**International Journal of Scientific Research and Management (IJSRM)**
**||Volume||10||Issue||06||Pages||EC-2022-886-906||2022||**
**Website: www.ijsrm.in ISSN (e): 2321-3418**
**DOI: 10.18535/ijsrm/v10i6.ec03**

# Technical and Economic Assessment of Maritime Accidents

**[1]Jose Marcio de Vasconcellos, [2]Antonio Carlos Fernandes, [3]Salvador Picolo**

[1]DSc., Professor of the Program of Naval and Oceanic Engineering (AENO), COPPE, Federal University of Rio de Janeiro, Brazil
[2]DSc., Professor of the Program of Naval and Oceanic Engineering (AENO), COPPE, Federal University of Rio de Janeiro, Brazil
[3]Doctoral Student of the Postgraduate Program of Naval and Oceanic Engineering (AENO), COPPE, Federal University of Rio de Janeiro, Brazil

**Abstract**
This article highlights the main technical and statistical aspects related to maritime accidents, including the various types of vessels that navigate rivers and oceans around the world. It seeks to understand the mechanics of different accidents, their recurrence for different causes and their financial impact. Technically, through case studies, it shows the different types of accidents that occur in different global locations. The preservation of human life as well as of the environment are determining factors in any maritime accident today.

**Keywords:** Maritime Casualties, Class Society, International Maritime Organization, Environment, Costs, Cases

## 1. Introduction

Through this article, we aim to address technical and statistical studies related to maritime accidents involving vessels that travel worldwide either in rivers or at sea, aiming to understand the mechanics of accidents with vessels and the methodology for re-floating said vessels, or cutting/slicing them while in the water, or scuttling them in case of structural fragility. Along with this data we have the preservation of human life and of the environment, in addition to compliance with regulations in effect, and the various studies already carried out.

The use of navigation for transportation dates back to the beginnings of humanity and started in the most rudimentary way possible by necessary survival instinct. On the calm waters of rivers, lakes, bays, and seas, without losing sight of the mainland, the genesis of the first evolutionary behaviors of rational beings was established; millennia later, humanity would dare to undertake memorable epic adventures across the most distant seas and oceans, performing fascinating discoveries of new civilizations and continents, initiating the first steps of commercial and cultural exchange between peoples.

In order to better understand the dynamics of maritime accident models, we refer back to 400 BC, when a Greek ship measuring 23.00 m in length and sailing on the route between the Mediterranean and Greek colonies on the coast of the Black Sea sunk and was discovered in 2018 more than 80 km from the Bulgarian city of Burgas [BBC NEWS-2018].

The shipwreck above is recorded as the oldest intact shipwreck in the world. The researchers, an Anglo-Bulgarian team, were surprised to find that the merchant ship looked a lot like the design of a ship that decorated ancient Greek wine amphorae. The rudder, rowing benches and even the contents of the hold remained intact until the date of its discovery.

Wood samples from her hull were collected for later determination of the age of the vessel through carbon equivalent analysis.

The vessel is similar in style to that represented by the so-called Siren Painter in the Siren Vase of the British Museum. Dating to around 480 BC, the vase shows Odysseus tied to the mast as his ship passes three mythical sea nymphs, whose music was supposed to lead sailors to their deaths [BBC NEWS-2018].

**Figure 1**: Boat at a depth of 2,000m – The name has not been discovered until today.

**Figure 2**: Siren Vase – British Museum

The reason that a wooden vessel 23.00 m long and supported in an aqueous environment on a 2,000 m bottom remains in such good condition for so long is that the water is anoxic, that is, free of oxygen.


**Figure 3**: Drawing and details of the boat - The name has not been discovered until today.

The navigation milestone emerged centuries later, with the exploration of the Atlantic Ocean by the Portuguese between the 15th and 16th centuries. In this period, new maritime routes were discovered until reaching Asia, and later, in 1492, they reached the American continent, which resulted, through their colonization, in the passage from the Middle Ages to the Modern Age. In Brazil, they arrived in 1500 [FRANCISCO, W. C., 2021].

Nowadays, with the technological advance and the available tools, shipbuilding has matured a lot, the same happening with the crew of the various types of ships that are submitted to different courses and training.

Navigation, maritime and river, is responsible for 70% of the goods transported and circulating worldwide [FRANCISCO, W. C., 2021 & Marine Accident Investigation Branch, 2015]. This fact is a result of the great transport capacity of ships in circulation on the globe.

Along with the technological advances inherent to shipbuilding, ships in operation and their crew, the array of accidents with victims and/or aggression to the environment, are decreasing every year thanks to the efforts of the various administrators of the different sectors of navigation.

## 2. Verification and Provisions in the Case of a Maritime Accident Abroad and in Brazil

### 1. Abroad

The world's best recognized system for handling maritime emergencies is in the UK.

The introductory milestone of this system for handling maritime emergencies comes from the accident with the oil tanker “SEA EMPRESS”, with 147,273 tons deadweight, while sailing under the guidance of a local pilot at Milford Haven Waterway in Pembrokeshire, Wales, on 15 Feb 1996 @ 20:07 GMT, with a cargo of 130,824 tons of light crude oil from fields in the North Sea, on its way to the Texaco refinery at Milford Haven. The accident in question was the grounding on the rocks at Saint Ann’s Head, at the entrance to

Milford Haven Bay. As a result of the stranding, around 70,000 mt of its North Sea crude oil cargo was spilled overboard, causing alarming damage to the environment and life there [Marine Accident Investigation Branch, 2015].

**Figure 4**: Sea Empress – Aground during bad weather

**Figure 5**: Sea Empress – Refloating efforts with satisfactory results on February 21, 1996

After the transshipment of 58,200 mt of crude oil that remained in 'Sea Empress' tanks to the vessels ‘Star Bergen’ and ‘Onward Mariner’, the ‘Sea Empress’ went into drydocking, for inspections and repairs.
Subsequently, due to the environmental disaster that had occurred, Lord Donaldson was instructed by the UK Government to carry out a thorough review of how the Government, through its various operational facilities and agencies, should respond to maritime emergencies in the future. In the course of his review, which produced the report entitled “Safer Ships, Cleaner Seas”, Lord Donaldson noted that “salvage by committee” was generally ineffective and inefficient. In his view, what was needed in such emergencies was a single voice, capable of making and enforcing decisions on behalf of the UK government and the overriding public interest and, if necessary, overruling the action of any and all other interested parties. Thus, was born the idea of a “SOSREP” [GARD NEWS-2009].
The acronym SOSREP stands for Secretary of State Representative. SOSREP is a civil servant accountable to the government for its actions, but in line with Lord Donaldson's recommendations, it is actually largely free to act on its own initiative, without having to consult its political bosses. This not only means that decisions can be made quickly, but also that these decisions are often made on the basis of facts, logic and reason rather than political and emotional considerations. SOSREP has the ultimate and decisive voice, ultimate control and ultimate accountability. As Lord Donaldson said, the government must "support him or fire him". Since the position was established in 1999, and considering an initial period of thirteen years, there have been about 1,100 incidents, including in the oil exploration area, in which SOSREP has been involved [GARD NEWS-2009].

Basically, we have:

A. The SOSREP is responsible for:

- Containment – ensure that the leak is stopped by the use of appropriate means, always taking into account that personnel safety is paramount.
- Rescue - ensure that the vessel, her cargo or bunker fuel do not pose a danger to navigation or to the safety of persons.
- In both cases, mitigate damage to the environment.

B. SOSREP is NOT responsible for:

- Cleaning up sea pollution
- Cleaning up pollution on the coast

Of the bodies involved in operations as described above in which SOSREP - (Representative of the Secretary of State for Maritime Accidents) is acting, the following, among others, are considered as integral parties:

- Shipowners
- Charterers
- Ship managers

- Hull & Machinery Underwriters (H&M)
- Protection and Indemnity Clubs (P&I)
- Cargo Owners (Shippers / Receivers)
- Cargo Underwriters
- Salvage Company
- Classification Society - Consulting
- Maritime Authority
- Health Authority
- Environment Authority

The above model created by the United Kingdom was adopted and is in force in European Union countries. Subsequently, Australia, through its Maritime Authority, created a system similar to the British one, and named it MERCOM – Maritime Emergency Response Commander.

