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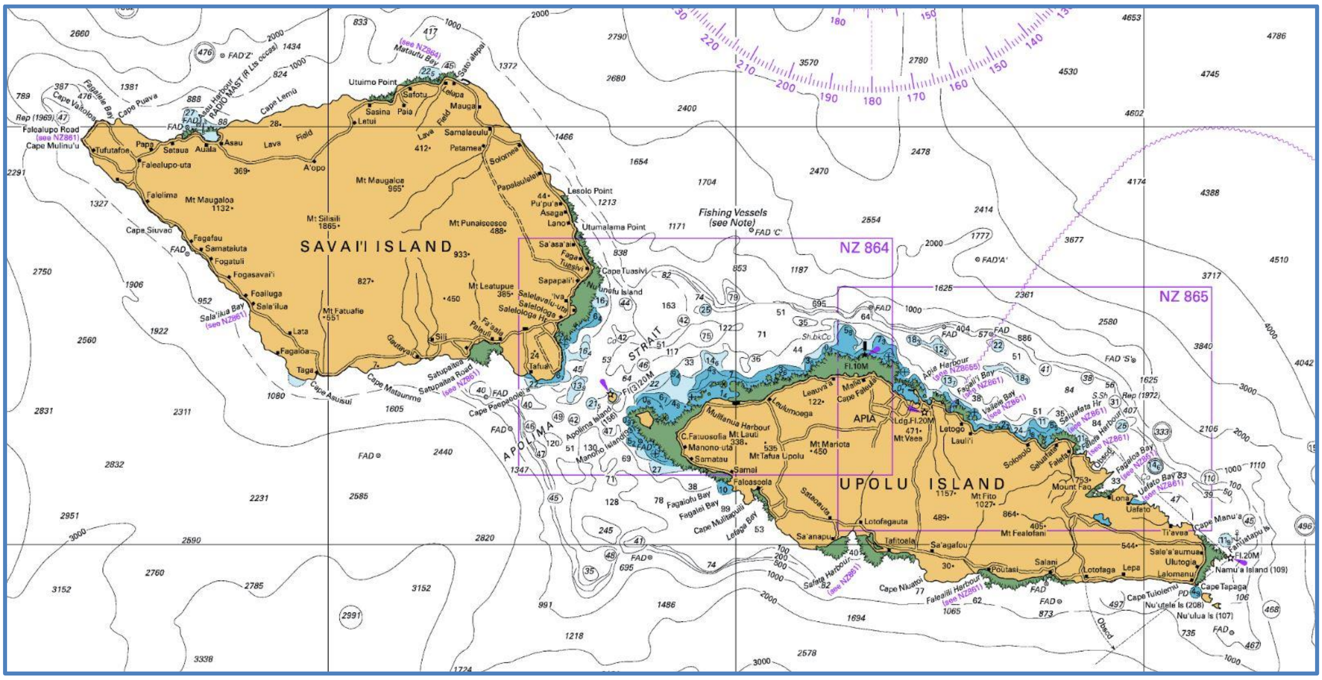
PACIFIC REGIONAL NAVIGATION INITIATIVE

SAMOA Hydrographic Risk Assessment



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PACIFIC REGIONAL NAVIGATION INITIATIVE

SAMOA Hydrographic Risk Assessment

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FOREWORD

This report details the hydrographic risk assessment of Samoan waters based on the Land Information New Zealand (LINZ) Hydrographic Risk Assessment Methodology, as published in Report Number 15NZ322 Issue 03[1]. This risk assessment is part of the continuing programme of Pacific regional hydrographic risk assessments being conducted by LINZ, supported by the Ministry of Foreign Affairs and Trade (MFAT), which is intended to cover the extent of New Zealand's area of charting responsibility. This assessment follows other published risk assessments of Vanuatu, the Cook Islands, Tonga and Niue, which are available from the International Hydrographic Organization website at this link.[2]

The intent is that these assessments, conducted using similar methodology, provide participating governments with consistent and comparable information that will assist them and other supporting aid agencies, to make informed decisions in relation to investment in hydrographic work, to improve safety of navigation, to deliver economic benefit and reduce the risk of loss of life.

ACKNOWLEDGEMENTS

Our thanks to the Samoan Government officials and citizens who provided invaluable advice and information to support this risk assessment, details of all personnel interviewed are contained in Annex H to this report. Additionally, the support of Measina Meredith, Development Programme Coordinator from the New Zealand High Commission, was invaluable in arranging the in-country visit.

[1] This report also builds upon the updated procedures developed during the Niue risk assessment (Land Information New Zealand and Rod Nairn & Associates Pty Ltd, 2016).
[2] https://www.iho.int/srv1/index.php?option=com_content&view=article&id=623&Itemid=407&lang=en

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EXECUTIVE SUMMARY

0.1 **Samoa** is a volcanic island group consisting of two main islands and seven smaller islands. It has a land area of 2,844km^2 and a small maritime Exclusive Economic Zone (EEZ) of approximately 120,000km^2 limited by neighbouring island states of Tokelau in the north, American Samoa in the north east and east, Tonga in the south and Wallis and Futuna in the west.

0.2 Most of the **maritime traffic** that traverses the Samoan EEZ calls at the Port of Apia, which is the only official first port of arrival, the centre of Samoa's international trade and a relatively busy port. These vessels include tankers (fuel and LPG), cruise ships, passenger ferries, general cargo, fishing, research and recreational/superyachts. There is a relatively small amount of other commercial traffic which bypasses Samoa and transits the EEZ, mainly in a generally NE/SW direction from SW Pacific to Hawaii/North America or in a NW/SE direction to connect between North Asia and American Samoa.

0.3 On a weekly cycle, Samoan Shipping Corporation (SSC) operates **international ferry/cargo services** from Apia to Pago Pago (American Samoa) in MV *Lady Naomi* and to Tokelau MV *SSC Fasefulu*. Charter services to Swains Island (American Samoa) and the Cook Islands are also available. A small passenger ferry *Mataliki* is also operated by the Tokelau Government.

0.4 A **domestic inter-island ferry service** of two vessels is operated by SSC between Mulifanua (Upolu) and Salelologa (Savai'i) normally providing six return trips per day across the Apolima Strait. A regular barge service operated by SSC also carries dangerous goods (petrol, diesel and LPG) from Apia to Salelologa.

0.5 Other domestic vessels are limited to *alia* fishing catamarans, a few ocean capable game fishing vessels up to 12m, and small dive runabouts in tourist areas, as well as numerous traditional fishing outrigger canoes.

0.6 Most of the traffic visiting Apia traverses Apolima Strait, this crosses the high frequency domestic inter-island ferry service making Apolima Strait the highest density traffic region in Samoa.

0.7 **Nautical charting** of Samoan EEZ is provided by New Zealand. The overall suitability of a nautical chart is defined by: the scale of the chart in relation to its intended use, whether the position and depth datums are compatible with modern navigation methods, and the quality of its underlying hydrographic survey information, known as CATZOC[3]. The Samoan chart coverage consists of a modern metric large scale chart of Apia Harbour, NZ 8655 at a scale of 1:7,500, and Salelologa and Mulifanua Harbours, NZ 8645 at a scale of 1:10,000, which are of a good standard. Medium scale 1:50,000 charts of Apolima Strait, NZ 864, and Approaches to Apia, NZ 865, provide good coastal navigation scale coverage of the north coast of Upolu but have areas of old and sparsely surveyed waters (CATZOC D), particularly near the coast, which should be updated with

[3] CATZOC is fully defined in the glossary

available data. Notably, there is no coastal scale coverage of the east and south coasts of Upolu Island nor of Savai'i Island outside Apolima Strait.

0.8 A small scale 1:500,000 chart, NZ 86 covers the Samoan Islands (including American Samoa) and is considered a good landfall chart but it is not considered suitable for coastal navigation and approaching coastal harbours.

0.9 Of critical concern is that there is no appropriate scale approach or harbour chart for the port at Aleipata (Satitoa) at the eastern end of Upolu, which contains a wharf and the only slipway in Samoa, and is capable of slipping vessels up to 1,000 tonnes and 50m in length. This port does not feature as high risk in the numerical assessment due to the lack of traffic data to the port but provision of adequate charting is a prerequisite for future development.

0.10 **Old charts and plans**. The port of Asau on the north-western coast of Savai'i is no longer used commercially. An older chart NZ 1414, scale 1:10,000 uses a non-GPS horizontal datum and parts of the chart are CATZOC U. It provides adequate coverage for recreational, game fishing vessels and occasional visits from patrol vessel *Nafanua*. This chart would require significant updating and positional shift to WG84 datum to produce an ENC which would be required should the port be required to support future commercial shipping. Re-establishment of leads and channel markers would also be required. Notably the replacement patrol vessel due in 2020 will also require ENC for navigation.

0.11 A sheet of 'fathoms' plans, NZ 861 at various scales, provides basic information for 11 small bays and harbours based on old, sparse sketch surveys. While the information is useful for recreational yachts and patrol vessel *Nafanua*, recompilation into metric units needs to be justified by potential future benefit.

0.12 The full extent of Samoa's EEZ is covered by small scale international charts NZ 14629 (INT 629) at a scale of 1:1,500,000 and partial coverage is also on NZ 14630 (INT 630) and NZ 14631 (INT 631) at the same scale. Chart NZ 14605 (INT 605) at a scale of 1:3,500,000 provides an overview of the ocean region. These small-scale charts are considered suitable for their intended purpose of ocean navigation.

0.13 **Hazards to navigation**. The Samoan EEZ is relatively free from offshore dangers with Pasco Bank on the western boundary, the only hazard charted at less than 20m deep. Most of the coastline is surrounded by fringing reef of varying width, these being wider on the northern coast. Outside the reef and within the 50m contour there are some isolated shoals with depths charted between 9m and 25m, other uncharted shoals may exist in the areas of old and sparse surveys. Some areas of the more exposed south coast are steep-to, with deep water right up to the coastal cliffs.

0.14 There are currently 23 **unlit FADs** charted in the coastal waters of Samoa. However, the Ministry of Fisheries advises that only one currently exists. This indicates that there is a failure of the communication channels to report changes to Maritime Safety Information (MSI) to the regional MSI and charting authority, LINZ. Fisheries Division intends to deploy new FADs from late June 2017 and game fishing interests are also known to deploy FADs. It is important that charts are kept up to date for the correct positions of FADs as they are unlit and constitute a navigational hazard near the coast. If a vessel becomes fouled on these devices and disables its propulsion or steering, then it could contribute to the risk of grounding on the nearby reef.

0.15 There is a **modern LiDAR bathymetric survey** of the coastal area of Samoa which was carried out by Fugro LADS[4] which provides good quality bathymetry at 5m spot spacing of the coastal waters down to depths of about 40m. This data was initially collected under the "Ridge to Reef" sea-level rise monitoring project. However, under the Pacific Regional Navigation Initiative, New Zealand funded additional processing of the data to extract further hydrographic information and identify seabed features significant to navigation. The relevant charts are currently being updated to include this new information. This risk assessment has been conducted using the standard of published charting in May 2017. However, the significant reduction in hydrographic risk that will be achieved once the LiDAR data has been included in published charts is also highlighted in sections 7 and 8.

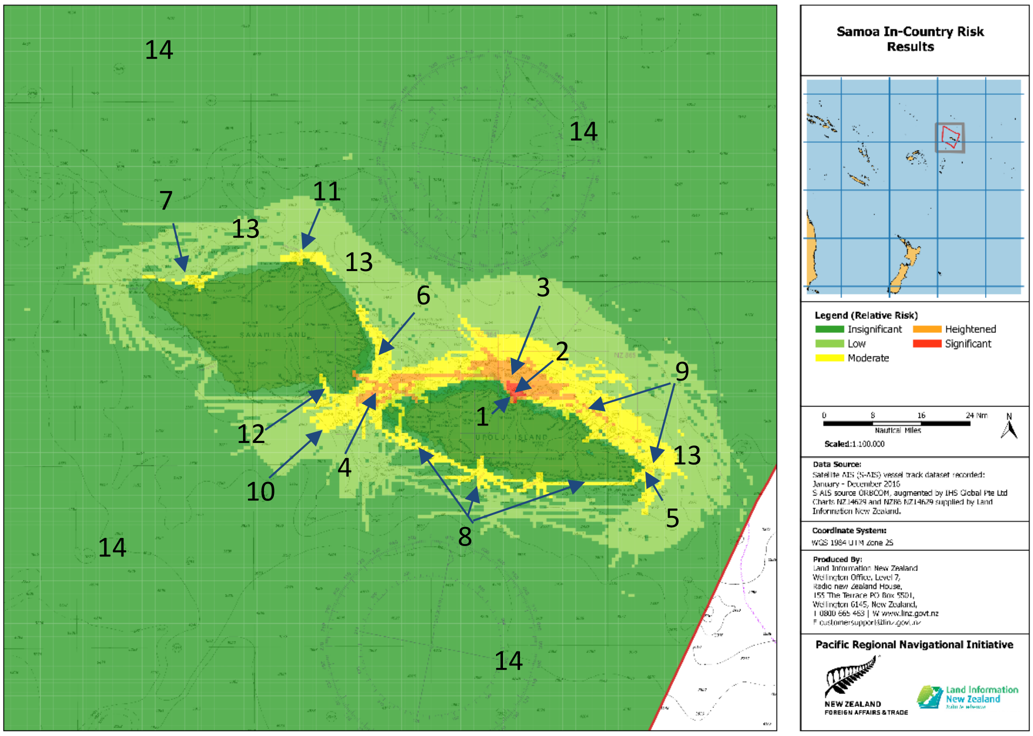

Figure 1: "In-country" Risk Results (see paragraph 0.17 for numbers)

0.16 The "**in-country**"[5] **risk assessment** found insignificant risk in the offshore areas of the EEZ. The *significant* hydrographic risk exists in the approaches to, and within the port of Apia. *Heightened* risk exists in the wider approaches to Apia and in the high traffic areas of Apolima Strait between Salelologa Harbour, Mulifanua Harbour and Apolima Island. This risk is associated

[4] Fugro LADS is a commercial hydrographic survey company based in Australia who was selected to collect data for the "Ridge to Reef" project.

[5] Refer to *Glossary and Definitions*

with the greatest vessel traffic density but the risk is lower than in the approaches to Apia because of the higher quality of hydrographic survey in Apolima Strait.

0.17 The risk results for Samoa are summarised in the following table (numbers refer to locations in Figure 1):

SAMOA Summary of Hydrographic Risk Assessment Results (Based on "In-Country" Risk)		
Location	**Explanation**	**Comparative Risk Level**
1. North coast Upolu, Apia Harbour	Sole international port, high GT traffic, close to sensitive reefs and reserves, charted at CATZOC B	Significant
2. North coast Upolu, near approaches to Apia Harbour	High GT traffic, close to important reserves charted at CATZOC B, C or D,	Significant
3. North coast Upolu, offshore approaches to Apia Harbour	High GT Traffic, close to important reefs, charted at CATZOC D	Heightened
4. Apolima Strait and Mulifanua Port to Salelologa Port	Very high GT traffic, close to coastal reefs, mostly charted at CATZOC A with some B and D areas	Heightened
5. East coast Upolu, Aleipata Port	Low GT traffic but no sufficient scale chart, close to reefs and reserves CATZOC D	Moderate
6. East coast Savai'i between Cape Tuasivi to Lesolo Point	Low GT traffic, close to coastal reef and reserves CATZOC U	Moderate
7. North-west Savai'i, approaches to Asau Harbour	Low GT traffic, close to coastal reefs, areas of CATZOC D and U	Moderate
8. South coast Upolu, route between Aleipata Port Falealili Harbour, Safata Harbour and Cape Fatuosofia	Low GT traffic, close to sensitive coastal reef and reserves charted at CATZOC D or CATZOC U	Moderate
9. North and east coasts of Upolu, out to 12 nm	Low GT traffic, close to sensitive reefs and reserves, mainly CATZOC U	Moderate
10. Approaches to Apolima Strait	High GT traffic, distant from sensitive reefs, CATZOC D or U	Moderate
11. North coast Savai'i: vicinity of Matautu Bay	Low GT traffic but occasional cruise ship, close to coastal reef, CATZOC D	Moderate
12. South coast Savai'i: vicinity of Palauli and Satupa'itea Road	Low GT traffic, close to coastal reef and reserves, CATZOC D	Moderate
13. Generally, out to 20 nm from the coast	Moderate GT traffic, distant from coastal reef, CATZOC D	Low
14. Offshore areas of EEZ further than 20 nm from the coast	Generally low GT traffic areas, distant from reefs and sensitive areas, CATZOC D or U	Insignificant

0.18 The **"regional" risk assessment** of Samoa is seen in the plot below. This plot calibrates the risk colour bands to the same scale as those used for the other south-west pacific risk assessments. The fact that the resulting Samoa risk shows risk areas across the full range of insignificant (green) to significant (red) indicates that Samoa's hydrographic risk is of a similar order of magnitude to previous assessments of Tonga and the Cook Islands (Niue results showed generally insignificant risk). However, this "regional" result does show generally less risk than the "in-country" result. Clearly, there is a significant reduction in the areas of moderate and heightened risk compared to the "in-country" analysis at Figure 1 above. The lower "regional" risk is a good result for Samoa. Note that the result is influenced by a combination of all the input risk factors described in Annex B and there is no simplistic explanation. However, there is some influence of the "regional" risk weightings being lower than the "in-country" risk weightings for some categories (see Annex E) and the risk classifications being quite sensitive to minor changes in the risk colour bands particularly in the mid ranges of *low* (light green), *moderate* (yellow) and *orange* (heightened risk).

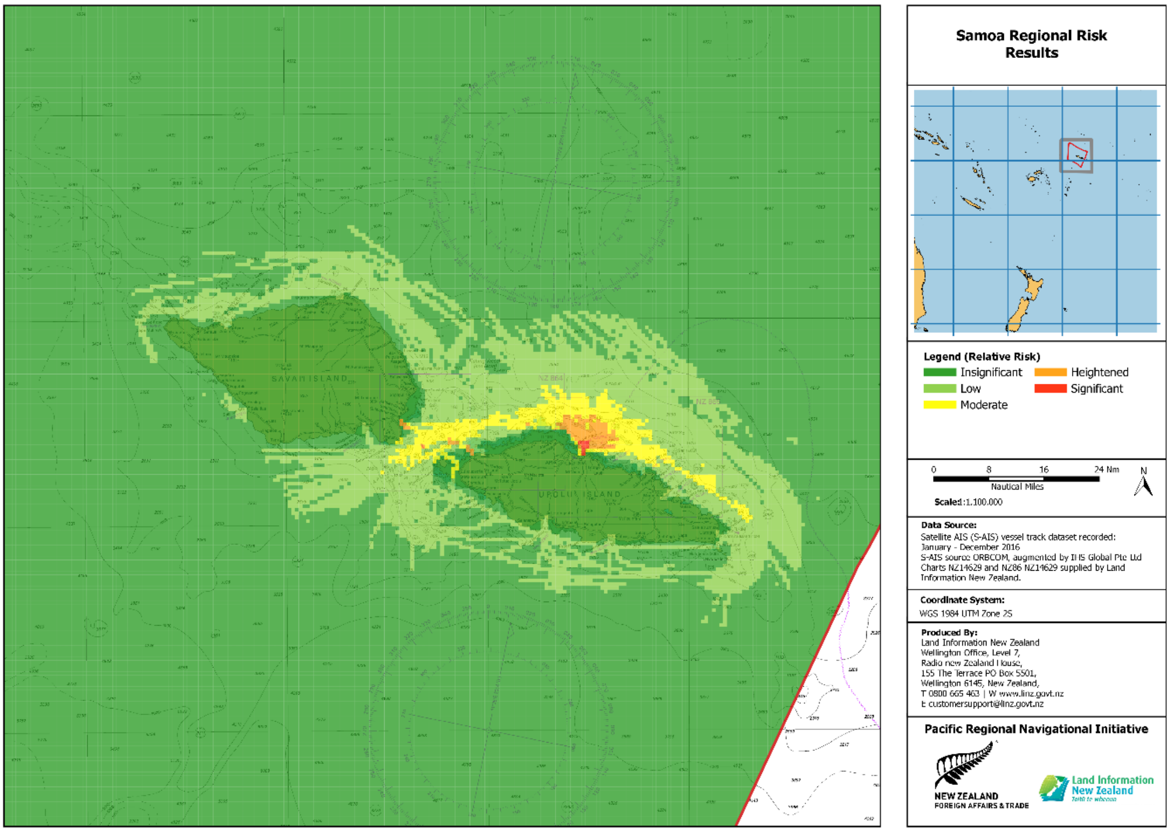

Figure 2: Risk results calibrated to "regional" colour bands

0.19 **Considering** the current hydrographic risk, the benefits and costs of hydrographic improvements, the likelihood of increased coastal traffic from future development initiatives and the cost of mitigation of maritime accidents, the following **charting improvements are recommended:**

a. The LiDAR bathymetry data should be incorporated into the published charts to extend the navigable area and reduce those areas currently indicated as "inadequately surveyed". This will reduce the hydrographic risk in near coastal waters, and particularly improve the safety of recreational, local fishing and patrol vessels that visit remote coastal areas. It will also support the potential expansion of cruise vessel destinations.

b. Produce an appropriate scale approach and harbour chart for Aleipata Port, (Satitoa) to support potential future use of the port.

c. The continuation of the 1:50,000 scale coastal chart series to provide a suitable approach chart for the port of Aleipata and to support future expanded cruise ship, recreational and commercial operations. The priority for this series is the eastern coast of Upolu and the northern coast of Savai'i covering the moderate risk areas near Asau Harbour and Matautu Bay. Consideration should also be given to charting the southern coast of Upolu where *moderate* hydrographic risk exists. The south coast of Savai'i is not considered necessary due to the lack of traffic or hydrographic risk. This chart series will be of a suitable scale as the source for ENC (compulsory for all SOLAS class vessels), and other electronic chart systems commonly used in recreational vessels.

d. Modernise chart NZ 1414 Asau by shifting it to WGS84 horizontal datum to be compatible with GPS positioning systems, and produce and equivalent ENC to support future patrol boat and future potential commercial port operations.

e. Modernisation (including metrication and incorporation of LiDAR data) of plans of those non-commercial ports that are most utilised for recreational/superyacht, cruise ship and patrol vessel visits to include:

   a. Vailele Bay – Modernisation of fathoms plan

   b. Saluafata Harbour - Modernisation of fathoms plan

   c. Fagaloa Bay - Modernisation of fathoms plan

   d. Safata Harbour - Modernisation of fathoms plan

   e. Siumu Bay - Production of a new plan

   f. Matautu Bay – Production of a larger scale (1:25,000) plan

f. Ensure effective communications of MSI from Samoan information sources to the regional MSI coordinator and charting authority so that changes that impact navigational safety, such as the charted status of navigational aids and FADS are kept up to date.

0.20 **Other hydrographic observations**.

a. The port of Mulifanua has a very shallow dredged channel charted at 2.5m deep. The ferry *Lady Samoa III* has a designed draft of 2.35m and operates on a routine schedule at all states of the tide. It is considered that at some states of the tide and in some weather conditions interaction between the vessel and the seabed could occur, this may cause the ship to shear off course resulting in an incident. It is recommended consideration be given to dredging the channel to provide greater under keel clearance.

b. The line of the outer leads at Mulifanua does not provide sufficient clearance from the reef on the southern side and ships must approach the channel from the north side of the lead line with the leads open. Consideration should be given to dredging to clear the channel (preferred) or repositioning the outer leads and adjusting the leading line.

c. The line of the outer leads at Salelologa does not provide sufficient clearance from the reef on the northern side and ships must approach the channel from south of the lead line with the leads open. Consideration should be given to dredging to clear the channel (preferred) or repositioning the outer leads and adjusting the leading line.

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GLOSSARY AND DEFINITIONS[6]

AIS Automatic Identification System. A ship transponder based system where ship-identify and positional information are transmitted and received. Vessels over 300 gross tons trading internationally are required to carry AIS transponders (Radio Regulations).

ALARP As Low as Reasonably Practical.

Alia A traditional Samoan catamaran vessel, now usually built of aluminium and between 8 and 15 metres in length. Used for sea transport and fishing.

AToN Aids to navigation. A floating or shore based light or mark that may be lit, or a virtual (electronically generated and transmitted) representation of such mark, that assists a passing vessel in its positional awareness. [Equipment fitted on a vessel to aid positional or situational awareness are known as Navigational Aids.]

CATZOC The S57 attribute of the M-QUAL object that specifies the Zone of Confidence determined by the hydrographic authority for a specified area of a chart. CATZOC is a mandatory attribute in an ENC, intended to give mariners an indication of the confidence they can place on the charted information. It depicts the final charted reliability of that area, which includes an assessment of the quality of survey. Areas are encoded against five categories (ZOC A1, A2, B, C, D), with a sixth category (U) for data which has not been assessed. The categorisation of hydrographic data is based on three factors (position accuracy, depth accuracy, and sea floor coverage).

CBA Cost Benefit Analysis. For consistency with previous reports the CBA is defined in US dollars.

Consequence Positive (particularly in a planned event) or negative (particularly in the case of an accident). Consequences can be expressed in terms of “most likely” and “worst credible” and a combination of the two gives a balanced overview of the risk. Note that “worst credible” is quite different from “worst possible”. For example, in the case of a passenger ship grounding on a reef at high speed the “worst credible” result might involve the death of 20% of the complement. The “worst possible” result would be the death of 100% of the complement. The latter is so unlikely to occur that it would not be helpful to consider it.

CRA Comparative Risk Assessment. This is the type used for Hydrographic risk work. It is a form of risk assessment, where the true quantum of the risk is actually unknown, so the risk numbers are used comparatively to identify and separate out high risks from low risks. This is done because the true number of incidents in each of the

[6] For consistency, where abbreviations / acronyms are common with previous LINZ Risk Assessment Reports the definitions have been aligned as far as practicable with those in (Marico Marine Report No. 14NZ262 – TM, Issue 1, 27 November 2014).

	areas is unknown, as is the true number of sea miles, but there is an approximation. In this form of risk assessment, the risk is truly being used as a currency.
ECDIS	Electronic Chart Display and Information System. The official IMO recognised bridge navigation system which when used with ENC meets navigational carriage requirements.
EEZ	Exclusive Economic Zone.
ENC	Electronic navigational chart. The official, government authorised navigational information dataset which, when used with a compliant ECDIS, will meet IMO chart carriage requirements for SOLAS class ships.
Event	An unwanted or unplanned occurrence with consequential harm (i.e. accidents).
FAD	Fish Aggregation Device. A man-made object consisting of buoys or floats tethered to the ocean floor used to attract pelagic fish.
Frequency	**(when referred to in relation to risk)** The measure of the actuality or probability of an adverse event occurring. It can be expressed descriptively (e.g. frequent, possible, rare) or in terms of the number of events occurring in a unit of time (e.g. more than one a year, once in every 10 years, once in every 100 years). Frequency can be absolute, i.e. derived entirely from statistics, or subjective, i.e. an informed estimation of the likelihood of an event occurring, or a combination of the two.
GIS	Geographic Information System
GT	Gross Tons. A measure of a ship's cargo carrying capacity. It is a volumetric measurement based system and not one of mass. The unit is therefore Tons and not Tonnes. GT is universally used for regulatory management of vessels.
HFO	Heavy Fuel Oil. A generic term used to refer to heavier grades of marine fuel that are mainly made up of the heaviest fraction of distillation of crude oil with small percentages of distillate added. It requires pre-heating before burning and is only used in large ships. HFO is close to crude oil in its pollution potential.
HR	Hydrographic Risk. This risk assessment methodology has been developed by LINZ. This Hydrographic risk assessment methodology relies on shipping traffic volume as a driver for the risk level; no traffic; no risk. In this risk concept, Risk is Traffic (with inherent potential loss of life, potential pollution (volume, Type and Size)) x Likelihood Criteria (Ocean conditions, Navigational Complexity, Aids to Navigation, Navigational Hazards) x Consequence Criteria (Environmental importance, Cultural importance, Economic importance). These components are combined in a GIS using Risk Terrain Modelling to output a spatial result.
HW	High Water.
IHO	International Hydrographic Organization.

IMO	International Maritime Organization.
"In-country"	Refers to results displayed using colour band classification break values calculated only from the local EEZ study area data, thus ensuring that the full colour range is utilised in the heat map. These are relative results across the local EEZ.
IR	Inherent Risk. The probability of loss arising out of circumstances or existing in an environment, in the absence of any action to control or modify the circumstances.
Jenks Breaks	**(or Natural Breaks)** is an algorithm for classification of statistical results that seeks to partition data into classes based on natural groups in the data distribution. It tries to maximize the similarity of numbers in groups while maximizing the distance between the groups. There are different implementations of the algorithm for different software packages, so results can differ from one application to another. The ESRI ArcMap implementation was used in this analysis.
km	Kilometre.
kt	Knot. One nautical mile per hour.
LiDAR	An acronym referring to **light detection and ranging.** This is a remote sensing technology that uses rapid pulses laser light in to make accurate measurements. It can be used from aircraft to measure both terrain height and depth of water.
LINZ	Land Information New Zealand. The national hydrographic authority of New Zealand.
LW	Low Water.
m	Metre.
MFO	Marine Fuel Oil. A generic term referring to lighter grades of fuel (such as marine diesel oil (MDO) or marine gas oil MGO)) consisting of mainly distillate oil that is normally used in bunkers of smaller commercial vessels or those that require frequent manoeuvring.
MMSI	Maritime Mobile Service Identity. A unique identifier for an AIS installation on a ship, base station, aid to navigation SAR aircraft or handheld VHF radio with digital select call that is allocated by the flag state (national maritime authority).
MSI	Maritime Safety Information. Nautical information of a temporal or permanent nature that impacts on safe navigation and needs to be communicated to mariners and relevant nautical charting authorities.
MNZ	Maritime New Zealand. The New Zealand maritime safety authority.
ML	Most Likely (referring to an Event).
nm	International Nautical Mile. A standard distance of 1852 metres.

NPV Net Present Value.

QGIS Open source geographic information system software useful for conducting spatial analysis of data. QGIS stands for "Quantum Geographic Information System", it is an official project of the Open Source Geospatial Foundation and supports numerous vector, raster, and database formats and functionalities.

QRA **Quantified Risk Assessment (QRA).** Undertaken for a safety case approach when measuring specifics. Totally numerical: For shipping this would be ship miles transited divided by the number of incidents of, say, collision, contact, grounding, or just expressed as the probability (or chance) of an incident occurring overall (e.g. aircraft passenger miles).

"Regional" Results described as **"regional"** are those displayed using the same colour band classification break values used in the regional risk diagrams of the previous South West Pacific hydrographic risk assessments. "Regional" results are therefore comparable to those previous assessments.

Risk A function of the combination of Frequency and Consequence of adverse events. The value of the function is unknown, in exactly the same way that a monetary currency has an unknown value. Risk is therefore a form of currency, used to measure the importance of adverse events proactively before they happen.

Risk is often quantified as *frequency x consequence* to keep arithmetic simple.

RTM Risk Terrain Modelling.

S-AIS Satellite (received) Automatic Identification System.

Shapefile A popular geospatial vector data format for geographic information system (GIS) software. It is developed and regulated by ESRI for data interoperability among ESRI and other GIS software products.

SOLAS The United Nations Safety of life at Sea Convention.

SOPAC Pacific Islands Applied Geoscience Commission. This commission was brought under the administration of SPC Pacific Regional Environment Program in 2010 and became part of the SPC Geoscience Division (GSD) in 2011.

SPC Secretariat of the Pacific Community.

SPREP Secretariat of the Pacific Regional Environment Programme. This is an intergovernmental organisation co-ordinating environmental projects across the Pacific region.

SWL Safe Working Load. The lifting capacity of a crane, derrick or other lifting equipment.

TEU Twenty-foot Equivalent Units. The standard reference size of a shipping container, though many containers are up to twice the capacity of a container ship is measured in the number of TEU it can carry.

UNCLOS The United Nations Convention on Law of the Sea.

VHF Very High Frequency. This refers to a frequency band of radio often used for short range marine voice communications.

WC Worst Credible (referring to an Event).

XML Stands for extensible markup language. It is a self-describing markup language designed to assist with storing and transferring data.

ZOC Zone of Confidence. The charted representation of CATZOC.

$ Dollars. Unless otherwise specified $ refers to New Zealand dollars.

1. INTRODUCTION

1.0.1 In the South West Pacific, island nations have generally seen an increase in SOLAS traffic transiting their waters as the volume of global maritime trade increases and a resurgence of marine tourism has spurred the cruise ship industry to find new destinations. These trends are likely to continue.

1.0.2 Additionally over the last twenty years the development of the UNCLOS and the formal recognition of the 200nm EEZ's (and in some cases extended continental shelves to 350nm) has brought with it additional responsibilities on nations of all sizes to ensure that there are adequate charts to support safe navigation through their waters.

1.0.3 This hydrographic risk assessment uses an established methodology of combining geospatial vessel traffic density information with risk likelihood factors (including chart quality), and risk consequence factors (such as proximity to regions of cultural, biological or economic importance) to provide a spatial heat map indicating relative levels of risk.

1.0.4 In reading this report it is important to understand the distinction between *Inherent Risk* and *Hydrographic Risk*. *Inherent Risk* is easiest to understand; a port may present a difficult circumstance such as constrained navigation, close to reefs and exposed to swell. This provides a clear individual risk for vessels visiting that port. *Hydrographic risk*, as defined in this methodology, measures traffic in all geographic areas by volume, type and size and then applies a range of consequence factors to provide a standardised risk outcome. Thus, the inherent risk of a single transit for an individual vessel may be relatively high, however the overall hydrographic risk result may be low because the number of transits per annum are low or the vessels involved are smaller than in other parts of the region.

1.1 Aim

1.1.1 The aims of this report are to:

a. describe the analysis of hydrographic risk relating to Samoa and Samoan waters based on the same LINZ developed risk-based methodology previously used to assess hydrographic risk in Vanuatu, the Cook Islands, Tonga and Niue in order to inform prioritisation of hydrographic survey and charting improvements,

b. analyse GIS derived plots showing the spatial distribution of shipping risk that enables the Government of Samoa and LINZ to identify priority areas for focussing hydrographic survey and charting improvements, and

c. provide the Government of Samoa with a GIS model that can be used to contribute to the ongoing monitoring and management of hydrographic risk and maritime areas.

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Land Information New Zealand Toitū te whenua

1.2 Methodology[7]

1.2.1 The method deployed uses risk assessment in a comparative way, to identify areas within the Samoan EEZ that are more susceptible to an incident involving either a large SOLAS vessel or smaller cargo, fishing or recreational vessels. This risk is determined in terms of the range of most likely and worst credible outcomes for potential for loss of life, damage to the environment, damage to economic development and impact to areas that are culturally important to Samoan people.

1.2.2 The types of accident that can occur to vessels are related to the type of vessel, as well as their size and cargo/passenger capacity. Details of vessel transit information is thus key to the methodology and was obtained from satellite AIS data (S-AIS), the Samoan Port Authority (SPA), Samoan Shipping Corporation (SSC) and Government ministries including Fisheries and Tourism[8].

1.2.3 Ship traffic was analysed in a Geographic Information System (GIS), the details of how the tracks were created and processed to remove anomalies is provided at Annex B. Information relating to domestic commercial vessels not fitted with AIS was added manually to the ship traffic plot from information collected during the site visit to Samoa 6-19 May 2017.

1.2.4 Event Trees (see Annex A) were used to derive the realistic types of navigational incident that could occur (grounding, foundering or collision) and their outcomes related to the vessel types and the size of those vessels. These outcomes confirmed that the risk multipliers and the consequence criteria for a risk matrix (Annex E), were valid for Samoa. These values were then used in the GIS risk calculations (see Annex F).

1.2.5 The information known about key economic infrastructure, important tourist destinations, the cultural and resource sensitivities of reefs and the coastline of Samoa were entered in the GIS and used to influence the risk/consequence criteria which was combined with the traffic analysis in the GIS. A plot of each layer of information used as an input to the analysis is included and described at Annex D.

1.2.6 The use of a GIS allowed a large number of geospatially referenced factors to be considered in terms of their risk contribution or consequence, and linked to the traffic density. The resulting risk levels, comparative in nature, could be displayed in the GIS as a coloured overlay “heat map". This process produced a graphical output that is visually easy to interpret. A detailed description of the GIS Analysis and Hydrographic risk assessment methodologies has been published by LINZ[9].

1.2.7 The methodology is advantageous as it is primarily data driven from existing factual information (i.e. reducing opinion-based input), and only uses expert judgement where necessary to identify the relevant risk factors (e.g. using event tree outcomes and risk criteria).

[7] This report applies the same methodology described in (Marico Marine Report No. 14NZ262 – TM, Issue 1, 27 November 2014), as further adapted in (RNAPL16002 - NIUE Hydrographic Risk Assessment, 2016) with minor adjustments to apply to Samoa.
[8] Refer to Annex H for a full list of consultations.
[9] (Marico Marine Report No. 12NZ246, Issue 3, February 2013) (Marico Marine Report No. 15NZ322 Issue 03, 5 August 2015)

1.2.8 In summary, the assessment was conducted as follows:

a. Vessel traffic analysis to build a model of shipping movements through Samoan waters was undertaken using satellite derived AIS data for January – December 2016,
b. Additional domestic vessel traffic was identified from local sources and manually added to the traffic layers,
c. a number of factors related to maritime risk were then identified and scored on a five point scale (i.e. Risk Matrix) across the study area; this included the confidence of the current nautical charting,
d. each risk factor was then weighted in terms of its relative importance to the final model and combined with the traffic analysis to produce a final cumulative plot of hydrographic risk in Samoa, and the risk results are presented in Section 7, and
e. consideration of possible future commercial operations at Asau and Aleiapata (Satitoa) were used as a basis to estimate additional traffic in these areas and re-run the risk model to estimate the potential impact.

1.3 Risk calculation and GIS implementation

1.3.1 As described above, and to maintain consistency with previous results, the risk criteria used throughout the analysis is common with similar work undertaken in Vanuatu, the Cook Islands, Tonga and Niue. The calculation of hydrographic risk for Samoa also uses a similar GIS implementation of a weighted overlay method to that used in the risk assessments of Vanuatu,[10] Cook Islands,[11] Tonga[12] and Niue.[13] The documents "LINZ Hydrographic Risk Assessment Methodology Update"[14] and the "Annexes to the Vanuatu Risk Assessment Report"[15] provide a good explanation of the method but additional details of this risk calculation are provided in Annex E.

1.4 Cost benefit analysis

1.4.1 Where recommendations for charting improvements are made these are supported by a cost benefit analysis. The details are provided in Section 8.

[10] (Marico Marine Report No. 12NZ246-1, January 2013)
[11] (Marico Marine Report No. 14NZ262MR Issue 02, 20 January 2015)
[12] (Marico Marine Report No. 14NZ262 – TM, Issue 1, 27 November 2014)
[13] (Land Information New Zealand and Rod Nairn & Associates Pty Ltd, 2016)
[14] (Marico Marine Report No. 15NZ322 Issue 03, 5 August 2015)
[15] (Marico Marine Report No. 12NZ246-1, January 2013)

2. COUNTRY INFORMATION AND ECONOMY

2.1 Upolu and Savai'i Islands

2.1.1 The Independent State of Samoa, previously known as Western Samoa,[16] lies south of the equator and occupies an almost central position within the Polynesian region of the Pacific Ocean. Situated between Tokelau and Niue, at latitude 13° 35' South and longitude 172° 20' West, Samoa lies half way between New Zealand and Hawaii approximately 130 km to the northwest of nearby American Samoa.

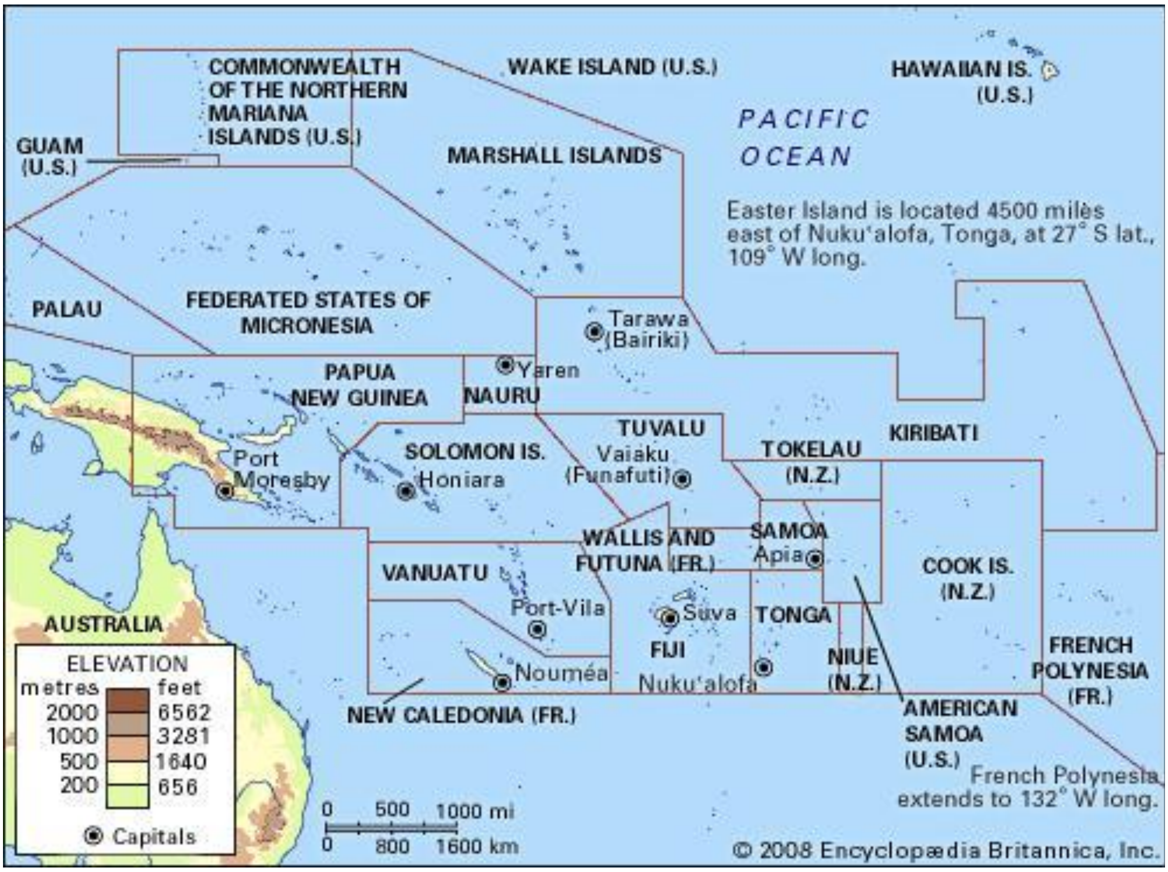

Figure 3: South West Pacific (Source: Encyclopaedia Britannica)

2.1.2 Samoa is one of the largest chain groups in Polynesia, comprising islands, atolls and submerged reef banks. There are nine individual islands: Upolu, Savai'i, Manono, and Apolima and the uninhabited islands of Fanuatapu, Namu'a, Nu'utele, Nu'ulua, and Nu'usafee. Savai'i Island (Savai'i) is Samoa's largest land mass covering approximately 1,707 km^2 (63 km long by 32 km wide). Lying a short distance southeast across Apolima Strait is Upolu Island (Upolu), Samoa's other main island. Upolu is slightly smaller in size at 1,119 km^2 (63 km long by 21 km wide). Samoa's remaining islands and islets lie close offshore, primarily around the southeast point of Upolu in the vicinity of

[16] The country dropped the Western' from its title 'Western Samoa in 1997.

Cape Tapaga and inside the southern part of Apolima Strait between Cape Paepaeolei'a and Cape Fatuosofia.

Figure 4: South coast of Savai'i Island (left) - and Falefa Valley, Upolu Island (right)

2.1.3 Sitting on the edge of the Pacific Plate some 70 miles north of the Tonga Trench[17] Samoa's islands are predominantly made up of basalt rock, having been formed through extensive volcanic activity. Samoa is still considered geologically active; as recently as September 2009 the Samoan archipelago recorded a significant undersea earthquake registering a magnitude of 8.3.

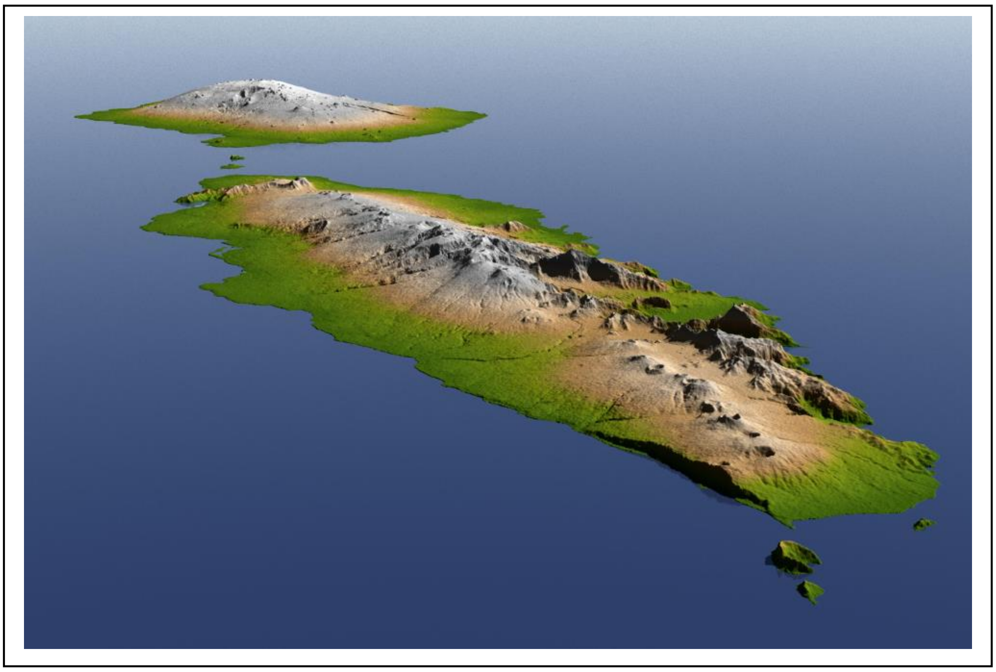

Figure 5: Savai'i Island (back) and Upolu Island (front) (Source: Google Images)

[17] (Hill, 1991)

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Land Information New Zealand Toitū te whenua

2.1.4 Both main islands feature a rugged mountain interior which is bordered by a flat to gently undulating coastal plain. Savai'i is home to an extensive shield volcano at its centre.[18] A similar central mountain range extends the length of Upolu, the highest peak being Mauga Fito (1,100 m).

2.1.5 **Coastline.** Samoa's coastline is approximately 404 km[19] and is generally rocky and steep-to. The coastline can be described as either having a wide fringing reef which transitions to a shallow barrier reef, is cliff-like with little if any adjacent reef development, or comprises a low, narrow coastal strip made up of fringing reefs and lagoons, long beaches, barrier spits and coastal swamp areas. Much of the coastline around Upolu for example has a fringing reef which encloses any number of shallow lagoons. An extensive shelf exists off Upolu's north coast. Conversely, apart from a few areas to the north and northwest of the island and along parts of the eastern coastline bordering Apolima Strait, Savai'i is predominantly clear of any significant barrier or fringing reef.

2.1.6 The oceanic seabed around Samoa rises sharply from several kilometres depth from a relatively short distance offshore.

2.1.7 **Exclusive Economic Zone (EEZ)**. Samoa's EEZ covers approximately 120,000 km^2 and is deep and otherwise unremarkable.[20] Bordering American Samoa, Tokelau, Tonga and Wallis and Futuna, it stands out as the smallest EEZ in the South Pacific.

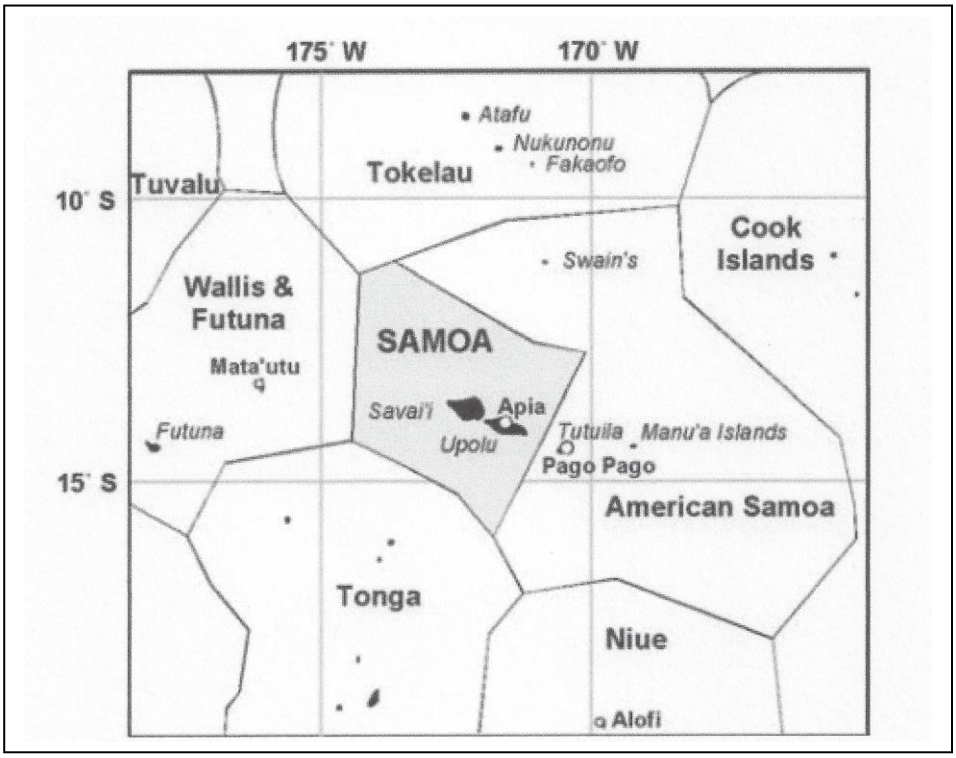

Figure 6: Samoa's EEZ (Source: Gillett, 2011)[21]

[18] At an elevation of 1,858 metres, Mauga Silisili is Samoa's highest point.
[19] (Commonwealth Governance Samoa, n.d.)
[20] (Fisheries Division, 2009). This approximation is supported by the Pacific Community (SPC) which estimates Samoa's EEZ to be 127,950 km^2 (Pacific Community (SPC), 2017)
[21] Further details regarding Samoa's EEZ can be obtained from Marineregions.org

2.1.8 While there are no offshore islands or drying reefs within Samoa's EEZ some significant submarine features do exist offshore. Most notable is the Machias Seamount (minimum depth approximately 600 m) in the southern reaches of the EEZ about 110 km south of Upolu. In addition, Pasco Bank (14 m) and an unnamed 21 m bank are located some 222 - 240 km to the west north west of Savai'i Island at the very western extremity of the EEZ, with Taviuni Bank (17 m) a further 20 km distant and outside the EEZ.

2.1.9 **Climate.** The region's tropical and humid climate is influenced by the mountainous nature of Samoa itself. The climate is relatively consistent throughout the year and is therefore conducive to the development of dense rainforest which tends to cover the rugged interior of both Upolu and Savai'i. Annual precipitation across Samoa varies from more than 2,540 mm (100 inches) on the northern and western coasts to more than 7,620 mm (300 inches) over the inland ranges.[22] Southeast trade winds prevail throughout the dry season (May to October) backing on occasion to the north during the wet season.

2.1.10 During the wet season (November to April) severe tropical storms can occur and invariably cause widespread damage.[23] According to the Samoa National Tropical Cyclone Plan, the country's tropical cyclone risk is rated as 'extreme'.[24] Between 1969 and 2010, 52 tropical cyclones passed within 400 km of Samoa[25] suggesting tropical storms and cyclones feature as one of Samoa's main natural hazards. The Pacific Catastrophe Risk Assessment and Financing Initiative has estimated that in the Samoan region, tropical cyclones of Category 2 and 3 intensities have a return period of 13 and 35 years respectively.[26]

2.1.11 **Heritage.** Samoa's ancestors originally made their way across the Pacific in ocean-faring canoes thousands of years ago. Over time, the people of Samoa have interacted with other groups throughout the Polynesian region. Interwoven cultures and bloodlines have helped strengthen the ties of Samoa and many of the country's South Pacific neighbours.

2.1.12 Samoans are mainly of Polynesian heritage; the majority are considered ethnic Samoans. European whalers and traders started to arrive in Samoa in the late 1700s, followed by missionaries in the early 1800s. Accordingly, people of mixed European and Polynesian ancestry account for much of the country's population and the culture holds strong Christian beliefs.

Figure 7: Impressive churches are a feature of Samoan Villages

(http://www.marineregions.org/eezdetails.php?mrgid=8445&zone=eezd)

[22] (Foster, 2016)

[23] In December 2012, extensive flooding and wind damage from Tropical Cyclone *Evan* (Category 4) displaced over 6,000 people and damaged or destroyed an estimated 1,500 homes on Upolu Island.

[24] (Samoa National Tropical Cyclone Plan 2006 , 2006)

[25] (Asian Development Bank, 2015)

[26] (Samoa Post-Disaster Needs Assessment Cyclone Evan 2012, 2013)

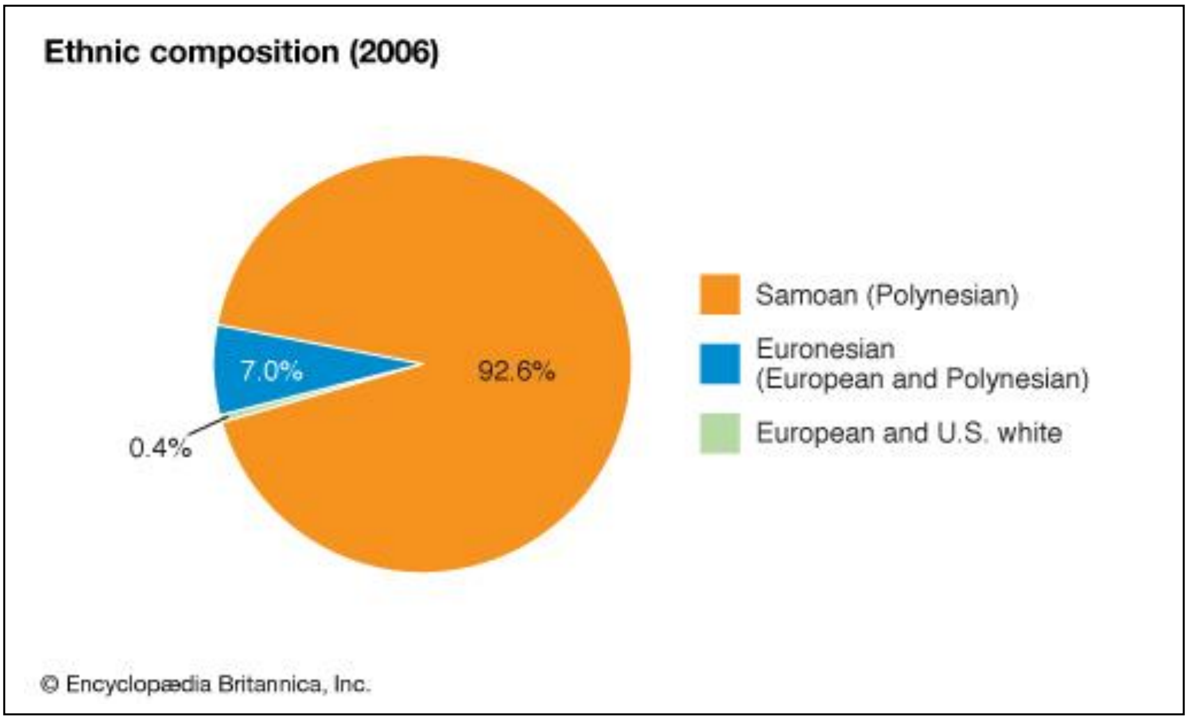

Figure 8: Samoa - Ethnic Composition 2006 [27]

2.1.13 **Population.** From an estimated 80,000 in the 1950s, Samoa's population had doubled by the mid-1990s and by 2006 was in the order of 181,000. The last official census (2011) recorded a population of 187,820. The current population of Samoa is 195,502,[28] with 81% of people residing outside the main urban areas.[29] While most Samoans live along the coastal margins in village settings, the capital Apia on the northern coast of Upolu, is home to approximately one-fifth of Samoa's population.

Region	No. of h'holds		Population	
	2011	2015	2011	2015
SAMOA	**26,205**	**28,119**	**186,889**	**194,335**
Apia Urban Area	5,389	5,554	36,400	36,232
North West Upolu	8,776	9,732	62,045	66,969
Rest of Upolu	5,925	6,311	44,235	45,303
Savaii	6,115	6,522	44,209	45,831

Figure 9: Demographic Situation in Samoa (Source: Samoa Bureau of Statistics)

[27] (Foster, 2016)
[28] (Samoa Population Live, n.d.)
[29] (Samoa Bureau of Statistics, n.d.) and (Commonwealth Governance Samoa, n.d.)

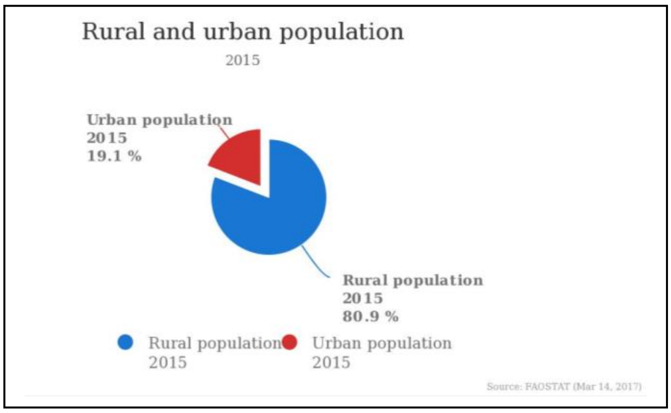

Figure 10: Samoa - Rural and Urban Population Breakdown [30]

2.1.14 Since the late 1950s the country has experienced a declining rate in population growth. While many Samoans continue to emigrate to New Zealand and Australia and even further afield to the United States, this decline has plateaued since the early 1980s. However, compared to the world average, population growth in Samoa is still relatively low with a current rate of approximately 0.6%.[31]

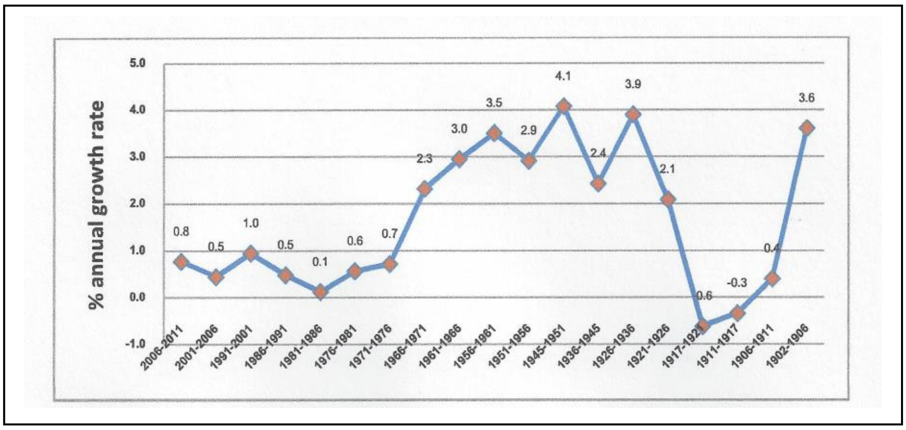

Figure 11: Samoa - Population Growth Trends (Source: United Nations FAO)[32]

2.1.15 **Government.** The national government of Samoa is a self-governing parliamentary democracy that incorporates various aspects of Samoan culture. The country maintains a Head of State with a Prime Minister heading up the Executive Government. The Prime Minister, having been elected by the Legislative Assembly, appoints a cabinet from among the Assembly's 49 members (two members are directly elected by the country's non-Samoan and mixed ethnic groups, while the remaining are directly elected from Samoan chiefs [*matai*]). The Legislative Assembly is responsible for the day-to-day management and administration of Samoa including the enforcement of all laws.

