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**WORLD MARITIME UNIVERSITY**

Malmö, Sweden

**A STUDY OF MARITIME SAR SERVICES AND  
SAFETY OF SMALL VESSELS: A REGIONAL  
PERSPECTIVE WITH FOCUS ON PAPUA NEW  
GUINEA**

By

**MIDDLETON KIRWASI GWADAY**

**Papua New Guinea**

A dissertation submitted to the World Maritime University in partial  
Fulfilment of the requirements for the award of the degree of

**MASTER OF SCIENCE**

**In**

**MARITIME AFFAIRS**

**(MARITIME SAFETY & ENVIRONMENTAL ADMINISTRATION)**

2019

## **DISSERTATION DECLARATION FORM**

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): **Middleton Kirwasi Gwaday**

(Date): **September 24, 2019**

Supervised by: **Dr. Anish Hebbar**

Supervisor's affiliation: **Associate Professor, MSEA**

## **ACKNOWLEDGEMENTS**

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## **ABSTRACT**

Title of Dissertation: **A study of maritime SAR services and safety of small vessels: a regional perspective with focus on Papua New Guinea**

Degree: **MSc**

This dissertation is a study of the provision of maritime search and rescue (SAR) services and safety of small vessels in small island developing states in Pacific region and focusing on Papua New Guinea (PNG).

Addressed in the study are problem areas related to policy, resources (facilities, & equipment), personnel training, personnel incentives, safety culture amongst coastal and island communities, cooperation amongst stakeholders and neighboring SRRs, and safety of small vessels, weather factors, communication challenges.

In this study a mix of research methods were used to gather necessary information which included surveys, questionnaires and interviews with relevant target groups and analyzed the current maritime SAR systems and maritime safety systems in PNG and neighboring SRRs.

Identified during the study are gaps/problems/issues currently impacting the maritime SAR services and safety measures of small vessels operating in PNG waters. As an archipelagic state it is challenging to meet these obligations in providing this service to the maritime community and stakeholders.

In addressing the problem areas, SAR systems in Indonesia, the Solomon Islands, Fiji and Vanuatu have been studied as well and the lessons learned on how these types of problems are addressed by these states with similar settings as PNG. Australia, being the regional coordinator and Sweden both were selected due to their effect on maritime SAR systems and the enforcement of safety measures on small vessels.

The study has contributed to ideas on how to effect maritime SAR services and the safety of small vessels in an archipelagic state, like PNG, with many challenges due to the isolation of coastal and small island communities.

**Keywords:** Search and rescue, SAR, safety, maritime safety, Formal Safety Assessment, FSA, safety of small vessels, small island developing states, Papua New Guinea. PNG.

## TABLE OF CONTENTS

<b>DECLARATION</b>	ii
<b>ACKNOWLEDGEMENTS</b>	iii
<b>ABSTRACT</b>	iv
<b>TABLE OF CONTENTS</b>	v
<b>LIST OF TABLES</b>	viii
<b>LIST OF FIGURES</b>	ix
<b>LIST OF ABBREVIATIONS</b>	x

### **CHAPTER 1: INTRODUCTION TO A STUDY OF MARITIME SAR SERVICES AND SAFETY OF SMALL VESSEL – A REGIONAL PERSPECTIVE WITH FOCUS ON**

<b>PNG</b>	1
1.1 Background	1
1.2 Maritime SAR and vessel safety	2
1.3 Research focus	3
1.3.1 Purpose	3
1.3.2 Aim	4
1.3.3 Objective	4
1.3.4 Benefit of the study	4
1.4 Geographical area of study	5
1.5 Major maritime accident	7
1.6 Chapter structure	10

### **CHAPTER 2: LITERATURE REVIEW OF MARITIME SAR SERVICES AND SAFETY OF SMALL VESSELS**

2.1 Introduction	11
2.2 International legal framework for maritime SAR services and safety of small vessels	11
2.2.1 The United Nations Convention on the Law of the Sea 1982 (UNCLOS)	11
2.2.2 International Convention on Maritime Search and Rescue (SAR) 1979	12

2.2.3 International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual.....	12
2.2.4 International Convention for the Safety of Life at Sea (SOLAS), 1974.....	13
2.2.5 The International Convention on Salvage 1989.....	13
2.2.6 Torremolinos Convention and the Torremolinos Protocol.....	13
2.2.7 Code of Safety for Fishermen and Fishing Vessels.....	14
2.2.8 FAO-ILO-IMO Voluntary Guidelines for the Design, Construction and Equipment of small Fishing Vessels.....	14
2.3 Maritime SAR provisions.....	14
2.3.1 Maritime SAR policy.....	14
2.3.2 Maritime SAR resources.....	15
2.3.3 Maritime SAR personnel training.....	15
2.3.4 MRCC staffing.....	16
2.3.5 Stakeholder cooperation.....	16
2.3.6 Mass rescue operation.....	16
2.3.7 Medical advice and assistance.....	17
2.4 Regional approach to maritime SAR services and safety of small vessels.....	17
2.5 PNG national legal framework on maritime SAR services and safety of non-convention size vessels.....	18
2.5.1 PNG Merchant Shipping Act (MSA)1975.....	18
2.5.2 PNG National Maritime Safety Authority Act (NMSAA) 2003.....	19
2.5.3 PNG Merchant Shipping (Safety) Regulation (MSSR) 2006.....	19
2.5.4 PNG Small Craft Act (SCA) 2011.....	20
2.6 Issues and challenges faced by PNG MRCC and NMSA.....	20
2.6.1 Internal.....	20
2.6.2 External.....	21
2.7 Conclusion.....	21
<b>CHAPTER 3: RESEARCH METHODOLOGY.....</b>	<b>22</b>
3.1 Introduction.....	22
3.2 Research strategy.....	22

3.3 Research method.....	22
3.4 Research approach.....	23
3.5 Data collection method and tools.....	23
3.5.1 Questionnaires.....	24
3.5.2 Interview and other sources.....	25
3.6 Sample selection.....	25
3.7 Research process.....	27
3.8 Data analysis.....	27
3.9 Ethical considerations.....	28
3.10 Research limitations.....	28
<b>CHAPTER 4: FORMAL SAFETY ASSESSMENT OF MARITIME SAR SERVICES AND SAFETY OF SMALL VESSELS IN PNG.....</b>	<b>29</b>
4.1 Introduction.....	29
4.2 FSA Step 1 – Identification of hazards.....	30
4.2.1 Historical data.....	30
4.2.2 Ranking of hazards and risk matrix.....	32
4.3 Step 2 – Risk analysis.....	42
4.4 Step 3 – Risk control options.....	50
4.4.1 Identification of RCOs.....	51
4.4.2 Listing of RCOs.....	58
4.4.3 Risk reduction.....	61
4.5 Step 4 – Cost-benefit assessment.....	64
<b>CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS.....</b>	<b>70</b>
5.1 Conclusion.....	70
5.2 Recommendations.....	71
5.3 Further areas of research.....	76
<b>REFERENCES.....</b>	<b>77</b>
<b>APPENDIX 1.....</b>	<b>86</b>
<b>APPENDIX 2.....</b>	<b>90</b>



## LIST OF TABLES

Table 4.1:	Hazards per risk index.....	33
Table 1:	Severity Index.....	90
Table 2:	Frequency Index.....	91
Table 3:	Risk Index.....	92
Table 4:	Severity index for oil spill from ship.....	92

## LIST OF FIGURES

Figure 1.1	PNG and neighboring countries.....	5
Figure 1.2	PNG SRR.....	6
Figure 1.3	NAVAREA X.....	7
Figure 1.4	Domestic and foreign vessel accidents.....	9
Figure 1.5	Small vessel common routes.....	9
Figure 4.1	Common hazards.....	31
Figure 4.2	Types of vessels affected.....	31
Figure 4.3	Maritime accidents trend – January, 2013 to July, 2019.....	32
Figure 4.4	Vessel types that capsized.....	34
Figure 4.5	Vessel types reported missing.....	35
Figure 4.6	Vessel types that encountered engine failure.....	36
Figure 4.7	Vessel types reported man overboard.....	37
Figure 4.8	Vessel types reported aground.....	38
Figure 4.9	Diamond 202 – capsized.....	40
Figure 4.10	FT – capsizing.....	43
Figure 4.11	Overloading of banana boats.....	43
Figure 4.12	FT – missing vessels.....	45
Figure 4.13	FT – engine failure.....	47
Figure 4.14	FT – grounding.....	48
Figure 4.15	FT – man overboard.....	50
Figure 4.16	SHEL model.....	51
Figure 4.17	FT – capsizing & RCOs.....	62
Figure 4.18	FT – missing vessels & RCOs.....	62
Figure 4.19	FT – engine failure & RCOs.....	63
Figure 4.20	FT – grounding & RCOs.....	63
Figure 4.21	FT – man overboard & RCOs.....	64

## **LIST OF ABBREVIATIONS**

AML	Advanced Mobile Location
AMSA	Australian Maritime Safety Authority
BASARNAS	Badan Nasional Pencarian Dan Pertolongan
COI	Commission of Inquiry
CCSS	Code of Safety for Caribbean Cargo Ships
EEZ	Exclusive Economic Zone
EMSA	European Maritime Safety Administration
EPIRB	Emergency Position-Indicating Radio Beacon
FSA	Formal Safety Assessment
FSC	Flag State Control
FSI	Flag State Inspection
GISIS	Global Integrated Shipping Information System
IAMSAR	International Aeronautical and Maritime Search and Rescue
IMSAS	IMO Member State Audit Scheme
IMO	International Maritime Organization
JRCC	Joint Rescue Coordination Center
MEDEVAC	Medical Evacuation
MCA	Maritime & Coastguard Agency
MRCC	Maritime Rescue Coordination Center
MRO	Mass Rescue Operation
MSAF	Maritime Safety Authority Fiji
MSSR	Merchant Shipping (Safety) Regulation
NEC	National Executive Council
NICTA	National Information and Communication Technology Authority
NMSA	National Maritime Safety Authority of PNG
NWS	National Weather Services
PacMA	Pacific Maritime Association
PFD	Personal floatation device

PICT	Pacific Island Countries and Territories
PIMLaw	Pacific Islands Maritime Law
PIW	Person in Water
PLB	Personal Locator Beacon
PNG	Papua New Guinea
POB	Person On Board
PSC	Port State Control
QLD	Queensland
RCC	Rescue Coordination Center
RCM	Risk Control Measure
RCO	Risk Control Option
SAR	Search and Rescue
SCA	Small Craft Act
SIMA	Solomon Islands Maritime Authority
SLA	Service Level Agreement
SMA	Swedish Maritime Administration
SMC	Search and Rescue Mission Coordinator
SPC	Secretariat of the Pacific Community
STA	Swedish Transport Agency
SRR	Search and Rescue Region
TAS	Tasmania
TCD	Technical Cooperation Division
TOMSR	Transport Operations (Maritime Safety) Regulation
UNHCR	The United Nations High Commissioner for Refugees
USCG	United States Coast Guard
USL	Uniform Shipping Laws

## **CHAPTER 1: INTRODUCTION TO A STUDY OF MARITIME SAR SERVICES AND SAFETY OF SMALL VESSELS: A REGIONAL PERSPECTIVE WITH FOCUS ON PAPUA NEW GUINEA**

### **1.1 Background**

Accidents at sea are common in many small island developing states due to isolation of coastal and island communities and the logistical impediments that these states encounter. The main mode of transportation is by sea to travel from island to island, coast to coast, and whilst doing so, many travelers may encounter accidents at sea. Providing a timely response to those in distress at sea and enforcement of safety measures on these vessels is a major challenge for the authorities. Unlike on land, the experience of the Pacific community indicates that it is difficult to mobilize resources in a timely manner to rescue persons in distress at sea. (Secretariat of the Pacific Community [SPC], 2011)

Papua New Guinea (PNG) is one those small developing island countries where an average of 25 lives are lost at sea and 99 persons unaccounted for or who go missing without trace, every year (PNG Maritime Rescue Coordination Center [MRCC], 2019). About 60 % of the country's total population that live on coastal and small islands heavily rely on sea transportation to access government services such as health, education, including fishing and agriculture (National Maritime Safety Authority [NMSA], 2019).

However, many accidents occur at sea because the small vessels used for transportation within national waters and neighboring states are unseaworthy and most do not have the necessary life-saving equipment on board, such as life-jackets, life-rafts, emergency beacons, and other safety equipment (NMSA, 2011). For a developing country like PNG, meeting the international obligation of providing maritime search and rescue (SAR) services and enforcement of safety measures on national flagged vessels is quite a challenge due to resource availability, the unequal sharing of current and available resources, capacity building obstacles, training, funding, organizational factors, assistance from the national government, and other factors. Differences in culture and custom is another challenge that prevents cooperation amongst staff in the organization, different state entities on a political level, and even the general population, due to hundreds of diverse cultural and customary practices across the country. (PNG MRCC, 2019)

## **1.2 Maritime SAR and vessel safety**

Maritime SAR is the operation of rendering assistance to person(s) in distress or in imminent danger at sea regardless of the nationality or status of such a person or the circumstances in which that person is found in accordance with applicable Maritime Law and Conventions (European Commission [EC], 2019).

SAR service is the performance of distress monitoring, communication, co-ordination and SAR functions, including the provision of medical advice, initial medical assistance, or medical evacuation, through the use of public and private resources, including co-operating aircraft, vessels and other craft and installations (International Maritime Organization [IMO] & International Civil Aviation Organization [ICAO], 2016). The objective of the maritime SAR services is to rescue as many people as possible in the shortest period of time, while reducing risk to rescuers (The United Nations High Commissioner for Refugees [UNHCR], n.d.).

Safety is defined as the quality of a system under definite conditions at a specific time, which is indicated by the scale where the management, engineering and operation of a system is without danger to life, property and the environment (Hui, 2001). Referring to the afore-mentioned definition, safety of a vessel covers safety on board, including the safety of crew and passengers, safety of the ship and cargo, and protection of the marine environment (Kaushik, 2019a). It can, also, be summarized as measures to safeguarding the ship and the environment (Baumler, 2019).

### **1.3 Research Focus**

#### **1.3.1 Purpose**

The purpose of choosing the topic on maritime SAR services and safety of small vessels is due to the rate of maritime incidents occurring in PNG waters and the inadequacy of current responses to those occurrences, including the challenges faced by the state maritime SAR authority and the stakeholder, and the safety of small vessels used by the coastal and island communities to travel from one island to another, coast to coast.

Having worked for the state maritime authority for nine years in various roles, the author has observed and experienced the challenges faced by the organization. The author seeks to assist the organization, in taking appropriate steps to improve maritime SAR services and safety measures on national flagged small vessels, including fishing vessels, passenger vessels and other small crafts.

The importance of this dissertation is to give an overview and analysis of the provision of maritime SAR services and the enforcement of safety measures on small vessels in PNG drawn on best practices of neighboring island states, with Sweden and Australia as additional reference points, in order to learn, identify gaps and mitigate those gaps, where necessary.

### **1.3.2 Aim**

The aim of this study is to understand and examine the provision of maritime SAR services and the enforcement of safety measures on small vessels in PNG. Furthermore, to identify issues related to both systems such as SAR policy; SAR resources; SAR personnel training/staffing/manning; SAR personnel employment terms and conditions; medical assistance services to seafarer; cooperation between stakeholders; safety regulations for small vessels; compliance, monitoring and enforcement of safety measures on small vessels and, facilities for possible mass rescue operations for passenger ships in PNG Search and Rescue Region (SRR).

### **1.3.3 Objective**

The objective of this dissertation is to explore possible means/ways/solutions to address the issues facing PNG's maritime SAR services and the safety of small vessels. With the current issues being identified, these will be compared to the provision of maritime SAR services and enforcement of safety measures on small vessels in the participating states in this research, and analysis to be used to make proposals for improvement to the provision of maritime SAR services and enforcement of safety measures on small vessels in PNG.

### **1.3.4 Benefit of the study**

The benefit of this study is that it will identify key issue areas with gaps and highlight measures that the authorized state SAR and Maritime Authorities, including the relevant stakeholders, can take to mitigate the issues identified in order to reduce the loss of lives, loss of property and damage to marine environment, and improve safety measures on small vessels in PNG.



#### 1.4 Geographical area of study

Papua New Guinea is a sovereign state located in the Pacific Region sharing international boundaries with five States - Indonesia to the West, Solomon Islands to Southeast, Nauru to the East, Australia to the South and Federated States of Micronesia to the North (Standish, 2011).



Figure 1.1: PNG and neighboring countries (Source: <https://Britannica.com/>)

PNG comprises 600 small islands, including the eastern half of the island of New Guinea, that is east of Indonesia. The climate is tropical, with high temperatures and humidity levels, and tropical forests cover much of the country. (The Commonwealth, n.d.)

The PNG National Maritime Safety Authority (NMSA) is the authorized state maritime authority responsible for maritime safety, maritime SAR services, and marine environmental protection within the waters of PNG. It was established by an Act of Parliament in 2003 and commenced operation on 1<sup>st</sup> of January 2006. (NMSA, 2019)

The PNG Maritime Rescue Coordination Center (PNG MRCC) is responsible for Maritime SAR matters within PNG SRR, which is managed by PNG NMSA. The PNG SRR maritime jurisdiction covers a sea area of 2.4 million square kilometers, including internal waters, territorial seas, continuous zone, and Exclusive Economic Zone (EEZ). (NMSA, 2019)

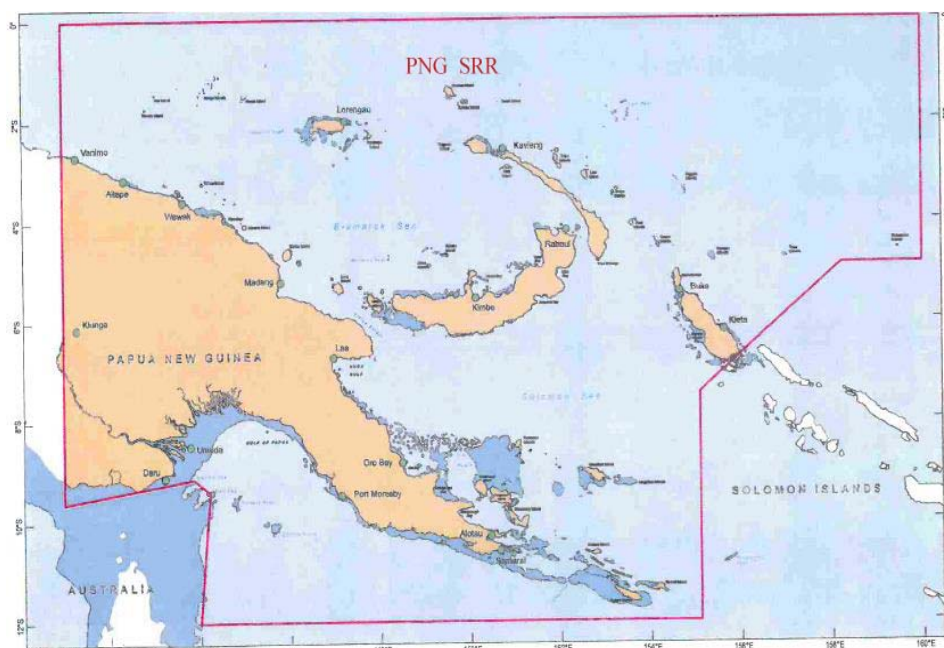


Figure 1.2: PNG SRR (Source: [www.nmsa.gov.pg](http://www.nmsa.gov.pg))

The department within NMSA responsible for the safety of PNG flagged vessels is Ship Surveys & Inspection, that is Flag State Control (FSC), including Port State Control (PSC) related matters within the PNG waters (NMSA, 2019).