**2. Brazil**

The activity of "Maritime Assistance and Salvage" in Brazil is under the supervision of the Brazilian State, and the execution and regulations involved with such operations are under the responsibility of the Brazilian Navy, with authority exercised by each of the commanders of its nine Naval Districts [BRAZIL-NAVY OF BRAZIL], namely:

1st Naval District – Comprised of the states of Rio de Janeiro, Espírito Santo and Southeastern Minas Gerais. It is the headquarters of the Brazilian Navy.

2nd Naval District – Comprised of the states of Bahia, Sergipe, North and Southwest of Minas Gerais.

3rd Naval District – Comprised of the states of Ceará, Rio Grande do Norte, Paraíba, Pernambuco and Alagoas.

4th Naval District – Comprised of the states of Amapá, Pará, Maranhão and Piauí.

5th Naval District – Comprised of the states of Rio Grande do Sul and Santa Catarina.

6th Naval District – Comprised of the states of Mato Grosso and Mato Grosso do Sul.

7th Naval District – Comprised of the states of Tocantins, Goiás and the Federal District.

8th Naval District – Comprised of the states of São Paulo, Paraná and southern Minas Gerais.

9th Naval District – Comprised of the states of Roraima, Acre, Amazonas and Rondônia.


On April 28, 1989, noting that significant facts, in particular the growing concern for the protection of the environment, indicated the need to revise the international norms contained in the Convention for the Unification of Certain Legal Rules Relating to Maritime Assistance and Salvage, signed in Brussels on September 23, 1910, the INTERNATIONAL CONVENTION ON MARITIME SALVAGE [INTERNATIONAL MARITIME ORGANIZATION-2019] was published by the members (Countries) of the International Maritime Organization - IMO (IMO).

For the purposes of this Convention, the following activities were considered, among others:

(a) Marine Salvage Operation means any act or activity undertaken to assist a ship or any other property in distress in navigable waters or in any other waters.
(b) Environmental damage means considerable physical harm to human health or marine life or coastal or inland water resources or adjacent areas, caused by pollution, contamination, fire, explosion or similar incidents.
On July 18, 2016, the Brazilian government issued Decree No. 8,814, through which it enacted the International Convention on Maritime Salvage - SALVAGE-89, signed by the Federative Republic of Brazil, in London, on April 28, 1989.
The enactment of the convention as above did not change in any way Law No. 7,203 of July 3, 1984, which describes the competence of the Brazilian State, through the Brazilian Navy, as follows [BRAZIL-LAW 7,203]:

> Art. 2 - It is incumbent upon the Ministry of the Navy to coordinate and control the assistance and salvage activities of vessels, things or goods in danger at sea, in ports and on inland waterways.
>
> Sole paragraph - The Ministry of the Navy may delegate the execution of such services to other federal, state and municipal bodies and, by concession, to individuals, in defined areas of jurisdiction.
>
> Art. 9 - The naval authority may intervene in assistance and rescue operations, or provide it, when necessary, to prevent, control or avoid damage to the property of third parties or to the environment.
>
> § 1 - The intervention does not depend on the request or the express will of those responsible for the assisted vessel.
>
> § 2 The intervention does not exempt the owners of the assisted vessel from liability for damages to third parties or the environment.

This way we have that “assistance and salvage”, by definition, means any act or activity performed to assist and salvage a vessel, thing or good in danger at sea, in ports and on inland waterways.
Within the precepts of the authority described above and the preservation of the vested authority, the NORMAMs - Maritime Authority Norms - were created, which replaced the PORTMARINSTs, and specify the procedures to be followed for the different branches, and the various aspects of the maritime area. Specifically, to the present theme, we have NORMAMs 08 (Partial) and 16 (Full).
In this way, we have that the procedures for the coordination of operations inherent to maritime perils carried out by the Brazilian Navy follow the rules and requirements of NORMAM 16, which establishes conditions and requirements for the concession and delegation of assistance and salvage activities of a vessel, thing or property, in danger at sea, in ports and inland waterways [BRASIL-MARINHA DO BRASIL-2003].
As stipulated, the entity authorized to carry out the assistance and salvage work will forward to the Naval Authority coordinating and controlling the work, within the deadlines set by it, partial reports containing:
a) progress of the execution of the planned events;
b) changes in the schedule of events;
c) unforeseen events, accidents, incidents occurred;
d) interruption of activities; and
e) other relevant aspects.
In the model created in Brazil and as previously described, the following Parties are part of this type of operation:
• Shipowners
• Hull & Machinery Underwriters (H&M)
• Protection and Indemnity Clubs (P&I)
• Cargo Owners (Shippers / Receivers)

• Cargo Underwriters
• Salvage Company
• Classification Society - Consulting
• Environment Authority

In the nine Naval Districts distributed in Brazil as described above, it is known and recorded that only in the port of Rio de Janeiro, the Brazilian Navy, through the Captain of the Ports and the Commander of the 1st Naval District, exercised articles 2 and 9 of Law No. 7,203 of July 3, 1984, all in accordance with the International Convention on Maritime Salvage - SALVAGE-89 [BRAZIL-LAW 7.203 & BRAZIL-decree 8.814].

By the edited law we have:

Art. 2 - It is incumbent upon the Ministry of the Navy to coordinate and control the assistance and rescue activities of vessels, things or goods in danger at sea, in ports and on inland waterways.

Sole paragraph - The Ministry of the Navy may delegate the execution of such services to other federal, state and municipal bodies and, by concession, to individuals, in defined areas of jurisdiction.

Art. 9 - The naval authority may intervene in assistance and rescue operations, or provide it, when necessary, to prevent, control or avoid damage to the property of third parties or to the environment.

§ 1 - The intervention does not depend on the request or the express will of those responsible for the assisted vessel.

§ 2 The intervention does not exempt the owner of the assisted vessel from liability for damages to third parties or the environment.

Such action, as mentioned above, refers to the imminent danger of oil pollution due to the flooding and partial sinking of the MV Angra Star.
For this re-floating operation, depletion of oily waste and fuel removal, the Port Authority, by specific ordinance, activated the Guanabara Bay Emergency Plan, composed of the following parts:
• Brazilian Navy – General Operations Coordinator
• Salvage Coordinator - Salvage Master
• Tugboat Company
• Marine Pollution Combat Company
• Pollutant Waste Disposal Company
• Port Authority
• Environment Authority

**Figure 6**: MV Angra Star, Guanabara Bay, on September 26, 2013


**Figure 7**: MV Angra Star, Guanabara Bay, on September 27, 2013

## Objective

The objective of this article is to approach technical and statistical studies related to maritime accidents, involving current vessels that travel worldwide, either in rivers or at sea, aiming to understand the mechanics of accidents with vessels and the costs involved, in addition to the methodology for re-floating said vessels, or cutting/slicing them while in the water, or scuttling them in case of structural fragility, through case studies. Along with this data we have the preservation of the environment, in addition to compliance with regulations in effect, and the various studies already carried out, as well as the main parties involved in a maritime accident scenario.

With the need to preserve the marine environment and the possibility of disastrous results to marine life in case of pollution, visual pollution and creation of navigation perils, several regulations have been developed through the Safety Committee of the International Maritime Organization - IMO (International Maritime Organization – IMO).

In the specific case of Brazil and comparing the cases that occurred in its territorial waters, it can be stated with technical reason that the total volume of oil spilled at sea has decreased in the last 30 years according to the studies available through the ITOPF. The same has been happening with maritime accidents related to groundings, intentional strandings, collisions and sinkings.

Oil production in Brazil according to the latest bulletin from the ANP – Agencia Nacional de Petroleo, in 2020, was 1,017,531,000 barrels and a large part of this total is transported by sea, either in coastal navigation or in overseas navigation.

Regarding major maritime accidents in the national territory, the one with the greatest impact occurred in Maranhao on February 25, 2020, with the 400,000 deadweight ton ship Estellar Banner, without pollution and which, due to the extent of structural damage to the bottom part, was intentionally sunk.

Structural damage to the ship from bow to stern, including but not limited to the various areas with open water, and dents to varying degrees, resulted in structural weakness to the vessel that rendered her unable to sail to a resource port without suffering a series of of temporary repairs as required by its Classification Society. In this way, after the inherent technical considerations, it was decided by the Underwriters involved that any attempt to recover the vessel was economically unfeasible, being then decided by its scuttling regardless of the costs involved with the value insured of the hull, of the cargo and the values of the salvage operation.

