating on which longitudinals could be seen and what was probably part of the longitudinal bulkhead between No.2 wing tanks and No.3 centre tank.

No markings were visible on the tank hatch which still had its cover. The tank hatch was fitted with a small pipe the end of which was plugged (it was probably a vent valve on the inert gas system which had been plugged when the tank was transformed into a segregated ballast tank).

Closer to the side and on the fracture side, two circular openings about 100 or 150 mm in diameter with welded lips could be observed; they were probably scuppers.

Two attempts were made to raise this fragment of the wreck which weighed an estimated 50 tonnes using the crane on board “CSO MARIANOS” and slings from the ship. They were not successful.

6.2.1.4* Examination of the so-called “La Perouse” fragment of the wreck.

This fragment of the wreck was found by the hydrographic survey vessel LA PEROUSE, hence its name. It was located 5.8 nautical miles west of the wreck of the fore section and bearing 050° at a distance of 3.6 miles from the position indicated by the Erika’s master at 0520 hours on 12 December 1999.

- Position : 47° 14’ 37.266” N / 004° 31’ 07.177” W
- Depth : 123.5 metres
- Bottom visibility at time of inspection: 2 metres

Examination of this piece of the wreck was carried out from 0315 hours to 0445 hours on 21 February 2000.

The approximate dimensions of the fragment were as follows : length : 10 m, width : 5 m, average height : 4 m, maximum height : 7 m. It was twisted and distorted in shape with numerous fissures. No trace of paint could be observed on the fragment on which the following elements were identified : numerous torn and twisted stiffeners and longitudinals, brackets, a vertical structure some 7 metres high and an almost completely detached web frame. A cross tie which had broken near the longitudinal bulkhead could clearly be seen. The weight of the fragment was estimated to be 100 tonnes.

A large part of the wreck fragment was hidden from view by a trawl net which had caught in it.

The fragment corresponds to all or part of the side plating which the master said had been torn from the side of the vessel at 0612 hours (see chart in annex). At this time No.3 centre tank and No.3 starboard tank (a part of the fragment was the side plating from the forward part of No.3 starboard tank) and No.2 starboard ballast tank were opened to the sea, leading to the break up of the vessel at 0820 hours, 8 nautical miles further on.

6.2.2* Analysis of the hull and structural elements recovered

Five fragments which can certainly, or at least very probably, be said to come from the wreck of the Erika were recovered.

a) A highly corroded element which might have been a bottom longitudinal was sent to the DGA establishment at Indret for analysis for the preliminary judicial investigation.
b) A bar thought to be a stringer from a longitudinal bulkhead or side shell which might have come from one of the No.2 wing ballast tanks. It was recovered by the SHOM mission of 03 February 2000 very close to the so-called “LA PEROUSE” fragment of the side shell in position 47° 14.3’ N / 004° 31’ W. It was analysed by the Laboratoire Central des Ponts et Chaussées in Nantes (LCPC).

c) Part of a bar recovered by the CSO CONSTRUCTOR at the foot of the wreck of the stern section towards the end of the pumping operations. It was handed over to BEAmer and could well have been a bottom longitudinal from No.3 centre tank.

d) A very small highly corroded fragment could not be identified. It was found inside the wreck and was recovered in the same conditions as the fragment in b) above.

e) A small fragment was picked up from the deck fragment located 150 metres to the side of the wreck of Erika’s stern section by the ROV from the ABEILLE SUPPORTER on 03 March 2000.

52 disks with a diameter of about 185 mm must be added to this list of pieces of debris. They had been drilled in their centres and then cut out from the deck and bottom plating of both sections of the wreck during the drilling operations which were carried out preliminary to pumping operations.

TOTAL handed over 39 of these disks to BEAmer under the supervision of a bailiff. They were then analysed at the LCPC .

Results of observations and analysis

a) Angle bar (bulkhead longitudinal or side longitudinal type)

The bar was a steel angle bar with unequal flanges measuring 300 x 11 mm (web flange) and 85 x 16 mm (face flange) respectively. This corresponds to a standard 300 x 90 mm angle bar.

This element was identified under numbers 25, 26 and 27 of the midship section as belonging to one of the horizontal stiffeners welded to the longitudinal bulkhead between two tanks or to the side plating.

Average residual thickness results – details of which are given in the annexes – show a decrease in thickness of about 28% - reaching 50% in some places – for the web and 22 to 35% for the face plate.

As far as the structure of the steel itself goes, chemical analysis and examination of the metallographic sections give results compatible with steel of good weldability (see table below).

Results of chemical analysis in % (weighted %)

	C	Mn	Si	S	P	Ni	Cr	Mo
Sample 1	0.17	0.71	0.044	0.016	0.022	0.014	0.017	<0.002
Sample 2	0.18	0.72	0.044	0.016	0.022	0.014	0.016	<0.002

The stiffener had originally been fixed to its plating by two non-penetrating semi-automatic single pass beads of welding. The weld metal of the beads had broken right through; the thickness of the beads at the break was between 2.7 and 3 mm.

Three multirun beads approximately 8 cms long were observed; they were about 20 to 25 cms apart on one side only of the upper surface of the connection between the stiffener and the plating.

These beads seemed to have been broken more recently as evidenced by the raised metal at the points where they tore away from the supporting plate.

Unlike the continuous seams the surface of which had been deteriorated by corrosion, the raised relief due to the rupture of these three beads was only lightly corroded.

These three discontinuous welds were probably connected with repair work carried out to fix the stiffener on to its support.

The break surfaces looked as if they had been stretched. The breakage had been preceded by significant tensile distortion.

b) the disks cut from the bottom and deck plating (batch analysed by the BEAmer)

The exact locations from which the disks were cut, their descriptions and thickness measurements are given in annex. Most of the disks were cut from the cargo tanks or the slop tanks. Only three disks came from the wing ballast tanks :

- one (No.9) came from the deck plating of No.4 starboard ballast tank (frames 57 –58 on the stern section of the wreck);
- the other two (EX1 and EX2) came respectively from the bottom plating of No.2 starboard and port ballast tanks (frames 73-74 on the fore section of the wreck).

The samples taken from the deck plating of the stern section showed reductions in thickness of between 16 and 63% (maximum value in a corrosion pit) and mostly above 20%; the average value was around 25%.

Those taken from the bottom plating showed reductions in thickness of 15 to 25%, reaching 30% in places. Chemical analysis by emission spectrometer of disks No.9 and No.10 gave the following results (see table).

	C%	**Mn%**	**Si%**	**S%**	**P%**	**Ni%**	**Cr%**	**Mo%**	**V%**	**Cm%**
Sample 9	0.19	0.56	0.23	0.011	0.013	0.037	0.043	0.002	0.036	0.051
Sample 10	0.15	0.73	0.20	0.013	0.014	0.012	0.009	0.002	0.005	0.018

These figures correspond to weldable steel with standard characteristics.

Sample No.9 was particularly interesting as it was cut from a new plate 12 mm thick (the original scantlings were 16 mm). This confirms the thickness indicated in the RINA report and in the shipyard's invoice but contradicts the thickness indicated on the shipyard's work diagram. The surfaces of the disks examined were severely deteriorated by corrosion with cracks and pitting on both sides sometimes reaching a depth of 4 to 5 mm. The preceding analyses confirm that the stiffeners and plating of section No.2 were seriously corroded and the coats of paint over the fairly deep corrosion pits explain the cosmetically acceptable appearance of the vessel.

c) angle bars (bottom longitudinal type)

This fragment was identified as being part of an L-shaped bottom longitudinal corresponding to an angle bar with a 500 x 11.5 mm web and a 150 x 22 mm face plate as indicated at the midship section.

Only the face plate (140 to 150 mm x 16 mm) was recovered and analysed. The residual thickness of 16mm compared to an original 22 mm shows a reduction in thickness of more than 28%.

It would have been preferable to have had other structural elements at hand for purposes of analysis.

6.2.3* The ERIKA's sister ships … and the others

a) The Erika was one in a series of eight ships built by the KASADO shipyard in Japan between 1974 and 1976.

According to a brief report from the International Association of Classification Societies (IACS) most of these ships experienced structural problems at some stage of their existence.

The Commission noted that the light displacement of these vessels was no more than 7000 tonnes, or about 1000 tonnes less than other tankers of this category without, for all that, their having the "corrosion control" class mark or high tensile steel in their construction. Besides the fact that their structure had been optimized by computer calculations, another reason for this difference in weight could have been that the engine installation of these ships was smaller (only one boiler and 2 gensets for example). This lighter displacement, especially at the stern, could also explain why there were problems in correcting the trim of these vessels.

All were followed by classification societies who were members of IACS but there was no exchange of information between them.

a) The SEA CROSS, Maltese flag, ABS classed – scrapped.

b) The ERIKA, Maltese flag, NKK classed, then ABS, then BV and finally RINA.

- 1985 buckling of the forward and after bulkheads of No.4 centre tank.
- 1997 replacement of plating and stiffeners in No.2 starboard ballast tank.
- 1998 replacement of 100 tonnes of plating and stiffeners.
- 1999 foundered.

c) The SIENA, Maltese flag, NKK classed, then BV and DNV.

- 1995 extensive corrosion of deck plating.
- 1998 replacement of plating and stiffeners.

d) The MARINER A, Maltese flag, NKK classed.

- 1990 fractured welds on deck stiffeners in No.1 port and starboard tanks.

e) The NEW VENTURE – PATRIOT, Panamanian flag, ABS classed then LR.

- 1991 accident
- 1992 fracture of deck at No.3 centre tank, detachment of deck longitudinals of No3.starboard and No.4 port tanks, repairs to No.3 centre tank.
- 1998 repairs to No.3 centre tank.
- 2000 repairs to No.3 centre tank.

f) The YASMEEN, Liberian flag, NKK classed.

- 1991 buckling of deck No.3 port tank. Detachment of deck longitudinals of No.3 port and starboard tanks.
- 1999 replacement of deck plating and stiffeners of No.2 starboard, No.4 port, No.3 port and centre and No.1 port and centre tanks.

g) The FENERBAHCE, Turkish flag, NKK and BV classed.

- 1986 longitudinal stiffeners in No.3 port and starboard tanks detached.
- 1987 longitudinal deck stiffeners in No.1 starboard tank broken.
- 1991 accident – fractures and buckling of deck No.3 port centre and

starboard tanks, detachment of stiffeners in Nos.2 and 3 port centre and starboard tanks.

- 1992 replacement of deck plating and stiffeners in No.1 starboard tank.
- 1994 renewal of welds of stiffeners in No.2 starboard tank in way of frame 67.
- 1995 extensive replacement of deck plating and stiffeners forward – 185 tonnes of steel of which 107 tonnes on main deck.
- 1998 renewal of upper stiffeners in Nos.2 and 3 port and starboard tanks.
- 2000 special survey – replacement of 650 tonnes of plating and stiffeners.

h) The GREEN KING –MUTANK VISION, Liberian flag, NKK classed then DNV,LR and CCS.

1990 accident – buckling of deck at frames 66 and 67 – excessive corrosion of Nos. 2, 3 and port and starboard tanks and severe corrosion of deck plating and stiffeners.

