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A CURRENT REVIEW ON OPERATIONS MANAGEMENT IN MANAGING MAJOR OIL SPILLS FROM SHIPS (TANKERS) IN THE STRAITS OF MALACCA, MALAYSIA

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ABSTRACT

Theoretically, operations management (OM) is concerned with the designing and controlling processes or redesigning business operations for production of goods and services. More so in managing oil spills from tankers in the Straits of Malacca (SOM). Mistakes in decision making couple with outdated practices exposed marine living and non-living resources to damages as a result of the shipping casualties. In any major global oil pollution from tankers or sometimes addresses as oil pollution disaster has hardly achieved a fully oils recovery due to several factors; natural or physical or both. In the case, the previous study found that this phenomenon happened anywhere in the world including in the SOM. Operations management of this specialised mechanism requires specialists from various expertise such as engineering, chemical, biological, nautical, environmental economics, legal persons and social scientists. The whole spectrum of expertise determined the structure of frameworks such as legislation, institutional and operational that assimilated into national oil spill contingency plan (NOSCP). The plan documentation dictated the requirement of oil spills preparedness and response, distribution of oil spill response equipment (OSRE) stockpile strategically, and the way how its operations be managed and maintained to undertake any eventuality of future oil spills disaster in the SOM.

Keywords: Operations management, national oil spill contingency plan, oil spill response equipment, expertise, disaster management.

INTRODUCTION

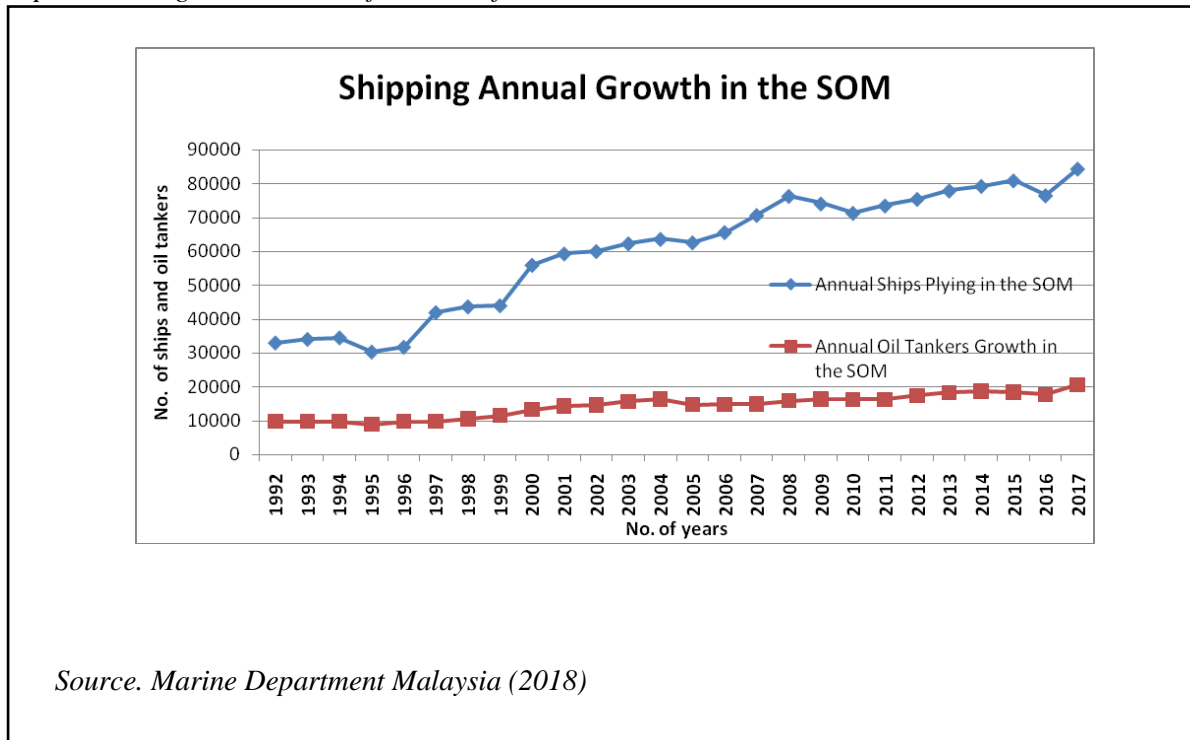
Theoretically, operations management (OM) is concerned with the designing and controlling processes or redesigning business operations for production of goods and services. In short OM is the study of decision making in the operations function. Specifically in its work, there are five main decision areas: quality, process, capacity, inventory and work force. OM was most suitable tool to review the past mechanism for managing major oil spills from ships (tankers) in the Straits of Malacca (SOM), Malaysia. The mechanism was established since way back in 1976 via approval by the Malaysian Cabinet. It was the beginning of its first edition of National Oil Spill Contingency Plan (NOSCP) (Department of Environment, 2014). Ever since, the plan had been enhanced for five times but it was found that no significant changes were made in term of policies and let alone the quality outputs such as key performance indicators and the level of efficiency.