[30] UN Food and Agriculture Organisation (http://www.fao.org/faostat/en/#country/244)
[31] (Foster, 2016) (CIA World FactBook – Samoa, n.d.) and (Samoa Population Live, n.d.)
[32] Population and Housing Census 2011 Analytical Report, Government of Samoa

2.1.16 There are eleven political districts (*itūmālō*) in Samoa with each district having its own established constitutional foundation (*faavae*);[33] five districts are located on Upolu, while the remaining six divide Savai'i. The capital village within each political district administers and coordinates the day-to-day affairs of the district. These political districts are further divided into 41 sub-districts (*faipule*) which have no administrative function but instead, serve as electoral constituencies.

2.1.17 At the local level, Samoa comprises over 360 villages, of which 45 make up the capital Apia. The direct consequence of this is that Apia does not have a common (centralised) administration. Local power still rests with the constituent villages (see Section 3).

2.2 Economic Overview

2.2.1 Samoa is susceptible to the effects of external forces that can seriously impact the country's relatively fragile economy. Natural disasters (ranging from tropical storms, floods, earthquakes and tsunamis etc) and international crisis events can expose the economy to significant risk. While Samoa had significantly reduced public debt levels since the late 1990's, the country's external debt increased from 34% in FY 2007/2008 to 60% of GDP in FY 2013/2014.[34] This was mainly because of the Government's need to adopt expansionary policies following the global economic crisis and the need for reconstruction expenditure following the 2009 tsunami and 2012 tropical cyclone events.

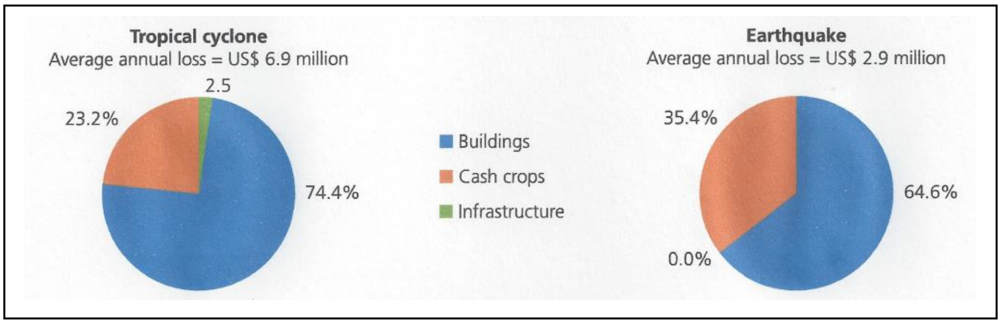

Figure 12: Average Annual Loss Due to Tropical Cyclones and Earthquakes[35]

2.2.2 **Trade.** Over the millennia, Samoan people have regularly engaged in trade with the country's neighbours, in particular Fiji, Tonga, and American Samoa. Today, because of its geography, trade remains just as important, particularly in terms of efforts to further develop the Samoan economy, in particular the export market. The country's main exports are automotive wire harnesses (to Australia), non-fillet frozen fish, beer, furniture, and fruit juice. By value, insulated wire remains the single largest export commodity followed by fish products. Unfortunately, the wire harness industry will close down by September 2017 when the Australian car manufacturing industry closes.[36]

[33] (Official Web Portal of the Government of Samoa, n.d.)
[34] (Asian Development Bank, 2014)
[35] (Samoa Post-Disaster Needs Assessment Cyclone Evan 2012, 2013)
[36] (Yazaki Corporation, 2016)

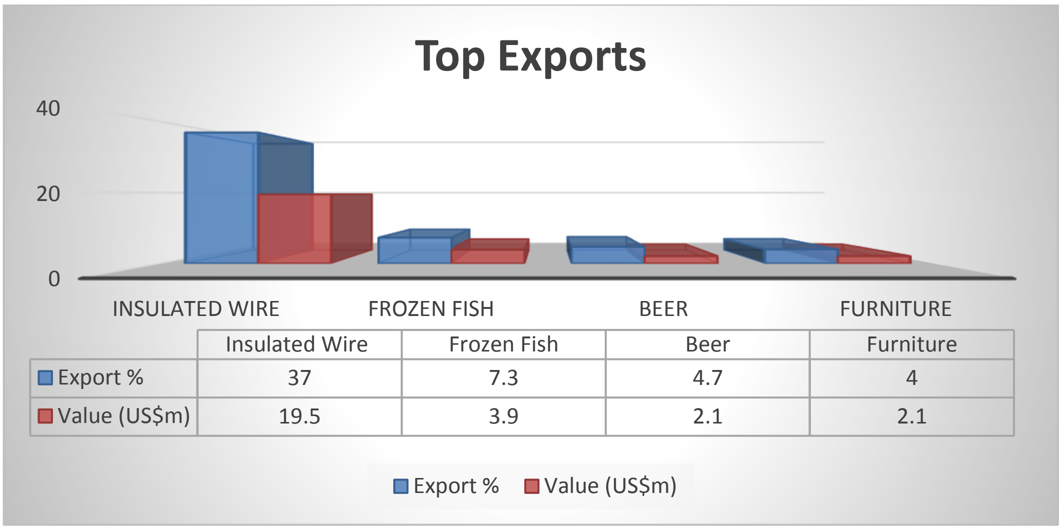

Figure 13: Samoa - Major Exports (Source: OEC)

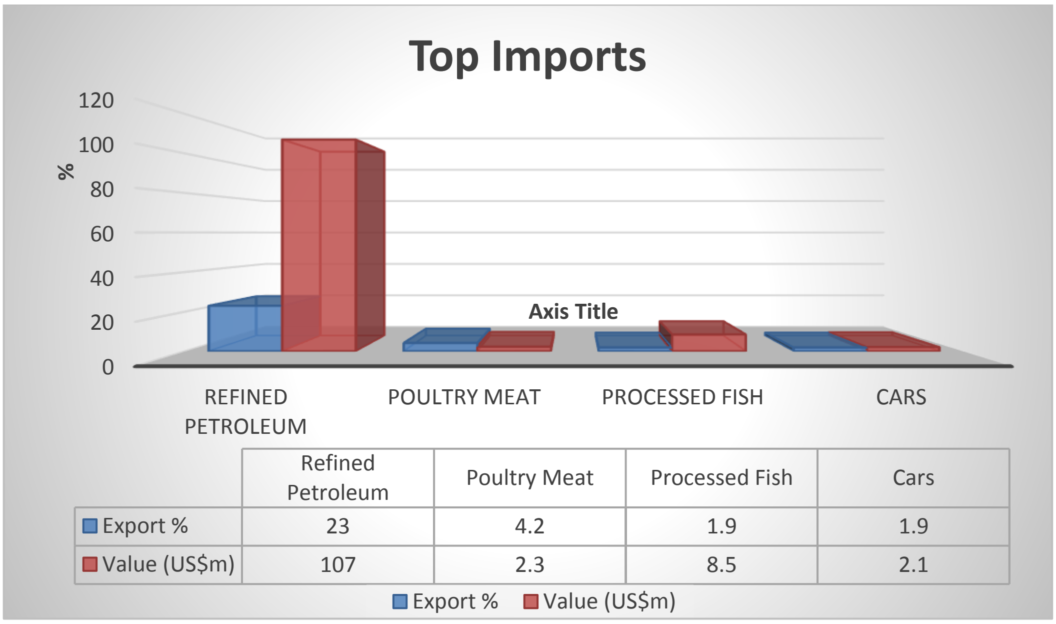

Figure 14: Samoa - Major Imports (Source: OEC)

2.2.3 Samoa's primary imports tend to be agricultural produce, industrial supplies, cars, machinery, consumer goods, processed fish, sawn wood, and petroleum products.[37] By value, refined petroleum is the country's single largest import followed by processed fish.

[37] (The Observatory of Economic Complexity, n.d.)

2.2.4 Samoa's main trading partners for imports are New Zealand, Singapore, China, the United States and South Korea while for exports, the top countries are Australia, New Zealand, the United States, American Samoa and Indonesia.[38] New Zealand and American Samoa feature as the primary destinations for exported fresh-chilled and frozen fish.[39] Australia has been a key destination for merchandise exports: in 2015, imported goods from Samoa were worth around AUS$34 million with the main import being automotive wire harnesses.[40] However, this industry will close in 2017 as a consequence of cessation of vehicle manufacture in Australia[41].

Figure 15: Yasaki EDS Samoa Ltd. Apia Plant will close in 2017

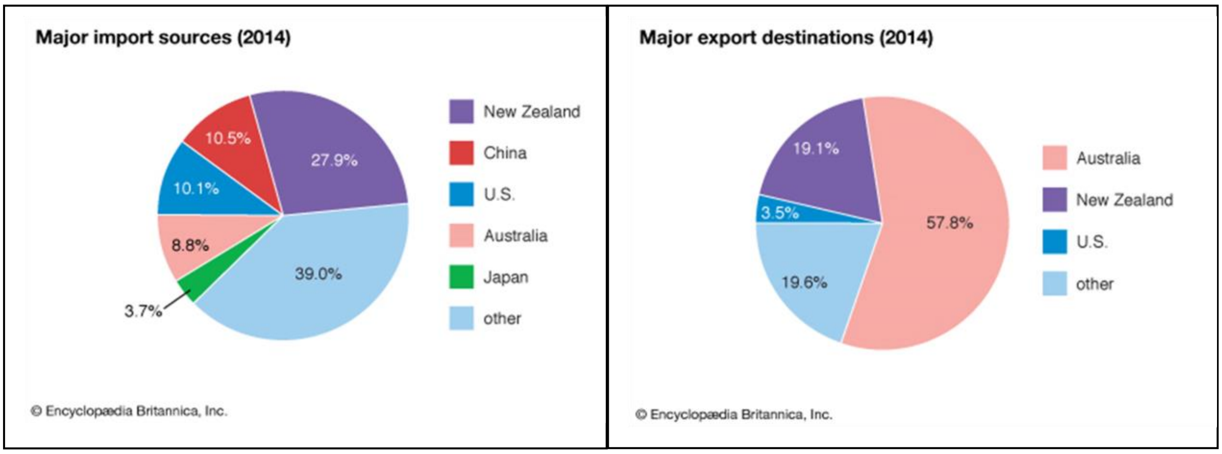

Figure 16: Samoa 's Major Trading Partners – Imports and Exports (Foster 2016)

2.2.5 **Balance of Trade.** Samoa's disproportionate value of imports over exports delivers a near constant negative balance of trade figure. In 2015, exports amounted to US$58.9 million (NZ$85.1 million) while imports totalled US$370.6 million (NZ$535.4 million). During the last five years, exports have decreased at an annualised rate of -4.2% while imports have increased at a rate of 3.2%.[42] This trend is unlikely to change significantly over the medium to longer term due to Samoa's isolation, limited natural resources, and narrow economic base.

[38] (Foster, 2016)

[39] (Ministry of Agriculture and Fisheries Annual Report 2013-2104)

[40] (Samoan Country Brief, 2017). Up to 60 containers of fabricated motor vehicle harnesses are shipped from Apia to Melbourne each month. These harnesses are manufactured by Yazaki Corporation, an international company with a wide-ranging global network. Yazaki EDS Samoa Ltd was established in 1995 with the company being Samoa's largest private sector employer.

[41] (Yazaki Corporation, 2016)

[42] (The Observatory of Economic Complexity, n.d.)

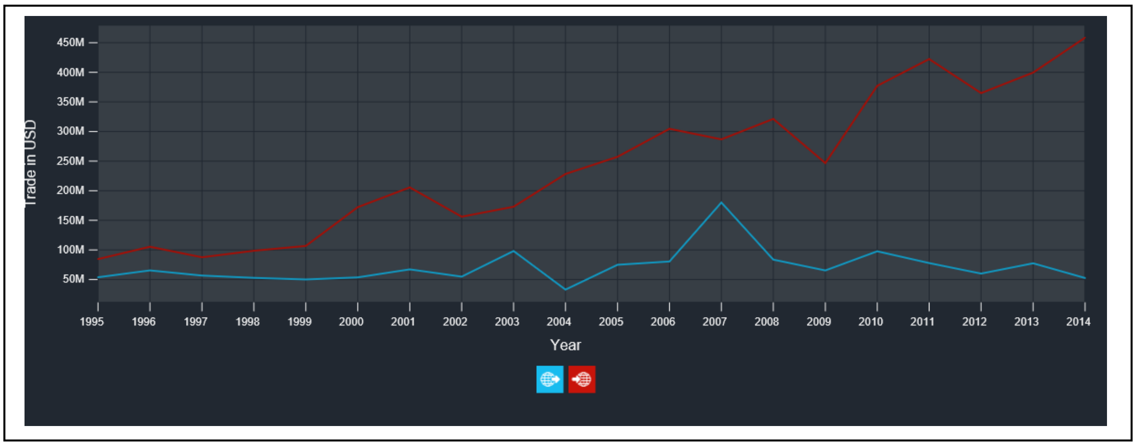

Figure 17: Imports and Exports (By Value) - 1995 - 2014 (Source: OEC)

2.2.6 **Trade Initiatives.** Initiatives such as the Pacific Agreement on Closer Economic Relations (PACER) plus initiative aims to assist Pacific Island Countries (PIC), including Samoa, enhance regional trade, integrate economies, and promote trade capacity-building. Once signed, this agreement should provide the opportunity for economic growth through development assistance designed to strengthen Samoa's ability to trade.[43]

2.2.7 **GDP.** The GDP figure for Samoa in 2015 was US$761 million (approximately NZ$1.1 billion); this equates to US$3,938 (NZ$5,689) per capita. Samoa's GDP has trended upwards since the mid-1990s; [44] GDP is projected to grow at 5% (2016) and 2% (2017).

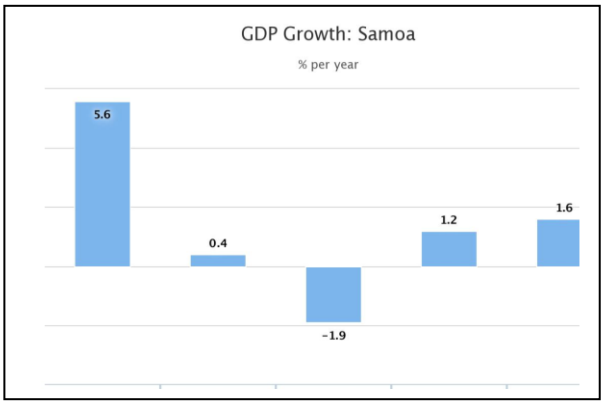

Figure 18: GDP Growth - Samoa - 2011-2015 (Source: ADB)

2.2.8 The Government acknowledges that ongoing reliance on foreign aid cannot be sustained over the medium to longer term. However, at present the economy is reliant on international investment along with capacity-building grants and related loans provided through the Asian Development Bank (ADB) and from countries like Australia, New Zealand and the United States. Since 1966, the ADB has partnered with the Samoan Government and approved a total of over NZ$491 million in loans, ADB Fund grants, and technical assistance to support Samoa's economic development, while aid from New Zealand in the 2015/16 Financial Year amounted to NZ$25.7 million.[45] This aid tends to be distributed across a number of developing sectors including agriculture

[43] (Department of Foreign Affairs and Trade, n.d.)
[44] (The World Bank, n.d.)
[45] (Asian Development Bank, 2015) and (Asian Development Bank, 2014)

and natural resources, education, energy, finance, and municipal infrastructure services, and includes projects designed to boost revenue and employment in Samoa's emerging tourist sector.[46]

2.2.9 An additional source of income for the economy are family remittances, which are sent back from Samoans living abroad. New Zealand, Australia and the United States are the main source of remittances which account for as much as one-sixth of household income.[47] In 2015, remittances from abroad accounted for 20.3% Samoa's GDP.[48]

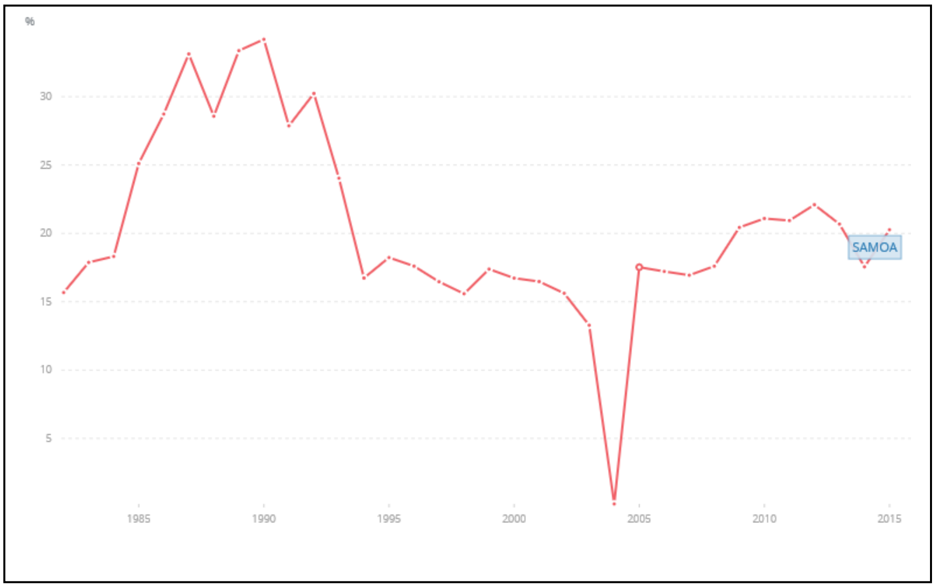

Figure 19: Samoa - Remittances (% of GDP) (Source: The World Bank)

[46] (New Zealand Foreign Affairs and Trade , n.d.)
[47] (Foster, 2016)
[48] (The World Bank - Remittances, n.d.)

2.3 Main Economic Sectors

2.3.1 Agriculture

2.3.1.1 Samoa comprises a land area of 2,840 km^2 (284,000 ha/702,000 acres).[49] Over 60% of Samoa is forested, while the area allocated to agriculture is approximately 77,295 ha (191,002 acres).[50] A significant portion of Samoa's total available land area is allocated to agriculture (27%).[51]

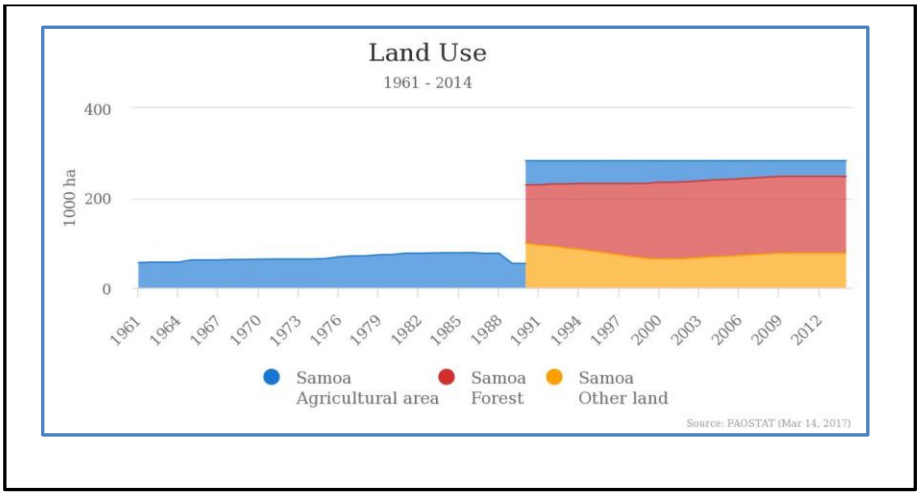

Figure 20: Land Use Across Samoa[52]

2.3.1.2 Agriculture continues to play a critical role in the country's economy and more generally, in Samoan society (see Section 3). It provides food for the family, employment, and is seen as a secondary source of household income. The sector employs around two thirds of the total Samoan workforce either in paid or unpaid labour and supports upwards of 180,000 rural families.[53]

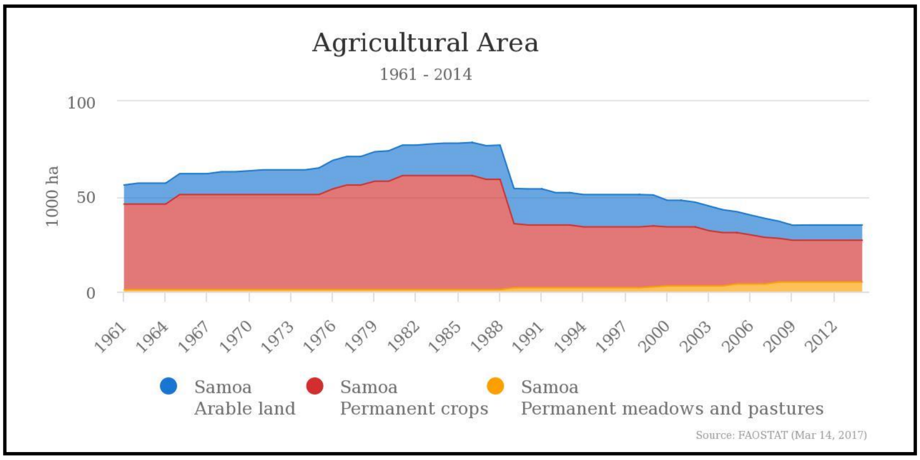

Figure 21: Agricultural Land Use in Samoa (Source: Agricultural Survey 2015 Report)

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[49] (Food and Agriculture Organization of the United Nations, n.d.)
[50] (CIA World FactBook – Samoa, n.d.)
[51] (Report on Samoa Agricultural Survey 2015, 2016)
[52] (Food and Agriculture Organization, n.d.)
[53] (Samoa Agriculture Competitiveness Enhancement Project, 2016)

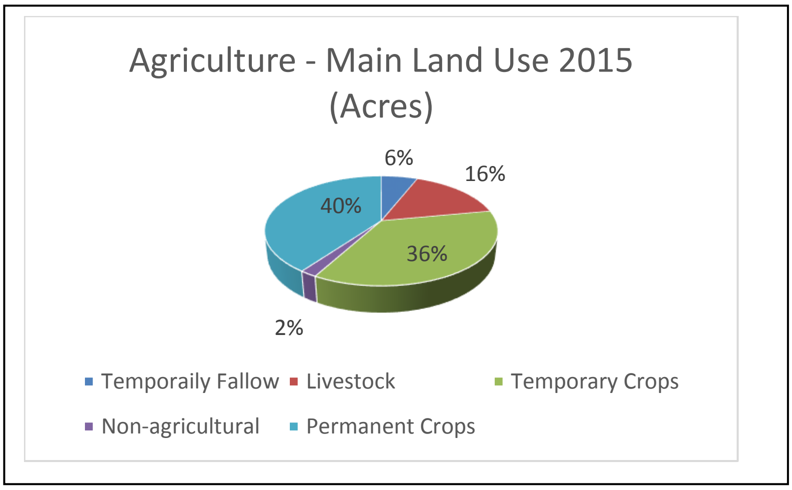

Figure 22: Agriculture - Main Land Use (Source: Samoa Agricultural Survey 2015)

2.3.1.3 Approximately 80% of Samoa's family farmers own and work the land along Samoa's coastal plains in what is termed 'village agriculture'.[54] As opposed to commercial/plantation agriculture, in which there is limited local involvement across Samoa, this localised form of subsistence farming uses the largest areas of all available land (12.4%) for crops and for raising livestock and employs the majority of Samoa's labour force. Produce grown in village enterprises delivers the major portion of staple and cash crops including coconuts, cocoa, bananas, taro, ta'amu, breadfruit, sugarcane, yams, manioc, and various fruits. Coconut products, cocoa, and bananas are produced for export.[55]

2.3.1.4 Samoans also maintain livestock and have in more recent times, diversified into cattle, pigs, poultry, goats and horses. Raising livestock is usually considered to be a household activity; again, there is little commercial activity in this area. Between 2009 and 2015 Samoa experienced a 20% increase in the number of households maintaining cattle livestock (19,208 households in 2015 compared to 15,955 in 2009).[56] As part of current sector reform and through receipt of development aid, cattle production might make more of a contribution to the Samoan economy in the future and develop to the extent that Samoa may be able to reduce current levels of frozen beef imports.

2.3.1.5 There is little if any new land being brought under cultivation; most land (89%) used for permanent or temporary crops has been cultivated for ten or more years. While there are marked differences between the soils of the lowlands and those of the highlands, the soil across Samoa is generally of poor quality. Further, apart from Afulilo Dam and Lake Fiti (on Upolu), there are few permanent lakes, rivers or water courses. These factors place added pressures on a sector that is generally considered to be under-performing with production having been in decline over the past three decades. Sector performance has continued to be poor in recent years due to the prevalence

[54] (Toleafoa, 2014)
[55] Taro is seen as being the most important staple food in Samoa. The number of households growing taro is increasing primarily due to the recent opening up of regular overseas markets for export along and through the active promotion of Samoa's export crops by the Government.
[56] (Report on Samoa Agricultural Survey 2015, 2016)

of crop disease, low labour productivity, substandard agricultural infrastructure and support services and the effects of natural disasters.

	Disaster Effects		
	Damage (thousand SAT)	Losses (thousand SAT)	Total (thousand SAT)
Sector			
Agriculture	4,905	58,061	62,966
Livestock	3,516	800	4,316
Fisheries	2,084	5,493	7,602

Table 1 Summary of Damage and Loss by Cyclone *Evan* in Samoa[57]

2.3.1.6 Significant quantities of food therefore need to be imported to sustain Samoa's population (in particular wheat flour, rice, sheep, pig and goat meat, butter, milk, vegetables and fruit). The reliance on food imports has a compounding effect on Samoa's balance of trade. The agricultural sector's contribution to GDP has fallen from 19% in 1995, to 12% in 2009, to a little over 10% in 2011.[58] In 2013, the sector still only accounted for around two fifths of Samoa's GDP at around 10%.[59]

2.3.1.7 As important as agriculture is to Samoa's economy, particularly in terms of employment, the sector does not provide many opportunities for actual paid work. In 2015 only 1% of households considered employment in the agriculture sector to be their main source of income.[60]

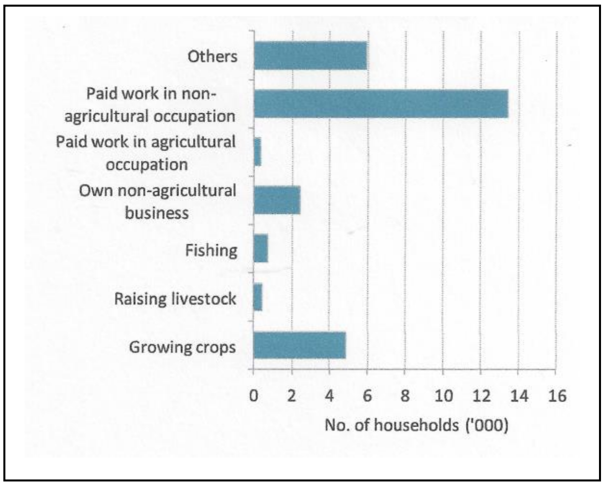

Figure 23: Number of Households by Main Sources of Income (Samoa Agricultural Survey 2015)

2.3.1.8 **Initiatives.** A range of sponsored programmes are in place to reduce the significant gap that currently exists in levels of income when comparing rural and urban areas. These programmes look to improve the country's food security and foreign exchange reserves primarily through food import substitution and increased export opportunities. For example, with the assistance of the World Bank,

57 (Samoa Post-Disaster Needs Assessment Cyclone Evan 2012, 2013)
58 (Lee, 2009) and (Samoa Post-Disaster Needs Assessment Cyclone Evan 2012, 2013)
59 (Foster, 2016) and (Asian Development Bank, 2015)
60 (Report on Samoa Agricultural Survey 2015, 2016)

Samoa's Ministry of Agriculture and Fisheries is implementing the Samoa Agriculture Competitiveness Project targeting the livestock and the fruit and vegetable sectors. This programme is striving to ensure local produce (vegetable crops) captures a growing proportion of the domestic food market to help increase rural household incomes. Similarly, the Scientific Research Organisation of Samoa has successfully produced flour from breadfruit, which is a seasonal staple crop. The Organisation is looking to market the product locally while at the same time, exploring potential export markets abroad.

2.3.2 Fishing

2.3.2.1 Samoa's fishing industry comprises inshore/coastal (troll) fishing and offshore commercial fishing. The vast majority of Samoa's fishing industry is undertaken on a national basis and is largely home-grown. In 2007, foreign-based commercial operations (primarily working offshore) only accounted for 0.2% of Samoa's annual catch while access (licence) fees paid by foreign fishing vessels only represented 0.15% of all Government revenue.[61]

	Coastal commercial	Coastal subsistence	Offshore locally-based	Offshore foreign-based[220]	Fresh-water	Aqua-culture
Volume of production (metric tonnes)	4 129	4 495	3 755	25	10	10
Value of production (USD)	19 557 592	14 903 842	8 362 836	49 300	33 206	33 206

Figure 24: Fishing Categories 2007 – Samoa (Source: Gillett 2011)

2.3.2.2 **Inshore/Coastal Fishing.** The main purpose of the inshore troll industry is to provide for home consumption (noting that fish forms a key component of the Samoan diet)[62] and to help supplement household income through local market or restaurant sales.[63] The vast majority of households in Samoa that engage in fishing, limit their activities to the inshore areas, primarily for subsistence purposes.

Region	No. of fishing h'holds	Inshore	Offshore	Fresh water
SAMOA	**5,943**	**5,533**	**872**	**377**
Apia Urban Area	288	213	51	24
North West Upolu	1,175	1,125	98	12
Rest of Upolu	2,051	1,952	208	66
Savaii	2,429	2,242	516	275

Figure 25: No. of Household by Fishing Habitat & Region (Source: Samoan Ag. Survey 2015)

[61] (Fishery and Aquaculture Country Profile - Samoa, 2009)
[62] (Food and Agricultural Organization of the United Nations, 2009)
[63] Trolling consists of towing several lines with bait or lures attached. Troll fishing tends to target albacore tuna and only accounts for a very small percentage of the world tuna catch of tuna. This is consistent with trolling being associated with subsistence fishing.

Market	Total Estimated Value (SAT)	Total Estimated Volume (mt)	% Weight	% Value
Apia Fish Market	$565,511.68	48.453	42.88	41.4
Fugalei Agriculture	$144,590.53	5.776	5.11	10.59
Roadside (Apia to Faleolo)	$489,383.93	42.23	37.37	35.83
Salelologa Market	$166,332.56	16.537	14.64	12.18
	$1,365,818.70	**112.996**	**100**	**100**

Figure 26: Annual Catch of Domestic Fish Species - Main Market Outlets 2014[64]

2.3.2.3 **Offshore Fishing.** Commercial operations further offshore are more critical to the economy. In 2007, commercial fishing activities (non-foreign based) contributed US$28.5 million (NZ$40.4 million) to the country's GDP (6.2%).[65] Samoa's offshore fishing industry is primarily focussed on the commercial tuna industry. With the conversion, and new builds, of the *alia* boat design to support offshore longline fishing in the mid 1990s, Samoa's commercial longline fishing industry commenced in earnest in the late 1990s and now comprises a combination of advanced *alia* boats (still for small scale operations only) and larger domestic mono-hull vessels of 12.5 or more metres in length.[66]

2.3.2.4 In 2013-2014 a total of 64 commercial longline vessels were licensed to operate in Samoa's EEZ. Size/class restrictions are currently placed on Samoa's longline vessel licence numbers in an attempt to regulate the industry. US purse seine vessels are also permitted to operate in the Samoan EEZ.

Vessel Class	License Caps	Licensing Fees ($ST)	Licensed Vessels
A (Up to 11m)	100	200	54
B (> 11-12.5m)	10	1,000	0
C (>12.5-15m)	10	5,500	2
D (>15-20.5m)	12	8,000	6
E (>20.5m)	5	10,000	2

Figure 27: Vessel Classes, Licence Caps and Licenced Vessels - 2013-2014[67]

[64] (Ministry of Agriculture and Fisheries Annual Report 2013-2104)
[65] (Fishery and Aquaculture Country Profile - Samoa, 2009)
[66] The *alia* fishing fleet's involvement in the tuna longline fishery is limited with much of the catch being taken by larger mono-hull vessels. (MAF, 2015).
[67] (Ministry of Agriculture and Fisheries Annual Report 2013-2104). MAF discussions 2017 indicate that an additional class F for vessels will be introduced in 2017 with a cap of 8 licences.

GROSS REGISTERED TONNAGE	CLASS	LENGTH (m)	FISHING METHOD	2010	2011	2012	2013	2014
0-10	A[1]	Up to 11	Longline and Troll	37	35	23	27	29
0-10	B	> 11-12.5	Longline	1	1	1	0	0
	C	>12.5-15	Longline	3	3	2	2	2
	D	>15-20.5	Longline	6	5	8	8	7
50-200	E	>20.5	Longline	3	2	2	2	4

Figure 28: No. of Samoan Vessels Active in Samoa's EEZ 2010-2014 (Source. MAF – Fisheries Div.)

2.3.2.5 Samoa's offshore longline fleet tend to unload their domestic catch in Apia, either on the main wharf area or across the fishery wharf at Savalalo in Apia Harbour.[68] Some of the smaller *alia* longliner boats also offload at a few of the smaller landing sites around Savai'i and Upolu.[69]

2.3.2.6 Currently the majority of the offshore tuna catch is packed and exported frozen whole, though limited fish processing is conducted in warehouse facilities and within the Port of Apia.[70] It has also been suggested the Government might be considering establishing a new fish processing plant at Asau or Aleiapata but no firm decisions have yet been made.

Figure 29: Fisheries Wharf, Savalalo, Apia Harbour (Source: Samoa Ports Authority)

[68] The facility at Savalalo however, generates little export revenue and tends to focus on the domestic market/restaurant trade.

[69] Salelologa Wharf (Savai'i) for example, has been identified as a potential commercial fisheries base to support the *alia* fishing industry. The Ministry of Agriculture and Fisheries of Samoa is currently discussing possible development plans with the Samoan Port Authority.

[70] (Asian Development Bank, 2015)

2.3.2.7 About 75% of the total offshore catch is sent abroad either by ship or air; 80% of this catch is exported as frozen tuna destined for the tuna cannery in neighbouring American Samoa. In 2007 over half of all Samoa's exports consisted of fishery products (55%) which represented a value of US$7.6 million (NZ$10.8 million).

EXPORT TYPE	2010	2011	2012	2013	2014
FROZEN	2,603	1,229	1,777	1,435	730
FRESH CHILLED	99	100	49	7	1.9
TOTAL	2,702	1,329	1,826	1,441	732

Figure 30: Volume of Frozen and Fresh Chilled Fish Exports - 2009-2013[71]

2.3.2.8 Samoa's offshore and coastal fishing industry continues to face a number of challenges. In 2014, the industry recorded its lowest tuna (albacore) catch in the last five years and the second lowest over the preceding twelve years. Compounding the situation is the fact that:

- due to the relatively small size of the EEZ and the cap on vessel numbers, increasing the offshore catch remains problematic;
- the fishing sector remains susceptible to significant damage and loss resulting from tropical storms;
- longline fishing remains dependent on selling catches to the tuna canneries in American Samoa;
- the ongoing viability of operations at these canneries is uncertain, primarily due to competition from centres operating in other foreign countries;
- Samoa's small-scale operations *alia* longliner fleet is being challenged through competition with larger domestic and foreign longliner vessels; and
- the tuna longline fishing sector continues to be constrained by Samoa's small EEZ, the availability of wharf space in Apia harbour, and increasing costs of air freight to transport fresh tuna to overseas markets.

2.3.2.9 **Initiatives.** The Government, through the Fisheries Division of the Ministry of Agriculture and Fisheries, continues to investigate opportunities to promote the inshore and offshore fishing sectors. Of note is the ongoing work of the Commercial Fisheries Management Advisory Committee in its efforts to develop and manage Samoa's tuna industry. Coupled with international development aid, fisheries-related projects, and bilateral technical cooperation, collaboration and assistance programmes with Australia, New Zealand, China, Japan, and the European Union, and with the assistance of various regional agencies, including the FFA, SPC, and SOPAC, national efforts continue to promote better management of coastal and offshore fishing areas/resources.

2.3.2.10 Other specific initiatives being investigated by the Ministry of Agriculture and Fisheries include:

- negotiating licensed access agreements with neighbouring countries which currently accommodate low levels of fishing effort in their EEZs;

[71] (MAF, 2015)

- developing charter arrangements with foreign fishing vessels to fish exclusively on the high seas under the framework of the Commission Management Measure on Charters;[72]
- encouraging foreign investment to establish viable coastal and offshore fishing operations with shore facilities for processing and exporting fresh or processed tuna;
- increasing the participation of private sector interests in the fishing industry through the provision of support infrastructure (e.g. better anchorages for fishing vessels and the development of the Salelologa Wharf on Savai'i as an alternate commercial fisheries base to support the more efficient handling and accumulation of fish from various sources for bulk shipping to market);[73] and
- investigating the feasibility of super *alia* vessels to supplement the existing Samoan fishing fleet to help improve the economics of the offshore fishing industry.

2.3.3 Tourism

2.3.3.1 Tourism in Samoa plays a large role in foreign exchange earnings and in realising balance of payments. It is also a consideration when assessing Samoa's employment figures.

2.3.3.2 While there are regular visitors to Samoa who arrive by sea, the majority visit by air.

Year	Visitor Arrivals (excluding Cruise Ships)		
	Air	Sea	Total
2004	93,946	4,209	98,155
2005	98,544	3,263	101,807
2006	112,411	3,471	115,882
2007	118,653	3,703	122,356
2008	118,459	3,743	122,202
2009	127,327	1,978	129,305
2010	126,970	2,530	129,500
2011	124,706	2,898	127,604
2012	131,945	2,749	134,694
2013	122,171	2,502	124,673
2014	128,011	2,944	130,955

Figure 31: Visitor Arrivals to Samoa 2004-2014 [74]

2.3.3.3 In 2016, 12 cruise ships visited Samoa carrying 16,150 passengers and 7,848 crew (this is similar to numbers obtained for 2012). However, revenue from cruise ship visitors (excluding port charges and agents' fees) was ST$1.93 million which represented 0.5% of overall tourist earnings of ST$390.2 million and contributes less than 0.1% to overall GDP.[75]

[72] (The Ministry of Agriculture and Fisheries of Samoa, n.d.)
[73] It is understood that the Fisheries Division is currently engaging the Samoan Ports Authority on the possible development of the harbour and wharf area.
[74] Ministry of the Prime Minister and Cabinet – Immigration Division, Ministry for Revenue – Customs Division, and Samoa Bureau of Statistics
[75] (Kitiona Pogi, Research and Statistics Manager, SAMOA Tourism Authority, 2017)

2.3.3.4 Samoa's tourist industry is not without its challenges with natural disasters having a significant influence on the ongoing efficacy of the tourist trade. The 2009 tsunami event adversely impacted both tourist numbers and tourism earnings more generally because an estimated 13% of Samoa's tourist sector was completely destroyed or severely damaged.[76] The damage caused by the tsunami not only resulted in significant physical destruction across the region, psychologically it also dealt a significant blow to Samoa's image as a safe and attractive holiday destination. Cyclones *Wilma* in 2011, *Evan* in 2012 and *Amos* in 2016 compounded these concerns. Cyclone *Evan* was considered the worst since *Val* in 1991 and storm damage recovery was estimated at US $207 million.

	Disaster Effects		
	Damage (thousand SAT)	Losses (thousand SAT)	Total (thousand SAT)
Sector			
Tourism	27,700	22,210	49,910

Figure 32: Summary of Damage and Loss Caused by Cyclone *Evan* in Samoa[77]

2.3.3.5 While tourism throughout the region follows a strong seasonal pattern, one of the more popular times to visit Samoa is over the December-January period, which happens to coincide with the holiday season in Australia and New Zealand. In January 2015, Samoa accommodated 10,002 visitors, which represented an increase of 4.9% compared to the preceding January.[78] During this particular summer period, Samoa appears to continue to enjoy a reasonably strong and steady number of visitors.

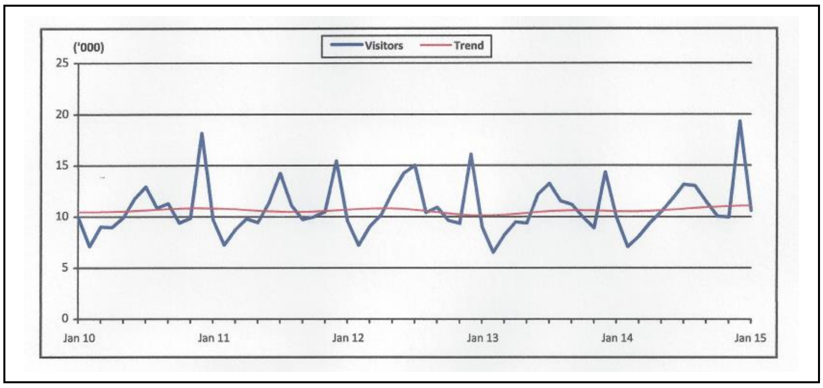

Figure 33: Visitors to Samoa for the month of January - 2010 to 2015 [79]

2.3.3.6 In 2015 New Zealand was Samoa's largest tourist market making up 46% of all visitor arrivals. This represents a net growth of 15% compared to 2014. The European market only accounts for about 7% of the total number.[80] The USA market continues to expand, achieving a growth of 29.7%; the US today contributes about 8% of total visitor arrivals.[81]

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[76] (Strategy for the Development of Samoa 2012-2016 , 2012)
[77] (Samoa Post-Disaster Needs Assessment Cyclone Evan 2012, 2013)
[78] (Samoa Bureau of Statistics - Migration (Tourism))
[79] (Samoa Bureau of Statistics, n.d.)
[80] (Samoa Tourist Authority, n.d.)
[81] (Samoa Tourist Authority, n.d.)

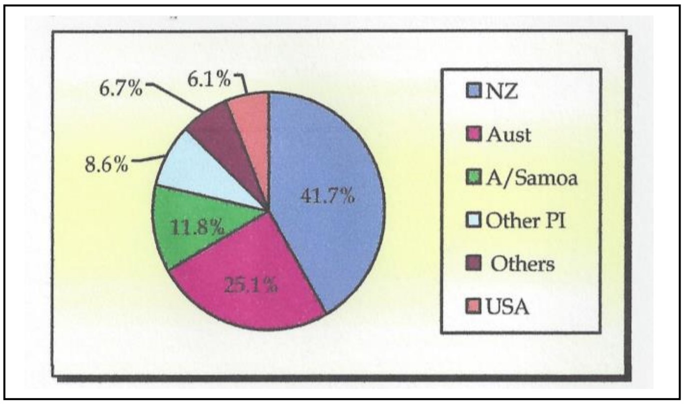

Figure 34: Visitors to Samoa in January - By Destination (Samoa Bureau of Statistics)

2.3.3.7 **Initiatives.** A government-sponsored tourism and promotional investment policy is currently in place to assist future tourism development and growth. Investment includes port/harbour and airport upgrades. Samoa Ports Authority for example, continues to promote the use of 'harbour' and other anchorage locations around Upolu and Savai'i to encourage additional cruise ship destinations beyond Apia. However, the only confirmed cruise ship calls outside of Apia have been two adventure cruise day visits to Fagamalo on the north coast of Savai'i. Other potential locations are being considered, including Palauli on Savai'i's south coast and Safata or Siumu on the central south coast of Upolu, but lack of access and infrastructure in these locations limits their possible use. These locations are already destinations for recreational vessels.[82]

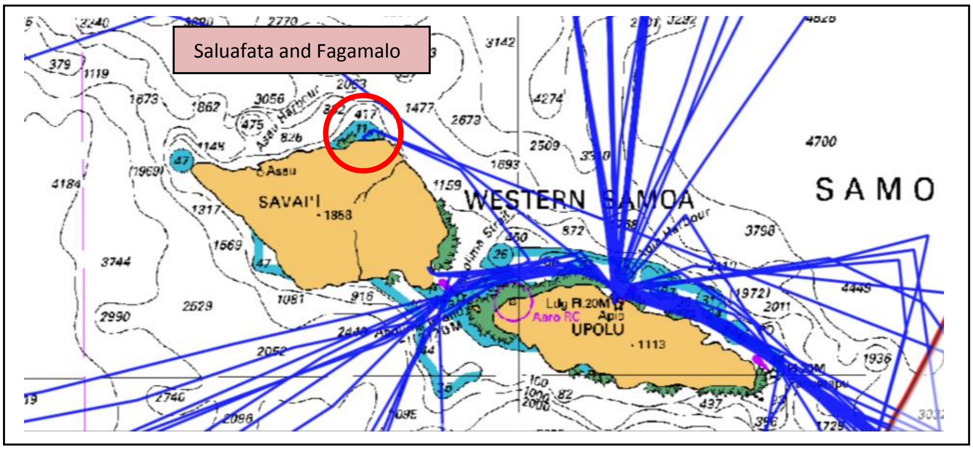

Figure 35: Passenger Vessel Routes Around Samoa (Source: LINZ)

2.3.3.8 Ongoing aid programmes with support from countries like Australia, New Zealand and Japan continue to support Samoa's tourist industry. Such efforts include work by New Zealand in line with its Aid Programme Strategic Plan 2015-2019 to improve the country's tourist-related infrastructure, such as the waterfront area in Apia. New Zealand's development aid efforts in recent times have contributed to the 5% increase in visitor numbers and tourism revenue as a share of GDP by 7%.[83]

[82] The current state and adequacy of charting for these areas is unknown.
[83] (New Zealand Foreign Affairs and Trade , n.d.)

2.3.3.9 **Cruise shipping and recreational vessels.** Samoa already has an established, albeit irregular, cruise ship visit programme. A number of large cruise ships frequently call into Apia annually, this being the only port capable of providing a suitable berth. For example, between September 2015 and April 2016, a total of 15 cruise ships were programmed to visit, while the period July and November 2016 listed eight cruise ships scheduled to berth alongside Apia.[84]

Figure 36: Port of Apia, Samoa (Samoa Ports Authority)

2.3.3.10 Most cruise traffic appears to route from the west coast of the US across to Samoa, via American Samoa then through Apolima Strait on to New Zealand and Australia. Much of the current cruise ship traffic is concentrated on routes transiting Samoa's northern coastline. The following table is representative of the sizes of cruise vessels that visited Apia in 2016,[85] or include Samoa in their current voyage itinerary. Of these vessels only the MS *Hanseatic* called at places outside Apia, that being Matuatu Bay (Fagamalo). A planned call at Salelologa did not take place.

Vessel	GT	Length	Beam	Passengers	Crew
MS Pacific Aria	55,819	219.4m	30.8m	1,391	617
MS Amsterdam	62,735	237.0m	32.25m	896	586
MV Artania	44,348	231.0m	32.2m	813	512
MS Marina (2 visits)	66,000	238.4m	32.0m	1160	761
MS Maarsdam	55,575	220.0m	30.9m	1139	569
MS Albatross	28,518	205.5m	27.0m	642	356
MS Dawn Princess	77,441	261.0m	32.2m	1953	853
MS Crown Princess	113,000	290.0m	48.0m	3142	1082
MS Hanseatic	8,378	122.8m	18.0m	173	120
MS Sea Princess	77,499	261.0m	32.0m	1,896	798
MV Aurora	76,152	270.0m	32.2m	1,718	833
Below vessels include Samoa in their visit itinerary					
MS Noordham	82,500	285.3m	32.2m	1,916	800
MS Crystal Serenity	68,870	249.9m	32.3m	1,070	655

Table 2 Cruise Vessel Characteristics (Sources: Samoa Tourist Authority and Wikipedia)

[84] (Samoa Ports Authority, n.d.)
[85] (Kitiona Pogi, Research and Statistics Manager, SAMOA Tourism Authority, 2017)

2.3.3.11 There are indications of a consistent positive upwards trend in cruise ship visits to Samoa. For example, in FY 2012-2013, 15 cruise ships visited Apia; the following FY saw 12 arrivals.[86] There were 15 cruise ships recorded during FY 2014/2015[87] reducing to 12 in 2016. Reportedly 32 ship visits from 16 different companies/ships were considering a visit to Samoa at various times in 2017.[88] However, current port development at Apia has resulted in a reduction in capacity, with only 12 visits likely in the year.

2.3.3.12 Apia harbour is also home to a large marina, which supports domestic and visiting recreational/pleasure craft. There are 25 berths in the marina. While Samoa still appears to be a favoured destination for many yachting enthusiasts (especially during the June to October period) the number of visits over the past few years has decreased. The marina was extensively damaged in Cyclone *Evan* (2012) and again in Cyclone *Amos* (2016), and in May 2017 was still under repair.

- July 2012 to June 2013 - 134 yachts
- July 2013 to June 2014 - 118 yachts
- July 2014 to June 2015 - 84 yachts
- July 2015 to June 2016 - 49 yachts

Figure 37: Apia Marina prior to cyclone damage (Source: Samoa Ports Authority)

[86] (Samoa Ports Authority Annual Report 2012-2013)
[87] (Samoa Ports Authority Annual Report 2014-2015)
[88] Information obtained from email discussions with a representative of Braemar ACM Shipbrokers in Perth, 22 March 2017. This figure is likely to include repeat visits from the same vessel during the same voyage.

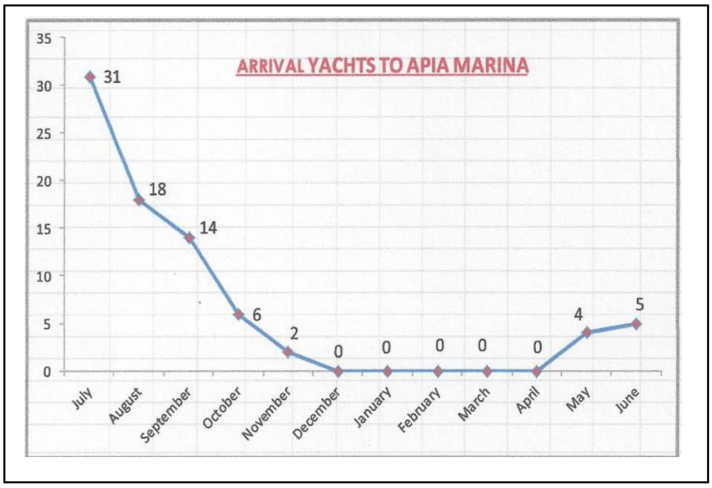

Figure 38: Yachts Calling into Apia by month - 2014 to 2015 (Source: Samoa Ports Authority)

2.3.3.13 Much of the recreational traffic around Samoa remains focussed on Apia. Vessels must apply for a cruising permit from the Department of Prime Minister in order to visit other parts of the Samoan coast, and also must return to Apia to clear out with Customs and Immigration. This requirement tends to discourage recreational vessels, unless they have time for a full circumnavigation. Those vessels that do obtain a cruising permit tend to visit various harbour and remote anchorage locations along the northern coastline of Upolu and the north/north-western coast of Savai'i, though some do visit the limited number of anchorages along Upolu's southern coastline. A cruising handbook has been produced by an Australian yachtsman, which relies heavily on the chart of fathoms plans NZ 861.[89]

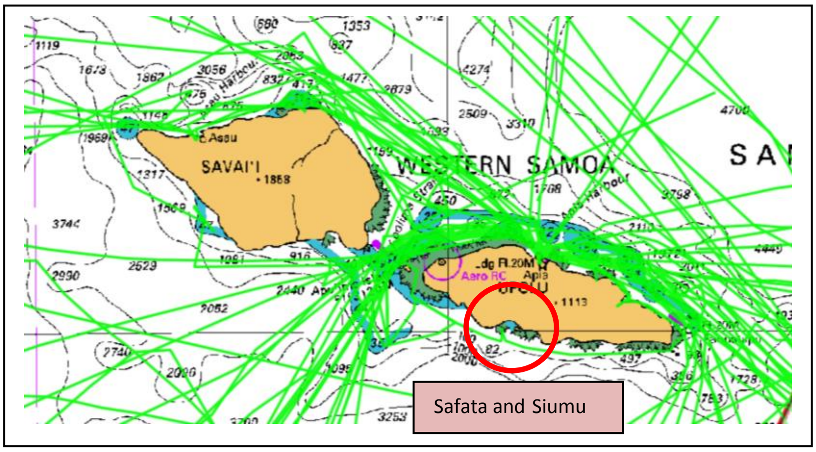

Figure 39: Recreational Vessel Movements Around Samoa (Source: LINZ)

2.4 Energy/Fuel Security

2.4.1 **Electricity.** Most of the electricity in Samoa continues to be generated through diesel power sources. Of the total energy produced in 2014, 16% was met by biomass, 81% by petroleum products, while the remaining 3% was met by hydropower, coconut oil bio fuel and other minor

[89] ('Outsider Australia', 2015)

renewables.[90] Upolu is supplied through an integrated hydro-diesel network, while Savai'i is entirely reliant on diesel generators.

2.4.2 Samoa is therefore reliant on petroleum products and imports all four of its required products, namely unleaded petrol, automotive diesel oil (ADO), jet fuel (DPK) and Liquid Petroleum Gas (LPG), along with some lubricants and greases.[91]

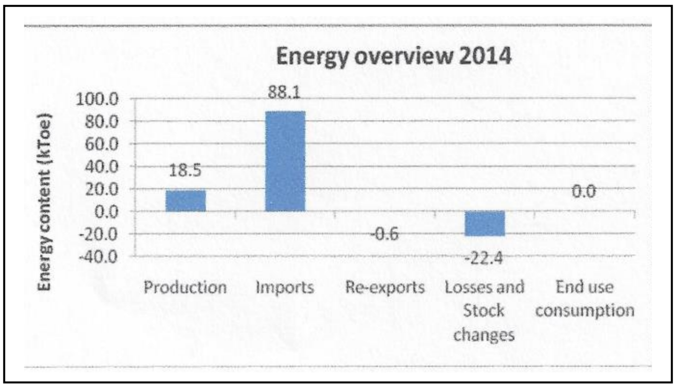

Figure 40: Energy Overview 2014 - Samoa (Source: Samoa Energy Review 2014)

2.4.3 In 2009, approximately 39.9 million litres of diesel, 27.3 million litres of petrol, 18.6 million litres of kerosene and 1.6 kilo tonnes of LPG were imported. [92] In 2014 fuel imports recorded 100.07 million litres, compared to 89.61 million litres in 2013 (11% increase).

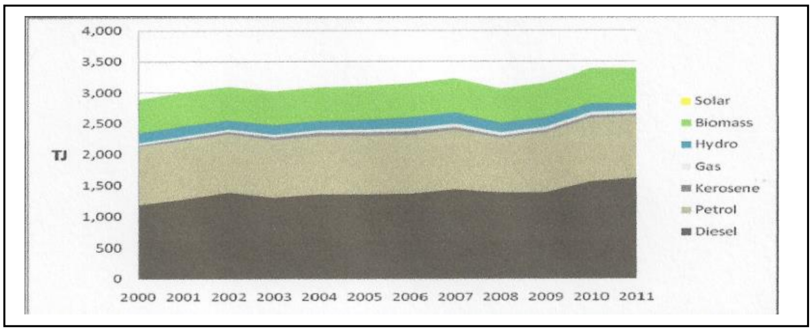

Figure 41: Samoa Energy by Primary Source 2000-2011 (Source: Energy Sector Plan 2012-16)

2.4.4 It has been calculated that the country maintains a reserve of 61 days in the event of a disruption to petroleum product supply.[93]

2.4.5 Imported petroleum is primarily used to generate electricity and support the transport sector (maritime, air and land); imports account for approximately 70% of all petroleum

[90] (Samoa Energy Review 2014, 2014)
[91] On average, there is one oil tanker and one LPG tanker arrival in Apia every month.
[92] (Country Energy Security Indicator Profile 2009 - Samoa, 2012)
[93] (Country Energy Security Indicator Profile 2009 - Samoa, 2012)

consumed).[94] Fuel product tankers discharge at the Matuatu (Apia) main wharf to storage tanks situated within the port, which are connected by pipeline to Sogi Terminal.

Figure 42: Fuel product tanker discharging at Main Wharf

2.4.6 LPG ships discharge at anchor/mooring on the western side of the harbour, transferring to the terminal on the Mulinu'u Peninsula, west of the harbour by seabed pipeline connected to a beacon.

Figure 43: LPG tanker discharges at mooring

2.4.7 Petroleum Products Supplies Ltd (PPS) operates the only petroleum fuel distribution contract in Samoa. This involves the regular importation of bulk petroleum fuels from Singapore (in association with ExxonMobil) and the management and maintenance of the main storage tanks in Apia (Sogi Terminal), the depot at Faleolo International Airport, the facilities at Salelologa, Fagali'i Airport, and the fuel infrastructure at Savalalo (Fisheries Wharf).[95] PPS is also responsible for the provision and distribution of the country's domestic fuel supply (that uses either road tanker or Samoa Shipping Company inter-island vessels).

2.4.8 The Government is the owner of all terminal and depot fuel facilities in Samoa including the main sea-board terminal in Apia and the aviation depot at Faleolo International Airport. In 2014 the Government secured a loan through OPEC Funding International Development to upgrade some of

[94] (Country Energy Security Indicator Profile 2009 - Samoa, 2012)
[95] These facilities are managed on behalf of the Samoan Government.

the existing fuel storage tanks and build three new tanks to increase overall storage capacity.[96] The capacity of the main fuel storage facilities in Samoa is detailed in Table 3:

Figure 44: Petroleum Storage Tanks at Sogi Terminal (Source: PPS)

Oil Storage Terminal	Amount		
	Diesel		Petrol
Salelologa	350,000 (litres)		185,000 (litres)
Apia (Sogi Terminal)	2,859 tonnes (ULP)	2,734 tonnes (ADO)	1,994 tonnes (DPK)

Table 3 Main Oil Storage Capacities (Source: Logistics Capacity Assessments)

2.4.9 Samoa also re-exports fuels to Tokelau. Sales to pleasure craft and yachts are also classified as re-exports, as this activity does not contribute to Samoa's fuel consumption.

2.4.10 **Renewable energy.** Petroleum imports represent approximately 12% of Samoa's GDP.[97] Due to the high and growing proportion of petroleum product use, since 2000 the renewable energy component of Samoa's energy sources has reduced from 25% to less than 20%.[98] Contributions from new renewable energy sources in 2014 only contributed to 0.06% of the total energy produced.[99]

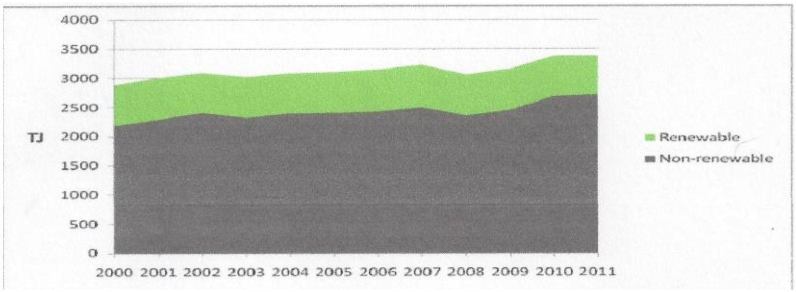

Figure 45: Samoa Annual Energy by Source 2000-2011 (Source: Energy Sector Plan 2012-16)

[96] A fire on Matautu Wharf in April 2016 seriously damaged one of these new storage tanks.
[97] (Country Information - Samoa, 2017)
[98] (Samoa Energy Sector Plan 2012-2016)
[99] (Samoa Energy Review 2014, 2014)

2.4.11 Nonetheless, promoting energy efficiency and developing indigenous, renewable energy sources has become an important development priority for Samoa. As part of Samoa's Energy Sector Plan 2012-2016 the overarching objective was to reduce the volume of imported fossil fuels by 10% by 2016 by implementing the following specific goals:

- an increase in the contribution of renewable energy to total energy consumption by 10% by 2016; and
- increase in the supply of renewable energy for energy services by 10% by 2016.[100]

2.4.12 Further, the ADB is currently financing a number of projects in Samoa to support greater access to renewable energy.[101] Under the ADB's Country Operations Business Plan for Samoa (2015-2017) a specific goal is to reduce annual diesel imports for power generation by at least 3.63 million litres by 2025 and to establish additional hydropower electricity capacity by 2019.[102] In 2013 Samoa received support through the ADB to refurbish and set to work three small hydropower plants already in place on Upolu and to construct three new hydro power plants for Upolu and Savai'i. As recently as April this year work commenced on the first hydro power station on Savai'i in the village Vailoa i Palauli.[103]

2.4.13 There have also been significant inroads made in developing the solar and wind sectors. The country's first wind farm (commissioned in August 2014) was financed through the UAE-Pacific Partnership Fund. An additional 500kW of solar power was brought online in 2015 along with Samoa's second wind farm.[104] Along with these alternate energy sources biomass and biofuel is also increasingly being used to power residences and infrastructure that supports the commercial and agricultural sectors.