The world's oceans are divided into 16 geographical sea areas called Navigational Areas (NAVAREA). The areas are comprised of Coastal Radio Stations (CRS) and Maritime Rescue Coordination Centers (MRCC). The PNG SRR falls within NAVAREA X, for which

Australia is the Regional Coordinator. (Australian Maritime Safety Authority [AMSA], 2018)

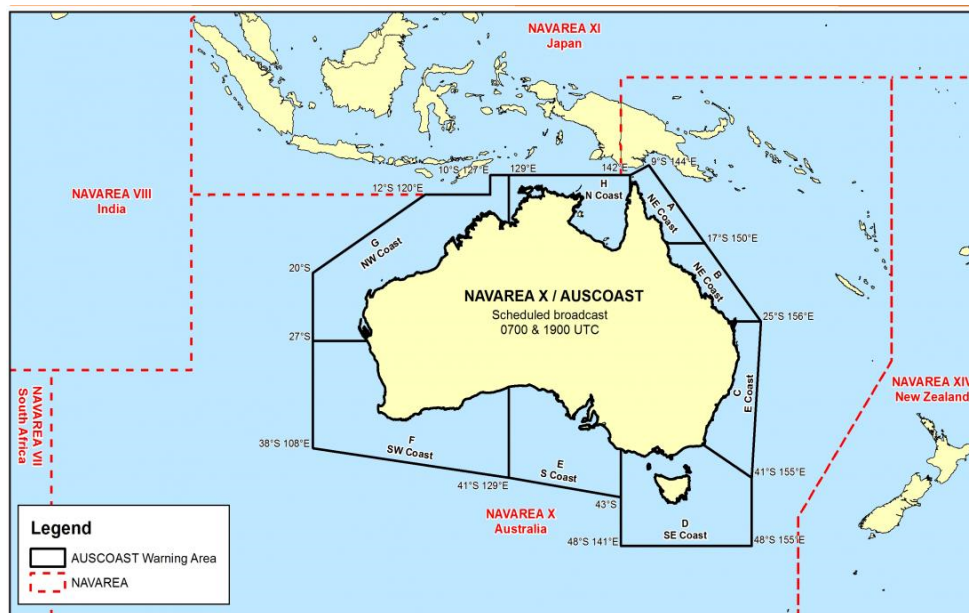


Figure 1.3: NAVAREA X (Source: [www.amsa.gov.au](http://www.amsa.gov.au))

## 1.5 Major maritime accident

The worst maritime disaster in the history of maritime transportation in PNG that changed the maritime SAR services was the sinking of MV Rabaul Queen, a PNG flagged passenger ferry with an overall length of 47m, beam 8m and 259 gross tonnage. A total of 392 passengers and crew were on board at the time of the accident, where only 246 were rescued, while 4 bodies recovered and 142 persons remain unaccounted for. (Rahman, 2012). Investigation into the accident revealed that the ferry was unseaworthy at the time of its departure, as per last Flag State Inspection (FSI) report (Andrew, 2012).

The Rabaul Queen disaster effected the way forward for capacity building for maritime SAR services in PNG, where SAR gap analysis was conducted by Australian Maritime

Safety Authority (AMSA) from September 23, 2012 to October 07, 2012. The purpose of the 'gap analysis' was to highlight deficiencies in PNG SAR arrangements and to make recommendations to improve PNG SAR system, with the goal of developing a robust maritime and aviation SAR co-ordination capability within PNG that is consistent with international standards. (AMSA, 2013)

Also, the International Maritime Organization (IMO), conducted a separate needs assessment of the PNG maritime authority from March 05 to 09, 2012, in Port Moresby, PNG. The aim of the assessment was to identify areas for strengthening the maritime administration and improve safety of shipping, particularly, the implementation of good safety standards for domestic/coastal shipping and effectively implement and monitor vessel safety and environmental protection from ship-sourced pollution, including training and certification of seafarers. (IMO, 2012)

Furthermore, the then Prime Minister of PNG ordered a Commission of Inquiry (COI) into the sinking of MV Rabaul Queen following public pressure due to the high number of casualties. The purpose of the COI was to establish facts about the disaster to ascertain the cause; establish evidence leading to any criminal and civil responsibility for the disaster; establish the reasons for huge loss of lives; and present proposals for any measure that would help to prevent future occurrence of a similar disaster, or may assist in future search, rescue and recovery of disaster victims. (Andrew, 2012)

Despite the aforementioned assessments and recommendations, maritime accidents and incidents involving foreign flagged vessels, national flagged vessels, and coastal communities travelling on small crafts continue to occur. Figure 1.4 shows the number of domestic and foreign vessels that were involved in accidents in PNG waters from January, 2013 to July, 2019, while figure 1.5 shows the common routes that small vessels usually take in PNG waters. (PNG MRCC, 2019)

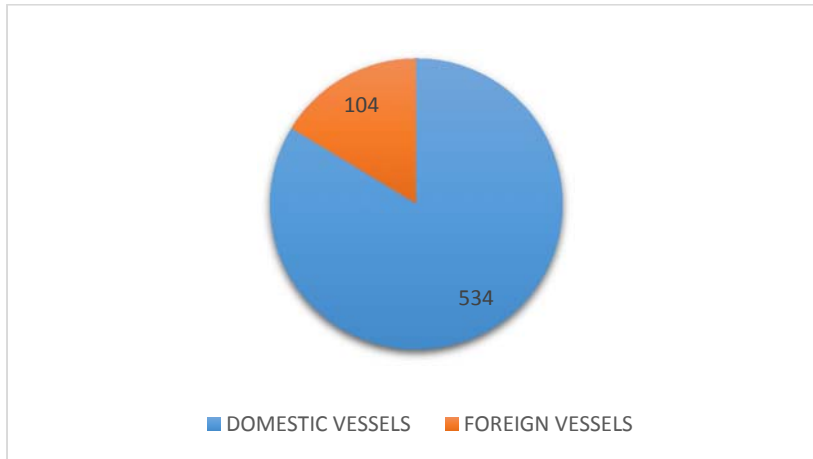


Figure 1.4: Domestic and foreign vessel accidents. Source: PNG MRCC

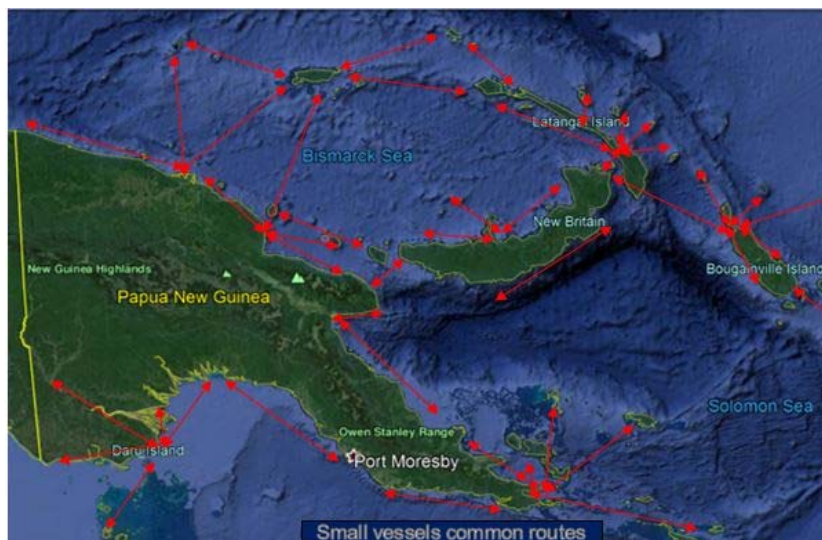


Figure 1.5: Small vessel common routes.

However, some progress had been seen currently in the provision of maritime SAR services and safety of small vessels, although at a slow pace and it would take time for these challenges and recommendations from afore-mentioned investigations to be fully

addressed by PNG MRCC and NMSA. For example, on September 05, 2018, the NMSA with the support from the Ministry of Transportation & Infrastructure, launched the first ever SAR boat, which is a commendable addition to SAR resources (NMSA, 2018).

## **1.6 Chapter structure**

Chapter two contains the review of international legal framework, maritime SAR provisions, regional approach, PNG national legal framework, challenges faced by PNG, including past studies undertaken on the issues related to maritime SAR services and safety of small vessels.

Chapter three discusses the methods used to collect data related to maritime SAR services and safety of small vessels.

Chapter 4 contains the analysis of the issues related to maritime SAR services and safety of small vessels in PNG using the IMO's Formal Safety Assessment (FSA) tool. Also, the data collected through questionnaires is analyzed using the SHEL model within step 3 of FSA.

Chapter 5 concludes the study with recommendations to relevant organizations and stakeholders for further improvements in provision of maritime SAR services and enforcement of safety measures on small vessels operating in PNG waters, including suggestions for further research.

## **CHAPTER 2: LITERATURE REVIEW OF STUDY OF MARITIME SAR SERVICES AND SAFETY OF SMALL VESSELS**

### **2.1 Introduction**

This chapter will briefly review the provision of maritime SAR services and enforcement of safety measures on small vessels, especially fishing vessels, passenger vessels and small crafts. The review covers the international legal framework, maritime SAR provisions, approach at regional level, national legal framework, and challenges faced by PNG MRCC and NMSA.

### **2.2 International legal framework for maritime SAR services and safety of vessels**

#### **2.2.1 The United Nations Convention on the Law of the Sea 1982 (UNCLOS)**

Article 98 of UNLCOS states the “duty to render assistance” as an international obligation, where, every state shall require the master of a ship flying its flag, in so far he can do without serious danger to the ship, the crew or the passengers to render assistance to any person or ship in distress at sea; and every coastal state to establish, operate and maintain an adequate and effective SAR services regarding safety on and over the sea, or through mutual agreements with neighboring SRRs.

Furthermore, Article 94 states duties of Flag States, where, every State shall effectively exercise its jurisdiction and control in administrative, technical and social matters over ships flying its flag; maintain a register of ships; and assume jurisdiction under its internal law over each ship flying its flag and its crew. Also, every State shall take necessary measures for ships flying its flag to ensure safety at sea with regards to construction, equipment and seaworthiness of ships; manning of ships, labor conditions and the training of crew, considering the applicable international instruments; use of signals, maintenance of communications and prevention of collisions.

### **2.2.2 International Convention on Maritime Search and Rescue (SAR) 1979**

The aim of the 1979 SAR Convention was to form an international SAR plan, so that, regardless of the location of the accident, the rescue of persons in distress at sea will be coordinated by a SAR organization and, if required, by cooperation between neighboring SAR organizations. The plan summarizes the operating procedures to be followed in the event of emergencies or alerts and during SAR operations (IMO, n.d.).

### **2.2.3 International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual, 2016**

The three volumes of International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual gives guidelines for a common aviation and maritime approach strategy to organizing and providing SAR services. Each volume can be utilized as a standalone document or, together with other two volumes, as ways to get a full view of the SAR system. (IMO, n.d.-c). The main objective of IAMSAR Manual is to help States in fulfilling their own SAR needs, and the obligations they accepted under the Convention on International Civil Aviation, SAR Convention, and SOLAS Convention. (IMO & ICAO, 2016)



#### **2.2.4 International Convention for the Safety of Life at Sea (SOLAS), 1974**

SOLAS Convention does not apply to vessels below 500 GT for international trade and below 300 GT for coastal trade, fishing vessels, wooden ships of primitive build and ships not propelled by mechanical means. However, chapter V deals with safety of navigation and identifies certain navigation safety services that should be provided by contracting Governments and sets forth provisions of an operational nature applicable in general to all ships on all voyages (SOLAS Convention, 2014).

Also, Regulation 7 of Chapter V requires contracting Governments to ensure that necessary arrangements are made for distress communication and coordination in their area of responsibility and for the rescue of persons in distress at sea around its coasts. Furthermore, SOLAS Regulation 8 requires contracting Governments to make arrangements for life-saving signals to be used by SAR facilities engaged in SAR operations for communicating with ships or persons in distress (SOLAS Convention, 2014).

#### **2.2.5 The International Convention on Salvage, 1989**

Article 10 of the Convention states the 'Duty to render assistance', where every master is bound to render assistance to any person in danger of being lost at sea without endangering his vessel and persons on board (Salvage Convention, 1989).

#### **2.2.6 Torremolinos Convention 1977 and the Torremolinos Protocol 1977**

The Convention for the Safety of Fishing Vessels, contains safety requirements for the construction and equipment of new, decked, seagoing fishing vessels above 24m in length, including those vessels also processing their catch, while, the Protocol applies to vessels of 45m and above. (Food and Agriculture Organization (FAO), n.d.)

### **2.2.7 Code of Safety for Fishermen and Fishing Vessels, 1968**

The Code has two parts: Part A is an educational tool covering the fundamentals of safety and health; and Part B serves as a guide to those concerned with framing national laws and regulations and applies to fishing vessels above 24m in length, excluding recreational fishing vessels and processing vessels (FAO, n.d.).

### **2.2.8 FAO-ILO-IMO Voluntary Guidelines for the Design, Construction and Equipment of small Fishing Vessels**

These guidelines cover the design, construction and equipment of fishing boats between 12m and 24m in length (Gudmundsson, 2013).

## **2.3 Maritime SAR provisions**

### **2.3.1 Maritime SAR Policy**

Legal framework is one of the first basic elements for a maritime SAR service, that is established by parties, either individually or in co-operation with other states (SAR Convention, 2004). A state, being a party to SOLAS convention and SAR convention, undertakes to provide maritime SAR coordination and services by establishing statutes and associated provisions to form a legal basis for forming a SAR organization and its resources, policies, and procedures. The legal basis to be in line with the accepted principles of international law, for the purpose of recognizing the SAR function as a State responsibility; implementing IMO and ICAO requirements and standards; designating SAR agencies and their general responsibilities and defining the jurisdiction and legal authority of the Rescue Coordination Center (RCC) in accordance with relevant standards of ICAO and IMO. (IMO & ICAO, 2016)

### **2.3.2 Maritime SAR resources**

Organization of available resources is the third basic element for a maritime SAR service, that is provided by parties, either individually or in co-operation with other states (SAR Convention, 2004). The primary resources of a SAR organization are the operational facilities made available to it by various authorities, through arrangements and embedded in the SAR plan. SAR managers must provide or arrange for the use of primary SAR facilities and use of existing facilities to the fullest extent possible. (IMO & ICAO, 2016)

Maritime SAR services requires reliable and available communication networks to support distress communication, where, mobile equipment to be used by persons in distress to alert SAR facilities and SAR units to locate those in distress. Facilities selected as SRU should be able to reach the scene of distress quickly and, in particular, be suitable for one or more of the following operations: providing assistance to prevent or reduce the severity of accidents and the hardship of survivors; conducting search; delivering supplies and survival equipment to the scene; rescuing survivors; providing food, medical or other initial needs of survivors; and delivering the survivors to a place of safety (IMO & ICAO, 2016).

The SAR system must have funding support corresponding to national goals. Funding can be minimized by making use of all available resources, but there may be specific maritime SAR needs, such as training, specialized equipment, and others, which require funding. (IMO & ICAO, 2016)

### **2.3.3 Maritime SAR personnel training**

Training is one of the basic elements for a maritime SAR service, that is provided to the maritime SAR personnel, either through individual arrangements or in co-operation with other states (SAR Convention, 2004). Training and experience are crucial to proper SAR response. SAR personnel require a good training program in order for them to become

true professionals and personnel who can do it right the first time. Training is critical to performance and safety, means to save those in distress when it can, and to lower the risks on personnel and facilities (IMO & ICAO, 2016). Tun (2000) further argued that the success of SAR operations is wholly dependent on the efficiency of the SAR personnel and training, as this is also a major concern in the implementation of SAR services and GMDSS.

#### **2.3.4 MRCC staffing**

Having undergone the required training, the MRCC should be properly staffed with the appropriate number of staff as per the IAMSAR manual and manned 24/7 basis. The purpose of staffing is to fill organizational roles with qualified persons (IMO & ICAO, 2016). Chao (2006) further indicated that RCCs should be arranged in such as a way where there is balance between workload and local knowledge is maintained. This principle is conditional on the organization's staffing level and communication capabilities.

#### **2.3.5 Stakeholder cooperation**

Domestic and international co-operation is required for maritime SAR service by parties and, whenever necessary, to co-ordinate SAR operations with those of neighboring States (SAR Convention, 2004). Cooperation amongst stakeholders at the national and international level will result in the effective use of all available resources for SAR, including private, commercial and volunteer resources (IMO & ICAO, 2016).

#### **2.3.6 Mass Rescue Operation**

Mass rescue operation (MRO) is an operation that requires provision of immediate assistance to large numbers of persons in distress such that capabilities normally available to SAR authorities are inadequate (IMO & ICAO, 2016). This requirement

presents different challenges to maritime SAR authorities as extraordinary measures will have to be effected in order to deal with large scale incidents (Goncalves, 2018).

### **2.3.7 Medical advice and medical assistance**

The SAR Convention (2004) provides for parties to provide, on request from masters of ships, medical advice and initial medical assistance and, as required, to make arrangements for medical evacuations for patients. Westlund et al. (2016) stated that medical advice can be crucial for optimal medical treatment on board ships.

## **2.4 Regional approach to maritime SAR services and safety of small vessels**

The IMO, through its Technical Cooperation Division (TCD), continues to fund and support the Pacific SAR (PACSAR) Workshop with continuous engagement and commitment to address lasting issues related to SAR services in the Pacific region. The workshop provides an opportunity for personnel involved in SAR to come together and share knowledge, ideas and expertise, and build collaborative relationships. (US Coast Guard [USCG], 2019)

Through the PACSAR workshop, the PACSAR Strategic Plan 2017-2021 was formulated and it consists of four pillars for effective SAR. The four pillars are: responsible SAR governance; effective SAR coordination; effective SAR operational response; and SAR prevention, with each pillar having a series of “our measures of success”. (Maritime New Zealand [NZ], 2017)

A core measure and highly beneficial for collaboration among the Pacific Island Countries and Territories (PICT) is the 2013 Maritime SAR Technical Arrangement for Cooperation, which was designed to meet three critical needs in the Pacific, that is to, recognize maritime SAR geographic boundaries; establish frameworks for bi- and multi-lateral SAR

arrangements; and improve maritime SAR coordination, communication, cooperation and planning. (SPC, 2014)

Furthermore, the IMO, through its TCD, is providing technical support on the safety regulations for non-convention size vessels in the Pacific region (Williams & Hoppe, 2011), where the Secretariat of the Pacific Community (SPC) is working with IMO to orient current legislation, standards and practice with international standards. The workshop on Global Regulations and Pacific Island Maritime Laws (PIMLaws) in 2013 following the adoption of an Action Plan at Pacific Forum on Domestic Ferry Safety in 2012 called for faster implementation and enforcement of relevant maritime provisions and regulations, including the adoption of the PIMLaws. PIMLaws are a set of model legislation and regulations that SPC member can use to legislate their national maritime laws (SPC, 2013).

The SPC, in collaboration with Pacific Maritime Association (PacMA) has developed a set of regional survey standards to improve the efficiency and effectiveness of FSIs and to set regional voluntary guidelines for the survey of non-convention vessels (Rounds, 2012). The regulations for non-convention size vessels in the Pacific region have been adopted based on the Asian harmonized regulations, Safety for Caribbean Cargo Ships (CCSS) Code, related IMO resolutions and the Australian Uniform Shipping Laws (USL) Code (Sakalayan, 2006).

## **2.5 PNG National Legal Framework on Maritime SAR Services and Safety of non-convention size Vessels**

### **2.5.1 PNG Merchant Shipping Act (MSA) 1975**

Ships are required to be registered under this Act and covers other aspects such as; safety, seafarer matters, shipping casualties, investigations, navigational aids, pilotage, and wreck and salvage. However, an air cushioned vehicle, a ship less than 10m in length

or of traditional built, employed solely in navigation on internal waters, or a pleasure craft are exempted.

Also, the Authority is required to assist vessels in distress in national waters, in order to preserve the vessel, lives onboard, and any wreck coming from the vessel. Furthermore, requires the master of a vessel that is registered under this Act to render assistance to any person who is found at sea in danger of being lost, regardless of State. (PNG Merchant Shipping Act [MSA], 1975)

### **2.5.2 PNG National Maritime Safety Authority Act (NMSAA) 2003**

The Act outlines the functions of the Authority, that is, to exercise the powers that are conferred upon it by this Act or under any other law; to co-ordinate SAR operations for vessels in distress or lost at sea pursuant to the terms and conditions of SAR plan; and to co-ordinate with other agencies and persons, including regional and international organizations and consultants on matters concerning maritime safety, marine pollution prevention and SAR operations at sea (PNG NMSA Act, 2003).

### **2.5.3 PNG Merchant Shipping (Safety) Regulation (MSSR) 2006**

This regulation covers the safety standards for vessels registered under the PNG MSA 1975. However, exempts the ship that is in the ordinary course of her voyage; is compelled by stress weather, or by force majeure, to take refuge in a port or in place in PNG; a troopship; a ship that is of traditional build; a pleasure craft; a ship that is less than 10m in length; or an air cushioned vehicle. (PNG Merchant Shipping (Safety) Regulation [MSSR], 2006)

#### **2.5.4 PNG Small Craft Act (SCA) 2011**

The purpose of this Act is to provide for the safety of persons operating and using small craft by providing a system of national and provincial regulation of small craft; and standards for the construction, safety and operations of small craft.

**Small Craft** refers to any craft or vessel less than 10 meters in length; an air cushioned craft or vessel; a pleasure craft more than 3 meters in length; or a dug-out canoe of any length powered by an engine and used as a commercial small craft; but does not include a ship registered under the PNG MSA 1975 and dug-out canoe or other craft which is of traditional build and not used as a commercial small craft. (Small Craft Act [SCA], 2011)

#### **2.6 Issues and challenges faced by PNG MRCC and NMSA**

The issues and challenges faced by PNG MRCC and NMSA are both internal and external, as discussed below.