The Straits of Malacca

Geographically, the Straits of Malacca (SOM) is 520 miles length and varies in width from 200 miles in the north to 11 miles in the south (Hamzah, 1977) where it meets with the Strait of Singapore. Due to its geographical constraints with surges of shipping traffic, the straits are exposed to ship collisions and other maritime casualties such as fire on-board, explosion and sinking that all lead to oil pollution. The SOM, besides being the importance and the pride of global as well as local communities because of its richness in marine resources, they are also served as one of the busiest strait in the world for international shipping. They provide a short cut passage between Europe, the Indian Sub-Continent and the Middle Eastern nations to Far Eastern countries. The Straits shipping volume have shown a high growth of an average 2.5% per year over 25 year period (Marine Department Malaysia, 2018) as shown in Figure 1.2. This increment was supported to global shipping growth of 4% over five year period, 2012 to 2017 based on the review of maritime transport from the United Nations Conference on Trade and Development (UNCTAD) in 2018. In 2017 alone, the ships carried about RM7.4 trillion of goods and services or about 30% of world trades. From that amount, about 80% of oils were transported from Middle East to China and Japan (United Nations Conference on Trade Development, 2018). Ships and oil tankers transiting in the SOM were 31,711 in 1992 and rose up to 84,456 in 2017, making it a big difference of 62.5%. This huge growth meant that the shipping traffic rises to an annual average of 2.4% since 1992 to 2017 (Marine Department Malaysia, 2018). The growth of traffic in the SOM also reflects a global shipping growth of 4% over the 5 year period, 2012 to 2017 (United Nations Conference on Trade Development, 2018).

Figure 1.2

Ships Transiting in the Straits of Malacca from 1992 to 2017



Under the same shipping statistics, the oil tankers grew up from 12,989 in 1992 to 27,340 in 2017 and there were an increment of 52.5%. Its growth reflects to the annual average increment of 1.9%. Comparing globally, it was recorded a slower growth of oil tankers of 2.4% in 2017 as compared to 4.0% in 2016 (United Nations Conference on Trade Development, 2018). Although there was a reduction in oil tankers volume but shipping risks are always high in the SOM due to other types of ship are on the rise. Most major oil spills were accidental but not operational and therefore they are unpredictable (Chen et al., 2019). Prevention is considered the best option to reduce the oil spill impacts but once the accident happens then the readiness of an efficient national oil spills contingency plan would make a difference. Since SOM are the busiest strait in the world for international shipping, it was reported that there were 888 casualties of various ship types over the past 25 years. Casualties may include ship collisions, grounding, beaching, on-board fire, explosion and sinking. Literature reviews indicate that these incidents were caused by a 75% human factor and the rest of 25% by technical factor (Kaur, 2016). The intensity of oil spills will depend on the carrying capacity and severity of the collisions of the oil tankers. Their carrying capacities are ranging from 10,000 tonnes to 320,000 tonnes depending on the oil tanker classes (The International Tanker Owners Pollution Federation Limited, 2018).