- 1995 idem.
- 1996 idem.
- 1997 corrosion of deck
- 1998 replacement of bulkheads in way of frames 74 and 82 and of longitudinal bulkheads port and starboard.
- 2000 special survey – vessel scrapped.

b) it should be remembered though that a few hundred ship built like the ERIKA and its sisterships are still operated ; a few tankers broke : the KATINA in 1992 in Mozambique, the THANASSIS A in 1994 in China, the NAKHODKA in 1997 in Japan the VOLGONEFT in 1999 in Turkey .

6.3* Analysis of the vessel’s structural strength.

Introduction

The BEAmer had a certain number of studies performed on the structure of the Erika with a view to :

- calculating the values of the stresses imposed on the hull in conditions corresponding to those experienced during her last voyage whether they were due to the way she was loaded or to the sea conditions encountered and that, throughout the whole process of failure and damage. The structure itself corresponded to the condition as defined by the last set of thickness measurements taken in 1998 and by the work carried out at the Bijela shipyard during the reclassification survey in August 1998;
- comparing the results of these calculations with the IACS requirements for this vessel.

The study first examined the static equilibrium of the tanker from her departure from Dunkirk until the moment when No.2 starboard ballast tank was flooded and took in all the damage sequences as well as the transfers of liquid by the crew.

There were 8 configurations :

- arrival in Dunkirk;
- departure from Dunkirk;
- arrival in the Bay of Biscay;
  - case 1 – rupture of the bulkhead between No.3 centre tank and No.2 starboard tank leading to the shifting of 2010 tonnes of oil from No.3 centre tank into No.2 starboard tank (this corresponds to the equalizing of the levels between No.3 centre and No.2 starboard);
  - case 2 – as before, with deballasting of No.4 starboard tank representing 1400 tonnes being pumped into the sea;
- Case 3 - as before, with equalizing between No. 2 port, No.3 centre and No.2 starboard tanks, corresponding to a load in these tanks of 1400 tonnes, 1812 tonnes and 1400 tonnes respectively;
- Case 4 – as before, with transfer from No.1 centre cargo tanks, representing 1491 tonnes and 1512 tonnes;

- Case 5 – opening to the sea of No.2 starboard tank, alone, and then taking into account the transfers of fluids previously described.

For each one of these configurations the state of equilibrium of the vessel in still water was assessed and the maximum loads on the hull girder were calculated. The results were then compared with the IACS allowable values.

These studies comprised two distinct phases :

- a global assessment of the stresses imposed on the ship girder(see § 6.3.1), as defined by her actual scantlings, and taking account of static loads (cargo) and quasi-static loads (swell, defined with reference to the sea states encountered) acting on her structure.

The calculations were made for each successive stage of the foundering taking into account communication and transfer between the various tanks. The state of static equilibrium of the vessel was estimated for each configuration enabling the results to be compared with the allowable stresses for the ship girder.

- A detailed assessment of the stresses imposed on the structural elements of section No.2 (see § 6.3.2) by applying the actual conditions of static and dynamic loading; finite element models were used for strength assessment in this study.

The two studies were performed by the Institut de Recherche de la Construction Navale according to technical specifications provided by the BEAmer. The IRCN's final report comprises four volumes :

- one volume dealing with the global strength of the ship girder, and an estimation of stresses due to wave loading,
- one volume presenting and commenting the finite element calculations,
- two volumes giving details of the stresses imposed on the longitudinal and transverse elements of section No.2, for each of the four cases of loading considered.

6.3.1* Analysis of hull girder strength

a) Introduction

The positions of equilibrium at sea were estimated using the hydrostatic and hydrodynamic loads applied to the vessel before and after damage, and the global strength of the ship girder was verified for the various load configurations.

The hull strength values were compared using :

- the design scantlings (construction drawings);
- the thickness measurements made during the special survey at Bijela in August 1998.

b) Displacement figures used in the calculations :

- light ship 7238 tonnes
- arrival at Dunkirk in ballast 18,858 tonnes
- departure from Dunkirk 42,187 tonnes
- when vessel began to list 42,057 tonnes
- after deballasting of No.4 starboard tank 40,657 tonnes

c) Still water equilibrium position

Trim Δ (positive by the stern) and list θ (positive to starboard) values are given in the following table for the eight cases considered :

Case	**Δ**	**θ**	**Free surface effect**	**θ total**
Arrival in Dunkirk	3.18 m			
Departure from Dunkirk	0.04			
Bay of Biscay	-0.10*			
Case 1	-0.76	+ 6°	+ 1.5°	+ 7.5° stbd
Case 2	-1.60	+ 1.9°	+0.5°	+2.4° stbd
Case 3	-1.87	- 5°	-1.2°	-6.2° pt
Case 4	-1.92	- 7.4°	-2.2°	-9.6° pt
Case 5	-2.23	+ 10.2°	+1.8°	+13° stbd

*- 130 tonnes of fuel burnt.

It can already be seen that Cases 1, 4 and 5 correspond to observations made during the events.

d) Internal loading of the ship girder : shearing stresses and bending moments

The following table summarizes the results of the calculations made for the different cases and compares them with the maximum allowable values (IACS criteria) at the midship section (MS) and at frame 71 (F71).

Internal loads in the ship girder in still water

		Shearing stress in tonnes	**Bending moment in tonne / metres**	**As % of maximum allowable bending moment**
Allowable maxima hogging sagging hogging sagging	MS MS F71	 ±6120 ± 5173	 +82 771 -77 372 + 82 771 - 77 732	
Arrival in Dunkirk	MS F71	- 1110 100	+ 22 500 - 31 000	27% 40%
Departure from Dunkirk	MS F71	480 500	-56 800 -5600	73% 7%
Bay of Biscay	MS F71	649 500	-57 500 -4000	74% 5%
Case 1 Rupture of Bulkhead 3C/2S	MS F71	1000 -100	-44 000 -7300	57% 9%
Case 2 Idem + deballasting of 4S	MS F71	650 -160	-37 000 -5600	48% 7%
Case 3 Idem + equalizing 2S/3C/2P	MS F71	800 -390	-30 000 -5200	39% 7%
Case 4 Idem + transfer 1S/1C	MS F71	800 -365	-31 000 -6700	40% 9%
Case 5 2S open to sea a) Bay of Biscay b) Transfers	 MS F71 MS F71	 -230 800 -650 880	 -67 000 -37 000 -70 000 -57 000	 86% 50% 90% 74%

To this first analysis which took as a working hypothesis only the rupture of the bulkhead between No.3 centre tank and No.2 starboard tank, and then, the later flooding of No.2 starboard tank was added the examination of those cases in which the tanks concerned are in direct communication with the sea following a breach of the hull; the calculations were also made incorporating the transfers of liquid.

It is recalled the calculations were effected using the “lost buoyancy” method which assumes that the tanks were in open communication with the sea, which was really only the case during the latter stages of the shipwreck. These results then can only serve as a guide to what possible consequences the flooding of the tanks might have had on the bending stresses affecting the ship girder.

The following table concerns case No.6 in which it is assumed that No.2 starboard and No.3 centre tanks are open to the sea (total collapse of the longitudinal bulkhead). In this case the vessel would have a list of +5.2° and a trim of –5.95 metres.

		Shearing stress	**Bending moment**	**% of allowable value**
Case 6 2S open to sea + 3C / 2S				
a) Bay of Biscay	MS	-1870	-128 000	165%
	F71	+2600	-80 000	103%
b) Transfers	MS	-2400	-125 000	161%
	F71	+2700	-105 000	135%

The **following conclusions** were drawn :

Up to and including Case No.4 (rupture of the bulkhead between No.3 centre tank and No.2 starboard tank plus the various transfers of liquid), the stresses - the bending moments in particular – remain lower than the allowable maximum values. The effect of the transfers is to decrease the bending moments considerably at the midship section and in section No.2.

In Case No.5, in which No.2 starboard tank is open to the sea, the stresses remain within the allowable limits; however, they are close to the maximum values and the bending moment increases by 50% at Frame 71 because of the transfers.

In Case No.6, in which both No.2 starboard and No.3 centre tanks are open to the sea, the bending moments exceed the maximum allowable values by 60%. Such a situation would lead very rapidly to the complete destruction of the hull. This assumes, as previously stated, that there is open communication between No.2 starboard tank and No.3 centre tank.

This case most closely fits the observations made during the events, from the time when the list started at 1240 hours on 11 December until the ullage in No.2 starboard tank decreased again at 0010 hours on 12 December.

e) Section modulus of the ship girder

The section moduli were calculated according to IACS rules and for the design scantlings of the vessel's structure. According to the thickness measurements taken they decreased between 1975 and 1998 in the following proportions :

- 10.9% at the midship section
- 12.9% at frame 71.

Furthermore, the collapse of the bulkhead between No.3 centre tank and No.2 starboard tank could lead to a decrease in the section modulus of :

- 16.5% if the strakes of plating are removed but the longitudinal stiffeners retain their efficiency,
- 23.2% if the total bulkhead efficiency is lost.

The following table shows that the section modulus values are greater than the IACS minimum criteria, except in the last case, in which total loss of the longitudinal bulkhead's efficiency is assumed.

Section moduli

- at deck line w_{deck}

- at bottom w_{bottom}

w Ship	**w_{min}** **IACS Ref. URS7**	**Margin as % of w_{min}**
1.Ship as built		
w_{deck} = 12.808 m3	11.9265 m3	+ 7.4%
w_{bottom} = 14.618	11.9265	+ 22.6%
2. Ship in 1998 – after leaving Bijela	**$w = w_{min}$ x 0.9**	
a- Midship section		
w_{deck} = 11.318 m3	10.73 m3	+ 5.5%
w_{bottom} = 13.149	10.73	+ 22.5%
b- Frame 71		
w_{deck} = 11.097 m3	10.73 m3	+ 3.4 %
w_{bottom} = 12.802	10.73	+ 19.3%
c- Loss of bulkhead 3C/2Stbd		
Stiffeners retained		
w_{deck} = 10.619 m3	10.73 m3	- 1%
w_{bottom} = 12.307		+ 9%
Stiffeners removed		
w_{deck} = 9.384		- 13%
w_{bottom} = 11.876		+ 11%

f) Global bending stress

Permissible stress values for old ships, according to the rules formulae are :

$$\sigma_{deck} = \sigma_{bottom} = 194.4 \text{ N/mm}^2$$

for the vessel obtained by applying the formula :

$$\sigma_{deck} = \frac{M_{sw} + M_w}{w_{deck}} . 10^{-3}$$

and

$$\sigma_{bottom} = \frac{M_{sw} + M_w}{w_{bottom}} . 10^{-3}$$

where M_{sw} is the still water bending moment, M_w the wave bending moment obtained from an empirical rules formula, viz. M_w = 13.119.106 kNm for the Erika and where w_{deck} and w_{bottom} are the section modulus values for the deck and bottom.

The following results were obtained :

- **before casualty, on leaving Dunkirk**

	Midship section	**Frames 71 - 72**
σ_{deck} (N/mm^2)	167.2 < 194.4	170.5 < 194.4
σ_{bottom}(N/mm^2)	143.9 < 194.4	147.8 < 194.4

The global stresses thus confirm the IACS minimum criteria, the wave bending moment value used for the calculations being greater than the estimated wave bending moment for direct calculation using actual sea state data.