Figure 46: Wind Farm – Vailoa Aleipata, Upolu (Source: Energy Matters)

[100] (Samoa Energy Sector Plan 2012-2016)
[101] ADB projects include the Power Sector Expansion Project (US$230.95 million) and the Renewable Energy Development and Power Sector Rehabilitation Project (US$23.83 million) (Source: ADB 2015, Pacific Energy Update 2015).
[102] (Asian Development Bank, 2014)
[103] (Samoa unveils more renewable power plans, 2016)
[104] (Samoa Bolsters Wind And Solar Power, 2015)

2.5 Economic Summary

- The country's EEZ is the smallest of all Pacific Island Countries in the South Pacific.
- Samoa's economy is susceptible to external factors including market forces, natural disasters and broader international economic developments and events.
- Trade is important to Samoa with the economy being heavily skewed towards a reliance on imports over exports.
- Samoa maintains a near constant negative trade balance.
- Agriculture and fisheries are important to the Samoan economy although the agricultural sector is under-performing, while the fisheries sector is facing various domestic and international challenges.
- The economy is also dependent on tourism, development aid, and family remittances from overseas as primary sources of revenue.
- Significant international investment is being leveraged to develop key economic sectors.
- Samoa is heavily reliant on imported fossil fuels as its main source of energy.
- The Government recognises the need to promote indigenous, renewable energy sources as a development priority.

3 CULTURAL ASPECTS AND TRADITIONAL RESOURCE MANAGEMENT

3.1 Cultural Aspects

3.1.1 Like many Pacific Island nations, Samoa has a rich culture that is underpinned by traditions, knowledge, customs and practices that have strong linkages with nature. Samoans adhere to Fa'a Samoa (the Samoan Way) which is a strong force in life and politics, and helps shape and influence the manner in which Samoans lead their lives, particularly in terms of upholding and embracing traditional spiritual values and culture. Importantly, Fa'a Samoa governs the interaction between the people and their environment.

3.1.2 There are three primary structural elements to Fa'a Samoa; the *matai* (village chiefs), the *aiga* (extended family) and the church.

- The *matai* forms the head of each extended family and has a key role in family, civic and political duties and issues in each village. The *matai* combine to form village councils to administer local affairs. These councils are formally recognised by the Village Fono Act 1990 (Samoa) and deal exclusively with village affairs, such as culture and significant cultural sites, customs and traditions, as well as all customary land matters. Villages, of which there are 362 across Samoa situated on the coast, retain significant autonomy from the state; village life plays a significant part in Samoan politics, culture and in maintaining harmony, security and order.
- The extended family unit (*aiga*) can be extensive reaching across cousins, nephews, nieces and even in-laws. Family in Samoa is all important; there is an expectation that elders will be respected, while it is the duty of every Samoan to be of service to their *aiga* for life.
- Religion is important to Samoans and Christianity has been one of the few western influences that has been accepted and incorporated into Fa'a Samoa. Samoans are very religious and are overwhelmingly Christian in their beliefs. Sunday is not only a day of worship but also a day of rest where no physical work is undertaken. Sunday is for spending time with the family.

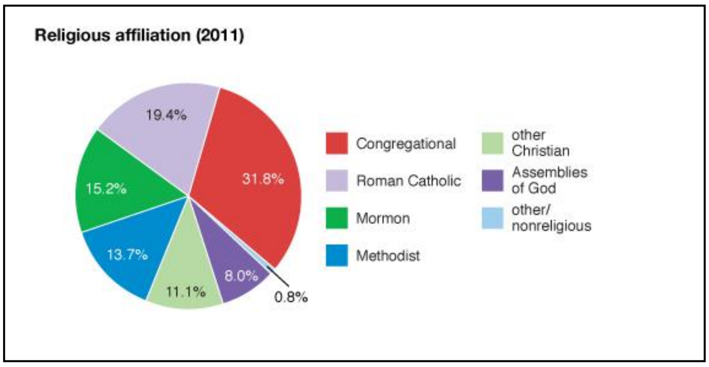

Figure 47: Religious Affiliation (Source: Foster, 2016)

3.1.3 **Subsistence farming.** *Aiga* maintain a strong spiritual and cultural association with the land. In addition to its importance to the economy, agriculture is just as important to Samoans domestically. Agriculture is considered a 'household' activity. In 2015 there were 27,411 'agricultural' households in Samoa, which represented 97% of all households across the country.[105] Most families engage in 'village agriculture' (crop and/or livestock subsistence farming) utilising land that is traditionally held under customary title by the *matai*. The *matai* is entrusted with its management and will distribute parcels of the overall land holding to his or her extended family.[106] The average holding is just under 3.5 ha (8 acres).

Region	Number of households	Number of agricultural households	Type of agricultural household			Number of crop households	Number of households raising livestock
			Crops but no livestock	Livestock but no crops	Both crops and livestock		
SAMOA	**28,119**	**27,411**	**8,203**	**53**	**19,156**	**27,359**	**19,208**
Apia Urban Area	5,554	5,060	3,306	4	1,749	5,056	1,753
North West Upolu	9,732	9,556	3,700	37	5,819	9,519	5,856
Rest of Upolu	6,311	6,311	864	-	5,447	6,311	5,447
Savaii	6,522	6,484	333	11	6,140	6,473	6,152

Figure 48: Number of Agriculture Households (Source: Samoa Agricultural Survey 2015)

Figure 49: Subsistence farming in Samoa (Source: Google Images)

3.1.4 **Fisheries management.** Like 'village agriculture' fishing is also important to Samoans, largely because households see fish as a major food source and because fishing provides income, particularly for rural households (although in 2015 only 2.6% of families considered fishing as their primary source of income).[107] The number of households engaged in fishing accounts for 21% of all households in Samoa, the majority of these households being outside the main urban centres. Only

[105] (Report on Samoa Agricultural Survey 2015, 2016)
[106] (Report on Samoa Agricultural Survey 2015, 2016)
[107] (Report on Samoa Agricultural Survey 2015, 2016)

5% of households in Apia were engaged in fishing compared with 32% across the rest of Upolu and 37% on Savai'i.[108]

3.1.5 While some inland fishing occurs in Samoa, the lack of any substantial permanent fresh water bodies on the islands means most fishing is predominantly undertaken at sea. The inability to afford larger seaworthy vessels that are necessary to target more substantive catches further offshore means the majority of subsistence sea fishing in Samoa is undertaken from either the shore, in lagoon areas, in the vicinity of the coastal reefs, or around inshore Fish Aggregation Devices (FAD). Of those households engaged in saltwater fishing in 2015, some 85% were engaging in inshore fishing primarily for subsistence purposes.[109]

3.1.6 Most inshore fishing is undertaken using outrigger canoes using traditional methods (nets, hook and line, and gleaning (gathering/collecting) or small aluminium *alia* boats.[110]

Figure 50: Traditional outriggers or *alia* boats are used for both subsistence fishing and trolling

Figure 51: Larger *alia* are used for longline fishing up to 12 nm offshore

[108] (Report on Samoa Agricultural Survey 2015, 2016)
[109] (Report on Samoa Agricultural Survey 2015, 2016)
[110] *Alia* boats are twin-hulled vessels originally built in Samoa and American Samoa as part of a UN Food and Agriculture Organization project in the mid 1970s for trolling and bottom fishing. These traditional craft have since been adapted to facilitate small-scale pelagic longlining. The majority of *alia* boats are approximately 8-10 metres in length, are un-decked and are powered by small outboard engines (40hp).

3.1.7 In recent years the importance of subsistence fishing has seen a decline in popularity; the percentage of households engaged in fishing recorded a decrease from 25% to 21% in the six year period 2009 to 2015.[111] At the same time there is a proliferation of larger *alia* of up to 15 m in length which are used for licenced commercial longline fishing. The Ministry of Fisheries is predicting that that the local fleet will grow from 55 to 100 licences in the next 5 years.

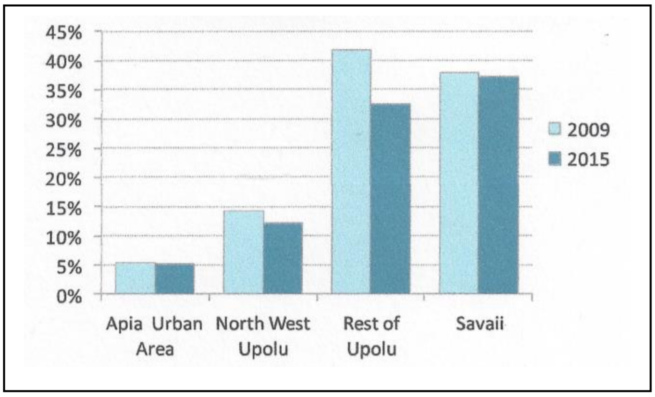

Figure 52: Households Engaged in Fisheries by Region[112]

3.2 Culture and Resource Management

3.2.1 In Samoa, as in other parts of the South Pacific, the culture manifests through links with the environment, ranging from natural landscapes, to archaeological sites, to places of regional and local importance. Important areas may be a coastal lava cave, star mound, sinkhole, waterfall, blowhole, or one of Samoa's Marine Protected Areas (MPA) and biodiversity areas/habitats (see Section 5). Five Mile Reef, north of Apia, for example, is known for its biodiversity and as a coral recruitment area, and Vailele Bay is sensitive for its medicinal sea grasses.

Figure 53: The coastline is dotted with local marine protected areas marked with white stakes

3.2.2 Villages throughout Samoa hold tenure and enacted rights to use allocated land for agriculture that is based around traditional ways of life and conservation practices. Such practices extend to the conservation and protection of adjacent coral reef ecosystems and marine habitats. Fishing activities for example, are managed in accordance with local rules and regulations whereby

[111] (Report on Samoa Agricultural Survey 2015, 2016)
[112] (Report on Samoa Agricultural Survey 2015, 2016)

village councils exert significant influence over fishing practices, as well as the sustainable management of local marine resources which might include:

- banning destructive fishing practices;
- preventing outsiders from fishing in nearshore waters adjacent to the local village;
- prohibiting fishing on Sundays; and
- imposing seasonal limitations on the harvest of certain marine species.

Figure 54: Marine reserves are important to fish stock sustainability

3.2.3 The Uafato Conservation Area, a region comprising 1,400 hectares of land on the north-eastern corner of Upolu between Fagaloa Bay and the Ti'avea area, exemplifies Samoa's cultural heritage linkages. Here, there exists a strong cultural and spiritual bond between the community and the environment. The Uafato Conservation Area includes the main village of Uafato, large tracts of rainforest, rugged topography, waterfalls, the coastline, coral reefs and adjacent marine areas; it is located on traditionally-owned land that is based around the *matai* system. Through the Uafato experience there exists a very special and close association between the local people and the environment; the area symbolises a particular form of community identity. This region was identified as a potential world heritage site but despite not being listed as such it remains of important regional cultural significance.

3.2.4 The safeguarding and preservation of such cultural interrelations and links with nature and the environment (*va tapui'a*) is of utmost importance to Samoan culture and heritage. This is discussed in more detail in Section 5.

3.3 Cultural Summary

- Fa'a Samoa means *The Samoan Way* and describes the socio-political and traditional-customary way of life underpinning Samoan culture.
- There are three structural elements to Fa'a Samoa; the *matai* (village chiefs), the *aiga* (extended family) and the church.
- Family is all important, a respect for one's elders is strictly adhered to, and being of service to your extended family is seen as one's duty.
- Samoa is a deeply religious society.
- Samoans value their natural surroundings, not only because of what the natural environment offers resource-wise but also because of its spiritual connections as part of Fa'a Samoa.
- *Aiga* maintain a strong cultural association with the land and with the sea for subsistence and economic reasons.
- Villages hold tenure and enacted rights to use allocated land and adjacent coral reef ecosystems and marine habitats and they manage their resources for sustainability.

4 MARITIME OVERVIEW

4.1 Upolu and Savai'i Islands

4.1.1 Samoa, comprising the two main islands of Savai'i and Upolu, is volcanic in nature and lies in relatively deep water. The coastline comprises a mixture of fringing reefs, steep-to cliff edges and expanses of beach. Both islands feature various bays and inlets, some of which are described as 'harbours'. Many of these 'harbours' are considered suitable as anchorages for small recreational craft and small fishing boats in a variety of weather and sea conditions. While charting information exists for some of these locations, not all are covered by large scale plans and those that are, often have dated and inadequate hydrographic data coverage. Some coastal harbours and anchorages present opportunities for potential development. However, the presence of fringing reefs, the depth of water, the proximity of a steep-to shoreline and the absence of suitable landing sites, the requirement for local knowledge, and the fact that many places are exposed to variable sea and weather conditions at certain times of the year, will be key determining factors in assessing the viability and practicality underpinning any future development.

4.1.2 **Savai'i.** Apart from a reported shoal (47 metres) lying close offshore Cape Mulinu'u on the island's western most point, a barrier reef extending out into Apolima Strait between Salelologa Harbour and northwest of Cape Tuasivi, and a similar reef structure fronting Asau Harbour and Matautu Bay on the island's north and northwest coasts, Savai'i is generally free of any offshore obstructions and dangers. Much of Savai'i's coastline is rocky and steep-to and is therefore often subject to heavy surf conditions. Along the island's south coast there are few places considered suitable for landing.

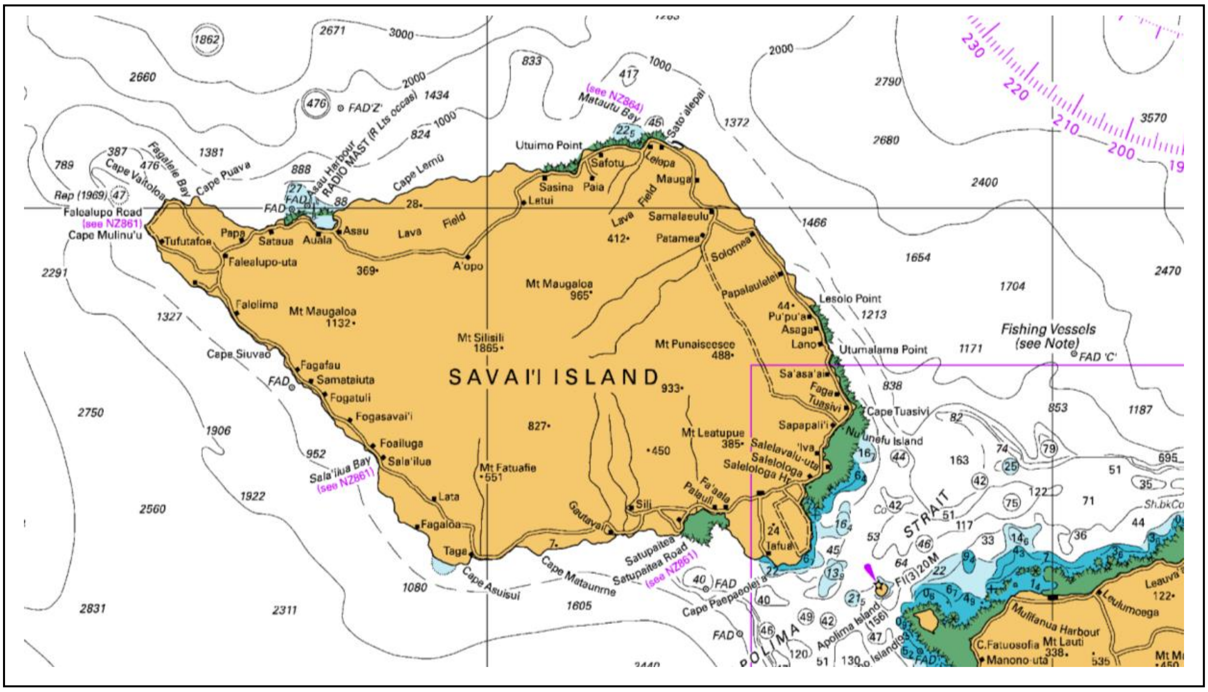

Figure 55: Savai'i Island (Source: Chart NZ 86)

4.1.3 A number of FADs have periodically been moored around the coastline, some close inshore and others up to 10 nm offshore, in the vicinity of Asau Harbour in the west and Cape Paepaeolei'a to the south east. These FADs, which have traditionally been large tethered rafts, have regularly broken free and been lost. The Ministry of Fisheries is undertaking a replacement programme of a new design FAD commencing in June 2017. These will consist of a submerged structure 10 or 20 metres deep with only a small surface buoy, which could improve their survival and reduce the risk of collision with surface traffic. Local *alia* fishing vessels tend to concentrate around these FADs.

4.1.4 The two main safe havens for vessels on Savai'i are the harbours at Asau and Salelologa. The channel at Asau is no longer marked and the port is not used for commercial activities. Salelologa is marked by buoys and leading lights. Other than this, there are no lights on the island to aid offshore navigation; the only significant landfall 'aid to navigation' is the radio mast at Asau Harbour (red lights). There are numerous conspicuous buildings (eg. churches) and structures (eg. towers) around the coastline which could prove useful in aiding the mariner, however they are not charted as there is no coastal scale chart covering Savai'i.[113]

4.1.5 **Upolu.** Upolu's coastline is more intricate than that of Savai'i. The south coast of Upolu, exposed to the prevailing south easterly ocean swell is deep and relatively clear of dangers with the exception of a few shoal areas and rocks lying close inshore. Parts of this coastline are fringed by barrier reef areas. The northern coastline is fringed by more extensive reef areas, particularly in the north west adjacent to Apolima Strait, the most protected from the prevailing ocean swell. A number of shoal areas and underwater rocks lie within five miles of the island along Upolu's north coast, particularly between Cape Faleula (in the northwest) and Cape Tapaga (in the southeast). A collection of small, steep islands and islets that make up the Aleipata island group lie close off Cape Tapaga at the southeast extremity of Upolu.

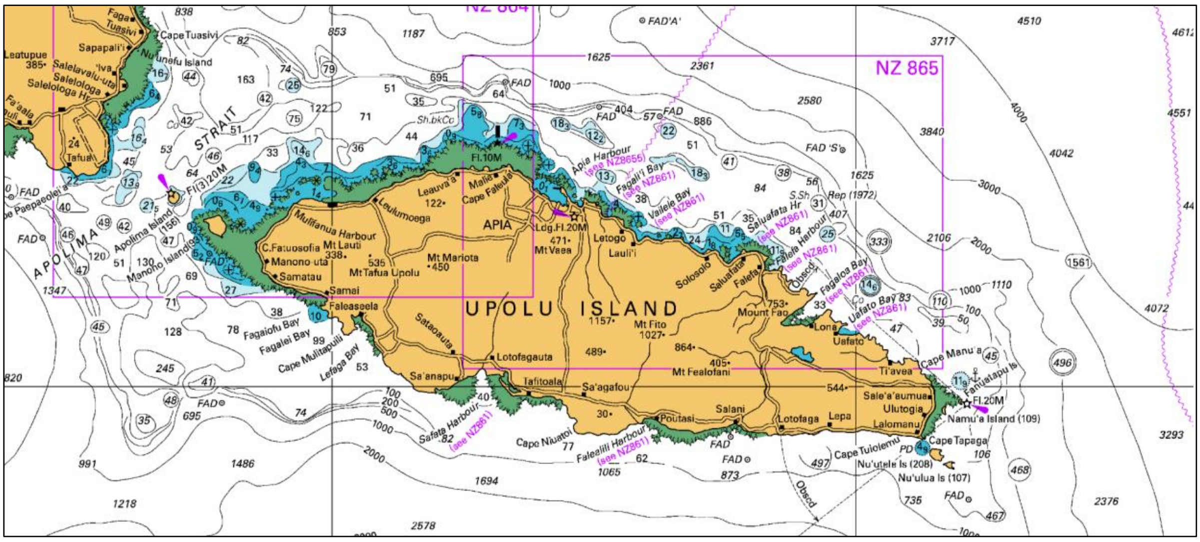

Figure 56: Upolu Island (Source: Chart NZ 86)

[113] This is not surprising given that the majority of Samoan households reside in villages in the coastal margins along the entire length of both main islands, as the central regions are generally rugged and mountainous.

4.1.6 There are only two commercial harbours on Upolu, Apia and Mulifanua, which are well marked with beacons or buoys, leading lights and other aids to navigation. In addition, Saluafata Harbour (NZ 861) on the island's northern coast is reported to be the best anchorage on Upolu Island but its approaches are not adequately charted and it is only suitable for small vessels.

4.1.7 There are three landfall navigation lights on Upolu; a light off Cape Faleula at the island's most northern point, the leading light at Apia and a light near Fanuatapu Islet (in the Aleipata island group) at the eastern extremity of Upolu. Numerous conspicuous buildings and structures also exist around the island, many of which appear on coastal scale charts NZ 864 and NZ 865 on the northern coast and may aid the mariner.

4.1.8 A number of FADs have been moored within 10nm of the coastline, but as with those near Savai'i, most have been lost. Refer to paragraph 4.1.3.

4.1.9 **Apolima Strait.** Apolima Strait is the main stretch of water that divides Upolu and Savai'i islands. Most international traffic visiting Apia passes through it and the domestic ferry route from Upolu to Savai'i crosses it. The Strait appears adequately surveyed and apart from Apolima Island and a large shoal area (13.9m) lying in the southern entrance between Apolima Island and Cape Paepaeolei'a on Savai'i Island, Apolima Strait is deep and free of any dangers. The light on Apolima Island is prominent from the southwest and from north through to east. It is the only navigation beacon in the strait.

4.1.10 The strait is the busiest waterway in Samoa as it is the primary route for commercial vessels transiting to/from Fiji, New Zealand and Australia, and the domestic interisland ferries regularly transit east/west across Apolima Strait between Upolu Mulifanua (Upolu) and Salelologa (Savai'i).

4.2 Nautical Charting and Navigation

4.2.1 Nautical charting of Samoan EEZ is provided by New Zealand. Where metric chart coverage exists, i.e. soundings are shown in metres and the horizontal position datum is WGS84, associated ENCs are also available. The chart coverage consists of a modern metric large scale chart of Apia Harbour, NZ 8655 at a scale of 1:7,500, and Salelologa and Mulifanua Harbours, NZ 8645 at a scale of 1:10,000 which are of a good standard. Medium scale 1:50,000 charts of Apolima Strait, NZ 864, and Approaches to Apia, NZ 865 provide good coastal navigation scale coverage of the north coast of Upolu but have extensive areas of old and sparsely surveyed waters, particularly near the coast. Notably, there is no suitable coastal scale coverage of the east and south coasts of Upolu Island nor of Savai'i Island outside Apolima Strait.

4.2.2 A small scale 1:500,000 chart, NZ 86 covers the Samoan Islands (including American Samoa) and is considered a good landfall chart but it is not considered suitable for coastal navigation and approaching coastal harbours.

4.2.3 The port of Asau on the north-western coast of Savai'i is no longer used commercially. An older chart NZ 1414, scale 1:10,000 based on a non-GPS horizontal datum, provides adequate coverage for recreational, game fishing vessels and occasional visits from patrol vessel *Nafanua*.

However, GPS positions cannot be plotted directly on this chart. During a visit to Asau it was noted that the front channel lead is missing.

4.2.4 A sheet of imperial (fathoms) plans, NZ 861 at various scales, provides basic information for 11 small bays and harbours based on old, sparse sketch surveys. The information is considered useful for recreational yachts and patrol vessel *Nafanua*, however users are cautioned that each plan is plotted on a local, undetermined horizontal datum, so GPS positions cannot be plotted on them. The plans are sparse in soundings and highlight the generally unsurveyed or inadequately surveyed status of the near shore areas away from the commercial ports.

4.2.5 The full extent of Samoa's EEZ is covered by small scale international charts NZ 14629 (INT 629) at a scale of 1:1,500,000 and partial coverage is also on NZ 14630 (INT 630) and NZ 14631 (INT 631) at the same scale. Chart NZ 14605 at a scale of 1:3,500,000 provides an overview of the ocean region. All of these small-scale charts are considered suitable for their intended purpose of ocean navigation.

4.2.6 While the standard of charting is generally good, in most areas the standard of underlying hydrographic surveying is old and inadequate. Data provided to the International Hydrographic Organization highlights 95% of depths less than 200 metres require re-survey, while in depths greater than 200 metres, 80% of waters have never been systematically surveyed.[114]

4.2.7 A comprehensive LiDAR topographic and bathymetric survey of Samoa covering water depths down to about 40m has recently been conducted under the "Ridge to Reef" sea-level rise monitoring project (see Figure below). Under the Pacific Regional Navigation Initiative, New Zealand has funded additional processing of the data to extract hydrographic information and identify seabed features significant to navigation. LINZ is currently updating the existing charts to include dangers and features identified in this data. This data may also be suitable for updating the large scale plans on legacy imperial chart NZ 861 and Asau Harbour NZ 1414 if required to support future tourism and commercial opportunities and enhance search and rescue capabilities.

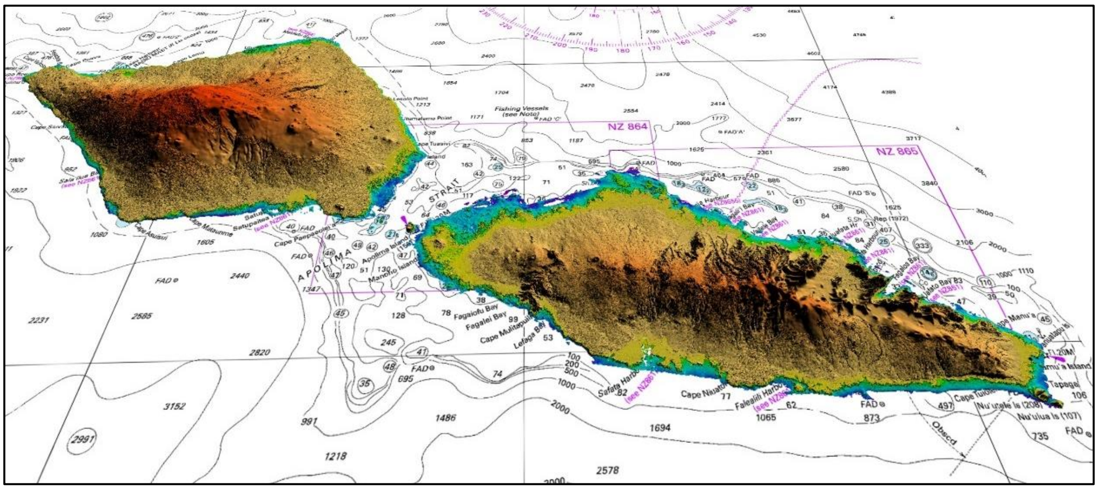

Figure 57: LiDAR Bathymetric and Topographic DEM – Samoa (Source: CRCSI) [1]

[114] (International Hydrographic Organization, 2017)

4.2.8 **Currents and Tidal Streams.** There is little if any tidal stream data shown on existing nautical charts. Due to the region's relatively small tidal range, tidal streams throughout Samoa (including Apia) are generally weak (less than 1 knot).

4.2.9 The South Equatorial Current in the vicinity of Samoa flows predominantly from east to west throughout the year and generally sets at 1.5 knots or less. This westerly current sets along the northern and southern coastlines of both islands; however, any influence is confined to the deeper offshore areas. Currents further inshore may be less apparent but can be variable. An easterly set may be experienced offshore during the months of January and February represented by the South Equatorial Counter Current which sets at 0.75 knots or less. It has been reported that an easterly counter current also occurs at various times throughout the year along the southern coast of Upolu and in the southern reaches of Apolima Strait.

4.2.10 In the vicinity of Apia, the prevailing current sets across the harbour entrance. While it too can be variable, it tends to set predominantly to the west at 1.5 knots or less. Under abnormal conditions, heavy rains during Samoa's wet season may impact variability and a rate of up to 4 knots can however, be experienced.[115]

4.2.11 There is no charted current or tidal stream information for Apolima Strait. However, a strong easterly current (up to 4 knots) has been reported in the southern approaches to the passage in the vicinity of Apolima Island. North of the island, there can often be an equally strong counter-current setting to the west.[116]

4.3 Main Harbours, Ports and Anchorages

4.3.1 The management of port and harbour infrastructure in Samoa is shared between the Samoan Ports Authority (SPA) and the Samoa Shipping Corporation (SSC). The SSC manages and operates the domestic ferry ports at Mulifanua and Salelologa, and operates the slipway at Aleipata which it leases from SPA. SPA is responsible for the ports of Apia, Aleipata and Asau.

4.3.2 **Apia (Upolu).** The Port of Apia (sometime referred to as Matuatu due to the Main Wharf location at Matuatu Point) on the north coast of Upolu, is Samoa's main commercial and international sea passenger port. The port remains Samoa's 'life line' and handles almost all of Samoa's foreign trade cargo (about 97%)[117] which is reflected in an inward cargo handling capacity of around 187,626 metric tonnes annually, along with an annual import rate of approximately 20,000 TEU.[118] The port receives regular vessel traffic, with most visits being container and general cargo vessels, which berth alongside either the New Wharf or Main Wharf. SSC also operates domestic fuel transfers to Salelologa (Savai'i) from Apia.

[115] (United Kingdom Hydrographic Office, 2017)
[116] (United Kingdom Hydrographic Office, 2017)
[117] (Samoa Ports Authority, 2017)
[118] (Logistics Capacity Assessment - Samoa, 2012)

	2012-2013		2013-2014		2014-2015	
Type	**Number**	**% of Total Vessels**	**Number**	**% of Total Vessels**	**Number**	**% of Total Vessels**
Container Vessels	76	20	94	27	131	36
General Cargo	47	12	43	12	51	14
Gas Carrier	10	3	9	3	8	2
Research & Naval	11	3	4	1	9	2.5
RoRo	18	5	19	5.5	0	N/A
Tankers	11	3	13	4.5	13	3.5
Cruise Liners	15	4	12	3.5	15	4
Fishing Vessels (Int.)	57	15	31	9.5	54	15
Tug Boat/Barge	2	<0.5	0	N/A	0	N/A
Yachts	134	35	118	34	84	23
Total	**381**		**343**		**365**	

Table 4: Vessel Visit Breakdown in Apia - 2012-2015 (Source: Samoa Ports Authority)[119]

Figure 58: Apia – Main Wharf and New Wharf (Source: Fugro LADS)

[119] Vessel numbers provided by the Soma Ports Authority have been interpreted to be single, distinct port visits alongside (as opposed to repeat visits during the same voyage/activity schedule).

Figure 59: New Wharf, Apia Harbour (Source: TranscoCargo)

4.3.3 Increases in vessel size, the availability of berths, and the predominance of certain environmental conditions within the harbour confines can make existing berthing operations challenging. Vessels secured alongside the New Wharf/Main Wharf at Matautu are often subjected to large swells, particularly during the wet season. Such factors pose significant operational hazards and safety concerns during loading and unloading operations, especially when heavy surges are being experienced.

4.3.4 The Main Wharf was originally constructed in 1966 for conventional cargo operations; an extension was commissioned in 2003 as the New Wharf. As part of a US$30 million project funded by the Japan International Cooperation Agency, the harbour is currently undergoing a safety enhancement programme. This project includes work to rehabilitate the port's aids to navigation and tugs, straightening and extending the Main Wharf to 302m to allow larger cruise ships to berth, and increasing the hard stand to facilitate more storage space for shipping containers. The work was underway in May 2017 with an expected completion date by mid-2018.

Figure 60: Details of Apia port enhancement

4.3.5 A second project identified in the Samoa Ports Development Master Plan, developed with the assistance of the Asian Development Bank, will extend the breakwater by 100m (doubling its length), to better protect the Main Wharf and marina from northerly swells, and enlarge the turning basin in order to meet a demand forecast of 35,000 TEU in 2035. This project is due for completion by 31 March 2018.[120]

4.3.6 In accordance with the Ports Development Master Plan to mitigate more broader port congestion issues going forward, and to reduce the potential impact of new developments in the port itself (e.g. a new tuna processing facility), the Government is:

- improving port facilities for servicing increased trade in line with the ADB's Country Operations Business Plan for Samoa (2015-2017); and
- in the long term, moving towards a new port facility with the development of a greenfield site at Vaiusu Bay which lies west of the existing port area on the other side of Mulinu'u Peninsula. This proposed development is considered controversial due to the cost and potential impact on the Vaiusu Bay mangrove areas, which is the largest mangrove area in Polynesia.[121] In October 2016 the Government had endorsed the Ports Development Master Plan and was pressing ahead with an Environmental Impact Assessment.[122]

4.3.7 In terms of modern survey coverage and the appropriateness of scale, Apia Harbour is adequately covered by current chart NZ 8655, but the chart will require significant update following the port enhancement and breakwater extension projects. However, there are no large scale navigational charts of the proposed Vaiusu Bay site.

4.3.8 **Salelologa (Savai'i).** The second busiest port in Samoa and operated by SSC. It is vital to the survival of Savai'i as the only operating commercial port, the terminal of the inter-island ferry service from Upolu and it also receives direct fuel transfer services from Apia. The harbour forms part of a small flat bay that opens onto Apolima Strait on Savai'i's southeast coast. The bay contains large expanses of barrier reef. The harbour lies in the south of the bay and affords good shelter to small vessels. The main passage into the harbour area is clearly marked by leading beacons, and small lateral buoys mark the deep channel that runs to the wharf. The positions of buoys were found to differ from those of the charted beacons during our visit in May 2017. Better communication of MSI to the charting authority is recommended, however as no vessels other than those operated by SSC ferries currently use the port, up to date information is shared directly between ships' masters.

4.3.9 The wharf and RoRo ramp is situated on the north side of the harbour and contains the ferry terminus. There are plans to renovate the inter-island passenger terminal at Salelologa. There have been various proposals to develop the port as a first port of entry for container vessels or as a small cruise ship destination. The wharf was extended to support these objectives and one small cruise vessel (MS *Hanseatic*) had reportedly planned to call at the port. The only container vessel to

[120] (Asian Development Bank, 2015)
[121] Interview with Ryan Wright, SPREP, 18 May 2017
[122] (Govt. moves with Vaiusu Wharf plan, 2016)

attempt to visit the port, MV *Southern Cross* grounded in January 2006 and this plan was abandoned.

Figure 61: Approaching the ramp and wharf at Salelologa

4.3.10 NZ 8645 (1:10,000) shows the harbour and the seaward approaches from Apolima Strait to be adequately charted. SSC masters advise that approaching Salelologa from seaward, coral growth has encroached from the northern side and vessels are required to track well south of the outer channel leads in order to clear the reef before a turn to starboard to enter the harbour then a gentle turn to port to approach the wharf[123]. They recommend that dredging should be conducted to clear the approaches.

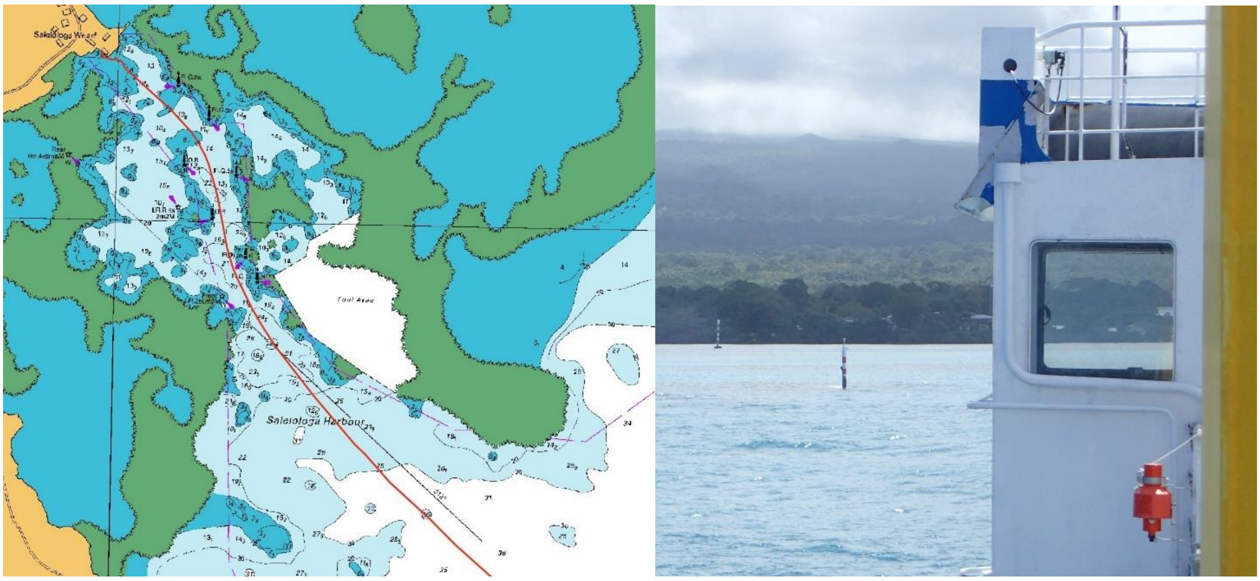

Figure 62: Ship track leaves outer leads open to the south to avoid coral growth close north of the line of leads

[123] (Phineas, 2017)

Figure 63: Salelologa Wharf (Source: Logistics Capacity Assessments)

4.3.11 **Mulifanua (Upolu).** Lying within the confines of an exposed harbour on the north-western tip of Upolu, Mulifanua is the main ferry terminal for inter-island vehicle and passenger travel to Savai'i across Apolima Strait. The initial passage into Mulifanua through the outer reef is relatively deep and quite narrow. SSC masters report that coral growth has narrowed the entrance and requires vessels to track well north of the outer channel leads in order to clear the reef off the southern side.[124] Once through the outer barrier reef vessels must kick to starboard then turn to port to follow the channel up to the wharf which becomes narrow and shoals sharply. This second leg, which was excavated in the early 1970s to facilitate better ferry access to the wharf, is well marked with navigation buoys and a set of leading lights. During our visit in March 2017 one port hand buoy was missing and positions of the buoys differed from those charted. SSC advise that the buoys are frequently being maintained and replaced. Better MSI information flow of

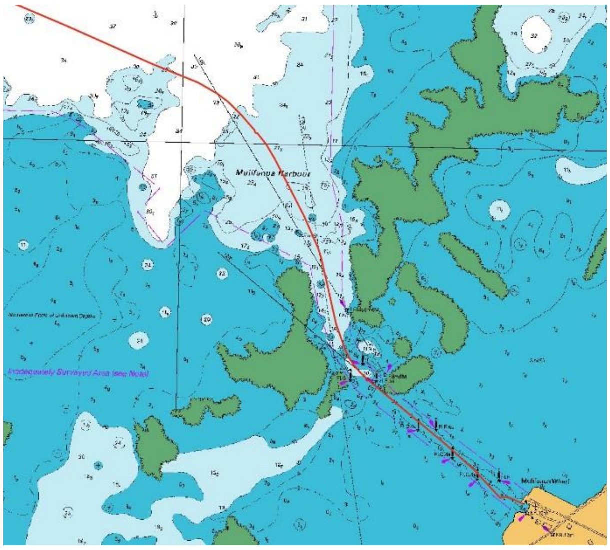

Figure 64: Vessels must stay north of the outer channel leads

[124] (Phineas, 2017)

changes to MSI to the charting authority is recommended, however as no vessels other than SSC ferries use the port, up to date information is always shared between ships' masters.

Figure 65: Mulifanua outer leads open to the north to remain clear of reef to south

4.3.12 SSC see a need for dredging to deepen and widen the channel. Proposed development for Mulifanua includes plans to upgrade existing wharf and harbour facilities.[125]

Figure 66: *Lady Samoa III* at Mulifanua Wharf - vehicle access

Figure 67: Mulifanua Wharf (Source: Fugro LADS)

[125] (Logistics Capacity Assessment - Samoa, 2012)

4.3.13 **Asau Harbour (Savai'i).** Asau is situated on the northwest coast of Savai'i and serves as the main business area for the western end of the island. It was once the centre of Samoa's burgeoning timber industry. In the 1960's the harbour was opened and the coral airstrip was constructed to support native timber exports by American company Potlatch Corporation.

Figure 68: Asau Harbour (Fugro LADS image overlaid on NZ 1414)

4.3.14 The port was once well used as it was well protected from the east and south by the island itself and from the north and west by fringing coral reefs. However, the entrance channel was never dredged to its planned depth of 10m by 68m wide, and due to a hard coral bed was only made 5.9m deep and between 38m and 54m wide.[126] Over time the narrow entrance channel has been partially obstructed through coral growth and sediment from the erosion of the previous airstrip. There is no remaining sign of the airstrip and causeway that previously existed on the northern protective reef. Although still accessible, Asau Harbour is seldom used today and then only by charter fishing boats, visiting yachts and recreational vessels, and patrol boat *Nafanua*. Asau is no longer a first port of entry.

4.3.15 An older chart NZ 1414 uses a non-GPS horizontal datum but still provides a useful depiction of this harbour, however this chart would require significant recompilation onto a modern horizontal datum to produce an ENC, which would be needed should the port be required to support future commercial shipping. Notably, the replacement patrol vessel due in 2020 will also require ENC for navigation. Dredging of the entrance channel and re-establishment of leads and channel markers would also be required. In 2011-2012 the Samoa Ports Authority advised an upgrade to Asau Harbour to boost business confidence and leverage further tourism opportunities.[127] Asau is a well-

[126] (SPA, 2017)
[127] (Samoa Ports Authority Upgrades Asau Port in Savai'i, 2011) and (Samoa Ports Authority Annual Report 2012-2013).

protected harbour with a substantial wharf and it has much potential for future development. Rumours abound that it could be considered for a possible fish processing plant.

Figure 69: Asau wharf looking west

4.3.16 **Aleipata Port at Satitoa (Upolu).** The Aleipata region is adjacent to the Aleipata Islands, a group of four islands off the eastern end of Upolu (in the vicinity of Cape Tapaga). The island group lies within a Marine Protected Area and is uninhabited apart from a small resort on Namu'a Island. Aliepata Port is at Satitoa. It consists of a passenger terminal, wharf and RoRo ramp (similar to those at Mulifanua), plus a 1000 tonne capacity slipway. This is the only slipway in Samoa and is used for slipping domestic ferries and commercial vessels. The port was constructed in 2009 but damaged by tsunami before construction was complete and it required extensive repair at a cost of ST$10.1m.[128] Its intended use as a ferry terminal for the route to Pago Pago was thus delayed and has never eventuated.

Figure 70: Aleipata Port – slipway, front lead, terminal & wharf (*Lady Samoa II* being dismantled)

[128] (Government of Samoa, 2009)

4.3.17 The port is controlled by SPA but the slipway is operated by SSC on a long-term lease. The slipway was previously covered, but cyclone damage in the 2012 (*Evan*) has seen the roof removed.

Figure 71: Aleipata slipway looking to the entrance channel

4.3.18 The entrance to the port is a short, straight, narrow channel cut through the fringing reef in a north-westerly direction. Thus, the port is fully exposed to the prevailing south-easterly wind and swell, though the relatively shallow channel does dissipate the impact of ocean swell. A set of leading beacons is fitted with daymarks and lights and port and starboard lateral buoys mark the entrance channel, however in May 2017 the rear lead light was unserviceable and two of these buoys were missing or submerged.

Figure 72: Aleipata Leading beacons (rear beacon light missing)

4.3.19 Slipway users are currently the only vessels using this port and there are no approved plans for its future expansion. However, the Government's broader port development plan discusses upgrading cargo wharf space at Aleipata and deepening the entrance channel.

4.3.20 There are currently no appropriate scale approach or harbour charts for the port at Aleipata. These are required for safe navigation.

4.4 Non-Commercial Harbours and Anchorages

4.4.1 The harbours and anchorages depicted as plans on imperial (fathoms) chart NZ 861 have mixed potential and are described briefly in this section.

4.4.2 **Safata Harbour (Upolu).** Located on the south coast of Upolu, the harbour lies within a designated Marine Protected Area. The harbour can be difficult to identify from seaward as there are no distinct landmarks to aid the mariner; an unlit beacon said to mark the head of the bay was not seen on a shore-side visit in May 2017. The harbour is open to the south and is well protected on all other sides by the reefs and mainland. There is a good anchorage in the outer harbour area for larger vessels and further inshore for smaller recreational boats and fishing vessels.

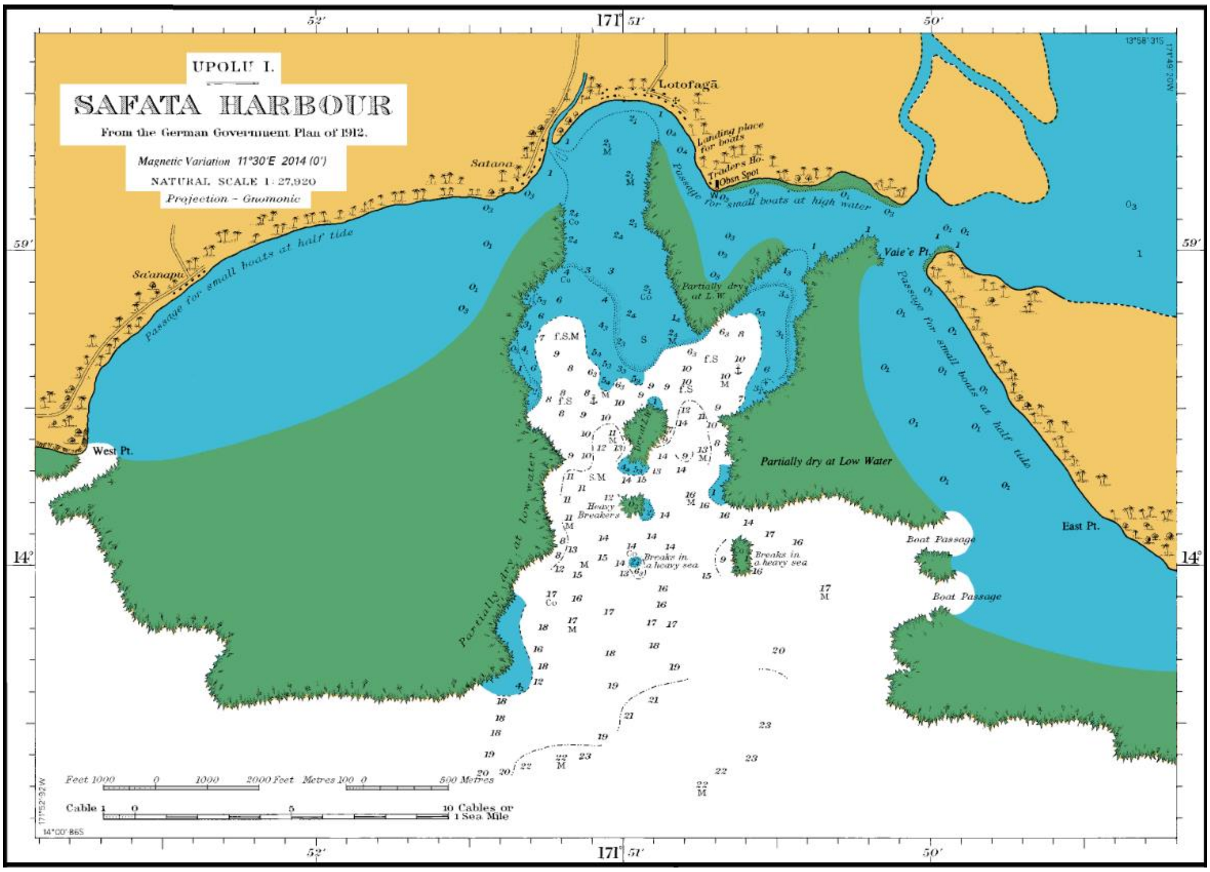

Figure 73: NZ 861 - Plan of Safata Harbour

The harbour is inadequately surveyed. There is currently no shore-side infrastructure that would support this harbour as a cruise ship destination, but it has potential and the chart should be modernised and metricated.

4.4.3 **Saluafata Harbour (Upolu).** This is probably the best harbour outside Apia as a large cruise ship destination. The passage is open to the north but the anchorage is protected from the sea by extensive reef areas. Patches to the north east of the passage break in heavy northerly winds. Since this location is protected from the swell by the fringing reef, a northerly swell, which can impact vessels berthed alongside in Apia appears to have little to no effect on vessels anchored in Saluafata.[129] The harbour appears to be systematically surveyed though the charted information is dated. This location has good access to the main coast road and the harbour could be used as a cruise destination by visiting yachts. Landing in Saluafata Harbour is best achieved at the village of Salelesi (at the head of the bay between Eva and Ariadne Points) utilising a narrow passage through the inshore reef. There is no port infrastructure in the harbour and any visiting cruise ships need to anchor within the harbour confines. This plan should be modernised and metricated.

[129] (Admiralty Sailing Directions, Pacific Islands Pilot Volume 2 - NP61, 2017)

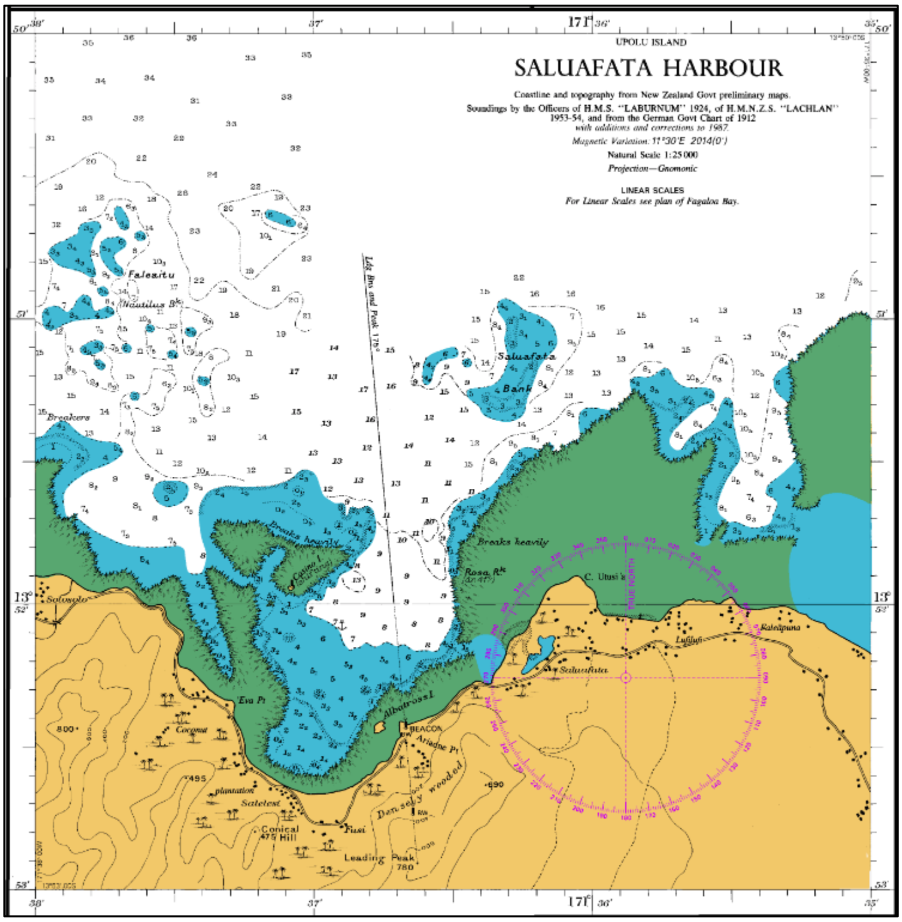

Figure 74: NZ 861 - Plan of Saluafata Harbour

4.4.4 **Fagali'i Bay (Upolu).** This small bay, only a few miles east of Apia, is the site for the landing of underwater communications cables, so should not be used as an anchorage and holds little value as a large-scale plan, particularly being composed of data dated 1879 and 1953-54.

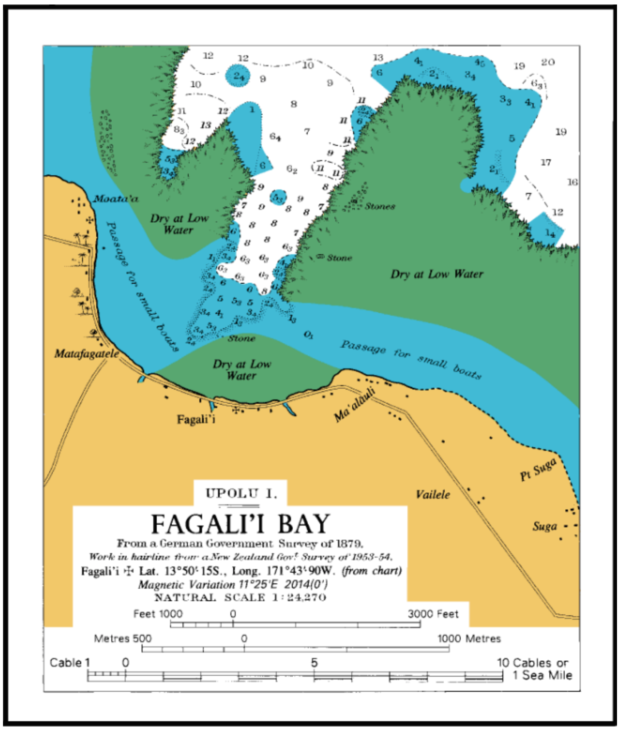

Figure 75: NZ 861 - Plan of Fagali'i Bay

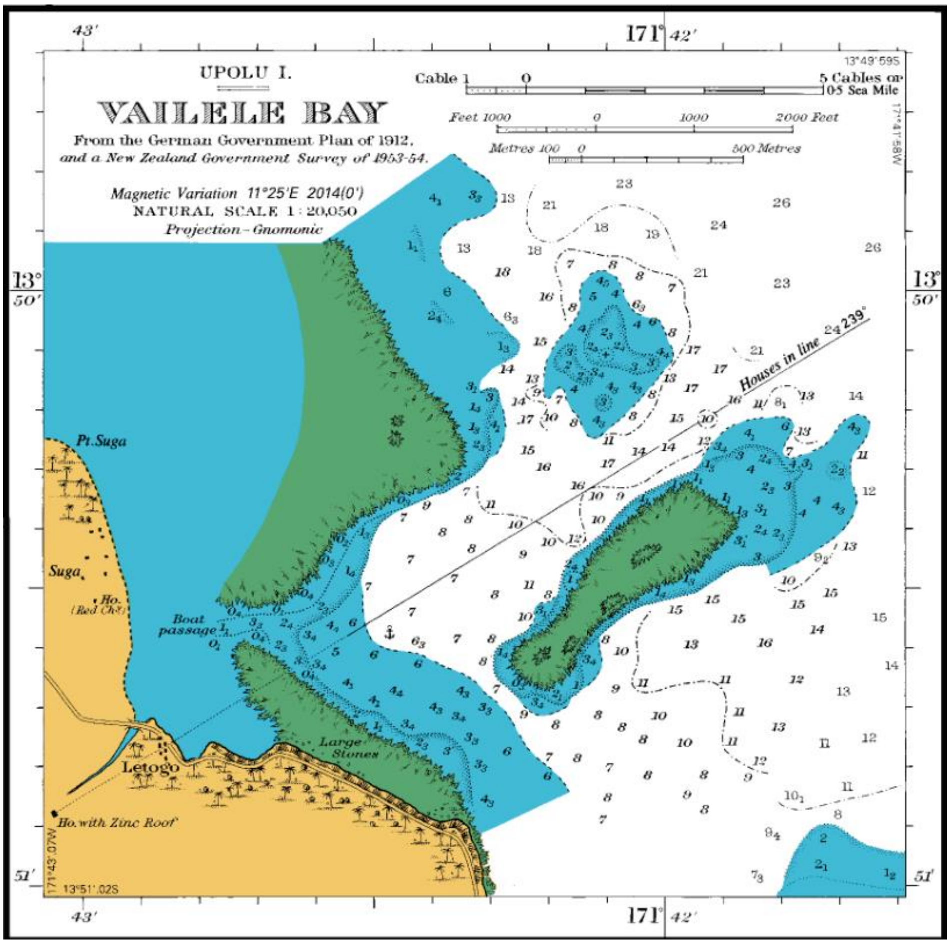

Figure 76: NZ 861 - Plan of Vailele Bay

4.4.5 **Vailele Bay (Upolu).** This small bay 3 miles east of Apia is open to the north-east but provides a well-protected anchorage for yachts or small ships with local knowledge. There is shore access through an opening through the reef at the head of the bay. This plan is comprises data from 1912 and 1953-54. This plan should be modernised.

4.4.6 **Falefa Harbour (Upolu)**. The substantial Falefa River empties into the head of Falefa Bay. The Bay is relatively deep and protected from north-west through to south east but very open to the north-east. This plan is composed of data dated 1912. There appears little justification for maintaining this plan.

Figure 77: Looking west into Falefa Harbour from above Tapuivi Point

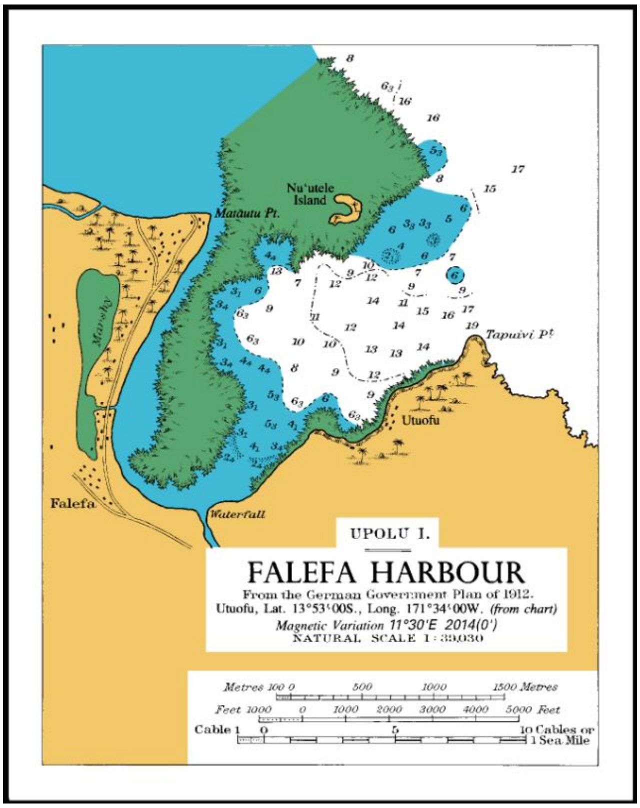

Figure 78: NZ 861 - Plan of Falefa Harbour

4.4.7 Fagaloa Bay (Upolu). A picturesque deep fjord with no noted navigational dangers and a good anchorage at the head, this bay on the northern edge of the Uafato Conservation Zone should be a must visit for recreational vessels. However, it is not recommended when the wind is in the north-east. This plan is composed from data dated 1942 and 1987 and should be modernised.

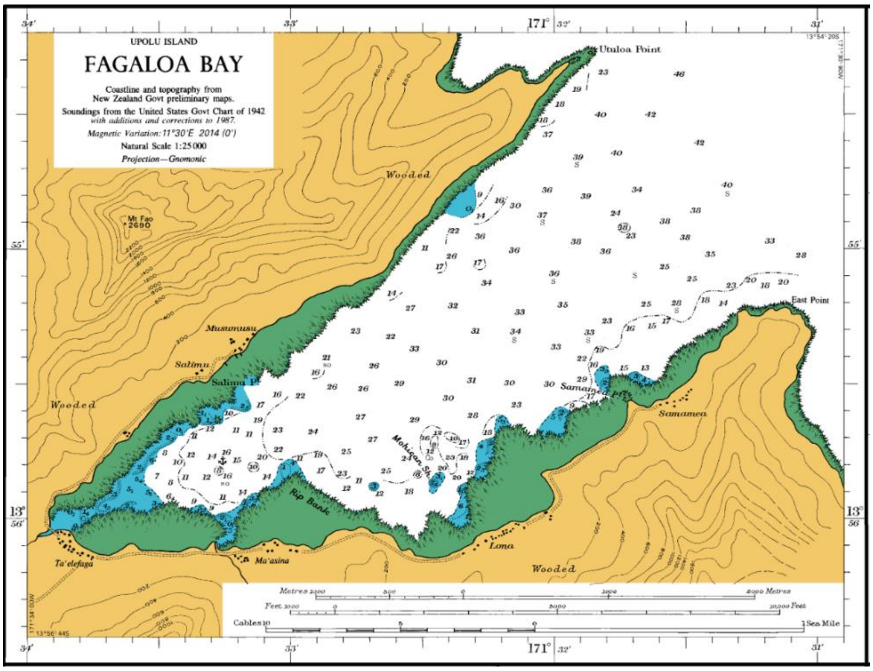

Figure 79: NZ 861 Plan of Fagaloa Bay

4.4.8 Uafato Bay (Upolu). This bay is located in the midst of the Uafato Conservation Zone and exposed from north-east through to east. With only a few lines of sounding dating from 1841 the chart plan cannot be relied on.