The last maritime accident that has been recorded and which resulted in the constructive total loss of the ship with the loss of three lives and pollution of the estuary of the port of Paranagua with about 900 ton of heavy fuel oil, was the "Vicuña" when unloading from the port of Paranagua its ethanol cargo at the Cattalini S.A. Maritime Terminal.

Considering the extension of the Brazilian coast of more than 7 thousand kilometers and 42 thousand kilometers of navigable rivers, the results observed in the Brazilian scenario are quite satisfactory [WIKIPEDIA-2020 GEOGRAFIA DO BRASIL]. The quick decisions of the parties involved in accidents as described here associated with agile decision and forceful regulations have shown to be extremely satisfactory for mitigating accidents as well as the spillage of pollutants in the marine environment.

## Major Maritime Accidents

Since the date recorded as the sinking of the Greek vessel mentioned previously in the introduction, which is fully preserved to this day, and recently discovered in the Black Sea, her construction and sinking having occurred before Christ (BC), there are few records of disasters with vessels. From the beginning of the Christian era (DC) that is, from before the 18th century to the present day, the largest available record of maritime accidents such as collisions, groundings, explosions and collisions with loss of human life is found on the website (https: //en.wikipedia.org/wiki/List_of_maritime_disasters) whose content is relative to the 18th, 19th, 20th and 21st centuries.

The main maritime accident in the world from the 18th century to the present day, in which at least 1,562 and at most 4,386 human lives were lost, took place on December 20, 1987 with the Ferry Boat **Doña Paz**, which collided with the oil tanker **Vector** in Tablas, in the Philippine Strait. The variation in the number of deaths is due to the existence of unmanifested passengers.

As can be seen in the list of world accidents related to the 21st century, Brazil has only two recorded accidents with fatalities, that occurred in 2008 (1) with the ferry boat **Comandante Sales**, which capsized in the Solimões River on May 4, 2008, killing 41 of the its passengers on board, and (2) the accident with the

yacht **Bateau Mouche** that capsized in the open sea, near Copacabana, Rio de Janeiro, on January 1, 1989, killing 100 people (passengers + crew).

**International Association of Classification Societies (IACS)**

In cases of groundings where assistance and rescue are required, the role of the Classification Society is none. The vessel automatically has its class suspended by rule condition and, when called to attend to one of these cases, normally such attendance is directly linked to bureaucratic formalities.

With the evolution of environmental policies, governmental and non-governmental regulations and the need for a quick response to the various maritime accidents, some classification societies, either on their own initiative or by specific requests, set up the Marine Casualty Responses Center. These centers, with vast databases and the use of computational tools, such as HecSalv™, Damage™ and other programs, are able to assist the movement of ships in ballast or loaded condition, of salvage with regard to reaction of a particular vessel at the time of the accident with sufficient accuracy, as well as providing responses to intended operations during the development of the vessel's movement or rescue operation.

**Maritime Accidents and Incidents**

As described in the Portuguese vernacular, it is well known that the common vocabulary words Accident and Incident, regardless of being similar, have different meanings.

**Definition of Accident**

Accident is a term that derives from a Latin word, *accĭdens*. It is an event that causes involuntary and unexpected damage. It occurs unintentionally that causes involuntary, personal, material damage (to property) and / or financial damage or that modifies the usual state of events [DICIONARIO ONLINE DE PORTUGUES-2021].

**Definition of Incident**

Incident is a term that derives from the Latin word, *incĭdens*. It is defined as an accidental circumstance, which is unplanned and has the potential to lead to or has given rise to an accident, or an episode that takes place in the course of a main event and that can alter the course of the same.

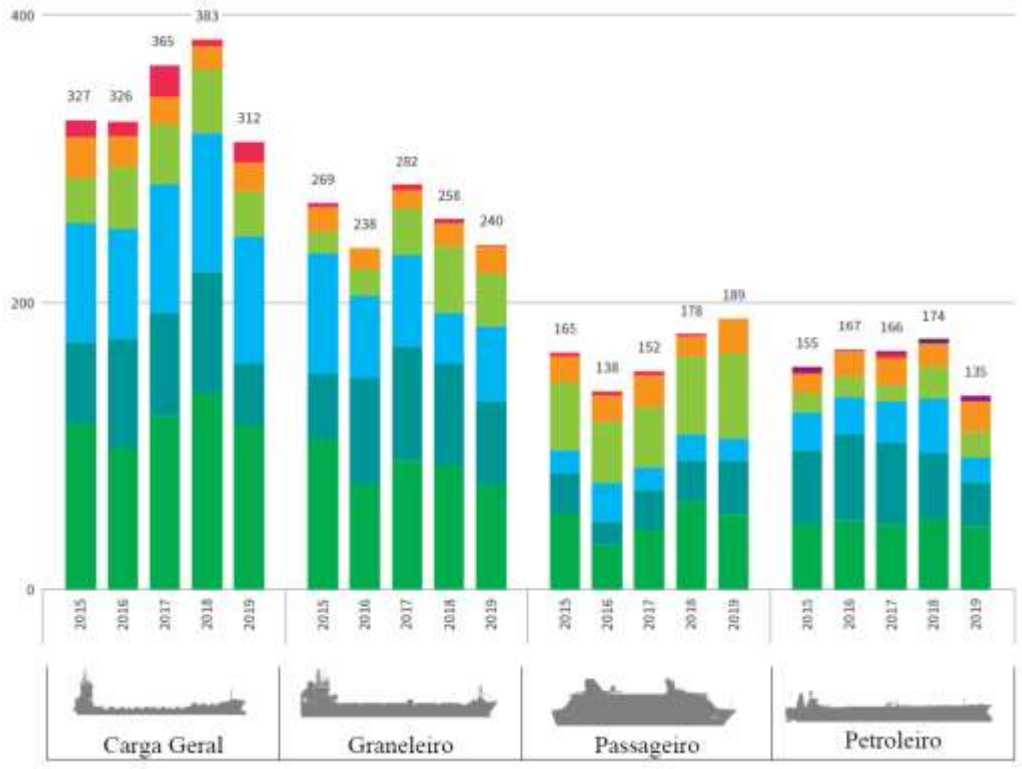
Briefly, we have to:

The two words indicate unexpected events, but each represents a different intensity. **Incident** refers to something not so serious and **accident** refers to something with more serious consequences.

Maritime accidents, as stated in several publications issued by different segments of the world maritime market [JAPAN TRANSPORT SAFETY BOARD SECRETARIAT-2021 & ELETRONIC QUALITY SHIPPING INFORMATION SYSTEM-2019] and their statistics found available until May 2021 [JAPAN TRANSPORT SAFETY BOARD SECRETARIAT- 2021], are reported as follows:

a. World number of claims occurred in different seas by type of ship, are as follows in the period from 2015 to 2019 [IHS MARKIT-2020][1]:

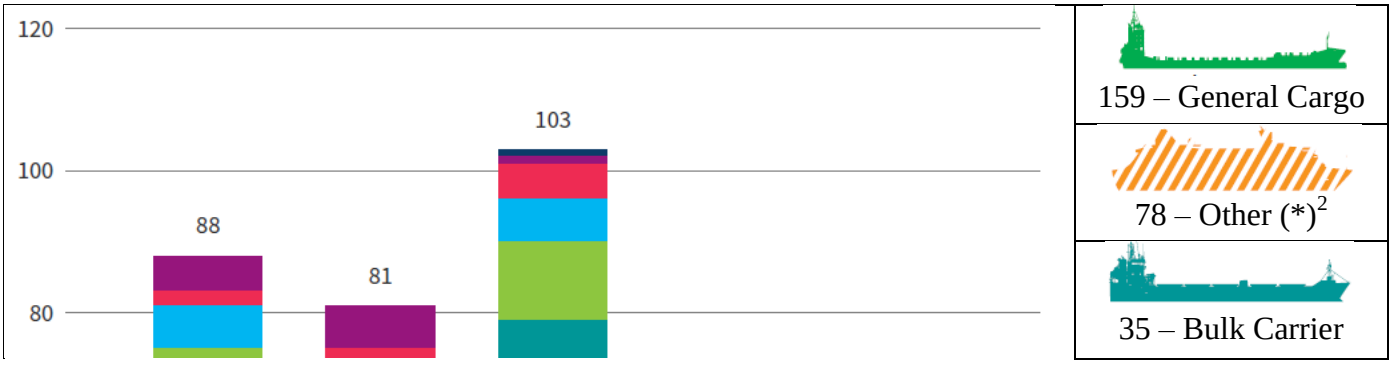
[1] Carga Geral=General Cargo / Graneleiro=Bulk Carrier / Passageiro=Passenger / Petroleiro=Tanker