- **after rupture of the bulkhead between No.3 centre tank and No.2 starboard ballast tank**

The efficiency of the bulkhead was not included in the calculations which yielded the following results :

	Including bulkhead stiffeners	**Excluding bulkhead stiffeners**
w_{deck}(m^3)	10.619	9.384
w_{bottom}(m^3)	12.307	11.876
σ_{deck} (N/mm^2)	178.2 < 194.4	201.6 < 194.4
σ_{bottom}(N/mm^2)	153.7 < 194.4	159.3 < 194.4

These theoretical calculations show that, without the longitudinal bulkhead, the allowable stress is exceeded on deck in section No.2.

6.3.2* Direct calculations on the structure of section No.2

It seems advisable to recall the underlying logic of these difficult, complex calculations :

. A model of the structure must first be generated using data from available and relevant documents. In the case in point, the object was to study the stresses in the strength components of section No.2, and specifically the local longitudinal stresses created by hydrostatic and hydrodynamic loading. Each of the structural elements, both plating and stiffeners, was therefore finely modelled into finite cells. With a longitudinal mesh dimension of 0.75 metres the final model comprised :

- 108,739 elements,
- 90,788 nodes (nodal points),
- 544,728 degrees of freedom.

The model covered the whole of sections 1 to 3, from frame 58 to frame 74, the fine mesh model being confined to section No.2 which was the only one used for the final analysis. Each structural element was modelled except for the connecting brackets between the elements. The model corresponded to the state of the structure as known in August 1998 (after the thickness measurements and repair work at Bijela). In view of the large number of measurements made on the structure, only a few elements of the model did not receive values : in section No.2 a value was extrapolated for these from measurements made on neighbouring elements.

In sections 1 and 3, a constant diminution factor was applied to the original values concerning the thickness to compensate for the stiffness of these sections in the model.

The software used for the mesh calculation and the graphical post-processing was IDEAS Master Series.

2. The load for the section was calculated and the model balanced over the whole length of the part being processed.

Two loading configurations were analysed :

Case **A** : upon entry into the Bay of Biscay, with a course of 210°.

Case **B** : the conditions of loading were the same, but with a swell of 30° to starboard with reference to the ship's centre line. In both cases, the structural integrity of the vessel was considered to be intact.

There was no ambiguity about the static loading. The only uncertainty was the exact weight of ballast water loaded at Dunkirk in No.4 port and starboard wing ballast tanks. The figure of 1400 tonnes in each of these tanks was retained as this was what was necessary to obtain an "even keel" condition.

The repercussions on the cargo and on the loaded hull were obtained by applying the AQUA PLUS code; the resultants of the movements and accelerations enabled the inertial forces acting on the hull and on the liquid cargo to be assessed.

The hydrodynamic loading was also calculated by AQUA PLUS and here again, the inertial component due to the ship's movements was applied.

At this stage it was necessary to define the swell load to be applied to the structure.

The quasi-static analysis of the structure implied a mode of applying the forces which was compatible with the linear model of AQUA PLUS and thus required a regular swell profile to be defined.

Two definitions of swell were retained, based on the actual sea states encountered :

a) Height (H) = 8 m, period (P) = 11 sec, speed (S) = 3.5 metres per second.

The swell was positioned in such a way as to obtain the maximum bending moment in a sagging condition between frames 66 and 70.

This type of calculation does not result in the maximum stresses which the vessel can withstand, if they are compared with the values given by a long term statistical method (10^{-8}) for a swell defined as having a height of 8 m and a period of 11 sec.

b) In order to obtain the most difficult conditions the ship could withstand - which were, as previously stated, obtained by a long term 10^{-8} statistical calculation – a regular swell was defined, which, when applied to the hull, gave a bending moment at the midship section (F62) which was equal to the long term bending moment, or 113,000 tonne metres. The characteristics of the corresponding swell were then far greater, 6.596 metres in height as against 4 metres for Case No.1. This swell model can only be theoretical as a swell height of this order is greater than the freeboard at the considered position on the vessel.

In the same way it is possible to define a regular swell giving a bending moment result which corresponds to a target value, for a swell bearing 30° relative to the vessel's centre line. The situation in this case is complicated by the fact that there are horizontal bending moments and moments of torsion. For this reason, we retained the same profile as for a swell from ahead.

Processing was carried out using the PERMAS calculation protocol. The IDEAS software was used for presenting and interpreting the results. Both types of dynamic loading were analysed and the results tabulated in two separate annexes :

- Cases A and B (regular swell with a height of 4 metres)
- Cases A' and B' (Wave bending moment of 113,000 tonnes metres at frame 62, calculated using the statistical method with a probability factor of 10^{-8}).

Analysis of results :

Reminder of the premises retained for the two calculations :

Case A – vessel upon entry into the Bay of Biscay with corresponding static load.

Swell from ahead with following characteristics : H = 8m (regular swell), P = 11 sec.

The speed of the vessel was taken as 6.8 knots.

The object of the calculation was to assess the maximum stresses imposed on the longitudinal elements of the ship girder if she had been head on to the sea.

Case B – vessel in the same conditions of loading as in Case A, with a swell having the same characteristics (H=8m, P=11 sec), but from a direction of 30° to starboard with reference to the centre line.

The object of this calculation was to take into account the transverse forces acting on the vessel which, although they were probably not the strongest she might have expected due to the course being followed, corresponded to those the vessel actually experienced before she altered course early in the afternoon of the 11th,

Case A' – same loading as A, but with a regular swell enabling a bending moment value of 113,000 tonne metres to be applied at 10^{-8}.

Case B' – same loading as B, but with a regular swell enabling a bending moment value of 113,000 tonne metres to be applied at 10^{-8}.

) Longitudinal stresses :

The analysis was limited to Cases A and A', with the swell from ahead, as they are the most significant for this type of stress.

The resulting diagrams/graphs showing the gradation of the longitudinal stresses of the elements of the model are expressed in Mpa.

The graphs show, for port and starboard :

- the deck plating
- the deck longitudinals
- the bottom plating
- the bottom longitudinals
- the side plating
- the side longitudinals

- the longitudinal bulkhead plating
- the longitudinal bulkhead longitudinals.

The vessel is in a sagging condition. The position of section No.2 forward of the midship section leads to a rapid decrease in the level of the longitudinal stresses from F66 to F74,

- on deck, from 92 to 21 MPa in compression in Case A.
  from 133 to 35 MPa in compression in Case A'.
- at the bottom , from 120 to 40 MPa in tension in Case A
  from 163 MPa in tension to –15 MPa in compression in Case A'

These values are significantly lower than the IACS permissible values which give, for a rules wave bending moment of 131,190 tonne metres(higher than the actual calculated bending moment of 113,000 tonne metre), an allowable value of 194.4 MPa.

As far as buckling is concerned, which is the main risk when the deck is subjected to a compressive stress, the critical value for the basic panel (of plating) (e = 785 mm, t=12 mm) is 155 MPa according to the IACS standard rules. The margin was almost 50% in Case A and 15% in Case A'.

For the other elements contributing to the strength of the structure, the observations were of a similar nature. (see recapitulatory tables).

Our intention in these calculations was to be as stringent as possible in our choice of hypotheses, using conditions which as nearly as possible matched real conditions, so that there could be no dispute about our findings on the grounds that the loading conditions had been chosen with a pessimistic bias. The margins of safety could then be estimated in order to take the margins of error in the hypotheses into account. These margins of safety were substantial, at least 30% at the after part of section No.2, and could thus easily absorb errors of up to 20% on the thickness values or an increase of 20% in the wave loads used in the calculations. In Case A' the margins were smaller but it must be remembered that higher bending moments were used in this hypothesis.

At this point in our analysis, it could be stated that the vessel as she was in1998, "somewhat the worse for wear", was capable of withstanding the stresses imposed on her structure as a whole, provided - and this is fundamental - that her structural integrity was totally intact, that all connections between the elements contributing to the structure were undamaged and that there was no discontinuity between these elements.

For example, if we look again at the risk of buckling of the deck plating which was mentioned earlier, the critical value for the deck panels which is 155 MPa when the longitudinals are spaced 785 mm apart, drops to 43 MPa if one of the longitudinals is no longer attached to the plating. This hypothesis is not very realistic on account of the work carried out on the deck structure, but the same logic can be applied to the upper strakes on the longitudinal bulkheads or to any stiffened panel of plating loaded in compression.

Longitudinal stresses in the longitudinal elements – Case A : head sea

Area		**Variation of σ_x in section (Mpa)**	**Variation of σ_x in section (Mpa)**	**Observations**
deck	plating	-92	-21	
	stiffeners	-87	-12	
bottom	plating	-40	120	
	stiffeners	-40	96	
starboard side plating	plating	-97	80	
	stiffeners	-98 (face plates : -145)	79 (face plates : 119)	Very localised peak values in face plates
port side plating	plating	-97		
	stiffeners	-99 (face plates : -147)	80 (face plates : 121)	Very localised peak values in face plates
starboard longitudinal bulkhead	plating	-81	109	
	Stiffeners except R15	webs : -91 face plates : -189	webs : 82 face plates : 256	Very localised peak values in face plates
port longitudinal bulkhead	plating	-82	110	
	Stiffeners except R15	webs : -91 face plates : -190	webs : 83 face plates : 257	Very localised peak values in face plates

Longitudinal stresses in the longitudinal elements – Case A'

		σ x minimum (	**MPa)**	**Observations**
deck	plating	-133	-35	
	stiffeners	-125	-18	
bottom	plating	-15	163	
	stiffeners	-26	137	
starboard side plating	plating	-129	109	
	stiffeners	-109 (face plates : -240)	95 (face plates : 103)	localised peak values in face plates
port side plating	plating	-128	105	
	stiffeners	-110 (face plates : -243)	93 (face plates : 103)	localised peak values in face plates
starboard longitudinal bulkhead	plating	-117	140	
	Stiffeners except R15	webs : -110 face plates : -225	webs : 104 face plates : 302	localised peak values in face plates
port longitudinal bulkhead	plating	-118	142	
	Stiffeners except R15	webs : -109 face plates : -226	webs : 105 face plates : 304	localised peak values in face plates

2.) Transverse structure :

Only Cases B and B' were considered in this analysis. They are representative of the forces imposed on the hull before the vessel made her 180° course alteration in the early afternoon of 11 December.

Assessment of the hydrodynamic forces shows that these stresses (shear stress and bending moment) are divided between the longitudinal and transverse planes. It would have been possible to choose a more unfavourable loading for the transverse webs by bringing the swell further abeam. But that would have been contrary to the guiding principle we had adopted for our calculations of not choosing the most pessimistic loading hypotheses.

To interpret the results, the graphs were drawn up using the Von Mises isovalues criterion, giving the norm for the main stresses.

Qualitative analysis of the stress distribution in the transverse webs revealed nothing out of the ordinary. The positions of the greatest stress concentrations were also the most likely ones given the patterns of forces applied.

The stress levels attained allow a considerable margin compared to the allowable values as, in the plating, they are still far below the elastic limit.