##### **2.6.1 Internal**

Firstly, PNG ratified the SAR convention in 1992 but has not enacted a national legislation, with no national SAR plan for the provision of maritime SAR services. (IMO Global Integrated Shipping Information System [GISIS], n.d.). Secondly, PNGMRCC has limited availability and access to resources to respond to distress alerts, where it only coordinates rescue operations and has currently one SAR boat. Other state agencies do have assets capable of conducting maritime SAR operations but PNG MRCC does not have access to these assets. Thirdly, funding for maritime SAR operations is another factor that prevents fast responds to rescue those is distress at sea, where, possible local SRUs cannot be deployed due to nil fuel. Fourthly, PNG MRCC currently has a lesser number of qualified SAR officers performing maritime SAR duties, and yet to be fully staffed and manned as required by IAMSAR manual. Lastly, the current maritime SAR



personnel are not fairly compensated for the amount of time and effort committed and inadequate supporting tools to aid in executing the required services to the international maritime community. (PNG MRCC, 2019)

### **2.6.2 External**

Firstly, there are no formal arrangements and agreements for cooperation between stakeholders and partner organizations, such as; Navy, Water Police, Port Authority, Provincial Disaster Office, shipping companies and operators, and other private organizations that assist in search and rescue efforts, including medical advice and assistance services. Secondly, the passenger and cruise ship calls into local ports have increased in recent years so requires arrangement for possible MRO. Thirdly, Safety culture is non-existent among the majority of the coastal and island communities travelling by sea on small vessels, resulting in accidents and missing at sea. The isolation of some small islands makes it difficult to deploy SRUs in time to rescue those in distress. Fourthly, weather conditions such as strong wind and high waves hampers rescue operations, preventing SAR assets from completing the designated tasks. Limited communication means to establish communication with SRUs and those in distress, especially limited radio & mobile network coverage. Lastly, it is very difficult to control and monitor the movements of coastal and small island communities as much of their economic activities and cultural practices mainly depend on sea. (NMSA, 2019)

### **2.7 Conclusion**

To conclude, it has been noted that the legal framework for provision of maritime SAR services and enforcement of safety measures on small vessels are stated in a number of international treaties, including domestic laws. The IMO also provides assistance through its TCD to enhance the provision of maritime SAR services and safety of small vessels in the Pacific region.

## **CHAPTER 3: RESEARCH METHODOLOGY**

### **3.1 Introduction**

This chapter discusses the research methodology of the dissertation, where the author outlines the research strategy, research method, research approach, data collection methods and tools, research process, sample selection, data analysis, ethical considerations and research limitations.

### **3.2 Research strategy**

The research conducted with regards to this dissertation was through the use of applied research as it was conducted to solve a practical problem in PNG and some new research shows PNG has different challenges to that of other states, though past research that has been conducted in small island developing states with similar challenges to that of PNG. However, no research has ever been conducted on the topic in PNG, so this research takes new form but on existing research subject.

### **3.3 Research method**

For the purpose of meeting the objective of the dissertation, both quantitative and qualitative research was conducted. The quantitative research was appropriate due to large sample size, where its outcomes were measured and quantified. The advantage of a large sample size is that the conclusions from the quantitative research are generalized and statistical methods mean that the analysis is often considered reliable, and

appropriate for situations where systematic, standardized comparisons are needed. On the other hand, qualitative research was used due to data gathered from relatively small samples of people, and a 'micro' view of issues being examined was provided. The advantage is that it provides depth and detail, creates openness, stimulates people's individual experience, and attempts to avoid pre-judgements (Lancaster University, 2016).

### **3.4 Research approach**

The inductive research approach was taken to meet the purpose of this dissertation. With regards to this approach, specific observations were initiated by the author, where generalized theories and conclusions were drawn. The reason for using the inductive approach is that it considers the context where research effort is active because it solves the issues identified (Langkos, 2014). However, the weaknesses of an inductive approach are that it is limited, and problems occur when observations are incorrect, that is generalized theories and conclusions, questioning the reliability of research results. (Jordan, n.d.)

### **3.5 Data collection method and tools**

In this research, data was collected from both primary and secondary sources. For primary sources, tools used were questionnaires and interviews to collect specific data related to maritime SAR services and the safety of small vessels. The advantages of questionnaires are that responses are gathered in a standardized way, relatively quick to collect information, and information can potentially be collected from a large portion of a group. (Milne, N.D.). With regards to secondary sources, common internet search engines such as; google, google scholar, World Maritime University online library and other relevant internet sites were used to search for data related to maritime SAR services and safety of small vessels, including related documents in the participating countries.

### **3.5.1 Questionnaire**

The questionnaire was sent out to national SAR and maritime authorities in the participating countries, and volunteer organizations in PNG. The questionnaire to national maritime SAR authorities contained both subjective and objective questions, whereas only subjective questions for national maritime authorities and volunteer organizations. These sample questionnaires for both national SAR and maritime authorities were first given to WMU students for their comments and changes made accordingly. Further to the questionnaires, respective maritime SAR organizations that participated in this study were requested for SAR accident statistics, national SAR plan, agreements, etc.

#### **Maritime Authorities**

The questionnaire for Maritime Authorities were subjective questions, where some were taken from pre-audit questionnaire, appendix 2 of part II in section 1, IMO Member State Audit Scheme (IMSAS), 2015. Only suitable questions were selected and modified to suit the context of this research and the problems identified with regards to the safety of small vessels in the focused country, including those questions to which the author was unable to get answers from common information systems or databases or other secondary sources. There were extra questions to certain countries due the technology used in the safety of small vessels. See appendix 1.1 for the questionnaires sent to maritime administrations of the participating countries. (IMSAS, 2015)

#### **Maritime SAR Authorities**

Both objective and subjective questions were included in the questionnaires for maritime SAR authorities which were developed based on Appendix H of IAMSAR Manual volume 1 (2016), where, only appropriate questions were selected and reviewed in line with the problems identified in the provision of maritime SAR services in PNG. Part A consisted

of objectives questions, while, Part B questions were subjective. See appendix 1.2 for the questionnaires sent to maritime SAR authorities in the participating countries. (IMO & ICAO, 2016)

### **Volunteer organizations**

The questions in appendix 1.3 were selected in order to identify ways in which the volunteer organizations in PNG can support the provision of maritime SAR services, especially, with their capabilities and resources.

#### **3.5.2 Interview and other sources**

The information provided by participating organizations in PNG was inadequate, especially the vessel accident statistics and reports. Due to that, extra effort was made by establishing communication with the respective ship owners or operators whose ships encountered accidents, and PNG seafarers. The ship owners were reluctant to give out information, however, the national seafarers managed to provide some information through interviews

### **3.6 Sample selection**

For this research, the purposive sampling method was used to develop the sample of the research, where sample members were selected based on their knowledge, relationships and expertise regarding the research subject (Freedman et al., 2007). The three participating counties, that is, Australia, the Solomon Islands and Indonesia, had special relationship with PNG by sharing common international borders. The other two participating countries, Vanuatu and Fiji, were selected based on the same challenges faced through the topic under investigation, as being small island developing and archipelagic states, with Indonesia and the Solomon Islands in this category, as well. Australia and Sweden were selected as reference point for this research due to their

effective maritime SAR services and enforcement of safety measures on their national flagged vessels, especially their knowledge and expertise. Technological innovation used in these two countries is also another factor to consider, especially in maritime SAR services and safety of small vessels.

Following are the targeted organizations in the respective participating countries.

1. Papua New Guinea

- I. National Maritime Safety Authority – authorized state maritime agency
- II. Papua New Guinea Maritime Rescue Coordination Center – authorized state maritime SAR authority

2. Australia

- I. Australian Maritime Safety Authority – authorized state maritime agency
- II. JRCC Australia – authorized state maritime SAR authority

3. Indonesia

- I. Directorate of Shipping and Seafarers, Directorate General of Sea Transportation – authorized state maritime agency
- II. BASARNAS – authorized state maritime SAR authority

4. Solomon Islands

- I. Solomon Islands Maritime Authority – authorized state maritime agency
- II. MRCC Honiara – authorized state maritime SAR authority

5. Vanuatu

- I. Office of the Maritime Regulator – authorized state maritime agency
- II. Vanuatu Police Force – Maritime Wing – authorized state maritime SAR authority

6. Fiji

- I. Maritime Safety Authority Fiji – authorized state maritime agency
- II. Suva RCC (Maritime) – authorized state maritime SAR authority

7. Sweden

- I. Swedish Maritime Administration (Sjöfartsverket) – authorized state maritime agency
- II. Swedish Transport Agency (Transportstyrelsen) – authorized state agency responsible for safety of ships

### **3.7 Research process**

The researcher sent out formal request letters to the respective organizations in the countries mentioned above to gain acceptance for their participation in this research. The letter briefly explained the nature and the scope of the study (purpose of this research and the topic under investigation). These formal letters were sent through email as attachment and there were positive responses, where acceptance letters were also sent back via email.

### **3.8 Data analysis**

The IMO's Formal Safety Assessment (FSA) was used to analyze the issues identified through observations and data provided by PNG MRCC. The FSA tool was chosen as the assessment tool as it identifies hazards, severity and frequency, and how they can be controlled or mitigated. Hawkins (1987) SHEL model was also used in the FSA to identify the Risk Control Options

### **3.9 Ethical considerations**

Ethical issues were considered in this study, where all participants agreed in writing to participate by signing the Consent Form. Additionally, as mentioned earlier, the agreement to participate in the research was also stated in the official response letter.

### **3.10 Research Limitations**

As is always the case in all studies, this dissertation had the following limitations:

- In some cases, participants may not have written the exact information in response to the questionnaire in order to hide their shortfalls in implementing international treaties and national legislations.
- Other participants may have not understood the question.
- Not all participants responded to the questionnaires. For SAR questionnaires, PNG MRCC, SMA, BASARNAS, and MRCC Honiara, including other staff of NMSA. With regards to safety of small vessels, response was received from AMSA, STA, and NMSA.



## **CHAPTER 4:            FORMAL SAFETY ASSESSMENT OF MARITIME SAR SERVICES AND SAFETY OF SMALL VESSELS IN PNG**

### **4.1 Introduction**

The IMO Formal Safety Assessment (FSA) tool has been used to analyze the issues related to the provision of maritime SAR services and safety measures on small vessels in PNG. FSA is a logical and systematic method of enhancing maritime safety through process of risk assessment and cost-benefit evaluation in order to protect life, health, the marine environment and property. It is possible to use FSA as a tool to help assess new regulations or to differentiate proposed changes with existing standards and allows a balance to be drawn between the various technical and operational problems, as well as the human element and between safety and costs (IMO, n.d.-b).

There are five steps in the FSA tool, namely: Step 1 - Identification of Hazards; Step 2 - Risk Analysis; Step 3 - Risk Control Options; Step 4 – Cost Benefit Assessment; and Step 5 – Recommendations for Decision Making.

In step 1, historical data was used to identify the common hazards affecting the safety of small vessels in Papua New Guinea. Out of several techniques mentioned in step 2 to analyze the hazards identified in step 1, Fault Tree Analysis (FTA) technique has been chosen to see if possible measures can be derived from the technique to mitigate the hazards. In step 3, the author uses the SHEL model to analyze the causes and

consequences identified in step 2, the issues and challenges mentioned in chapter 2, and the responses from the participating countries to determine the RCOs. For step 4, the cost and benefits of RCOs identified in step 3 are discussed in relation to identified measures to enhance safety of life at sea. The last step, step 5, discusses the recommendations derived from the steps 1 to 4, however, this will be elaborated in the next chapter. (IMO, 2018)

## **4.2 FSA Step 1 – Identification of Hazards**

According to the IMO MSC-MEPC 2 –Circular 12 (2018), hazard is an event that has the potential to threaten human life, health, property, or the environment. The potential hazardous scenarios related to maritime SAR services and safety of small vessel have been identified, included in a list and prioritized by their risk level, causes and consequences to human life, property and environment, where the reference point was provided for the next step. (Hermanski & Dr. Daley, 2010)

### **4.2.1 Historical data**

The historical data used to identify the common hazards is from the PNG maritime casualties and accidents statistics for a six-and-a-half-year period from January 2013 to July 2019. The common hazards from the afore-mentioned historical data have been labelled to match the common accident types as per IMO's Guide to In-the-field job aid for investigators, EMSA's annual overview of maritime casualties and incident reports from many developed countries.

Figure 4.1 shows the common hazards identified that vessels encounter, while figure 4.2 shows the types of vessels that have been affected by the identified hazards in PNG waters.

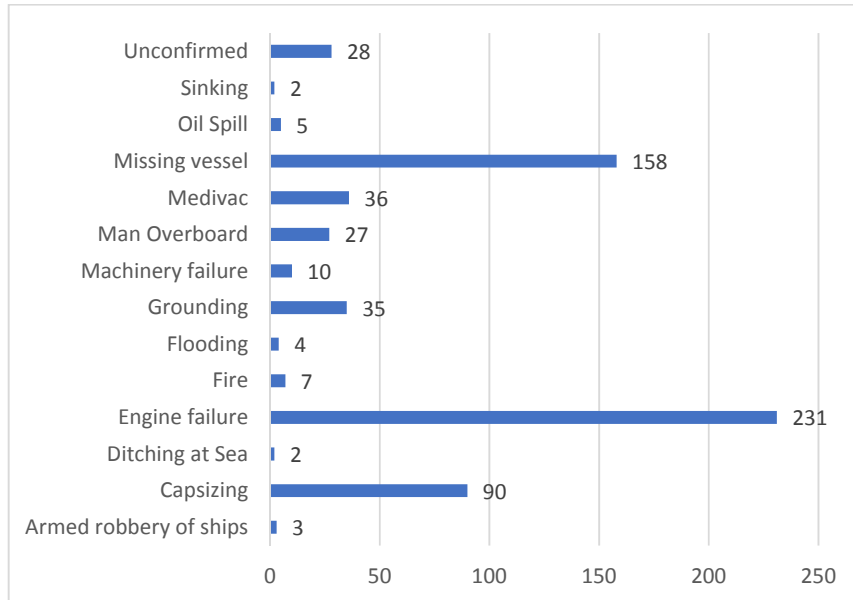


Figure 4.1: Common hazards. (Source: PNG MRCC)

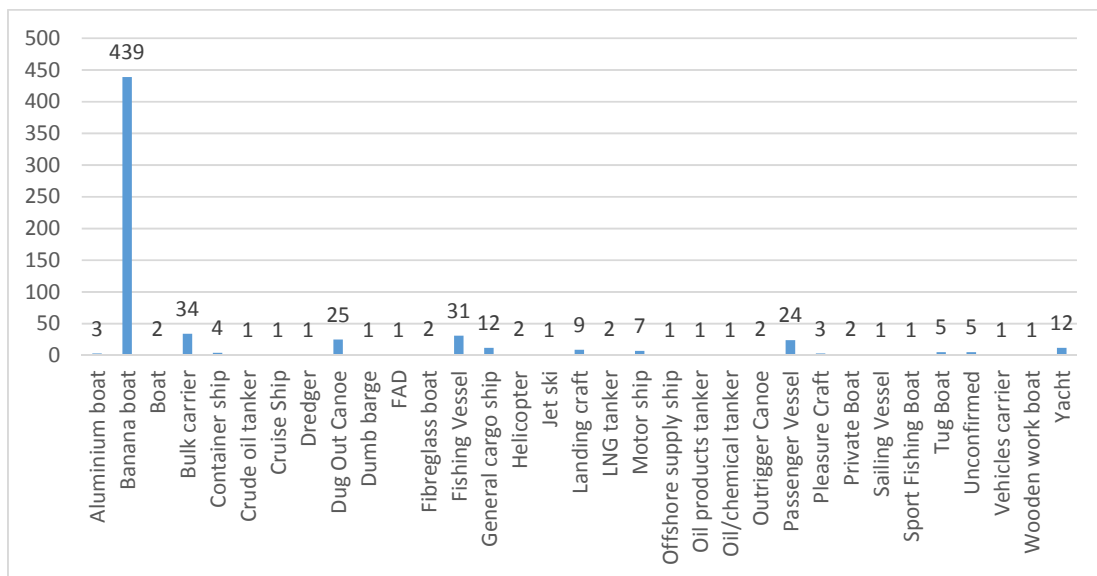


Figure 4.2: Vessel types affected. (Source: PNG MRCC)

Maritime accidents have gradually increased since 2016, where the figure for 2019 is expected to go beyond that of 2018, as half of the year has passed and the accident statistics are about to reach the figures of 2018. Figure 4.3 show the trend in maritime accidents in PNG.

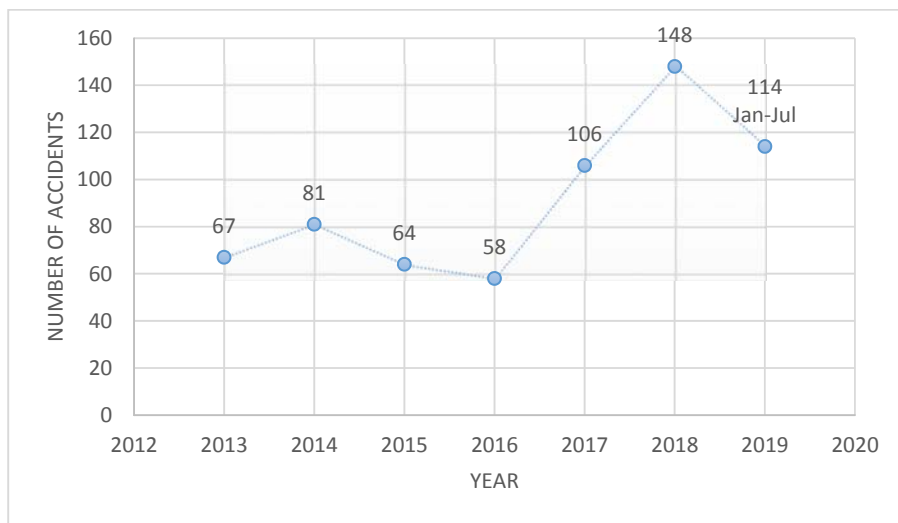


Figure 4.3: Maritime accidents trend – January, 2013 to July, 2019. (Source: PNG MRCC)

#### 4.2.2 Ranking of hazards and risk matrix

The number of occurrences of a particular accident and casualties, as indicated on table 4.1, have been used to rank the hazards according to their risk index. The severity index (SI) has been picked with reference to the number of casualties, as reported, and frequency index (FI) was predicted by examining the number of occurrences per accident, where, the likelihood of its occurrence in the future was then worked out. After entering this information onto the risk matrix table, the risk index (RI) was then worked out. The severity index, frequency index, risk index, and severity index in case of oil spill were calculated in line with tables 1, 2, 3, and 4 in Appendix 2, respectively.

Accident type	Number of cases	Persons reported	Persons Rescued	Medevac	Missing Persons	Deceased	Severity Index	Frequency Index	Risk Index
Capsizing	90	865	636	n/a	179	50	4	7	<b>11</b>
Missing boat	158	926	722	n/a	198	6	3	7	<b>10</b>
Engine failure	231	2023	1912	n/a	47	5	2	7	<b>9</b>
Man Overboard	27	31	9	n/a	16	6	3	3	<b>6</b>
Grounding	35	576	572	n/a	0	4	3	3	<b>6</b>
Medical emergency	36	36	n/a	31	n/a	5	2	3	<b>5</b>
Armed robbery of ships	3	12	6	n/a	4	2	2	3	<b>5</b>
Unconfirmed	28	122	76	n/a	44	2	2	3	<b>5</b>
Fire	7	212	211	n/a	0	1	2	3	<b>5</b>
Flooding	4	7	1	n/a	6	0	3	1	<b>4</b>
Machinery failure	10	46	45	n/a	1	0	1	3	<b>4</b>
Sinking	2	12	12	n/a	0	0	1	1	<b>2</b>
Ditching at Sea	2	2	2	n/a	0	0	1	1	<b>2</b>
Oil Spill	5	n/a	n/a	n/a	n/a	n/a	1	1	<b>2</b>

Table 4.1: Hazards per risk index. (Source: PNG MRCC).

All the identified hazards are discussed below.