Generally, mitigation oil spill from ships is about the readiness of legislation framework along with institutional and operational frameworks. With global demand on the importance of protecting marine environment from the possible damages from the International shipping activities, Malaysia ratified and became a party to the United Nations Convention on the Law of the Sea, 1982 (UNCLOS 1982) in 14 November 1996. It became the significant mark for Malaysia to embark for its interest on the vast maritime areas not limiting to preservation and conservation to marine environment.

Some of the example of recorded marine resources found on the SOM which are on the Malaysian waters (Kaur, 2016): mangroves areas having 93,505 hectares; coral reefs are naturally found in Port Dickson, Pulau Payar and Pulau Perak; seagrass is found in Langkawi, Port Dickson, Seberang Perai and Teluk Nipah; and total fishery landings were 700,000 metric tonnes. Beside marine resources, economics lost to fishermen, aquaculture and tourism industries especially seaside beaches of Melaka, Port Dickson, Pangkor, Penang and Langkawi must be addressed as well. They are right things to do since all these claims fall under *polluter pays principle* (PPP) (Cordato, 2001). Without efficient operations management in

managing oil spills in the SOM, these marine resources had already shown the damages as a result of the impacts of oil pollution from ships and tankers.

LITERATURE REVIEW

Operations Management

A discipline in operations management can be traced way back for more than 200 years. Adam Smith, an economist had discussed the division of labour in his book, *Wealth of Nations* (1776). Then, came the standardisation of parts and it was advocated by the first car maker, Henry Ford (1913) and later enhanced by Chase and Aquilano. Next phase was the industrial revolution in the seventh century which saw human power was slowly replaced by machine power. In 1764, James Watt's steam engine had successfully transported agriculture outputs to factories. After the industrial revolution, there came the interests on scientific study work and later some of them were incorporated from physical and natural systems. These ideas were first mooted by Frederick Taylor in 1911 and later enhanced by Frank and Lillian Gilbreth throughout the early 1900s. Moving from the scientific study work, an area of human relations were emphasised on human motivation and human element in work design. These works were developed by Elton Mayo and others at Western Electric, United States in 1930s and the famous case was Hawthorne studies. From there on, decision models were introduced and the famous one is the "simplex method of linear programming" developed by George Dantzig in 1947. In the 1950s, computers were tasked to do operations management in selected businesses.

The dynamics of operations management was very rich and therefore there were resurgence of its application in nineteenth and twentieth century when global manufacturing and trades competed for competitiveness for exports (Schroeder, 1993). Internally in the same periods for developed nations, their economists suggested more investments for more competition with other nations whilst the technologists keep on asking for more funds on research and development. Lastly, the human resources experts wanted to compete by changing in approaches of managing people in order for better exports. But the answers to competitiveness issues simply laid on the application of operations management into their businesses.

The main objectives of this current review is to look on the operations management of managing major oil spills from tankers in the SOM into all the operations function, its system and decision making. There are five major operations function based on the definition of operations management, quality, process design, capacity planning and scheduling, inventory management and workforce management (Schroeder, 1993).

Oil Spills Preparedness and Response

Legislation Framework

Malaysia had ratified the UNCLOS 1982 and under its Article 235, every state obliges to have availability within the legal system for immediate and adequate compensations or other relief to undertake damages caused by oil pollution from ships into the marine environment. For this instant, Malaysia as a coastal state and flag state has to provide recourse to any oil pollution from ships in Malaysian waters and as well as beyond its territory that involve Malaysian ships. More so, there are six national legislations and seven international conventions are used to enforce, control and manage the oil spills in Malaysia by different government agencies as shown in Table 3.2.1 (Department of Environment, 2014). These legislations serve to those organisations for the functioning of administration, law and enforcement but they are also sourced as the basis to establish National Oil Spill Contingency Plan (NOSCP) and ASEAN Regional Oil Spill Contingency Plan especially from the International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990 (OPRC 1990). These legislations will be enforced by its respective agencies but most of the maritime enforcement now is being delegated to Malaysia Maritime Enforcement Agency (MMEA) via legal instrument, Malaysia Maritime Enforcement Agency Act 2004 (Act 633).