The tables below give a general idea of the sensitive areas and indicate the maximum stress values calculated for Cases B and B'. Although the phenomena studied obviously yield fairly similar-looking results in both cases, the values are higher in Case B'. In conclusion, the transverse webs are loaded but not dangerously so compared to the maximum permissible values. (See tables and Annex : calculations)

Stresses in transverse elements – Case B

Area	σ Von Mises maximum values (MPa)	Observations
F66	76	Close to starboard bilge axis – bending + incident pressure to starboard
F67	87	At the limit between wing tank and centre tank above the floor, to port
F68	110	Lower inside corners of port and starboard wing tanks
F69	104	Idem (maximum to starboard) + turn of bottom transverse
F70	104	Lower inside corner of starboard wing tank
F71	90	Turn of port centre bottom transverse
F72	120	Turn of port centre bottom transverse
F73	100	Turn of port centre bottom transverse + inside top corner of starboard cross tie
F74	63	Close to starboard bilge axis – bending + incident pressure to starboard

Stresses in transverse elements – Case B'

Area	σ Von Mises maximum values (MPa)	Observations
F66	91	Starboard wing tank on a level with stringer with z = 9.35 m
F67	97	At the limit between wing tank and centre tank above the floor, to port
F68	140	Turn of port centre bottom transverse
F69	118	Turn of port centre bottom transverse
F70	137	Lower bottom corner of starboard wing tank
F71	121	Lower bottom corner of starboard wing tank
F72	146	Lower bottom corner of starboard wing tank
F73	144	Lower bottom corner of starboard wing tank
F74	78	Close to starboard bilge axis – bending + incident pressure to starboard

As was done for the strength elements resisting longitudinal bending, these stress values could be increased to compensate for uncertainties concerning actual thicknesses and wave loading. Allowing 20% as a margin of uncertainty, stress values of 130 to 150 MPa could be reached. These are quite substantial values for thin structures and for fairly complicated shapes like web frames.

Regarding the transverse elements, it may be concluded that the structure was capable of resisting the stresses set up the weight of the cargo and by wave loading. In a structure of a fairly complicated design, with numerous connections, intersection of elements and mating of face plates etc. …, we can only emphasize once again that the validity of our calculations depends on the structural integrity of all the elements considered being intact.

We also recall that our calculations which were carried in the field of elastic/plastic deformation in a quasi-static manner did not take into account dynamic forces due to the movements of liquids nor non-linear local forces caused by swell.

The same is true of any thermal stresses caused by the heating of the cargo which was maintained at a temperature of about 60°C, with the concomitant consequences on the tank sides.

The calculations showed that an overall collapse of the hull girder was not the underlying cause of the accident. But the accident did happen; its initial cause was therefore the failure of one particular element of the structure. We shall come back to this problem later in the report.

6.3.3* Direct analysis of sea keeping (see cartography)

This study assessed the movements of the vessel and the forces imposed on her in the prevailing weather conditions (7 to 8 metre swell with a period of 9 to 11 seconds and a length of 150 to 200 metres), as loaded upon entry into the Bay of Biscay, and for the courses followed on 11 and 12 December.

The parameters calculated were :

- pounding
- pitching;
- shearing stress and bending moment at midship section and at frame 71.

The sea conditions used for the calculations were as follows :

- head sea;
- sea from 30° on the starboard bow;
- following sea.

The following tables enable so-called "rule" values to be compared with values obtained by direct calculation (Volume two of the study carried out by the IRCN contains the hypotheses used in these calculations).

The three above-mentioned configurations are shown. The sea state is the same in all cases, defined by a significant height of H = 8 m and a period of 11 secs.

The speeds of advance used were :

- S = 0 and S1 = 6.8 knots for the head sea;
- S = 6.8 knots for swell 30° on starboard bow;
- S = 9 knots for the following sea.

- **statutory values :**

		Sagging	Hogging
MS	Shearing stress	-1.439 $10.^{4}$ kN	+1.439 $10.^{4}$ kN
	Bending moment	-1.3119 $10.^{6}$ kNm	+1.219 $10.^{6}$ kNm
F71	Shearing stress	-1.902 $10.^{4}$ kN	+2.056 $10.^{4}$ kN
	Bending moment	-0.9347 $10.^{6}$ kNm	+0.8643 $10.^{6}$ kNm

– **Head sea :**

		S= 0 knots	S = 6.8 knots
MS	Shearing stress	1.38 $10.^{4}$ kN	1.52 $10.^{4}$ kN
	Bending moment	1.4 $10.^{6}$ kNm	1.13 $10.^{6}$ kNm
F71	Shearing stress	2.12 $10.^{4}$ kN	2.11 $10.^{4}$ kN
	Bending moment	0.744 $10.^{6}$ kNm	0.745 $10.^{6}$ kNm

The values of the bending moments are lower than the rule values.

– **Swell 30° on the starboard bow S = 6.8 knots.**

		Vertical	Horizontal	Torsional
MS	Shearing stress	$10.^{4}$ kN	$10.^{4}$ kN	
	Bending moment	$1.1\ 10.^{6}$ kNm	$0.73\ 10.^{6}$ kNm	$0.04\ 10.^{6}$ kNm
F71	Shearing stress	$1.9\ 10.^{4}$ kN	$1.6\ 10.^{4}$ kN	
	Bending moment	$0.7\ 10.^{6}$ kNm	$0.54\ 10.^{6}$ kNm	$0.33\ 10.^{6}$ kNm

– **Following sea S = 9 knots**

MS	Shearing stress	$10.^{4}$ kN
	Bending moment	$1.0\ 10.^{6}$ kNm
F71	Shearing stress	$1.9\ 10.^{4}$ kN
	Bending moment	$0.64\ 10.^{6}$ kNm

The values of the forces are similar to those obtained for the head sea.

The following comments can be made about these calculations :

a) head sea : the vessel's movements at S1 compared to S0 increase by :

- 50% for pounding;
- 25 % for pitching.

On the other hand, the shearing stresses and bending moments are practically the same for V0 and V1.

The shearing stresses exceed the IACS values by 5 to 10% while the bending moments reach 93% of the maximum allowable values.

b) swell 30° on starboard bow :

This situation corresponds to the course the Erika actually followed. Compared to the "head sea" situation, the results show :

- about 20 to 25% less pitching and pounding;
- internal forces of roughly equivalent values, with the angle of the swell setting up vertical and horizontal shearing stresses and bending moments which need to be combined when assessing the overall forces acting on the hull.

c- following sea :

This corresponds to the course to Donges. It is to be noted that if the vessel had turned back towards Brest, from the morning of the 12 December onwards she would have been navigating in different conditions, notably with a beam sea.

The speed of 9 knots used in this calculation was that indicated by the vessel, but was in fact slightly higher than the vessel's actual speed.

The amplitude of the ship's movements was less than for the head sea situation by about 20 to 25%.

The values of the stresses imposed on the ship girder were similar.

In conclusion, these calculations confirm that the courses followed by the vessel and the speed she made were not decisive factors in the cause of the disaster.

6.4* Conclusion - the process of collapse of the structure

6.4.1* THE CAUSE OF THE DISASTER IS TO BE SOUGHT IN THE WEAKNESS OF ONE OF THE TRANSVERSE ELEMENTS IN THE STRUCTURE OF NO.2 STARBOARD BALLAST TANK.

It has been established, in the conditions of loading and for the sea states encountered before the accident, that the deck structure of section No.2 was subjected to relatively small compressive stresses when compared to the allowable values for buckling of panels of plating and their stiffeners; this remains true even if the stress values are increased by 20 to 30% to allow for locally higher wear rates. Furthermore, the deck structure had been renovated in August 1998 when the deck transverses and every other deck longitudinal had been replaced.

The bottom structure in this section was subjected to tensile stresses and, here again, the stress values were far below the allowable limits.

The appearance of a crack running longitudinally in one of the strakes of the longitudinal bulkhead between frames 66 and 70 and vertically above the cross tie bracket is considered to be incontrovertible. This scenario corresponds to the observations made by the crew about the shifting of cargo from No.3 centre tank into No.2 starboard tank which, at first, resulted only in an increase of 3.5 m in the ullage.

If these observations are accepted as being correct, it must be concluded from the ullage measurements made as soon as weather conditions permitted the crew to go on deck that sea water had entered No.2 ballast tank.

The damage suffered by the starboard longitudinal bulkhead led to a **weakening of one or more transverse webs** due to the fact that the plating attached to the vertical stiffeners was no longer intact. The web frame would begin to buckle or the cross tie would begin to bend. All of the web frames were affected by this weakening and **the side shell cracked at right angles to the weakened web frame.** This, in turn, led to the vessel taking in water, but only in the area of the crack which can be assumed to have been on a level with or slightly higher than the cross tie.

This scenario was compatible with the observations made on board. At this stage of our explanation, it must be noted that it is difficult to be entirely sure of the trustworthiness of measurements made in conditions which, although not dramatic – the vessel was not sinking and the master had cancelled his distress message – were sufficiently difficult, owing to the state of the sea and the list, for those responsible for the vessel to have made errors in measurement and judgement, without our wishing to cast any discredit upon them.

Thus the figure of 12° for the list, as indicated by the vessel, was not retained for use in the simulations made of the successive stages of the casualty, because it does not correspond to any practically imaginable situation of distribution of liquids on board. Hydrostatic calculations show that the list obtained in this first stage of the casualty can be explained by the simple fact of communication between No.3 centre cargo tank and No.2 starboard ballast tank, without ingress of sea water. In this case, of course, the ullage measurements are no longer consistent with those provided by the vessel.

This uncertainty about the angle of list and the levels in the tanks has no bearing on our line of argument concerning the way things developed, in as far as the order of events remains the same; the only differences concern the times at which each one of the different phases of the collapse of the structure actually happened.

To summarize : the failure of the longitudinal bulkhead resulted in the weakening of the transverse webs which, in turn, led to crack starting in the side plating.

Returning to the order of events, it is noted that the various transfers of ballast carried out by the crew after the list to starboard was discovered had no influence on the forces imposed on No.3 centre tank and No.2 starboard tank, except for the equalizing of Nos.2 port and starboard tanks. This took place at 1830 hours on 11 December, apparently without problems, and the ullages were equalized.

If the statements made by the crew are to be believed, No.2 starboard tank was not at that time open to the sea, except via the crack in the side plating and via the cracks on the forward part of the main deck. Our analysis has not forgotten the existence of these cracks and they will be discussed further on.

Speaking more generally, it is to be noted that the transfers of liquid made by the crew as the situation developed were analysed with reference to the hydrostatic equilibrium of the vessel as well as to the forces imposed on the hull. The consequences of these operations was not to increase the forces but rather to diminish them.

In the afternoon of the 11 December, during which the vessel turned back, the crew were able to inspect the forward part of the deck and then carry out a number of transfers**, the initial crack in the longitudinal bulkhead grew bigger. So too, and more significantly, did the crack in the side plating which was subjected to greater hydrodynamic forces than the bulkhead**. The forces acting on the bulkhead were lessened by the fact that part of the cargo in No.3 centre tank had shifted into No.2 starboard ballast tank. The web frames continued to break up with consequent distortion in the side plating.

When the crew inspected the deck after the vessel had changed course, they discovered cracks forward of No.2 starboard ballast tank; one crack ran transversely, one diagonally and a third longitudinally, they were fairly wide - about 2cms.

In the scenario adopted by the Commission, the presence of these cracks can be explained in the following way :

- The transverse webs gradually lost their rigidity and began to buckle; as a consequence of this the side plating became more flexible in the transverse direction.
- The deck panel retained adequate rigidity but the horizontal girders it formed was no longer correctly connected to the side plating. In an obviously extreme hypothesis a slight sideways movement of the deck panel could be imagined. This movement would set up stresses in the transverse bulkheads at frames 66 and 74. The stresses could cause the plating panels near the bulkheads to buckle. More simply put, two contiguous transverse webs which were partially detached from the side plating could lead to a sideways movement of the deck transverses, setting up shear forces in the plating, hence the aspect of the cracks.