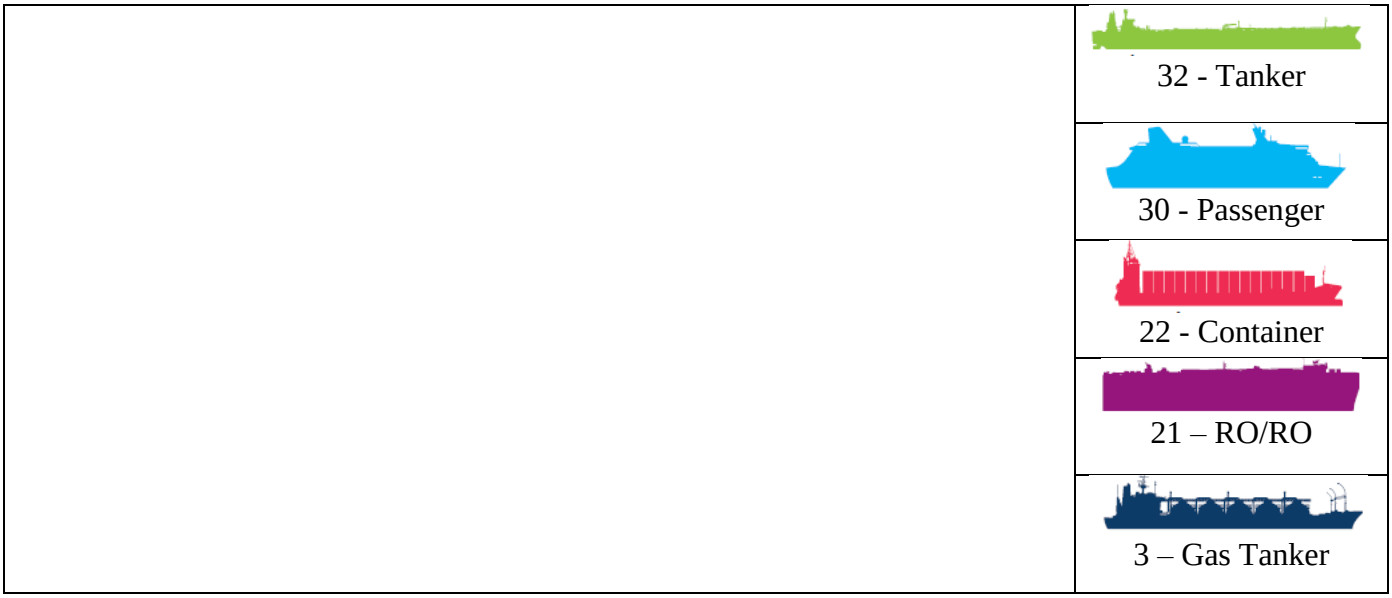

## 1.1 Total Loss of Vessels

The total loss of vessels occurs mainly due to the sinking and the statistical data available and in detail are those up to 2019. The specialized Japanese company IHS Markit, informs that in 2020 12 vessels were considered total loss and in 2021 until the month of May, 1 vessel. Such information does not contain details of these claims.

Going back to the period from 2015 to 2019, we have recorded a total of 380 total vessel losses, which are represented below by vessel type [IHS MARKIT-2020].




[2] (*) → Other are types of crafts not listed in this table




**The Environment**

Oil pollution in the ocean is caused by oil entering the seas not only as a result of tanker or oil platform disasters, but also - and mainly - from diffuse sources such as spills during oil extraction, illegal operations cleaning tanks at sea or discharges into rivers that are then taken out to sea [AUSTRALAIAN MARITIME SAFETY AUTHORITY-2003].

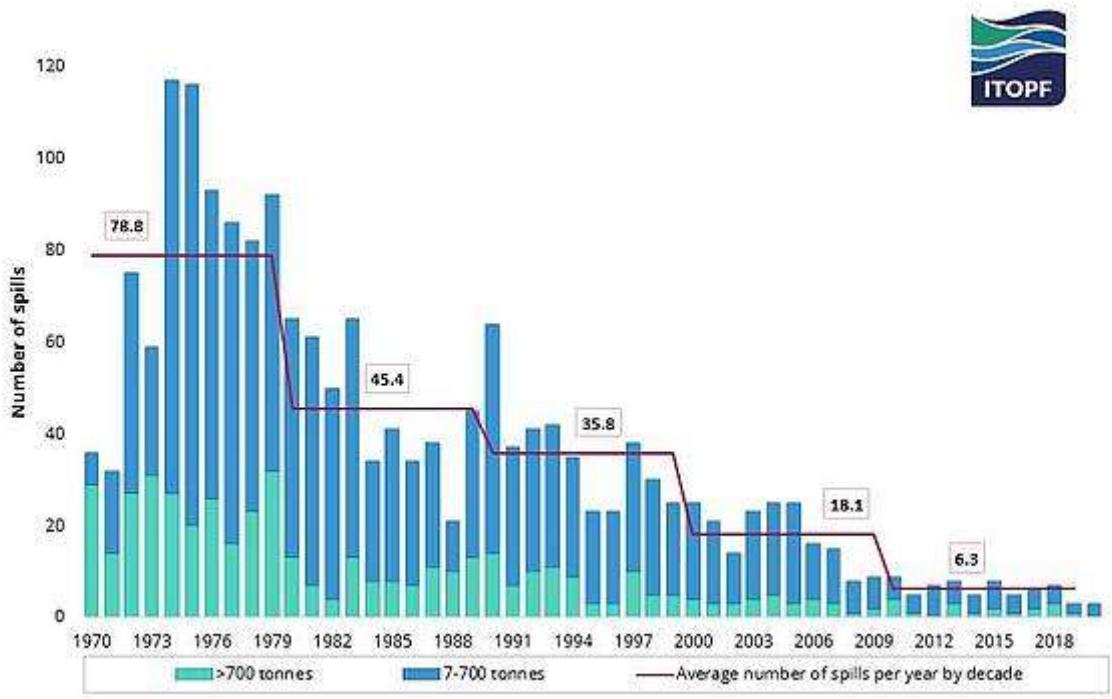
Brazil has as a common heritage to almost all its states, from North to South - the Atlantic Ocean and, in the interior, in any direction, its navigable rivers [PICOLO, S. P., 2009]. Due to this geographic conformity, such states and cities share economic opportunities related to the exploitation of petroleum, tourism, fishing, port, industrial activities and, more generally, all the benefits related to the marine environment. However, in the same way, they jointly support the risks inherent to such activities, in addition to the risks arising from natural phenomena.

Coastal damage in the world, caused by storms or bad weather, is amplified by the consequences that these phenomena have on ships and fixed or floating structures: pollution by hydrocarbons and/or chemical products caused by navigation accidents (groundings, shipwrecks, collisions) or simply visual pollution caused by the abandonment of derelicts, and, in some cases, these derelicts cause disturbances to waterways.

In addition to accidents that can be attributed to natural causes, maritime and river traffic also faces the risks inherent in the transport of petroleum products, chemicals, hazardous materials, discharge of ballast water, or loss of cargo (overboard).

In the world, the concern and the scenario are no different. The vast majority of oil spills at sea are in quantities smaller than 7 metric tons (quantities details are incomplete), according to data available through ITOPF – International Tanker Owners Pollution Federation 2020/2021, which is a non-profit technical organization based in London and involved with all aspects relating to preparedness and response to spills at sea of oils, chemicals and any other substance. ITOPF was founded in 1968 with the main purpose of administering the TOVALOP – Tankers Owners Voluntary Agreement – concerning liability for pollution. The creation of such an entity was due to the grounding of the oil tanker “Torrey Canyon” on the southwest coast of the United Kingdom, causing the spill of its cargo of 119,000 mt of crude oil.