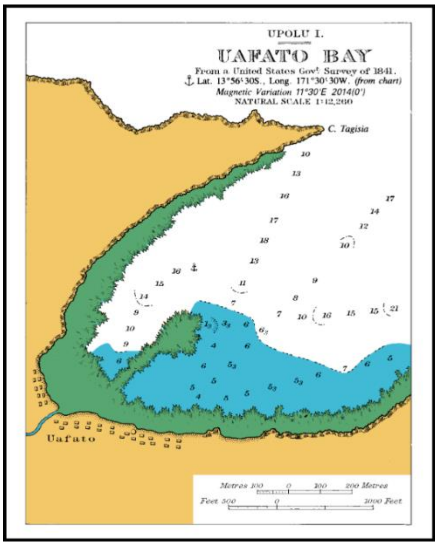

Figure 80: NZ 861 Plan Ufato Bay

4.4.9 Falealili Harbour (Upolu). On the exposed south coast this chart plan shows a number of rocks and shoals amongst a few soundings, dated 1912, behind Nu'usafe'e Island. Small vessels may use the area when the wind is in the north as there is a narrow break in the reef that provides access to Vaovai Beach.

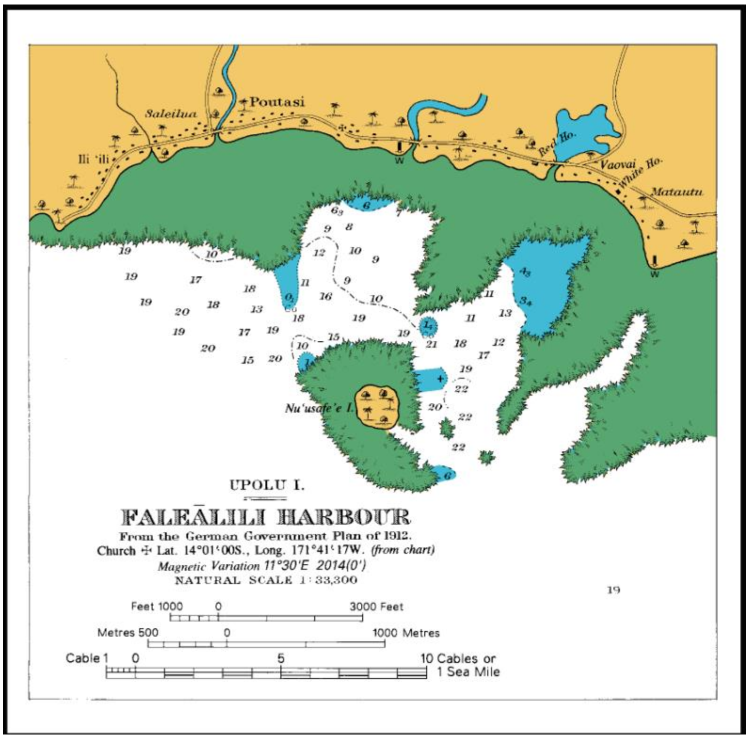

Figure 81: NZ 861 Plan of Falealili Harbour

Figure 82: South coast Upolu looking east - Nu'usafe'e Island with Aleipata Group beyond

4.4.10 Siumu Bay (Upolu). This bay open to the south, has no large-scale plan coverage but has reportedly been used by at least one cruise ship to land passengers to Sinalei Reef Resort at the head of the bay where there is a small break in the reef providing access for small boats. A plan of this bay may be of benefit to recreational, patrol and potential cruise ship visits.

Figure 83: Siumu Bay with access to Sinalei Resort

4.4.11 Satupa'itea Road (Savai'i). While there may be an anchorage close to the coast in northerly winds and possible access to the beach shore through a break in the reef. The plan on NZ 861 comprises only a few sounding from pre-1912 and is of little value.

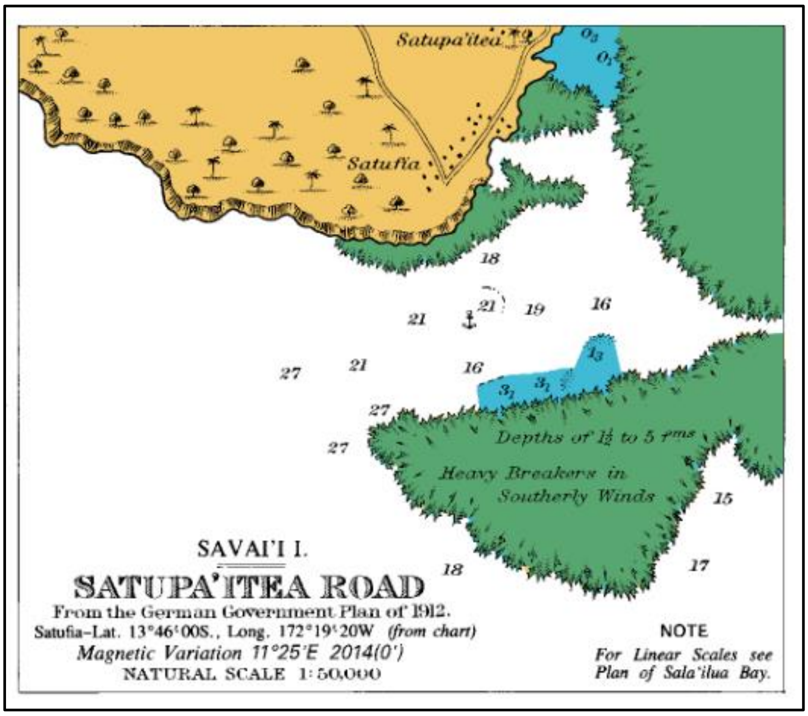

Figure 84: NZ 861 Plan of Satupa'itea Road

4.4.12 Falealupo Road (Savai'i). This roadstead at the western extent of Savai'i is subject to diffracted swells from the north and south, and is likely to be an uncomfortable anchorage. It does provide deep water close to the shore and access ashore with no fringing reef. There seems little benefit in maintaining this plan.

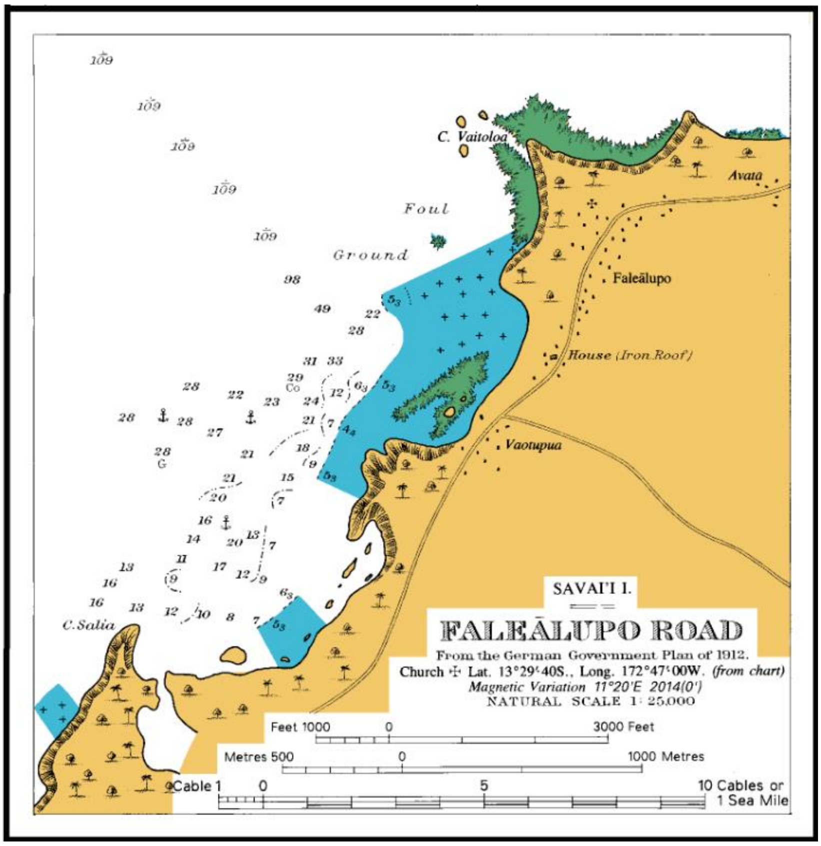

Figure 85: NZ861 - Plan of Falealupo Road

Figure 86: Looking north from Cape Salia to Falealupo Road

4.4.13 Matautu Bay – Fagamalo (Savai'i). This bay on the mid north coast of Savai'i is open to the north but protected from east through to south-west. A metric plan of the bay exists as an insert on chart NZ 864 but the soundings are sparse and the scale of 1:50,000 is inadequate to enable safe navigation. The cruise ship MS *Hanseatic* conducted a day visit here in 2016 and hove to without anchoring. There are many resorts and fales in this coastal area and the Government indicates that there is interest in further developing it as a cruise ship destination. A larger scale plan is recommended to support expansion of cruise ship visits.

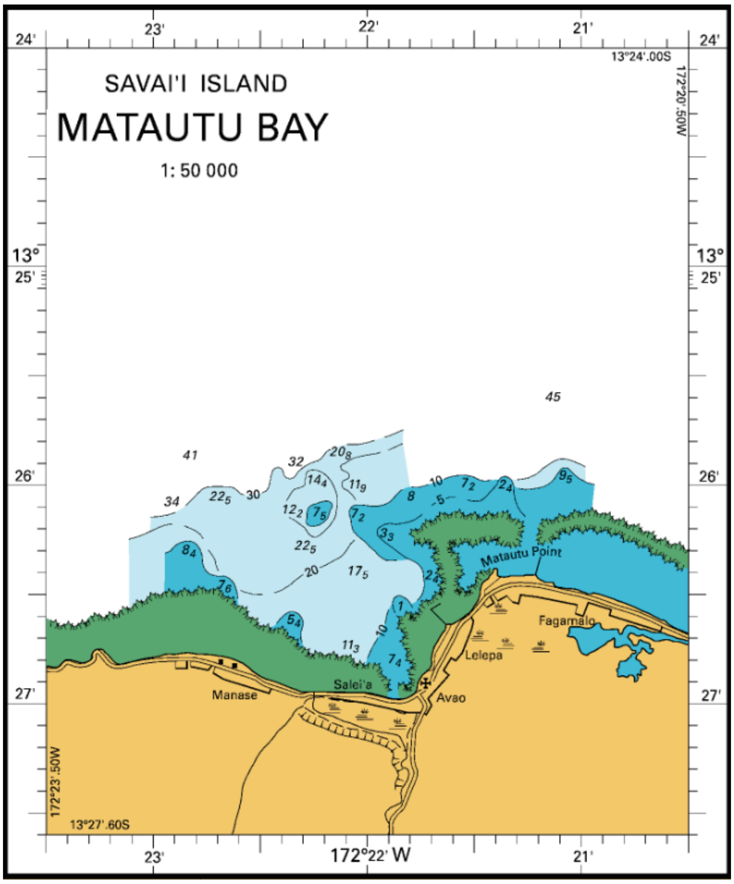

Figure 87: NZ 864 Plan of Matautu Bay

Figure 88: Looking south-west from Fagamalo across Matautu Bay

4.5 International Trade

4.5.1 Apia is the only port in Samoa authorised as a first port of entry and all international maritime trade is conducted there. In terms of general trade, Samoa is well serviced by dedicated international cargo services. A number of commercial shipping companies/agents, whose services are generally considered reliable and of a satisfactory quality, provide regular freight services to Samoa (generally, every ten days from New Zealand and every 15 days from Australia). Neptune Pacific Line, Pacific Direct Line, Pacific Forum Line and Sofrana Unilines operate their SOUTHPAC service between Auckland, Nuku'alofa, Apia and Pago Pago on a two-week cycle.[130] Their AUSPAC service from Australia operates through New Caledonia, Vanuatu, Fiji, Samoa and American Samoa. Examples of other shipping services to Samoa include: 700 tonne LPG shipments from Brisbane using MV *Pacific Gas* (2,602 dwt), MV *Boral Gas* (3,000 dwt), MV Victoire (3,854 DWT) and the MV *Maea* (3,850 dwt); and general cargo from Brisbane/Gladstone/ Mackay using the MV *Scarlett Lucy* (4,152 dwt), MV MCP *Famagusta* (7,709 dwt) and the MV *Floragracht* (12,178 dwt).[131]

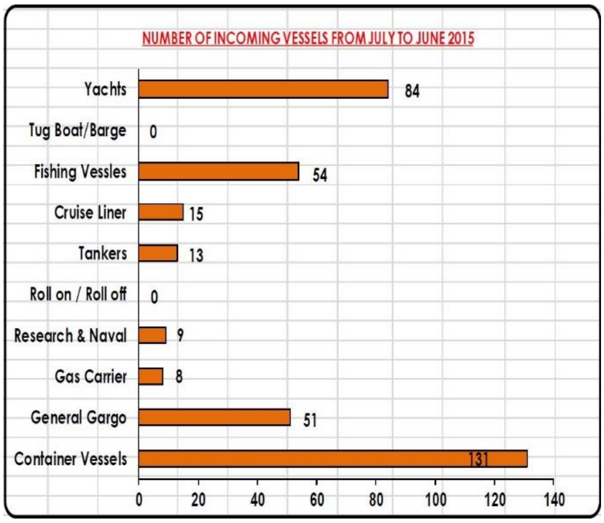

Figure 89: Ship calls at Apia FY 2014/15 (Source: SPA)

4.5.2 As international shipping companies strive to lower their cost of operations, many lines are reducing direct services or forming consortia or slot sharing agreements to service smaller ports jointly, resulting is less frequent visits by larger capacity ships. Companies that previously operated independent direct international container services to Samoa are increasingly consolidating

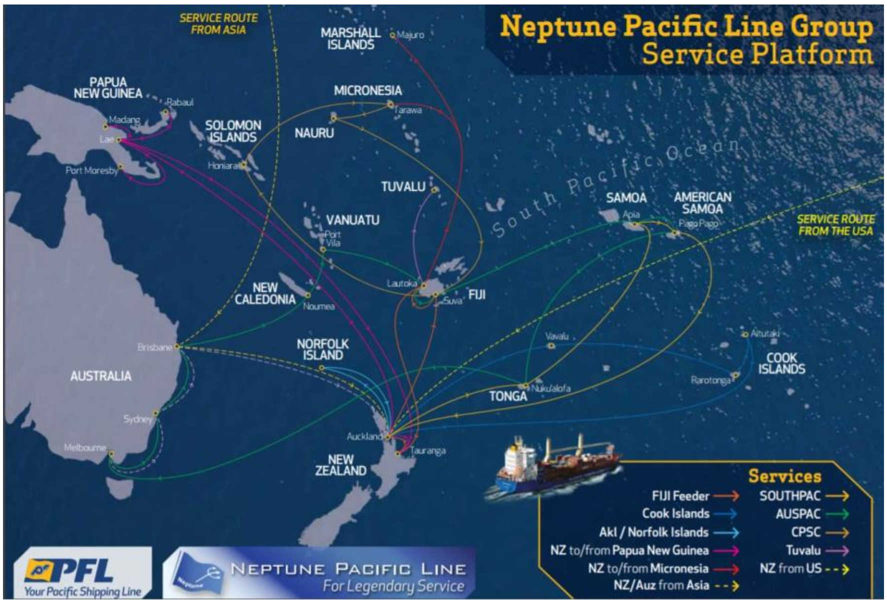

Figure 90: Neptune Pacific Line - Southwest Pacific Loops (incl. shared services)

[130] Two vessels operate this route; MV *Southern Lily* (13,017 dwt) and MV *Capitaine Dampier* (22,968 dwt)
[131] Data obtained through discussions with Braemar ACM Shipbroking (Perth).

operations to utilise transhipments via Fiji. This may impact commercial shipping patterns, resulting in less regular commercial vessel traffic to Apia and lower than normal berth occupancy rates.

4.5.3 Merchant vessels servicing Samoa through Apia predominantly utilise Apolima Strait and the coastal route around Upolu's eastern tip. There is very little vessel traffic around the northern part of Savai'i and little to no inshore traffic along the south coasts of either Savai'i or Upolu.

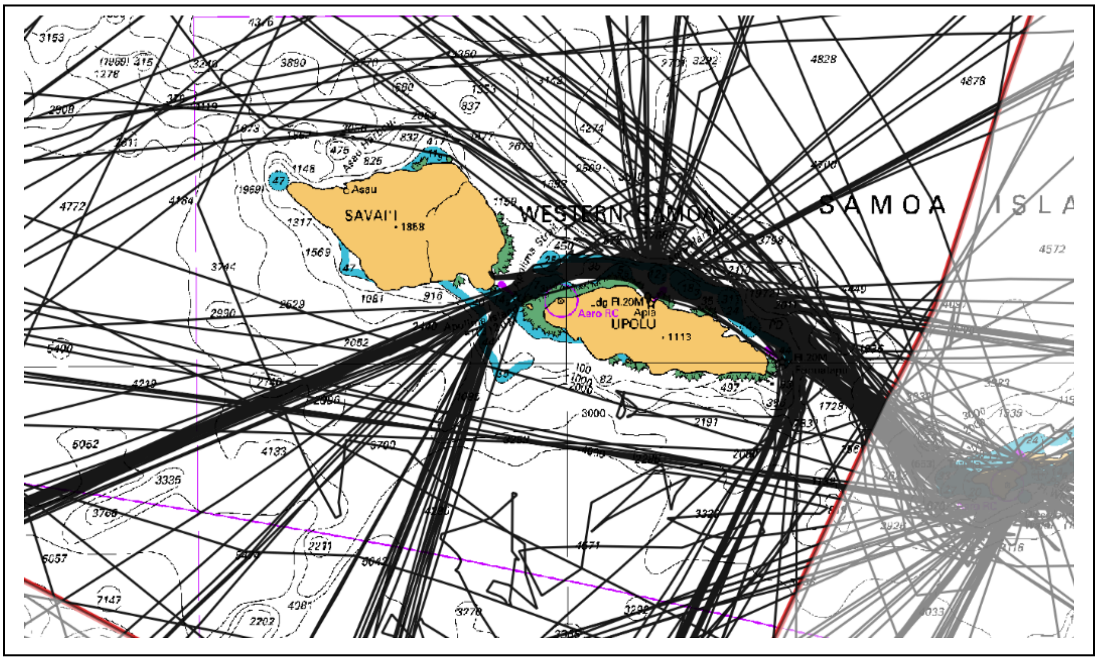

Figure 91: Cargo Vessel Traffic Routes Around Samoa (Source: LINZ)

4.6 Domestic Shipping (Inter-Island)

4.6.1 The main mode of inter-island transport is by ferry. Samoa's two main islands are linked by a dedicated passenger and car ferry service. SSC vessels operate multiple services daily across Apolima Strait between Upolu (Mulifanua) and Savai'i (Salelologa). The listed schedule for this route Monday to Saturday, is three sailings each day; the frequency reduces to two sailings on Sunday.

Figure 92: Ferry Link - Upolu and Savai'i Islands (Source: Samoa Shipping Corporation)

4.6.2 The SSC registered fleet (5 vessels) is a mix of two RoRo passenger ferries and three cargo barge ramp vessels. The largest vessel in the fleet is the MV *Lady Samoa III* (46m LOA, 720 passengers, 1,045 GT).

Figure 93: MV Lady Samoa III (left) and MV Fotu-o-Samoa II (right) (Source: SSC)

4.6.3 SSC also operates charter services to domestic and international destinations to meet demand.

Inter-Island Ferry - Facts and Figures (Nansen, 2013)

Passengers

- approx. 30,000 passenger/month (RoRo vessels)
- approx. 4,000 passengers/month (landing barge)
- total annual passenger movements – 400,000

Cargo (Vehicles)

- approx. 3,500 vehicles/month (RoRo vessels)
- approx. 1,000 vehicles/month (landing barge)
- total annual vehicle movements – 45,000

Vessel Movements

- approx. 160 trips/month [three trips per day on average] (1 x RoRo vessel)
- approx. 130 trips/month (landing barge)
- approx. 4 dangerous good trips/month (landing barge)
- domestic service – seven days/week - fuel charters (PPS) – twice/week
- other charters – one/twice/week

4.7 Regional Shipping - International

4.7.1 SSC also operates a weekly passenger and sea-forwarding service to American Samoa (Pago Pago)[132] using *Lady Naomi*, and conducts charter services to Tokelau, the Cook Islands and Swains Island. The Tokelau Government also operates a passenger service from Apia to Tokelau (approximately weekly) in their state-owned vessel *Mataliki* (funded by New Zealand), which entered service in March 2016.

4.7.2 The Samoan Government maintains an interest in international shipping with partial ownership of Pacific Forum Line, recently merged with Polynesian Shipping Line under majority ownership of Neptune Pacific Line.

4.8 Other Maritime Assets

4.8.1 Samoa's police service's maritime wing operates a Pacific Class patrol boat *Nafuana* that was gifted to Samoa in 1988 under Australia's Defence Cooperation Programme. In-country Royal Australian Navy maritime surveillance and technical advisers provide support for this vessel and assist in developing indigenous maritime surveillance and response capabilities. This vessel is due to be replaced in the first half of 2020.

Figure 94: Samoa Patrol Vessel *Nafuana* (Source: NZ Govt)

[132] The main domestic cargo includes vehicles, construction materials, food supplies, and fuel.

4.9 Maritime Summary

- Samoa's prosperity and economic future is heavily dependent on maritime transportation and trade.
- Shipping companies and agents provide regular freight services to Samoa from New Zealand, Australia and other SW Pacific nations.
- The Port of Apia is Samoa's primary commercial and passenger hub and handles all the country's international sea freight. Its operation is crucial to the economy.
- Inter-island travel is primarily undertaken by ferry, operating regularly between Salelologa Harbour (Savai'i Island) and Mulifanua Harbour (Upolu Island).
- The Port of Salelologa is the only operating port on Savai'i and is crucial to the sustainability of the island and its people.
- The disused port of Asau is a good natural harbour with an excellent wharf but its use is impeded by a constrained entrance channel and there is no modern nautical chart.
- The slipway at Aleipata is an important national asset but the port is exposed to prevailing weather and has no suitable nautical chart.
- More than 200 container, general cargo ships and tankers call at Apia annually.
- International aid continues to support upgrades and improvements to Samoa's maritime infrastructure, primarily through new port development and upgrades to existing facilities.
- Along the coastlines of both main islands there exist numerous 'harbours', inlets and anchorages that could potentially be developed to support new commercial and tourism opportunities.
- Much of Samoa's coastal/inshore waters are shown as being either unsurveyed or inadequately surveyed.
- Data from a recent (2015) LiDAR survey is currently being used to improve the current nautical charts.

5. KEY SITES OF SIGNIFICANCE

5.1 Sites of Environmental Significance – Overview

5.1.1 There are a number of areas across Samoa considered to be either environmentally significant or important from a biodiversity perspective. Descriptions of these areas along with examples of particular sites of natural and cultural significance were introduced in Section 3, including a brief description of the Uafato Conservation Area.

5.1.2 The total area of land in Samoa listed as a key biodiversity area is about 940 km^2 (33% of Samoa's total land area). There are eight important terrestrial biodiversity areas across Samoa of which seven have some form of protection (including Uafato).[133]

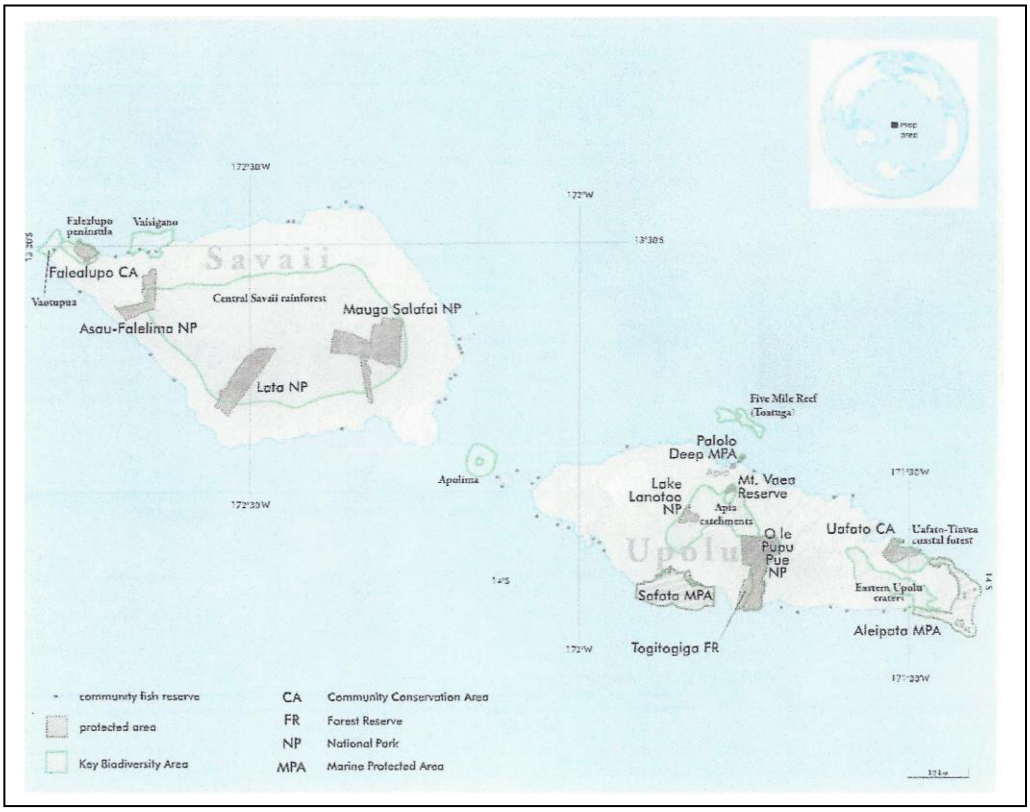

Figure 95: Key Biodiversity Areas in Samoa[134]

5.2 Sites of Cultural Significance – Marine Reserves

5.2.1 The total area of Samoa's marine reserve is about 173 km^2 (23% of the inshore reef area). Approximately 14% (108 km^2) have some form of protection either as a Marine Protected Area (MPA), a marine managed area, or as a recognised marine key biodiversity area.[135]

[133] (Atherton, 2010)
[134] (Atherton, 2010)
[135] (Atherton, 2010). MPA are confined to near shore areas and have been defined as extending one mile seaward of the outer reef edge.

5.2.2 While there are seven marine areas of significance, only three have protected status:

- Safata MPA – Upolu mid-south coast;
- Aleipata MPA – south-eastern end of Upolu; and
- Palolo Deep MPA – in the vicinity of Apia.

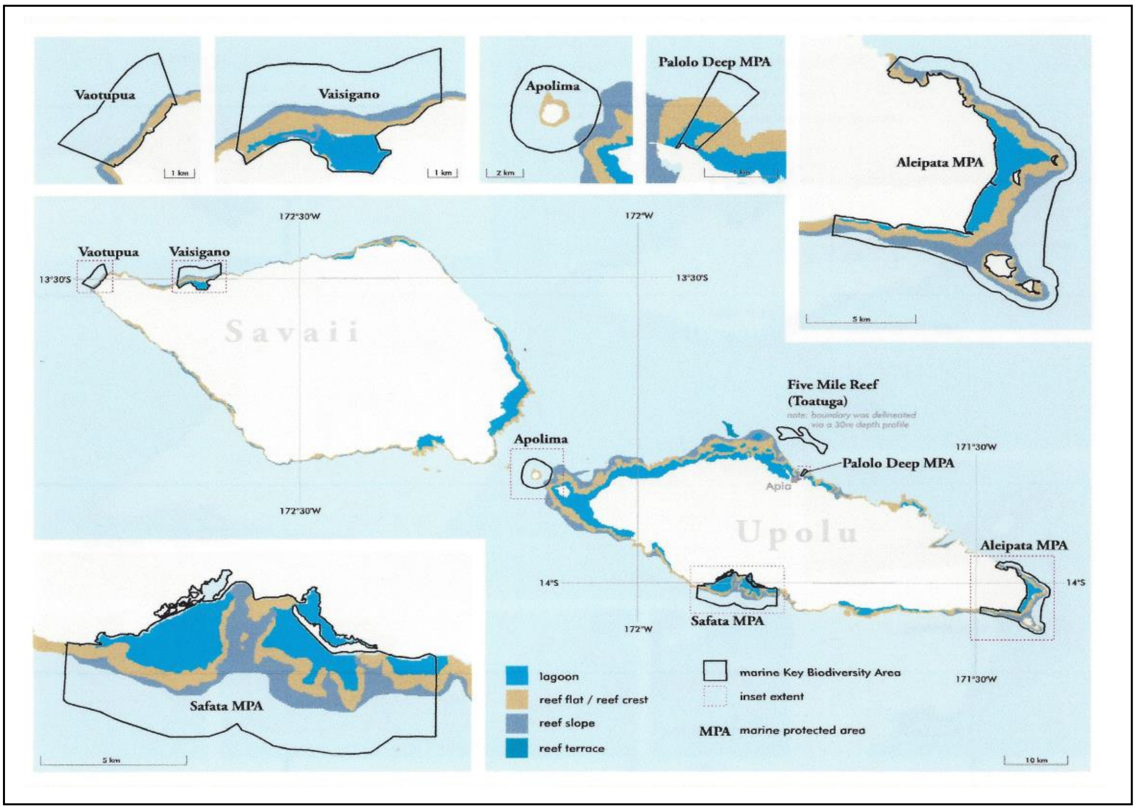

Figure 96: Marine Key Biodiversity Areas and Marine Habitat[136]

There are no MPAs in western Upolu or on Savai'i. It has also been recognised that regions further offshore within Samoa's EEZ require some measure of conservation management.[137]

5.2.3 Notwithstanding the protection status of those current coastal marine areas identified for conservation, Samoans will continue to have enduring links with the sea and inshore coastal areas. Under Samoa's Ministry of Agriculture and Fisheries' Community Base Fisheries Management Program, 99 Village Fisheries Management Plans were in place overseeing the supervision and sustainability of inshore areas (56 across Upolu and 43 on Savai'i).[138] Because there exists this strong community involvement and spiritual connection with the surrounding marine environment, because many Samoans live along the coastal margins in over 360 village settings that rely on the sea for both subsistence and economic reasons, and because most key marine biodiversity areas in

136 (Atherton, 2010)
137 (Atherton, 2010)
138 (Ministry of Agriculture and Fisheries Annual Report 2013-2104)

Samoa remain under customary tenure, a significant portion of the coastline and inshore waters remains very important to Samoa's village communities.

5.3 Significant Site Summary

- There are many areas in Samoa considered to be either environmentally significant or important from a biodiversity perspective.
- There are seven marine areas of significance; only three have protected status as a Marine Protected Area (MPA).
- MPA management plans tend to be developed around partnerships between the Government and the village communities of a particular district.
- Much of the coastline is culturally significant to the majority of Samoans.
- Local marine reserves have been established around much of the coastline to assist in managing sustainable fish stocks and marine biodiversity.

6. INTERNATIONAL SHIPPING TRAFFIC DATA (AIS)

6.1 Introduction

6.1.1 This section discusses the results of the traffic data analysis for Samoa's EEZ. Raw ship S-AIS data for the periods January – December 2016 were used for the ship traffic analysis and calculation of hydrographic risk. This is different from the common periods used for previous assessments of the Cook Islands, Tonga and Niue (Vanuatu used only the 2012 dataset) but was chosen to improve the currency and completeness of the traffic information. The impact is that the traffic levels in this assessment are likely to be higher (and more realistic and up to date) than those previously used, which may increase the apparent risk on a "regional" basis. Full details of the dataset sources, method of track creation and track processing are provided in Annex B. This section provides an overview of the processed traffic results.

6.2 Traffic Analysis by Vessel Type

6.2.1 Samoa has a small EEZ and the majority of vessels passing through it call at Apia. The plot below depicts the total traffic through Samoa's EEZ during the assessment period, colour coded for vessel type. It can be seen that all traffic, including fishing vessels, avoids the shoal area at Pasco Bank to the west of the EEZ.

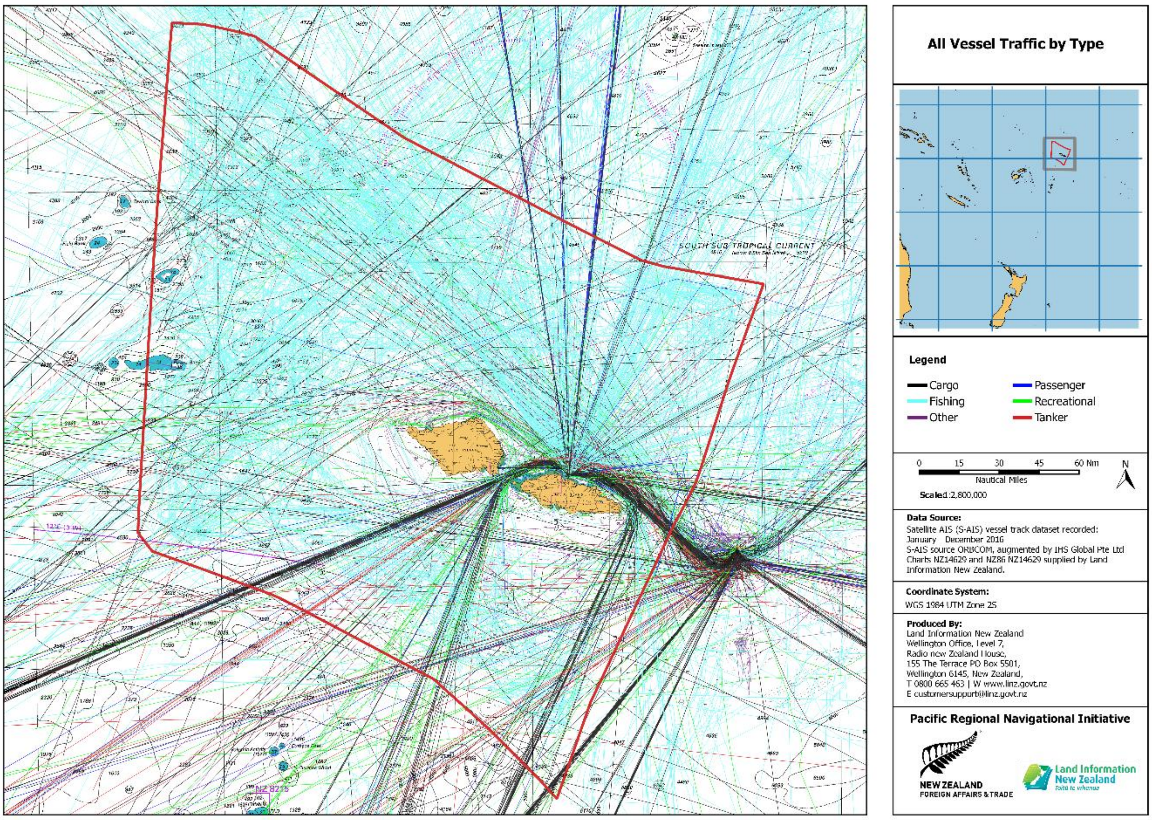

Figure 97: All vessel tracks across Samoa EEZ, colour coded by type

6.2.2 As can be seen from the legend in the plot, the vessels are classified in 6 classes

- Cargo;
- Fishing;
- Other;
- Passenger;
- Recreational (including superyacht); and
- Tanker

Note: The "other" category includes research, search and rescue and military vessels.

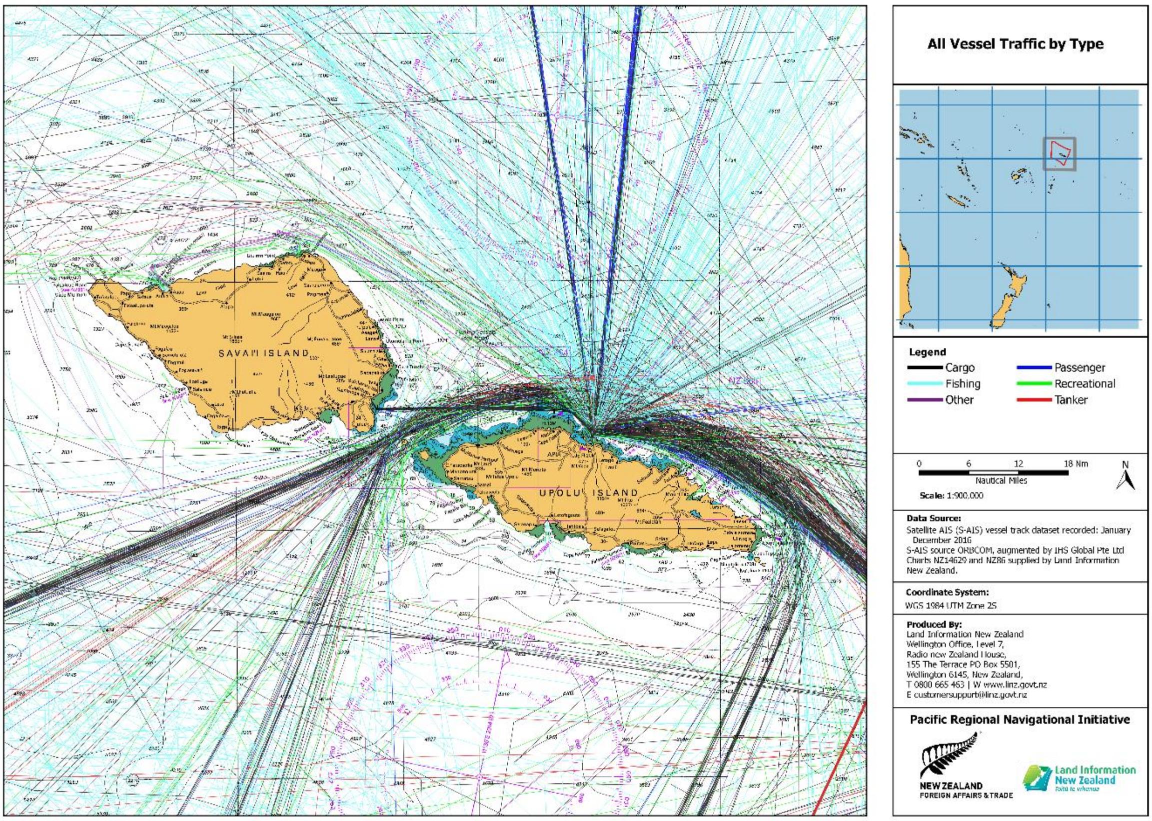

Figure 98: All vessel tracks near Samoa, colour coded by type

6.2.3 From the plot above it is apparent that the majority of traffic passes through Apolima Strait, or around the eastern end of Upolu Island, calling at Apia. A smaller amount of traffic passes north of Savai'i and virtually no traffic passes close south of either island, with the notable exception of a few recreational vessels. Individual plots of each vessel type are shown below.

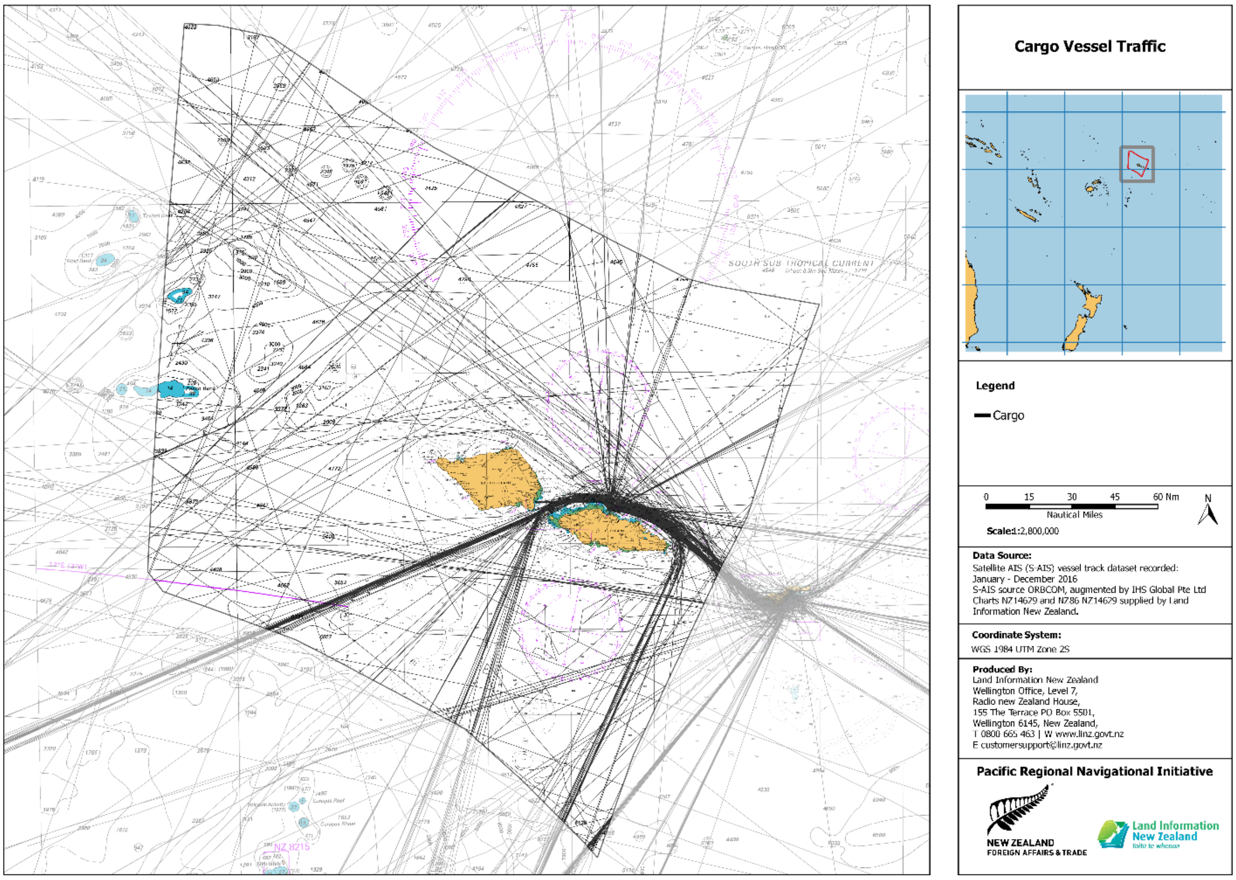

Figure 99: Cargo vessel tracks

6.2.4 Cargo vessels account for a high proportion of the overall traffic. They tend to follow regular, repeated routes. The tracks above are created by a small number of distinct vessels making multiple voyages.

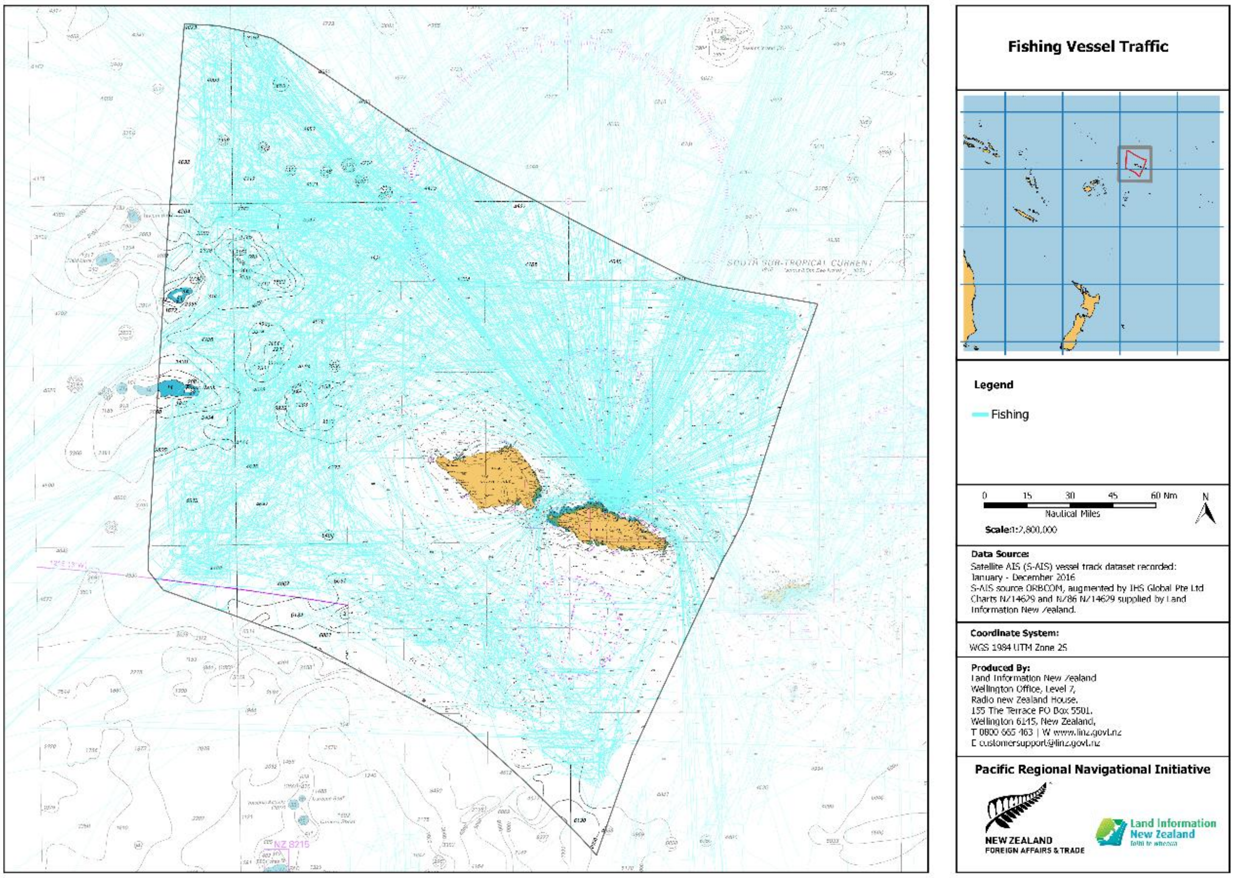

Figure 100: Fishing vessel tracks

6.2.5 Note that only international fishing vessels are fitted with AIS. These vessels are not permitted to fish within the 12 nm territorial seas so their tracks radiate from Apia (for their port calls) only remain in the territorial seas during passage. Otherwise they meander between the territorial sea limit and the limit of Samoa’s EEZ.

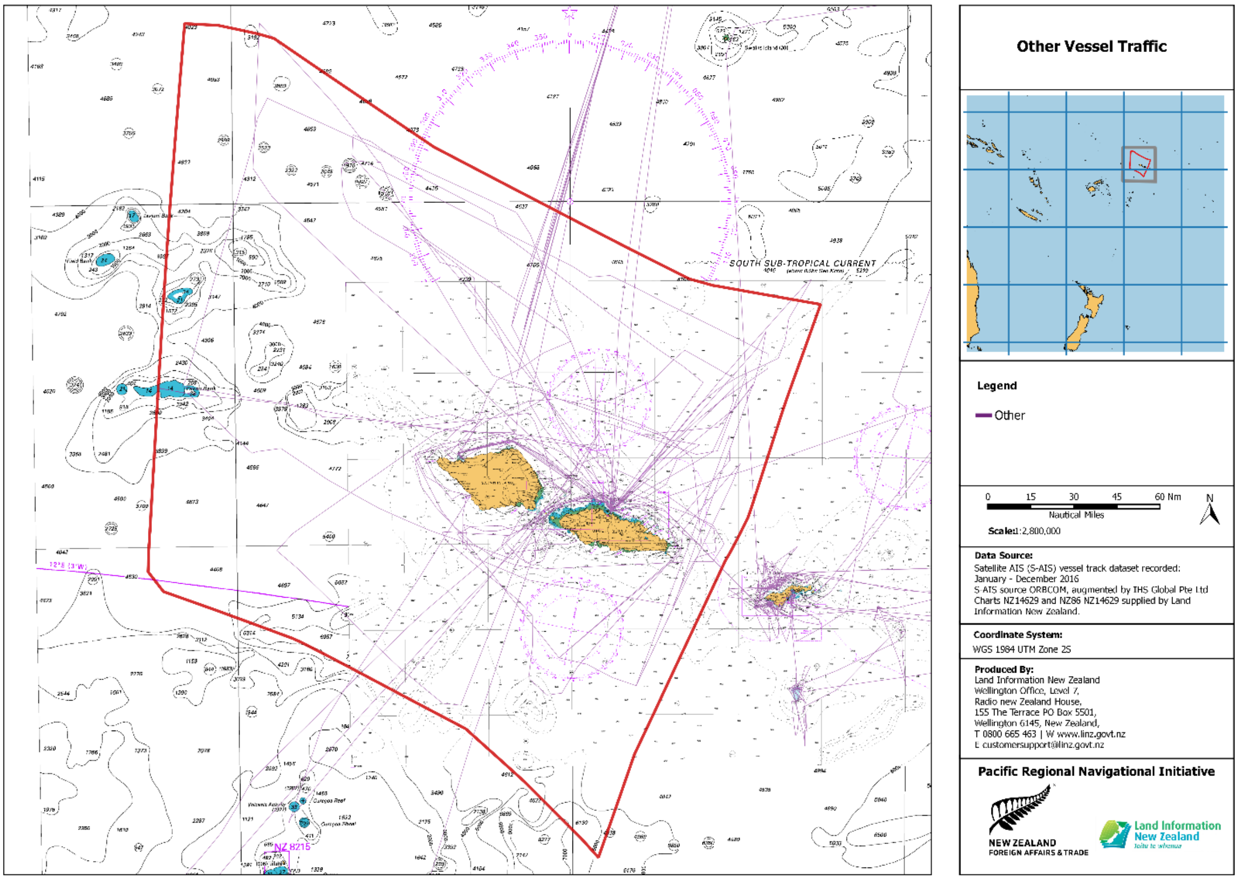

Figure 101: Other vessel tracks

6.2.6 'Other' vessels include research, search and rescue and military vessels. These vessels do not follow regular trade routes and are more likely to navigate into coastal areas that may be less well charted. Therefore, despite their relatively low GT they do have an impact on the overall risk. Additionally, their ability to do their task, thus their overall effectiveness, may be restricted by inadequate charting.

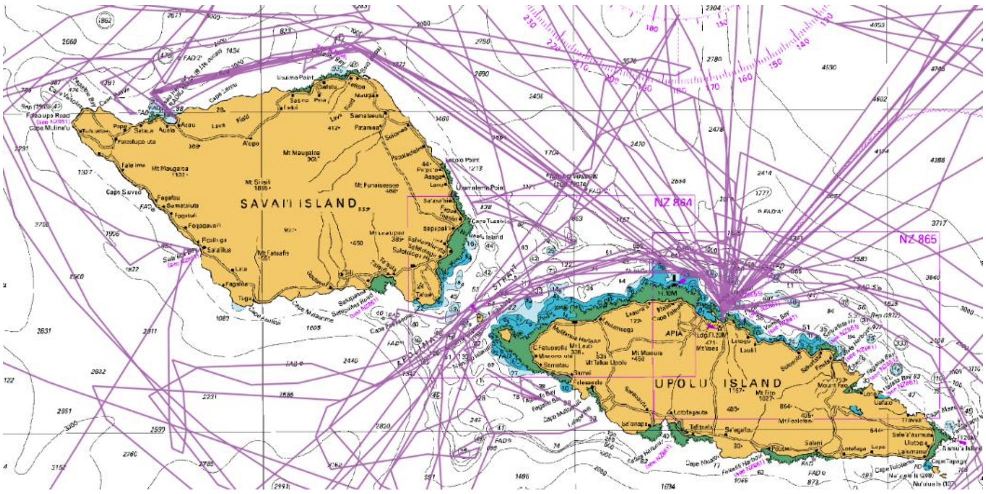

Figure 102: Coastal tracks for "other" vessels

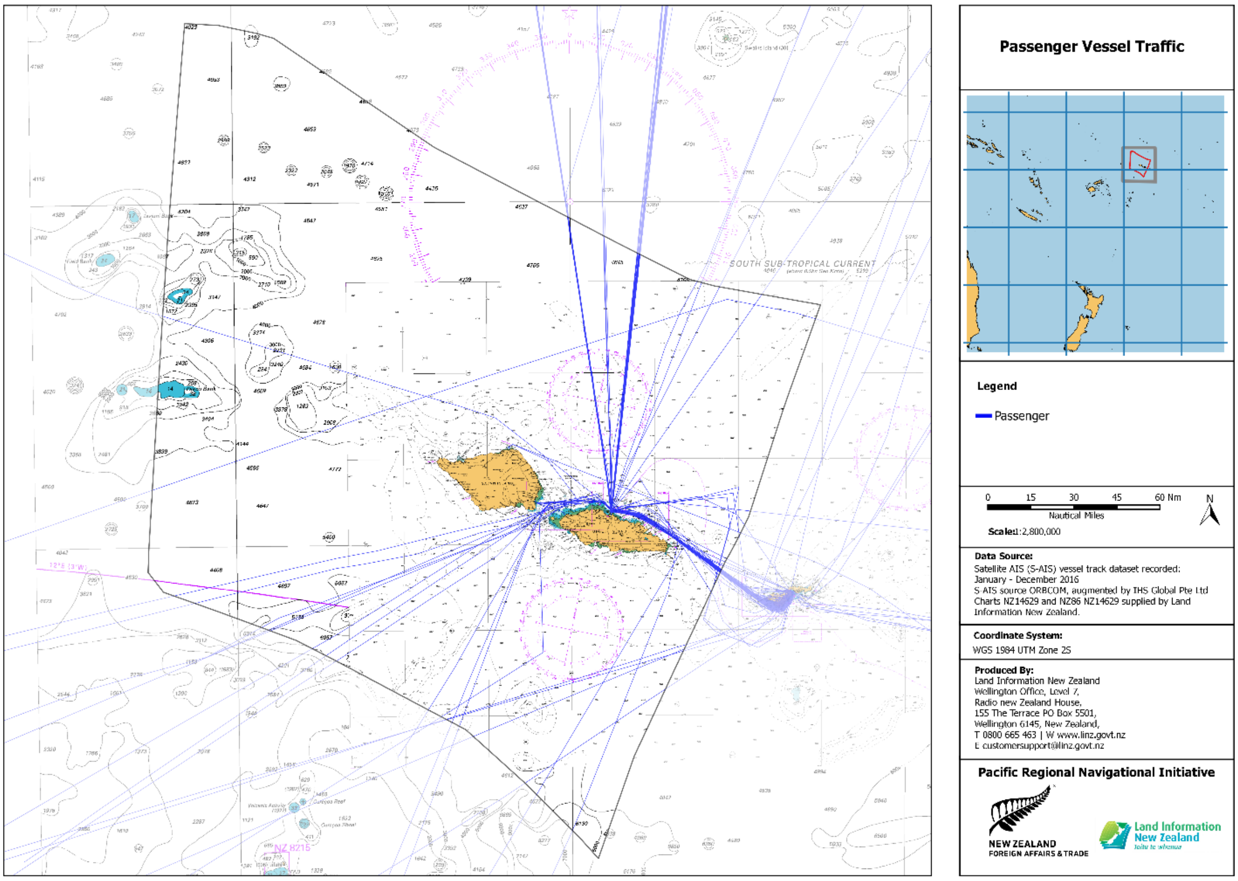

Figure 103: Passenger vessel tracks

6.2.7 Most of the international passenger vessels voyages are the routine ferry services between Apia and Tokelau to the north and Apia and American Samoa to the east. The other international passenger vessels are cruise ships. Note that there are some passenger vessels tracks between Apia and Salelologa and one track between Mulifanua and Salelologa. These are the domestic ferry routes on which the vessels do not have AIS fitted.

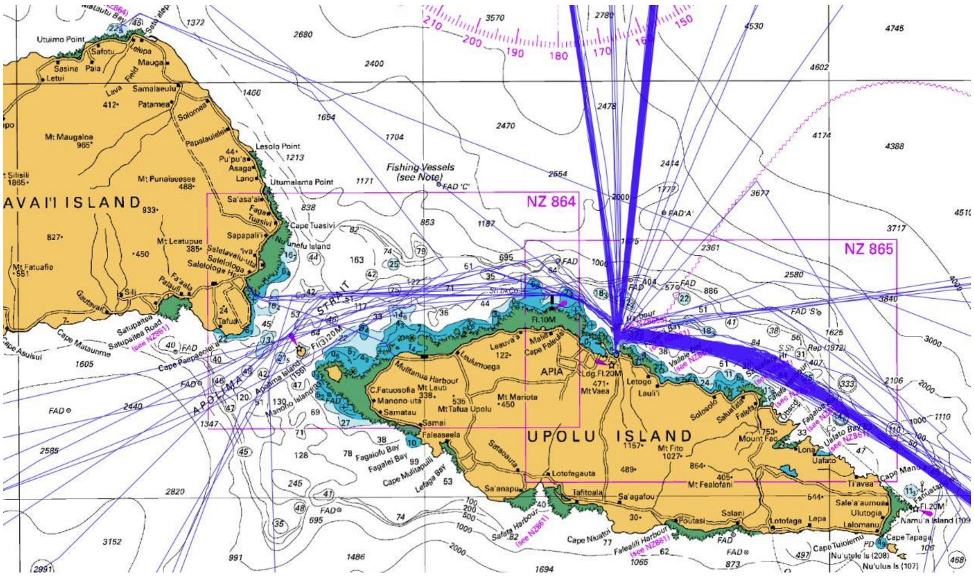

Figure 104: Coastal tracks for passenger vessels

Occasionally, the SSC use vessels which normally operates on the international routes and do have AIS fitted. For this analysis, the calculated GT of the domestic ferries operating between Mulifanua and Salelologa was added to the model.

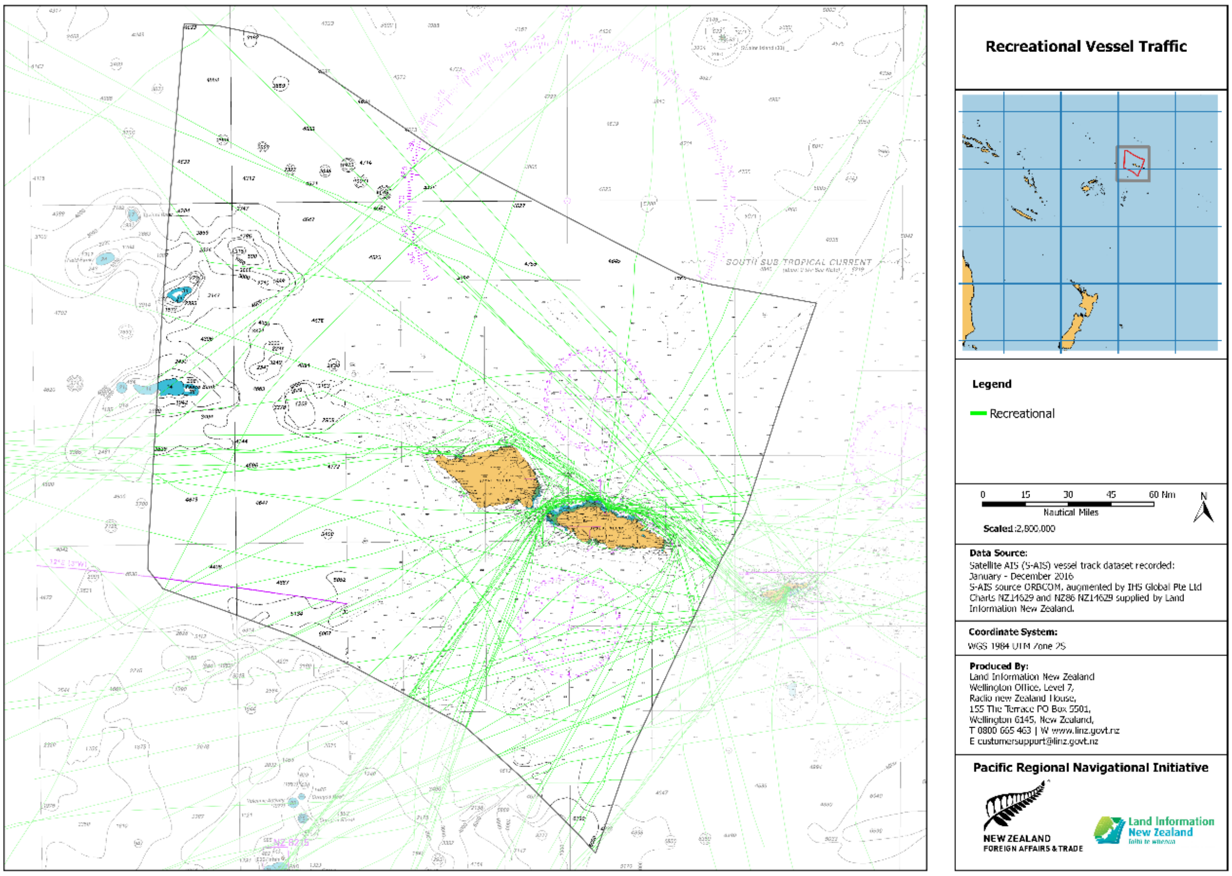

Figure 105: Recreational vessel / Superyacht tracks

6.2.8 Recreational vessels do not follow regular trade routes and with their shallow draught will invariably proceed into coastal areas that may be less well charted. As non-commercial vessels, they do not have a registered GT so for this assessment they have been allocated an estimated GT based on comparison with commercial vessels of a similar size. The requirement for recreational vessels to obtain a cruising permit and return to Apia to clear out of Samoa tends to limit the number of vessels that are cruising to remote coastal areas. This fact, combined with their very low GT results in this class only having a small impact on the overall hydrographic risk.