This is a plausible explanation compatible with a failure of the vessel's side shell.

6.4.2* The final phase of the collapse

Between 0000 hours and 0400 hours in the morning of 12 December, the internal structure of No.2 starboard ballast tank continued to fall apart and the tank became increasingly more open to the sea. The following scenario for the final stages of the shipwreck can be built up based on information gathered from inspecting the wreck.

Rupture of the side plating in way of frame 66

The panel from the side shell broke off and pivoted around the bulkhead in way of frame 66 taking with it part of the side plating of No.3 starboard tank. This represented the last phase of detachment from the hull (plating of No.3 starboard tank "peeled off"). The upper part of the panel which broke away passed under the sheerstrake and the lower part above the round of bilge.

After the video film was viewed the transverse bulkhead in way of frame 66 was seen to be intact with its stiffeners. The side shell stringers broke practically at right angles to the bulkhead. The horizontal web of the lower stringer apparently remained in place while that of the upper stringer seems to have been carried away with the side shell.

Rupture of the side shell in way of frame 74

The appearance of the fracture on the forward part of the wreck is the same as that at frame 66. It stops above the round of bilge. The side shell plating broke away from the rest of the internal structure. Due to the action of the sea, it broke off flush with transverse bulkhead 74.

What has gone before would seem to indicate that the side plating broke away from the ship in at least two pieces. This appears to be quite a normal state of affairs because of its own basic lack of rigidity and its great length, 30 metres.

A panel of plating was found on the sea bottom about 5 nautical miles from the forward section of the wreck (about 100 tonnes). A cross tie broken near the longitudinal bulkhead can clearly be seen.

Judging by the appearance of the plating still attached to both parts of the wreck, **the bottom of the vessel broke due to tensile stresses**, probably towards the middle of the section around frame 70. The tension exerted on the bottom structure was not very strong in the initial stages of the casualty. But it should be noted that, as soon as the fact that No.2 starboard tank was fully open to the sea is taken into account, the loss of buoyancy led to a substantial increase in the longitudinal bending moment which **came close to the maximum allowable value**.

If to this is added the fact that the structure had already been weakened by the collapse of the bulkhead and the side plating, the effect of which was to reduce the section modulus, it becomes clear that the cracks which started in the side plating were propagated towards the bottom with the inevitable result that the hull broke in two.

At this stage of the rupture of the bottom, the hull still retained a relatively rigid structure in the shape of a parallelogram formed by the centre tanks (the scantlings were certainly greater than those of the lateral sections). On the starboard side of the vessel, the side shell was carried away in two or three pieces; the panel of deck plating which can be assumed to have been intact and fairly rigid, was no longer supported outboard and broke in way of frame 66 or 74.

This 30 metre long panel then tore along the longitudinal bulkhead.

The central part of the hull then broke away after the bottom had been pulled apart. The fore part of the wreck drifted to port, resulting in the rupture of the deck plating and the side plating on the vessel's port side.

The scenario which has just been described is certainly open to criticism. Nevertheless, it is corroborated by the following established facts :

- THE LOSS OF PART OF THE SIDE PLATING, about 2 hours before the shipwreck. A fragment of this element was found 5 nautical miles from the wreck.
- When No.2 starboard tank was fully or almost fully open to the sea, the longitudinal bending moment to which the vessel was subjected was close to the maximum allowable value. In these conditions THE RUPTURE OF THE BOTTOM STRUCTURE WAS INEVITABLE.
- The deck and side of No.2 wing tanks broke into SEVERAL PIECES AS THEY BROKE AWAY FROM THE HULL. It is noteworthy that during inspection of the wreck and the surrounding area of the sea bottom only a very few fragments of these structures were discovered. It may be concluded that the initial weakness of the structure, or corrosion, led to its breaking into a great number of small pieces which were scattered over a wide area.

In short, the total loss of the Erika can be attributed to a failure of part of the vessel's structure. This failure took the form of :

- the rupture of an element of the longitudinal bulkhead between No.3 centre tank and No.2 starboard tank;
- the subsequent weakening of one or more transverse webs in No.2 starboard tank, leading to the appearance of cracks in the side plating;
- the appearance of cracks in the deck plating resulting from the weakening of the transverse webs.

These events brought about the gradual collapse of the transverse webs and of the side plating of No.2 starboard tank, a panel of which broke away from the hull about 2 hours before the shipwreck. The bottom structure then broke apart under tension, the deck plating folded as if it were hinged and the hull finally broke in two at the after part of section No.2.

7* Other factors

7.1* The decisions made by the master – the SOPEP

The master was well aware that the Erika was an old ship. He was also aware that the No.2 port and starboard ballast tanks were "heavily corroded", but he was unable to draw any conclusions from this concerning the structural integrity of his vessel.

According to his own declarations, the vessel, which had a fairly satisfactory outside appearance :

- had had a major reclassification survey one year previously and, all in all, undergone a considerable amount of work,
- had been assigned its highest class by a classification society which was a member of IACS,
- had undergone an annual survey carried out by this same classification society in August and November 1999, the only reservation being that it was necessary to carry out thickness measurements in No.2 starboard ballast tank and in the forepeak before the end of January 2000.

Moreover, the ship's equipment : cargo and ballast pumps, propulsion and auxiliary machinery (steering gear and bridge equipment) all worked satisfactorily, with the exception of the INMARSAT A transceiver (telephony) which was, moreover, not absolutely necessary for the type of navigation in which the Erika was engaged, as the vessel also had an INMARSAT C transceiver (telex) on the bridge.

The weather conditions for the voyage from Dunkirk to Leghorn were certainly not very good, but they had hardly been any better for the previous voyages, even in the Mediterranean. Besides, a force 8 or 9 westerly wind is nothing out in the ordinary in the Bay of Biscay at that time of the year and is not insuperable for a tanker of the Erika's size.

So the master was surprised when he observed a substantial and gradually increasing list to starboard at 1240 hours on 11 December. As the ullage in No.4 starboard ballast tank had not changed (it was half full), the only possible cause of the list was the accidental shifting of cargo from No.3 centre tank, which was full, into No.2 starboard ballast tank which was almost empty. This was corroborated shortly afterwards by the ullages and the traces of oil on the sounding rod in No.2 starboard ballast tank.

His initial reaction was to deballast No.4 starboard ballast tank to correct the list before turning back so that he could check the situation sheltered from the force of the sea. The load master permitted this movement and later calculations confirmed, as for the other movements of liquid, that the bending moment decreased. (It was not possible to deballast No.2 starboard tank at that time as there was known to be oil in it).

The MAYDAY sent at 1410 hours corresponded to a "*request for immediate assistance for persons in danger with a view to their rescue*". The vessel's course was still 210° and she was listing. To send the MAYDAY by telex all that is required is to press two buttons simultaneously which automatically sets in motion the procedure by giving the vessel's position, course and speed, in particular.

At 1502 hours the situation had improved considerably : the list had begun to decrease, the vessel had turned back and there was no question now of abandoning the ship. The MAYDAY was therefore cancelled and downgraded into a SECURITE or safety message which is basically concerned with keeping communications open and standing by. This new message was cancelled, in turn, at 1624 hours.

From this moment on (1627 hours) the master, after receiving confirmation of the shifting of oil from No.3 centre tank into No.2 starboard tank and learning about the cracks and buckling in the deck plating, decided with the approval of the ship manager to make course towards a port of refuge, which happened to be Donges, and reduced the main engine speed from 107 to 75 rpm.

From 0300 hours onwards the cracks which had been under surveillance since they were discovered, widened; the collapse of the vessel accelerated with the detachment of part of the side plating from 0500 hours onwards and the master had no other choice but to transmit the "real" MAYDAY, which led to the crew being rescued from the ship.

THE MASTER'S ACTIONS WITHIN THE FRAMEWORK OF THE SHIPBOARD OIL POLLUTION EMERGENCY PLAN – SOPEP

Article 8 and Protocol 1 of the 73/78 Marpol convention require the nearest coastal state to be advised in the event of any actual or likely spill.

The aim of this regulation is to make sure that coastal states are informed without delay of any pollution or threat of pollution to the marine environment, as well as of any assistance rendered or rescue , so that appropriate decisions can be made.

The procedure to be followed must be carried out by the master or any person entitled to act in his name in accordance with the recommendations of IMO Resolution A. 648 (16) within the framework of the *Shipboard Oil Emergency Plan.*

The event must be reported simultaneously to the coastal station (vessel at sea) or the port authorities (vessel in harbour), as appropriate, and to the persons responsible for operating the ship on shore.

The plan uses flow charts and check lists to help decision making to prevent omissions or errors being made and risks being taken by careless, hurried thinking in the initial stages of a major event.

The vessel had had such a plan since 1997, approved first by BUREAU VERITAS then by RINA, by delegation from the Maltese maritime authorities.

The plan contains instructions to be followed in the event of pollution or the risk of pollution. It describes the steps to be taken and the procedures to be carried out in order of priority as well as the information to be supplied. It also lists the authorities or persons to be contacted as well as giving information on how to contact them (telephone, fax or telex numbers).

The plan stipulates that the coastal state and the competent authorities must be informed immediately of any oil pollution incident, risk of oil spill or threat of pollution, particularly in the following cases :

- damage affecting the safety of the vessel itself or that of other vessels following a collision, a stranding, a fire, an explosion, **a structural failure** or ingress of water;
- damage to the engine or other equipment jeopardizing the safety of navigation.

Cards containing check lists enumerate the measures to be taken by the crew and the part to be played by each member of the crew according to the seriousness of the situation in 9 cases of pollution or potential pollution :

Three of them are particularly relevant to the Erika incident :

- check list No.3 : suspected hull leakage,
- check list No.7 : hull failure,
- check list No.8 : excessive list.

The information must be sent to the coastal state authorities and persons to be contacted listed in annex 1 "Coastal State Contacts" and in annex 3 "Ship Interest Contacts" by means of a formal communication called "Initial notification" containing the necessary information.

In the case of the Erika, the master should first have sent the Initial notification :

- to the Secrétariat général de la mer ;
- to MRCC Corsen ;
- to the Préfecture maritime de l’Atlantique ;
- to the PANSHIP ship manager ;

- to the RINA technical advisor.

The ship manager, in turn, should then have sent the notification to the owner of the cargo and to the representatives of the insurance company and the P&I Club.

Secondly, the master should have sent the technical advisor details of the stability and strength of his vessel in the formal *"stability and strength assessment notification ".*

The master should then have regularly brought the interested parties up to date concerning any changes in the situation and reported any action taken using form No.3 *("Follow up notification").*

Consequently the Commission is of the opinion that, even if he had the necessary inspections carried out, the master did not follow the laid down emergency plan in his management of the incident in spite of the fact that he was well acquainted with the contingencies of the plan because exercises involving it had been noted in the log book :

- an anti-pollution exercise on 16 November,
- an exercise involving grounding and engine failure on 26 November.

The commission considers that the SOPEP should have been entirely brought into operation (*check list No.8*) as soon as the list to starboard was observed around 1300 hours on 11 December, or at the very least at 1448 hours when the ullage measurements had been made and oil had been detected in No.2 starboard ballast tank, not to mention the cracks in the deck plating (*check lists Nos. 3 and 7*).

In fact, at the beginning of the incident the master tried, initially without success, to contact his ship manager and the French authorities became aware of these problems only late in the evening of 11 December 1999, just a few hours before the shipwreck.

