27º Congresso Internacional de Transporte Aquaviário, Construção Naval e Offshore

Rio de Janeiro/RJ, 23-25 de outubro de 2018

Qualitative Comparative Analysis between Specialized Multitasking Vessels and Ships with External Equipment in the Event of an Oil Spill

Alejandro Roldán León, UFPA, Belém/Brasil, aleroldan19@hotmail.com
Hito Braga de Moraes, UFPA, Belém/Brasil, hito@ufpa.br
Jean-David Caprace, UFRJ/COPPE, Rio de Janeiro/Brazil, jdcaprace@oceanica.ufrj.br

Abstract

This research paper looks at some of the main elements to consider during an oil spill in open or restricted waters, focusing on the emergency first response, and the most suitable equipment available in the market. The first section reviews global figures of oil spills, the international legislation and criteria for claiming compensation, and the marine effects of an oil spill from different angles. The paper also explains how oil behavior, exposure time, and available resources are the parameters needed to establish the most time-efficient and cost-effective response strategy. Lastly, resorting to a comparative analysis, it concludes that specialized oil-spill vessels have proven to add significant value in responding to emergencies at sea and mitigating environmental damages.

1. Introduction

Since 1970, and according to the International Tanker Owners Pollution Federation, (ITOPF) database, 81% of approximately 10,000 oil spills from tankers, combined carriers and barges, were less than seven tons.

Bigger incidents (>700 tons) from 2010 to 2016 represent approximately 7% of that (10,000 oil spills), during the 1970´s in average; this reduction implies that governments, oil shipping handlers, private and non-lucrative organizations (among others), have made combined efforts to improve safety and environmental management.

Currently, the total amount of oil spills varies. However, a few large spills are responsible for a high percentage of the total annual quantity.

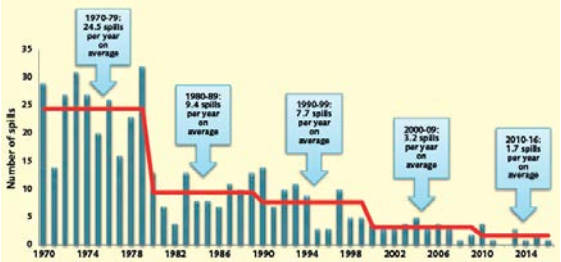

Figure 1 – Numbers of large spills (over 700 tons) (ITOPF, 2017)

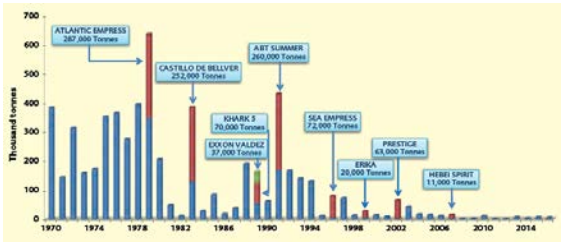

Figure 2 – Quantities of oil spilt, 1970 – 2016 (ITOPF, 2017)

During the period 1970-2016, 50% of large spills (>700 tons) occurred while the vessel was underway in open waters, 18% while underway in restricted waters, but the main causes of large incidents resulted in allisions/collisions (30%) and groundings (33%). Other causes include hull failure and/or fire and explosions, although in a lower proportion.

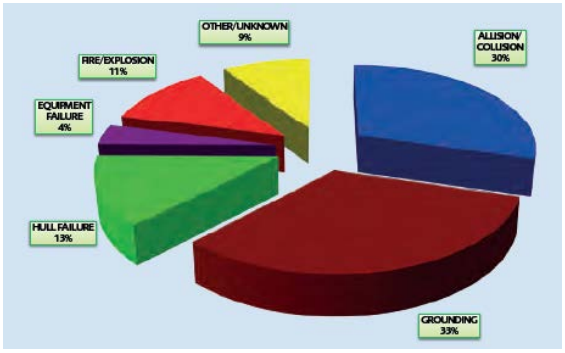

Figure 3 – Causes of large spills (>700 tons), 1970 – 2016 (ITOPF, 2017)

The biggest leaks during the oil spill "history" are not necessarily the most environmentally destructive. For instance, the tanker Exxon Valdez, which ran aground on Bligh Reef, Alaska in 1989, caused serious damage to the environment, killing thousands of seabirds as well as seals, sea otters, whales and fish. The overall impact of an oil spill cannot be measured solely on size; weather conditions, the type of oil and -most importantly- the time it takes to react, to stem the flow, direction and/or impact area, are some of the many factors that also need to be considered.