### Hazard 1: Capsizing

Capsizing is ranked the highest hazard in PNG, as witnessed, because 50 persons have lost their lives and 179 remain missing to date. PNG witnessed 90 cases of ships capsizing between 2013-2019 amounting in 1 incident every month. Loss of life at sea is a serious consequence of these incidents, where almost 3 lives are lost every month. Of the 865 persons involved in the above mentioned incident, only 636 were rescued. Figure 4.4 illustrates that whereas almost all types of non-convention vessels are vulnerable to capsizing, banana boats are the biggest casualties. (PNG MRCC, 2019)

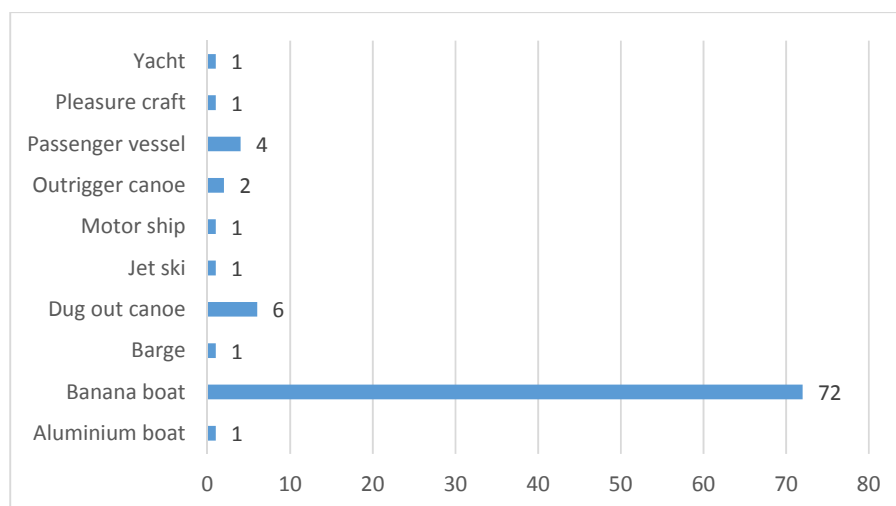


Figure 4.4: Vessel types that capsized. (Source: PNG MRCC)

Example: A 7 m banana boat, carrying 11 persons, including a mother and two children, capsized on July 12, 2019, on a short voyage between Bagbag Island and Karkar Island. Only 3 persons swam ashore, while 2 bodies were recovered and 6 persons remain missing. (PNG MRCC, 2019)

## Hazard 2: Missing vessel

Having ranked with second highest RI, vessels going missing at sea have resulted in 6 persons losing their lives and 198 missing to date. In this scenario, 158 cases were observed from 2013 to 2019, leading to 2 incidents every month. Loss of life is also a major consequence of this accident with almost 2 lives lost every month. Out of 926 persons involved, only 722 were rescued. Figure 4.5 illustrates that banana boats are most prone to go missing at sea. (PNG MRCC, 2019)

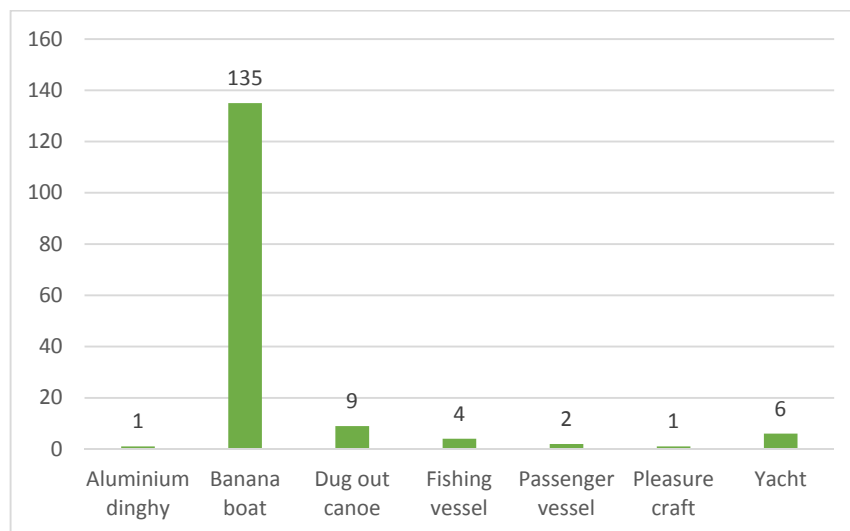


Figure 4.5: Vessels types reported missing. (Source: PNG MRCC)

Example: A 7 m banana boat, powered by 40HP outboard motor, carrying 6 persons and some goods, went missing on July 07, 2019, between Konos and Simberi Island. Local search was conducted by a helicopter and AMSA challenger jet, including safety broadcast to ships within the area, however, nil sighting of the target boat. (PNG MRCC, 2019)

### Hazard 3: Engine Failure

The hazard of engine failure was ranked the third highest, where 5 persons lost their lives and 47 remain missing to date. For this incident, 231 cases were seen from 2013 to 2019 totaling to almost 3 accidents every month. Loss of life is a consequence of this accident which results in 4 lives lost every 6 months. Of the 2023 persons affected, only 1912 persons were rescued. Figure 4.6 shows that banana boats are more subject to encountering engine failure than any other vessels. (PNG MRCC, 2019)

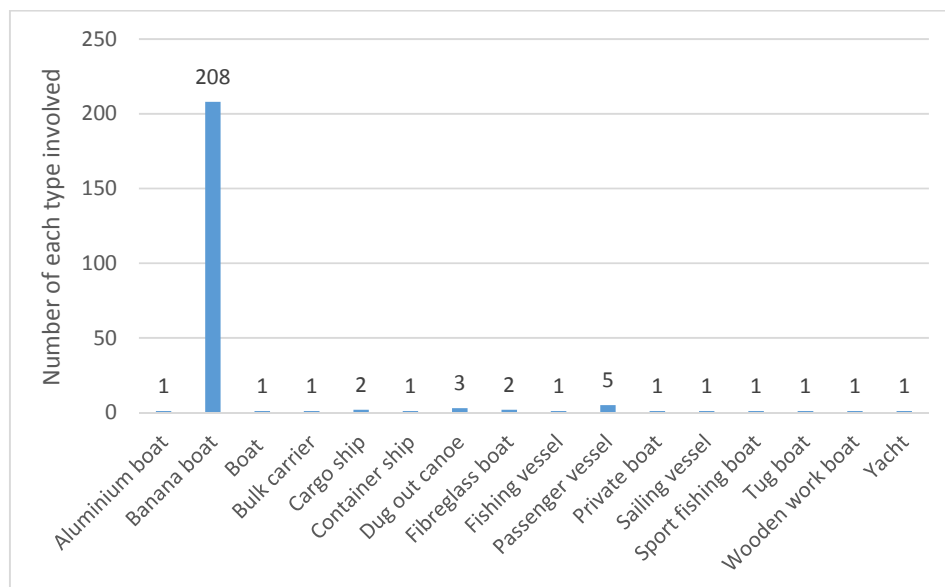


Figure 4.6: Vessel types that encountered engine failure. (Source: PNG MRCC)

Example: In September, 2015, 5 persons drifted out to open seas for 41 days, after their banana boat encountered engine failure and ended up in FSM. Only two survived and three other passengers, including pregnant women, died during the voyage. (The Telegraph, 2016)



#### Hazard 4: Man Overboard

Being ranked the fourth highest hazard, man overboard has resulted in 6 deceased and 16 persons missing to date. PNG has noted 27 cases from 2013 to 2019 signifying almost 2 cases every six months in open seas and coastal waters. Loss of lives is a consequence of this accident where almost 3 lives are lost every year. Of the 31 persons involved, only 9 were rescued. Figure 4.7 shows that banana boats and bulk carriers are more likely to encounter man overboard than other vessels. (PNG MRCC, 2019)

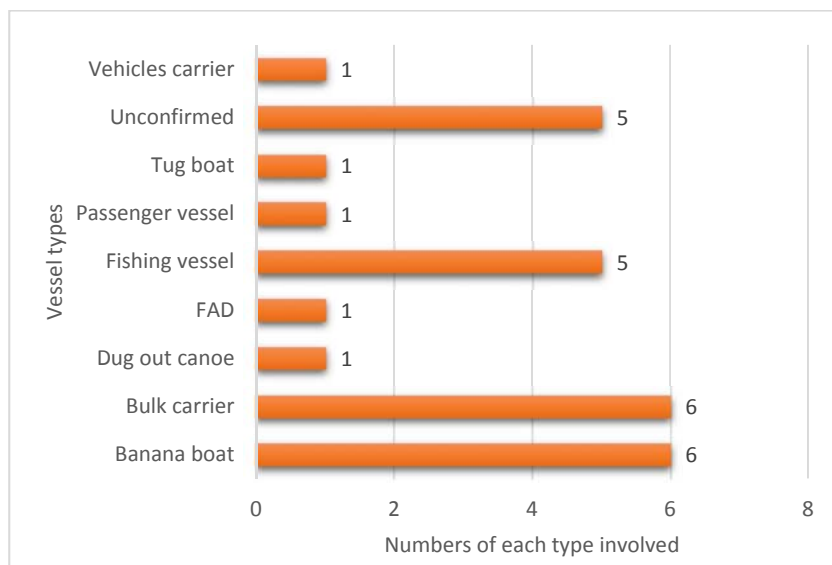


Figure 4.7: Types of vessels that encountered man overboard. (Source: PNG MRCC)

#### Hazard 5: Grounding

Grounding hazard is ranked the fifth in RI, where 4 persons have lost their lives. PNG has seen 35 cases from 2013 to 2019 amounting to almost 5 accidents every year. Loss of life is the consequence of this type of accident with almost 2 lives lost every three years. Of the 576 persons affected, 572 were rescued. (PNG MRCC, 2019)

Figure 4.8 shows that passenger vessels and landing crafts are more vulnerable to grounding accident then other vessels.

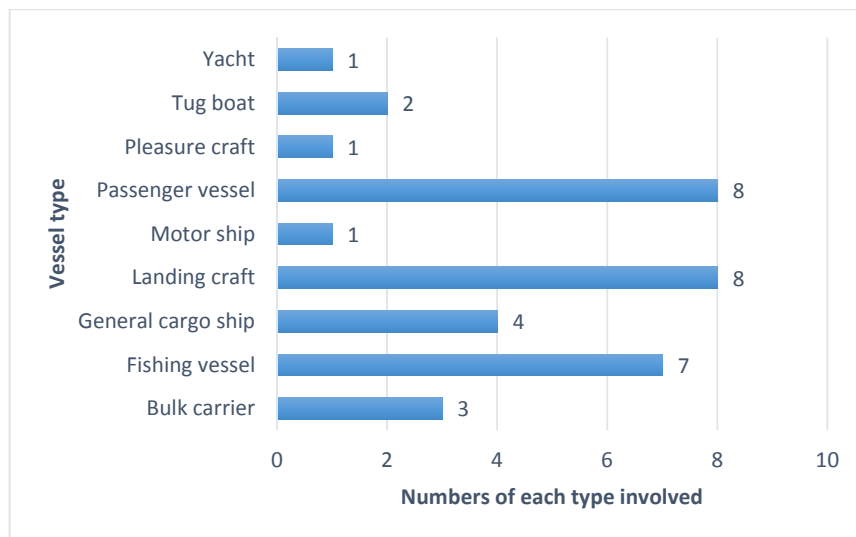


Figure 4.8: Vessel types reported aground. (Source: PNG MRCC)

Example: A tug, Viking 27, ran aground on December 29, 2018, onto a reef, while towing a dumb barge with a long tow line. The dumb barge got washed onto the reef due to swells and strong wind, so the tug attempted to salvage the dumb barge but unfortunately, she also ended up on the reef and grounded. She was declared total loss. (NMSA, 2019)

#### **Hazard 6: Medical emergency**

Medical emergency is the sixth hazard where 5 persons have lost their lives due to inadequate treatment, late response to receiving treatment after the condition of the patient had worsened. As per data for 2013-19, 36 cases were reported in PNG for medical evacuation representing almost 5 emergency situations every year. Loss of life

is also a consequence of this incident with almost one life lost every year. Out of 36 persons, 31 were successfully evacuated and treated. (PNG MRCC, 2019)

Example: On April 30, 2019, master of a bulk carrier requested a medical evacuation for a crew member with a serious heart condition and chest pain. Upon the direction from PNG MRCC, the master proceeded to the nearest port of Lihir and successfully transferred the sick crew member to an emergency ward at Lihir mining medical center. (PNG MRCC, 2019)

#### **Hazard 7: Armed robbery against ships**

Armed robbery of ships ranked the seventh hazard with the loss of two lives and 4 missing in five incidents between 2013 to 2019 with possibly many more unreported cases. Armed robbery could affect the safety of the vessel and persons on board (POB). The POBs on small vessels may even jump into the sea for fear of losing their lives. (PNG MRCC, 2019)

Example: Armed robbers attacked a boat carrying 6 persons between Sudest Island and Alotau on October 24, 2018, and took away the outboard motor along with 30 bags of sea cucumber. Consequently, the boat with POBs drifted for three days before assistance was rendered. (PNG MRCC, 2019)

#### **Hazard 8: Unconfirmed**

Unconfirmed is ranked 8 as per the RI, however, it is not actually a hazard but due to accidents that have not been verified due to misreporting, lack of information and other factors, where 2 deceased and 44 missing to date. PNG has observed 28 unconfirmed cases from 2013 to 2019 accounting for almost one incident every year. Loss of lives is a pressing consequence, where almost 7 lives lost every year. (PNG MRCC, 2019)

### **Hazard 9: Fire**

Ranked number 9 on the RI is fire hazard which resulted in one deceased. PNG has seen 7 cases of fire accidents from 2013 to 2019 amounting to almost one fire accident every year. Of the 212 persons affected, 211 were rescued. Loss of life is an isolated consequence of this accident where one life is lost every 6 years. (PNG MRCC, 2019)

Example: A fishing vessel, Diamond 202, reportedly caught fire on May 03, 2019 and the crew were unable to contain the fire so they abandoned the vessel on a life-raft. All crew members were safely rescued by another fishing vessel, however, the vessel capsized and was declared a total loss. Figure 4.9 shows the vessel that caught fire and capsized. (PNG MRCC, 2019)



Figure 4.9: Diamond 202 – capsized. (Source: NMSA)

### **Hazard 10: Flooding**

Flooding is ranked 10<sup>th</sup> on the RI with 6 persons missing to date. PNG has noted 4 cases of this accident representing four accidents every 6 years. Of the 7 persons affected, 1 was rescued. (PNG MRCC, 2019)

### **Hazard 11: Machinery failure**

Being ranked the eleventh on RI, only one person remains missing and to date is presumed dead. PNG noted 10 cases of this accident from 2013 to 2019 making it almost one accident every year. All 10 vessels were rendered assistance at sea and towed to safety. Out of 46 persons, 45 were safe. (PNG MRCC, 2019)

### **Hazard 12: Sinking**

Ranked at twelfth place on RI is the sinking hazard with no casualties from 2013 to 2019. PNG noted 2 cases of this type of accident that is two accidents every 6 years. All of the 12 persons affected were successfully rescued. (PNG MRCC, 2019)

Example: Tug Viking 28 sank on December 29, 2019 while attempting to tow Viking 27 off the reef. Tug Viking 28 was washed up on the reef by waves and the hull got pounded on the reef by waves and ripped, it took in water, slid off the reef and sank to a depth of 10 – 12 m. It was declared a total loss and fortunately, all the crew were rescued. (NMSA, 2019)

### **Hazard 13: Ditching at sea**

Ditching at sea is the least common hazard as ranked on the RI with no casualties reported. PNG has seen 2 cases from 2013 to 2019 of this accident that is two cases every six years. The two pilots involved were successfully rescued. (PNG MRCC, 2019)

Example: A lone New Zealander pilot ditched a helicopter on February 22, 2017, on the reef. The pilot was rescued by the locals and the helicopter was left stranded on the reef (PNG MRCC, 2019).

#### **Hazard 14: Oil spill**

Oil spill was ranked the least hazardous, as it is not related to human casualties but the environment. There were 5 cases of oil spills witnessed in PNG from 2013 to 2019 equaling almost five incidents every six years. (PNG MRCC, 2019)

#### **4.3 FSA Step 2 – Risk Analysis**

Risk analysis is the thorough procedure of examining the cause of the hazards and its consequences, where, a number of techniques, theories and concepts are applied in its process (Eswara, 2013). Hermanski & Daley (2010) further elaborated that risk is a product of accident probability and its consequences.

In this step, the causes and consequences of scenarios identified in step 1 have been investigated in detail, using the Fault Tree Analysis (FTA) technique to further analyze the hazards that had high rankings or RI of 6 and above. This has allowed attention to be focused on high risk areas and the factors which influence the size of the risk have been assessed. (IMO, 2018)

The hazards to ships in Papua New Guinea waters are indicated on the fault tree (FT) diagrams, which apply to both conventional and non-conventional sized vessels, however, for this research only the scenarios that have occurred on small vessels will be analyzed.

#### **Hazard 1: Capsizing**

Of all the vessels that have capsized, the majority involved were small crafts. The factors which reportedly contributed to these occurrences are discussed below.

The causes and consequences with regards to vessels capsizing in PNG waters are shown on figure 4.10 (PNG MRCC, 2019).

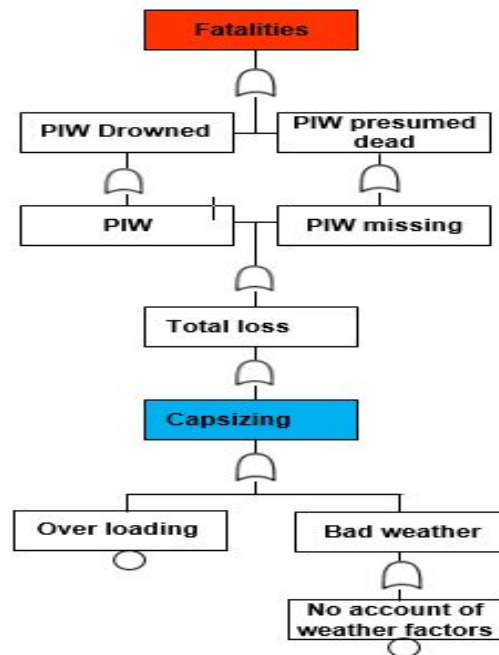


Figure 4.10: FT - capsizing.



Figure 4.11: Overloading of banana boats. (Source: NMSA)

Overloading of small boats is common as it is the only means of transport to get from one island to another or to main urban centers. Both passengers and cargo are transported on these small boats. Impacts of the surrounding environment cause the small craft to capsize. Figure 4.11 shows some photographs of overloaded banana boats with passengers and cargo (PNG MRCC, 2019).

Bad weather is one of the most contributing external factors that have caused many small boats to capsize. Tropical cyclones affect southern PNG between November and April (National Weather Service [NWS] & Pacific Climate Change Science Program [PCCSP], 2011), thus the surface wind-wave driven processes have an impact on many aspects of island and coastal environments, for example, shipping (Pacific Climate Change Science [PCCS], 2014). Either the weather information was not received or was ignored during the time of departure.

Consequences of capsizing is that all POBs end up in water, and their ability to survive depends on whether they are wearing personal floatation devices (PFD) or hanging onto whatever object is floating nearby. Unfortunately, in most cases, many POBs do not wear life jackets and if they are unable to find a floating object nearby, the person will drown. The problem relating to a small vessel, when out at sea, is that there is no way of knowing that it capsized as many do not carry emergency beacons, such as emergency position-indicating radio beacon (EPIRB), or a portable radio to send distress alerts. (PNG MRCC, 2019)

If the incident happens close to shore, the energetic persons in the water (PIW) are able to swim ashore and alert the nearby villagers to assist in rescuing the others' that were left drifting or fending for their last breath. Swift response results in the rescue of all PIWs, whereas, slow response rescue others, recover bodies while some remain missing. Those that remain missing are presumed dead after several days of searching. (PNG MRCC, 2019)



## Hazard 2: Missing vessel

There is a lot of mystery surrounding cases of small vessels going missing there are a number of factors presumed to have caused this these occurrences, as discussed below.

Firstly, a small vessel that capsizes whilst on its way to its final destination is due to the factors mentioned in the first hazard scenario and not made known to the people on shore or local authorities they will be regarded as missing after failing to arrive within the usual travel timeframe. In some cases, debris was found from the vessel, or only the submerged small vessel was found with no persons, or bodies located and identified. (PNG MRCC, 2019)

Figure 4.12 shows the possible events connecting to small vessels going missing at sea.

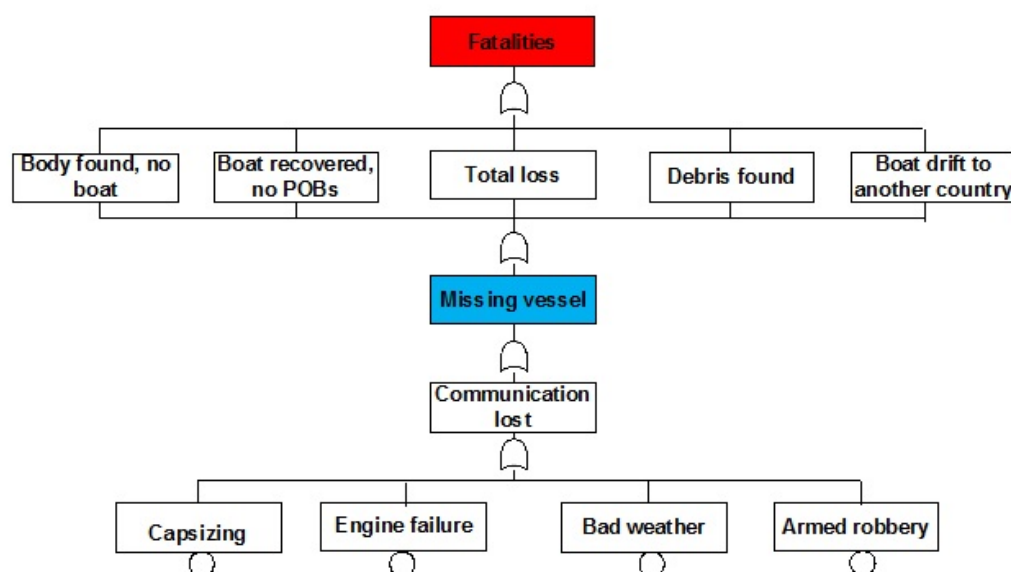


Figure 4.12: FT – missing vessels.