Over the last half century, statistics for the frequency of spills greater than 7 tons from tankers have shown a marked downward trend, as illustrated below.




Number of spills greater than 7 tones between 1970 and 2020

The considerable reduction in the amount of oil and other contaminants spilled into the oceans was a direct consequence of the joint technical efforts of the Administrations of the Flags, Classification Societies, and mainly of the **Underwriters**, which in 1981 decided through the Hull Committee (Joint Hull Committee) to technically audit all ships before accepting them for insurance. To this end, the survey named JH 722 was put into practice regardless of the condition and classification status of the ship [SOYER, B., 2006].

**Case Study – Stellar Banner**

**Historic**

On February 24, 2020, after loading 294,871.00 metric tons of iron ore in the port of Ponta da Madeira, São Luís, MA, maximum draft of 21.47 m, displacement of 337,742 metric tons, the ship set sail from the terminal at 2:42 pm. The pilot disembarked at 3:00 pm and she continued its journey through the demarcated port channel, with a speed of 8 knots, accelerating progressively.

When passing the buoy no. 6 at 20:30 hours, the captain claimed that he had to change the ship's course due to draft restrictions, leaving the demarcated channel, leaving the other buoys on the port side.

At 21:18 he adjusted the main engine speed to 58 rpm (open sea cruising speed, equivalent to approximately 14 knots), and shortly thereafter at 21:32 he felt an impact / vibration, and the speed started falling.

The ship was anchored, and after inspection and soundings, damages were verified in the forepeak tank, ballast tanks 1 and 2 on starboard and duct keel, which had water ingress; later it was identified that the starboard fuel oil storage tank was also damaged, with seawater ingress into it.

The ship's pumps were not enough to overcome the water inflow speed, and, after 6 hours of attempts, the captain decided to suspend anchor on February 25, 2020, at 5:00 am, and purposely ran aground the ship on a nearby sandbar, at 6:15 am, at the geographic coordinates of Latitude $01^0$ 45,07 South and Longitude $043^0$ 41,7010 West, approximately 63 nautical miles from the port of Sao Luís, with heading of 290 degrees, heeling of 25º to starboard, and bottom reaction of approximately 155,000 t [US NAVY SALVORS HANDBOOK].

On June 1, 2020, after removing and jettisoning approximately 145,000 t of cargo, 3,900.00 cubic meters of fuel oil and arrangements that allowed high-flow, low-pressure air injection into some damaged ballast tanks, the ship was refloated. [DERRETT, D.R., 1985 & VASCONCELLOS J.M., 2007 & STOKOE, E.A., 1991]. Subsequently, it was inspected by the different interests involved who confirmed the extent of

damage to the bottom and sides [IACS-2008]. On June 12, 2020, with approximately half of the original cargo on board, removal of pollutants, it was towed as planned, successively flooded and scuttled at a location previously defined by the Brazilian Navy.

The vessel and her entire cargo were considered as total loss.


Vessel route after leaving the channel and up to intentional stranding

**Vessel's Background**

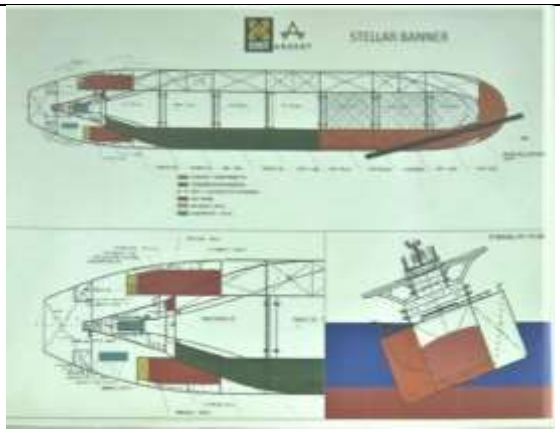
The vessel was a VLOC Ore carrier VALE MAX class of 300,000 DWT, entered into operation in 2016, having operated until 2020 in the transport of iron ore from Ponta da Madeira, in Maranhão, when it touched high bottom, was intentionally grounded, and then was refloated and sunk in deep waters on June 12, 2020.

**Technical Conditions of the Stranded Vessel**

The vessel, in the condition of aground, presented unsatisfactory technical conditions, with open water in the fore peak tank, ballast tanks 1 and 2 on starboard and duct keel, which had water ingress; later it was identified that the starboard fuel oil storage tank was also damaged, with seawater ingress into it.

It was also verified during the ship's stabilization operation that there was constant water ingress through the cargo hold hatches.

The bow of the ship varied by 5 degrees for each side, with an average of 290 degrees, the starboard bilge was touching the bottom with a grounding reaction around 100,000 ton, and list varying from 21 to 26 degrees, depending on the tide.




Vessel's flooded condition

Vessel's condition after intentional stranding

The vessel's drafts were read in a daily basis by contracted Salvors, there was a lot of tide variation (local tide has an amplitude of 6 m); and as an example, here are the drafts read on March 3, 2020:

| | Starboard | Port |
|---|---|---|

| | | |
|---|---|---|
| Forward | Not read | 19,40 m |
| Mid ship | Not read | 14,40 m |
| Afterward | Not read | 17,10 m |

The list angle in the above condition was 21 degrees.
The iron and ore cargo, in a total of 294.871 tons, was distributed on board in 7 cargo holds.
The displacement of the vessel with the above cargo was calculated and resulted in 337.742,20 tons.
The deadweight calculation resulted in 299.867,20 tons.
The liquids on board before the intentional stranding were as follows:

| | |
|---|---|
| Heavy Fuel Oil = | 3,424.46 tons |
| Diesel Oil = | 138.33 tons |
| Fresh Water = | 310.00 tons |
| Ballast = | 273.30 tons |

Notes on quantity of seawater into cargo holds:
The sounding of the water level in the cargo holds varied according to the tide and the angle of list, and it increased with the passing of the days; as an example, here is the reading of the water levels on March 5th:

Water level in the cargo holds

| Cargo Hold Portside Bilge Well sounding (m) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #1 F | #1 A | #2 F | #2 A | #3 F | #3 A | #4 F | #4 A | #5 F | #5 A | #6 F | #6 A | #7 F | #7 A |
| 21.1 | 17.7 | 9.1 | 11.8 | 13.9 | 12.9 | 14.6 | 14.6 | 8.4 | 7.4 | 2.2 | 0 | 0 | 0.1 |