After the Exxon Valdez oil spill, the US government passed the Oil Pollution Act of 1990, known as OPA 90, which is a legislation about how companies are required to prevent, respond to, and pay for oil spills.

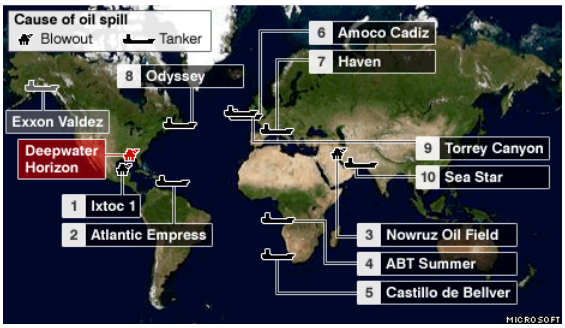

Figure 4 – Larger Oil Spills to date (BBC, 2010)

In Brazil the main events that are directly related to the creation of the oil spill legislation were the oil pipe brake in Guanabara Bay in 2000 (1.3 millions of cubic meters) and also the Petrobras refinery spill in Araucaria (4 thousand cubic meters), 2000.

Choosing the most appropriate oil spill clean-up techniques is crucial to reduce the environmental impact. Every guide, ship owner, and customer agree on the fact that a timely response will determine the best cost-effective strategy plan. If the spill is already over the water surface, it is known that the spill must not touch shore and vice versa. Consequently, all the techniques and environmental equipment will try to reduce the time lapse, facilities are now been loaded with Oil Spill Response (OSR) gear for inshore and offshore. This equipment is easily loaded into any vessel to perform the recovery. Most of the time, the room space for the "heavy" equipment is limited by the vessel operation or by safety and operational issues, which leads to maintain the "necessary" gear only, and sometimes zero equipment like Offshore Boom, Skimmers systems and Temporary additional Storage; leaving only the conventional oil spill deck kit.

This is highly problematic in case an incident offshore occurs, as the time lapse between the first alarm, activating the contingency plan, setting the equipment, loading -if necessary- and departing to the encounter of the leak will be increased unnecessarily. Needless to say the delay would be even greater if the response vessel was not at the dock ready for dispatch.

The best and most obvious option would be to have a dedicated oil response ship; however, its main limitation would be the high operational costs. There are several alternatives to equip any vessel with external gear in line with the risk and the contingency plan. However, a few options for a Multitasking Vessel that besides the main oil response duty, could also act as a working platform.

In the pages to follow, I will present a qualitative comparison between ships with external equipment to be loaded after an incident and multitask vessels with inbuilt equipment, based on a time-efficient strategy.

2. International Organizations and Legislation.

Over the years, the oil industry has developed a great know-how to prevent and combat oil spills. Those affected by spills created successfully a unique international compensation regime (up to USD 1.02 billon), applied in any State that chooses to ratify them, irrespective of the owner and flag of the tanker or the owner of the cargo.

Undoubtedly, wide recognition of the problems caused by heavy bunker oil spills by non-tankers, led to the adoption of the International Convention on Civil Liability for Bunker Oil Pollution Damage, which entered into force internationally in 2008.

Those IMO conventions (has been more than one since 1969) seek to ensure that adequate compensation is promptly available to persons who are required to clean up or who suffer damage because of oil spills.

A number of countries have their own domestic legislation, some of them based on IMO-MARPOL (International Convention for the Prevention of Pollution) or Canadian Coast Guard references. However, and despite of the standards set in these international norms, individual States still go for more stringent national laws. Therefore, all contingency plans should be regularly tested and updated having in mind local regulations and tailored solutions according to the risks and the context at the local facility.