In Malaysia, all the international maritime conventions are officially administered by the Marine Department, Malaysia (MARDEP) or generally termed as the lead agency except for OPRC 1990 and the United Nations Convention of the Seas (UNCLOS), 1982. OPRC 1990 was given to Department of Environment (DOE) as its lead agency by the Malaysian government whilst UNCLOS 1982 was given to Ministry of Foreign Affairs (MOFA). Under legislation framework, Malaysia had ratified all the international maritime conventions and enacted all the national legislations to control oil spills from ships and tankers. This framework is the foundation and the backbone for the other two frameworks, institutional and operational. However, the latter two require rapid enhancements over time due to new technologies, new benchmarks and new standard operating procedures (SOPs).

Table 1

List of National Legislations and International Maritime Conventions in Malaysia (Source: MARDEP (2018))

No.	Name of National Legislation/Conventions	Lead Agencies in Malaysia
1.	Merchant Shipping Ordinance, 1952 (Ord. 70/1952)	Marine Department
2.	Environmental Quality Act, 1974 (Act 127)	Department of Environment
3.	Malaysia Maritime Enforcement Agency Act 2004 (Act 633)	Maritime Enforcement Agency
4.	Fisheries Act, 1985 (Act 137)	Fisheries Department
5.	Exclusive Economic Zone Act, 1984 (Act 311)	Ministry of Internal Trade, Consumer Affairs and Cooperatives
6.	Continental Shelf Act, 1974 (Act 83)	D. G,of Land Department
7.	United Nations Convention of the Seas (UNCLOS), 1982	Ministry of Foreign Affairs
8.	The International Convention for the Prevention of Pollution from Ships 1973/78 (MARPOL 73/78)	Marine Department Malaysia
9.	The International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990 (OPRC 1990)	Marine Department Malaysia
10.	The International Convention on Civil Liability for Oil Pollution Damage, 1992 (CLC 92)	Marine Department Malaysia
11.	The International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1992 (the 1992 Fund)	Marine Department Malaysia
12.	The International Convention on Civil Liability for Bunker Oil Pollution Damage, 2001 (Bunkers Convention 2011)	Marine Department Malaysia
13.	The Convention n Limitation of Liability for Maritime Claims, 1976 (as amended by the Protocol of 1996)	Marine Department Malaysia

Institutional Framework

Under the requirement under Article 6 of the International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990 (OPRC 1990), the coastal states through the lead agency, DOE must establish a national and regional systems for oil spills preparedness and response. As a comparison, the United Kingdom uses relevant parts of the OPRC 1990 to enact the National Contingency Plan (NCP) and hand-over to Maritime and Coastguard Agency (MCA) as its lead agency and the owner of OPRC 1990.

So here we can see different application between Malaysia and UK in term of institutional framework. Not only UK, the same practices are used in United States of America, European Countries, Japan, Korea, Singapore and Philippines. For further comparison between Malaysia and other ASEAN countries can be viewed in Table 3.2.2. In Malaysia, similar OPRC Articles were used to formulate the NCP but the lead agency is given to DOE with other core government agencies are given implementation and supporting roles in managing oil spills. The Malaysian Cabinet had directed DOE to be the lead agency on NCP or National Oil Spill Contingency Plan (NOSCP) as for Malaysia (Department of Environment, 2014). Lead agency has to play important roles to coordinate various strategies in managing oil spills especially in congested sea lane such as the SOM. However, management inefficiency had been observed due to poor operations coordination effort and they should be avoided. If inefficiency persists, it will affect inventory and logistics management leading to more exposure to pollution damages.

Multi-government agencies are given tasks to address oil spills at sea may result to inefficient management coordination in oil spills preparedness and response that will be affected onto the high economic values of marine resources and socio-economic of the impacted areas (Ishak et al., 2018; Albert, 2018; Chang et al., 2014; Bozeman, 2011; Kirby & Law, 2010). Former Malaysian Prime Minister had said in a forum that poor governance and overlapping jurisdictions of national maritime regimes will lead to inefficient utilization of resources (Mahathir, 2019). This framework concludes that the existing institutional framework operated under multi agencies where the lead agency is DOE by virtue as the custodian of OPRC 1990 should be given to another agency that really can focus on the maritime administration or maritime enforcement. Under the present arrangement, MARDEP is the implementation agency to combat oil spills at site whilst the MMEA is doing maritime enforcement at sea. Three different organisations, DOE, MARDEP and MMEA doing similar activities will have not produce better outputs because they have their own working cultures, priorities and variations of competent in human resources.