Did he consider that his vessel did not represent a pollution risk insofar as he had taken measures such as transferring oil from No.1 starboard tank into No.1

centre tank - in case the cracks propagated above No.1 starboard tank – or, later, monitoring the deballasting of No.2 starboard tank, when this became necessary?

The oil leak forward of the manifold mentioned in the 1442 message was not confirmed by the subsequent inspection of the deck. The master did not speak about "traces of oil being spilt into the sea" until his 0330 message on 12 December.

Although the Erika's master was perhaps found lacking in his manner of communicating information to the maritime authorities, it seems rather that the events were too much for him to deal with without outside assistance, except for the rescue.

Moreover, and generally speaking, the Commission considers that the numbers of statutory documents and procedures were for too great for them to be used efficiently in the circumstances pertaining.

. **Action taken by the owners**

Concerning the management of the vessel : the owners themselves dealt with the financial, commercial and administrative management of the vessel as well as any legal matters and insurance. The technical management and manning were entirely entrusted to a ship management company and a specialist crewing agency respectively. The decision to replace Bureau Veritas by RINA as the ship's classification society was made on advice from the shipmanager.

Lacking technical experience, the owner relied on PANSHIP :

- to schedule the vessel's refits and surveys ;
- to organize the work, buy spare parts and manage the annual budget for repairs and maintenance;
- to negotiate and choose the repair yard (the owner nevertheless took an active part in commercial negotiations and in paying the invoices).

The owner never had any direct dealings with the Classification society RINA, nor with the shipyard in Bijela. He had, however, been informed of the classification pre-entry survey carried out in Aliaga in February 1998 and of the one in Augusta in November 1999. He could not therefore be unaware of the real condition of his vessel.

The choice of suppliers and more especially of the repair yard was undoubtedly based on economic considerations alone.

Concerning the casualty : the owner of the vessel was informed of the first technical difficulties experienced by Erika by PANSHIP at about 1500 hours on Saturday 11 December. He was told about the list , the cracks in the deck and the fact that the vessel had sent out a distress message. He did not issue any particular instructions upon receiving the information, relying on the shipmanager to make the necessary decisions.

He only asked to be regularly brought up to date on any developments in the Erika's situation. He was last in contact with PANSHIP at about 23/2330 hours on 11 December.

He was informed on 12 December, after the accident, that the vessel had broken in two and that the rescue operation was in progress.

7.3* Action taken by the shipmanager – case of the ISM

The different steps taken by the shipmanager during the incident were basically limited : (cf. § 5.5* above)

- to following developments in the Erika's situation, becoming preoccupied, in truth rather late in the proceedings, about the cracks in the deck and trying to avoid pollution;
- to informing all the "commercial" actors in the affair;
- to having an agent designated for the Erika's call at Donges.

Let us recall that RINA, by delegation from the MMA had certified ISM (by issuing a "document of compliance" or DOC) both the shipmanagement head office and their ships, after audit, in 1998.

Now, in August 1999, after a PANSHIP-managed ship had been detained, the MMA asked RINA to run a check of PANSHIP by carrying out another audit.

During this audit, Rina noted a large number of major deficiencies symptomatic of serious failings in the safety management system run by PANSHIP. These points were confirmed by a second audit carried out by the head of the section responsible for ISM at Rina's head office.

By a letter dated 23/08/99, the RINA therefore recommended that the MMA should suspend PANSHIP's DOC. This recommendation was not acted on.

The Commission considers that if the shipmanager's ISM certification had been suspended as soon as the alarm had been raised by the above recommendation, the shipmanager might well have had to find time to redefine all their procedures and that, had that been done, what happened afterwards might have been different.

After the Erika sank, the MMA asked RINA to carry out a further audit. This was done jointly by RINA and the MMA on 26 and 27 January 2000. The observations made during this audit and recurring deficiencies were proof for RINA that there were still serious failings in PANSHIP's management and led to a further recommendation that their DOC should be withdrawn by the MMA. This was not necessary as PANSHIP voluntarily returned its DOC to the MMA at the beginning of February.

The initial audit of the Erika was carried out in June 1998 by RINA who issued the ISM certification for the vessel (SMC or "Safety Management Certificate"). Another audit was carried on board the Erika in September 1999. On this occasion, the RINA noted that all the necessary documents and the SOPEP "Shipboard Oil Emergency Plan" in particular, were on board.

The designated person for emergency situations at PANSHIP did not apparently refer to the emergency procedures in accordance with the ISM code and the SOPEP, as he did not try to make contact with the French authorities on 11 December 1999, as he or the master should have done, to inform them about the Erika's situation and the details concerning the real condition of the vessel. Before he even talked directly to the master by voice telephony, the designated person had already contacted :

- the "casualty" service at Lloyd's List, the British daily publication(advised in early afternoon by MRCC Milford Haven),
- the owner of the vessel,
- the insurers,
- the classification society
- the possible port agents for the ship,
- SMITTAK, the towing and salvage company,

in short, practically all the interested parties except for the competent maritime authorities, whose addresses were explicitly listed in his emergency SOPEP plan.

During this phase, the designated person was assisted by a tanker master (acting as a consultant) of the same type of ship also managed by PANSHIP. Although he had informed RINA of the Erika's problems, the shipmanager (who could not have been unaware of the structural state of the vessel), did not deem it necessary to ask them for any technical assistance.

It therefore seems that the persons mainly concerned with the operation of the vessel showed not the slightest concern, on 11 December and during the night of 11 to 12 December, as regards the coastal state authorities, about pollution or the safety of life at sea and that they underestimated the situation of the Erika. That is why RINA considered that PANSHIP's management of the crisis of 11 December 1999 constituted a serious lack with regard to the ISM code.

Furthermore, the Commission draws attention the following points with regard to certain items of the Erika's safety equipment :

- the INMARSAT A equipment (telephony) which the ship carried although it was not required under GMDSS regulations, was out of order throughout 11 December 1999 at the time when it was most needed, due to the fact that there was no officer specifically in charge of emergency communications with the shore;
- the engine of the lifeboat in which a number of the crew found themselves did not start;
- the hydrostatic release units and/or the inflation mechanism of the inflatable life rafts (there should have been two of them on board) did not work;
- the hydrostatic release unit and/or the transmission trigger mechanism of the EPIRB which the vessel theoretically carried, also did not work.

That such a large number of deficiencies should occur at the same time may have been accidental but, coming as they did after the observations made during the audits by RINA as the certifying body, they were certainly a cause for concern.

The Commission considers the shore-based shipmanagers did not provide the master with the support to which he was entitled in the circumstances.

7.4* Action taken by the flag state

A) – For Malta registered ships, the INTERNATIONAL SAFETY CERTIFICATES (cf. § 3.4 above) are issued and renewed after annual survey by surveyors representing the classification societies which have been approved for this task and which are remunerated by the owners of the vessels inspected.

The Commission requested a copy of the report of last annual survey made as per the above, but they did not receive it.

It was therefore not possible to ascertain whether the report mentioned any deficiencies or preliminary signs of local structural weakness which may have had a bearing on the casualty of 12 December 1999. As the vessel was not detained there is every reason to surmise that no particular observations were made.

The Commission was also unable to ascertain whether a representative of the MMA was present during the survey.

B) – Concerning the ISM CERTIFICATION which was carried out by RINA after audit (cf. §3.3* above), the Commission noted that as soon as PANSHIP was formed, the company got in touch with RINA to ask them to perform, at PANSHIP's expense, the audit which was necessary for their ISM certification.

The Commission noted that the MMA subsequently did not act on RINA's recommendations (cf. § 7.3* above) advising them to suspend PANSHIP's ISM certification in August 1999 following inspections carried out both on the company's ships and at their head office.

It took the sinking of the Erika, and a further audit by RINA in January 2000 which came to the same conclusions for PANSHIP to rescind their ISM certification voluntarily in February 2000.

7.5* Action taken by the classification society

Before agreeing to assign class to the vessel, RINA, in accordance with normal practices, had an in-depth survey conducted by one of its class surveyors.

The survey report was, to say the least, pessimistic about the structural state of the vessel and the extent of the corrosion. The report to RINA head office - in whose hands the final decision lay - states that the vessel was unacceptable and indicated, without committing RINA, what work needed to be done for her to be assigned class by RINA.

As Rina eventually accepted to assign class to the vessel, this survey and the thickness measurements made in June 1998 constitute the basis for the work required for the five-yearly special survey carried out in August 1998. In order to prepare the special survey, the inspections and work to be done must be scheduled almost a year in advance by the owner and the classification society. In the Erika's case, there was not enough time to make these preliminary preparations.

Be that as it may, the work list should have been drawn up only after an in-depth inspection of the structure (and notably the ballast tanks). This was the only way of assessing how much work was to be done, after consultation between all the interested parties.

Any guarantee that the work had been correctly carried out would, of course, be given by the repair yard under the supervision of the class surveyor. The Commission observes that the latter was not permanently present while the work was being carried out.

While such work is going on errors can easily be made; some of them may be difficult to see and may even be beyond repair. The annual survey in 1999 (in August and November at Augusta) was considered to be a "routine survey" compared to the special survey (1998) or even to the intermediate survey which was scheduled for February 2001.

The surveyor in Augusta can have conducted no more than a cursory inspection of No.2 starboard ballast tank. Nevertheless, what little he did see (corroded ladder, worn longitudinal) incited him to ask for a new survey to be conducted and for further measurements and repairs to be made as soon as possible

(January 2000). The validity of the class certificates was accordingly prolonged until 31 January 2000 .

Action taken by the classification society within the ISM framework

In February 1998 the ISM document of compliance was issued to PANSHIP for tankers.

The Erika was certified on 3 June 1998 before the refit in Bijela.

RINA is not empowered to withdraw approval but to make recommendations to the flag state authorities according to any nonconformities observed during audit. The decision to withdraw approval can be taken only by the flag state authorities (in this case, Malta).

Action taken by the classification society concerning the casualty

RINA was advised by the shipmanager of the technical problems encountered by the Erika (list, cracks and buckling of the main deck) from the outset of the incident.

The hull specialist designated to intervene in this kind of situation is said to have been informed, but no specific assistance seems to have been asked for.

Although the RINA is listed as technical advisor in the SOPEP, the Erika did not subscribe to the "Technical Advising Service" which is available on a round-the-clock basis to answer urgent calls from shipowners – or ships – and to provide technical assistance to vessels in difficulty.

This service was set up in application of the provisions of the Oil Pollution Act 90 as required by the US Coast Guard for vessels calling at United States ports.

Subscription to the service is optional for shipowners. A specific contract is drawn up ship by ship and assumes that all the characteristics of the ship named in the contract have been entered in a computer database. Some technical training is required.

It is thought that PANSHIP had not put the service in operation at the time of the Erika's shipwreck.

Indeed RINA is not thought to have been asked for this type of assistance, either as "Technical Advisor" or even as Surveyor/Classification society. In this latter case it is more than likely that they would have done everything possible to provide assistance, although not obliged to do so, and in spite of the lack of information they required to do so, contrary to the information to which they would have had immediate access if the "Technical Advisor" service had been in operation.

Only 3 vessels managed by PANSHIP had access to this service but the Erika was not one of them, although the telephone numbers of the Technical Advisors were listed in her SOPEP. The Erika's SOPEP had in fact been approved by Bureau Veritas on behalf of the Maltese authorities on 03 September 1997 and RINA had done nothing more than endorse it as being on board on 10 July 1998 during the vessel's class transfer.