Secondly, engine failure causes the small boats to drift and go missing. This will be further elaborated in the next hazard scenario (engine failure). (PNG MRCC, 2019)

Thirdly, bad weather forces small vessels to take shelter on nearby islands whilst on their way. Again, due to communication difficulties, this is not communicated to the persons either at the place of departure or final destination. (PNG MRCC, 2019)

Lastly, armed robbery of ships has resulted in the disappearance of some banana boats and the murder of persons. One particular example is the disappearance of five scientists off the coast of West New Britain Province in 2011. (Radio New Zealand [RNZ], 2019)

However, misreporting, incorrect recording of accidents and the inability to investigate and establish the causes adds to the statistics of missing vessels. (PNG MRCC, 2019)

### **Hazard 3: Engine failure**

Factors which contributed to engine failure are discussed below.

Firstly, contaminated fuel causes the engine to stop and disables the vessels ability to make its way to its final destination, this is caused by sea water intrusion into the fuel tank, especially in rough weather. (PNG MRCC, 2019)

Secondly, running out of fuel disables the engine as it will not operate without fuel for combustion. This happens when no extra fuel is carried in the event the engine fuel consumption rate increases. On other occasions, mainly for open boats, bad weather can cause the skipper to be disoriented and steer the boat in the wrong direction losing sight of land or the correct route or keeps changing direction, thus running out of fuel. (PNG MRCC, 2019)

Lastly, nil spare parts to replace the malfunctioned part which can cause the boat to be left without power to propel the engine. For banana boats, the spark plugs of the engine are the most common part that malfunctions and when there are nil spares to replace, the boat drifts. (PNG MRCC, 2019)

Figure 4.13 shows the relationship of the causes and consequences of engine failure on small vessels.

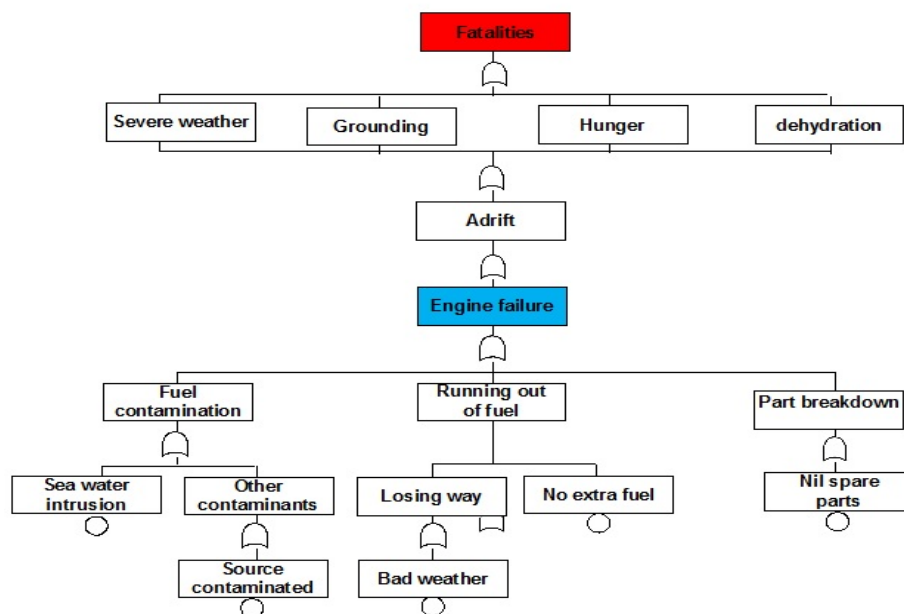


Figure 4.13: FT - Engine failure

When a boat is adrift, persons on board (POB) notify people ashore for assistance, mainly using mobile phones and the search party are able to locate the disabled boat and render assistance. However, once it is out of the mobile network coverage area, it will be difficult to keep in touch with people ashore, where the boat is not located and it may drift out to open seas. Also, the engine can breakdown at a location where POBs are unable to contact people ashore due to there being no communication equipment or being outside

of mobile network coverage area, where the boat may drift out to open seas and end up in other small island countries in the Pacific. Whilst adrift, some POBs have lost their lives due to hunger or dehydration due to direct sunlight and no shade, and other natural factors, such as severe weather, as per earlier example. (PNG MRCC, 2019)

#### Hazard 4: Grounding

Figure 4.14 shows the causes and consequences of vessels running aground in PNG.

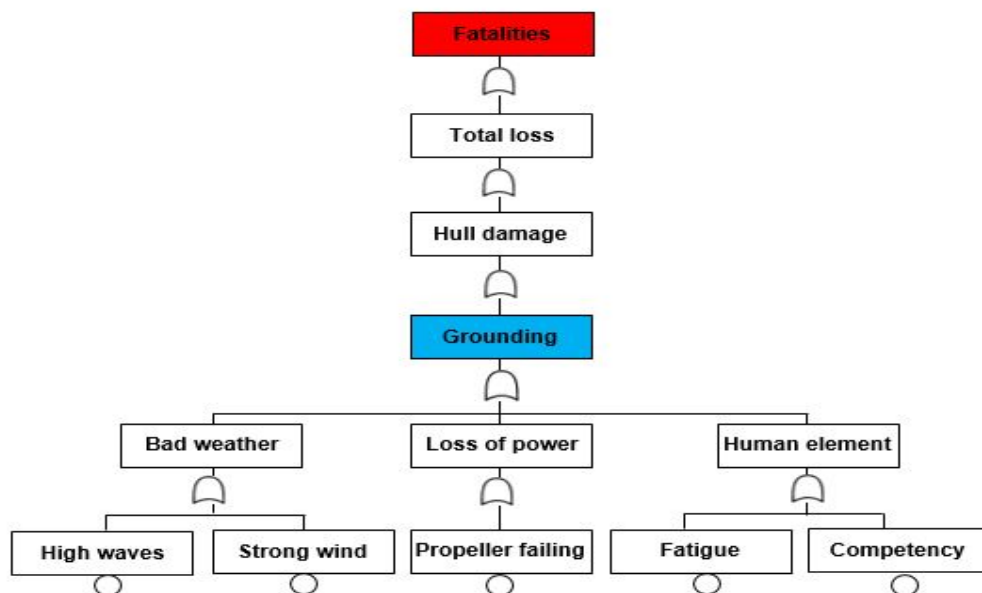


Figure 4.14: FT - grounding.

Factors that contributed to groundings are discussed below.

Firstly, heavy weather creates strong winds and big waves, where the wave height increases on shallow waters and may push the small vessels onto shallow waters or reefs.

Secondly, engine failure due to failed propeller, where there is no propulsion power, causes the vessel to drift and run aground on the reef with potential damage to the hull and environment. For example, on December 26, 2017, the propeller of MV Sulu Express failed due to running on improvised propeller without notifying NMSA, where the vessel lost power and got washed onto the reef whilst on the way to Lae. The vessel encountered hull damage and was towed to Madang slipway for repair. (NMSA, 2019)

Lastly, human element related factors such as fatigue and competency level of the crew contributed to vessels running aground. Lack of rest due to minimal crew on small vessels have caused fatigue that has led to the crew on duty unable to make the right decision and resulted in running aground. Also, lack of competence and confidence lead to a ship running aground. For example, crew not confident enough to manoeuvre the vessel in a narrow channel. (NMSA, 2019)

#### **Hazard 5: Man overboard**

Two factors reportedly contributed to the occurrence of man overboard. Firstly, weather in the form of rough seas, strong winds, and high waves which result in heavy rolling and pitching of the vessel and secondly, sudden speed or direction changes due to striking a debris or obstructions in water, also resulted in persons going overboard from small vessels at sea. In either case, the PIW could be fatally injured by the boat propeller, or face a shark attack, or end up drowning if they are a non-swimmer. (PNG MRCC, 2019)

From the analysis, it can be noted that weather is the common cause of many small vessel accidents where safety equipment such as life-jackets, emergency beacons, communication equipment, etc., are not being carried on small vessels in order to enable their immediate rescue. Some do have communication equipment such as portable radios and mobile phones, however, the limited service coverage for this devices impede their usefulness. Also, the POBs are unable to give the exact location of their distress as

they do not have the means to know their location when at open sea. Furthermore, PNG MRCC faces the same challenge in establishing communications with SRUs.

Figure 4.15 is a fault tree diagram showing the causes and consequences of a person falling over board a vessel.

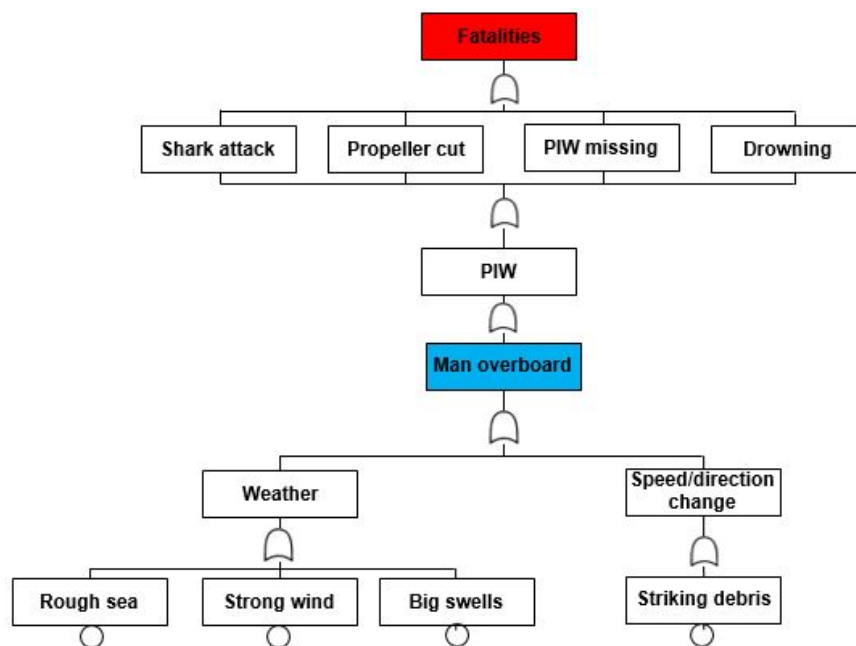


Figure 4.15: FT – Man overboard.

#### 4.4 FSA Step 3 – Risk Control Options

In this step, the Risk Control Measures (RCMs) have been picked out and categorized into a restricted number of Risk Control Options (RCOs) to be used as practical regulatory options (MSC-MEPC, 2018). RCM is a means of controlling a single element of risk and RCO is a combination of RCMs (Kontovas, 2005).

#### 4.4.1 Identification of RCOs

In this stage, RCMs have been grouped into a limited number of well thought out RCOs. The identification of RCOs is done using the SHEL model by analyzing the causes and consequences identified in FSA step 1 and 2, the issues and challenges mentioned in chapter 2, and the analysis of the responses to the questionnaires by the selected participating countries in this research. (IMO, 2018)

Metso et al (2016), defined Hawkins 1987 SHEL model as a framework that can be used to study the interactions between individuals, the systems in which they function, and the environment which influences the individuals' activities. Figure 4.16 show the diagram for Hawkins SHEL model.

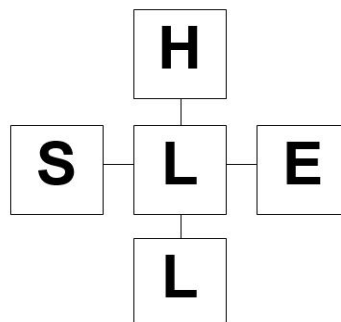


Figure 4.16: SHEL Model.

#### **S – SOFTWARE**

The software consists of regulations, agreements, standard operating procedures, national plans, manuals, checklists, etc., used in PNG and participating countries for maritime SAR services and safety of small vessels, as discussed below.

## **S1 – International Legal framework**

PNG has ratified the SAR Convention in 1992, however, yet to pass the SAR legislation and national SAR plan, where these two documents are currently in draft stages and undergoing review.

## **S2 – International Cooperation and agreements**

SAR Convention and IAMSAR manual requires SAR agreements for cooperation with neighboring states for sharing of resources. PNG has existing agreements with Indonesia that were signed in 2002 and Australia in 2007. Arrangements are currently in progress to sign an agreement with the Solomon Islands but no plan yet to sign an agreement with US Coast Guard Sector Guam. Also, PNG is yet to sign Pacific Island Regional SAR Agreement, an initiative by the PACSAR for regional SAR cooperation. (PNG MRCC, 2019)

## **S3 – National cooperation and agreements**

SAR Convention and IAMSAR manual requires SAR agreements or service level agreements (SLA) for cooperation with other state agencies and voluntary organizations for sharing of resources.

According to PNG MRCC, there are no formal internal arrangements and agreements with other state agencies, except one that has already been prepared by the authority to work closely with PNG Water Police. Also, no formal agreements and arrangements with voluntary organizations, however, only a common understanding with the maritime Provincial Disaster Offices, based on the National Disaster Act, one private company, and local communities whom PNG MRCC works closely with in providing assistance to others in distress. The current draft nation SAR plan does mention volunteer organizations, however, it does not specify the organizations, agreements and



arrangements. For example, Swedish Maritime Administration (SMA) has agreement with the Swedish Sea Rescue Society (SSRS) for the provision of maritime SAR services for free, where the organization is funded by contribution from members and through fund raising activities (Swedish Maritime Administration [SMA], 2019). In Australia, there are a number of volunteer marine rescue associations or groups that sustain their operations through donors (AMSA, 2019).

#### **S4 – Regulation for small vessels**

The PNG MSSR 2006 is applicable to vessels of 20 m in length and above (PNG MSSR, 2006), while the PNG SCA 2011 is applicable to craft below 10 m (PNG SCA, 2011). The PNG Merchant Shipping (Small Vessel Safety) Regulation 2018 which is proposed to be applicable to small vessels between 10m and 15 m is still under draft and no regulation for small vessels between 15m and 20 m.

### **H – HARDWARE**

The hardware includes safety equipment, tools, devices, assets, etc., used for the purpose of maritime SAR operations and safety of small vessels, as discussed below.

#### **H1 – Lifejacket**

The PNG MSSR 2006 and PNG SCA 2011 requires carriage of lifejackets. However, the PNG SCA 2011 does not specify type of life-jacket for an area of operation. For example, the Queensland (QLD) Transport Operations (Marine Safety) Regulation (TOMSR) 2016, requires each individual to wear lifejacket level 100, 50 or 50S or a compliant inflatable diver's jacket on board a ship and personal crafts of 5 m in length and above operating in partially smooth waters and beyond (QLD TOMSR, 2016).

## **H2 – EPIRB**

The PNG MSSR 2006 requires carriage of radio beacon for ship on an international voyage. There is no provision for carriage of EPIRB in the PNG SCA 2011. However, there should be a consideration for provision for carriage of EPIRB. For example, the QLD TOMSR 2016, requires a Queensland regulated ships of 5 m in length and above in Queensland waters to carry an EPIRB, operating beyond smooth or partially smooth waters and beyond 2 n miles from land. (QLD TOMSR, 2016)

## **H3 – Communication equipment**

The PNG MSSR 2006 requires carriage of radio facilities, while the PNG SCA 2011 requires carriage of a mobile phone on which an emergency call can be made. The difficulty when receiving distress alert from mobile phones is the identification of the location of the caller. The solution is to use a system where the caller's location can be immediately known by the emergency services. For example, in Sweden, advanced mobile location (AML) services is used by JRCC Sweden to know the location of the person calling the emergency number (SMA, 2019). AML allows smart phone technology to transmit GNSS or Wi-Fi based location data to emergency services via SMS or HTTPS and provides outdoor and indoor locations with an accuracy of less than 50 m and 25 m radius respectively (EENA, 2018). Also, the Tasmania (TAS) Marine and Safety (Motor Boats and Licenses by-Laws) (M&SMB&LL) 2013, requires carriage of marine radio on motor boats less than and more than 6 metres in length in waters other than sheltered waters (TAS M&SMB&LL, 2013).

## **H4 – Signaling devices**

The PNG MSSR 2006 requires carriage of signaling devices such as handheld flares, smoke floats, etc., by applicable PNG flagged vessels. The PNG SCA 2011 requires carriage of mirror or similar device for signaling, however, no specifics about the devices.

Specifications about other signaling devices should be considered. For example, the QLD TOMSR 2016, requires a Queensland regulated ships of 5 m in length and above in Queensland waters to carry signaling devices such as V sheet, handheld red flares, and handheld orange smoke signals, operating in or beyond smooth or partially smooth waters (QLD TOMSR, 2016). Radar reflectors should also be considered for installation on small crafts to become more visible on radar. For example, TAS M&SMB&LL 2013, requires installation of radar reflectors on motor boats less than and more than 6 metres in length in waters other than sheltered waters (TAS M&SMB&LL, 2013).

#### **H5 – SAR resources**

As require by SAR Convention 2004 and IAMSAR manual 2016, SAR organizations must arrange available resources for the provision of maritime SAR services. PNG MRCC is yet to fully make arrangements for use of available resources. Sometimes the distress is sent ashore but the limited resource capabilities impedes the maritime SAR response. Many times, the villages assist others in distress and the factor that stops them from going out is inadequate fuel, and other factors. The PNG Defence Force currently operates two helicopters, four fixed wing aircrafts (Aeroflight, 2017), and eight vessels (McHugh, 2018). Also, funding to be made available to SAR system corresponding to national goals, which is one of the obstacles in providing effective maritime SAR services in PNG.

#### **H6 – Accident and SAR records**

The IAMSAR manual requires maintenance of proper records for all maritime SAR events, sufficient to construct incident scenarios. PNG MRCC record keeping has improved since 2013, however, some information requires recording such as causes and consequences of the SAR events, including accurate information. In comparison, the Ship Survey and Inspection department keep records for convention size vessels through

the casualty investigations. However, records for non-convention size vessels requires improvement.

## **E - ENVIRONMENT**

Both internal and external factors of the environment with regards to maritime SAR services and safety of small vessels are discussed below.

### **E1 – Internal factors**

Employment terms and conditions should be favorable for maritime SAR personnel and national ship inspectors to aid effective job performance. In order for an organization to thrive, it must build an environment that strives to retain existing staff, and not only to lure people to join and give their best every day. The retention of competent experienced, productive and knowledgeable employees can be the origin of competitive advantage for the organizations. (Acton & Golden, 2002)

### **E2 – External factors**

Weather is an external factor that can affect the provision of maritime SAR services and safety of small vessels (Maritime & Coastguard Agency [MCA], 2018). Weather information is provided by the National Weather Service and broadcasted through local AM/FM radio, TV stations and published on local newspaper. However, illiteracy rate and the mode of receiving weather information is a change for many coastal and islands communities. Due to illiteracy rate, many coastal communities do not understand the weather information disseminated through all mediums.

## **L – LIVEWARE**

Human factors such as people or relationships, that are involved in the maritime SAR services and safety of small vessels are discussed below.

## **L1 – Safety Culture**

Safety culture is not practiced widely by many citizens of PNG, which is evident in the number of accidents involving small crafts, especially banana boats. Despite the awareness program conducted by NMSA throughout the maritime provinces, not much change has happened. The operators are more interested in earning a living than safety. This can be seen in road transport, as well, where traffic laws are not observed and intentionally violating them whenever traffic police are not in control. (NMSA, 2019)

Also, the willingness-to-pay to avert fatality is not there amongst many citizens. Safety equipment such as, life-jacket, etc., can be afforded by many but the excuse is that it is expensive and yet they can spend on things that are not important and cost more than a single life-jacket, which can save a life. Comparing this to Sweden, safety culture is widely practiced by many citizens, so the willingness-to-pay to avert a fatality is high. For example, the inflatable helmet is becoming common on many riders to prevent head injuries when falling off, though that is about three times more than the standard bicycle helmet. This clearly shows the willingness-to-pay to avert fatalities by many riders in purchasing the inflatable helmet, despite the cost. (Hovding, n.d.)

The author is of the opinion that a different approach should be taken in the awareness program, including stringent policies, to quickly change the mindset of coastal and island communities to practice safety culture by adopting measures that other countries have taken. For example, in Iceland, safety culture was an issue and a lot of fishermen lost their lives and this trend changed when the authorities started engaging families of fishermen, widows, and the community (Christiansen & Hovmand, 2017).

## **L2 – Training**

Training, qualification, SAR exercises are required by IAMSAR manual for proper SAR responses. However, PNG MRCC is yet to outline training policy for the SAR staff due to legislation and national being under draft, including regular SAR exercises with other state agencies and neighboring SRRs. For example, Swedish Maritime Administration facilitates training for SAR staff, crew of SRUs for sea and air, and every year, there is national and international SAR exercises conducted by Regional SAR coordinator (SMA, 2019). In comparison, BASARNAS facilitates training for SAR staff and conduct routine SAR exercises with neighboring SRRs, excluding PNG (Basarnas, 2019).

## **L3 – Functional capacity**

Both international and national maritime laws require compliance, monitoring and enforcement of safety standards on national flagged vessels. The NMSA enforces compliances standards on national flagged vessels of 20 m and above and less than 20 m are excluded. Casualty investigation is conducted on convention size vessels and rely on reports from owners for non-convention vessels when accidents occur. Further to that, NMSA has only one compliance officer who responds to compliance issues on PNG flagged vessels (NMSA, 2019). Considerations should be given to all classes of vessels under the flag to be investigated during accidents.