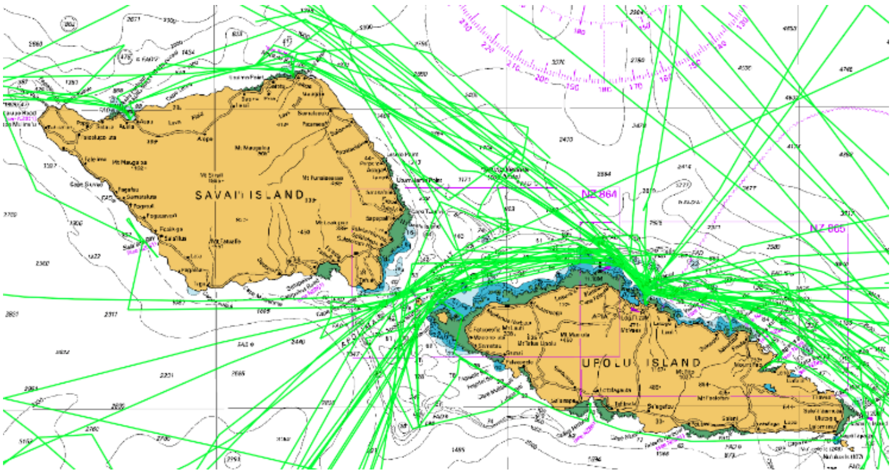

Figure 106: Coastal tracks of recreational vessels

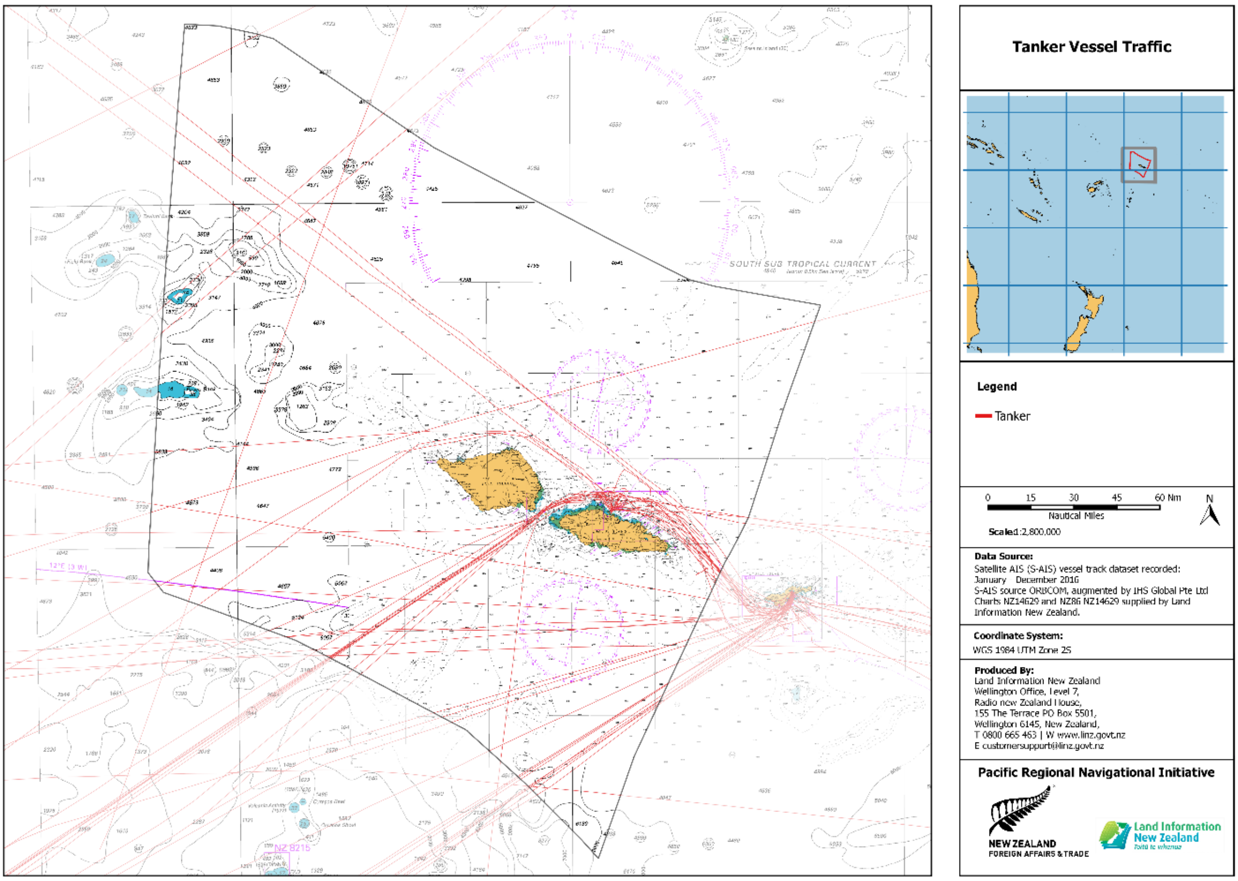

Figure 107: Tanker vessel tracks

6.2.9 Tankers represent the greatest pollution potential but tend to navigate on repeated, proven routes from port to port whilst maintaining good clearance from navigational hazards. Nevertheless, their high GT and high pollution potential make them a large contributor to the hydrographic risk.

6.3 Traffic Analysis by Attribute

6.3.1 In addition to vessel type, from a risk perspective it is informative to consider the draught, length and GT of vessels in relation to their tracks. From the following Figures it can be seen that the vast majority of tracks in the outer EEZ are green, being vessels less than 100m long, but vessel on the commercial ship routes that include Apia are generally between 107m and 230m long.

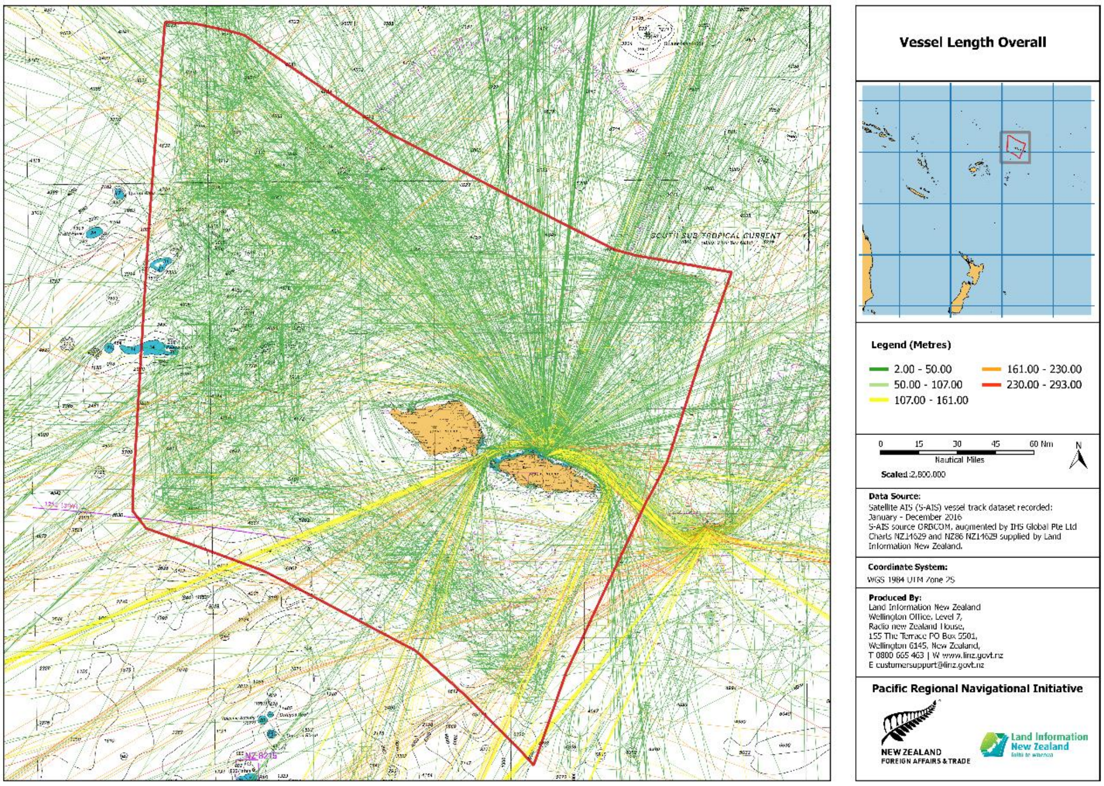

Figure 108: Vessel tracks colour coded by vessel length

There are only a few red tracks of vessels over 230m long. These tracks align with the tracks of vessels with the red GT vessels in the following Figure.

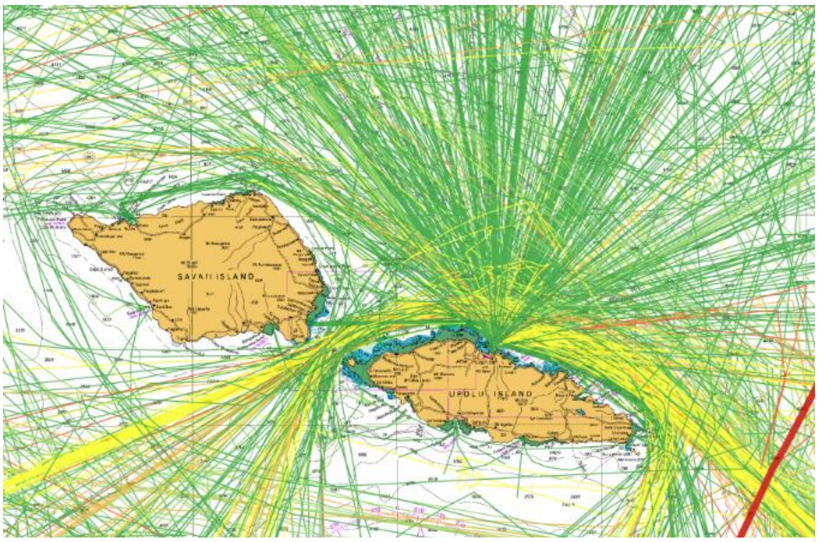

Figure 109: Expanded plot of vessel by length - colours as above

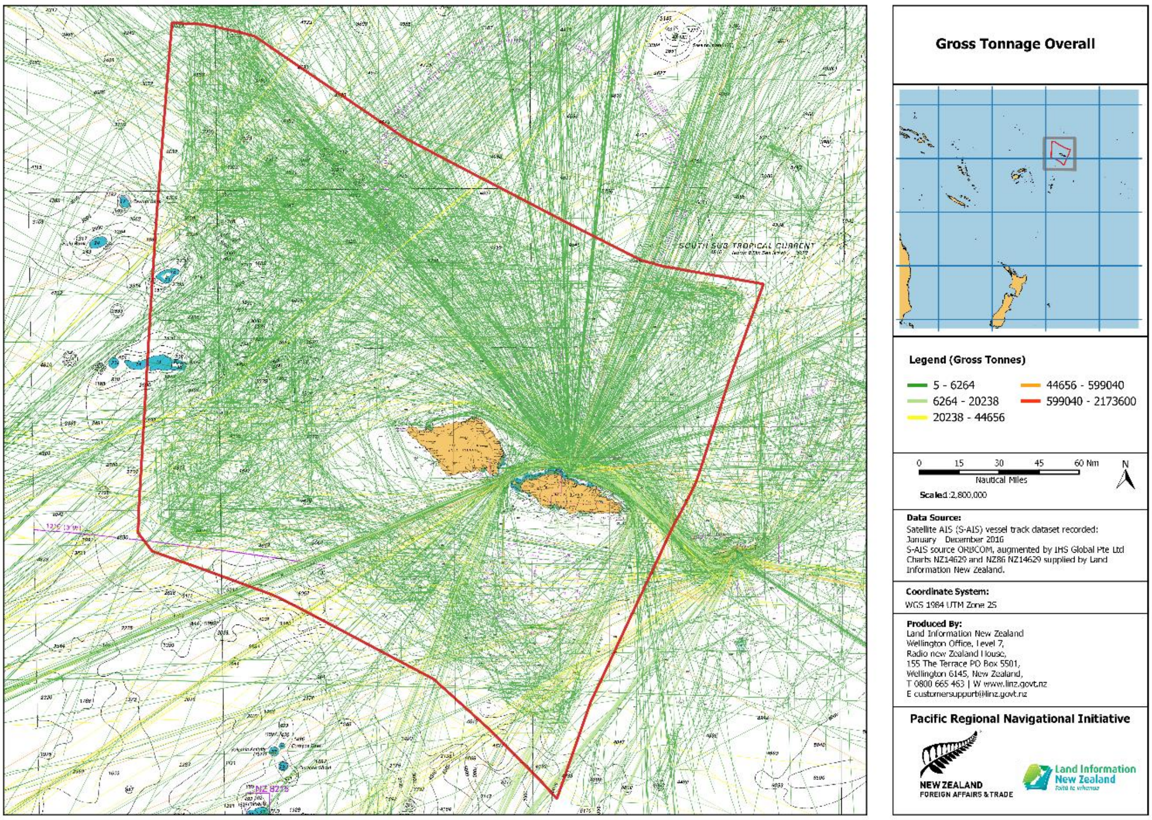

Figure 110: Vessel tracks colour coded by vessel GT

6.4 Conclusion - Shipping Traffic Data (AIS)

6.4.1 Apia is a relatively busy port with routine visits from general cargo, tanker, fishing and passenger vessels. A small number of large vessels exceeding 68,000 GT transit the outer EEZ without calling at Samoa. The majority of traffic in the outer EEZ are small fishing vessels less than 107m long. Most commercial traffic in the EEZ passes through Apolima Strait and calls at Apia. These commercial vessels are generally between 107m and 230m long and between less than 40,000GT. As a general rule, vessels not calling at Apia pass Samoa at least 20nm distant.

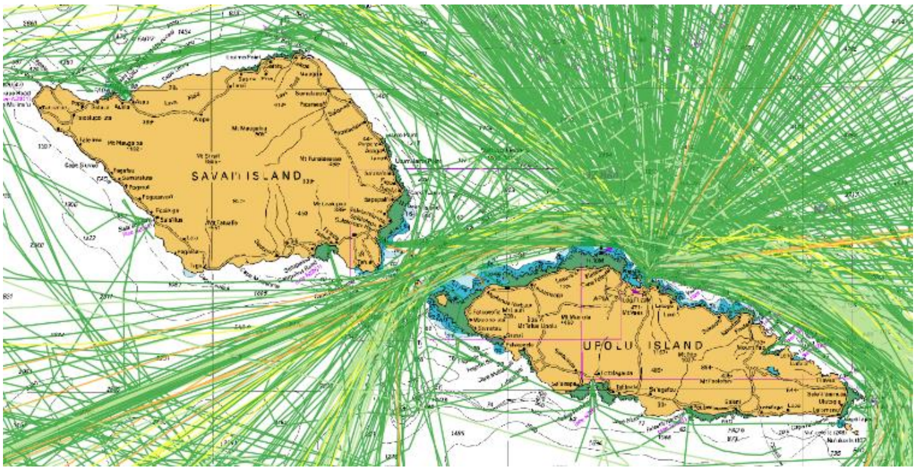

Figure 111: Expanded plot of tracks by GT - colours as above

7. RISK ANALYSIS RESULT

7.1 Introduction

7.1.1 This section presents the overall risk results for Samoa's EEZ, focussing on the coastal areas and especially the three commercial ports. Section 7.2 displays the "in-country" results, discusses the major contributors to those results and highlights the sensitivity of results to changes in ship traffic and hydrographic charting quality. Section 7.5 then displays and discusses the "regional" risk results comparative to the previous analyses of Tonga, Cook Islands and Niue.

7.1.2 The details of calculation of the hydrographic risk are provided in Annex F. The visual representation of risk is divided into colour bands ranging through: *insignificant, low, moderate, heightened and significant*.

7.1.3 **Heat map interpretation**. It is reiterated here that the use of Jenks Natural Breaks to allocate the colour mapping for the final "in-country" risk plots has the effect of converting the risk results into a relative risk heat map across the Samoa study area. This is because this method will represent the lowest risk as *insignificant* (green) and the highest risk as *significant* (red), across the numerical range of calculated risk values. This effect was observed to limit the risk rating in lower traffic areas within the Tonga risk assessment[139]. In that assessment, relative differences in traffic density between the different island groups had the effect of showing less risk in some poorly charted areas that did in fact have regular traffic flows and would substantially benefit from charting improvements. The hydrographic risk in such areas was not as high as in other higher traffic areas where the charting was of a better standard. Within the Samoa EEZ the same effect is particularly noticeable due to the high traffic concentration near Apia or Apolima Strait, in comparison with other low traffic minor ports, harbours or coastal areas.

7.1.5 **Numerical risk results**. The numerical risk results are influenced by the risk factor weightings. These are explained and provided in Annex E. The generic low traffic risk factor weighting matrix was developed by LINZ/Marico Marine[140] for the previous regional South West Pacific risk analyses and is used for the comparative analysis in section 7.5. These risk factor weightings were slightly modified for the Samoa "in-country" assessment, by removing risk and consequence factors that are not present and redistributing their weights to other factors (see full explanation in Annex E). The "in-country" risk results thus obtained are considered to be more representative of the relative hydrographic risk across the Samoa EEZ.

[139] (Marico Marine Report No. 14NZ262 – TM, Issue 1, 27 November 2014, pp. 96-98)
[140] (Marico Marine Report No. 15NZ322 Issue 03, 5 August 2015, p. D2)

7.2 Samoa "In-country" Risk Overview

7.2.1 The overview of the Samoa EEZ hydrographic risk colour map, using the Samoa local risk factor weightings is shown below. The "in-country" colour band classification uses break values calculated only from the study area data, thus ensuring that the full colour range is utilised in the heat map. The majority of the Samoa EEZ, is relatively deep water and away from dangers, so appears as *insignificant* or *low* risk. The only area of *significant* risk is in Apia and its approaches. There are *heightened* risk areas in Apolima Strait and the approaches to Apia. Moderate risk areas extend from the Aleipata Island group at the eastern end of Upolu anticlockwise around Upolu to Apolima Island (except where higher risk categories apply), the eastern exposed coast of Savai'i north of Cape Tuasivi and the vicinity of Matautu Bay and Asau on the north coast of Savai'i. The south coasts of both main islands are mainly *insignificant* to *low* except in the immediate vicinity of harbours used by local long line *alia*.

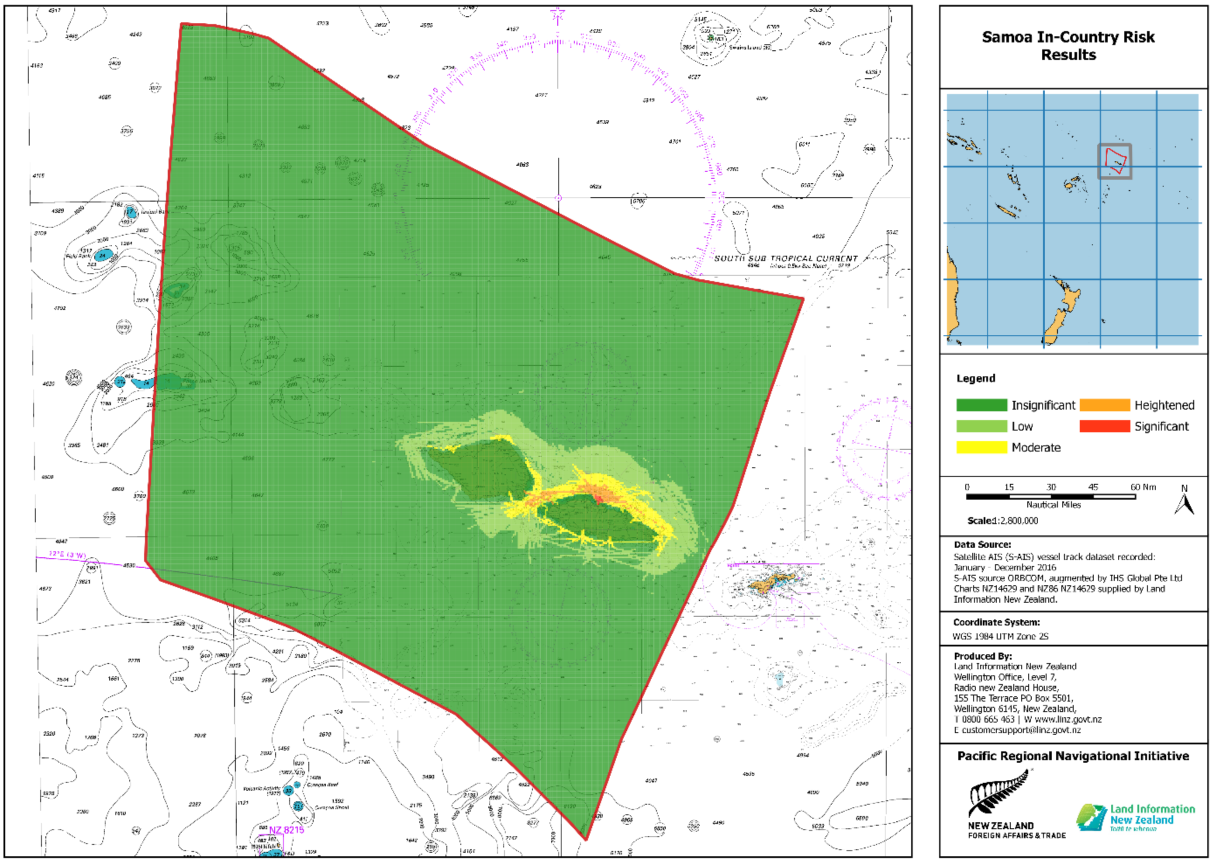

Figure 112: Samoa "In-Country" risk result - Samoa risk matrix

7.2.2 The detail of the different risk areas can be more clearly seen on the enlarged plot of the Samoan Islands below.

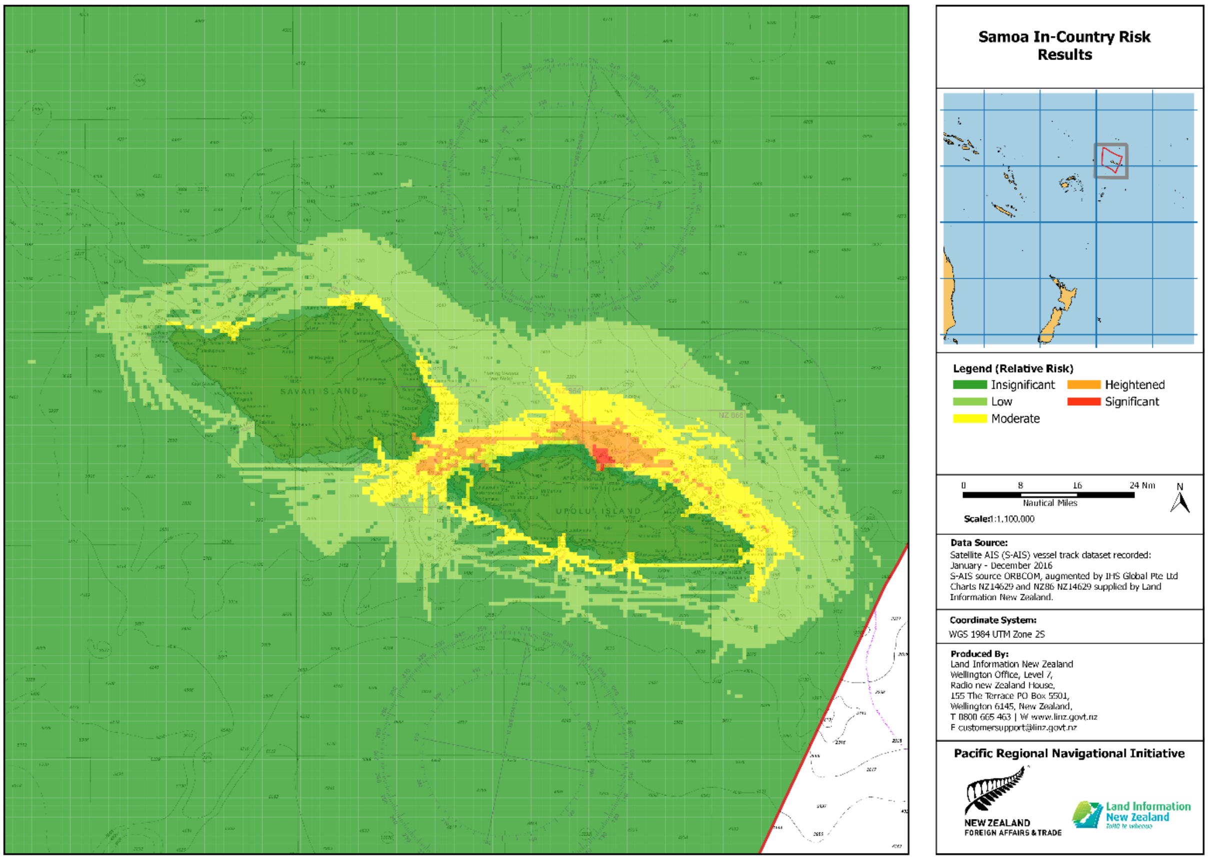

Figure 113: "In-Country" risk results - Samoan Islands

7.2.3 The only surprises are the *moderate* risk areas on the south coast of Upolu and the east coast of Savai'i north of Cape Tuasivi both of which have very little traffic. On investigation, the south coast of Upolu was found to have a charting quality rating CATZOC D or U and some local fishing and recreational vessel traffic. Along the east coast of Savai'i the level of risk is attributable to a relatively low GT research vessel navigating in poor survey quality waters (CATZOC U) close to high consequence areas.

7.3 Apolima Strait to Apia – Including Mulifanua and Salelologa

7.3.1 The hydrographic risk profile of the dense traffic area through Apolima Strait and the approaches to Apia are shown below.

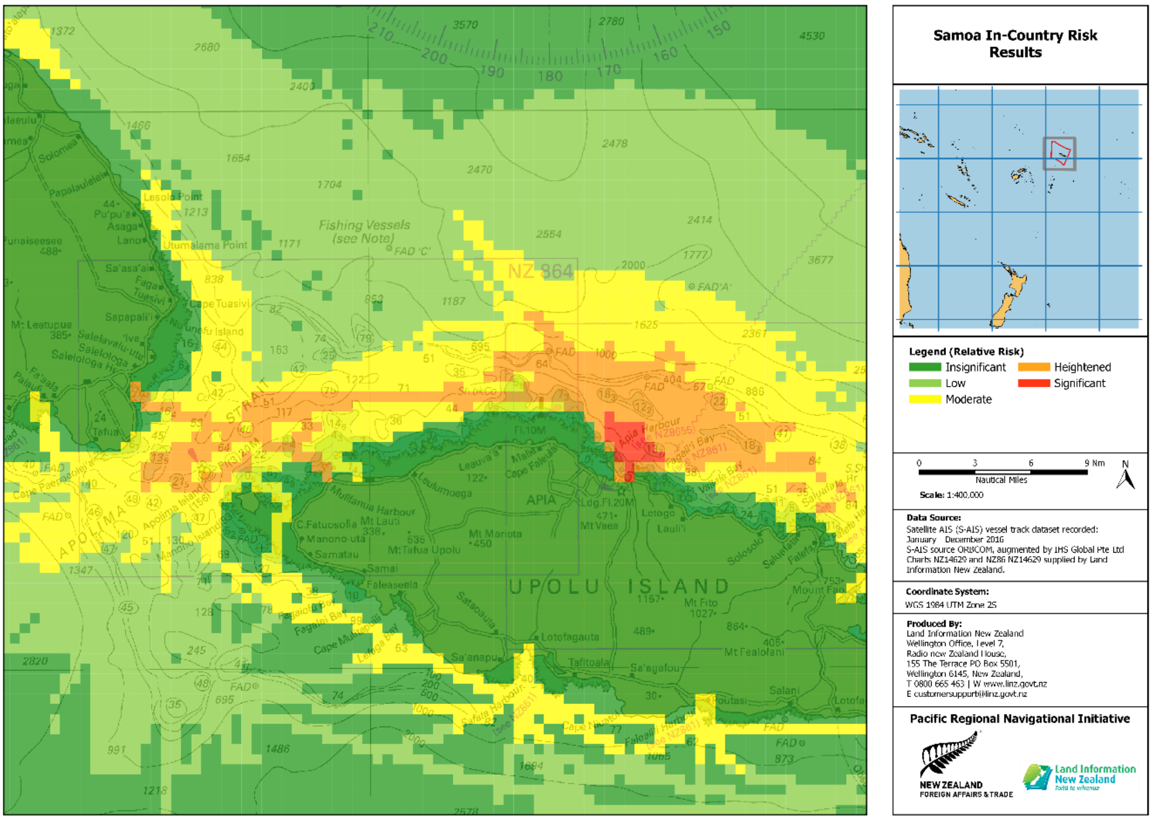

Figure 114: Apolima Strait to Apia risk heat map

7.3.2 These results are generally as expected and the highest risk areas correspond to the highest traffic areas. The only area of *significant* risk is in Apia Harbour and its nearby approaches. These areas have very high traffic and most of the approach area has a charting quality rating of CATZOC D. The Apolima Strait is the highest traffic area in Samoa where the domestic ferry crosses the main international shipping route (as can be seen by the following plot of GT per cell) but also has the highest quality of charting, this results in a lower risk category of *heightened* despite the proximity to reefs and sensitive areas.

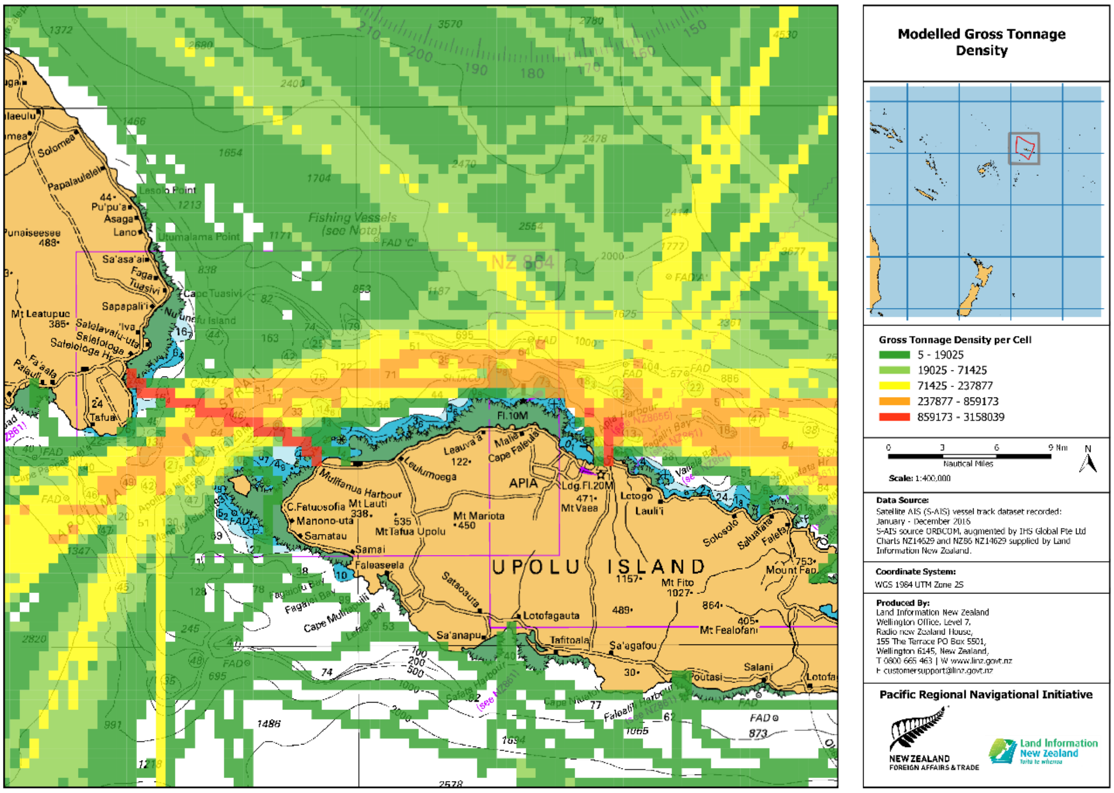

Figure 115: Traffic density in GT per cell

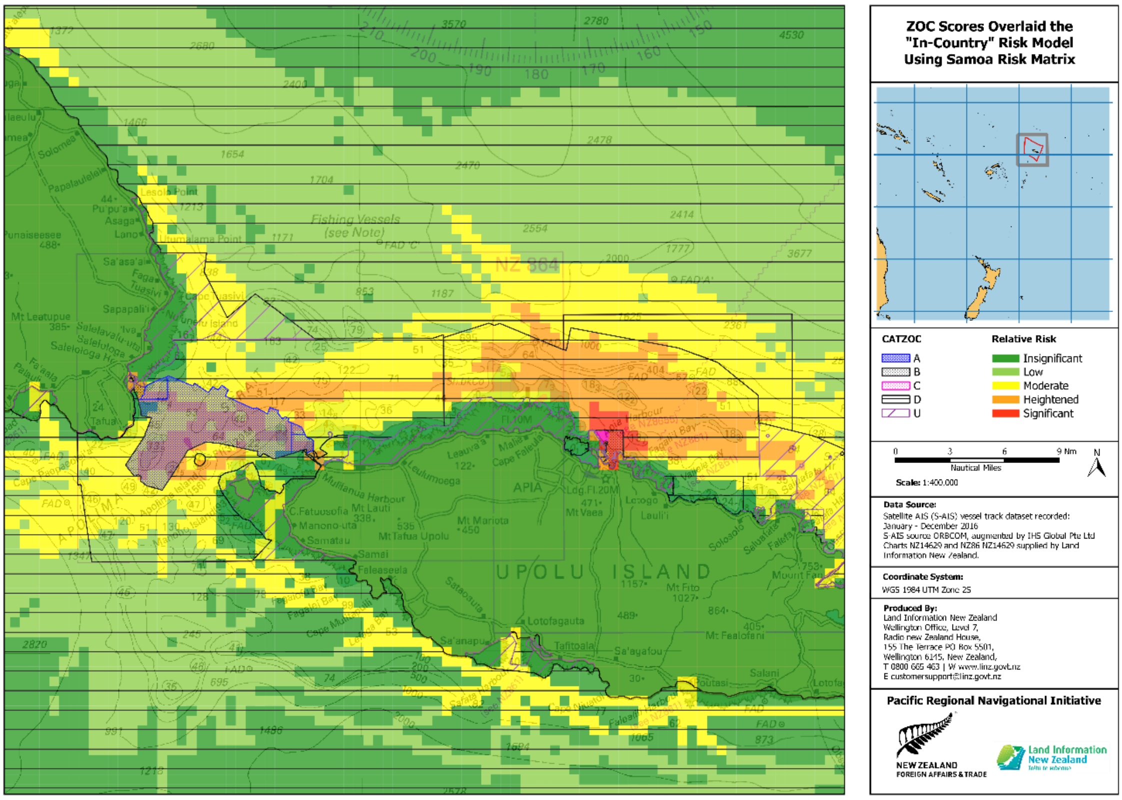

Figure 116: Risk result with CATZOC overlay – Apolima Strait to Apia

7.3.3 The above Figure shows the risk result overlaid by shaded areas showing the chart CATZOC. The *significant* (red) risk area outside Apia coincides with a CATZOC D area. Apia Harbour itself is CATZOC B and is also *significant* risk due to the high volume of traffic. Most of the *heightened* risk areas in this Figure coincide with areas of CATZOC D. However, Apolima Strait, and particularly the domestic ferry route from Mulifanua to Salelologa is classified as *heightened* or moderate risk despite its CATZOC A rating. This risk is a consequence of this route being the highest traffic area in Samoa, constrained navigation and close to sensitive and high value areas.

7.4 Other Ports and Harbours – Hydrographic Risk

7.4.1 The risk results overlaid with CATZOC for the entire Samoan Islands are shown in the Figure below.

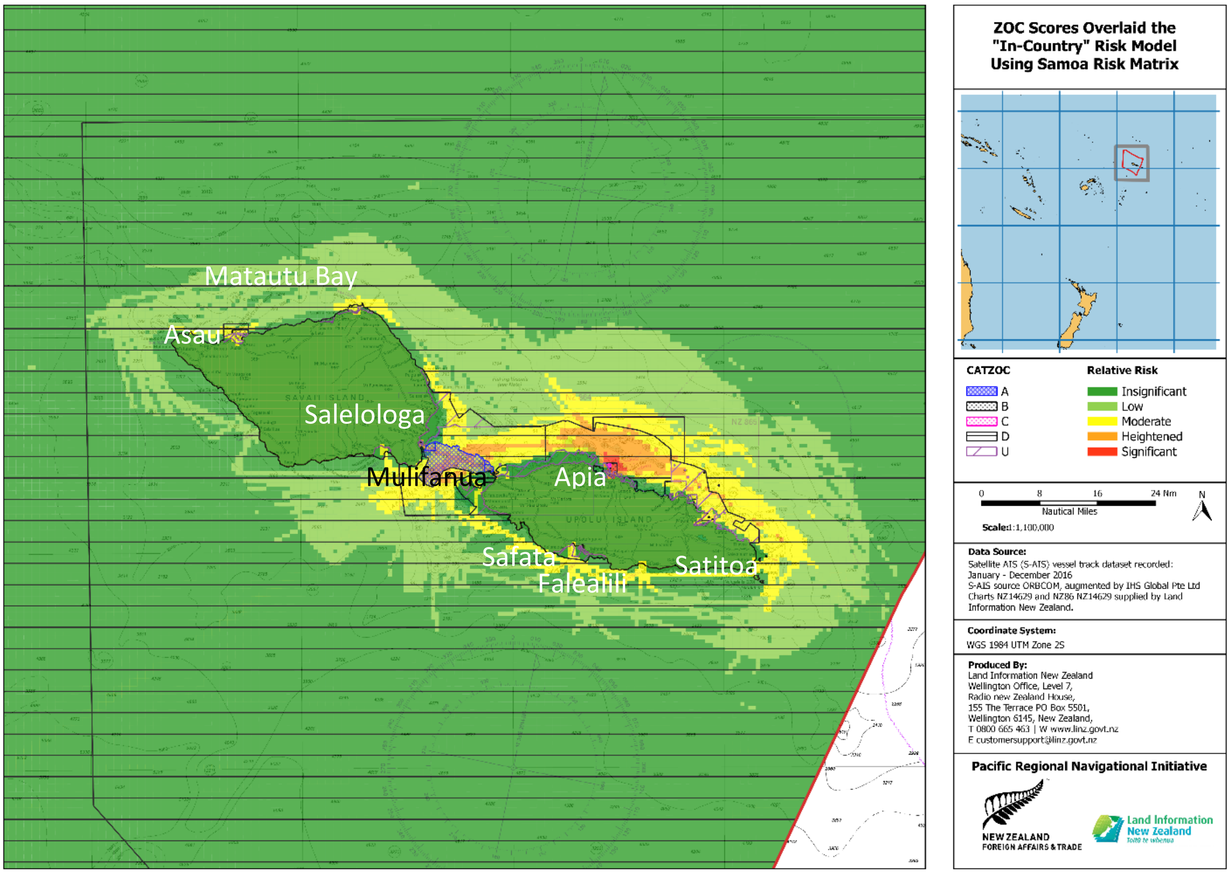

Figure 117: CATZOC ratings overlaid on risk result - Samoan Islands

7.4.2 All the coastal areas of Samoa, apart from the three main ports of Apia, Mulifanua and Salelologa and the disused port of Asau, are assigned CATZOC D or U, the two lowest charting quality indicators. As a consequence, even a small amount of traffic will raise the risk level. This can be seen above, where the entire south coast of Upolu falls within the lowest GT band yet moderate hydrographic risk areas exist at all the minor harbours, Safata, Falealili and Satitoa. The same is true for most of Savai'i including Matautu Bay and the approaches to Asau.

7.5 "Regional" Risk Assessment

7.5.1 In order to compare the results of this assessment with those of the other regional South West Pacific hydrographic risk assessments, a further heat map was produced using the regional South West Pacific low traffic risk matrix[141] and the same risk colour band break values as those in the Tonga, Cook Islands and Vanuatu risk assessments. The result is seen in the Figure below.

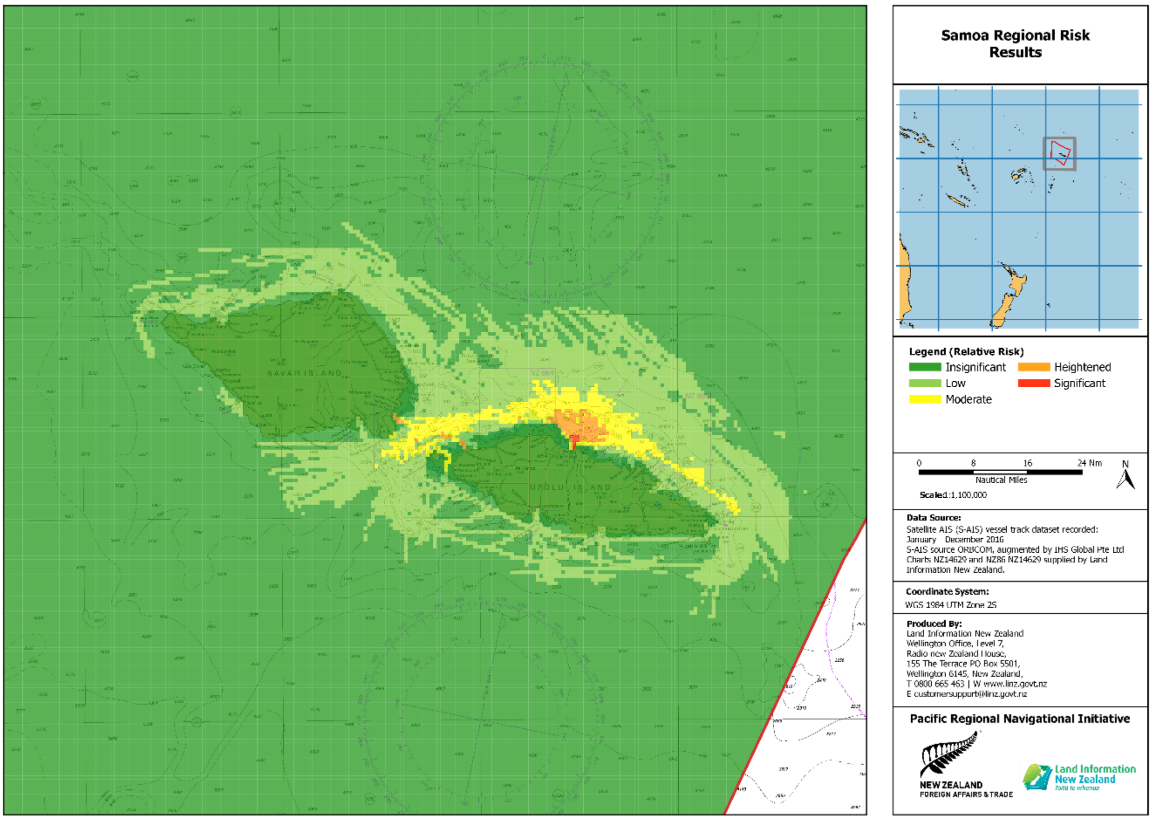

Figure 118: Samoa "Regional" Risk Result - Calibrated to Regional SW Pacific Risk Colour Bands

7.5.2 The resultant risk plot covers the full range of risks from green to red indicating that the overall risk levels in Samoa are of the same order of magnitude as those for previous assessments. Note that the plot differs from the Samoa "in-country" risk model results, showing all the risk category areas somewhat reduced in extent, indicating that overall, Samoa has slightly less hydrographic risk. This is likely a consequence of lower traffic outside the main shipping routes and good quality charting in the highest traffic areas of Apolima Strait and Apia Harbour.

[141] The SW Pacific low traffic area risk weightings were developed for LINZ as those most relevant to the regional hydrographic risk assessment programme (Marico Marine Report No. 15NZ322 Issue 03, 5 August 2015, p. D2)

7.6 Hydrographic and Chart Improvements

7.6.1 The CATZOC of the existing chart coverage is shown in the Figure below.

7.6.2 The airborne LiDAR bathymetry data collected as part of the Ridge to Reef project[142] (following additional hydrographic processing) has been assessed as sufficient to support upgrading the nautical charts to CATZOC A within the LiDAR coverage. This potential CATZOC as shown below represents a major improvement in chart quality.

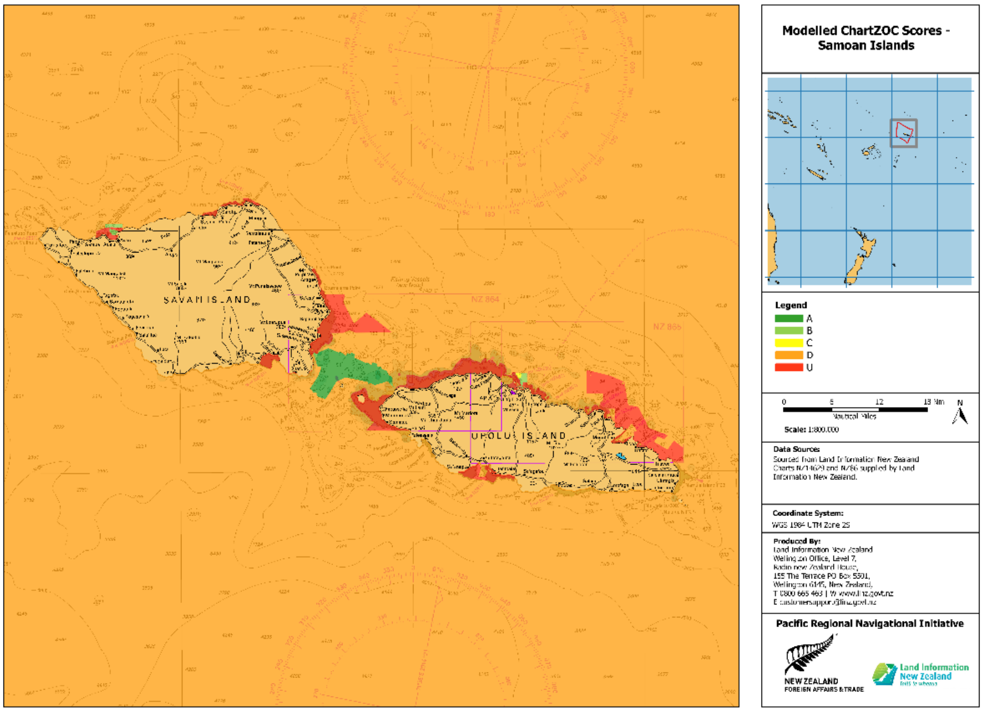

Figure 119: Existing Chart CATZOC

7.6.3 The benefit of upgrading existing charts using this LiDAR survey data is demonstrated by repeating the risk analysis using the modelled CATZOC input layer.

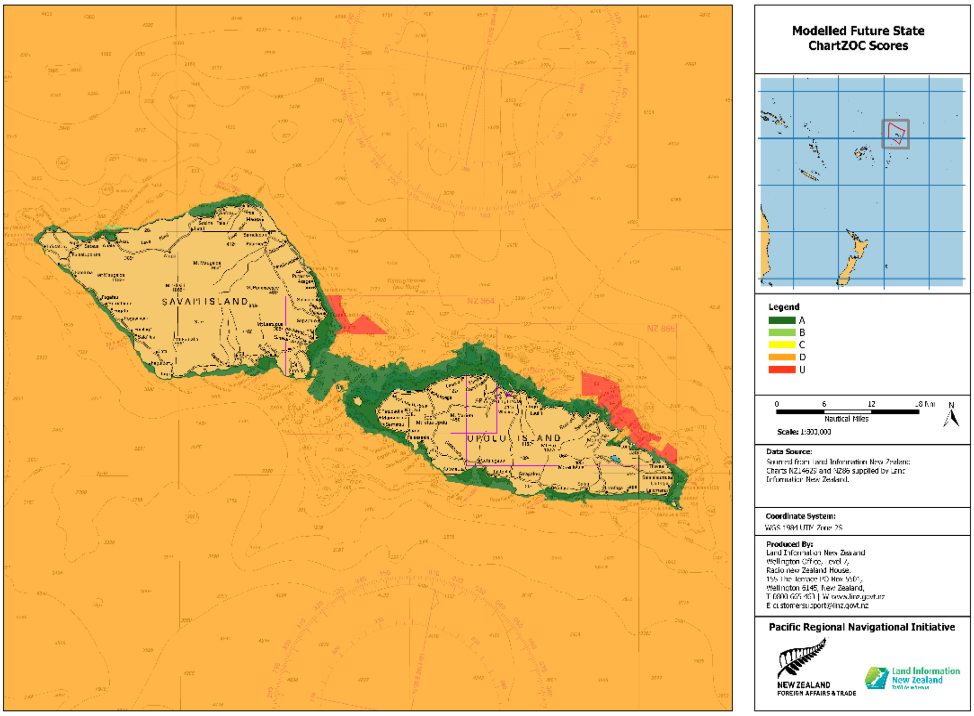

Figure 120: Modelled CATZOC After incorporating LiDAR bathymetry

7.6.4 The results in Figure 121 below should be compared with the earlier Figure 113. Disappointingly, there is very

[142] LiDAR bathymetry collected by Fugro LADS (World Bank, 2014)

little visible difference between these plots; some of the visible risk reductions have been highlighted. As the improved CATZOC only extends out to about the 40m contour, which is generally quite close to the coast, there is currently a lack of vessel traffic in many of the coastal areas, and no traffic means no risk in the model. Also, if two CATZOC values fall within a cell the model with use the worst-case value. Finally, where there is a risk reduction, the sensitivity of the colour bands is not always sufficient to move the risk classification to the next lower category.

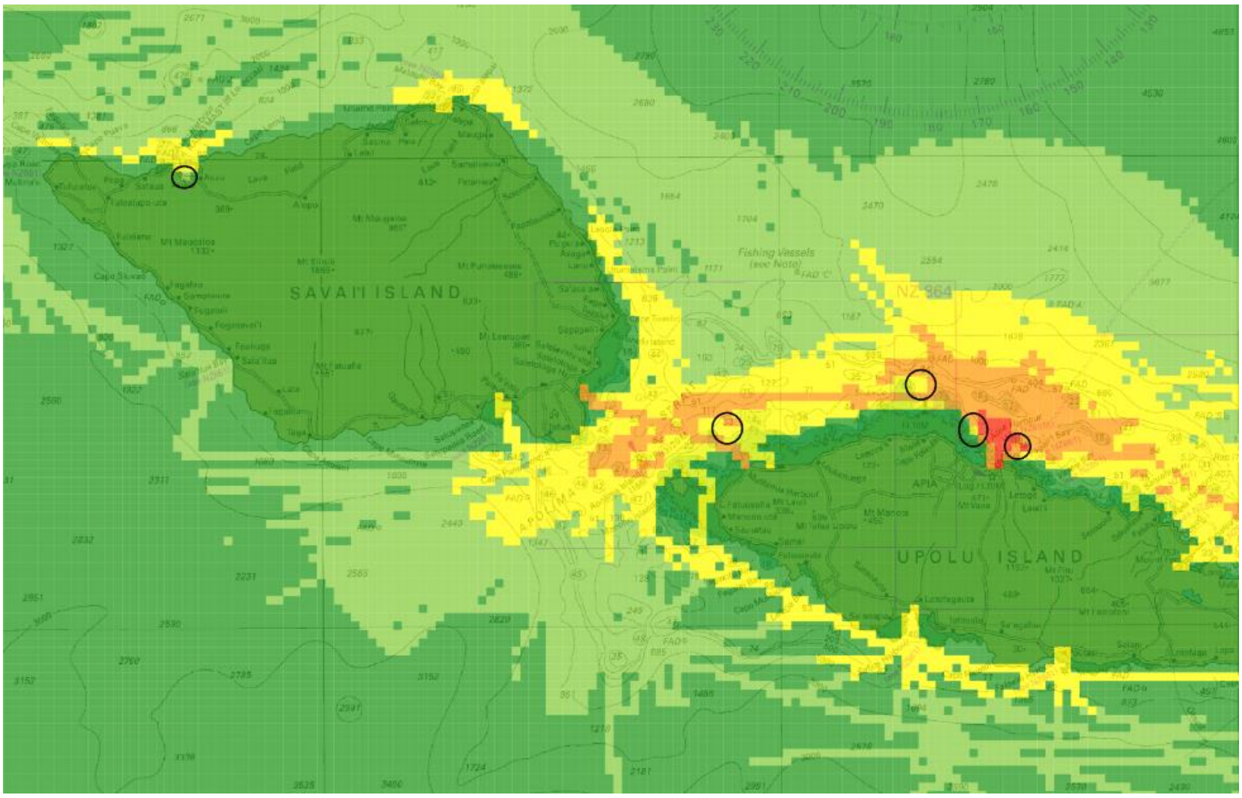

Figure 121: Risk reduction highlighted after by incorporating LiDAR data upgrading chart quality

7.6.5 The hydrographic risk reduction resulting from the incorporation of the LiDAR data is easier to see when plotted as the percentage risk reduction per cell which is provided in the Figures 122 and 123 below (over the existing CATZOC). The plots show a minimum risk reduction in low traffic areas of between 5% and 9% but up in some areas, dependent on traffic and existing CATZOC, this reduction increases to 25%. Of specific interest are the areas of Aleipata Port which reduced by 13-17% and Matautu Bay which spans 13-25% reduction and Asau Harbour which reduces by 21-25%.

7.6.6 These Figures also make it clear that where there is no traffic, there is no risk in the model, hence no risk current reduction. However, there is a reduction in the inherent risk in all cells within the new CATZOC area and this would become apparent should there be future vessel traffic. The reduction in inherent risk is used in the cost benefit modelling in section 8.

7.6.7 Noting that these risk reductions that can be achieved by incorporating the LiDAR data without the need of further expensive hydrographic survey. This LiDAR data should be incorporated into all published charts.

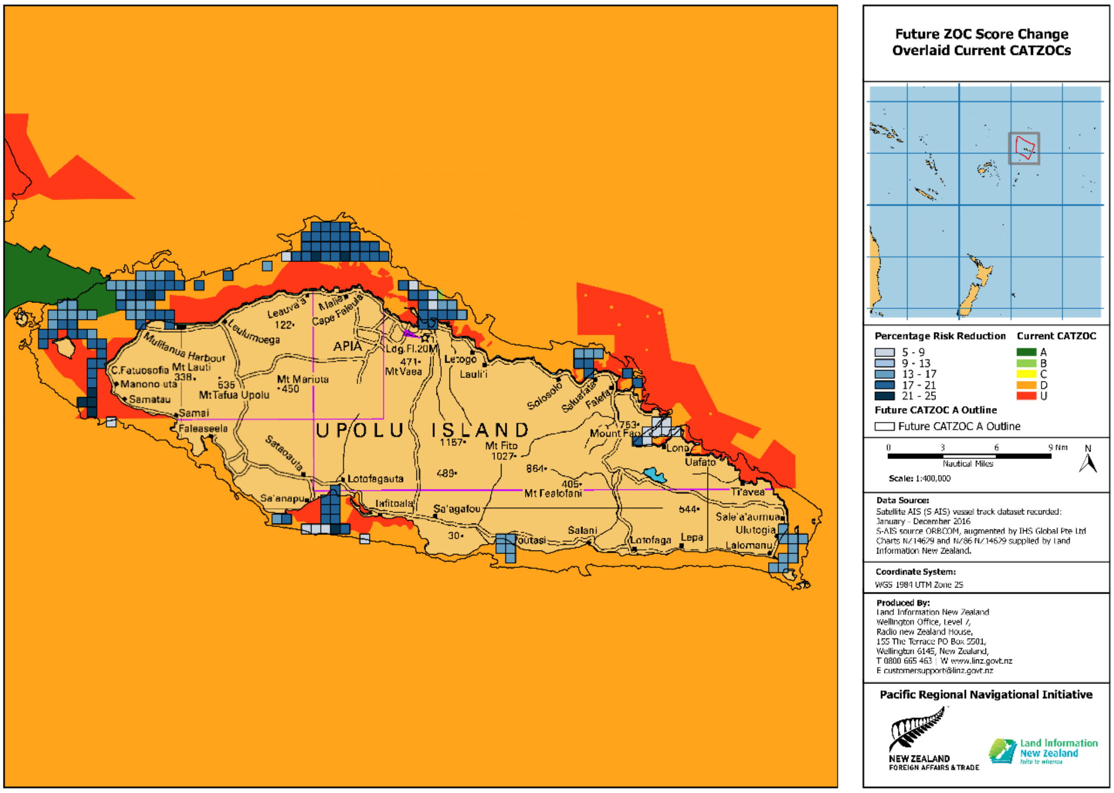

Figure 122: Percentage Risk Reduction Using LiDAR Data - Upolu

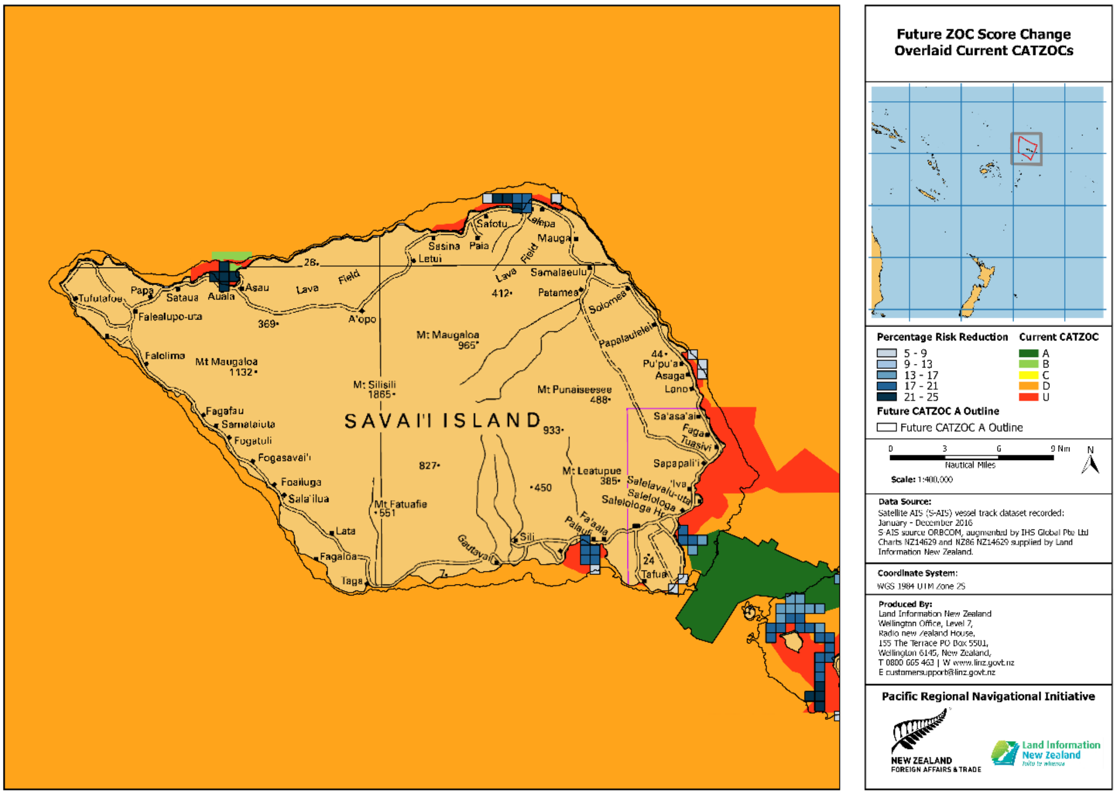

Figure 123: Percentage Risk Reduction using LiDAR data - Savai'i

7.7 Sensitivity Testing - Future Traffic Scenarios

7.7.1 To test the sensitivity of the hydrographic risk to potential future port developments the risk model was re-run after adding additional traffic that would arise from:

a. development of an international fish processing plant at Aleipata, and
b. development of an expedition cruise ship destination at Asau Harbour with ships also calling at Matautu Bay.