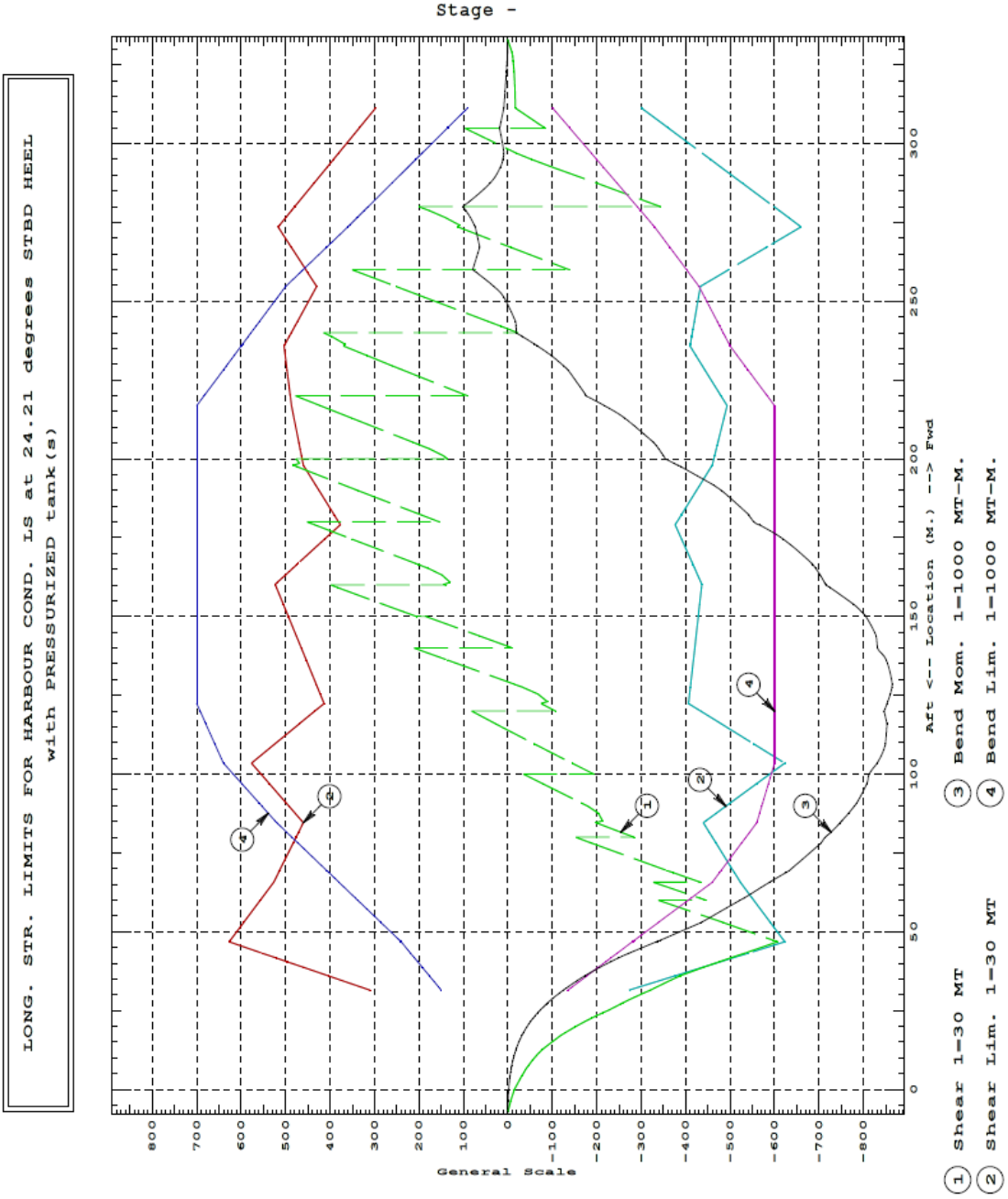
**Note:** Readings could only be taken from the port side, as part of the starboard deck was below the waterline, therefore, any water depth verified in the soundings had to be increased by approximately 10 meters to the theoretical water level by starboard.

Calculations were performed to visualize the bending moment diagram and shear force of the ship by the company in charge of the salvage, as follows.

```
06-04-20 07:43:20            Ardent Global, LLC                    Page 12
GHS 16.88                        RUN  - STAGE
                      STELLAR BANNER SALVAGE CALCULATIONS
                             eng  - Geo  - Tide 0
                                 Condition 4-2

                                    Stage -

DRAFT FP      25.33[M]      HEEL          24.21[DEG]      GMT(SOLID)      67.47[M]
DRAFT MS      23.47[M]      R.A.           0.00[M]        CORR. FSM        0.01[M]
DRAFT AP      21.61[M]      WIND               [KN]       GMT(FLUID)      67.46[M]
TRIM          -0.65[DEG]    WATERSPGR     1.025[T/M3]
LCG         -177.70[M]      VCG           12.89[M]        TCG              0.58[M]
DISPL.     240630.6[T]                                    TPCM          2906.98[T/CM]

  LONGITUDINAL STRENGTH with PRESSURIZED tank(s) at Heel = Stbd 24.21 deg.

-------------------------------------------------------------------------------
          LONG. STR. LIMITS FOR HARBOUR COND.  CRITERION SUMMARY
                 Largest Shear/limit:   117.5% at  31.500f
       Largest Bending Moment/limit:   144.1% at 128.700f (Sagging)
                 Largest Shear:    -18,208.2 MT      at  46.800f
       Largest Bending Moment:     -864,812 MT-m.   at 128.700f (Sagging)
```

STELLAR BANNER SALVAGE CALCULATIONS
eng - Geo - Tide 0
Condition 4-2

Stage -




**The Refloating Operation**

Calculations performed by the salvage company indicated the need to relieve 143,000 tons of cargo, out of a total of approximately 300,000 tons, together with recovery of the watertightness of some hatch covers and preparation for injection of air in the starboard ballast tanks [US NAVY SALVORS HANDBOOK-2004].

Also planned (and carried out) was the removal of the entire amount of diesel oil and heavy fuel oil on board, by means of transfer to other vessels, before the beginning of the cargo relief operation [AUSTRALIAN MARITIME SAFETY AUTHORITY].

Cargo relief was carried out by a ship moored alongside (ship to ship), with the assistance of a barge with a crane and ships equipped with a crane and, after problems with the crane barge, only with the support of vessels.

Originally the schedule would be to transfer the dry cargo (which soon proved not to exist on board, since all the cargo was wet, to a greater or lesser degree) and the wet cargo back to VALE, which had already spoken

with respect to the absence of contamination of the cargo by contact with sea water; however, soon after, VALE issued a new opinion, saying that it did not have the means to receive the wet cargo back, for logistical reasons (lack of equipment for unloading and transporting the cargo back to the storage yard).
In view of this development, the option was to unload the Stellar Banner vessel to other support vessels, but these vessels would unload the cargo at sea (would drop the cargo).

**Note:** This decision was due to the wetting of the cargo and the risks of liquefaction in case of overseas transport.

The dumping site for the cargo was defined in agreement between the Brazilian Navy and IBAMA (which confirmed that the cargo would not have an environmental impact) and the salvage company, having been defined a deep water location approximately 15 nautical miles to the west from the stranded position, as follows:

Local for cargo dumping

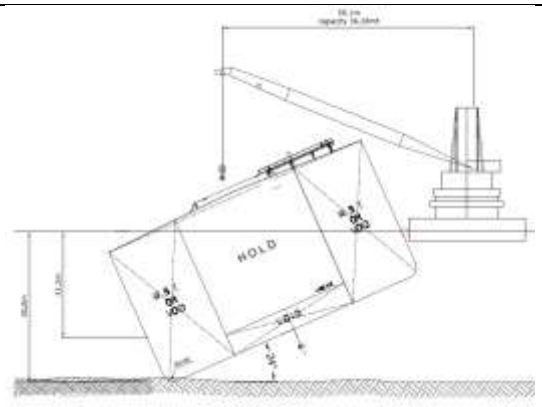



Diagram of Operation, vessel – crane barge

Ship to Ship Operation

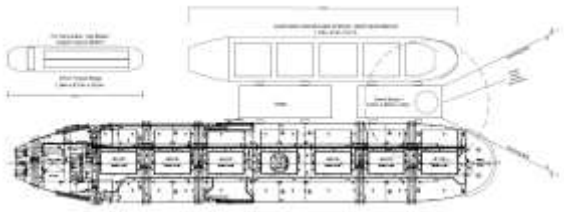


Diagram of transshipment with ships

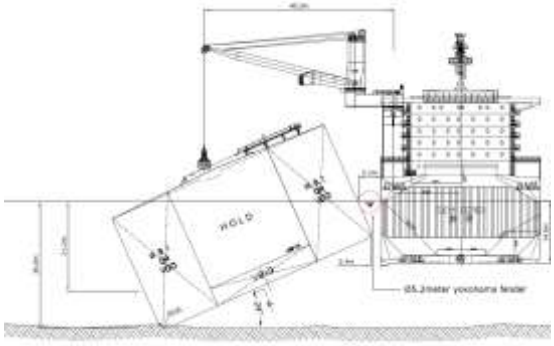



Diagram of Operation. Ship to ship

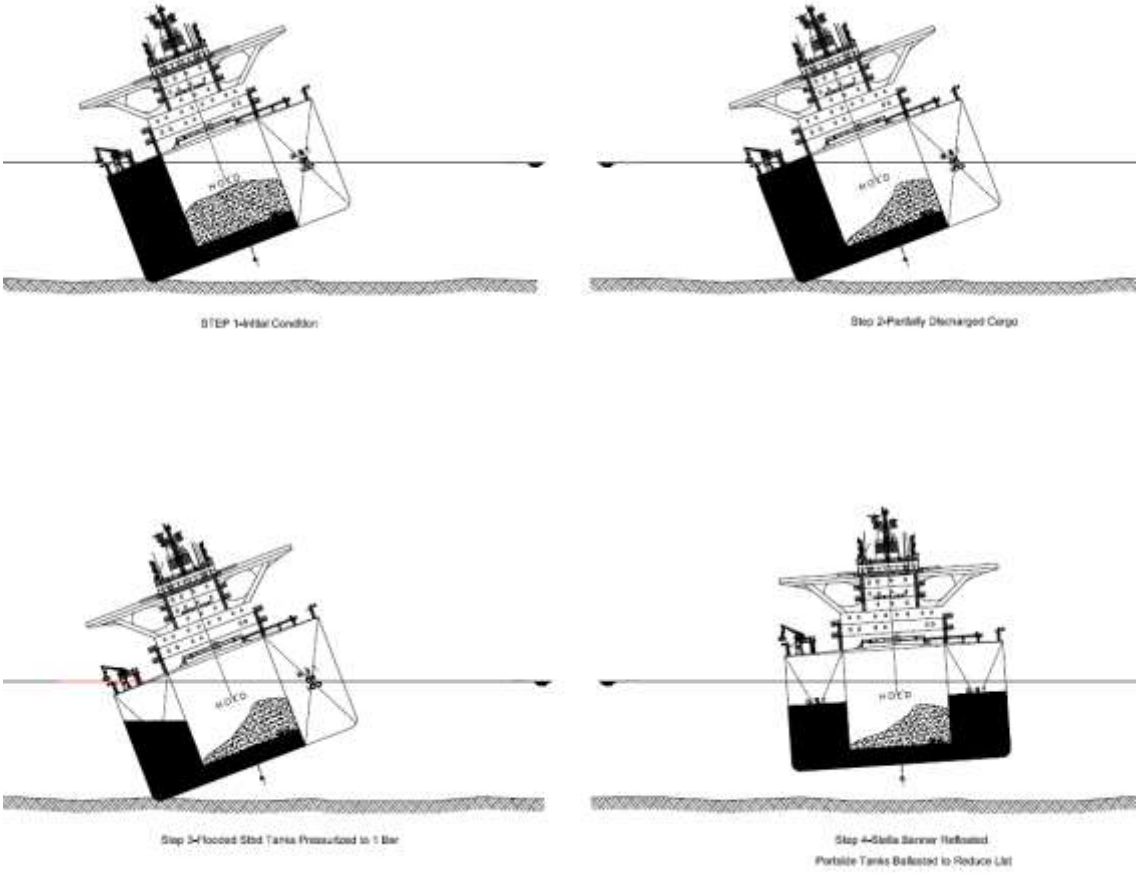


Diagram of the refloat sequence, with cargo relief and
air injection to recover buoyancy of the damaged ballast tanks

**Vessels and Tugs contracted**

For the intended Operation, the following crafts were contracted by owners with agreement of H&M Underwriters:

a. General support and pulling maneuvers of the vessel after refloating

| Name | Type |
|---|---|
| Normand Installer | Support and salvage tugboat |
| Bear | Offshore Support and Anchor Handling (AHTS), Ocean going vessel |
| 4 x Tugboats from SAAM / SMIT | Coastwise tugboats with 70 T Bollard Pull, each |

b. Transshipment of the cargo

| Name | Type |
|---|---|
| Normand Installer | Support and salvage tugboat |
| Superpesa 2 | Oceanic crane barge |
| Jan Blaken | Barge split hopper type |
| Leeuw | Barge split hopper type |
| TBN | Bulk carrier |
| Oldendorff | Bulk carrier for transportation of dry / wet cargo |

c. Transshipment of Diesel oil and Heavy Fuel Oil

| Name | Type |
|---|---|
| ALP Defender | Offshore support vessel |
| HOS Brass Ring | Offshore support vessel; transferred the combustible oils and retained on board 607 $m^3$ of oily residues for further discharge to shore in Niterói, RJ |
| Stellar Iris | Bulk carrier of the same Company of Stellar Banner, received the good combustible oils and also segregated on board the seawater contaminated ones |
| Leeuw | Barge split hopper type |
| TBN | Bulk carrier |
| Oldendorff | Bulk carrier for transportation of dry / wet cargo |

**The Operation Carried Out**

After removal of onboard fuels, removal / dumping of approximately 145,000 ton of cargo and arrangements that allowed air injection into some damaged ballast tanks, the ship was refloated on June 1st with the remaining cargo still on board, towed and scuttled, in sequence at a location previously defined by the Navy, and with authorization from IBAMA, on June 12, 2020.

After re-floating and underwater inspection, which confirmed the extent of the major damage, together with the costs of temporary repairs for traveling by tow to a suitable shipyard, and without technical guarantees, to dock and carry out the necessary permanent repairs, and the risk inherent to the damages and efforts suffered by the ship during the grounding and the refloating operation, confirmed the hypothesis of total constructive loss, and consequently the schedule of controlled sinking by successive flooding (Scuttling) of the ship was carried out [US NAVY TOWING MANUAL & BRAZILIAN NAVY – SCHOOL OF ASSISTANCE AND SALVAGE].

When re-floating and anchoring for the necessary inspections and before deciding on scuttling, the vessel's stress calculations showed satisfactory results.

Finally, on June 12, 2020, after towing, and upon arrival at the previously determined location, the scuttling of the ship was carried out through successive flooding from bow to stern [DERRETT, D. R., 1985 & VASCONCELLOS J. M., 2007 & IACS-2008]. At the time of the scuttling, the ship still had about 50% of the total iron ore cargo previously loaded in its cargo holds. This fact was due to the inherent risk of the cargo that, due to exposure to wetness when moving, could liquefy in overseas transport.



Scuttling of the vessel with successive floading

**Summary of Events**

| | |
|---|---|
| Sailing from the port in loaded condition | February 24, 2020 |
| Vessel touched bottom, and damages are discovered | February 24, 2020 |
| Vessel is intentionally stranded by her captain in order to avoid sinking and safeguard of life on board | February 25, 2020 |
| Vessel is refloated after partial relief of cargo (dumping) and injection of air in the damaged tanks | June 1, 2020 |
| Vessel is scuttled with remaining cargo on board | June 12, 2020 |

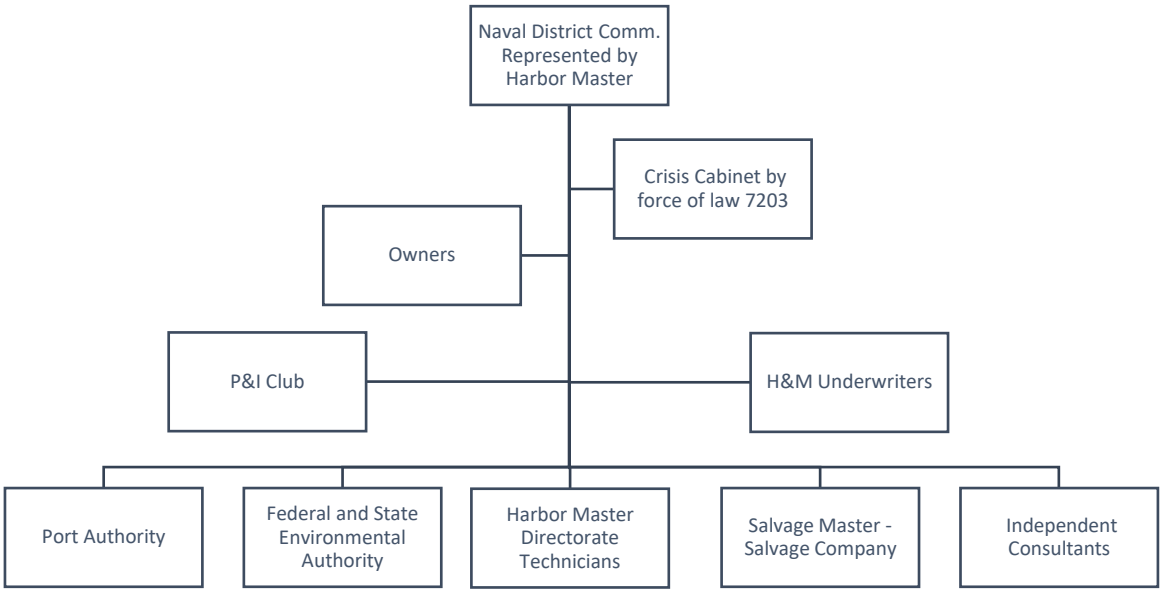
**Involved Costs**

The costs, borne in full by the Underwriters, including the value of the vessel, its cargo, supporting vessels, salvage companies and unforeseen events, can be estimated as follows:

| **Item** | **Value – US$** |
|---|---|
| Vessel cost (a) | 100,000.000.00 |
| Cargo cost (b) | 30,000.000.00 |
| Support vessels (c) | 7,000.000.00 |
| Salvage companies (d) | 12,000.000.00 |
| Unforeseen costs (10% of c+d) | 1,900.000.00 |
| **Total** | **US$150,900.000.00** |

**Conclusion**

Finally, due to the joint efforts of the different Parties involved in scenarios as described above, we currently have, under existing laws in Brazil, the requirement that, in the event of maritime accidents, the following parties act directly or indirectly in these operations:




Operational Chart

It is common knowledge that it is not possible to completely eliminate the occurrence of major maritime accidents. However, their incidence can be reasonably reduced and limited by applying joint work of the parties involved, that is, the state, underwriters, shipowners, charterers, national and environmental regulatory organizations. Added to that, schools and universities in the country, bringing specific technical knowledge and laboratories, a capacity that is still poorly used in this market segment.