### **4.4.2 Listing of RCOs**

The RCOs identified are listed as follows.

**RCO 1** – Completion of national maritime SAR legislation and plan with inclusion of specific provisions for voluntary organization, other state agencies, and neighboring SRRs to specify cooperation for timely response to maritime accidents.

**RCO 2** – Review existing SAR agreements with Australia and Indonesia based on the needs analysis of the maritime SAR services in PNG and establish outstanding agreements with the Solomon Islands and US Coast Guard Sector Guam for sharing of resources, especially on possible MRO and other maritime accidents. Establish maritime SAR committee to oversee the above arrangements.

**RCO 3** – Establish Service Level Agreements (SLAs) and arrangements with the PNG Defence Force and other possible state agencies for the use of their assets, including voluntary organizations for better coordination and response to rescue those in distress. Also, encourage respective maritime provinces to create volunteer organizations or associations or groups, similar to that of Sweden and Australia.

**RCO 4** - Implementation of PNG Merchant Shipping (Small Vessel Safety) Regulation 2018 to enforce safety standards on small vessel between 10 m to 15 m, as required by the law. Also, amendment of PNG SCA 2011 to include measures and standards that have been omitted earlier. For example, mandatory requirement and stringent enforcement measures with tough penalties, including compliance monitoring and enforcement of standards.

**RCO 5** – Carriage of lifejacket to be made mandatory by all small vessels operating in PNG waters. The type of lifejacket to be carried on board will depend on the area of operation. For example, small vessels operating in rough sea conditions to have different requirements than those operating in calm waters.

**RCO 6** – Carriage of emergency beacons, such as EPIRB, to apply to all small vessels operating beyond 2 n miles from land and smooth or partially smooth waters. For example, small vessels travelling further to outer islands to have different requirements than those operating in short routes or along the coast only.

**RCO 7** – Carriage of communication equipment, such as portable VHF radio, to enable the persons on board to communicate with passing ships and local authorities ashore for

assistance in the event the vessel is in distress. The carriage of such equipment will depend on the size of the small vessel and the area of operation.

**RCO 8** – Consideration of other technological innovations such as AML to aid maritime SAR authority to pinpoint location of persons in distress. This services will allow PNG MRCC to locate the persons calling the maritime SAR emergency number using mobile phones when the caller (s) is/are not able to immediately give their location of distress.

**RCO 9** – Formulate specific provisions for carriage of signaling devices such as V sheet, handheld red flares, handheld orange smoke signals, in certain areas of operation and included in the PNG SCA 2011. Using these devices attract attention from passing ships and aircrafts. Also, installation of radar reflectors to be considered on small crafts and relevant provisions to be inserted in the PNG SCA 2011. This will enable big vessels to detect the small craft and, also, aid maritime SAR operations.

**RCO 10** – Readily available response assets for maritime SAR to aid the successful rescue of those persons in distress at sea. Also, National Government should make available adequate funds at the disbursement of PNG MRCC and provincial disaster offices in order to render immediate assistance and save lives of those persons in distress at sea.

**RCO 11** – Maintenance of proper and accurate records by PNG MRCC and Ship Survey and Inspection in order to construct accident scenarios for prevention in future.

**RCO 12** – Favorable employment terms and conditions for maritime SAR personnel in order to perform effectively and efficiently.

**RCO 13** – Provision of timely and accurate weather information should be made available to all the coastal and islands communities for decision making in order to avoid accidents. Awareness should be conducted by the National Weather Services (NWS) to



educate the coastal and island communities on how to understand the weather information disseminated and the consequences of not adhering to such information.

**RCO 14** – Changing the educational and awareness approach for communities to heed safety culture in order to value human life than economic or other reasons by involving stakeholders and communities. Also, development of policies related to building and developing safety culture in the maritime transport.

**RCO 15** – Training the maritime SAR personnel and conducting regular SAR exercises between state agencies, voluntary organization, and neighboring SRRs to ensure that maritime SAR personnel perform their job effectively.

**RCO 16** – Establishment of separate entity for Marine Casualty Investigation, preferably a National Transport Safety Board, for investigation of casualties involving convention and non-convention size vessels. This organization will investigate any accident involving ships in PNG waters and make recommendations to NMSA based on the finding.

The organizations affected by the identified RCOs are: NMSA, PNG MRCC, PNG DF & other state agencies, small vessel owners / operators, coastal and island travelling communities, Ministry of Transport & Infrastructure, Ministry of Information & Communication, National Information & Communication Technology Authority, National Weather Services, provincial governments, victims and families of those that have been affected by maritime accidents in PNG.

#### **4.4.3 Risk reduction**

The FT diagrams from step 2 of the FSA have been reconstructed to see where the RCOs fit in to control the risks. The afore-mentioned RCOs have been indicated on the FT diagrams, as shown on figures 4.17 to 4.21, where the RCOs can possibly have an effect on different stages of the occurrences leading to final outcome.

## Hazard 1: capsizing

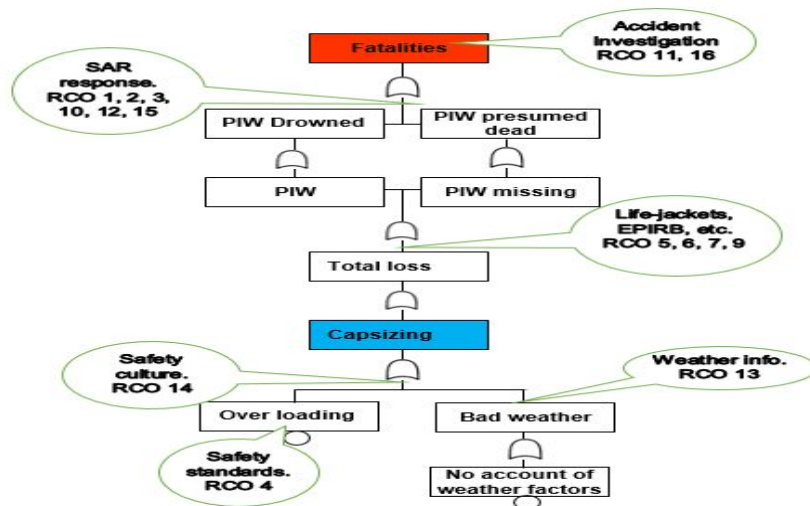


Figure 4.17: FT - capsizing & RCOs.

## Hazard 2: missing vessel

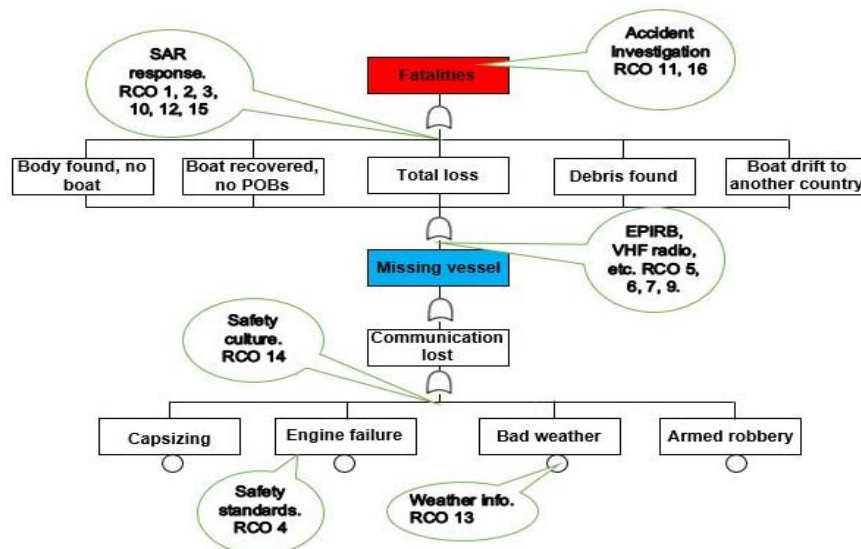


Figure 4.18: FT - missing vessel & RCOs.

### Hazard 3: engine failure

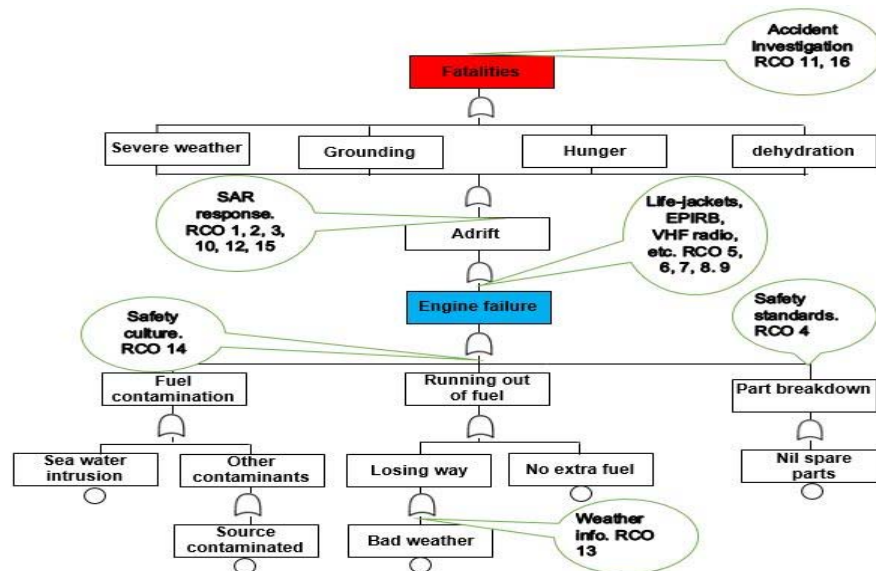


Figure 4.19: FT - engine failure & RCOs.

### Hazard 4: grounding

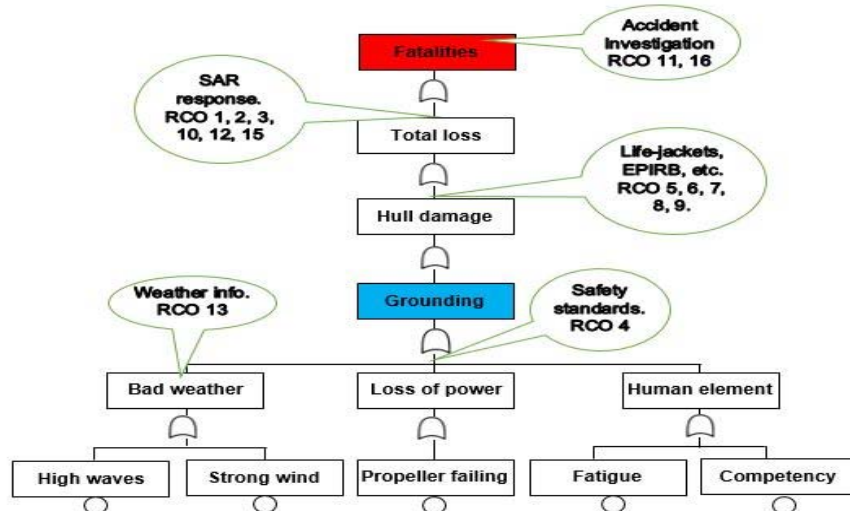


Figure 4.20: FT – Grounding & RCOs

## Hazard 5: Man overboard

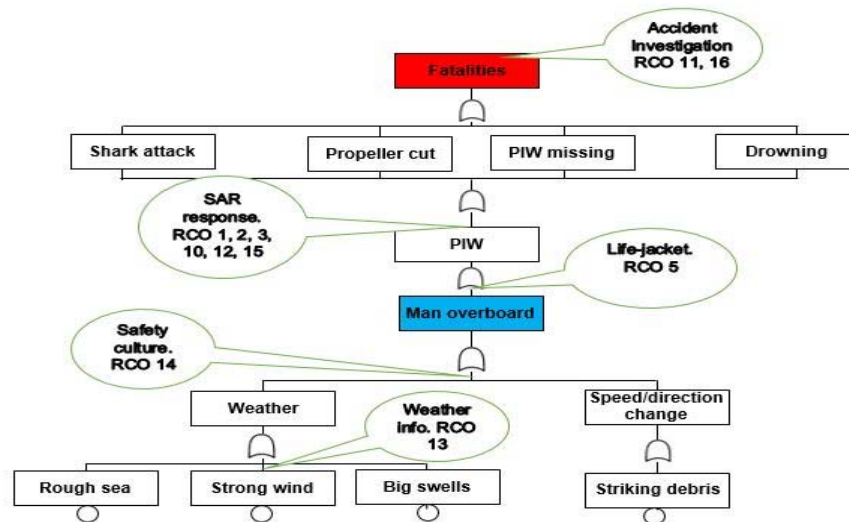


Figure 4.21: FT - man overboard & RCOs.

### 4.5 FSA Step 4 – Cost-benefit assessment

In this step, benefits and costs related to the implementation of each RCO pinpointed and defined in step 3 have been identified and contrasted (IMO, 2018).

#### RCO 1

The cost of completion and implementation of the PNG Maritime SAR Legislation and National SAR Plan will be included in the operational cost of PNG MRCC and NMSA, Ministry of Transport, Ministry of Justice, and National Executive Council (NEC).

#### RCO 2

Respective countries will meet the costs involved for reviewing of existing SAR agreements and establishing of new agreements. For PNG, the costs will be met by PNG

MRCC, NMSA, and the Ministry of Foreign Affairs and Trade through individual organizational operational costs.

### **RCO 3**

The cost related to establishing agreements and arrangements with other state agencies and volunteer organizations will be met through the individual organizations operational costs. The benefit is that costs involved in sharing of resources will be reduced.

### **RCO 4**

The completion and implementation of PNG Merchant Shipping (Small Vessel Safety) Regulation 2018 will cost NMSA, Ministry of Transport & Infrastructure, Department of Justice, and NEC through the normal operational costs of respective organizations. Additional costs to NMSA will be incurred on the resources required for the compliance, monitoring and enforcement of the Regulation, including the review and implementation of PNG SCA 2011.

### **RCO 5**

Carrying a lifejacket will have cost implication on small vessel owners, operators, coastal and islands communities that regularly travel by sea. For example, one inflatable life-jackets cost around PGK233.69 and foam filled life-jacket (50) cost around PGK105.15. For a banana boat that usually transport 11 persons in partially smooth waters, it will cost the owner or operator around PGK2570.61 for inflatable PFDs and PGK1156.63 for foam filled lifejackets. (Boating Camping Fishing [BCF], n.d.)

However, the benefit of buying and carrying lifejackets is that it keeps a person afloat and saves lives. The life span for a lifejacket is 10 years where service is required every 2 years for inflatable and service free for foam filled, while, annual visual inspection

required for foam filled lifejacket for wear and tear. If regular sea travelers buy their own lifejackets, then it will cut the cost for the boat owners or operators. (Secumar, n.d.)

Furthermore, it will be of great benefit if the national government or NMSA assist small vessel owners or operators by subsidizing the cost for each life-jacket. For example, in 2007 the Senegalese government subsidized the cost of life jackets and is required by ministerial decree that they be carried by every fishing vessel (Danielsson et al., 2008).

## **RCO 6**

Carriage of emergency beacons, such as EPIRB and PLB, will have cost implications on the small vessel owners and operators. For example, a standard GME 406MHz digital EPIRB costs PGK698.81 and GME 406MHz digital EPIRB with GPS costs PGK817.98, which is high cost for many small vessel owners to afford. PLB, also, cost PGK698.81. (BCF, n.d).

However, the benefit of carrying an EPIRB is that it will alert SAR services when in distress at sea and transmits a signal with position to aid SRUs to locate the person (s) in distress (Bhattacharjee, 2019). Also, with the latest materials and technologies permits emergency beacons up to 20 years' useful life with battery life of up to 10 years. The time frame of usefulness and battery life depends on the model of the product and brand, where some have 12 – 14 years' useful life and 6 – 7 years' battery life. (GME, n.d.).

## **RCO 7**

Carrying communication equipment, such as portable marine VHF radio transceivers, will have cost implications in small vessels categories required to carry it. For example, the ICOM transceiver cost around PGK853.06 and requires registration for licensing purposes.

However, the benefit of having a new design is that it provides reliable communication 1 meter above the water at a distance of up to 20 nautical miles from shore. It is just like carrying a mobile phone and can be used outside of mobile coverage areas and it is free to send out a distress message. Also, any passing ship maintaining listening watch on VHF channel and can pick up the alert. (Corke, 2015)

#### **RCO 8**

The use of technological innovations such as AML to aid PNG MRCC to pinpoint location of persons calling emergency numbers will cost the government and the mobile network operators. However, the cost can be recouped through their commercial services. The benefit of this service is that it will allow PNG MRCC to immediately know the location the persons calling the emergency number and render assistance quickly.

#### **RCO 9**

The usage of signaling devices such as, handheld red flare and orange smoke signals will have cost implications on the small vessel owners and operators. The offshore kit that consist of 2 handheld red flares and 2 orange smoke signals cost PGK292.12. The V Sheet cost is less and affordable, that is about PGK30.27 (BCF, n.d.). Also, installation of radar reflectors, where tabular radar reflector cost PGK109.82 (Defender, n.d.).

However, the benefit of carrying flares and smoke signals is that it is used to get the attention of other boats or aircraft in the area when in need of assistance and also warn other boats about your position as to avoid potential collision. A v-sheet is displayed to attract the attention of other boats or overpassing aircraft. (Maritime Safety Queensland [MSQ], 2019). The benefit of installing a radar reflector is that it is used to assist big vessels spot small vessels on their radar screens to help avoid collision on the water, and also to facilitate SAR operations (Canadian Safe Boating Council [CSBC], 2017).

**RCO 10**

The cost of providing and maintaining readily available response assets for maritime SAR in order to successfully rescue those persons in distress at sea will be met by PNG MRCC and other organizations as part of agreements with states agencies, volunteer organizations, and neighboring SRR. The benefit is that the costs of SAR operations will be reduced. Also, making funds available for the provision of maritime SAR services will come from the government national budget, including NMSA. (IMO & ICAO, 2016)

**RCO 11**

Maintenance of proper and accurate records by PNG MRCC and Ship Survey and Inspection will not be a cost to NMSA as this will be covered through the operational cost of the employment of staff to maintain the records.

**RCO 12**

Offering better working terms and conditions will be met by PNG MRCC and NMSA through normal operations costs. Also, cost will be reduced on recruitment drive of qualified officers are retained in the organization.

**RCO 13**

There is no separate or additional cost involved for the dissemination of weather information by the National Weather Services, local newspaper, local AM/FM radio stations, local TV stations, and internet based. The operational and administration cost incurred by NWS is met by the National Government budget appropriation. The local newspaper, AM/FM radio and TV stations are commercial so they will recover the costs through their various commercial services.



#### **RCO 14**

The change in the educational and awareness approach will have additional cost implications to NMSA, however, in the long run, this cost will be less than the cost that is usually incurred in one maritime SAR operation. For example, a single awareness program conducted by NMSA cost about PGK20, 000, which covers transport, logistics, and other administration costs (NMSA, 2019). For SAR operations, it covers, transport, logistics, charter of SRUs, allowance for SRU crew, etc. The charter of private helicopters for an aerial search cost around PGK 40, 000, as per PNG MRCC records. Perhaps the associated cost will decrease once the coastal and island communities start practicing safety culture.

#### **RCO 15**

The cost of facilitating training for maritime SAR personnel is usually included as part of the operational cost for PNG MRCC. SAR exercises between state agencies, voluntary organizations, and neighboring SRRs can be counter funded. The benefit of training is that maritime SAR personnel will do their job correctly, while the SAR exercise refreshes what they have learnt in their training, also, enable them to acquire new skills and knowledge.

#### **RCO 16**

The establishment of National Transport Safety Board, for investigation of casualties involving convention and non-convention size vessels, will cost the national government with additional funds through national budget allocation. The benefit of setting up this organization is that the findings through investigations will enable NMSA to rectify safety issues and in turn reducing further accidents and cost for response and recovery.

## **CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS**

### **5.1 Conclusion**

The ultimate purpose of this dissertation was to improve the effectiveness of maritime SAR services and safety measures on national flagged small vessels in PNG by understudying the neighboring SRRs and selected countries on how they provide maritime SAR services and enforce safety measures on their flagged small vessels. This study was not to create new ideas or theories but to learn from the participating countries in order to address the current issues affecting the provision of maritime SAR services and safety of PNG flagged small vessels.

This research has noted that the issues related to maritime SAR services and safety measures on small vessels can be addressed by implementing the international requirements for both maritime SAR and safety of vessels. For example, the requirements of SAR Convention and IAMSAR manual for provision of maritime SAR services. With regards to safety of small vessels, it is the requirements of relevant IMO instruments and national regulations. However, other issues can be addressed by good practices from other countries. For example, there were number of practices learned from Australia and Sweden, in relation to SAR and safety.