7.6* Action taken by the charterers

The action taken by the charterers can be assessed at two levels :

- the economic conditions in which the Erika was operated,
- their reactions on first learning of the vessel's problems.

The charter party conditions

The Commission noted that they corresponded to the normal market practices at the time of the incident. The situation, however, was the same for all vessels of this type. It was sufficient to cover everyday running costs but did not enable the renewal of the ageing fleet used for transporting black products to be contemplated, and certainly not the development of any new technology dealing with these particular products and taking their dangerous polluting character into account.

The reaction of the charterers when the vessel's problems were announced

The Commission noted that even before he called the Erika's master by voice telephony, the designated person at PANSHIP had contacted the vessel's **time charterer** through his agent. There was no direct communication between the designated person and the vessel's voyage charterer nor between the time charterer and the voyage charterer.

The **voyage charterer,** owner of the cargo, listened at about 2130 hours to a message recorded at 1834 hours on the answering machine at his emergency number(notifying him of the problems affecting the vessel according to instructions which had been added to the charter party). At the same time, the voyage charterer received a similar message from the shipping agents who had been contacted by the shipmanager so that they could organize the Erika's call at a port of refuge; he was also informed that Donges had been chosen as the port of refuge.

Following this, the voyage charterer's crisis cell got in touch with the Erika's master by voice telephony at about 2100 hours. The latter confirmed what he had said in his initial 1834 message which indicated :

- the vessel's position (46°47'N 006° 43'W);
- internal leakage between No3.centre tank and No.2 starboard tank;
- the measures taken to correct the ensuing list;
- the local weather conditions;
- a reduction in speed and a course alteration;

and to which were added :

- the course to Donges;
- the presence of cracks on the deck.

During the course of this conversation the master confirmed that the situation was under control, that the vessel could be steered and that no oil was spilling into the sea.

The Commission therefore observes that the voyage charterer's crisis cell was informed of the situation and of the vessel's condition in the same conditions as the state services concerned.

During the evening of 11 December 1999, the voyage charterer’s crisis cell finished gathering information by obtaining confirmation of data about the cargo and the charterers of the vessel. As it was unable to gain more precise information about the vessel's condition from the shipmanager, the cell simply remained on stand-by.

From 2300 hours on 11 December until 0700 hours on 12 December no action was taken by the crisis cell as it had received no further messages.

During the 11 and 12 December the time charterers took no particular action.

7.7* Action taken by the coastal state

7.7.1* The regional centres for surveillance and rescue operations (CROSS)

Generally speaking the regional centres for surveillance and rescue operations (CROSS), placed under the organic authority of the ministry of transport and the operational authority of the Maritime prefects (PREMAR), carry out all or some of the following missions :

- search and rescue,
- surveillance of maritime traffic,
- fisheries surveillance,
- pollution prevention and monitoring,

- broadcasting safety information.

They are equipped with the statutory radiocommunications equipment required by merchant ships for GMDSM (which military vessels are not required to carry) and can be considered as the "ears" and intermediaries of the maritime prefects.

A) The CROSS Corsen.

Generalities :

- The area covered by the CROSS Corsen (CROSS.CO) extends from the bay of Mont Saint-Michel to the parallel of latitude through the Pointe de Penmarc'h.
- Its principal mission is indisputably the surveillance of the maritime traffic off the point of BRITTANY, to be more precise, in an area within 35 nautical miles of the Ushant radar tower, an area in which there is a traffic separation scheme at the entry of which ships are required to call in and report any problems they might have.

In the case of a vessel in difficulty and especially if it turns out that the vessel requires assistance, the CROSS.CO informs the Naval Centre of Operations (COM) in Brest who can deploy the necessary resources, and notably the tug ABEILLE FLANDRES.

Concerning the ERIKA :

- The vessel reported in at 1407 hours on 10 December 1999 and made no mention of any problems. She left the area covered by the CROSS.CO at about midnight on 10 December 1999.
- Subsequently, on account of the characteristics of its HF transceiver, the CROSS.CO was able to pick up and record messages on 2182 kHz (which was not compulsory for technical reasons), albeit with some difficulty.
- This is what happened for the conversation between the Erika and the British warship FORT GEORGE which took place from 1450 hours to 1455

hours on 11 December 1999 and during which a crack in the deck plating was mentioned.

- In fact, this barely audible conversation was not really "heard" by the CROSS.CO but recorded by chance. When it was listened to again on 05 January 2000, the maritime prefect requested the British Royal Navy to send him a copy of the FORT GEORGE'S radio log, which they did on 11 January 2000.
- It was the text of this transcript that really enabled the recording to be understood.

B) The CROSS.A Etel

Generalities

The area covered by the CROSS.A Etel extends from the parallel of latitude through the Pointe de Penmarc'h to the Spanish border and takes in most of the Bay of Biscay
to the meridian of 8° W.

Its principal missions are search and rescue in the area it covers and beyond (as international correspondent for foreign SAR centres/MRCCs), as well as fisheries protection, policing and surveillance.

Activity of the CROSS.A on 11 and 12 December 1999 :

On Saturday 11 December 1999 the duty "crew" was made up as usual :

- of a duty officer who was also the SAR mission coordinator (SMC);
- of a watch officer;
- of an operator and a transmitter who were responsible for all VHF, MF,INMARSAT and telex communications … etc. …

Because of the storm that day, the CROSS was in command of ten or so search and rescue operations involving the lives of several people. Besides this, with the maritime Prefecture (PREMAR), the CROSS was following developments in the situation of the MARIA K., a vessel which was likely to run aground and thus cause pollution.

This 180 metre long Maltese bulk carrier was in the Loire estuary in heavy weather and was having great difficulty in manoeuvring due to being insufficiently ballasted.

When they were informed at 1955 hours that the vessel was drifting towards shallow water by the Chemoulin signal station, the CROSS informed the COM at 2020 hours and then followed the incident throughout the night of 11 December (15 messages) until the MARIA K. finally managed to get under way at 0744 hours on 12 December after a long ballasting operation in an unsafe anchorage.

It is to be noted that the MARIA K. which was built in Japan in 1977 had had four previous owners and that inspections carried out within the framework of Port state control (PSC) had led to a number of deficiencies being recorded and to her being given a target factor of 22 (as against 12 for the Erika).

Concerning the Erika :

The CROSS.A only learnt about the Erika's presence, by then practically in the middle of the Bay of Biscay, through the MAYDAY transmitted by INMARSAT C at 1408 hours on 11 December.

When they received the MAYDAY from the Erika via INMARSAT C (telex) at 1408 hours, the CROSS :

- acknowledged it at 1411 hours and asked for confirmation as they knew that 90% of the alerts from this system were false alerts;
- then asked the PREMAR what major resources could be used so far out (in the middle of the Bay of Biscay, 300 kms from the French and Spanish coats) to organize a rescue operation.

At 1455 hours, 47 minutes later, the CROSS learnt that the vessel's list was being corrected and that assistance was no longer required.

At 1801 hours the CROSS learnt that the ERIKA was heading towards Donges to seek shelter.

At 2101 hours in the course of a conversation with the port of Donges about the MARIA K., they learnt incidentally that the Erika had "cracks" and that her stop over in Donges would cause problems if there were any leaks.
They called the vessel to obtain further information and at 2227 hours received confirmation that there were cracks in the deck plating but not of any oil spills(this seems normal as it was the deck plating of No.2 starboard ballast tank which was cracked).

Thus it was only at this time that the CROSS.A became fully aware of the situation, with the master confirming that he had the situation under control.

The PREMAR duty officer was not advised of the new developments by the CROSS.A until 2330 hours (by a message which he received at 0003 hours).

The rescue of the Erika's crew

At 0600 hours on 12 December 1999, received a distress message from the ERIKA by INMARSAT C :

- the vessel was 35 miles south of Penmarc'h ;
- there was ingress of water due to a breach in the hull ;
- there were 26 crew members to be rescued ;
- the wind was west by northwest 50 knots. Sea state 6

At 0617 hours, after setting up the relay procedures for the MAYDAY and trying unsuccessfully to get in touch with the ERIKA by HF radio, The CROSS asked the COM to deploy the stand by aircraft, viz. :

- an ATLANTIC 2 based at Lann Bihoué ;
- a SUPER FRELON based at Lanvéoc ;

- respectively 52 and 64 nautical miles from the ERIKA.

The two aircraft took off at 0700 and 0739 hours respectively arriving on scene at 0740 hours and 0800 hours.

At 0814 hours as the vessel began to break up, the helicopter began winching the crew off the ship.

At 0821 hours, after 5 crew members had already been winched off the vessel (there were still 21, plus the diver, left on board), the winch broke down and the SUPER FRELON had to return to base.

The CROSS then requested the intervention of other helicopters.

At 0904 hours, a LYNX arrived on scene.

At 0924, it had lifted off 6 crew members (its maximum capacity). There were then 3 persons still on board including the diver, the 13 others having abandoned the ship in a lifeboat.

At 1012 hours, the LYNX, back on scene, winched off the remaining three persons, including the diver. There remained only the 13 crew members in the lifeboat.

At 1015 hours, as two British SEAKINGS were arriving on scene, the SUPER FRELON, which had returned to the scene, began lifting the 13 crew members off the lifeboat, an operation which ended at 1043 hours.

The 26 crew members of the ERIKA were rescued.

The Commission considers the rescue to have been a remarkable operation on account of the circumstances and the particularly severe weather conditions, even for the heavy helicopters. Its success is a tribute to the courage and skill of the crew, pilots and divers of the French naval helicopters.

7.7.2 THE MARITIME PREFECTURE*

Generalities :

The maritime prefects (PREMAR) are responsible for coordinating the action taken by the state at sea (AEM) and, on this count and others, for preventing and fighting pollution.

To accomplish this, they have at their disposal, especially in difficult waters such as the Ushant and Casquets landfalls and in the Straits of Dover :

- VTS/MRCC centres which monitor traffic using radar and maritime radiocommunications equipment ;
- powerful tugs (160 tonnes pull), chartered by the navy. It must be noted that these tugs cannot go more then 60 miles from Brest or Cherbourg.

In the event of an incident, the CROSS contacts the General staff duty officer (OSEM), on watch at the naval centre of operations (COM),and together, they make a first assessment of the situation. According to this analysis the OSEM follows the way the situation develops and, if necessary, contacts the <u>operations and AEM (Action taken by the state at sea) deputies</u> who then also assess the situation, and possibly advise the PREMAR on the steps to be taken.

These can consist of :

- simple surveillance of the vessel by the CROSS if, for example, repairs are being carried out, and weather permitting,
- sending an "assessment-intervention" team by helicopter in order to inform the PREMAR on the precise situation of the vessel and to <u>prepare</u> any subsequent interventions.

- formally notifying the shipowner to take the measures necessary, in a given time, so that his vessel no longer represents a danger , failing which the PREMAR will take them, at the owner's expense, notably by taking the vessel in tow.

The activity of the COM on 11 and 12 December 1999 :

On Saturday 11 December 1999, the duty crew was made up, as usual by :

- a General staff duty officer (OSEM);
- several watch officers and operators.

There were few resources at sea, and none in the Bay of Biscay.