7.7.2 **Aliepata Scenario**. The port would develop an international fish processing plant which could initially support 30 tuna longliners of 150GT visiting 5 times per year. Importing supplies and exporting product would be done by one 400GT vessel making the loop to Apia 10 times per year. The traffic created by this scenario is shown in the Figure below.

7.7.3 **Asau and Matautu Scenario**. Asau would support 10 visits of expedition size cruise ships of up to 8,000GT and 4.9m draught per year. These vessels would first call at Apia then travel north west to Matautu Bay, thence to Asau and then depart west of Savai'i towards Fiji. The traffic created by this scenario is shown in the Figure below. Based on average numbers of 180 passengers and 90 crew per ship these visits would generate $410,000 plus pilotage and harbour dues per year.[143]

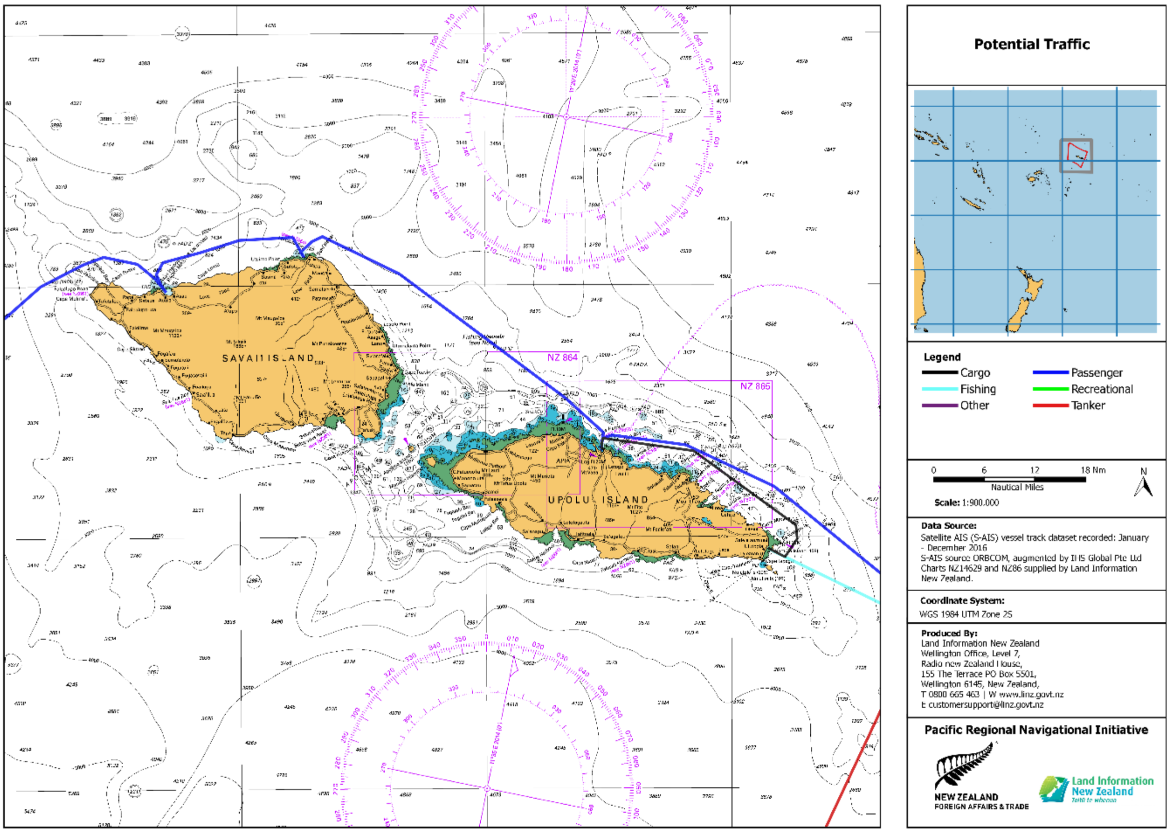

Figure 124: Potential Traffic from Asau and Aleipata Development Scenarios

[143] (Marico Marine Report No. 15NZ322 Issue 03, 5 August 2015, p. 38) using a conversion rate of USD$1=NZD$1.30

7.7.4 The Asau cruise ship scenario generates a total of 80,000GT on the coastal route across the north of Samoa and 160,000GT in Matautu Bay and Asau Harbour. The Aleipata fish processing scenario generates 45,000GT of fishing vessel traffic through Aleipata Port and 8,000GT of cargo vessel traffic around the north east and east coasts of Upolu between Aliepata and Apia. The risk impact can be seen in the Figure below with the differences highlighted (compared with the current risk shown in Figure 113).

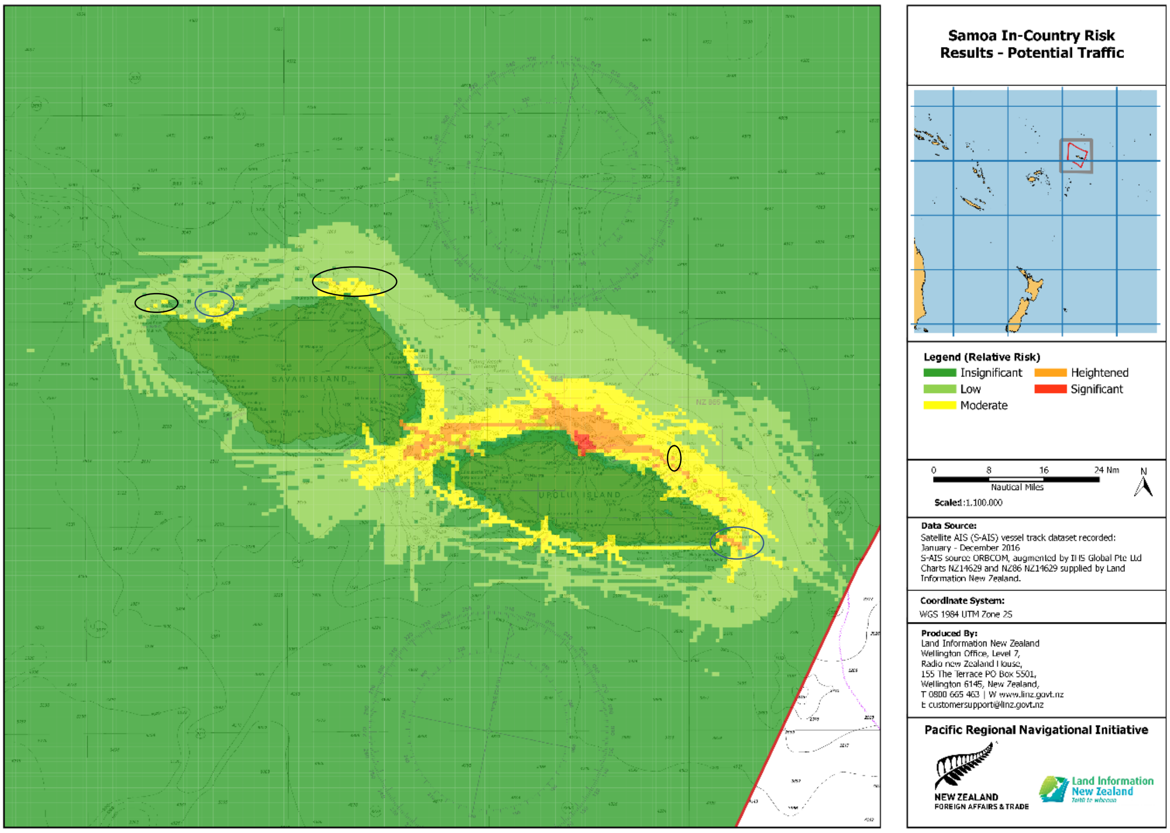

Figure 125: Risk Impact of Potential Scenario Traffic

7.7.5 These scenarios show that the existing model is quite robust and not significantly changed by reasonably significant changes in shipping traffic. Nevertheless, h*eightened* risk can now be seen in the approaches and port of Aleipata and new and expanded areas of *moderate* risk are apparent on the north coast of Savai'i, particularly in the approaches to Asau and Matautu Bay. Decisions on current charting requirements should be taken with consideration of potential future developments.

7.8 Summary of Chart Improvement Recommendations

7.8.1 Considering the current status of charting, the current traffic profile and the potential for future developments the following chart improvements are recommended:

a. The LiDAR bathymetry data should be incorporated into the published charts to extend the navigable area and reduce those areas currently indicated as "inadequately surveyed". This will reduce the hydrographic risk in near coastal waters, and particularly improve the safety of recreational, local fishing and patrol vessels that visit remote coastal areas. It will also support the potential expansion of cruise vessel destinations.

b. Produce a large-scale harbour chart for Aleipata Port, (Satitoa) to support current and potential future use of the port.

c. The continuation of the 1:50,000 scale coastal chart series to provide a suitable approach chart for the port of Aleipata and to support future expanded cruise ship, recreational and commercial operations. The priority for this series is the eastern coast of Upolu and the northern coast of Savai'i covering the moderate risk areas near Asau Harbour and Matautu Bay. Consideration should also be given to charting the southern coast of Upolu where *moderate* hydrographic risk exists. The south coast of Savai'i is not considered necessary due to the lack of traffic or hydrographic risk. This chart series will be of a suitable scale as the source for ENC (compulsory for all SOLAS class vessels), and other electronic chart systems commonly used in recreational vessels.

d. Modernise chart NZ 1414 Asau by shifting it to WGS84 horizontal datum to be compatible with GPS positioning systems, and produce the equivalent ENC to support future patrol boat and future potential commercial port operations.

e. Modernisation (including metrication and incorporation of LiDAR data) of plans of those non-commercial ports that are most utilised for recreational/superyacht, cruise ship and patrol vessel visits to include:

   i. Vailele Bay – Modernisation of fathoms plan

   ii. Saluafata Harbour - Modernisation of fathoms plan

   iii. Fagaloa Bay - Modernisation of fathoms plan

   iv. Safata Harbour - Modernisation of fathoms plan

   v. Siumu Bay - Production of a new plan

   vi. Matautu Bay – Production of a larger scale (1:25,000) plan

f. Ensure effective communications of MSI from Samoan information sources to the regional MSI coordinator and charting authority so that changes that impact navigational safety, such as the charted status of navigational aids and FADS are kept up to date.

7.8.2 **Other hydrographic observations**.

a. The port of Mulifanua has a very shallow dredged channel charted at 2.5m deep. The ferry *Lady Samoa III* has a designed draft of 2.35m and operates on a routine schedule at all states of the tide. It is considered that at some states of the tide and in some weather conditions interaction between the vessel and the seabed could occur, this may cause the ship to shear off course resulting in an incident. It is recommended consideration be given to dredging the channel to provide greater under keel clearance.

b. The line of the outer leads at Mulifanua does not provide sufficient clearance from the reef on the southern side and ships must approach the channel from the north side of the lead line with the leads open. Consideration should be given to dredging to clear the channel (preferred) or repositioning the outer leads and adjusting the leading line.

c. The line of the outer leads at Salelologa does not provide sufficient clearance from the reef on the northern side and ships must approach the channel from south of the lead line with the leads open. Consideration should be given to dredging to clear the channel (preferred) or repositioning the outer leads and adjusting the leading line.

8. ECONOMIC ANALYSIS – COST BENEFIT ANALYSIS

8.1 Introduction

8.1.1 The CBA methodology of previous work in LINZ SW Pacific hydrographic risk assessment programme is based on comparing the cost of conducting hydrographic survey for each cell with a benefit calculated from reduced personnel loss and oil spill clean-up costs, plus an estimated economic benefit of arising from the availability of better charts. The percentage of reduced inherent risk in each cell is dependent on its current CATZOC rating as shown in the following table.

CATZOC Rating	Risk Reduction
A	2.5%
B	5%
C	10%
D	20%
U	30%
Fathoms Charts	45%

Figure 126: Effectiveness of Improved Charting[144]

8.1.2 This method is valid for those areas where maritime traffic routinely transits and hydrographic survey and chart quality directly impacts the safety of navigation, such as in shallow areas where ships are depth constrained, confined navigational areas where the width of the navigable water will restrict the ability of vessels to manoeuvre to avoid collision, or unsurveyed waters where unknown seabed obstructions dangerous to surface navigation may exist.

8.1.3 In the case of Samoa, once you are 10nm from the coast the water is consistently deep and there is no risk of surface ships grounding except in the vicinity of Pasco Bank on the western extremity of the EEZ. This assessment is indicatively confirmed by the lack of reported maritime incidents in Samoa's EEZ. In these circumstances, whilst the conduct of a systematic, deep water multibeam survey of the entire Samoan EEZ would produce benefits in terms of mapping of ocean resources, the effort and cost would not result in any practical reduction in the risk of grounding; the benefit of improved CATZOC would only be theoretical. Therefore, it is it unnecessary to conduct a cost benefit analysis to assess value of investing in hydrographic surveys in the deep ocean areas. Clearly, the result would yield a substantial negative NPV for all these deep offshore areas.

8.1.4 This analysis provides a generalised cost benefit comparison. It considers the cost of updating existing charts, or producing new larger scale charts of some near coastal areas against the potential cost savings in oil spill clean up costs and fatalities from reduced hydrographic risk as well as the direct benefits of potential future maritime developments (such as those discussed in section 7.7 above). A unique opportunity for Samoa is that there is a recent LiDAR survey of the shallow coastal waters where dangers likely to impact surface navigation may be found. This enables significant charting improvements without the high cost of a broad area hydrographic survey, though detailed surveys of limited areas are still considered beneficial.

[144] (Marico Marine Report No. 15NZ322 Issue 03, 5 August 2015, p. 36)

8.2 Coastal Chart upgrades – Costs and Benefits

8.2.1 The following table summarises the costs and benefits of recommended upgrades to charts. A key element of the benefit in each case is the reduction in likelihood of a maritime incident which is expressed as a percentage risk reduction. Avoiding one average dry cargo vessel grounding of 150 tonne MFO spill (see Annex A-3) saves $2.2 million in oil spill clean-up costs.[145] Avoiding one fatality is valued at $4.3 million.[146]

Item	Description	Cost (NZD)[147]	Benefit (NZD)[148]
1.	**Upgrade existing charts with new coastal LIDAR bathymetry** Reprocessing of LiDAR data Update of Charts	 $40,000 $65,000	Average 20% risk reduction in likelihood of a maritime incident (1 in 5)
2.	**New large scale chart of Aleipata Port** Chart production Limited detail hydrographic survey	 $15,000 $100,000	Meet SOLAS requirements for international port operation and enable commercial port development iaw scenario paragraph 7.7.2 Average 30% (1 in 3.3) risk reduction in likelihood of a maritime incident.
3.	**New 1:50,000 coastal chart east coast Upolu and approaches to Aleipata** Chart Production	 $45,000	Support commercial port development iaw scenario paragraph 7.7.2 Average 20% (1 in 5) risk reduction in likelihood of a maritime incident.
4.	**New 1:50,000 coastal chart north coast Savai'i** Chart Production	 $45,000	Average 20% risk reduction in likelihood of a maritime incident.

[145] Oil spill clean-up costs calculated per (Marico Marine Report No. 15NZ322 Issue 03, 5 August 2015, p. 38) using a conversion rate of USD $1=NZD $1.30
[146] Implied Cost of Averting a Fatality adopted from (Marico Marine Report No. 15NZ322 Issue 03, 5 August 2015, p. 37) using a conversion rate of USD$1=NZD$1.30
[147] Details of costs of chart upgrade and modernization provided by LINZ
[148] Risk reduction potentials explained at para 8.1.1 above

			Encourage further cruise ship and recreational vessel tourism.
5.	**Modernise NZ 1414 Asau Harbour (WGS84 datum, additional soundings and production of ENC).** Chart production Additional hydrographic survey	 $15,000 $100,000	Meet SOLAS requirements for international port operation to enable use as a commercial port Enable port development such as scenario paragraph 7.7.3 (valued at $410,000 per year plus maritime charges) Average 20% (1 in 5) risk reduction in likelihood of a maritime incident.
6.	**Modernisation of fathoms charts of Valilele Bay, Saluafata Harbour, Fagaloa Bay, Safata Harbour** Chart production Additional hydrographic survey	 $25,000 ($5,000 each) $100,000	Enable commercial utilisation and patrol vessel access to these harbours. Encourage additional recreational vessel tourism. Average 45% (1 in 2.1) risk reduction in likelihood of a maritime incident.
7.	New large scale charts of Siumu Bay and Matautu Bay Chart production	 $20,000 ($10,000 each)	Enable/encourage potential cruise ship destinations. Average 30% (1 in 3.3) risk reduction in likelihood of a maritime incident.

8.2.2 From the above table it is apparent that the investment in hydrography, and in particularly the upgrade or modernisation of charts, provides a substantial positive cost benefit in all proposed chart improvement recommendations.

9. OBSERVATIONS ON THE SAMOA HYDROGRAPHIC RISK ASSESSMENT

9.1 The formal hydrographic risk analysis of Samoa's EEZ was conducted using a new, comprehensive vessel traffic AIS dataset collected over the 2016 calendar year. This is a more complete dataset than that previously used to estimate the traffic using non-contiguous observation periods. The impact is that the traffic levels in this assessment are likely to be higher (and more realistic and up to date) than those previously used, which will increase the apparent risk on a "regional" basis.

9.2 The risk analysis parameters for the "regional" analysis are the same as those used in earlier assessments of the Cook Islands, Tonga and Niue in order to provide, as nearly as possible, a result that would be consistent across the regions for comparative purposes. However, the "in-country" risk assessment was conducted by first removing the risk consequence categories that did not occur in Samoa and redistributing the risk for that consequence category across the remaining criteria. This was intended to emphasise the differing risk levels within Samoa.

9.3 As in previous assessments, it is recognised that, despite standardisation of risk matrices, the comparative results would be greatly impacted by significant differences in current vessel traffic volumes, and differences in the geological characteristics of the seafloor between different regions. For this assessment, the differences have been compounded by use of a newer vessel traffic dataset and a different grid cell size. For these reasons, it is considered that the most useful results are those represented by the "in-country" analysis while the "regional" results still provide a useful but not numerically comparative result. Furthermore, the new dataset reflects changes to traffic over the last 5 years, since that collected for the Vanuatu, Tonga, Cook Islands and Niue risk assessments. The benefit of using a comprehensive and recent traffic data set provides the most up to date "in-country" analysis possible. This is considered to outweigh the alternative option of using a dated but common dataset which would provide a more consistent "regional" comparative result.

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ANNEXES

ANNEX A - Event Trees

1. Event trees were used to determine the most likely and worst credible impacts of defined unwanted navigation events. For consistency and commonality across the South West Pacific hydrographic risk assessment area, the event trees in this Annex are based on the generic event trees in the Risk Assessment Methodology[149] and those used in the Cook Islands[150] and Tonga[151] and Niue[152].

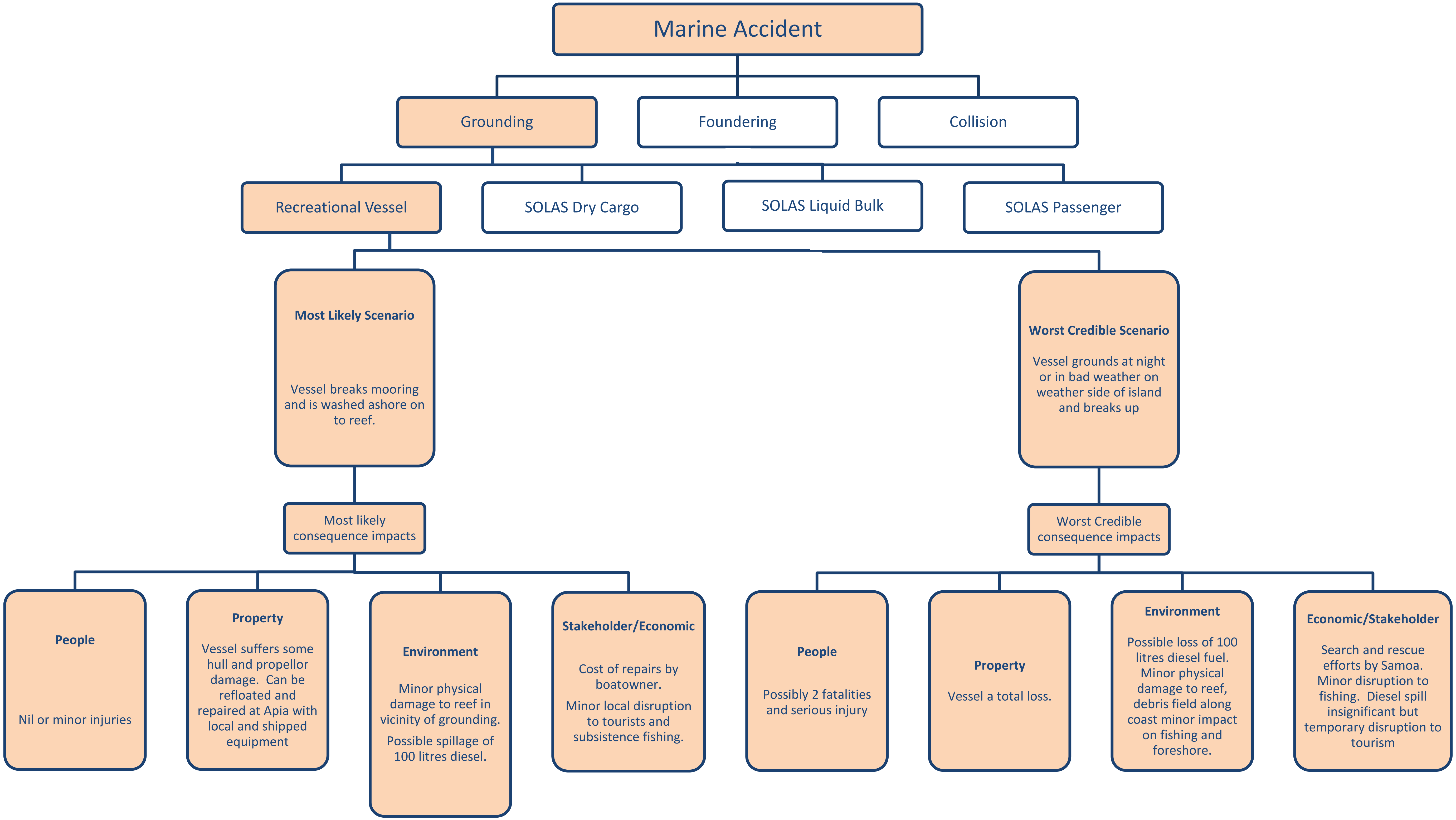
2. Samoa has substantial domestic traffic due to the frequent inter-island passenger/vehicle ferry service from Mulifanua to Salelologa and regular cargo/fuel journeys from Apia to Salelologa. This category represents the highest likelihood of incident due to the frequency of passages and the constrained navigation at the terminal ports.

3. Recreational vessels present a different type of risk in that this class of vessel is more likely to navigate into poorly charted waters in remote areas and therefore do present a risk, though consequence is limited to personnel casualties. Accordingly, an event tree that covers the grounding of recreational vessels has been included.

3. The event trees were used to confirm the veracity of the weightings of the risk consequence factors employed in the overall risk calculations and to estimate consequential costs of incidents in the cost benefit analysis (described in Section 8 of the main report).

[149] (Marico Marine Report No. 15NZ322 Issue 03, 5 August 2015)
[150] (Marico Marine Report No. 14NZ262MR Issue 02, 20 January 2015)
[151] (Marico Marine Report No. 14NZ262 – TM, Issue 1, 27 November 2014)
[152] (RNAPL16002 - NIUE Hydrographic Risk Assessment, 2016, p. Annex A)

ANNEX A - Event Trees



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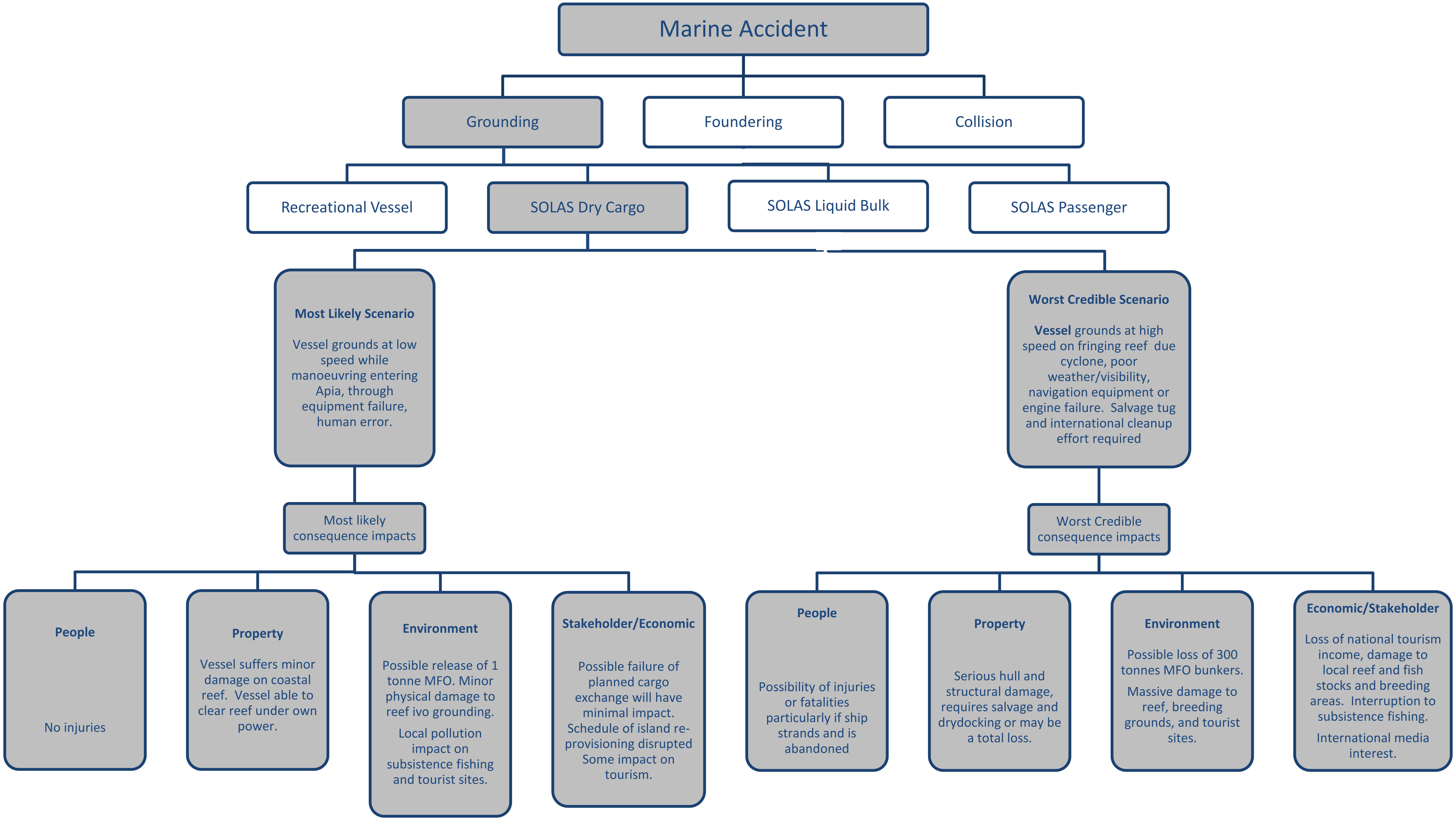
ANNEX A - Event Trees



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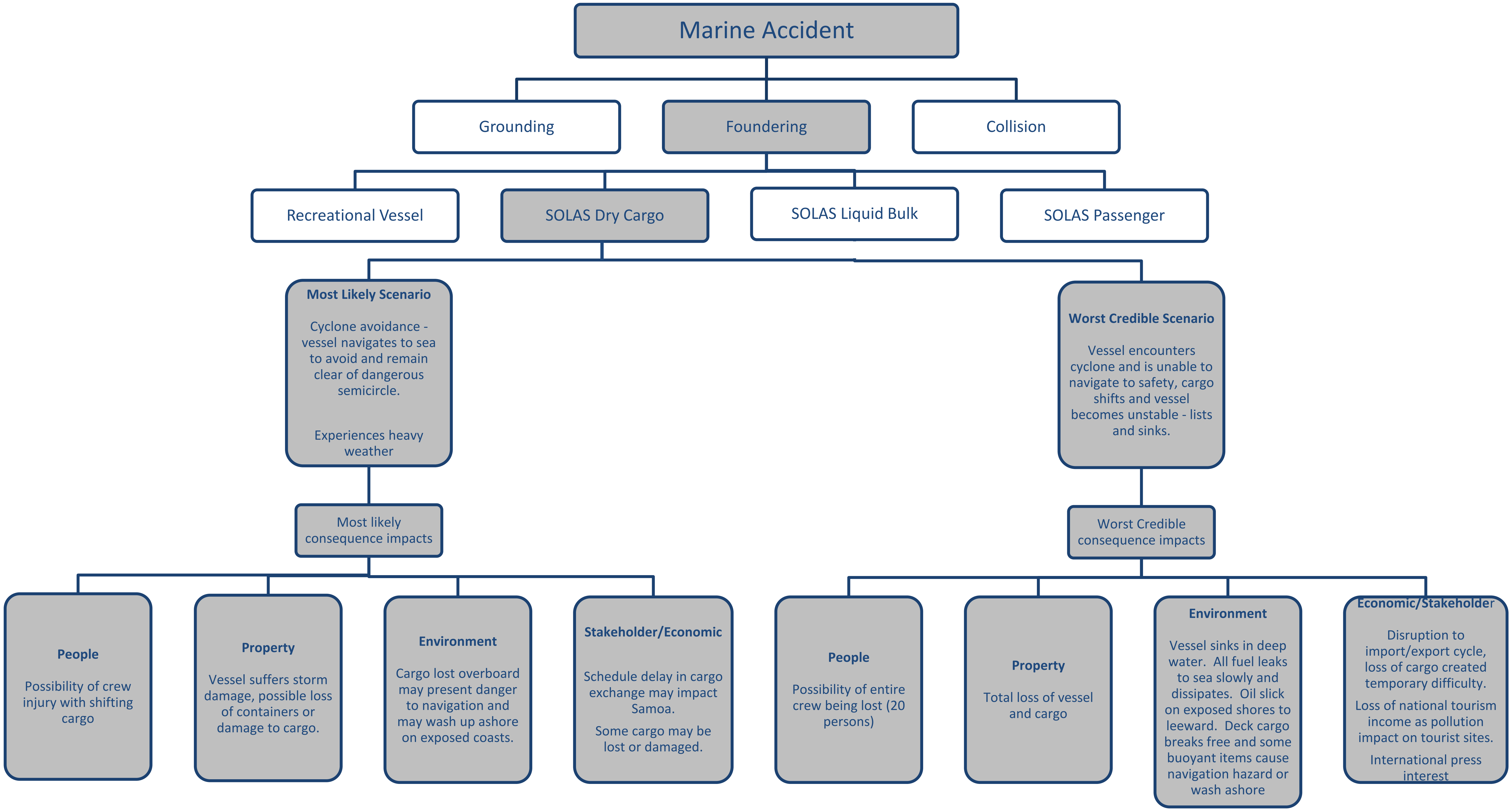

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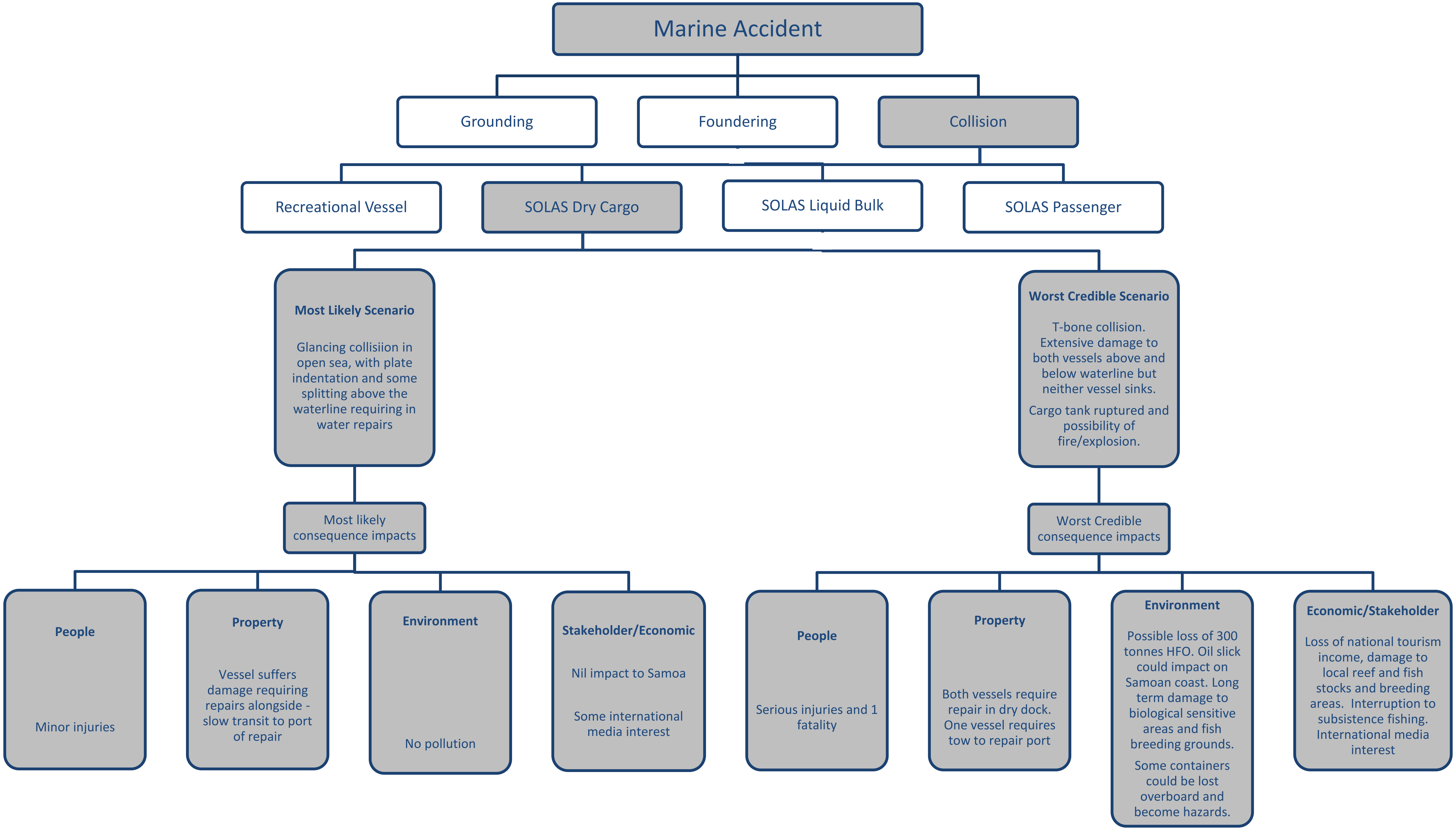

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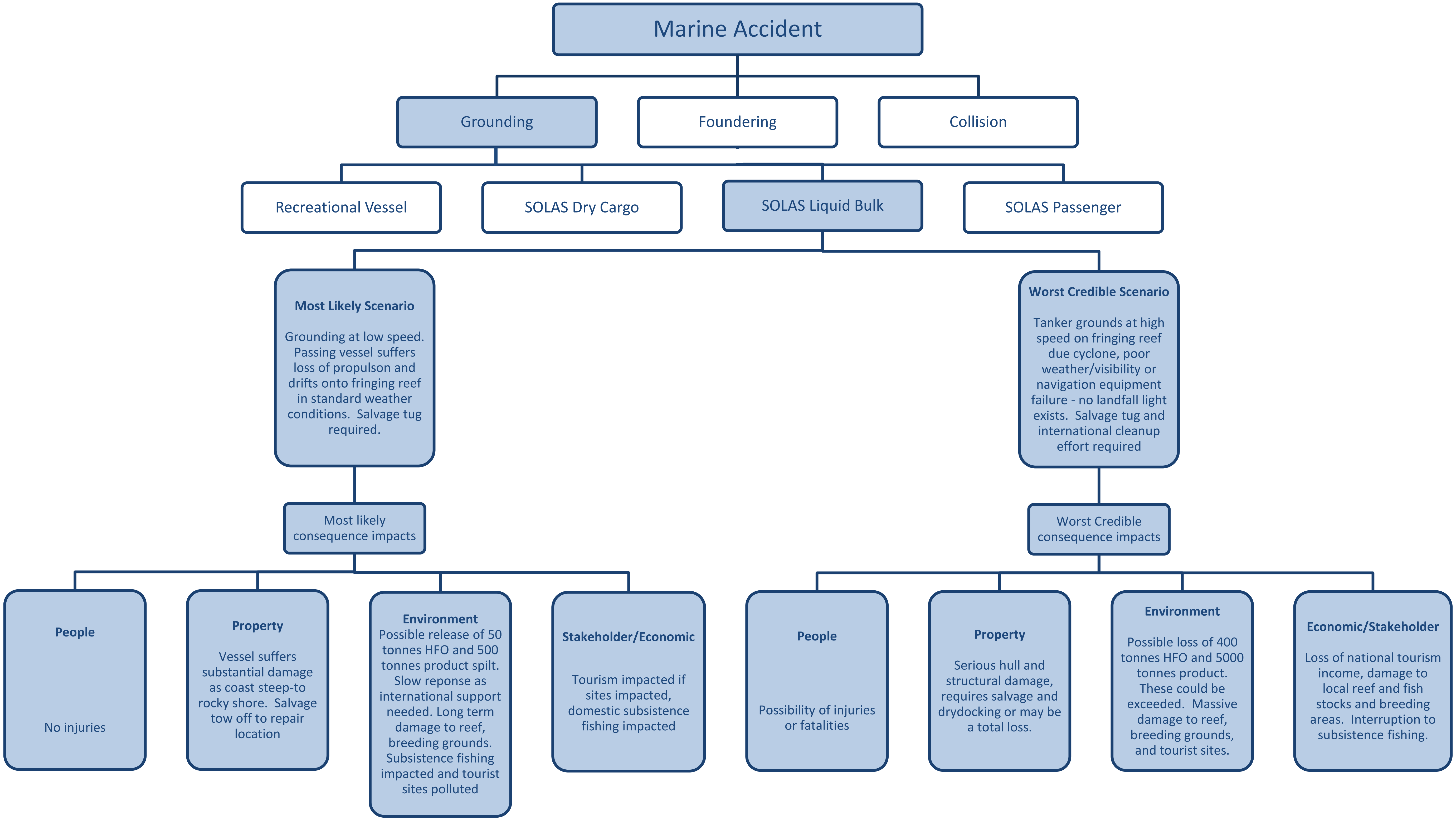

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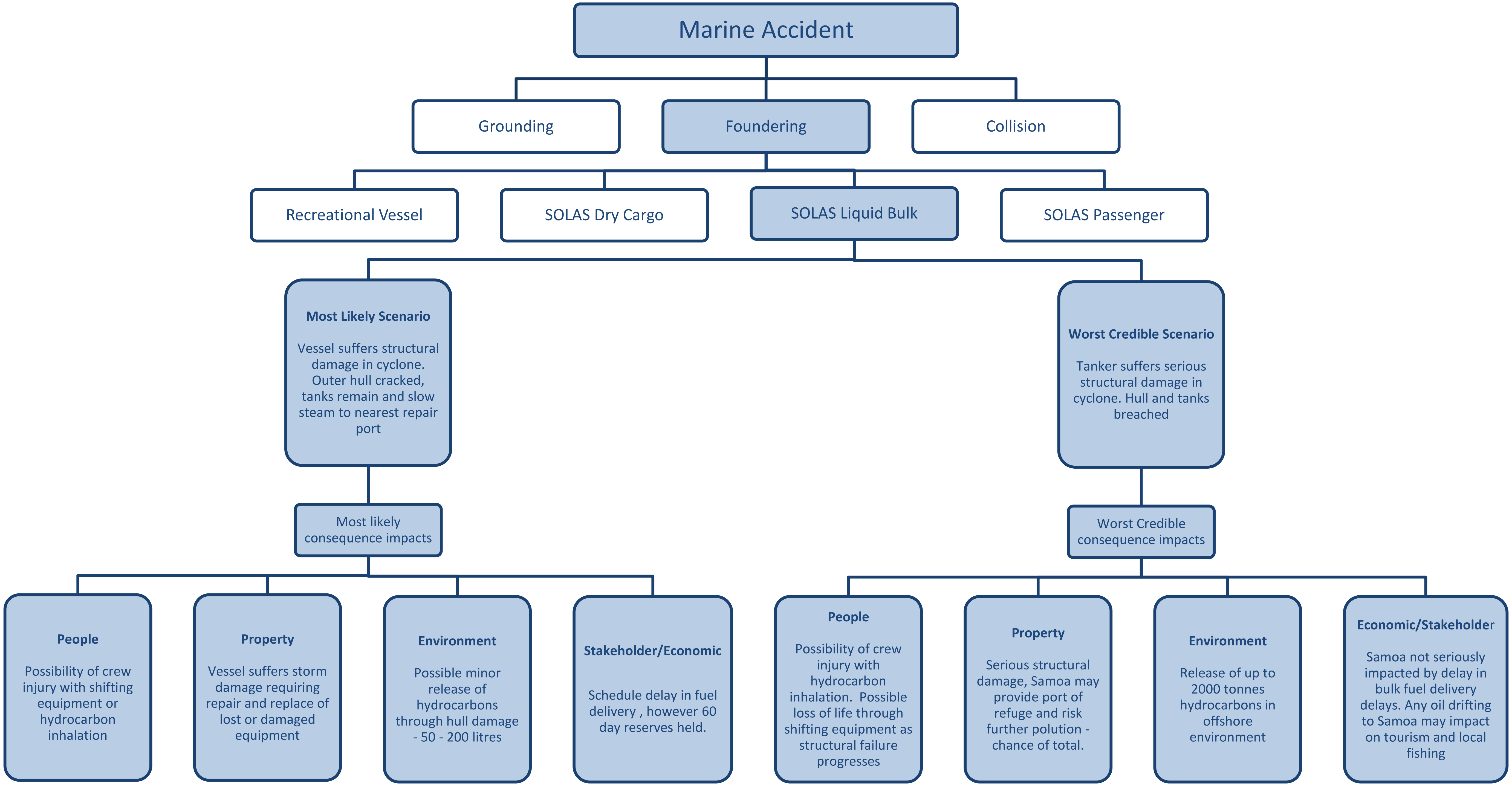

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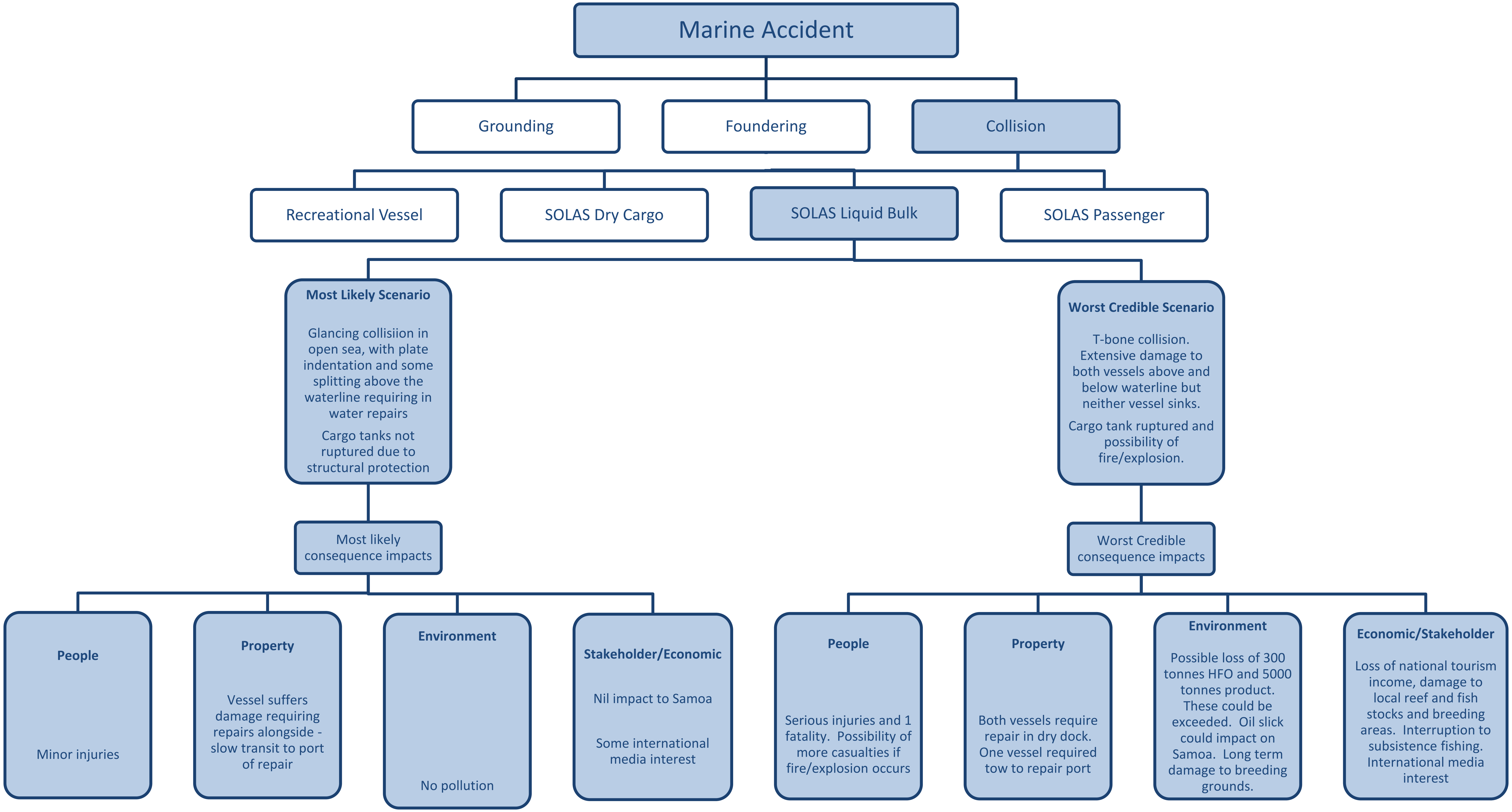

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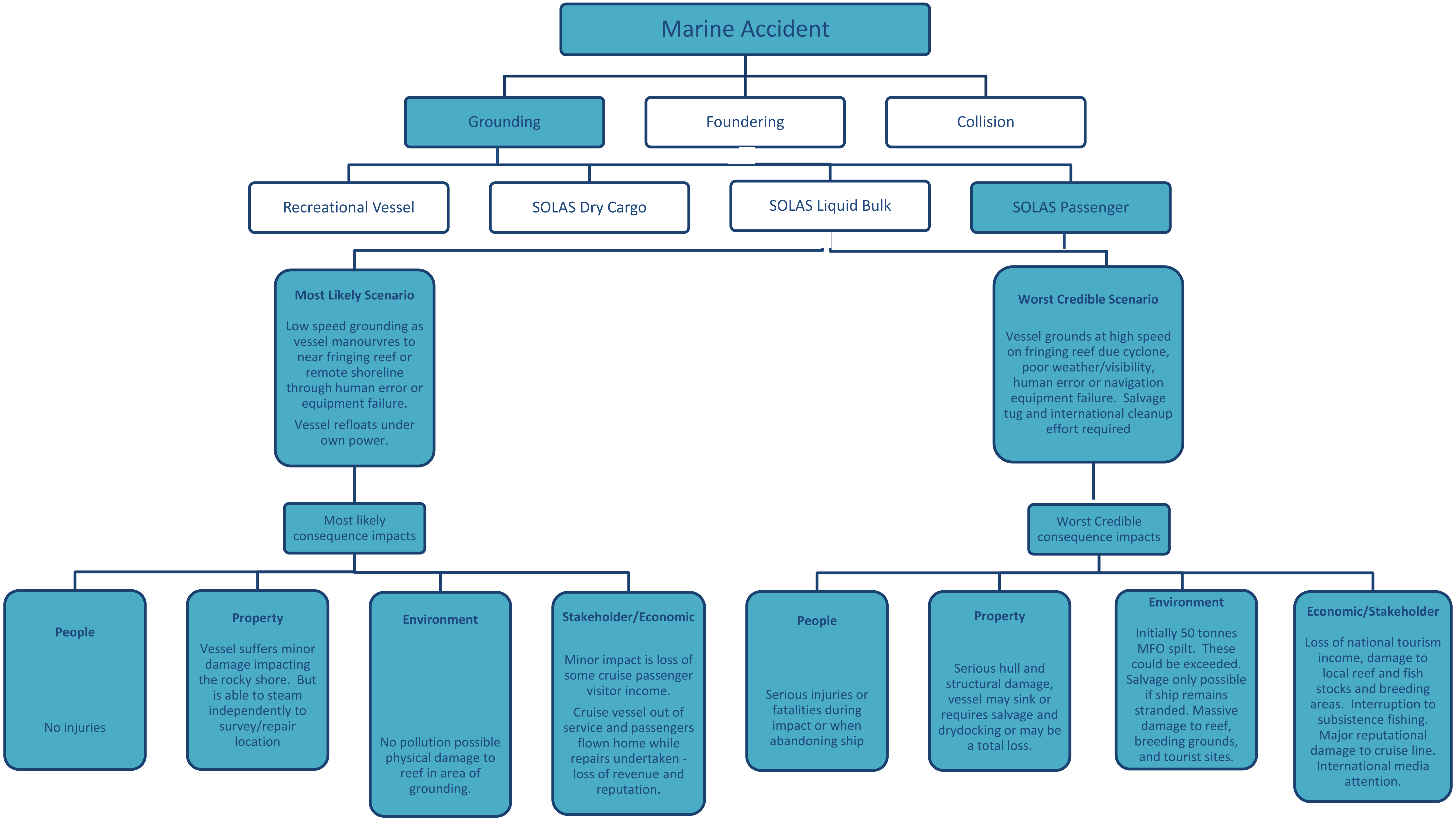

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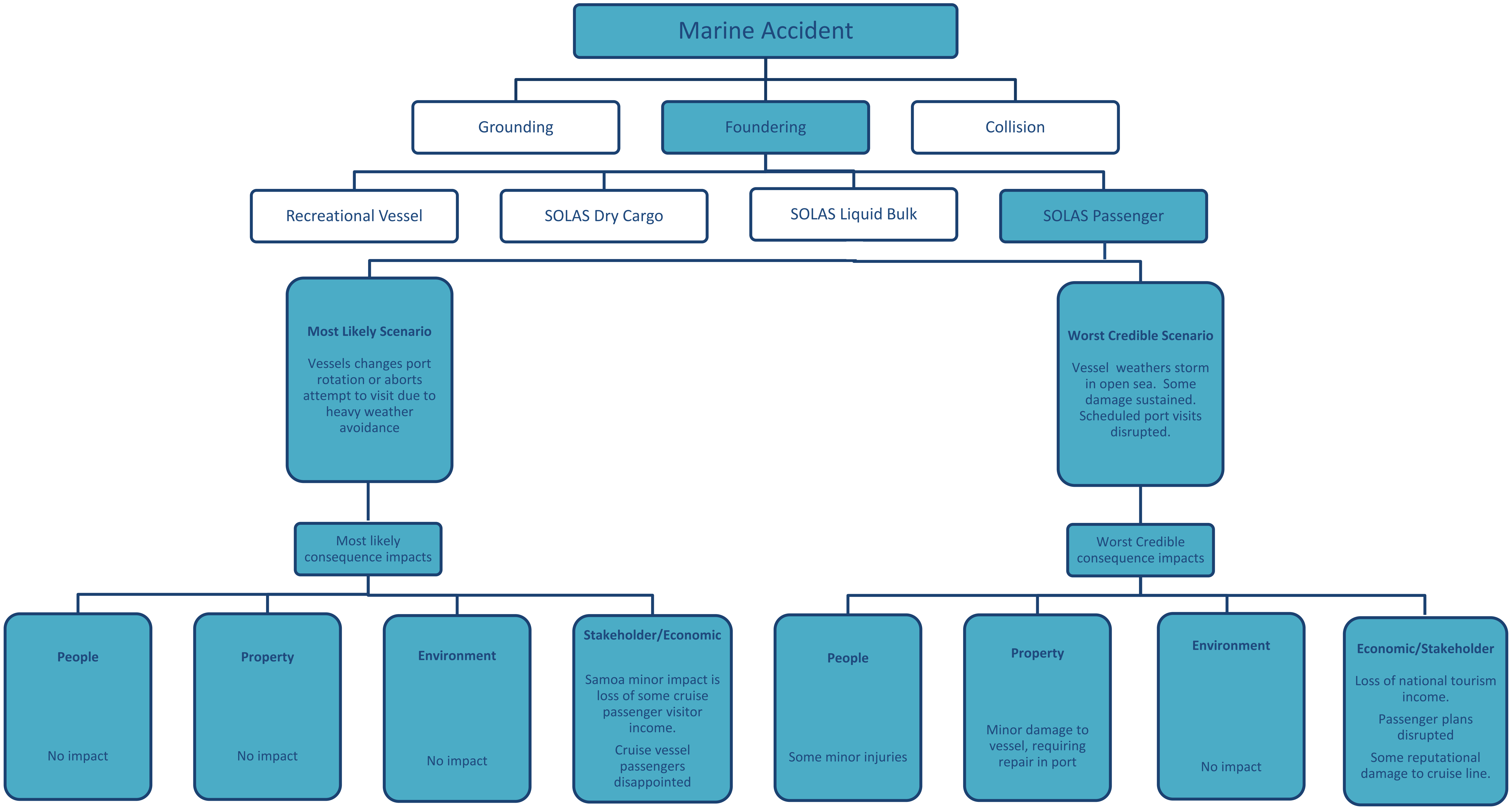

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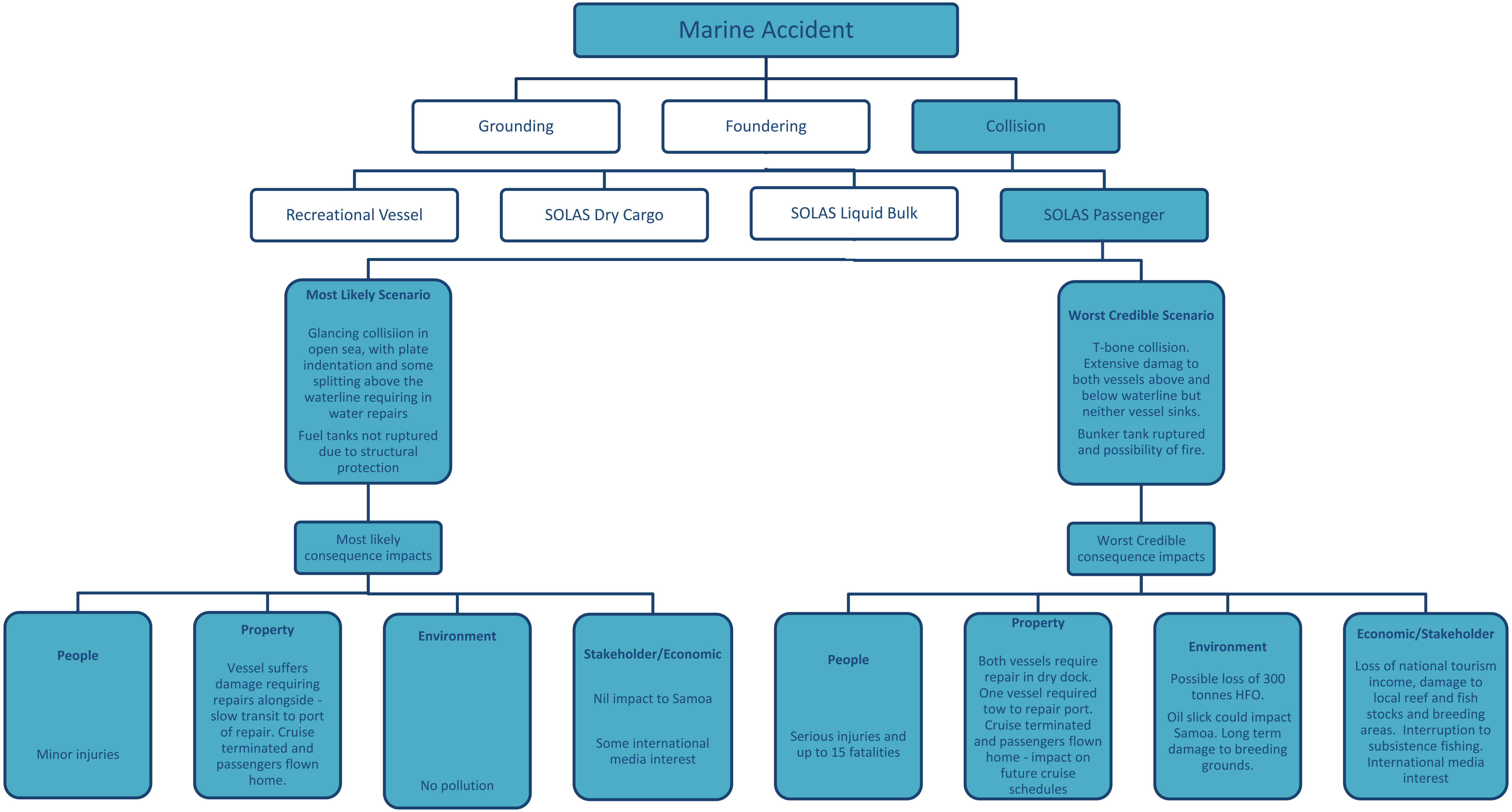