Brazil was part of the CLC in 1969 and ratified the OPA 90 (ITOPF, 2017). Indeed, during the year 1990, Brazil issued the Federal Law 6.938, which establishes the mechanisms for prevention, awareness and recuperation of the environmental quality. Afterwards, the governmental entity CONAMA (Conselho Nacional do Meio Ambiente) was created. The CONAMA legislation is under the law 4.136/02 and the Oil Federal Law 9.666/00.

With the enactment of domestic laws and the ratification of international conventions, a State commits itself to establishing a national system for responding promptly and effectively to oil pollution incidents. This should include a national contingency plan. Ship operators, E&P facilities, ports and oil terminals are also required to prepare oil pollution emergency plans, including the sanctions and restoration works the incident may lead to.

3. Common Effects of Marine Oil Spills

Oil spills produce environmental damage, affect marine life, discredit institutions, lead to monetary sanctions and -ultimately- cause conflicts within communities.

The first step on the road to recovery is usually a well-conducted clean-up operation. (ITOPF, 2017).

The impacts from an oil spill depends on a number of factors, including the type, amount, weather conditions, sea conditions, area characteristics, economic factor, response time "gap" among others.

Typically, oil spills can impact offshore as well as inshore. For example, shallow coastal waters, Shorelines, People nearby, communities, Mari-culture, Plankton (long-term damage), Seabirds (its vulnerability and mortality), Sea mammals, economy, facilities and International Relationships. Therefore, the following steps "Recovery and Restoration" must began immediately.

4. Oil Spill - Behavior

When oil spilt on the water surface, it will move and spread under several changes both, Physical and chemical. This is called by the term "Weathering".

Oil weathering processes (OWP) act naturally on oil slicks conceived after oil spills, on the sea surface. It includes spreading, evaporation, dissolution, dispersion, emulsification etc. These processes are complex, self-competing and act simultaneously. Although, the processes like evaporation removes major fraction of volatile parts, the residue still thrive on the sea surface as a result of emulsion formation with enhanced oil volume. Then, not all oils emulsify; some even break and separate into oil and water phases. (ADITYA, 2015).

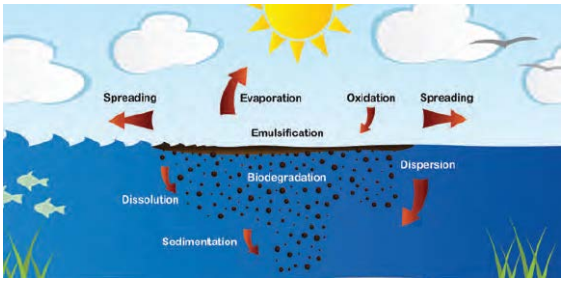

Figure 5 – Weathering Processes (ITOPF, 2017)

It is crucial to know the weathering or OWP as every detail counts when performing recovery and environmental mitigation tasks. As the Exxon Oil Spill Response Field Manual states, "speed is essential in recovery efforts" (EXXON, 2014).

While determining the properties and characteristics of the spilt oil, the Incident Commander will lead the teams into a proper and safe operation. Indeed, in establishing the oil persistence, the responders would certainly know the key for a complete oil recovery and mitigation operation. Both the lack of understanding and underestimating the effects of the oil spill, might exacerbate the already negative impact of the entire situation.

Although every oil spill is different and unique, considerations related to volume discharge, location and possible impact could be categorized in three tiers (EXXON, 2014):

Chart 1 – Three-Tiered Response (EXXON, 2014)

TIER 1	Accidental discharges at or near a vessel or facility due to disruption in routine operations. Low impact, in-house response.
TIER 2	Medium size spills occurring within the proximity of vessel or facility due to a non-routine event. Significant impacts, external support is required.
TIER 3	Large spills occurring near to or remote from a vessel or facility due to a non-routine event. Requires substantial resources and support, national or international.

The Tiered Response described in Chart 1 above provides guidance for purposes of decision-making. Afterwards, the team leaders will come up with the tactics for a clean-up response. Choosing the most appropriate technique will depend on the exact circumstances and facts, as explained in the previous section. Moreover, in some cases, a response might not be necessary, meaning that the oil will remain offshore and will dissipate and eventually degrade naturally without affecting coastal resources or wildlife. In such cases, monitoring the leak would be enough.