On the other hand, as per regulations, and on account of the storm :

- the ABEILLE FLANDRE was on a mooring buoy in the Baie du Stiff, in the vicinity of the Ushant traffic separation scheme;
- a maritime patrol and reconnaissance aircraft (PATMAR) and a heavy SUPER FRELON helicopter were on one hour standby.

Concerning the ERIKA ... and the MARIA K :

… ERIKA **…**

When informed of the ERIKA's first MAYDAY (1408 hours on 11 December 1999) by the CROSS at 1438 hours, the OSEM replied that he had no resources in the area.

He was advised at 1505 hours by the same source that the vessel no longer required assistance.

As he was kept up to date by phone on the development of the incident by the CROSS, like them but a little later, he only became aware of what had happened since 1408 hours by a written message received at about midnight.

... MARIA K ...

Meanwhile, at 2020 hours the OSEM was informed by the CROSS.A and the Chemoulin signal station about the highly worrying, to say the least, situation of the 180 metre Maltese bulk carrier MARIA K. (1977) which, with little or no ballast, first drifted in the storm towards shallow water in the Loire estuary and then, after managing to anchor, began to drag anchor.

The situation was such that, as soon as they were informed, the AEM division (Action of the state at sea) went to the maritime prefecture and had the PREMAR sign a formal notice addressed to the MARIA K.'s owner, which enabled them to send a tug from the port of St Nazaire to the MARIA K.'s assistance from 2245 hours until 0700 hours on 12 December.

We recall that the MARIA K.'s target factor (22) was greater than the ERIKA's (12).

... ERIKA ...

When informed of the ERIKA's MAYDAY at 0600 hours on Sunday 12 December, the head of the operations division deployed the rescue resources requested by the CROSS.A. He also ordered the ABEILLE FLANDRE to get under way and at about 0900 hours she reached what was already nothing more than a wreck. It is to be noted :

- that towing the vessel, even if she had not been broken, could have accelerated the break up process;
- that the maritime prefecture took a risk in sending the tug beyond the limits of its area of navigation which had been fixed to protect the Breton landfalls.

7.7.3* *THE SAINT-NAZAIRE HARBOURMASTER'S OFFICE*

Harbourmasters are responsible for the safety and security of their ports within the administrative boundaries fixed for them. According to the provisions of the maritime ports Code, they can refuse access to the installations under their responsibility to vessels which might endanger the port installations or access, the goods in transit or the people there.

Bearing in mind the poor quality of some of the vessels that forwarding agents or consignees sometimes approve, the word responsibility in this context is not empty of meaning.

Be that as it may, this in no way relieves harbourmasters of their general obligations to give assistance to persons in danger. It is perfectly true to say that it is far easier for ships to seek shelter or repairs in a port – to which they obviously need to gain access.

This being the case, working in conjunction with the services at the maritime prefecture, the necessary compromises are made between the requirements of port security, the safety of life at sea and the protection of the environment.

Concerning the ERIKA, the harbourmaster's office was informed late in the evening, around 2100 hours on 11 December, by the potential agent, of the vessel's arrival for the following morning.

The ERIKA was reported to be listing and to have cracks in her hull, although these were supposed to have been stopped. The harbourmaster stated that the list would not prevent the vessel calling at Saint-Nazaire but that it would make manoeuvring and berthing difficult. He added that leaks, on the other hand, would be unacceptable in the Loire because of the current.

Although very reticent at the idea of accepting a laden, probably damaged tanker, the Saint-Nazaire harbourmaster concurred straightaway that could admit the ERIKA if no other solution was forthcoming.

8* CONCLUSION

- **The ERIKA was certainly an old ship, but she was used above all for transporting black products at freight rates which were insufficient to**

cover costs, unless costs, especially maintenance costs, were drastically reduced.

. **The ERIKA had always been "sensitive" to corrosion, but she really began to fall into disrepair when No.4 tanks and especially No.2 wing tanks became dedicated ballast tanks, as witnessed by :**

a) before the casualty

- the thickness measurements made in 1997 and especially 1998 which, generally speaking, gave an acceptable overall average thickness, **except in section No.2**
- the replacement of half the longitudinal deck stiffeners and those of the upper parts of practically all the transverse webs in the No.2 ballast tanks.
- the absence or poor condition of the protective coating and **insufficient cathodic protection**;
- the extensive corrosion and deposits of rust observed, even by the ROV;
- the state of the ladder in No.2 starboard ballast tank and the perforce incomplete report on the corrosion of a deck longitudinal, all leading to a request, in December 1999, for a further, more complete survey to be carried out in January 2000, less than18 months after a special reclassification survey.

b) during the casualty

- the fracture / collapse of the bulkhead between No.3 centre tank and No.2 starboard ballast tank;
- the cracks and buckling of the deck plating on the forward part of No.2 starboard ballast tank;
- the propagation of the cracks in the hull plating and the collapse of No.2 starboard ballast tank;
- the detachment and loss of part of the side plating of No.2 starboard ballast tank and of No.3 starboard tank;

- the inevitable opening to the sea of No.3 centre and starboard tanks and No.2 starboard ballast tank;
- the breaking of the vessel in section No.2;

c) after the casualty

- the observation of the state of the wreck by the ROV which can be summarised as follows : if what can be seen of the bulkheads of No.2 centre tank – which represents only half the width of section No.2 – is excluded, then **section No.2 no longer exists.**
- the analysis of the hull elements which show :
  - that for some of the replaced deck plating 12 mm instead of 16 mm plating was used;
  - that the scantlings of the original plating had decreased by more than 30%;
- the analysis of the stiffeners which show :
  - that some weld seams had disappeared;
  - a diminution of scantlings which exceeded 30%

all of which confirms that there was general corrosion but also that there were isolated points of corrosion affecting only a few cm^2 in many places but which were by far the more dangerous.

These isolated spots of corrosion were deep.

The work carried out in the Bijela shipyard was also a decisive factor in the sequence of events leading up to the casualty.

Modifications of the stress distribution in the hull may have resulted from the work carried out due to :

- the use of steel plating of differing, smaller scantlings;
- rash decisions as to the positions of the cut outs made in the structures, in the plating and the bulkheads;
- errors of accuracy in assembly, in the quality of the welding etc. ...

The stresses set up in this way can only have contributed to the appearance of cracks and other fractures and when a crack does appear a major damage process is set under way which may take several months to reach its final stages.

The weakening of the structure of section No.2 of the ERIKA was thus due to insufficient maintenance and the corresponding rapid development of corrosion, leading to a succession of ruptures which caused the whole structure to collapse.

This factor was decisive; to such an extent that the other factors can be considered as secondary. In short, the state of the vessel and her rapid deterioration in the last hours of her life were such that nothing could have prevented the disaster

9* RECOMMENDATIONS

The Commission recommends :

. That the competent **INTERNATIONAL ORGANISATIONS** endeavour to limit the proliferation of instructions, check lists and other guide lines which are imposed on masters who, precisely because there are so many of them, are unable to put them all to good use in the event of an emergency.

. That **FLAG STATES** who delegate all or part of their prerogatives for the issue of statutory international certificates endow themselves with the necessary legal and technical means to effectively monitor the way these delegations are implemented

. That the **CLASSIFICATION SOCIETIES** :

a) Make sure that any tanks liable to corrosion are properly protected as built, then surveyed and maintained at intervals that are conditional upon observation of the way their condition changes.

b) Conduct more comprehensive periodic surveys incorporating thickness measurements, strength calculations and the surveyors' expertise.

c) Develop and use equipment and methods for thickness measurements giving more reliable and more representative results than those in use now.

d) Computerize the records of the vessels to which they assign class, notably as far as structure and stability are concerned.

e) Transmit the complete classification file which they hold to the gaining classification society when a vessel undergoes a transfer of class.

f) Set up round-the-clock "safety watches" able to answer questions from a master or ship owner about what action to take, when a vessel has suffered damage affecting its structure and/or stability.

g) Be able to make a diagnosis, with a team of experts which could comprise a class surveyor from the vessel's classification society, a class surveyor from another society, a Flag state and a Port state inspector, as soon as significant corrosion is seen to be developing. This diagnosis would lead to the scrapping of the vessel in the short or middle term if :

- the corrosion became too extensive;
- repairs also became so extensive that they could do more harm than good, by creating discontinuities, stresses etc. …

h) Transmit the dossiers they hold on ships to the Port state or the Coastal state in the event of an accident or doubts concerning their seaworthiness, without being able any longer to invoke confidentiality - due to the ship owner on the grounds of class, or on the grounds that they are holding delegation for certification from the Flag state.

i) Examine further the possibility of installing in new ships and if necessary in existing vessels which are particularly affected by corrosion and loss of hull girder strength, systems enabling real time monitoring of vessel fatigue, and capable of providing the operators with indications of what course to follow and what speed to make so that it does not increase.

j) Mutually exchange information on a permanent basis about serious problems in certain types of ships, especially in sister ships.

. That **VESSEL INSPECTION SERVICES** :

a) Concentrate more on inspecting hull and internal structure both during statutory surveys and occasional surveys carried out when there is doubt about the real condition of a vessel.

b) Make sure that the loading sequences of tankers (and bulk carriers) are given to the departure port before the vessel sets sail.

. That **OIL COMPANIES** (including traders in oil products who can be considered as charterers) align the conditions concerning safety and vessel quality of their voyage charters – which they need to make from time to time - on the time charter conditions they use at the present time.

The Commission also considers that these companies need to be as demanding about the quality (especially as far as their age is concerned) of the ships they charter for the transport of black oil products (fuel oil, tar, crude oil) as they are for those transporting white products (naphtha, kerosene, petrol, diesel oil).

The Commission also recommends charterers, as a simple "just-in-case" precaution, only to hire vessels whose management and conditions of ownership are open and straightforward.

The Commission further recommends them not to charter old vessels which have undergone a change of ownership within the preceding 24 months and/or the operating conditions of which have recently been modified, without taking the strictest precautions.

The Commission finally recommends them not to charter ships without first obtaining as many PSC reports and records concerning them as are available. The better qualified ship brokers would, moreover, be able to supply them with this information if they did not already have it.

Furthermore, they would do well not to charter vessels if the owners cannot guarantee immediate and permanent access to all classification and ISM certification documents (for both ship and management).

French oil groups could go a long way to removing uncertainty about the quality of the vessels they charter by directly owning, manning and operating the greater part of their oil (crude and products) fleets, under their national flag. Other oil groups would do well to follow suit.

. That **OIL REFINERIES AND EXPORTERS OF OIL PRODUCTS**, and shippers in general, make the necessary arrangements for shippers or forwarding agents to keep a copy of the loading plan and sequence so that it may be consulted by the maritime authorities in the event of an accident in compliance with IMO Resolution No. A849(20) and the International convention on the law of the sea.

. That the target factor of **PRE-MARPOL TANKERS** be raised considerably and generally made available, on demand, together with the reports on the 12 previous PSC inspections to charterers and brokers, for the <u>purposes of information</u>. Classification societies should also receive the same information and would undertake to immediately, completely and without hindrance, make all records concerning a vessel's classification and ISM certification (ship and management) available to any board of enquiry acting within the framework of

IMO Resolution No. A840(20) and the International convention on the law of the sea.

. That ongoing projects concerning the setting up of **DATABASES** concerning the quality of ships (EQUASIS), which will be accessible to all users of the sea for the purposes of information, also include all necessary information about a vessel's ownership, compulsory insurance, shipmanagers and agents.