In the recent past, we have that this model used with the coordination of the Maritime Authority and by force of Law nº 7203 of Maritime Salvage and with application of the NORMAMs 8 - Traffic and Permanence of Vessels in Brazilian Jurisdictional Waters, 16 - Assistance and Salvage Activities of Vessel, or Good in Danger at Sea and 17 - Aid to Navigation has proved to be quite fruitful.

Marine accidents are low-frequency. Undesirable events mainly due to the consequences and risks are not always linked to costs.

The celerity of actions by the participants in any of the operations listed here will significantly reduce not only the costs, but also the damages and risks involved.

In Brazil, this extremely important subject - "Technical and Economic Assessment of Maritime Accidents" - is under the control and coordination of the Ministry of the Navy which, due to its technical maturity, seeks to control and interfere in the technical aspects of rescue operations using its Port Captaincies and respective Naval Districts.

In recent years, the participation of the shipowner, together with hull and machinery underwriters and civil liability underwriters, has resulted in greater speed in solving major accidents, with very good results for the environment, thus avoiding pollution by hydrocarbons or visual pollution.

## BIBLIOGRAPHY

1. BBC NEWS, 2018. Shipwreck found in Black Sea is 'world's oldest intact'. *BBC News*. Disponível em: https://www.bbc.com/news/world-europe-45951132. Acesso em: 28 maio 2021
2. FRANCISCO, W. C., 2021, Transporte marítimo. *Mundo Educação*. Disponível em: https://mundoeducacao.uol.com.br/geografia/transporte-maritimo.htm. Acesso em: 29 jun. 2021, 12:15
3. Marine Accident Investigation Branch, 2015, *Grounding of oil tanker Sea Empress and the subsequent salvage operation*. Disponível em: https://www.gov.uk/maib-reports/grounding-of-oil-tanker-sea-empress-in-the-approaches-to-milford-haven-wales-and-the-subsequent-salvage-operation - Acesso em: 7 ago. 2021, vários horários

4. GARD NEWS, 2009, Salvage by committee? The UK system of handling marine emergencies. Disponível em: https://www.gard.no/web/updates/content/52016/salvage-by-committee-the-uk-system-of-handling-marine-emergencies. Acesso em: 15 ag. 2021.
5. BRASIL. Marinha do Brasil. *Você sabe o que é um Distrito Naval (DN)?* 2021. Disponível em: https://www.marinha.mil.br/sspm/?q=noticias/voc%C3%AA-sabe-o-que-%C3%A9-um-distrito-naval-dn - Acesso em: 19 ago. 2021, 10:00
6. International Maritime Organization, 2019, *International Convention on Salvage*: Adoption: 28 April 1989; Entry into force: 14 July 1996. Disponível em: https://www.imo.org/en/About/Conventions/Pages/International-Convention-on-Salvage.aspx - Acesso em: 19 jun. 2021, 08:00
7. BRASIL. Lei nº 7.203, de julho de 1984. Dispõe Sobre a assistência e salvamento de embarcação, coisa ou bem em perigo no mar, nos portos e nas vias navegáveis interiores. *Diário Oficial da União.*
8. BRASIL. Marinha do Brasil, 2003, *NORMAM-16/DPC – Normas da autoridade marítima para estabelecer condições e requisitos para concessão e delegação das atividades de assistência e salvamento de embarcação, coisa ou bem, em perigo no mar, nos portos e vias navegáveis interiores*. Disponível em: https://www.marinha.mil.br/dpc/sites/www.marinha.mil.br.dpc/files/normam16_0.pdf
9. BRASIL. Decreto nº 8.814, de 18 de julho de 2016. Promulga a Convenção Internacional sobre Salvamento Marítimo - SALVAGE-89, firmada pela República Federativa do Brasil, em Londres, em 28 de abril de 1989.
10. WIKIPÉDIA, 2020, Geografia do Brasil. *Wikipédia*. Disponível em: https://pt.wikipedia.org/wiki/Geografia_do_Brasil. Acesso em: 29 jun. 2021, 11:35
11. WIKIPEDIA, 2021, List of maritime disasters Pre-18th century. *Wikipédia.* Disponível em: https://en.wikipedia.org/wiki/List_of_maritime_disasters. Acesso em: 24 jun. 2021.
12. WIKIPEDIA, 2021, List of maritime disasters in the 20th century. *Wikipédia.* Disponível em: https://en.wikipedia.org/wiki/List_of_maritime_disasters_in_the_20th_century. Acesso em: 14 jul. 2021, 09:20
13. WIKIPEDIA, 2019, MV Spice Islander I. *Wikipédia*. Disponível em: https://en.wikipedia.org/wiki/MV_Spice_Islander_I. Acesso em: 15 jul. 2021 às 09:30
14. DICIONÁRIO ONLINE PORTUGUÊS, 2021, *Significado de Incidente*. Disponível em: https://www.dicio.com.br. Acesso em: 2 de jul. 2021.
15. IHS MARKIT, 2020, *State of Maritime Safety report launched today*. Disponível em: https://ihsmarkit.com/research-analysis/state-of-maritime-safety-report-launched-today.html. Acesso em: 27 jun. 2021.
16. PICOLO, S. P., 2009, *Principais aspectos no salvamento de embarcações mercantes no brasil e uma proposta de um modelo de gestão de encalhes*. Dissertação de M.Sc., COPPE/UFRJ, Rio de Janeiro, RJ, Brasil.
17. INTERNATIONAL TANKER OWNERS POLLUTION FEDERATION, 2020, *ITOPF – Handbook 2020/2021*. London, ITOPF Limited. Disponível em: https://www.itopf.org/fileadmin/uploads/itopf/data/Documents/Company_Lit/ITOPF_Handbook_2020.pdf. Acesso em: 03 jun. 2021, 09:00
18. SOYER, B., 2006, *Warranties in marine insurance*. 2 ed. London, Cavendish.
19. U.S. NAVY SALVOR'S HANDBOOK, 2004. [S.l.], Direction of Commander, Naval Sea Systems Command.
20. DERRETT, D. R., 1985, *Ship stability for masters and mates*, chapter 13, 14, London, Maritime Press.
21. VASCONCELLOS J. M., 2007. *Apostila Engenharia de Sistemas Flutuantes Offshore – ESFO – Estabilidade Aplicada*. [*S.l., s.n*]. [48] NAVIOS E PORTOS, 2021. *NORSUL Amazonas – 1987*. Disponível em: https://navioseportos.com.br/br/index.php/acervo-digital/navios/87-n/1432-norsul-amazonas-1987 - Acesso em: 09 ago. 2021, 13:00
22. STOKOE, E. A., 1991, *Reed's naval architecture for marine engineers*, chapter 5, 6, Sunderland: Thomas Reed.
23. U.S. NAVY TOWING MANUAL, 1971. *Washington, Office of the Supervisor of Salvage, U.S. Navy, Naval Ship Systems Command*.

24. AUSTRALIAN MARITIME SAFETY AUTHORITY, 2003, *Oil Spill Monitoring Handbook*. Canberra, AMSA. Disponível em: https://www.yumpu.com/en/document/read/8076796/oil-spill-monitoring-handbook-australian-maritime-safety-authority. Acesso em: 04 jun. 2021, 08:00
25. Ministério da Marinha - Escola de Socorro e Salvamento - Catálogo SOS - C-001