During spills, common oil types will behave as described below:

a. Light to volatile oils will spread rapidly. These tend to form unstable emulsions, have high evaporation and solubility, may penetrate the substrate, making it easy to remove from surfaces by agitation and low pressure flushing.
b. Moderate to heavy oils (medium to high viscosity) tend to form stable emulsions under high energy marine environments, the penetration depends on substrate size, may be absorbed by sediment and can form tar balls; recovery might require the use of heavy equipment.
c. Asphalt, Bunker C or waste oil will form tar balls at ambient temperatures, resist spreading and may sink or be suspended, can flow when exposed to sunlight, very difficult to recover from water, easy to remove from surfaces; heavy duty equipment required.

4.1. Time elapsed process

The chemical and physical processes versus the time elapsed between the spill and the exposure is explained in the next figure:

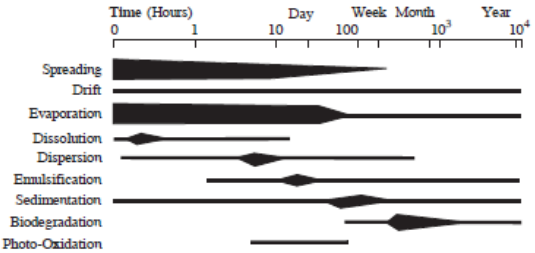

Figure 6 – Time Elapsed vs Oil exposure (EXXON, 2014)

Which means that the oil will evaporate and spread rapidly during the first hours to a few days; therefore, the time lapse to be more effective will be within that period.

5. Response Time

Any compensation under the international conventions named before, would require passing a reasonableness test in terms of incurred; costs as well as preventive measures themselves have to be "reasonable".
Interpreted to mean that the measures taken or equipment used in response to an incident were, according to an expert technical appraisal at the time the decision was taken, likely to have been successful in minimizing or preventing pollution damage. (ITOPF, 2017). Therefore, the "Response Time" to mitigate the impacts of the incident is crucial.

In fact, this is why property damage, economic loss, recovery, institutional discredit, etc. may be literately diminished when the right strategy is in place, proper equipment is used and trained personal take over.

6. Response Resources & Equipment

Once the alert is given and the incident command chain activates the contingency plan, the main resource is trained staffs. Usually, the vessel crew is also the response team because these staffs will operate and perform the containment and recovery either at open or restricted waters.

6.1. Containment Boom

In accordance with the spill behavior at sea and the OWP, oil will try to expand and move along with the current and the wind. This movement can be predicted by knowing the spill location and the bathymetric conditions. To limit the spreading, different types of Containment Boom may be used depending where the incident occurred. What is important to know is that if the spill is near the harbor or surrounding areas, the gear is oceanic boom (1.0 to 1.3 m height). However, if the spill occurs offshore and deep offshore, the type of boom will be heavy-duty oceanic boom, 1.5 to 3.5 meters height. The maximum length of boom deployed recommended is 500m because of the tension in the boom during the drag against the water; which in any case leaves us with a minimum of two reels of 250m of boom to load on a deck of any vessel available. Also, note that the reels will occupy less space.

6.2. Skimmers and Pumps

Once the spill is contained, the recovery process begins; the equipment used for this task is called Skimmer. There are different technologies, shapes and sizes, depending on the type of oil, viscosity, and recovery rate.

Some are remote controlled matched with the built in pump (generally positive displacement pump), hoses (hydraulic and discharge), driven by a powerful hydraulic power pack (PP). It is very rare that the hydraulic line from the vessel is available because of the pressure requirements. Note that if the spill occurs deeply offshore, or the recovery rate needed is more than 250 m^3/h, the Skimmer will have approximately 3m radio and the PP can reach a 20 feet container footprint on deck. If not, the equipment could be “medium” size and might be deployed from the harbor.

6.3. Temporary Storage

The temporary storage is a big concern during the process. Imagine arriving at the incident’s area with the Boom, Skimmer and floating storage tank, but not knowing the amount spilt or maybe knowing it but only several hours later. it is probably you who would find an intemperate oil or an emulsion (oil mixed with water) many hours away from shore; then the consequences become huge.
During the recovery, product comes in with a big amount of water, which can full the storage tanks earlier than expected. Sometimes the vessels have built-in storage tanks that help; but the best option is to have tanks that can be able to decant during the process.