Table 2

Lead and Implementation Agencies Variation in Managing Oil Pollution in ASEAN Countries (Source: IMO/ASEAN (2009))

No.	ASEAN Coastal States	Lead Agency	Implementation Agency
1.	Brunei	Marine Department	Marine Department
2.	Cambodia	Marine Department	Marine Department
3.	Indonesia	Sea Transportation	Sea Transportation
4.	Malaysia	Department of Environment	Marine Department
5.	Myanmar	Marine Administration	Marine Administration
6.	Philippines	Coast Guard	Coast Guard
7.	Thailand	Marine Department	Marine Department
8.	Singapore	Maritime and Port Authority	Maritime and Port Authority
9.	Vietnam	Marine Administration	Marine Administration
10.	Laos	Land-locked Country	Land-locked Country

Operational Framework

As a coastal state, Malaysia has a comprehensive National Oil Spill Contingency Plan (NOSCP) since 1976 and it had been subsequently revised in 1986, 1989, 1994, 2000 and the latest in 2014 (Department of Environment, 2014). Its main contents and main committee members are still the same except the inclusion of Malaysia Maritime Enforcement Agency (MMEA) and Department of Marine Parks Malaysia (MPM) (Department of Environment, 2014) and later, in 2018 MPM was reorganised back to its former

department, Fisheries Department Malaysia. Operational framework in Malaysia is guided by the NOSCP and had being drawn up according to national legislations and international maritime conventions as stated earlier and also shown in Table 3.2.1.

Basically, OPRC 1990 via its various convention articles played important roles in formulating and establishing the Malaysian NOSCP. These articles promote the establishment of each coastal state to have its own national contingency plan under one lead agency. Other promotions include the coastal states should have regional and international cooperation with regard to assistance, training and technology development. In Malaysia, NOSCP comprises of 17 members that sit on as National Oil Spill Control Committee (NOSCC) for giving advisory and guidance on the control of oil spills for Malaysian waters as well as for regional cooperation between neighbouring states. This is the official document for operational framework in Malaysia working on a Tier System. Activation of Tier 1 is carried out by terminal owner but for Tier2 and Tier 3 must come from the DOE headquarters' directives based on the NOSCP where each agency will be assigned to their responsibilities to undertake their roles in managing oil spills in Malaysia. The functions and responsibilities of these agencies are shown in Table 3.2.3.

A famous modelling oil spill trajectory study in Bosphorus Strait, Turkey had shown that a contingency planning is very important to prevent oil spills reaching the shorelines and they will take less than four hours if no response taken place. Second conclusion is that emergency stations must be determined at suitable arrangement to minimise the oil spill impact (Bozkurtoglu, 2017). Under this framework, it can be concluded that the existing NOSCP is still relevant but it is subjected to be updated to complement with the latest use of technology and new benchmarks in managing oil spills at sea. Whoever takes the responsibility of single entity preferably as both lead and implementation agency will be the new custodian of NOSCP including OPRC 1990.

Table 3

Malaysia National Oil Spill Control Committee (NOSCC) Members (Source: Department of Environment (2014))