The study revealed that in order to provide for an effective maritime SAR services, as per the international requirements, national maritime legislation and plan have to be developed. Issues related to maritime SAR services can be collaboratively addressed through cooperation and arrangements. One possible way is through the engagement of voluntary organizations and inter-governmental agencies. Agreements and

arrangements have to be organized in order to share resources to save lives and reduce costs. Similarly, agreements have to be established with neighboring states to arrange and share resources. Another benefit of agreements with neighboring states is in regards to Mass Rescue Operation (MRO), as facilities of one state are always inadequate for such operations to be conducted. Also, training of SAR personnel and regular SAR exercises contributes to effective maritime SAR services.

With regards to safety of small vessels, it was noted that the safety measures can be addressed at two levels, that is, legal framework and resources in terms of compliance, monitoring and enforcement. Regulations with tough penalties and stringent compliance, monitoring and enforcement standards and procedures will improve safety on small vessels.

On the other hand, safety culture is a big issue adding pressure to response capabilities of PNG maritime SAR services where many coastal and islands communities lack. As discussed in the assessment, many of the accidents could have been avoided if safety culture was practiced. Furthermore, natural or environmental factors also contributed to many accidents. However, these issues can be addressed by learning from other countries, particularly Iceland, on the measures it has taken to address safety culture, as discussed in the previous chapter.

## **5.2 Recommendations**

These list of recommendations is non-exhaustive and have been made to the relevant decision makers based on the comparison and ranking of all hazards and their underlying causes and identification of risk control options to keep those risks as low as reasonably practicable.

## **Recommendations for PNG MRCC**

- ❖ Accelerate the process of completing the National Maritime SAR Legislation and National Maritime SAR Plan, in collaboration with NMSA legal team, SAR stakeholders, Justice Department and Ministry of Transport for approval by the National Parliament, to specify PNG MRCC's jurisdiction and responsibilities for provision of maritime SAR services.
- ❖ A review of current SAR agreements with Australia and Indonesia in collaboration with the Ministry of Foreign Affairs and Trade, based on the need's analysis of the maritime SAR services in PNG. Accelerate the process for signing agreement with the Solomon Islands and consider an agreement with US Coast Guard Sector Guam, in collaboration with Department of Foreign Affairs and Trade. Also, formulate agreements and arrangements for regular joint SAR exercises between neighboring SRRs and SAR personnel to do on-the-job training with JRCC Australia, BASARNAS, MRCC Honiara on a rotational basis.
- ❖ Establish service level agreements (SLA) and arrangements with other state agencies, especially finalizing the agreement that NMSA has already prepared to work closely with PNG Water Police, and collaborating with PNG Defence Force and the Ministry of Defence to formalize agreement for use of their assets in conducting maritime SAR operations.
- ❖ Include specific local voluntary organizations, with SLAs and arrangements in the National Maritime SAR Plan for provision of maritime SAR services in PNG. Also, liaise with authorities at provincial, district, Local Level Government, ward levels to form possible volunteer organizations or associations or groups to look out for community members travelling on small vessels and respond to distress alerts. These volunteer organizations or associations or groups could be funded by contributions from the provincial government, MPs, working class, and other

organizations of goodwill to sustain their operations or maybe, even using crowdsourcing.

- ❖ Formulation of contingency plan for maritime SAR operations, especially on the specific resources from neighboring SRRs to be used in different areas on search in PNG waters. For example, Indonesian air SRU can be used for aerial search in northern seas of PNG and Australian air SRU be utilized for searches in the southern and eastern seas, considering the timeframe to respond to distress.
- ❖ Ensure maritime accidents are reported using standard formats, correct terminology, including vessel descriptions and recorded under common accident types. Also, ensure that accidents are investigated properly to establish causal factors and resulting events, and recorded. For example, if there is an unconfirmed case reported with casualties, causal factors and consequences have to be established and recorded. Additionally, issue administrative instructions to provincial and local authorities to always update PNG MRCC on maritime accidents so that records are updated. Furthermore, statistics of maritime SAR accidents be published in a certain time frame for public consumption on public media.

#### **Recommendations for National Maritime Safety Authority (NMSA)**

- ❖ Accelerate the process of completing the Merchant Shipping (Small Vessel Safety) Regulation 2018, in collaboration with stakeholders, Justice Department, and Ministry of Transport & Infrastructure for approval by the National Parliament to enforce safety standards on small vessels.
- ❖ Amend the Small Craft Act 2011, in collaboration with stakeholders and Justice Department to include provisions and further requirements for safety of small crafts under the Act, such as:

- Carriage of lifejacket or a compliant inflatable diver's jacket on boats operating in smooth waters, partially smooth waters and beyond;
  - Carriage of EPIRB or other emergency beacons on boats under operating beyond smooth or partially smooth waters and beyond two nautical miles from land;
  - Carriage of marine radio on boats operating in waters other than sheltered waters;
  - Carriage of signaling devices on boats operating in or beyond smooth and partially smooth waters; and
  - Carriage of radar reflectors on boats operating in waters other than sheltered waters.
- ❖ Change the educational and awareness approach for communities to heed safety culture in order to value human life than economic or other reasons. The awareness program to involve the families of small craft operators and owners, victims, and families of those who have been involved in small craft accidents. Allow the victims to tell their ordeals, families of the victims to tell about how they felt or were affected when they lost a loved one, women to talk to their husbands, including the community leaders. Talk to the communities in a way that will make them feel scared of losing their lives or loves ones at sea. Intense awareness program to be conducted in provinces where more incidents are occurring. Transfer the powers of Small Craft Act, 2011 to provincial transport authorities for the compliance, monitoring and enforcement of safety standards on all small crafts that fall under the Act. Milne Bay Province to be used as model example to effect in other maritime provinces. NMSA to investigate all accidents involving small crafts, where it is more like auditing the performance provincial transport authority and will improve safety measures through investigation and recommendations.

### **Recommendations to National Weather Services (NWS)**

- ❖ Provide timely, accurate and simplified weather information to all the coastal and islands communities for decision making in order to avoid accidents.
- ❖ Conduct awareness campaigns to educate the coastal and island communities on how to understand marine weather forecast supplied and the consequences of not adhering to such information. Furthermore, encourage each coastal and island communities to buy and install marine VHF/HF radio to listen and get weather information broadcast by Port Moresby Radio.

### **Recommendations for National Information and Communication Technology Authority (NICTA)**

- ❖ NICTA to consider implementing the advanced mobile location (AML) services in PNG, in collaboration with Digicel, Bemobile Vodafone, and Telikom PNG, so that the emergency service providers will know the location of the person calling the emergency number to swiftly respond to the accident or distress situation on land or at sea, including inland waterways.

### **Recommendations for Ministry of Transport & Infrastructure**

- ❖ The Ministry of Transport & Infrastructure to consider establishing a separate entity for Marine Casualty Investigation, for example, National Transport Safety Board or Marine Accident Investigation Board. This entity will investigate all marine casualties and incidents on both convention and non-convention size national flagged vessels under the jurisdiction of NMSA, where it is more or less auditing the performance of NMSA and will improve safety standards on PNG flagged vessels through investigation and recommendations.

### **Recommendation for Provincial Transport Authority**

- ❖ Small vessel reporting center to be formed by the respective Provincial Transport Authorities in order to monitor and track the movements of small vessels within the provincial waters or neighboring provinces. The small vessel owner or operator will contact the center and inform of the vessel's departure, time, vessel particulars / name / call sign, number of persons on board, destination, travel distance, estimated time of arrival and other related information.

### **Recommendation for other state agencies**

Stakeholders and other state agencies are encouraged to cooperate with future researchers in providing factual information as this kind of research will make recommendations and bring changes and improvements in PNG.

### **5.3 Further areas of research**

This research suffered some setbacks due to insufficient data provided and attempts to rectify and establish facts or full information about common accidents were unsuccessful. This means that the data which forms the basis of this research was not a full reflection of all the casual factors and consequences in PNG. Therefore, further research would be required to establish the complete casual factors and consequences on all PNG flagged non-convention size vessels.

**WORD COUNT: 16579**



## REFERENCES

- Acton, T & Golden, W. (2002). *Training: The Way to Retain Valuable IT Employees?* Retrieved from: [https://www.researchgate.net/publication/320654573\\_Training\\_The\\_Way\\_to\\_Retain\\_Valuable\\_IT\\_Employees](https://www.researchgate.net/publication/320654573_Training_The_Way_to_Retain_Valuable_IT_Employees)
- Aeroflight. (2017). *Current Aircraft Inventory - Papua New Guinea Defence Force*. Retrieved from <http://www.aeroflight.co.uk/user/in-service/papua-new-guinea-df-current-inventory.htm>
- Alexander, D. W. (1999). *The development of maritime search and rescue in the Republic of Fiji* (Master's dissertation, World Maritime University, Malmö, Sweden). Retrieved from [https://commons.wmu.se/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1130&context=all\\_dissertations](https://commons.wmu.se/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1130&context=all_dissertations)
- Andrew, W. (2012). *Commission of inquiry into the sinking of Rabaul Queen*. Retrieved from <http://www.coi.gov.pg/documents/COI%20MV%20RABAU%20QUEEN/Rabaul%20Queen%20COI%20final%20report%20June%202012.pdf>
- Australian Maritime Safety Authority (AMSA). (2013). *Papua New Guinea Search and Rescue Gap Analysis: Final Report*. Port Moresby: National Maritime Safety Authority.
- Australian Maritime Safety Authority (AMSA). (2018). *Maritime Safety Information*. Retrieved from <https://www.amsa.gov.au/safety-navigation/navigation-systems/maritime-safety-information>
- Baumler, R. (2019). *OSH Safety Construction* [pdf]. Retrieved from: <https://academics.wmu.se/mod/folder/view.php?id=6538>
- Bhattacharjee, S. (2019). *What is an Emergency Position Indicating Radio Beacon (EPIRB)?* Retrieved from <https://www.marineinsight.com/marine-safety/what-is-epirb-emergency-position-indicating-radio-beacon/>
- Boating Camping Fishing (BCF). (n.d.). *EPIRB*. Retrieved from <https://www.bcf.com.au/boating/safety/epirb>
- Canadian Safe Boating Council (CSBC). (2017). *Radar reflector*. Retrieved from <http://www.smartboater.ca/equipment/radar-reflector>
- Chao, W. (2006). *Principles and practices towards SAR services: a comparative study on states' approaches to improving maritime SAR* (Master's dissertation, World Maritime University, Malmö, Sweden). Retrieved from [https://commons.wmu.se/cgi/viewcontent.cgi?article=1251&context=all\\_dissertations](https://commons.wmu.se/cgi/viewcontent.cgi?article=1251&context=all_dissertations)

- Christiansen, J.M. & Hovmand, S.R. (2017). *Prevention of accidents at work in Nordic fisheries – What has worked?* Retrieved from <https://norden.diva-portal.org/smash/get/diva2:1078287/FULLTEXT02.pdf>
- Corke, M. (2015). *Handheld VHF Radios*. Retrieved from <http://www.boatus.com/boattech/articles/handheld-vhf-radios.asp>
- Danielsson, P., Faye, M., Faye, B., Kuyateh, M., Mbodj, A., Ndiaye, M., & Yahya, B.O. (2008). *Safety at sea for small-scale fisheries in the developing countries*. Retrieved from <http://www.fao.org/3/ak809e/ak809e.pdf>
- Defender. (n.d.). *Radar Reflectors*. Retrieved from <https://www.defender.com/category.jsp?id=2290118&path=-1|135|2290117>
- Denzin, K., & Lincoln, Y. (2005). *The Sage Handbook of Qualitative Research*, 3<sup>rd</sup> edition, Thousand Oaks, CA: Sage Publications.
- Dino, A. E. T. (2018). *Combustion engine failures: an analysis of accidents, incidents and near misses surrounding marine combustion engines on board ships* (Bachelor's thesis, Chalmers University of Technology, Gothenburg, Sweden). Retrieved from <http://publications.lib.chalmers.se/records/fulltext/255971/255971.pdf>
- Ehlers, P. (2019). *Part 4: Enforcement by Flag State* [pdf]. Retrieved from <https://academics.wmu.se/mod/folder/view.php?id=5940>
- Eswara, A. K. (2013). *Formal Safety Assessment in Maritime Industry – Explanation to IMO Guidelines*. Retrieved from <https://www.researchgate.net/publication/256471309>
- European Commission (EC). (2019). *Search and rescue (SAR) operation*. Retrieved from [https://ec.europa.eu/home-affairs/content/search-and-rescue-sar-operation\\_en](https://ec.europa.eu/home-affairs/content/search-and-rescue-sar-operation_en)
- European Maritime Safety Agency (EMSA). (2018). *Annual overview of marine casualties and incidents 2018*. Retrieved from [http://www.leadsmar.com/upload/publications-file/EMSA\\_MAR\\_2018.pdf](http://www.leadsmar.com/upload/publications-file/EMSA_MAR_2018.pdf)
- FAO / International Labor Organization (ILO) / International Maritime Organization (IMO). (2012). *Safety Recommendations for decked fishing vessels of less than 12 metres in length and undecked fishing vessels*. Retrieved from [http://www.fao.org/fishery/docs/DOCUMENT/COFI/COFI\\_29/made\\_available/fao\\_ilo\\_imo\\_e.pdf](http://www.fao.org/fishery/docs/DOCUMENT/COFI/COFI_29/made_available/fao_ilo_imo_e.pdf)
- Food and Agriculture Organization (FAO). (n.d.). *International conventions and guidelines on safety at sea*. Retrieved from <http://www.fao.org/3/X9656E/X9656E01.htm>
- Freedman, D., Pisani, R., & Purves, R. (2007). *Statistics*, 4<sup>th</sup> edition, New York: Norton Publications.

- GME. (n.d.). *Beacon information*. Retrieved from <https://www.gme.net.au/beacon-information.aspx>
- Goncalves, R. P. (2018). *Estimating the Efficiency of Mass Rescue Operations in Ocean Areas with Vehicle Routing Models and Heuristics* (PhD Thesis, Science College, Lisbon University, Lisbon, Portugal). Retrieved from [https://repositorio.ul.pt/bitstream/10451/35137/1/ulsd732255\\_Rui\\_Deus.pdf](https://repositorio.ul.pt/bitstream/10451/35137/1/ulsd732255_Rui_Deus.pdf)
- Gudmundsson, A. (2013). The FAO/ILO/IMO Safety Recommendations for Decked Fishing Vessels of Less than 12 metres in Length and Undecked Fishing Vessels – a major milestone to improve safety for small fishing vessels. *International Ship Stability Workshop 2013*. Retrieved from [http://www.shipstab.org/files/Proceedings/ISSW/ISSW\\_2013\\_Brest\\_Brittany\\_France/04\\_Session\\_Fishing/ISSW\\_2013\\_Gudmundsson.pdf](http://www.shipstab.org/files/Proceedings/ISSW/ISSW_2013_Brest_Brittany_France/04_Session_Fishing/ISSW_2013_Gudmundsson.pdf)
- Hanson-Nortey, G. (1994). *Maritime search and rescue in the Republic of Ghana* (Master's thesis). World Maritime University, Malmö, Sweden.
- Hebbar, A. (2019). *Enforcement tasks: Structure and mandates in India* [pdf]. Retrieved from: <https://academics.wmu.se/mod/folder/view.php?id=6069>
- Hermanski, G & Daley, C. (2010). *On Formal Safety Assessment (FSA) Procedure*. Retrieved from [https://www.researchgate.net/publication/44057113\\_On\\_formal\\_safety\\_assessment\\_FSA\\_procedure](https://www.researchgate.net/publication/44057113_On_formal_safety_assessment_FSA_procedure)
- Hovding. (n.d.). *The world's safest bicycle helmet isn't a helmet*. Retrieved from <https://hovding.com/>
- Hui, X. (2001). *Risk-based approach to maritime safety* (Master's dissertation, World Maritime University, Malmö, Sweden). Retrieved from [https://commons.wmu.se/all\\_dissertations/204/](https://commons.wmu.se/all_dissertations/204/)
- IMO Global Integrated Shipping Information System (GISIS). (n.d.). *In-The-Field Job Aid for Investigator*. Retrieved from [https://gis.imo.org/Members/Shared/Public/Download.aspx?FileType=UnsecuredFile&FileCode=MCI\\_AIDEMEM](https://gis.imo.org/Members/Shared/Public/Download.aspx?FileType=UnsecuredFile&FileCode=MCI_AIDEMEM)
- International Convention for the Safety of Life at Sea (SOLAS) (adopted 1 November 1974, entered into force 25 May 1980) Sixth Edition 2014 288.
- International Convention on Maritime Search and Rescue (SAR) (Adopted 27 April 1979, entered into force 22 June 1985) 2004 amendment.
- International Convention on Salvage (Adopted 28 April 1989, entered into force 14 July 1996) 5. Retrieved from: [https://www.pravo.unizg.hr/\\_download/repository/1989\\_Salvage\\_convention.pdf](https://www.pravo.unizg.hr/_download/repository/1989_Salvage_convention.pdf)
- International Maritime Organization (IMO) & International Civil Aviation Organization (ICAO) (2008). *International Aeronautical and Maritime Search and Rescue*

- Manual: Volume 1 – Management and Organization* (2016 Ed.). London: IMO; Montréal: ICAO.
- International Maritime Organization (IMO). (2010). *Code of practice for the investigation of crimes of piracy and armed robbery against ships*, Resolution A.1025(26), London: Author.
- International Maritime Organization. (2012). *Needs Assessment Mission for Strengthening the Maritime Administration, Port Moresby, Papua New Guinea: Mission Report*. Port Moresby: National Maritime Safety Authority.
- International Maritime Organization. (2013). *Linkage between the Integrated Technical Co-operation Programme and the Millennium Development Goals*. Retrieved from:  
<https://www.transportstyrelsen.se/contentassets/00bb629ad9c847c7a1969b500e274fbc/63-inf3.pdf>
- International Maritime Organization. (2018). *Revised Guidelines for Formal Safety Assessment (FSA) for Use in the IMO Rule-Making Process*, MSC-MEPC.2/Circ.12/Rev.2, London: Author.
- International Maritime Organization. (n.d.-a). *5<sup>th</sup> Pacific Maritime Search and Rescue Workshop*. Retrieved from  
<http://www.imo.org/en/OurWork/TechnicalCooperation/TCActivities/Pages/5th-Pacific-SAR.aspx>
- International Maritime Organization. (n.d.-b). *Formal Safety Assessment*. Retrieved from  
<http://www.imo.org/en/OurWork/Safety/SafetyTopics/Pages/FormalSafetyAssessment.aspx>
- International Maritime Organization. (n.d.-c). *IAMSAR Manual*. Retrieved from  
<http://www.imo.org/en/OurWork/Safety/RadioCommunicationsAndSearchAndRescue/SearchAndRescue/Pages/IAMSARManual.aspx>
- International Maritime Organization. (n.d.-d). *Integrated Technical Cooperation Programme (ITCP)*. Retrieved from  
<http://www.imo.org/en/OurWork/TechnicalCooperation/ITCP/Pages/Default.aspx>
- International Maritime Organization. (n.d.-e). *International Convention for the Safety of Life at Sea (SOLAS), 1974*. Retrieved from  
[http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-\(SOLAS\),-1974.aspx](http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx)
- International Maritime Organization. (n.d.-f). *International Convention on Maritime Search and Rescue (SAR)*. Retrieved from  
[http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Maritime-Search-and-Rescue-\(SAR\).aspx](http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Maritime-Search-and-Rescue-(SAR).aspx)

- International Maritime Organization. (n.d.-g). *International Convention on Salvage*. Retrieved from <http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Salvage.aspx>
- Jordan, J. (n.d.). *Advantages and disadvantages of inductive reasoning*. Retrieved from <https://www.theclassroom.com/advantages-disadvantages-inductive-reasoning-8491871.html>
- Kaushik, M. (2019a). *Marine Safety: Measures Taken During Shipboard Operation for the Safety of Ship's Crew, Cargo, and Marine Environment*. Retrieved from <https://www.marineinsight.com/marine-safety/measures-taken-during-shipboard-operation-for-the-safety-of-ships-crew-cargo-and-marine-environment/>
- Kaushik, M. (2019b). *What is an Oil Spill at Sea?* Retrieved from <https://www.marineinsight.com/environment/what-is-an-oil-spill-at-sea/>
- Kharim, K. (2006). *Save lives, property and the environment: A practical application of the concept of Risk Management to enhance the effectiveness of the SAR service provision in developing countries* (Master's dissertation, World Maritime University, Malmö, Sweden). Retrieved from [https://commons.wmu.se/cgi/viewcontent.cgi?article=1065&context=all\\_dissertations](https://commons.wmu.se/cgi/viewcontent.cgi?article=1065&context=all_dissertations)
- Kontovas, C. A. (2005). *Formal Safety Assessment: Critical Review and Future Role* (Diploma thesis, Division of Ship Design and Maritime Transport, School of Naval Architecture & Marine Engineering, National Technical University of Athens). Retrieved from <http://martrans.org/docs/theses/kontovas.pdf>
- Langkos, S. (2014). *Chapter 3 – Research Methodology: Data collection method and research tools*. Retrieved from [https://www.researchgate.net/publication/270956555\\_CHAPTER\\_3\\_-\\_RESEARCH\\_METHODODOLOGY\\_Data\\_collection\\_method\\_and\\_Research\\_tools](https://www.researchgate.net/publication/270956555_CHAPTER_3_-_RESEARCH_METHODODOLOGY_Data_collection_method_and_Research_tools)
- Mail speed marine. (n.d.). *A guide to distress flares*. Retrieved from <https://www.mailspeedmarine.com/on-the-water/guides/a-guide-to-distress-flares/>
- Marine and Safety (Motor Boats and Licenses) by-laws 2013. <https://www.mast.tas.gov.au/wp-content/uploads/2014/05/Marine-and-Safety-Motor-Boats-and-Licences-By-Laws-2013-Consolidated-Version.pdf>
- Maritime & Coastguard Agency (MCA). (2018 1). *Maritime & Coastguard Agency Annual Report and Accounts 2017-2018*. Retrieved from [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/728109/MCA\\_Annual\\_Report\\_and\\_Accounts\\_2017-18\\_final\\_v1.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/728109/MCA_Annual_Report_and_Accounts_2017-18_final_v1.pdf)