7. Strategy

An effective logistics strategy during any event in open or restricted waters requires that these resources and gear are already loaded or fixed in the response vessel´s deck with enough space to maneuver the Boom, Skimmer, Pump and Storage tank (if needed); in the shortest time possible.

In order to fulfill that scoop, some responders have the equipment already loaded and ready for dispatch by air, road or sea. International organizations like the Oil Spill Response Limited or the National Response Coordination Center, two of the biggest ones, have a membership for customers who may eventually require assistance. Most of the times, this works only for a Tier 3 status, which means that the majority have their own equipment accordingly to its contingency plan.

The key in a strategy, not only to save time, effort and resources without major interruptions, is a well thought planning process.

8. Suitable Vessels for an Oil Spill Event

8.1. Non Specialized Vessels

During an emergency, any vessel available to assist the Incident Command Chain (ICC) requirements, is called “vessel of opportunity”. Generally, suitability is determined by the type and flexibility (maneuverability) of such vessels. Many companies include this option in their own contingency plans. In fact, even third party response companies have special agreements with ship owners if needed.

Nevertheless, not all ships can be called to assist during a response plan because of the lack of training, lack of qualified personnel, lack of space, unexperienced crew, or economic issues, among others. In addition, not all vessels are available at the harbor within the expected timeframe as they are involved in their own daily operations (not waivable).

Briefly, using a vessel of opportunity would imply additional time to set the equipment, as described below.

Time needed before departing:

- Localize the nearer shore or offshore and the appropriate equipment for the recovery (Operators, Boom, Skimmer, Pumps, Hoses, PP, Tanks)
- Set the backup equipment
- Perform a systems run up to check failures
- Set the transport logistics
- Transport the whole equipment "package" to the harbor, maybe several trucks or trips,
- Load properly the equipment on deck,
- Distribute the equipment on deck, if the vessel does not have a crane or bollards.

Furthermore, the input data from the Incident Command, such us relative position of the leak, type of oil, weather conditions, quantity and distance between the departure port to the contingency point, will be essential to calculate the response time.

The most common type of non-specialized vessel to assist in the occurrence of an incident are the TUG Boats and the Suppliers, mainly because of the deck space and the proximity during an operation (bunkering, load and discharge).

Small fast boats are used to help with the boom configuration and support any operation required during the maneuver.

8.2. Specialized Vessels

These are first line response vessels designed and built to provide immediate assistance in major oil recovery operations. These vessels are dedicated to attend any event in open or restricted waters, some others also fulfill other daily operations the owner may conduct.

The main characteristics related to the construction and purpose of these ships are:

a. Medium size, minimum 15.5 m up to 35 m where the space deck allows the responder to store the Boom, Skimmer, pumps, storage tanks and hoses. Depending on the type of oil and the location, the stability will roll a great impact in the maneuver. This also means that the ship can carry more equipment to be selective in the recovery and carry a backup system.
b. Built in storage tanks with a decanting pump, which will allow the responders to recover the oil only, and decanting the water while they are operating the skimmer. The bigger the better.
c. Lightweight with short draft to be used in open and restricted waters.
d. Fast and powerful. It has to reach the incident location as fast as possible and be powerful to tow the boom during the configuration process. As the maneuverability while performing the operation is an important issue, the vessel may have two main engines.
e. With the skimmer device built in. Saving space on deck, taking advantage of the hydraulic line, directly controlled from the wheelhouse and making possible to have a big recovery rate. Minimum 100 m^3/h.
f. Raised wheelhouse to provide a better oil vision and more operational control.

Therefore, to attend an oil spill, these vessels loaded already with the equipment, certainly with an experienced crew and ready for dispatch, will no longer need the previous timeframe described before.

In addition, time during a first response action can even be diminished if the ship is already surrounding the operation area where the incident might occur. This includes operations like bunkering or any other according with the contingency plan.