Agencies	Functions and Responsibilities
1. Department of Environment (DOE)	Lead agency. Director General is the Chairman of the Committee
2. Marine Department Malaysia (MARDEP)	Implementation agency and On-scene Commander for Tier 2 and Tier 3 oil spills
3. Malaysia Maritime Enforcement Agency (MMEA)	Vessels provider, maritime enforcement and investigation
4. National Security Council (NSC)	Overall national security
5. Ministry of Foreign Affairs (MOFA)	Advisory on foreign aids
6. Department of Fisheries (DOF)	Fisheries resources provider and claim from fishermen
7. Department of Meteorology	Meteorology on weather and sea conditions
8. Royal Malaysian Navy (RMN)	Advisory on maritime boundaries and sovereignty
9. Royal Malaysian Air Force (RMAF)	Air surveillance on oil slick movement and dispersant spraying whenever required
10. Royal Malaysian Police (Air Force)	Air surveillance on oil slick movement
11. Royal Malaysian Police (Marine Force)	Oil spills site supervision and security controls
12. Royal Malaysian Customs	To facilitate oil spill response equipment (OSRE) imports

13. Immigration Department Malaysia	To facilitate foreign manpower and professionals into Malaysia to assist oil spills disaster
14. Fire and Rescue Department Malaysia	Dispersant spraying whenever required
15. Department of Marine Parks Malaysia	Provider for sensitive sea areas, biodiversity and ecotourism
16. Petroliaam Nasional Berhad (PETRONAS)	Advisory on oil spills
17. Petroleum Industry of Malaysia Mutual Aid Group (PIMMAG)	Advisory on technical and operation of OSRE

METHODOLOGY

The approach on the methodology for this review will be based on a “grounded theory”. This theory used qualitative data to explain why a certain phenomenon happened by studying a variety of similar cases in different settings and using the data to derive causal explanations. It was first introduced by Glazer and Strauss in 1967 (Merriam, 2009). Data from the grounded theory came from documents, statistics, reports and observations are analysed. The analysis of the existing oil spill mechanism frameworks that comprises of the legislation, institutional and operational arrangements in managing major oil spills from tankers in the Straits of Malacca (SOM) are the main focuses. The fundamentals of oil spill mitigation of oil spill from tankers in Malaysia did not change much but minor amendments did materialise in the national oil spills contingency plan (Department of Environment, 2014). Therefore, this analysis will explore and identify on the current practices and processes efficiency of these frameworks. All the outcomes from the analysis will be made known and recommends for changing the existing norms for new norms. The results will not only increase the efficiency and quality of the operations management of the mechanism in managing oil spills in the SOM but they will raise better oil spill compensations than the past cases.

RESULTS AND DISCUSSION

To sustain and protect our marine environment from damages as a result of international shipping activities in the SOM, the priority should be given to establish an efficient inventory and logistics management to undertake operations in combating oil spill at sea promptly. The marine environment impacts will be huge burdened to the stakeholders if prompt preparedness, response and combating are neglected. Multi agencies with different legislation, institutional and operational frameworks will distort the command and planning structures of the national oil spill contingency plan (NOSCP) including funding and regular maintenance of OSRE. New frameworks should be explored to create new norms in mitigation major oil pollution in the SOM.

Legal Framework

Malaysia legal framework has no issue since all the international maritime conventions had been ratified by the government as shown in Table 3.2.1. National legislations were well instituted by various related government agencies that deal with oil pollution unless the oil spill preparedness and response mechanism going to be reformed for a better one.

Institutional Framework

Changing to the New Norms

The old practices gave Malaysia some indicative of negative results in managing major spills especially in the SOM compared to some developed coastal states such as in United States of America, European countries, Japan or even to our neighbouring country, Singapore. Therefore the new norms should be opted in to revolutionise the way it manages the activities. It was no doubt that by forgoing the multi agencies to a single entity or single agency will definitely eliminate inefficiency, duplicating functions and responsibilities, dubious quality management, inadequacy of OSRE stockpiles and lack of response team training. In short, the single entity should be given to either MMEA as first option since it has the assets, functions, and maritime communication infrastructure and facilities. For second option, it is a right idea to hand over to MARDEP since it manages the OSRE assets as well as the implementer in combating oil pollution at sea closes to two decades. Both options will address the first obstacle of having different lead agency, DOE and implementation agency, MARDEP. Hopefully, it will later be managed by a single agency. To make things clearer, a comparison table to identifying the duplication of functions and responsibilities of the authorities are given in matrix forms as shown in Table 5.2. A careful selection will be made in order to transfer some of the functions and responsibilities to single agency as shown in its right column of the matrix. By having single agency, the efficiency of inventory and logistics management will definitely be resolved hence can boost further efforts to combat spilled oil at sea from damaging our marine resources and its coastal communities.