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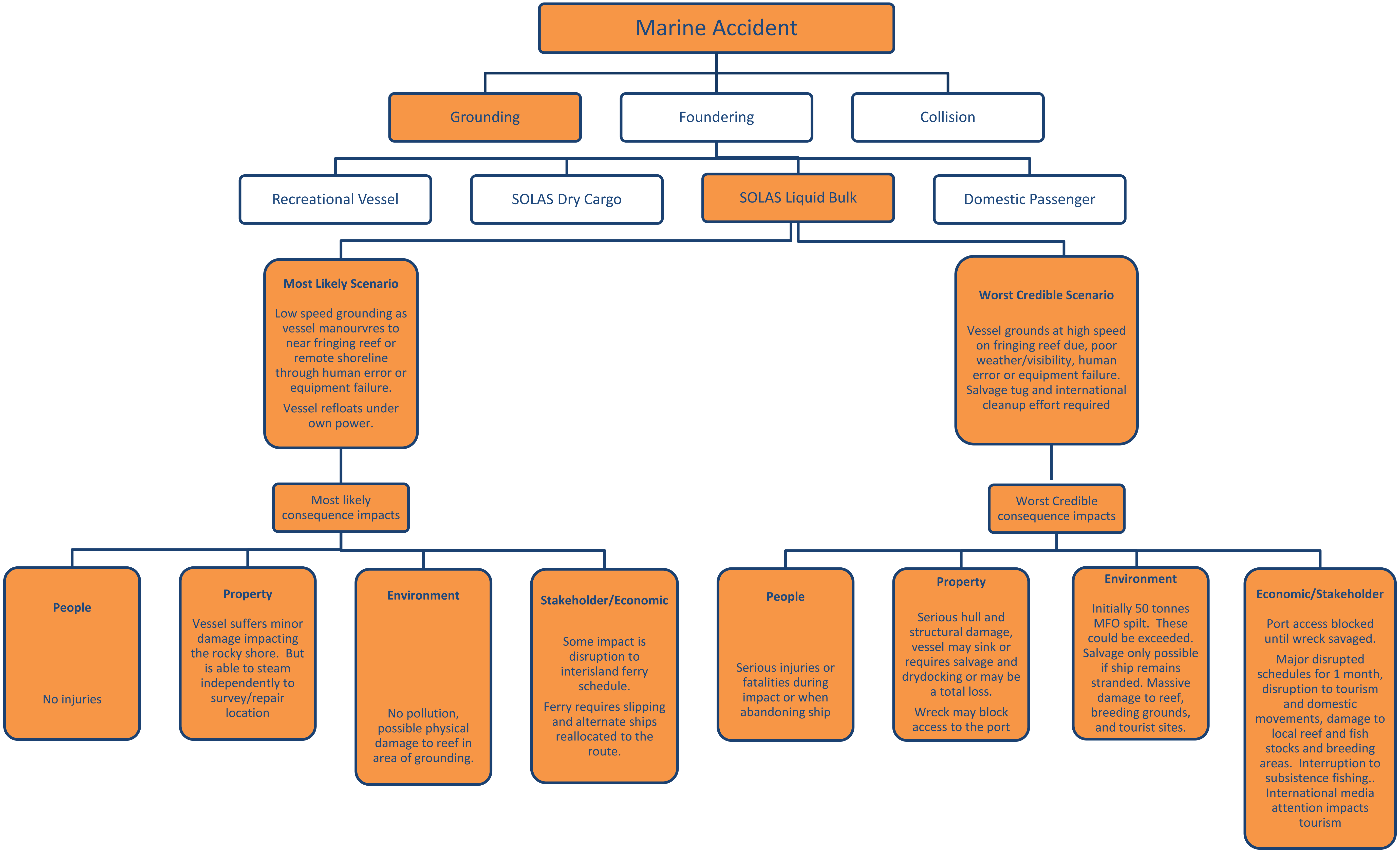

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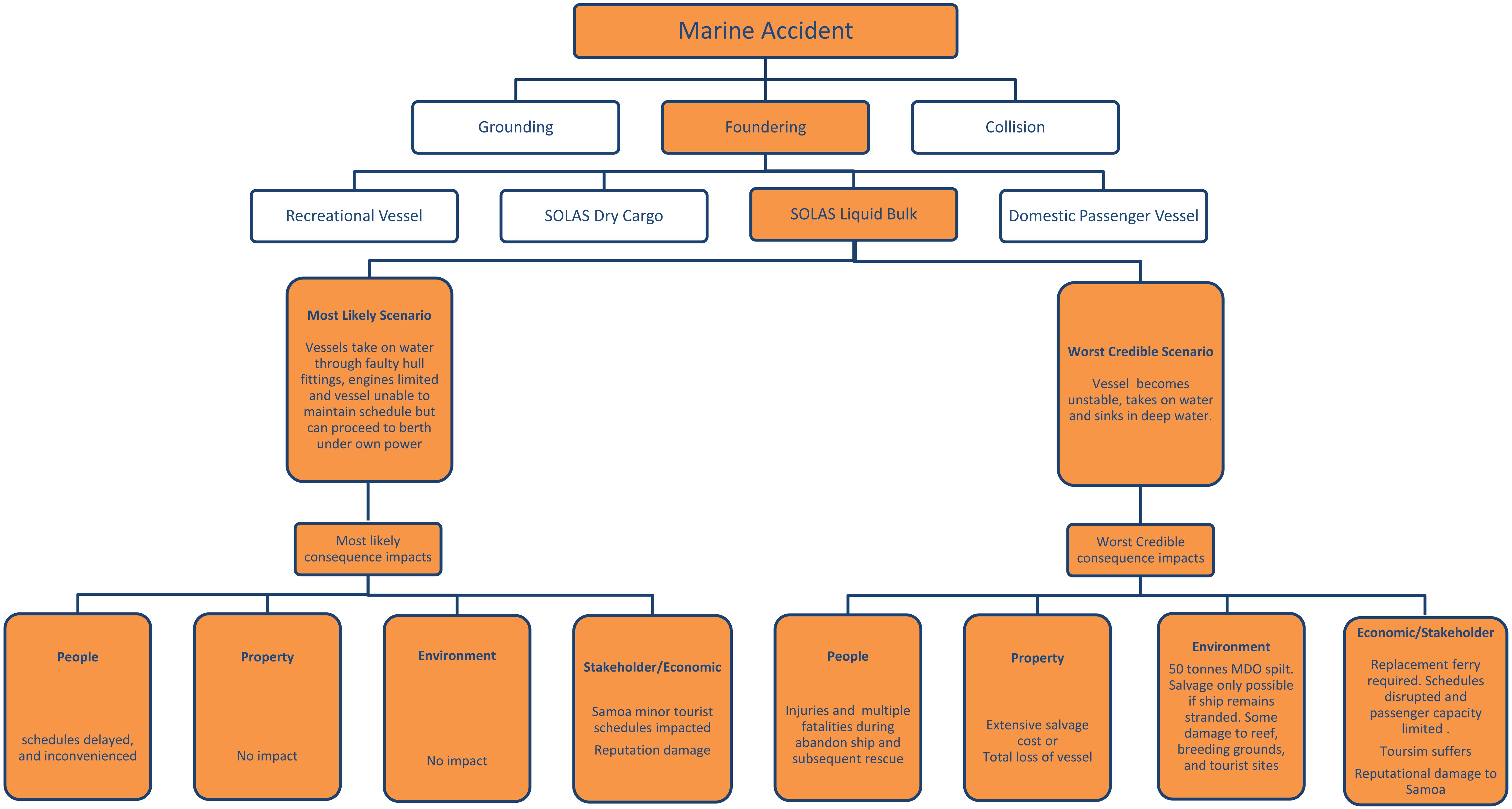
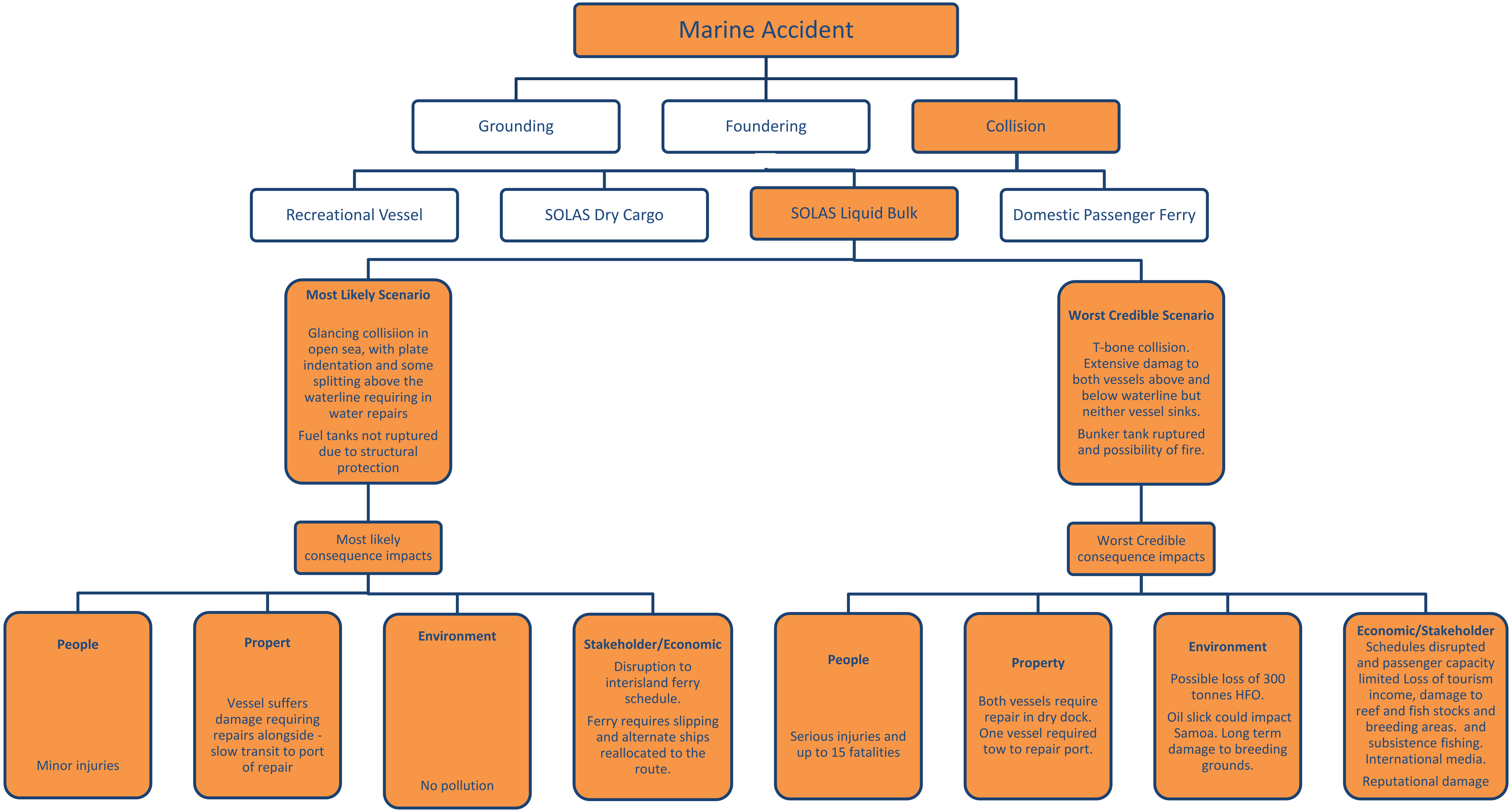


ANNEX A - Event Trees



ANNEX B - GIS Track Creation and Processing

1 Track Creation[153]

1.1 Raw AIS data was acquired from ORBCOM for the contiguous 12 month period from January–December 2016. While this varies from the periods used for previous assessments of Vanuatu, the Cook Islands, Tonga and Niue, (January – March 2012; July – October 2013; and December 2013 – January 2014), the decision to update the source AIS data was made on the following basis:

a. The AIS data from the previous assessments had become out dated and no longer reflected the current traffic patterns which had changed over recent years, particularly with the increase in cruise shipping activity.

b. The AIS data from the previous assessments had gaps for the months of April – June and November, which may have resulted in the exclusion of certain maritime activities that may have occurred in these periods.

c. ORBCOM has added additional satellites to its AIS network in recent years and was now able to provide a contiguous dataset with a higher update rate and less gaps than previously, thus providing a more comprehensive and reliable dataset.

d. The previous assessments showed that the substantial variations in volume of traffic between national assessments and between differing regions within EEZs caused such a variation of the final risk values that the "regional" risk plot was not a crucial output of the assessment and that the "in-country" risk plot provided the most useful product for hydrographic planning.

1.2 The raw AIS data was received in KML format and was converted to ESRI shape file using QGIS. The full dataset was processed for track information and subsequently, the area for risk assessment was limited to the EEZ boundaries of Samoa and Tokelau as provided by marineregions.org. The geographic boundaries of this dataset acquired for use in the study of Samoa and Tokelau were:

Northern Boundary: 06°05' S

Eastern Boundary: 176° 30' W

Western Boundary: 176° 00' W

Southern Boundary: 16° 15' S

1.3 Shapefiles were loaded into a PostgreSQL database for processing prior to line generation. The MMSI attribution was converted from string format to integer, and the movement date field

[153] The format of this Annex has been aligned as for Marico Marine Report No. 12NZ246-1, Issue 1, January 2013, D14 – D23. The content has been updated for Samoa.

was converted to a date time format and transferred to a new field labelled “ping_times.” The table was then exported as a FileGeoDatabase.

1.4 NOAA’s Marine Cadastre Track Builder[154] was used to convert these AIS points into a network representing vessel movements based on the vessel’s MMSI number and a user specified threshold of a maximum distance of 1200nm and a time factor of 48 hours between a pair of points. These factors were selected by trial and error to provide the best overall result.

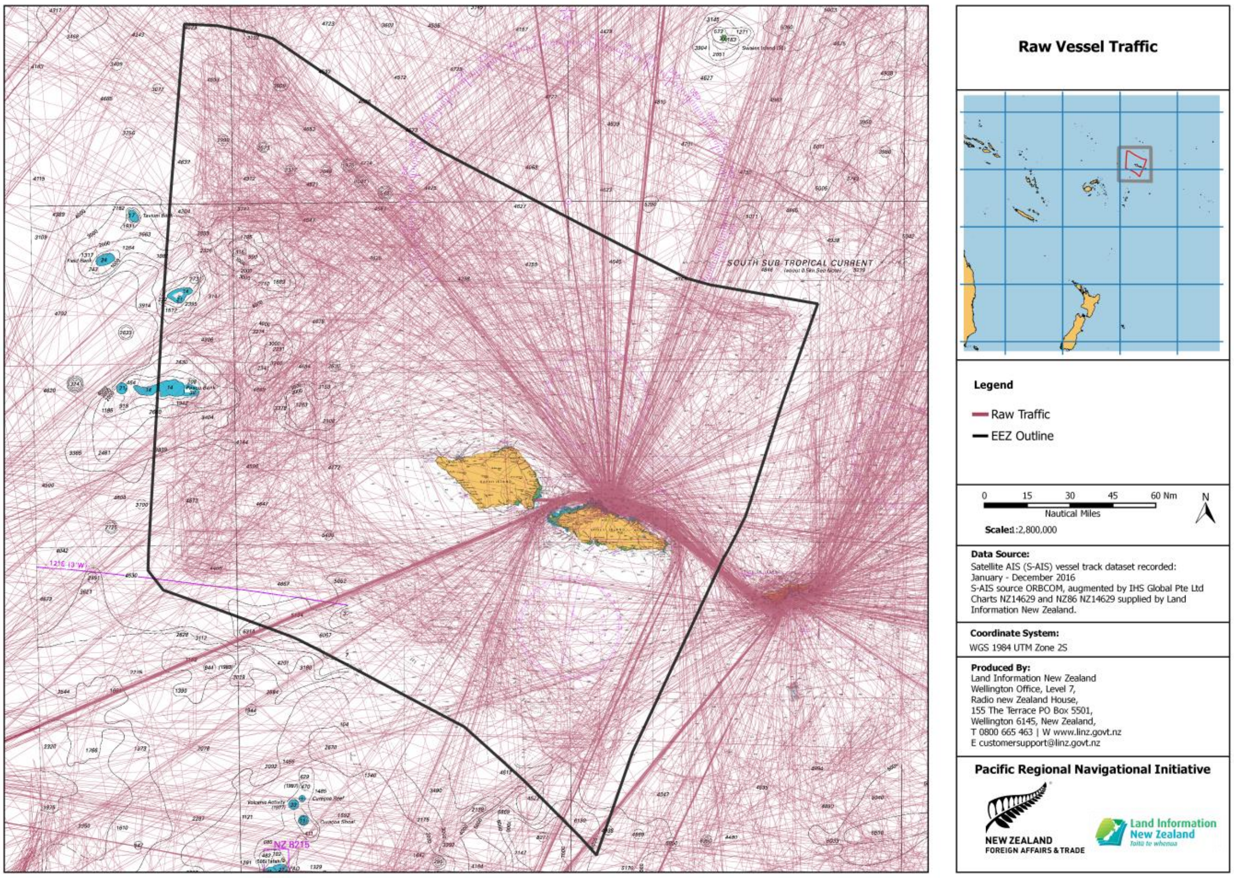
1.5 In QGIS, a non-spatial join was used to associate MMSI with IMO number, using the ancillary xml dataset provided by ORBCOM, containing IMO vessel numbers and ship gross tonnage (GT). To reduce the tracks to a more manageable dataset, PostgreSQL was used to create a new shapefile where only tracks that intersected with the Samoan EEZ were used. Vessel attributes, such as type and GT, were then attached to each vessel track from checking MMSI number against online databases such as Marine Traffic and International Telecommunication Union (ITU).

1.6 Figure 1, below shows vessel track lines created using NOAA’s Marine Cadastre Track Builder, such that each line connects multiple points for an individual vessel. This plot shows the raw nature of tracks and some anomalies that would degrade the analysis. In particular:

- At the extremities of the study area, vessel track lines did not reach the boundary of the EEZ. The cause of this was that the track lines ended when the last transmission was received and so it was possible that eight hours before a vessel reached the edge of the study area the track would stop;
- There were multiple vessels shown as transiting across land, these are more clearly shown in Figure 2. These overland vessel tracks could not be simply discounted as this would skew the analysis into suggesting that fewer vessels transited in areas of fine navigation and so manual track processing was required to adjust the track to its likely route; and
- There were multiple vessels shown as transiting across drying reefs, more clearly shown in Figure 2. These were commonly the result of reefs being between AIS pings, therefore the line generated gave the appearance of vessels transiting drying depths. As with vessels transiting land these could not be discounted, particularly due to the large volume of transits, and so manual track processing was required.

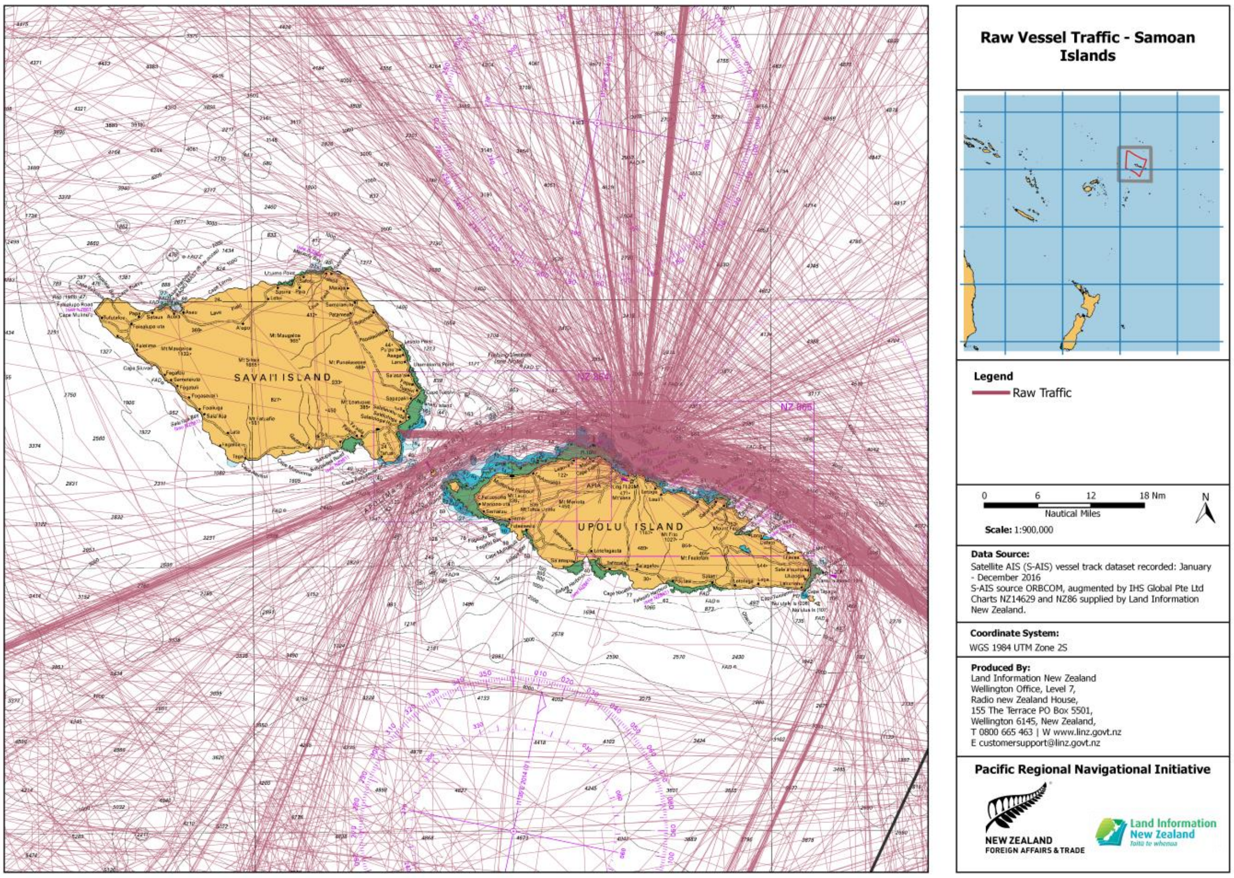
[154] National Oceanic and Atmospheric Administration. “Marine Cadastre Track Builder.” Office for Coastal Management - National Oceanic and Atmospheric Administration. 2016. https://coast.noaa.gov/digitalcoast/tools/track-builder (accessed May 13, 2016).

ANNEX B - GIS Track Creation and Processing



Annex B - Figure 1: Vessel tracks across the study area

ANNEX B - GIS Track Creation and Processing



Annex B - Figure 2: Raw vessel tracks around Samoa

2 Track Processing

2.1 A number of techniques were used to improve the raw vessel traffic data for use in the analysis of this study, these were:

- Extrapolating track lines to the edge of the study area. This processing was based on visual assessment assuming that those vessels near the limits of the study area that have a steady track will maintain that track to the boundary of the EEZ;

- All tracks that crossed land or drying reefs were manually routed around the coast along their likely course based on:

    - Other vessels' behaviour, in particular the distance vessels of a similar size keep offshore;
    - Adjustments to conform to areas of high traffic density; and
    - Logical pathing corrections, for example where a vessel goes straight through a wharf, it now routes around it.

ANNEX B - GIS Track Creation and Processing

- Using multiple database sources to correct errors in sourced dataset, including incorrectly spelt vessel names, incorrect MMSI numbers, and the addition of GT values where not provided;
- Utilising information from data gathering visit to generate tracks for domestic ferries and fishing vessels not captured via AIS (*alia*'s) and modelled values for GT applied; and
- Assignation of GT to tracks with a GT of 0 to either a value set by other vessels of similar size and type, or on an agreed upon value (typically for recreational vessels).

3 Non AIS Domestic Traffic

3.1 The majority of domestic traffic is not fitted with AIS. It is made up of the inter-island domestic ferry and numerous *alia* vessels of up to 12m in length.

3.2 To account for the ferries their route was tracked by GPS and two tracks were manually entered in the model, one for the *Lady Samoa III* at 40 transits per week and the other for the landing barge which operates in tandem at 36 transits per week. The GT entered for each track was the calculated total GT for each vessel in a year: 2,173,600 GT and 599,040 GT respectively.

3.3 To account for the *alia,* typical tracks for their operational areas were added based on the number licenced to operate as fishing vessels from each port[155]. *Alia* were given a nominal GT of one, and the tracks based on spending 120 days at sea per year in 3 day deployments and travelling at an average speed of 10 knots

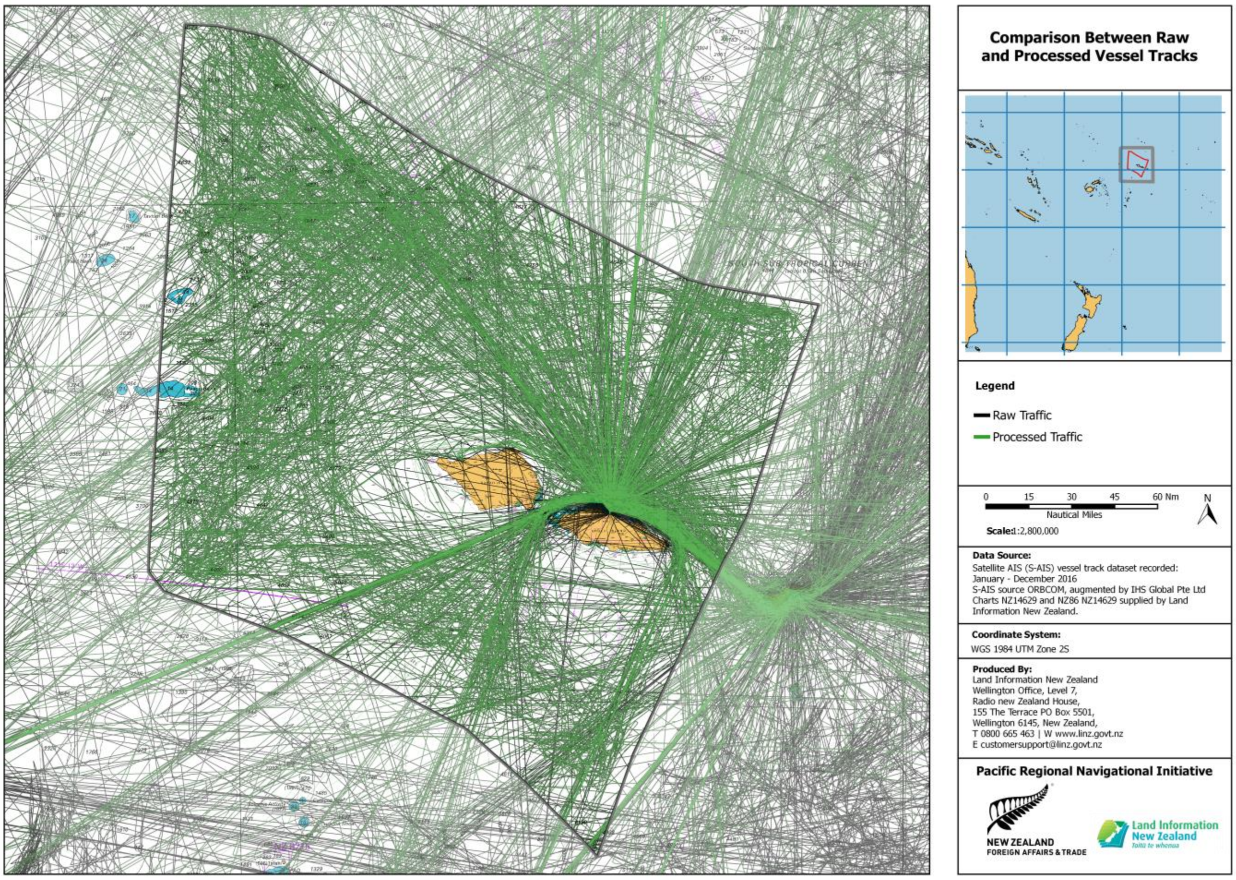
[155] Information from Ministry of Fisheries.

ANNEX B - GIS Track Creation and Processing

4 Final Results

4.1 This Section presents before and after comparison plots of the raw and processed vessel tracks. The plots show an improvement in the consistency and quality of the data post processing that allows a more robust analysis to take place particularly around Samoa.

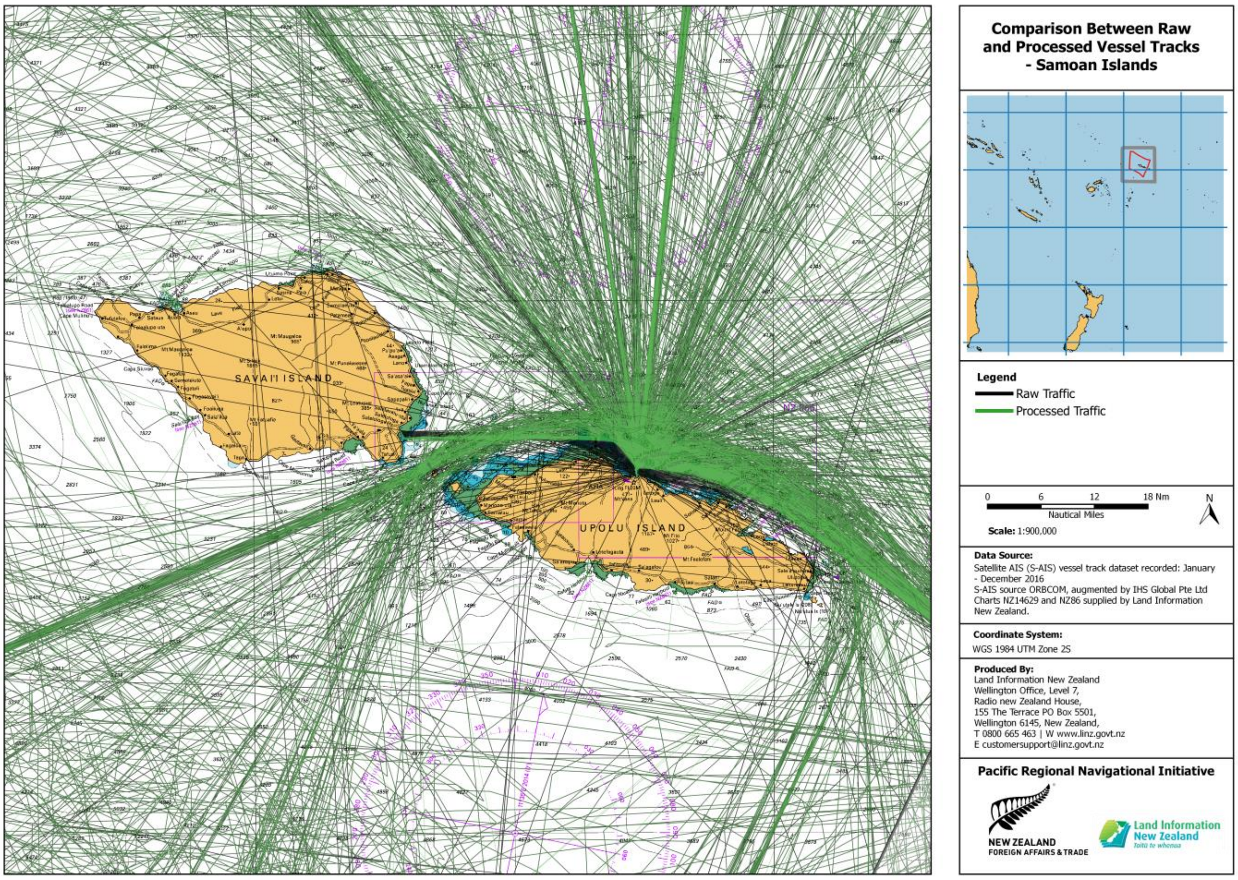
4.2 Figure 3 shows that all vessel tracks in the study area that intersects with the EEZ, with comparison between both raw and processed data. All vessel tracks that crossed land and drying reefs have been manually routed around the coast of Samoa.



Annex B - Figure 3: Comparison between raw and processed vessel tracks across the study area

ANNEX B - GIS Track Creation and Processing

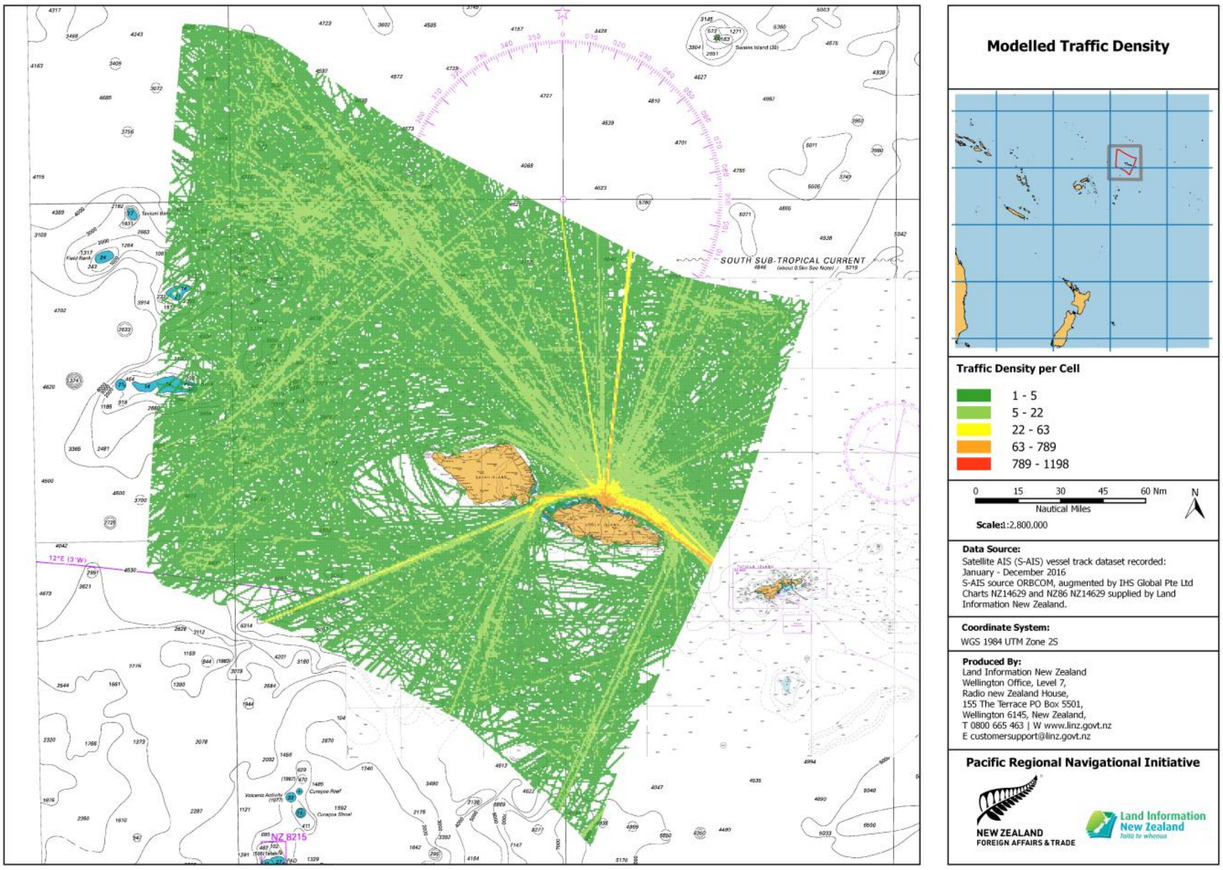
4.3 The difference between the raw and corrected tracks can be more clearly seen in Figure 4, a larger scale plot of the raw and processed tracks in the vicinity of Samoa.



Annex B - Figure 4: Comparison between processed and raw vessel tracks around Samoa

ANNEX B - GIS Track Creation and Processing

4.4 Figure 5 represents the modelled traffic density of all processed vessel tracks across the study area. Traffic density is defined as the number of tracks intersecting a cell. Therefore, you will note that the inter-island ferry route from Mulifanua to Salelologa (which was inserted as only two tracks) does not feature on this plot. A more complete representation of the traffic is given by GT density per cell (the sum of the GT of all the tracks). This is discussed in Annex C.

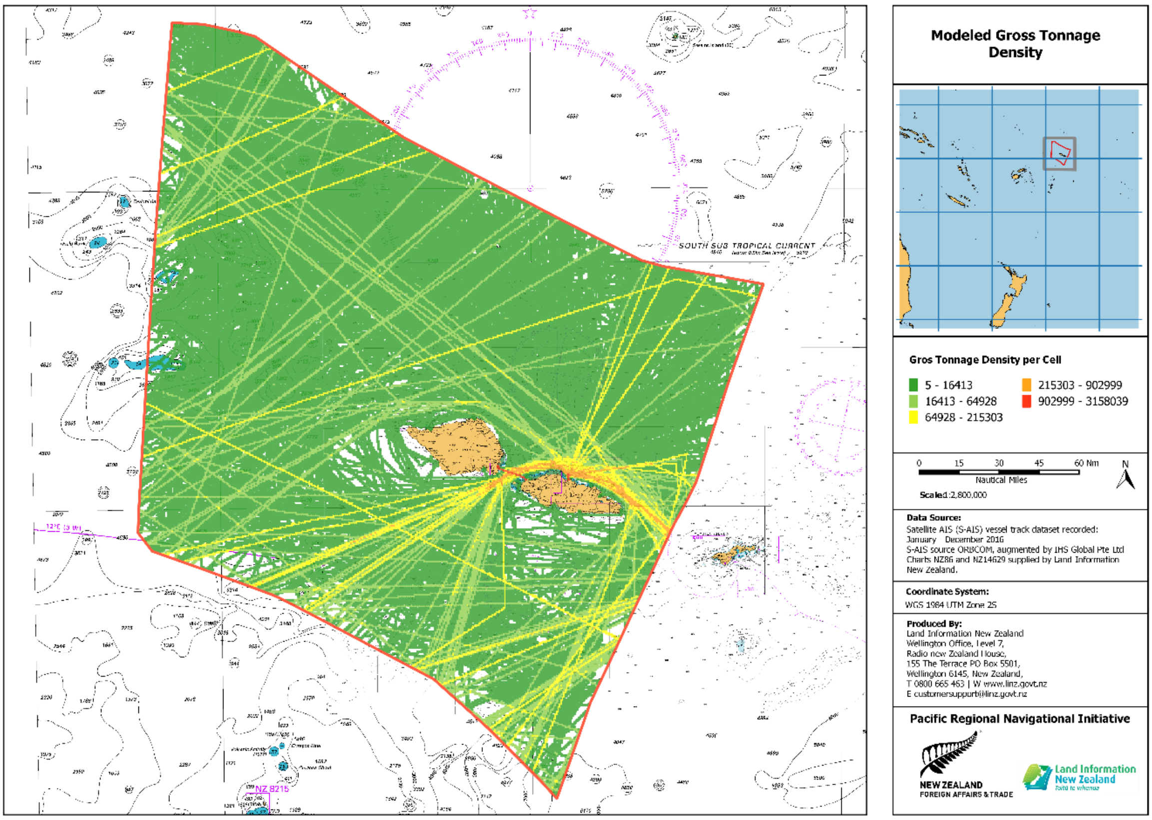


Annex B - Figure 5: Processed traffic density by cell (number of tracks)

ANNEX C – Traffic Risk Calculation

1 Traffic Risk Calculation[156]

1.1 After processing the AIS data to produce tracks, and applying the GT per vessel, a vessel traffic GT density plot was created (see Figure 1). For this purpose the definition of a vessel transit was adopted as "*a sequence of position reports from a particular ship, without significant time gaps, which show some level of purposeful motion*".[157] This overcomes the problem of an anchored vessel biasing the traffic density. A transit starts when a vessel leaves a berth and ends when she leaves the study area. If a vessel stops and starts again then this has been interpreted as two separate transits.



Annex C - Figure 1: Vessel Traffic Density Plot Showing GT per cell

1.2 The basis of this risk analysis is that each vessel transit has an inherent potential for loss of life or pollution and that this potential is the product of the size and type of a vessel. For example, a large tanker has a higher pollution risk than a smaller one. A large cruise ship may have a smaller pollution risk than a small tanker but a higher potential risk to life. The table at Figure 2 provides GT multipliers for each vessel type in order to calculate the risk inherent in that ship type for pollution or loss of life. This table is taken from *Marico Marine Report No. 12NZ246-1, Issue 1, January 2013, p. D18* and is used to maximise consistency between this risk assessment and the previous LINZ

[156] For consistency with previous LINZ SW Pacific hydrographic risk assessments and convenience of the reader, sections of this Annex have been reproduced by copy from (Marico Marine Report No. 12NZ246-1, Issue 1, January 2013).
[157] (Calder, 2009)

ANNEX C – Traffic Risk Calculation

hydrographic risk assessments conducted for other South West Pacific States. The referenced report states that the multiplier was "originally created by taking a model ship with a median tonnage that transits through South West Pacific waters and calculating the most likely and worst credible consequences of an incident from *event trees*."[158] For this Samoa risk analysis, the event trees previously used in the Vanuatu, Cook Islands and Tonga were considered applicable due to commonality of the general sizes and types of vessels visiting Samoa. The applicability of these accident /incident scenarios confirmed the validity of adopting the same risk multiplier calculation table as shown in Figure 2 below.

Ship Type	Loss of Life Risk Multiplier		Pollution Risk Multiplier	
	ML	WC	ML	WC
Tankers	$5*10^{-6}$	$7*10^{-5}$	$5*10^{-3}$	0.2
Passenger Ships	$1*10^{-5}$	$1.7*10^{-3}$	$1.6*10^{-5}$	$8.5*10^{-4}$
Cargo Ship	$8*10^{-6}$	$1.7*10^{-4}$	$1.5*10^{-3}$	$7.5*10^{-3}$
Fishing Ships	0.01	0.07	$1*10^{-5}$	0.04
Recreational/ Superyacht	0.01	0.07	$1*10^{-5}$	0.04
Other (Defence, Research & SAR)	$1*10^{-5}$	$1*10^{-5}$	$1*10^{-5}$	0.04

Annex C - Figure 2: Table of risk multipliers used to transform GT to a risk potential for the specified vessel types

1.3 This approach is a necessary simplification of reality in a number of ways. Firstly, it is not possible to know the individual crew numbers and cargo volumes of each individual vessel transiting through the study area and so a model ship type will be used. Secondly, the approach is limited in assuming a simplistic linear relationship between GT and consequence potential. This is not always the case and may vary considerably with some vessel types and depending on the employment of the vessel. For example, fishing vessels have a relatively high loss of life potential due to their small size and relative instability, dangerous work over the ship's side and their necessity to work in all weather conditions. This risk is likely to be higher for small vessels which are more vulnerable to sea and wind conditions, or trawlers working in shallow waters where there is a risk of snagging nets on the seabed. However, a large fishing vessel working in deeper water is more seaworthy, has more automated equipment and is less likely to snag nets. Additionally, it is exposed to even less risk when not actually engaged in fishing, and when simply on passage is more likely to have the risk profile of a cargo ship. This analysis cannot account for such variations in vessel profile or employment.

[158] (Marico Marine Report No. 12NZ246-1, January 2013, p. D.18)

ANNEX C – Traffic Risk Calculation

1.4 The potential risk of a vessel transit in terms of pollution or loss of life is calculated as the average of the *most likely* and *worst credible* cases and is calculated by the formula below:

$$Potential = ((GT * ML\ Multipler) + (GT * WC\ Multiplier))/2$$

For example, the calculation for the pollution potential of a 30,000 GT tanker is:

- Most Likely = 30,000(GT)*0.005(Multiplier) = 150 tonnes spilt.
- Worst Credible = 30,000(GT)*0.2(Multiplier) = 6,000 tonnes spilt.
- Average = (ML+WC)/2 = 3,075 tonnes spilt.

1.5 Using a Jenks Natural Breaks interval method, the distribution of average potential loss of life and average potential pollution were transformed to a 1 to 5 scale. This method of data classification seeks to partition data into classes based on natural groups in the data distribution. Natural breaks occur in the histogram at the low points of valleys. Breaks are assigned in the order of the size of the valleys, with the largest valley being assigned the first natural break.[159]

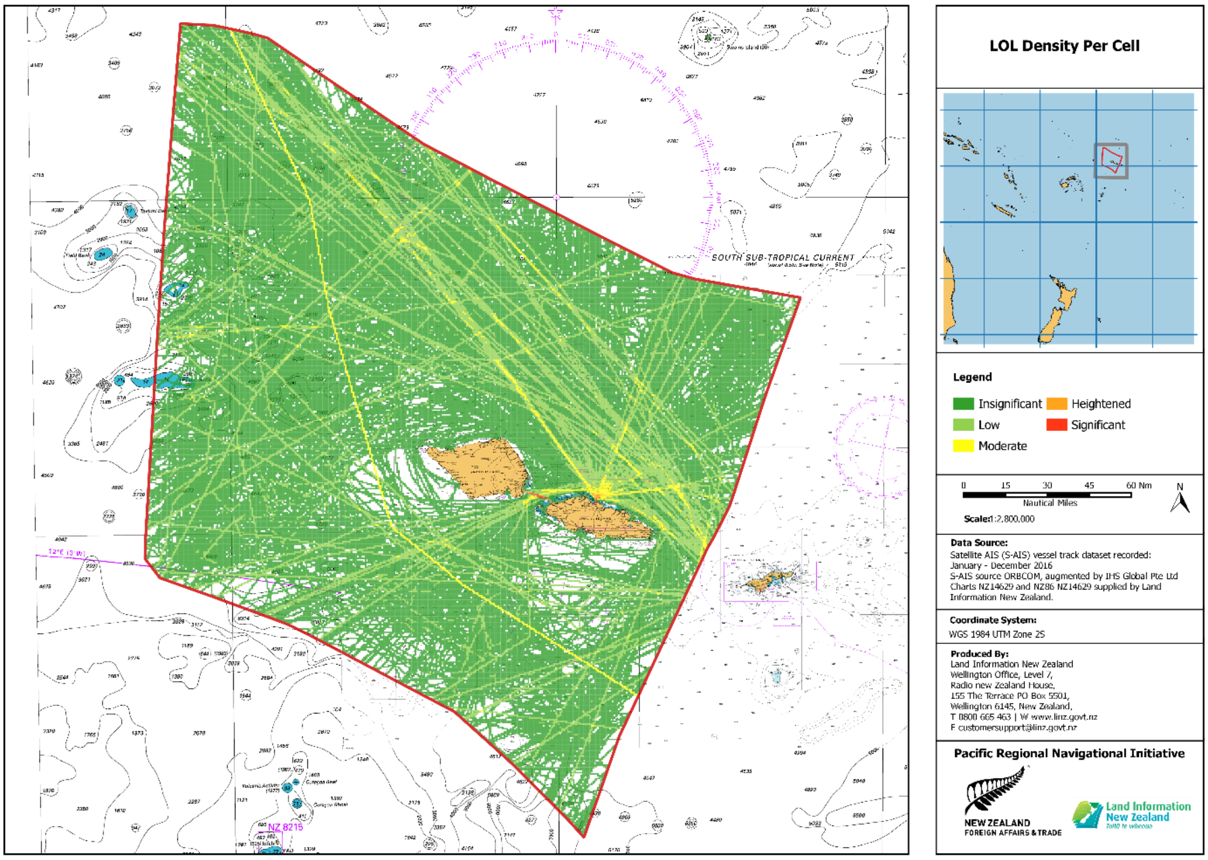
Modelled potential loss of life

1.6 Figure 3 below shows the modelled potential loss of life across the study area. The only areas with significant loss of life potential are: the near approaches to Apia and along the inter-island domestic ferry route where there is a high total GT of passenger vessel traffic. This route also intersects with the major commercial route through Apolima Strait. Note that this is a measure relating to ship type and GT only (not the quality of chart data or potential impact factors) therefore the highest potential will occur where high GT of vessel types with a high risk potential (see Annex C Figure 2 above) exist. It is also a relative measure using the natural breaks method described above to portray the potential risk variation across the 5 colour bands. The values of the colour bands used in these plots are as follows:

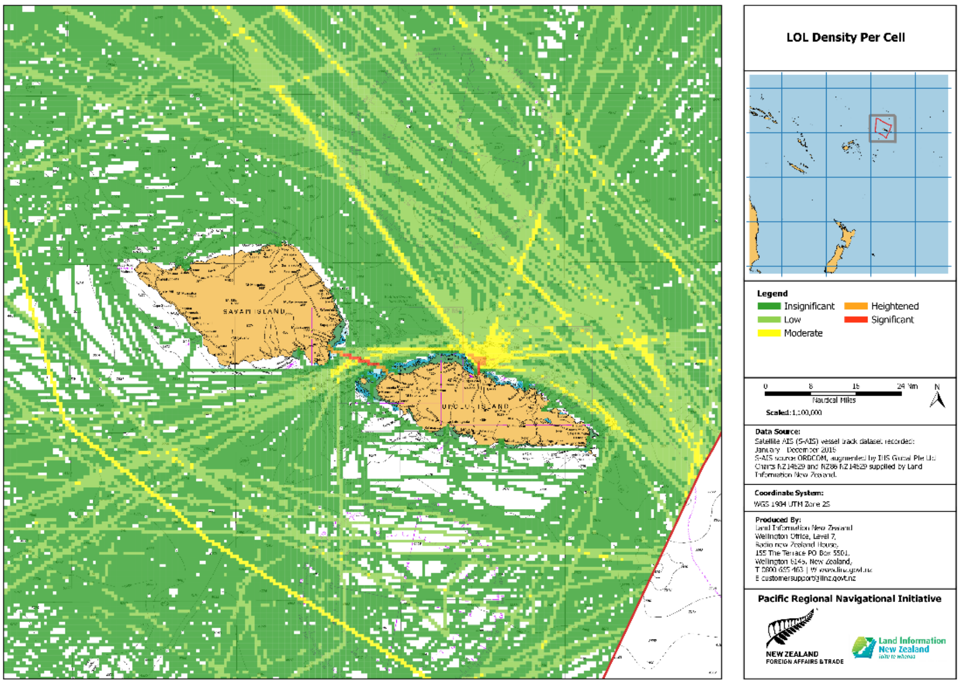
Potential loss of life colour bands	
0-49	insignificant
49-187	low
187-922	moderate
922-2378	heightened
2378 and greater	significant

[159] This definition was acquired from esri. "GIS Dictionary." *esri.* 2016. http://support.esri.com/en/knowledgebase/GISDictionary/term/natural%20breaks%20classification (accessed May 16, 2016).

ANNEX C – Traffic Risk Calculation



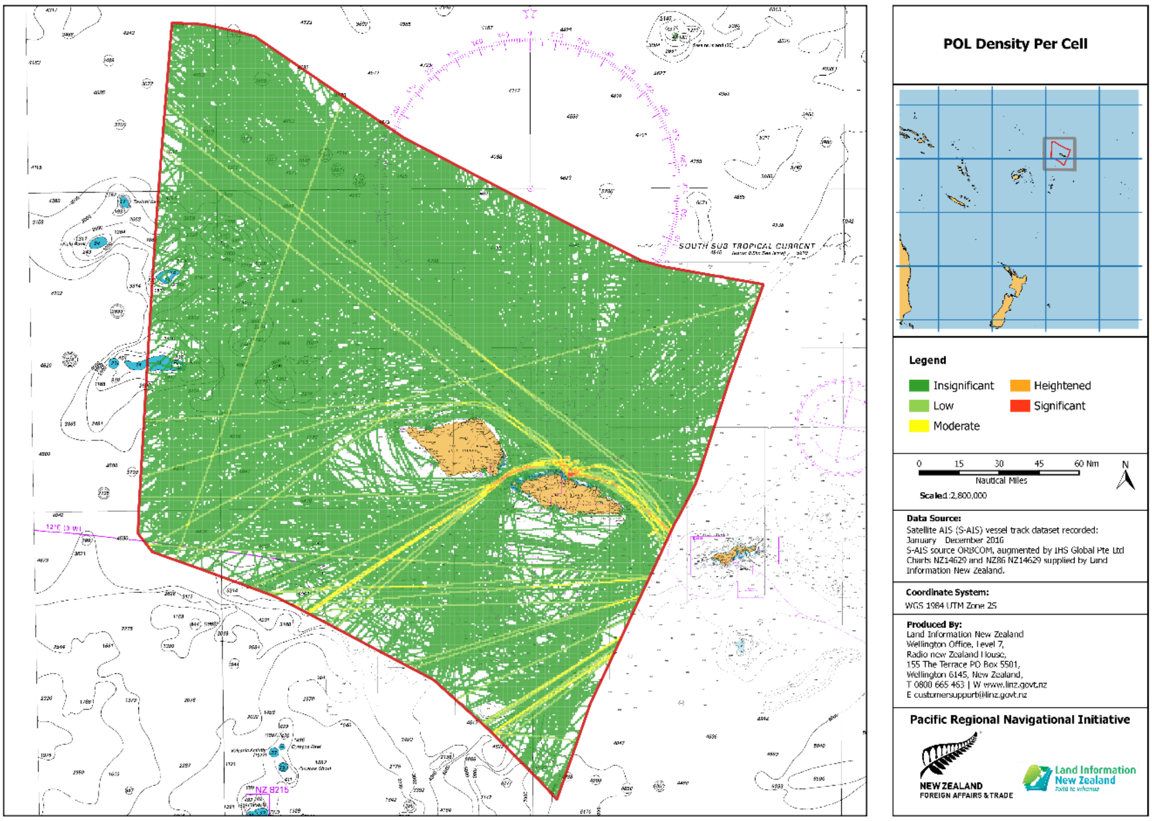
Annex C - Figure 3: Modelled Potential Loss of Life (expanded view below)



1.7. The two areas of *significant* LOL cell density described above both link to small areas of *heightened* LOL density. The remainder of the area is *insignificant* to *low* with some lines of *moderate* LOL density where multiple ship tracks coincide. The fact that a single ship track passing south of Samoa also has a moderate rating indicates that the plot is relatively sensitive.

ANNEX C – Traffic Risk Calculation

Modelled potential pollution



Annex C - Figure 4: Modelled Potential Pollution

1.8 Figure 4 shows the modelled potential pollution across the study area. The waters with a moderate to significant potential pollution occurred along the routes travelled by tankers or where the main traffic routes where vessels with a relatively high GT overlap the same cells, most of this traffic passes through Apolima Strait and across the top of Apolu Island, calling at Apia. Again, it is important to note that these values are relative to the total pollution potential across the Samoan EEZ, for reference the actual values of the colour bands are as follows:

Potential pollution colour bands	
0-1612	insignificant
1612-5277	low
5277-10492	moderate
10492-24075	heightened
24075 and greater	significant

ANNEX D – Likelihood and Consequence Factors

Overview

1.1 This Annex presents, in GIS form, the likelihood and consequence factors used in the calculation of hydrographic risk and the cost or benefit of addressing areas at risk across the study area. Full details of the level of risk for each factor and its relative importance or influence are shown in the Risk Score Table provided at Annex E. The risk contribution for each element is related to its geographic extent and reduces with distance from the determining feature. This is shown graphically in the Figures of this annex and while the specific measurement scale for each element varies, the relative contribution is generally represented by colour codes as follows:

Grey: (only included when relevant)	Nil
Dark green:	insignificant
Light green:	low
Yellow:	moderate
Orange:	heightened
Red:	significant

1.2 The likelihood factors are those that contribute to the probability of a vessel being involved in a marine accident. These factors are identified as: met-ocean conditions, navigational complexity, aids to navigation, bathymetry and navigational hazards.[160] Figures in section 2 of this Annex show the level of hydrographic risk due to the proximity of vessel traffic to a feature which is likely to cause or be impacted by a marine accident.

1.3 Consequence factors are used to quantify the effects of an incident.[161] The principal consequence factors are: the environmental impact, damage to culturally sensitive areas and damage to areas that would impact on the Samoan economy

[160] For consistency, this explanation was taken from (Marico Marine Report No. 15NZ322, Issue 3, August 5th, 2015, 29).

[161] For consistency, this explanation was taken from (Marico Marine Report No. 15NZ322, Issue 3, August 5th, 2015, 30).

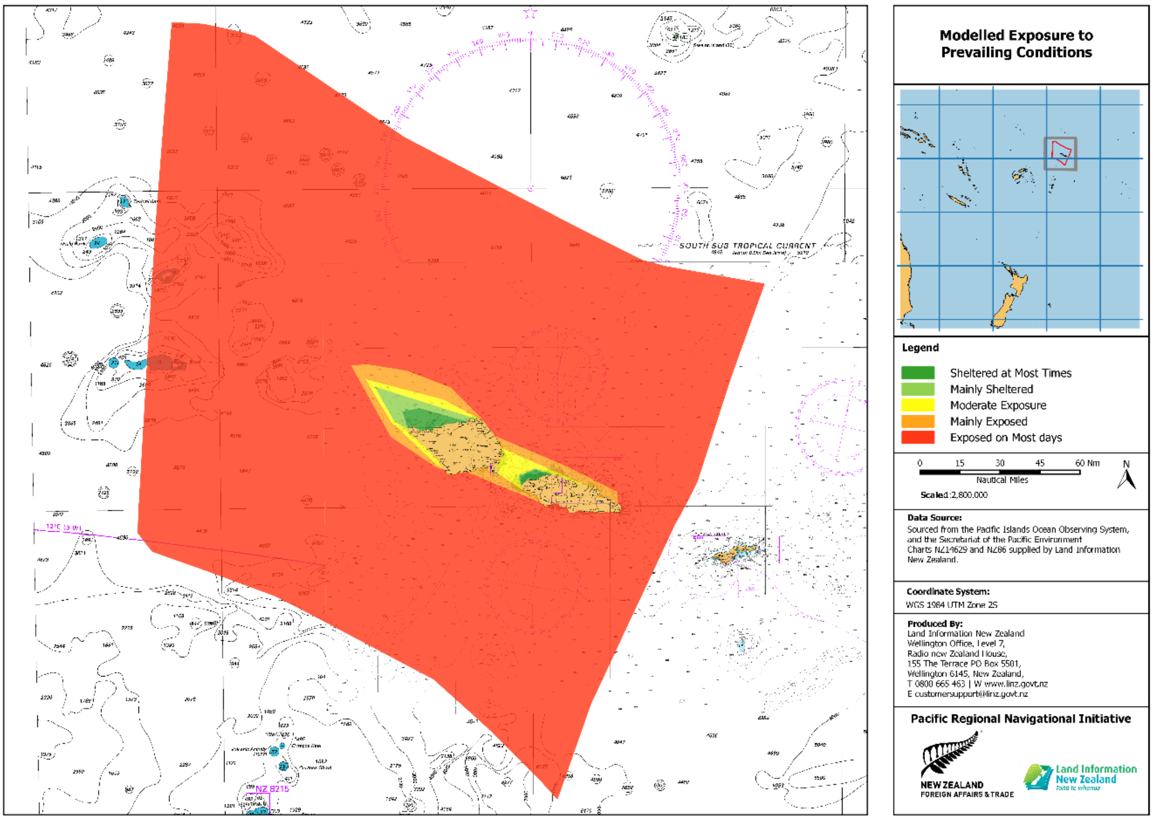
ANNEX D – Likelihood and Consequence Factors

2. Likelihood Factors

2.1 Met-Ocean Conditions

The met-ocean conditions which present a hydrographic risk across the study area are exposure to prevailing conditions, spring mean current speed and visibility.

2.1.1 Exposure to Prevailing Conditions



Annex D Figure 1: Modelled Exposure to Prevailing Conditions

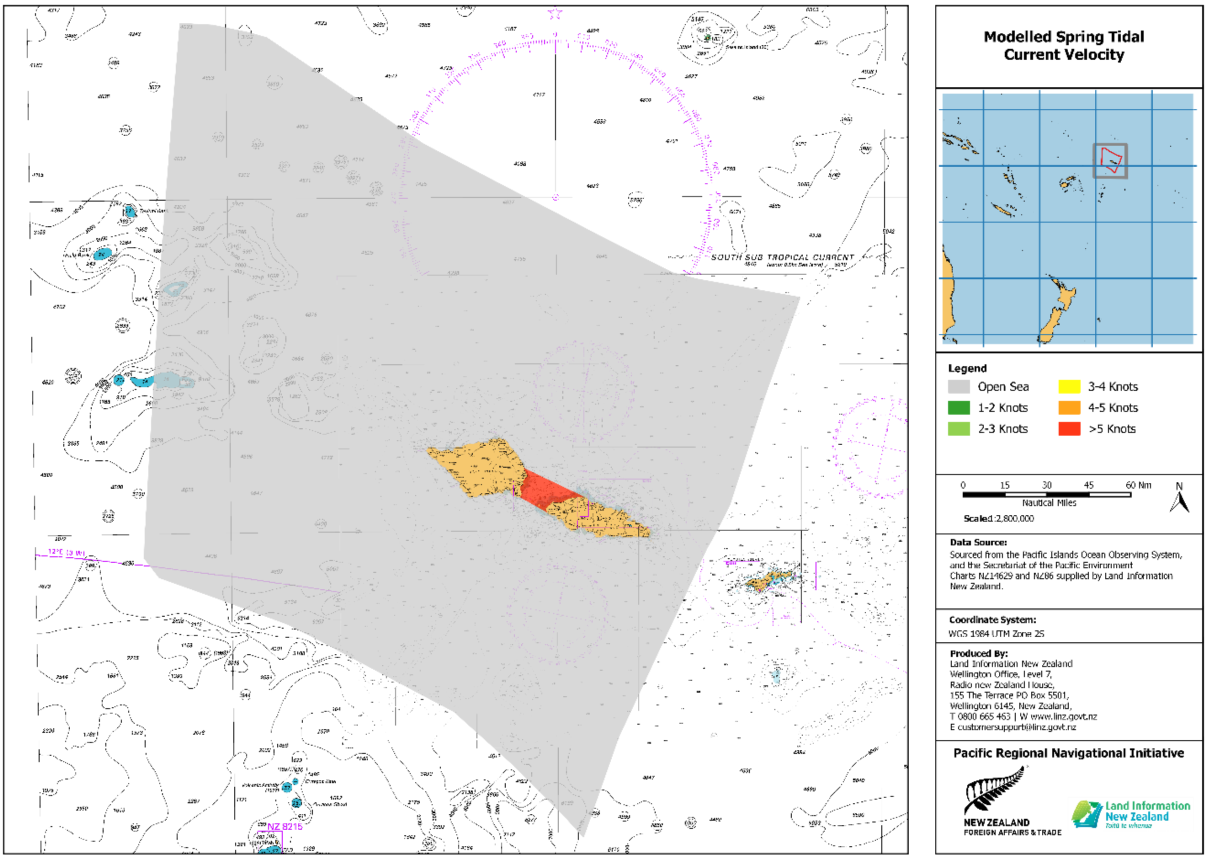
Figure 1 represents relative hydrographic risk due to exposure to prevailing conditions across the study area. Information about the wind speed and direction and prevailing wave and swell conditions were taken from the Pacific Islands Ocean Observing System model.[162] This was consistent with but more detailed than information contained in NP61[163] and advice from the Samoa Meteorology Department. There is a predominance of winds and seas from the east and the south east throughout the year. Cyclone events are considered random.