8.3. Types of Specialized Vessels (results and discussion)

Different types of recovery vessels are available in the market, but only a few were taken by the World Catalogue of Oil Spill Response Products which matched the characteristics described before. (WC, 2017)

Both selected vessels are built in steel and have a catamaran hull where the skimmer is built in the middle of the two twin hulls. This hull type is lightweight and fast to reach the muster point.

The main difference between the two vessels is the operational performance; one will use the principle Zero Relative Velocity, the other needs to wait for the spill and avoid overcoming the critic velocity of 0.7 knots (oil against the current). In addition, one has the space on deck to load the Reel Boom the other does not (smallest models).

Figure 7 – DESMI Pollcat 15.5m (DESMI, 2018)

DESMI principle ZRV states that the skimming process can be performed relatively while the spill moves along with the current. Therefore, the critical velocity can be avoided and the skimming process can reach 6-7 knots.

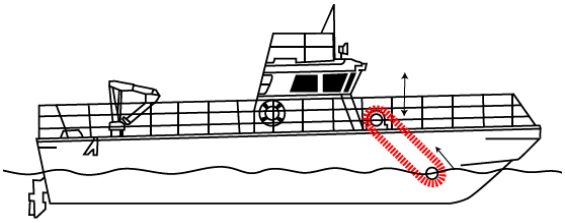

Figure 8 – Pollcat ZRV Zero Relative Velocity (DESMI, 2018)

Figure 9 – LAMOR JBF DIP4500 17.4m (LAMOR, 2018)

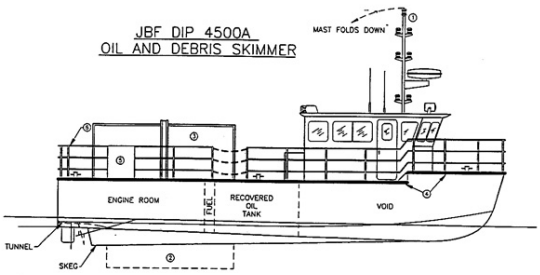

Figure 10 – Submersion moving plane (LAMOR, 2018)

Both vessels can also perform extra activities such as:

- Dispersant application,
- Fire fighting
- Command center duties,
- Debris recovery
- Towing duties
- General workboat duties.

In general, the two options from the WC 2017 matched the scheme but only one has the deck space to suit the boom and further more equipment, it is also useful to increase the recovery rate as much as possible to reduce the operational cost. Accordingly, the Pollcat may be more effective during the recovery operation.

9. Conclusion

The key for any recovery operation in an oil spill incident is the reacting time. This of course includes using the best available “tools” for this purpose.
As explained in this paper, in order to optimize time, having a vessel with the equipment onboard, or being itself the equipment, would make the difference to prevent or mitigate environmental impact.
According to the oil´s behavior, spills of lighter viscosity could result in emulsion over time, which is very difficult to recover and requires heavy equipment.
Figure 6 -describing time elapsed vs oil exposure process- shows that it is critical to act within the first hours, because the oil will evaporate and spread rapidly. Therefore, the option or method that allows a quicker response, diminished the logistics time will improve the operation significantly.

Finally, having multitasking vessels dedicated to combating and mitigating oil spills within the contingency plan will not only contribute to the decrease of response time increasing the

effectiveness of the strategy, but will empower the operator to respond to a great variety of scenarios with different types of hydrocarbons for both open and restricted waters. In parallel, based on the statistics of previous incidents and opportunities for improvement, the development of this concept "first response" decreasing the reaction time, is a technical solution for handling spills optimizing the equipment and with 24/7 availability.

10. References

ADITYA, K.; MISHRA, SURESH K. Weathering of Oil Spill: Modeling and Analysis Aquatic. 435 – 442. India. 2015.

CALIXTO, EDUARDO. Contribuições para plano de contingência para derramamento de Petróleo e derivados no brasil. UFRJ. 124 – 127. Brazil. 2011.

EGAWHARY, ELENA. How big is the Deepwater Horizon oil spill? BRITISH BROADCASTING CORPORATION. Magazine News. United Kingdom. 2010.

EXXONMOBIL. Oil Spill Response Field Manual. 2014 edition. England. 368 pages.

SLROSS. The World Catalog of Oil Spill Response Products. 11th edition. Canada. 2017.