Table 4

Matrix Functions from Multi Agencies to Single Agency/Entity to Enhance Inventory and Logistics Management in Managing Oil Spill in the SOM (Source: Author (2024))

No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Government Agency's Functions and Responsibilities	The Convention of OPRC, 1990	National Oil Spill Contingency Plan	Tier System Declaration	Oil Spill Committee Chairman	Oil Spill Compensation Regime	OSRE Stockpiles	OSRE Funding	OSRE Maintenance	OSRE Response Team	OSRE Response Vessels	On-Scene Commander	Maritime Competent Authority & IMO	Maritime Administration & IMO	Maritime Enforcement	Vessel Movement Monitoring	Search and Rescue (SAR)	Vessel Assets and Fleets Availability	Maritime Operations Communication	Post-Oil Spilled and Restoration
Department of Environment, Malaysia (DOE)	✓	✓	✓	✓	✓														✓
Marine Department Malaysia (MARDEP)					✓	✓	✓	✓	✓	✓	✓	✓	✓						
Malaysia Maritime Enforcement Agency (MMEA)														✓	✓	✓	✓	✓	
Single Agency/ Entity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	

Currently, there are three main agencies looking for oil pollution from ships and tankers excluding other those sitting on National Oil Spill Contingency Committee (NOSCC). The three main agencies are DOE, MARDEP and MMEA. Their functions are also shown in Table 5.2. To have effective and strong management in managing oil spills at sea particularly in the SOM, Malaysia needs to have just one entity or single agency. Other agencies can be maintained as per the existing National Oil Spill Contingency Plan (NOSCP) in providing inputs for this regime in case there are new technologies and new standard operating procedures (SOP) that can be adopted and utilised. To change to new norms are not an easy task for the government agencies but it will need strong political wills to revolutionise since it had been operating the existing framework for more than two decades. Political wills here meant to break loose the strong empire building from each individual government agency which later needs strong endorsement from the Malaysian Cabinet.

Operational Framework

Lead and Implementation Agency

Issues on the OPRC 1990 is going to be a cross-cutting issue between DOE, MARDEP and MMEA because of their nature and similarities of functions, responsibilities, assets and funding. It is an urgent need to address these problems for further future policy direction. This convention looks simple but operational wise it may react differently due to different government agencies having different scope of activities, operations and responsibilities couples with their own legislations. It is recommended that the government should consider the OPRC 1990 to be led by other maritime agencies such as Marine Department Malaysia (MARDEP) or Malaysia Maritime Enforcement Agency (MMEA). Some relevant maritime legislation under respective agencies should be amended to support the change of OPRC 1990 custodianship to other agency. The change of lead agency from DOE to a new single entity will definitely improve the efficiency of inventory and logistics management in managing oil spill in the SOM since the duplication of functions and responsibilities are eliminated as well as funding can be streamlined and focussed.

Performance of the Old Norms

After a thorough study of the OSRE stockpiles capability equipped along the SOM currently, it was found that it has only 62.5 kilobarrels (KB) or 9,938 tonnes (Department of Environment, 2014). The unit of 62.5 kilobarrels capability means the oil spill response equipment (OSRE) can vacuum the oil slicks from the incident site at rate of 9,938 tonnes per hour. Experienced from MT *Evoikos* incident in 1997, it had shown that 29,000 tonnes oil had spilled into sea (The International Oil Pollution Compensation Funds, 2007). It had taken three months for oil slick to completely diminished from sea surfaces in the SOM which later ended in Pangkor, Perak. This meant that SOM's OSRE stockpiles were below capacity by 19,000 tonne under current arrangement. Adequacy OSRE stockpiles is one of the parameter for successful disaster mitigation to any major oil spills of the affected areas. The data in Table 5.4 had shown five major oil spills in the SOM over the 20 year period at an interval of one to ten year and the pollution intensity ranging from 2000 – 29,000 tonnes per oil tanker. The oil pollution incident had impacted the coastlines, sensitive ecosystem, socio-economic of the local and most of fishermen on the said areas could go to sea to earn a living. One of the major oil pollution was a collision between *Evoikos* (80,823 GT) and *Orapin Global* (138,037 GT) in 15 October 1997. *Evoikos* was carrying 130,000 tonnes of heavy fuel oil suffered damage to her three cargo tanks. As a result of the incident, 29,000 tonnes oil spilled into the Straits but there was no spilled from another vessel, *Orapin Global* because she was on ballast (The International Oil Pollution Compensation Funds, 2007).