- Maritime New Zealand. (2017). *Strategic Plan 2017 – 2021*. Retrieved from <https://nzsar.govt.nz/Portals/4/Publications/NZSAR%20Strategic%20Documents/The%20Pacific%20Search%20and%20Rescue%20Steering%20Committee%20Strategic%20Plan%202017-2021.pdf>
- Maritime Safety Queensland (MSQ). (2019). *Distress signals, flares, and emergency beacons*. Retrieved from <https://www.msq.qld.gov.au/Safety/Distress-signals.aspx>
- MCA. (2018 2). *Offshore Renewable Energy Installations: Requirements, Guidance and Operational Considerations for Search and Rescue and Emergency Response*. Retrieved from [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/762365/OREI\\_SAR\\_Requirements\\_v2.0.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/762365/OREI_SAR_Requirements_v2.0.pdf)
- McHugh, G. (2018). *New PNG Patrol Boat ready to serve* [Press release]. Retrieved from <http://news.navy.gov.au/en/Dec2018/Fleet/4993/New-PNG-Patrol-Boat-ready-to-serve.htm#.XWaatOMzblV>
- Merchant Shipping Act 1975*. (2006). Retrieved from <http://nmsa.gov.pg/wp-content/uploads/2017/02/Merchant-Shipping-Act-1975.pdf>
- Milne, J. (n.d.). *Questionnaires: Advantages and Disadvantages*. Retrieved from [http://www.icbl.hw.ac.uk/ltidi/cookbook/info\\_questionnaires/printable.pdf](http://www.icbl.hw.ac.uk/ltidi/cookbook/info_questionnaires/printable.pdf)
- National Maritime Safety Authority (NMSA). (2019). *Improving Casualty Survivability as Sea: The PNG Initiatives*. 20<sup>th</sup> Session of Asia-Pacific Heads of Maritime Safety Agencies (APHoMSA).
- National Maritime Safety Authority Act 2003*. Retrieved from <http://nmsa.gov.pg/wp-content/uploads/2017/02/National-Maritime-Safety-Authority-Act-2003-1.pdf>
- National Weather Service & Pacific Climate Change Science Program. (2011). *Current and future climate of Papua New Guinea*. Retrieved from [http://world.350.org/pacific/files/2014/01/14\\_PCCSP\\_PNG\\_8pp.pdf](http://world.350.org/pacific/files/2014/01/14_PCCSP_PNG_8pp.pdf)
- NMSA. (2011). *Basic boating safety in Papua New Guinea waters. SPC Sea Safety Information Bulletin*. Retrieved from <https://spccfpstore1.blob.core.windows.net/digitallibrary-docs/files/bf/bff22a6356156a245b5ddf4474d4359d.pdf?sv=2015-12-11&sr=b&sig=bp97%2B3mTtljVIS2y7SaSGEuLcJMZwzL%2BctHAcagT5BM%3D&se=2020-02-20T09%3A11%3A25Z&sp=r&rsc=public%2C%20max-age%3D864000%2C%20max-stale%3D86400&rsct=application%2Fpdf&rscd=inline%3B%20filename%3D%22SeaSafety6.pdf%22>
- NMSA. (2018). *NMSA commission first Search and Rescue boat* [Press release]. Retrieved from <http://nmsa.gov.pg/news/nmsa-commission-first-search-and-rescue-boat/>

- NMSA. (n.d.). *Search and Rescue*. Retrieved from <http://nmsa.gov.pg/search-and-rescue/>
- Pacific Climate Change Science (PCCS). (2014). *Papua New Guinea*. Retrieved from [https://www.pacificclimatechangescience.org/wp-content/uploads/2014/07/PACCSAP\\_CountryReports2014\\_Ch11PNG\\_WEB\\_140710.pdf](https://www.pacificclimatechangescience.org/wp-content/uploads/2014/07/PACCSAP_CountryReports2014_Ch11PNG_WEB_140710.pdf)
- Petursdottir, G., Hannibalsson, O. & Turner, J.M.M. (2001). *Safety at sea as an integral part of fisheries management*. Retrieved from [https://www.nts.gov/news/events/Documents/2010\\_Fishing\\_Vessel\\_Safety\\_FRM-29-FAO-Pub-966.pdf](https://www.nts.gov/news/events/Documents/2010_Fishing_Vessel_Safety_FRM-29-FAO-Pub-966.pdf)
- PNG Merchant Shipping (Safety) Regulation 2006. Retrieved from <http://nmsa.gov.pg/wp-content/uploads/2017/02/Merchant-Shipping-Safety-Regulation-2006.pdf>
- Radio New Zealand (RNZ). PNG police close investigation into disappearance of five scientists [Press release]. Retrieved from <https://www.rnz.co.nz/international/pacific-news/382635/png-police-close-investigation-into-disappearance-of-five-scientists>
- Rahman, N. (n.d.). *Sinking of the MV Rabaul Queen – the Story* [Press release]. Retrieved from: <http://edd.spc.int/en/download/finish/64-imo-pacific-forum-on-domestic-ferry-safety/752-21png-captnururrahman-mvrabaulqueenpaper2012>
- Reichenberg, N. (2016). Getting the Right People: How to Recruit and Retain Qualified Staff. *Government Finance Review*, 34-37. Retrieved from <https://www.gfoa.org/sites/default/files/121634.pdf>
- Rounds, J. (2012). Background to SPC's role in the Pacific maritime sector. *Pacific Maritime Watch*, 53, 3-5. Retrieved from <https://edd.spc.int/en/download/finish/55-pacific-maritime-watch/634-pacific-maritime-watch-issue-53/0>
- SAGE. (2008). *Questionnaire*. Retrieved from <http://methods.sagepub.com/reference/encyclopedia-of-survey-research-methods/n424.xml>
- Sakalayan, Q. M. H. (2006). *Non-conventional ferry safety and the potentiality of inland waterways for multimodal transportation: a comparative analysis for the betterment of Bangladesh's situation* (Master's dissertation, World Maritime University, Malmö, Sweden). Retrieved from [https://commons.wmu.se/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1342&context=all\\_dissertations](https://commons.wmu.se/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1342&context=all_dissertations)
- Schröder-Hinrichs, J-U. (2019 a). *Introduction to IMO Member State Obligations: Coastal State Obligations* [pdf]. Retrieved from <https://academics.wmu.se/mod/folder/view.php?id=5892>

- Schröder-Hinrichs, J-U. (2019 b). *Maritime Risk Management: Part 1 – Safety and Risk* [pdf]. Retrieved from <https://academics.wmu.se/mod/folder/view.php?id=6186>
- Secretariat of the Pacific Community (SPC). (2013). *IMO, SPC Work to Raise Pacific Maritime Standards*. Retrieved from <http://www.pireport.org/articles/2013/10/01/imo-spc-work-raise-pacific-maritime-standards>
- Secumar. (n.d.). *Limitations on the life span of life jackets*. Retrieved from <https://www.secumar.com/en/limitation-on-the-life-span-of-lifejackets/>
- Sleight, K. (2012). *Ships Engine Rooms – Ships Main Engines & Central Machinery Placement On Ships – The Bottom Platform Explored*. Retrieved from <https://www.brighthubengineering.com/marine-engines-machinery/54036-engine-room-bottom-platform-explored/>
- Small Craft Act 2011*. Retrieved from <http://nmsa.gov.pg/wp-content/uploads/2017/02/Small-Craft-Act-2011.pdf>
- SPC. (2014). *Pacific Maritime SAR Cooperation - The Second Meeting of the ICAO Asia/Pacific Search and Rescue Task Force, APSAR/TF/2 – WP07*. Retrieved from <https://www.icao.int/APAC/Meetings/2014%20APSAR%20TF2/WP07%20Pacific%20Maritime%20SAR%20Cooperation%20-%20SPC.pdf>
- Standish, W. (2011). *Papua New Guinea*. Retrieved from <https://www.britannica.com/place/Papua-New-Guinea>
- The Commonwealth. (n.d.). *Papua New Guinea*. Retrieved from <http://thecommonwealth.org/our-member-countries/papua-new-guinea>
- The Maritime Executive (ME). (2017). *IMO Promotes Fishing Vessel Safety* [Press release]. Retrieved from: <https://www.maritime-executive.com/article/imo-promotes-fishing-vessel-safety>
- The United Nations Convention on Law of the Sea (UNCLOS)* (adopted 10 December 1982, entered in force 16 November 1994) 58
- Theodore, S & Loannis, K. (n.d.). *Shipping Accidents, damage assessment & accident consequences*. Retrieved from <https://www.onthemosway.eu/wp-content/uploads/2015/06/ship-accidents-1final.pdf>
- Transport Operations (Maritime Safety) Regulation 2016*. Retrieved from <https://www.legislation.qld.gov.au/view/pdf/inforce/2017-08-25/sl-2016-0154>
- Tun, Y. M. (2000). *Proposal for the implementation of search and rescue and GMDSS in Myanmar* (Master's dissertation, World Maritime University, Malmö, Sweden). Retrieved from [https://commons.wmu.se/cgi/viewcontent.cgi?article=1240&context=all\\_dissertations](https://commons.wmu.se/cgi/viewcontent.cgi?article=1240&context=all_dissertations)



- UNHRC. (n.d.). *Search and rescue response and coordination (natural disasters)*. Retrieved from: <https://emergency.unhcr.org/entry/258567/search-and-rescue-response-and-coordination-natural-disasters>
- United Nations (UN). (n.d.). *Oceans and the law of the sea*. Retrieved from <https://www.un.org/en/sections/issues-depth/oceans-and-law-sea/>
- United States Coast Guard (USCG). (2019). SAR Governance, Coordination, Response & Prevention. *8<sup>th</sup> Pacific Regional SAR Workshop, 22 – 26 July 2019, Honolulu, Hawaii*.
- University of Lancaster. (2016). LUMS Effective Learning: Qualitative and quantitative research [pdf]. Retrieved from: <https://www.lancaster.ac.uk/media/lancaster-university/content-assets/documents/learning-skills/quantitativevqualitativeanswers.pdf>
- Wankhede, A. (2019). *Man Overboard Situation on Ships and Ways to Tackle it*. Retrieved from <https://www.marineinsight.com/marine-safety/man-overboard-situation-on-ship-and-ways-to-tackle-it/>
- Westlund, K., Attvall, S., & Jensen, O. C. (2016). Telemedical Maritime Assistance Service (TMAS) to Swedish merchant and passenger ships 1997 – 2012. *International Maritime Health*, 67(1), 24-30. Doi: 10.5303/IMH.2016.0006
- Williams, I & Hoppe, H. (2011). *Safety Regulations for Non-Convention Vessels – The IMO Approach*. Retrieved from <https://wenku.baidu.com/view/1c6c0dc20c22590102029d6b.html?re=view>
- Williamson, A.P. & Van Til, J. (2001). Voluntary Organizations. *International Encyclopedia of the Social & Behavioral Sciences*, 16306 – 16308. <https://doi.org/10.1016/B0-08-043076-7/04255-8>

## APPENDIX 1

### RESEARCH QUESTIONS

#### 1.1 Maritime agencies

Following are the questionnaires that were sent to respective maritime agencies in participating countries. These questions were chosen to gather information on how the participating countries are regulating, monitoring, and enforcing safety measures on small vessels.

1. Please describe how the Maritime Administration develops and promulgate legislation with regards to safety of national flagged non-conventional size vessels?
2. Please describe how the Maritime Administration:
  - a. stimulates a culture which provides for improvement of performance in the safety of small vessels
  - b. identifies and eliminate the root cause of any non-conformities; and
  - c. anticipates potential non-conformities in order to prevent their occurrence.
3. Please describe how Maritime Administration assigns responsibilities for implementing safety legislation and national policies including how these are periodically reviewed?
4. Please describe how Maritime Administration develops or implements an inspection programme for ships entitled to fly the flag, especially non-conventional size vessels, fishing vessels, small crafts?
5. Please describe how the state fulfils the following:
  - a. promulgating navigational warnings and dangers to navigation;

Please describe if applicable:

  - b. any maritime traffic routing schemes or restricted areas enforced within national waters and any ship reporting systems;
6. Please describe how the Maritime Administration keeps track of non-convention size vessels, including fishing vessels and other small crafts, that do not have AIS?
7. Please state which law applies to non-conventional size vessels, including fishing vessels and other small crafts? What size and length does the law apply to?
8. Please describe how safety standards are enforced and monitored on non-conventional size vessels, including fishing vessels and other small crafts? Which organization is responsible?
9. Please specify vessel types or categories not covered by any national or local law? If so, describe the measures implemented for ensuring level of safety is equivalent to that of conventional size vessels.
10. Please clarify if the state requires fishing vessels and small crafts to carry safety equipment or appliances such as distress beacons (EPIRB, PLB), life jackets, etc.? If so, how is this requirement enforced? What is the minimum size of vessel required to carry these equipment?
11. Please state if the national and local authorities require small boat operators or owner for regular checks and maintenance of their boats? If so, how are these activities enforced?
12. Please specify any insurance coverage for non-conventional size vessels, fishing vessels, and small craft.

## 1.2 Maritime SAR authorities

### Part A – Objective questions

1. Does the state have a national maritime SAR plan, which describes the role of all government and non-government organizations which have resources that can support SAR?
2. Do provisions exist to keep maritime SAR authorities informed of aeronautical distress situations, and to coordinate SAR responsibility to them when an aircraft has an actual or potential ditching at sea?
3. Has the State made arrangements for the use of SAR units and other available facilities to assist any vessel or its occupants that are, or appear to be, in a state of emergency?
4. Does the Maritime SAR Authority have full information about the capabilities (range, number of persons they could rescue, alert status, launch authority point of contact, etc.) for all primary rescue units in the area of responsibility?
5. Does the Maritime SAR Authority have an operations manual which provides procedures and guidance material for handling all foreseeable SAR situations?
6. Does the Maritime SAR Authority use international systems that assist SAR, e.g. Amver, Cospas-Sarsat, computer-assisted search planning?
7. Do crews of primary rescue units participate in regular maritime SAR related training or exercises?
8. Is there a formal planning and evaluation process for these exercises?
9. Does the Maritime SAR Authority carry out exercises involving other MRCCs and rescue units on a regular basis?
10. Are complete records (sufficient to reconstruct the incident) maintained of all maritime SAR events?
11. Are there rapid, reliable means for communication between MRCCs and between MRCCs and MRSCs?
12. Does the Maritime SAR Authority have reliable radio communications capabilities covering their entire area(s) of responsibility for working with ships, aircraft and maritime SAR units?
13. Is the 406 MHz beacon registrations database available on a 24-hour basis to maritime SAR authorities?
14. Has the Maritime SAR Authority prepared detailed plans of operation for the conduct of maritime SAR operations within its SRR?
15. Does the Maritime SAR Authority coordinate with hospitals to receive all personnel evacuated due to medical emergencies?
16. Has the State arranged for all aircraft, vessels, and local services and facilities which do not form part of maritime SAR organization to cooperate fully with the latter in maritime SAR and to extend any possible assistance to the survivors of maritime accidents?
17. Do the state send delegates to participate directly in meetings of IMO that deal with maritime SAR issues?

## Part B – Subjective questions

1. Please explain where the authority and responsibility for coordination of maritime SAR is described (law, regulation, agreement, etc.)?
2. Please describe the issues and challenges encountered when working with JRCCs/MRCC's outside your region? If so, please describe steps taken to solve these?
3. Please describe the states formal maritime SAR agreements with adjoining countries for maritime SAR coordination? If so, please state countries that have formal agreements with?
4. Please state if the Maritime SAR Authority has formal maritime SAR agreements with other national agencies for use of maritime SAR resources and coordination? If so, which agencies?
5. Please state if Maritime SAR Authority's operation manual include guidance on the use of voluntary SAR resources? If so, to what extent have voluntary SAR resources, including privately owned aircraft and boats, fishing vessels, industry-owned helicopters and boats and professional organizations being organized? How many and which voluntary organizations?
6. Please describe what means are most often commonly used to notify the Maritime SAR Authority of a distress at sea?
7. Please describe what means are commonly used to alert and inform rescue units of a distress, and to direct them?
8. Please describe how do your maritime SAR managers stay informed on decisions, and outcomes of meetings conducted by IMO?
9. Please describe the rate of incidents in fishing vessels and other small vessels? What measures has the state taken to address maritime SAR incidents involving these types of vessels?
10. Please describe how the Maritime SAR Authority monitor the surface SAR assets that do not have AIS transponder on board?
11. Please describe the facilities and assets available in the country for possible Mass Rescue Operation (MRO).
12. Please describe the formal procedures for providing medical assistance and advice and for making medical evacuation decisions?
13. Please briefly describe the training policy and programme for Maritime SAR Authority staff, including appropriate SAR exercises?
14. When a person dials the emergency number to report an incident, the GPS position is also displayed at the JRCC. Please describe how this system works? What are the arrangements or agreements with the mobile or landline services providers for the GPS position to be transmitted?

### 1.3 Voluntary organizations

1. Please describe the main causes of accidents involving small crafts in your local waters or area of operation.
2. Please describe the type of assistance provided by your organization to small crafts and other small vessels in distress within your local waters or area of operation.
3. Please state which parties are involved in maritime Search and Rescue operations within your area of operation.
4. Please describe the Search and Rescue assets at your disposal.
5. Please describe the arrangements or agreements your organization has with the National Maritime Search and Rescue Authority.
6. Please provide your general comments on the level of safety on small vessels within your area of operation.
7. Please provide list of safety equipment are carried regularly on board small crafts.
8. Please provide the number and list names of private airline companies (fixed-wing and rotary-wing) that operate in the province capable of providing assistance in maritime SAR operations.
9. Please describe how small boat operators get weather information before travelling by sea.
10. Please describe if there are reporting systems in place at local level for small crafts departing to next destination.

## APPENDIX 2

### RISK MATRIX TABLES

#### Risk matrix

Following are the respective tables that have been used to work out the severity index, frequency index, risk index, and severity index in case of oil spill, including the formulas, for the afore-mentioned hazards.

Risk = Probability x Consequences

Log (Risk) = log (Probability) + log (Consequences)

Severity index				
SI	SEVERITY	EFFECTS ON HUMAN SAFETY	EFFECTS ON SHIPS	S (Equivalent fatalities)
1	Minor	Single or minor injuries	Local equipment damage	0.01
2	Significant	Multiple or severe injuries	Non-severe ship damage	0.1
3	Severe	Single fatality or multiple severe injuries	Severe damage	1
4	Catastrophic	Multiple fatalities	Total loss	10

Table 1: Severity Index [MSC-MEPC.2/Circ.12]

Frequency index			
FI	FREQUENCY	DEFINITION	F (per ship year)
7	Frequent	Likely to occur once per month on one ship	10
5	Reasonably probable	Likely to occur once per year in a fleet of 10 ships, i.e. likely to occur a few times during the ship's life	0.1
3	Remote	Likely to occur once per year in a fleet of 1,000 ships, i.e. likely to occur in the total life of several similar ships	$10^{-3}$
1	Extremely remote	Likely to occur once in the lifetime (20 years) of a world fleet of 5, 00 ships	$10^{-5}$

Table 2: Frequency Index [MSC-MEPC.2/Circ.12]

Considering the following equation

$$\text{Risk Index} = \text{Frequency Index} + \text{Severity Index}$$

the Risk Matrix can be constructed.

Risk Index (RI)					
FI	FREQUENCY	SEVERITY SI			
		1	2	3	4
		Minor	Significant	Severe	Catastrophic
7	Frequent	8	9	10	11
6		7	8	9	10
5	Reasonably probable	6	7	8	9
4		5	6	7	8
3	Remote	4	5	6	7
2		3	4	5	6
1	Extremely remote	2	3	4	5

Table 3: Risk Index [MSC-MEPC.2/Circ.12]

Severity Index		
SI	SEVERITY	DEFINITION
1	Category 1	Oil spill size < 1 tonne
2	Category 2	Oil spill size between 1-10 tonnes
3	Category 3	Oil spill size between 10-100 tonnes
4	Category 4	Oil spill size between 100-1,000 tonnes
5	Category 5	Oil spill size between 1,000-10,000 tonnes
6	Category 6	Oil spill size >10,000 tonnes

Table 4: Severity index for oil spill from ship