Table 5

Oil Spill Disasters in the Straits of Malacca from 1990-2010 (Source: Department of Environmental Malaysia (2018))

Incident	Year	Location	Estimated oil spilled (tonnes)	Length of affected areas	Environmental effect
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MT Nagasaki	1992	Langkawi	13,000	14 miles	Fisheries, beaches, Spirit small islands and tourism
MT Evoikos	1997	West coast of Johor, Malacca, N.Sembilan, Selangor and Perak	29,000	391 miles	Fisheries, beaches, small islands, sea-grass and tourism
SS Sun Vista	1999	Coast of Perak	2,226	23 miles	Fisheries, beaches, small islands and tourism
MT Natuna Sea	2000	Eastern coast of Johor	7,791	23 miles	Fisheries, beaches, small islands and tourism
MT Bunga Kelana 3	2010	Eastern coast of Johor	2, 067	23 miles	Fisheries, beaches, small islands and tourism

Table 6

Average Clean-up Cost per Tonne Oil Spilled (Source: Erik V. et al. (2008))

Region	Cost per tonne spilled (USD per tonne)	Share of global oil tanker traffic in region (%)
Middle East	300	8
South America	3800	18
Africa	3900	18
Oceania	6900	2
Europe	13,100	11
North America	24,000	19
Asia	33,000	24
Weighted global average 15,900		100

The overall managing oil spill at sea is not a simple and cheap operations but the costs are extremely high unless clean-up costs can be recouped back from claims paid by the oil spill compensation regime. Based on the report in Table 5.4b, Asia had the highest average clean-up cost per tonnes oil spilled throughout the globe (Vanem et al., 2008). Therefore, they must be reasoned why the average costs was high and the answers were generally inefficiency of inventory and logistics in the system of operations management. These negative practices should be corrected cohesively under the new practices or new standard operating procedures (SOPs) in NOSCP. Also a review of the past oil spill claims, Malaysia had been compensated for US\$0.792 for *Evoikos* oil spills in 1997 incident but it was less 26% than the amount that had been claimed. Surprisingly, for the same incident, Singapore was compensated for a full amount of US\$8.038 or 100% of her claims (The International Oil Pollution Compensation Funds, 2007). Malaysia had put claims less due to inefficient, substandard submissions and also not fulfilling the compensation or insurance admissibility.

CONCLUSION

The outcomes on the literature review and data analysis of this paper, we can conclude that the levels of priority and coordination were different from each agency on managing major oil spills from ships and tankers in the SOM. It is inferred that the efficiencies of inventory and logistics management will be at optimum when managed by single agency rather than by multi-agencies. With crowded agencies, every capital and maintenance costs translated into higher costs of operations with lower efficiency of inventory and logistics management. These outcomes may result more damages to the marine environment and displacement of coastal communities especially to local fishermen. It is recommended that it is a high time for the Malaysian government to opt for a single agency to manage the major oil spill in the SOM. In order

to change to single agency, legislation and institutional frameworks must be transfer to single agency in order for it to manage more efficiently. Main instruments of legislation that must be took place is OPRC 1990 and follows by national legislation. For institutional framework, the government via cabinet directive must make decision to endorse which single agency will consolidate both responsibilities of leading and implementing mechanism from two different agencies, DOE and MARDEP respectively. It is suggested that the best agency, MMEA or MARDEP should be appointed as single agency to address the efficiency issues in operations management in managing major oil spills from ships and tankers in the SOM.

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