[162] Pacific Islands Ocean Observing System (PacIOOS) http://www.pacioos.hawaii.edu/

[163] (Admiralty Sailing Directions, Pacific Islands Pilot Volume 2 - NP61, 2017) Chapters 1 & 13

ANNEX D – Likelihood and Consequence Factors

2.1.2 Spring Tidal Current Velocity



Annex D Figure 2: Modelled Spring Tidal Current Velocity

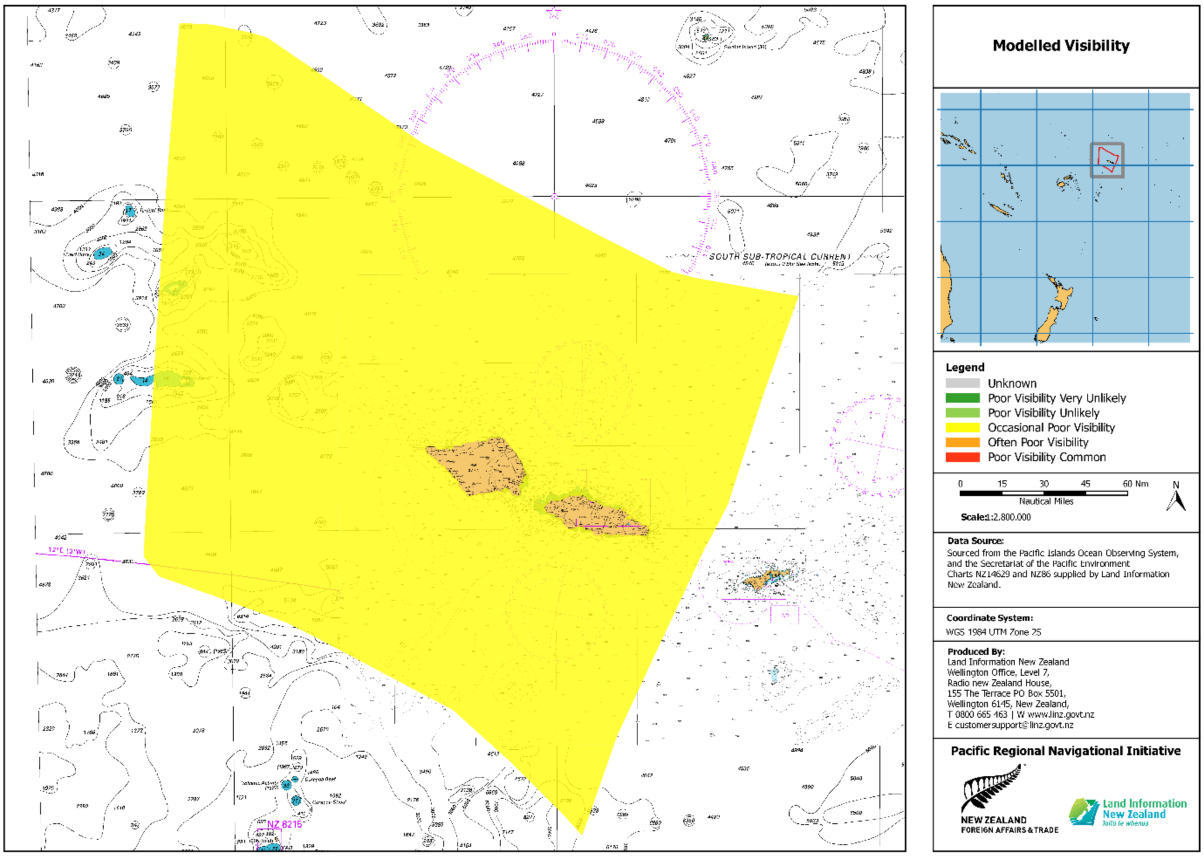
Figure 2 represents relative hydrographic risk due to the spring tidal current velocity across the study area. This figure was created based on data from PacIOOS,[164] currents as described on chart NZ 86 and NP61, and confirmed by discussion with SSC.

[164] Pacific Islands Ocean Observing System at http://www.pacioos.hawaii.edu/currents/model-samoa/

ANNEX D – Likelihood and Consequence Factors

2.1.3 Visibility

Poor visibility can occur across the study area and is normally associated with passing rain squalls of short duration. Nevertheless, it can increase the risk of a navigational incident especially in high traffic areas and close to land. The entire Samoan EEZ has been classified as occasional poor visibility.

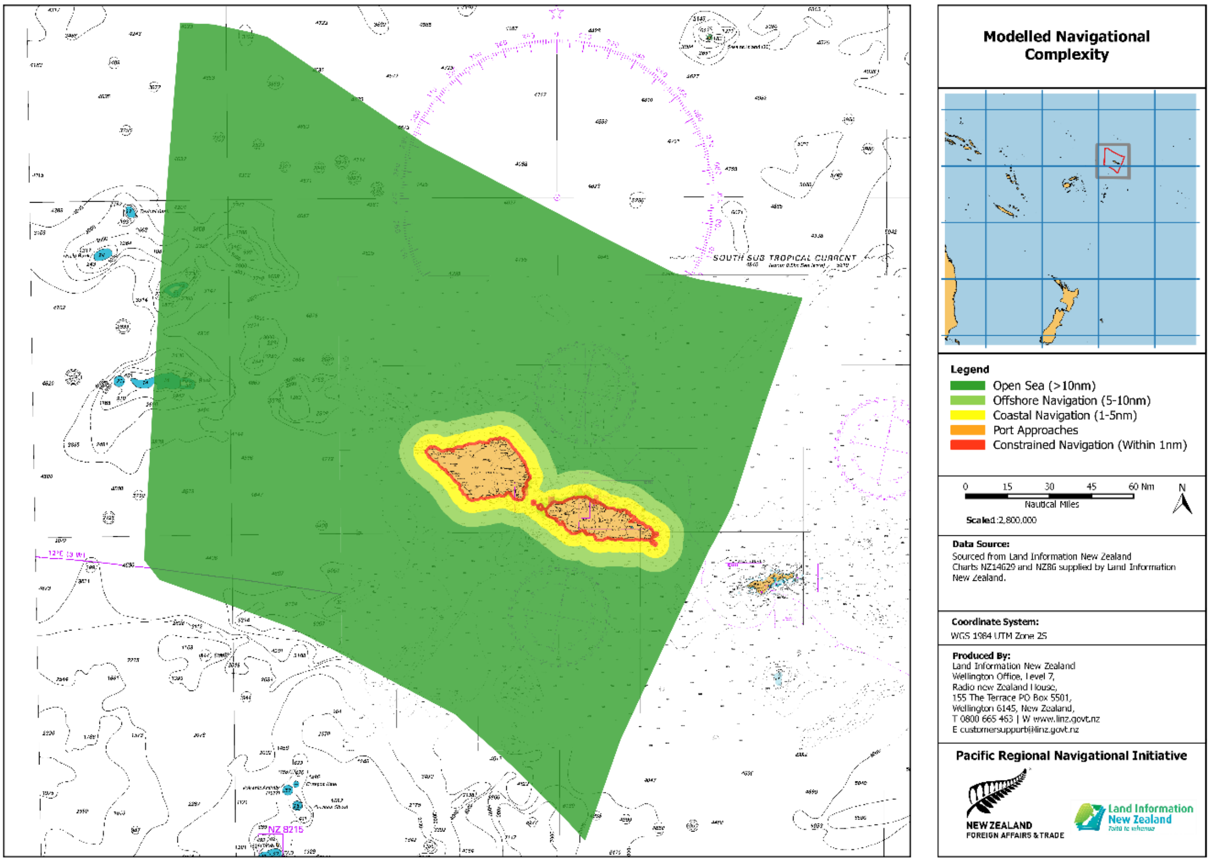


Annex D Figure 3: Visibility

ANNEX D – Likelihood and Consequence Factors

2.2 Navigational Complexity

The risk for transiting vessels is greater the more complicated the navigational track. In open waters with considerable sea room on either side of the route, the risk is significantly reduced in comparison to a constrained navigation channel in a port.[165] In this study, the risk related to navigational complexity was defined by the type of navigation required across the Samoa EEZ.



Annex D Figure 4: Modelled Navigational Complexity

Figure 4 represents relative hydrographic risk due to the type of navigation required across the study area. This Figure was created based on site visits to all ports, as well as interviews with relevant harbour masters. The figure shows constrained navigation within 1nm of the coastal reef and within the commercial ports and gradually reducing risk with distance further to seaward as defined in the legend.

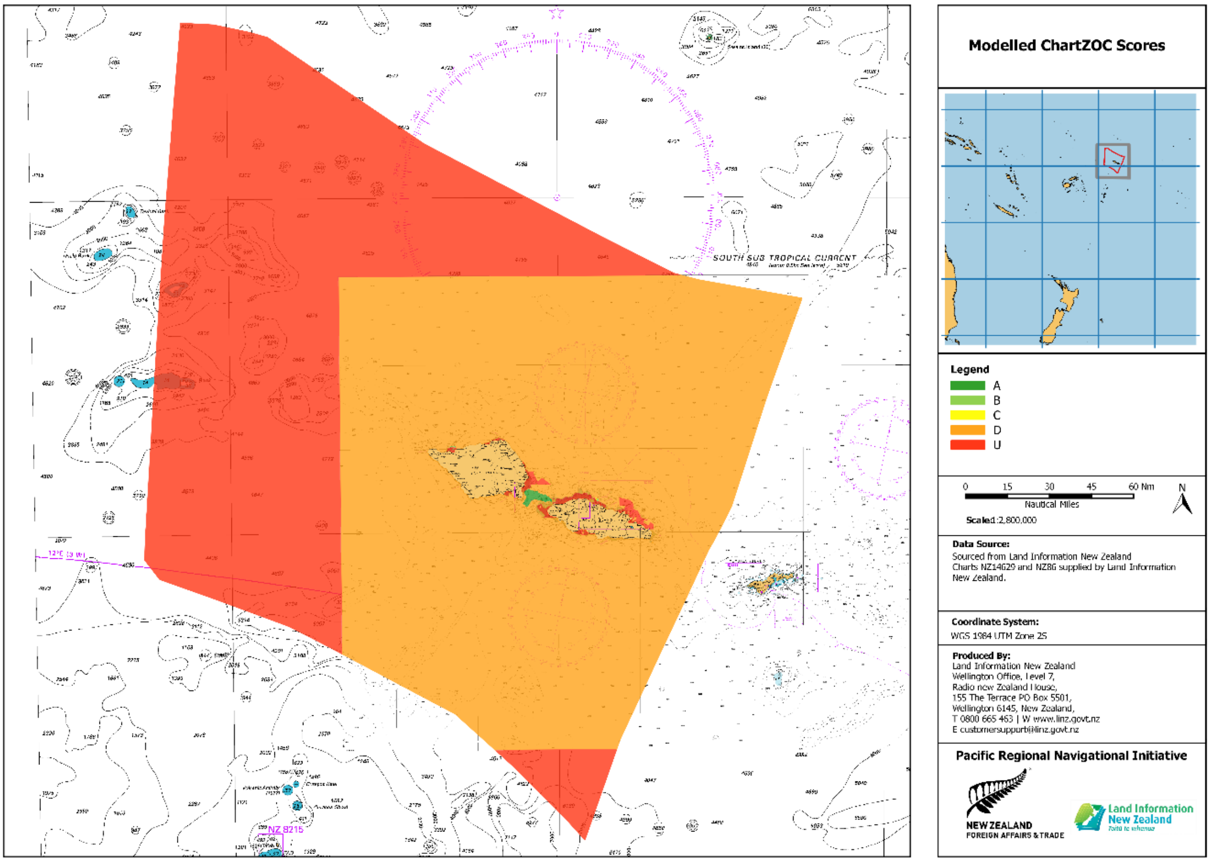
[165] For consistency, this explanation was taken from (Marico Marine Report No. 12NZ246-1, Issue 1, January 2013, D29).

ANNEX D – Likelihood and Consequence Factors

2.3 Aids to Navigation (AtoN) and Charting

The risk of a maritime incident is considered to be increased if AtoN are not charted; are incorrectly charted; or are not working. For consistency with previous South-West Pacific risk assessments, the methodology used in this assessment identified two particular hazards; namely, out of date nautical charts and incorrectly marked AtoN such as buoyage or lights.[166] The other navigational risk factors in Samoa are the possibility that unlit FADs are deployed in positions other than those charted, and whether the scale of the nautical charts in some locations is sufficient for their intended use. These factors are not included in the GIS risk calculation but are discussed in the risk results and recommendations.

2.3.1 Charted Zones of Confidence



Annex D Figure 5: Modelled Charted Zones of Confidence Score

Figure 5 represents relative hydrographic risk due to the charted zones of confidence; the seafloor of the study area beyond the extents shown in this figure has not been assessed. This Figure was created based on zone of confidence assessment ratings provided by LINZ. The larger scale extract of this Figure for the region of Apia to Apolima Strait shows the detail of how CATZOC classifications

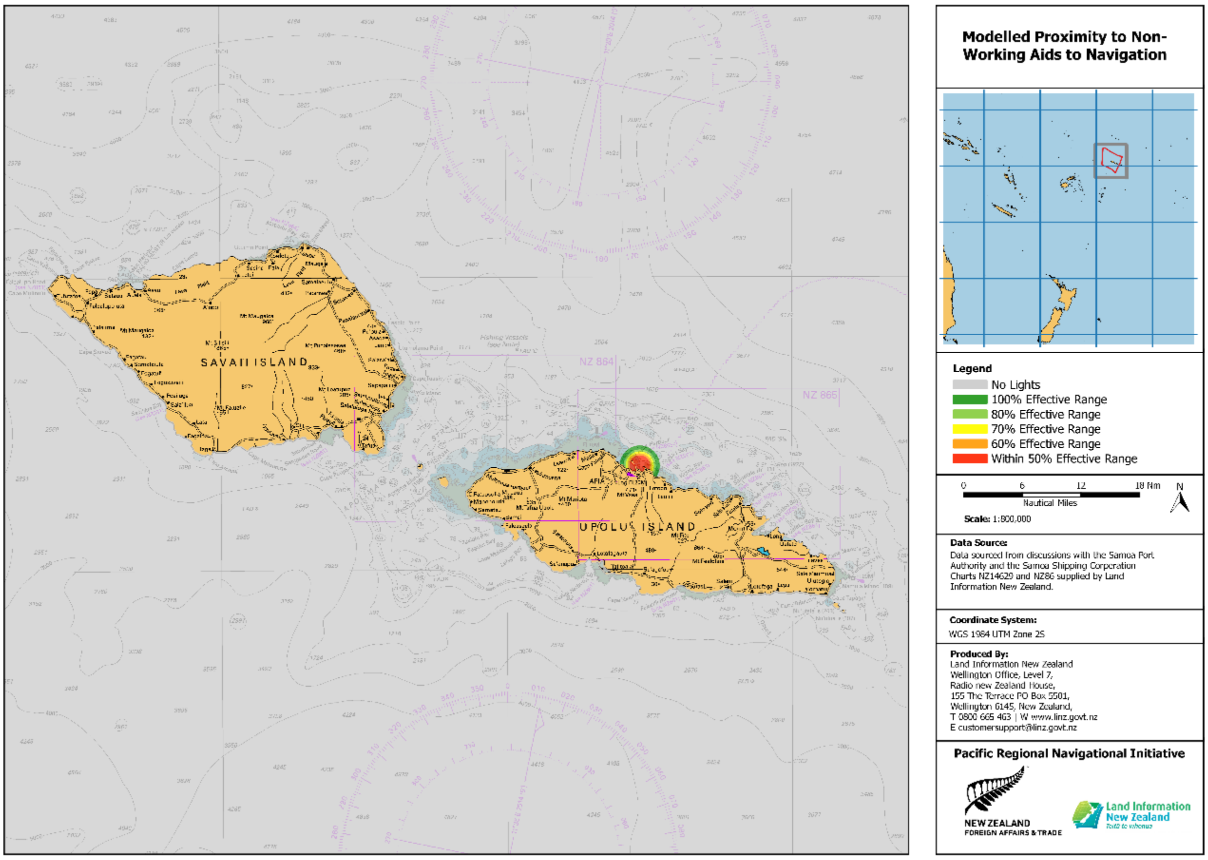
[166] For consistency, this methodology is similar to that used in (Marico Marine Report No. 12NZ246-1, Issue 1, January 2013, D31).

ANNEX D – Likelihood and Consequence Factors

are divided into specific areas related to the different standard of hydrographic information available.

2.3.2 Proximity to Non-Working Aids to Navigation

In Samoa, there are only a small number of formal AtoN, with two, Apolima Island light and Malua light (west of Apia) being the only navaids outside port limits. Malua light was reported to be charted and operating correctly. Apolima Island light was reported to be operating correctly but the light's intensity had been reduced to 12nm. Within the port of Apia, the beacon (Fl.4s) marking the western entrance reef was noted to be unlit. This is the only item that has been included in the "proximity to non-working aids to navigation" GIS layer. Local advice from Captain Sam Fineas (SSC) is that the charted lit beacons in the vicinity of Manono Island have not existed for a long time. These lights were only useful for local navigation and are not included in this risk layer.



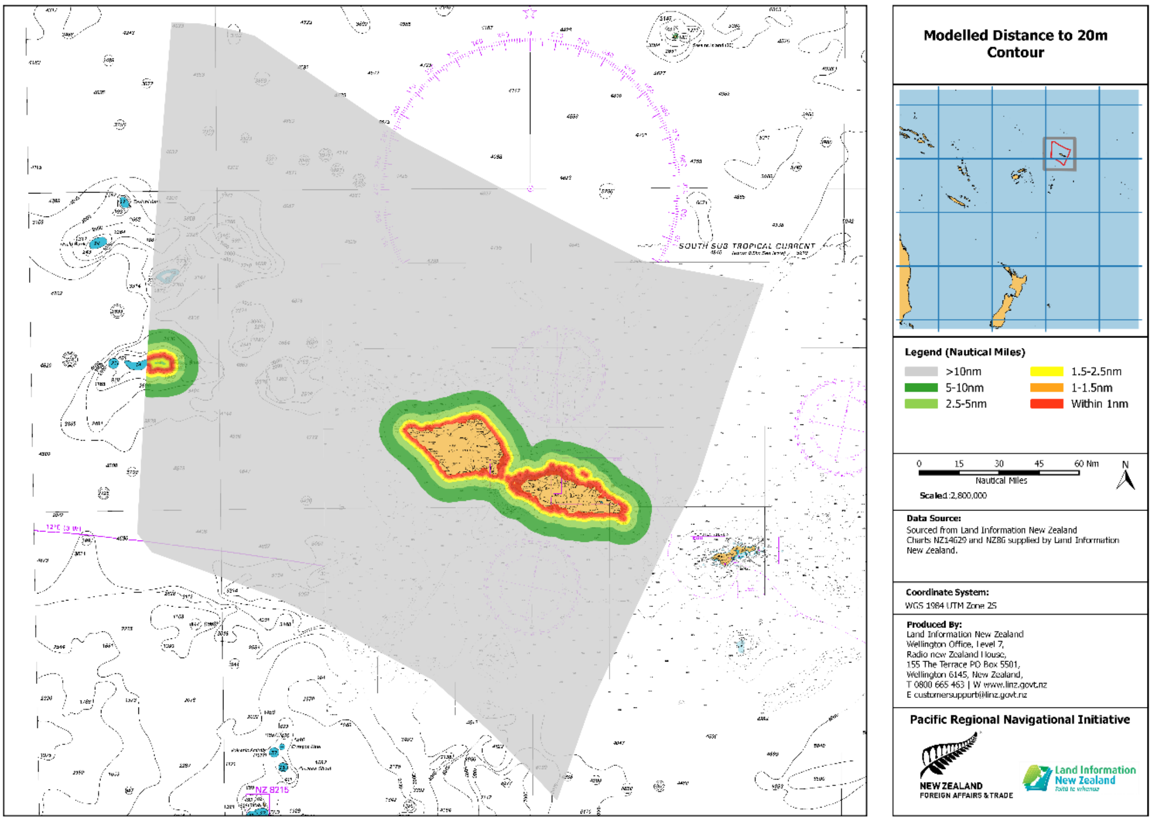
Annex D Figure 6: Proximity to non-working aids to navigation

ANNEX D – Likelihood and Consequence Factors

2.4 Bathymetry

Depth of available water (or lack thereof), in relation to the draught of vessels navigating in the vicinity, is a considerable hazard to navigation. The hazard is normally considered as the risk of a vessel running aground, however the presence of shallow water also has a secondary effect in limiting the room for vessels to manoeuvre in order to avoid a danger, object or another vessel. Additionally, if a major shipping route is proximate to an area of shallow water then a vessel that becomes disabled has little time to conduct repairs, anchor or obtain assistance before she is aground.[167] In this assessment the 20m contour was selected for convenience as it could be extracted directly from ENCs. The difference between this and the 15m depth contour used in previous assessment is considered negligible.

2.4.1 Depth of Water - 20m Contour



Annex D Figure 7: Modelled Distance to 20m Contour

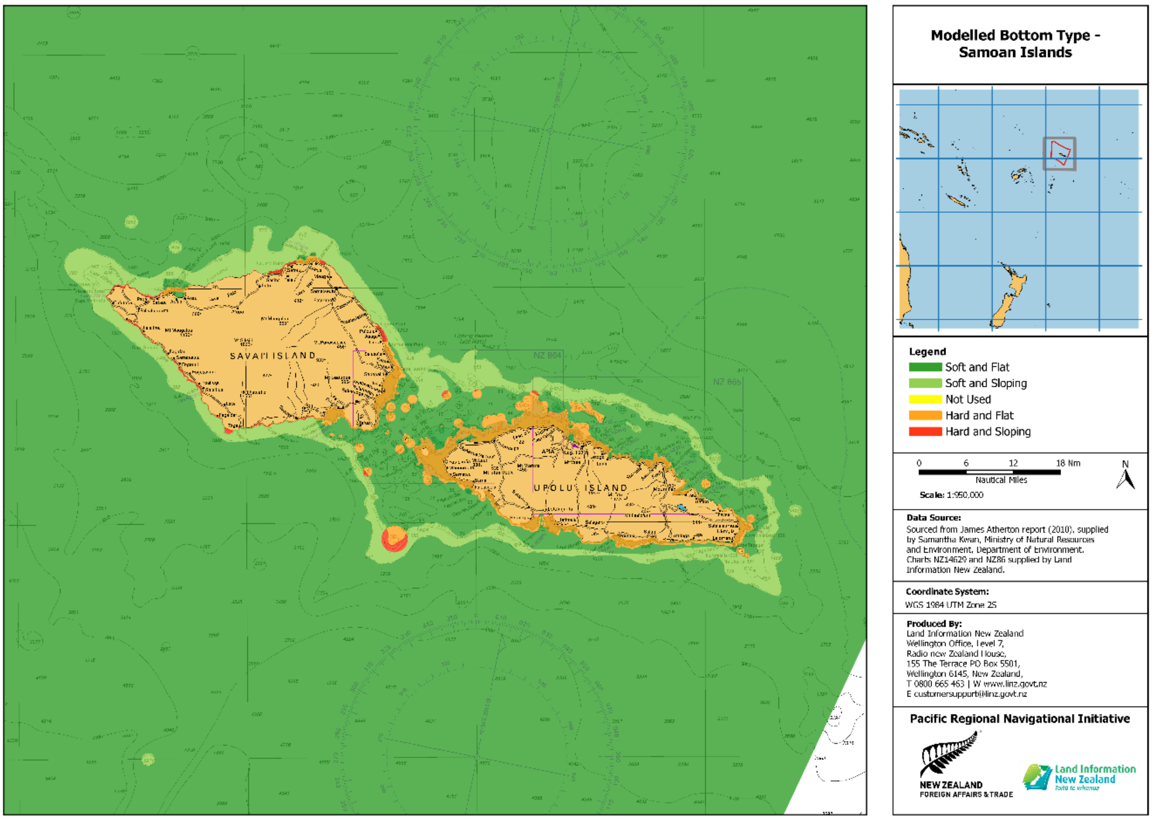
Figure 7 shows relative hydrographic risk due to the proximity to areas at a minimum depth of 20m. This figure was created from the latest Fugro LiDAR bathymetry available.[168]

[167] This explanation has been modified for additional clarity from the original work in (Marico Marine Report No. 12NZ246-1, Issue 1, January 2013, D36).

[168] Bathymetry collected by Fugro LADS under the World Bank project (Enhancing the Climate Resilience of Coastal Resources and Communities Project for Samoa, 2014)

ANNEX D – Likelihood and Consequence Factors

2.4.2 Bottom Type



Annex D Figure 8: Modelled Bottom Type

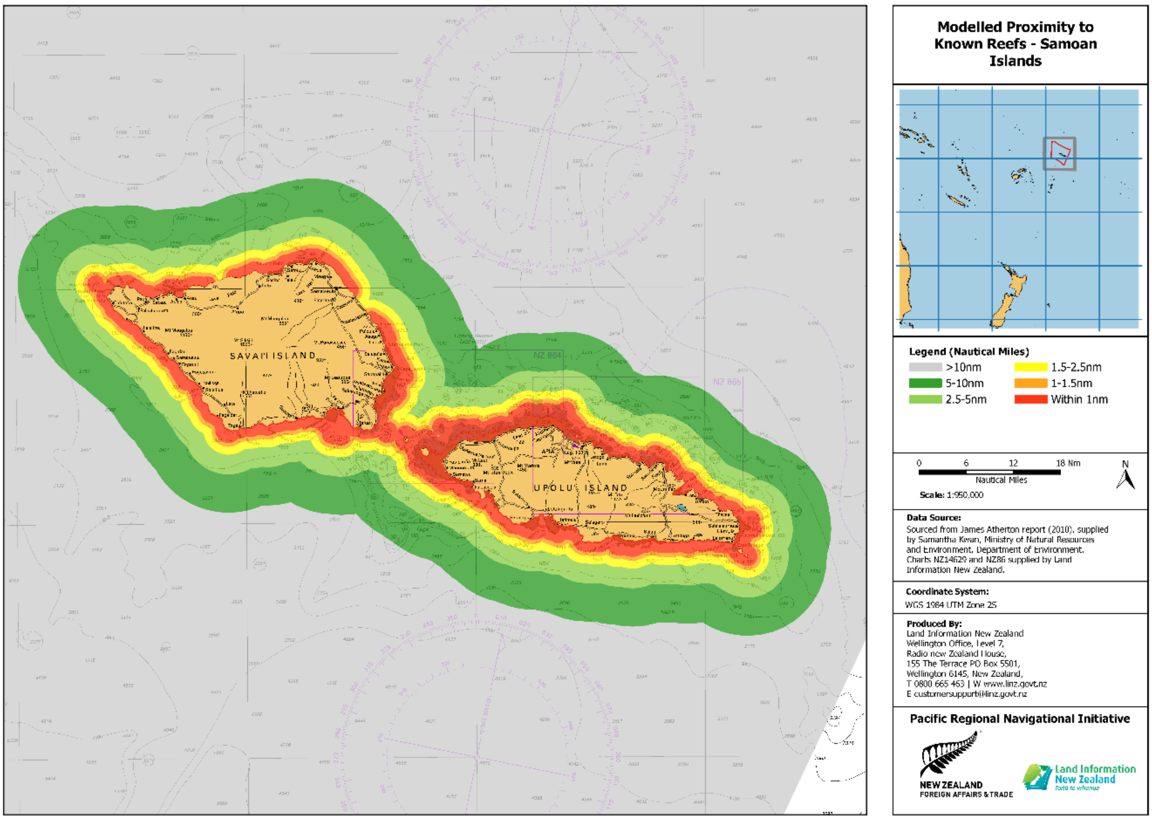
Figure 8 represents relative hydrographic risk due to the nature of the seabed across the study area. This figure was derived from information available on the largest scale chart.

ANNEX D – Likelihood and Consequence Factors

2.5 Navigational Hazards

A number of hazards exist that are obstructions to navigating vessels; the risk for a transiting vessel is greater the closer the regular route is to such hazards.[169]

2.5.1 Proximity to Known Reefs



Annex D Figure 9: Modelled Proximity to Known Reefs

Figure 7 represents relative hydrographic risk due to the proximity to known reefs across the study area. This figure was created based on the location of reefs as marked on the largest scale chart with additional information regarding some coastal reefs provided by MNRE.[170]

2.5.2 Sub-Sea Volcanic Activity

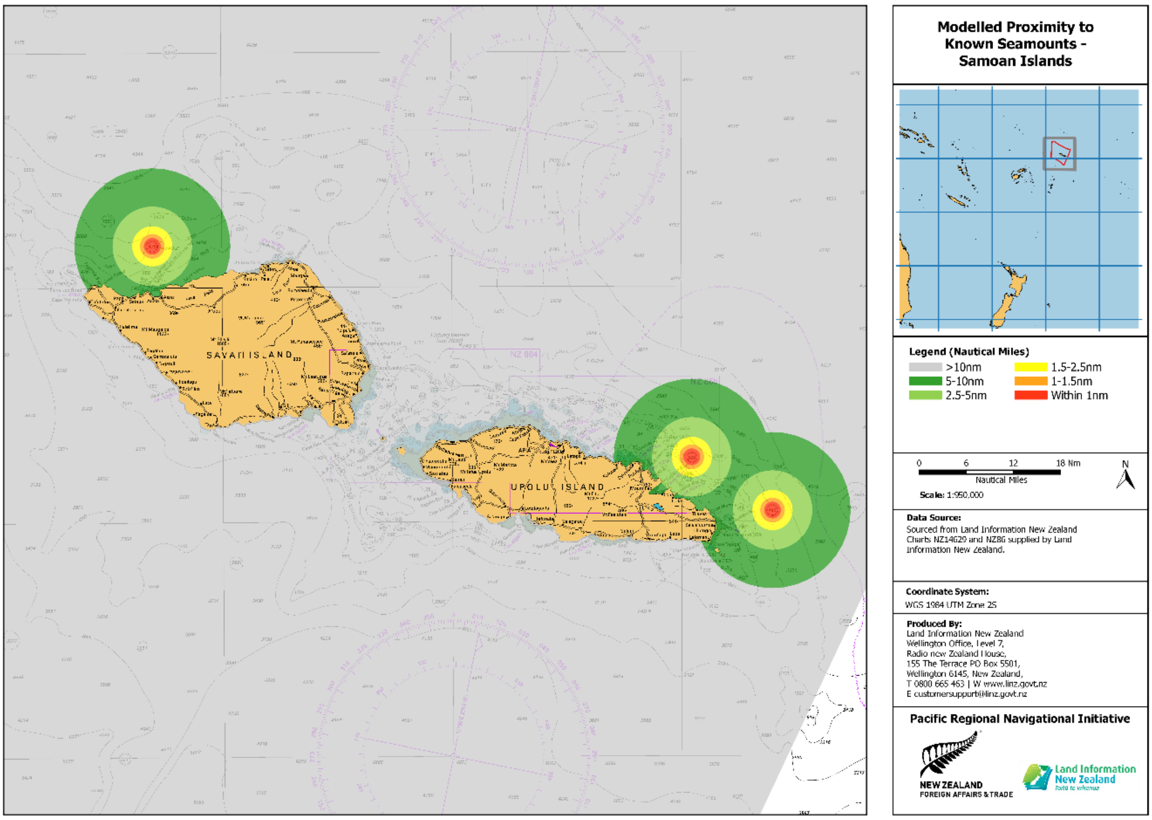
The study did not find evidence of recent sub-sea volcanic activity across the study area. The level of hydrographic risk due to the proximity to sub-sea volcanic activity was therefore assigned a weight of 0 (zero) in the calculation of hydrographic risk.

[169] For consistency, this explanation was taken from (Marico Marine Report No. 12NZ246-1, Issue 1, January 2013, D40).

[170] Data sourced from Ministry of Natural Resources and Environment, Department of Environment (Samantha Kwan) with reference to (Atherton, 2010).

ANNEX D – Likelihood and Consequence Factors

2.5.3 Proximity to Known Sea-Mounts



Annex D Figure 10: Modelled Proximity to Known Seamounts

Figure 10 represents relative hydrographic risk due to the proximity to known seamounts across the study area. This figure was created based on existing charts and information provided by SPREP,[171] but only seamounts rising 1000m above the surrounding seabed and to within 500m of the surface were included.

2.5.4 Proximity to WW2 Military Sites

The study did not find any WW2 military sites, former mined areas or dumping grounds for unexploded ordinance, in the study area. The risk due to the proximity to WW2 military sites was therefore assigned a weight of 0 (zero) in the calculation of hydrographic risk.

2.5.5 Proximity to Charted Tidal Hazards (Overfalls/Race)

The study found that charted tidal hazards (overfalls/race) were not present across the study area. The risk due to the proximity to charted tidal hazards (overfalls/race) was therefore assigned a weight of 0 (zero) in the calculation of hydrographic risk.

[171] Interview with Ryan Wright, Spatial Planning Officer, Secretariat of the Pacific Regional Environment Program.

ANNEX D – Likelihood and Consequence Factors

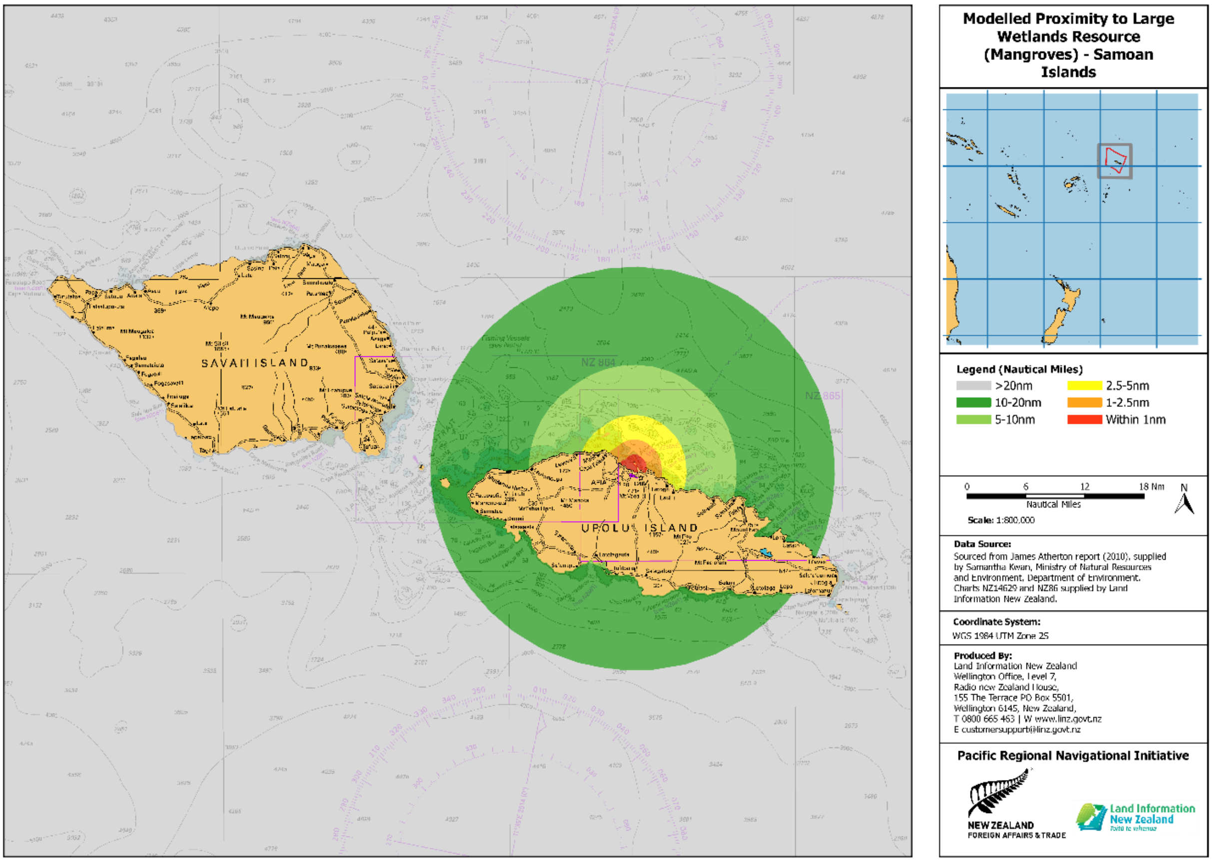
3. Consequence Factors

3.1 Environmental Impact

The effect on the marine environment following a major maritime disaster can be devastating. In particular, a considerable risk exists in the potential for a fuel tank or a cargo hold to be breached, releasing pollutants. Shoreline habitats can be destroyed by either the primary physical impact of grounding or through the secondary release of a pollutant.[172]

3.1.1 Proximity to Wetland Resources (Mangroves)

Large and small wetland resources can be impacted by a maritime incident within the South West Pacific. Samoa has a number of significant wetlands including the largest mangrove area in the South-West Pacific at Vaiusu Bay. These figures were compiled from information provided by MNRE.[173]

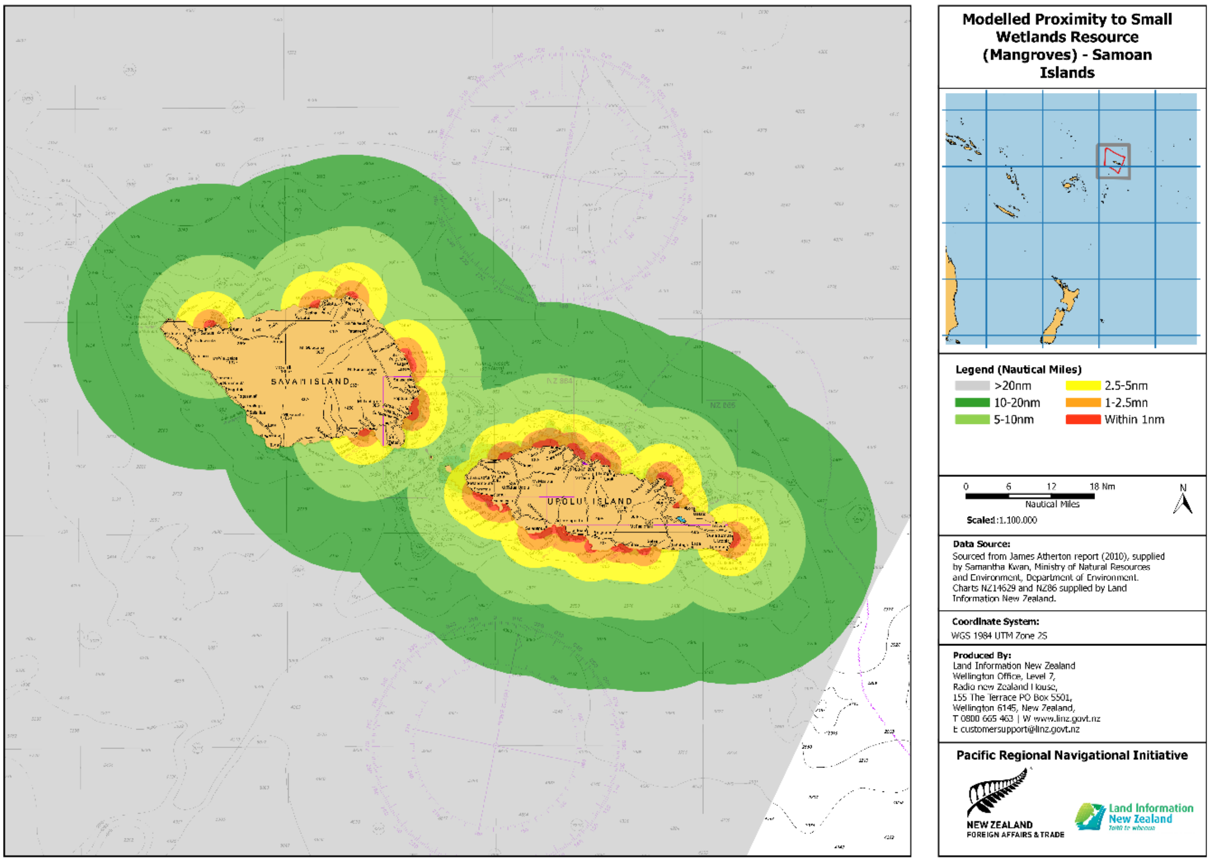


Annex D Figure 11: Proximity to large wetland resource

[172] For consistency, this explanation was taken from (Marico Marine Report No. 12NZ246-1, Issue 1, January 2013, D51).

[173] Data sourced from Ministry of Natural Resources and Environment, Department of Environment with reference to (Atherton, 2010)

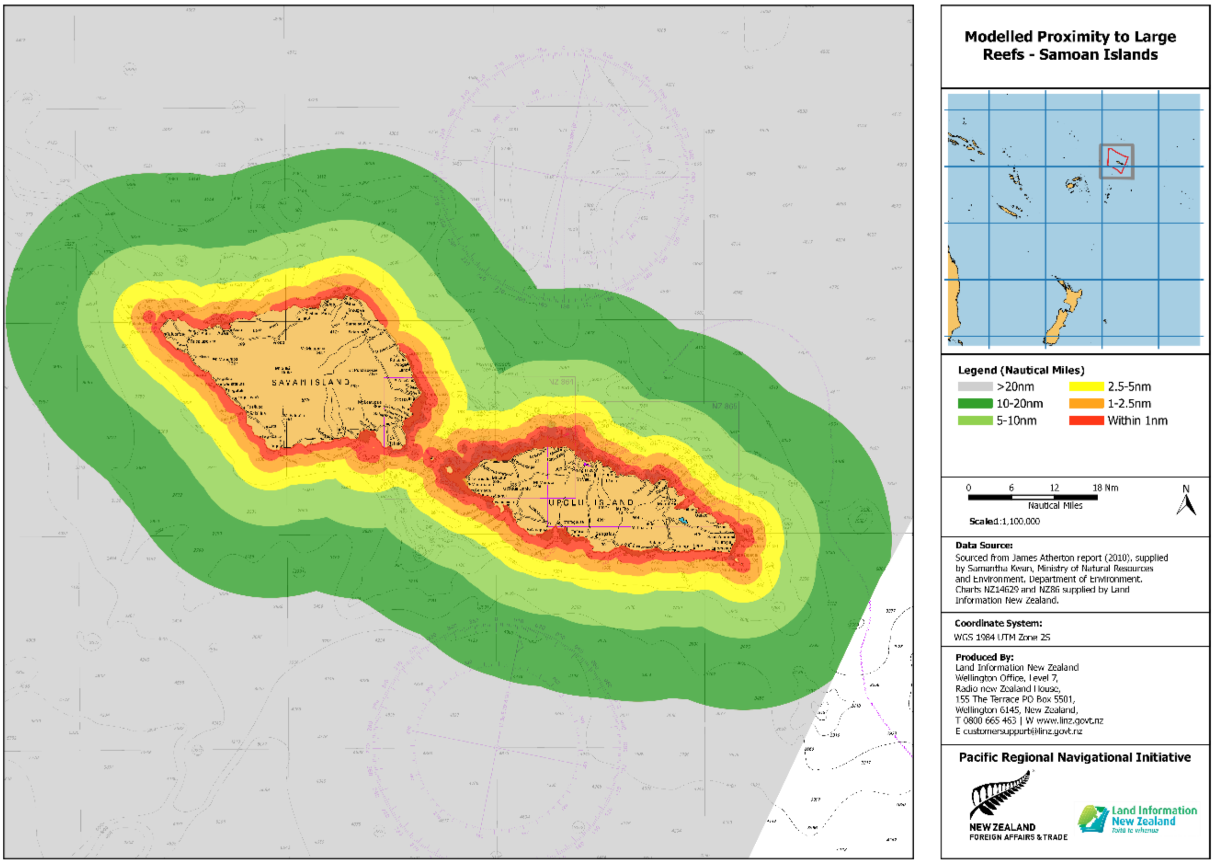
ANNEX D – Likelihood and Consequence Factors



Annex D Figure 12: Proximity to small wetland resource

ANNEX D – Likelihood and Consequence Factors

3.1.2 Proximity to Large Reefs

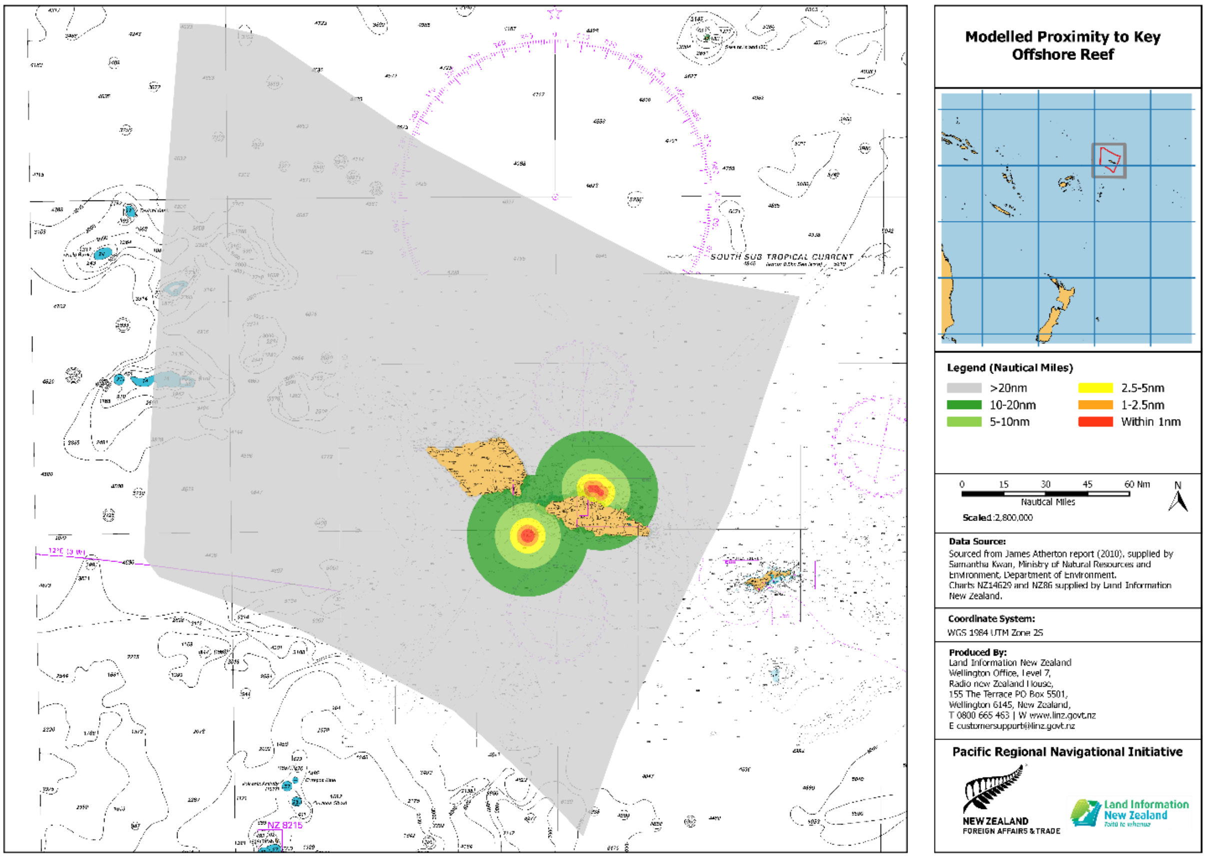


Annex D Figure 13: Modelled proximity to large reefs

Figure 13 represents relative hydrographic risk due to the proximity to large reefs across the study area. Virtually the whole coastline of Samoa is surrounded by fringing reef, though on the southern coast this is narrower and there are some areas where the sea breaks onto coastal cliffs. For this analysis, the entire coastline of Samoa is defined as a large reef. There are no other large reefs throughout the Samoan EEZ

ANNEX D – Likelihood and Consequence Factors

3.1.3 Proximity to Key Offshore Reef

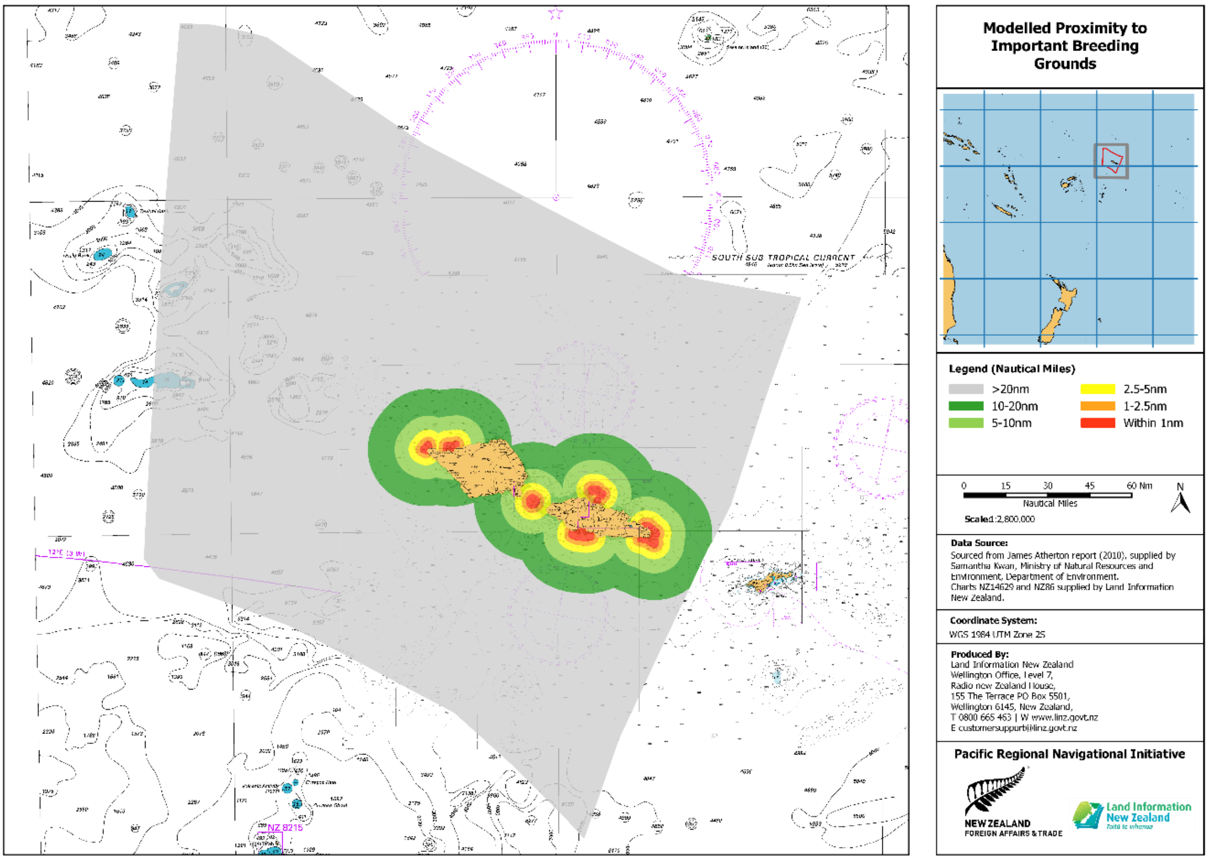


Annex D Figure 14: Modelled Proximity to Key Offshore Reef

Figure 14 represents relative hydrographic risk due to the proximity to key offshore reefs across the study area. This figure was created based on information provided by Ministry of Natural Resources and independently corroborated by SPREP. There were two, key offshore (but submerged) reefs identified, these were “Five Mile Reef,” north of Apia and “15 Mile Reef,” south-west of Faleaseela.

ANNEX D – Likelihood and Consequence Factors

3.1.4 Proximity to Important Breeding Grounds



Annex D Figure 15: Modelled Proximity to Important Breeding Grounds

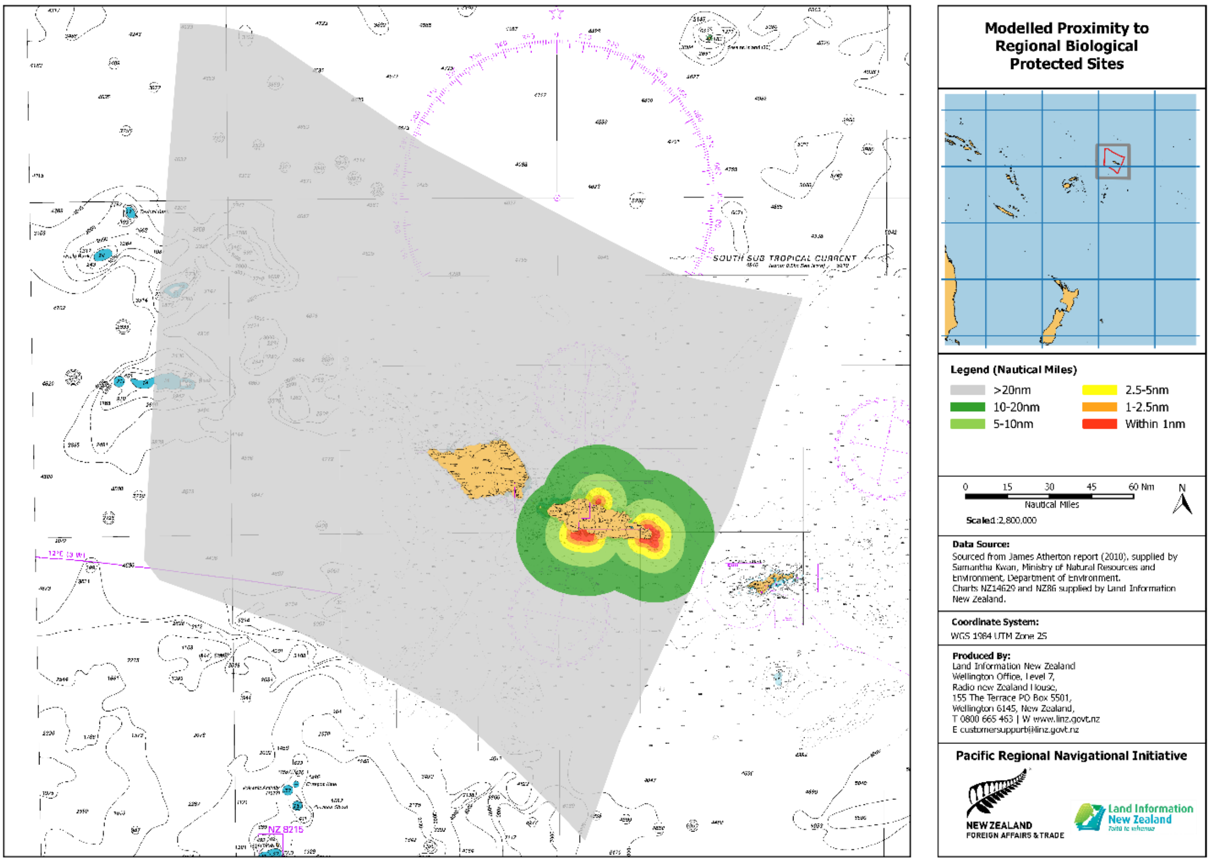
Figure 15 represents relative hydrographic risk due to the proximity to important breeding grounds across the study area. This figure was created based on information provided by MNRE[174] and SPREP.[175]

174 (Atherton, 2010)

175 (United Nations Environment Program (UNEP), 2015)

ANNEX D – Likelihood and Consequence Factors

3.1.5 Proximity Regional Biological Protected Sites



Annex D Figure 16; Modelled Proximity to Regional Biological Protected Sites

There were no world biological protected sites in the study area. Consequently, the risk weighting for this criterion was distributed across regional and local biological protected sites. Figure 16 represents relative hydrographic risk due to the proximity to regional biological protected sites across the study area. The sites shown in this figure were given the significance of a regional biological protected site from information provided by MNRE[176] and corroborated by SPREP[177].

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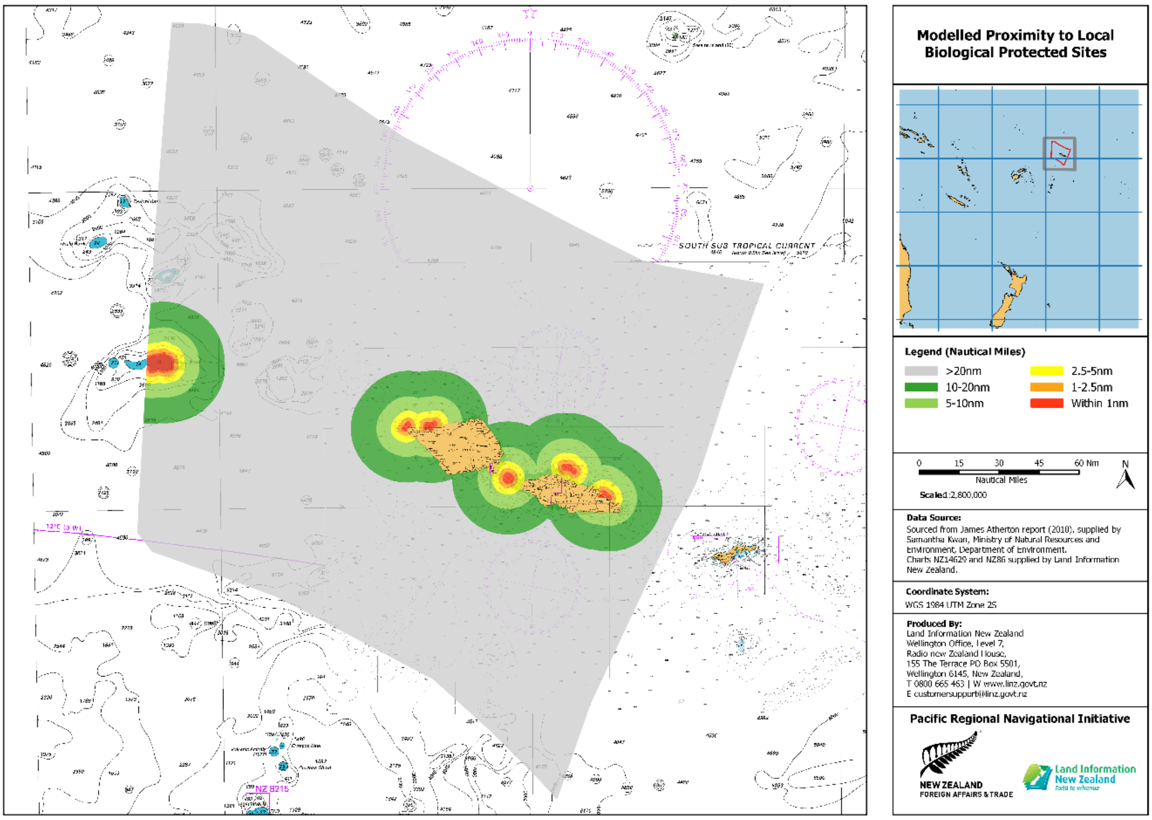
176 (Atherton, 2010)

177 (United Nations Environment Program (UNEP), 2015)

ANNEX D – Likelihood and Consequence Factors

3.1.6 Proximity to Local Biological Protected Site



Annex D Figure 17: Modelled Proximity to Local Biological Protected Site

This Figure represents relative hydrographic risk due to the proximity to local biological protected sites across the area of study. This figure was created based on the information provided by MNRE[178] and SPREP.[179] Pasco Bank was additionally included due to its potential as a fish breeding area and to ensure that the consequence value would be non-zero.

3.2 Culturally Sensitive Areas

The consequences of a shipping incident may cause damage beyond the environment. Areas of high cultural significance need to be allocated appropriate consequence weightings. As with environmentally significant sites the relative importance of these sites can range from sites of global significance such as World Heritage Sites to local village taboo.

As in previous South West Pacific risk assessments, three designations were created relating to the relative significance of a cultural site. Cultural sites can be globally, regionally or locally significant

[178] (Atherton, 2010)

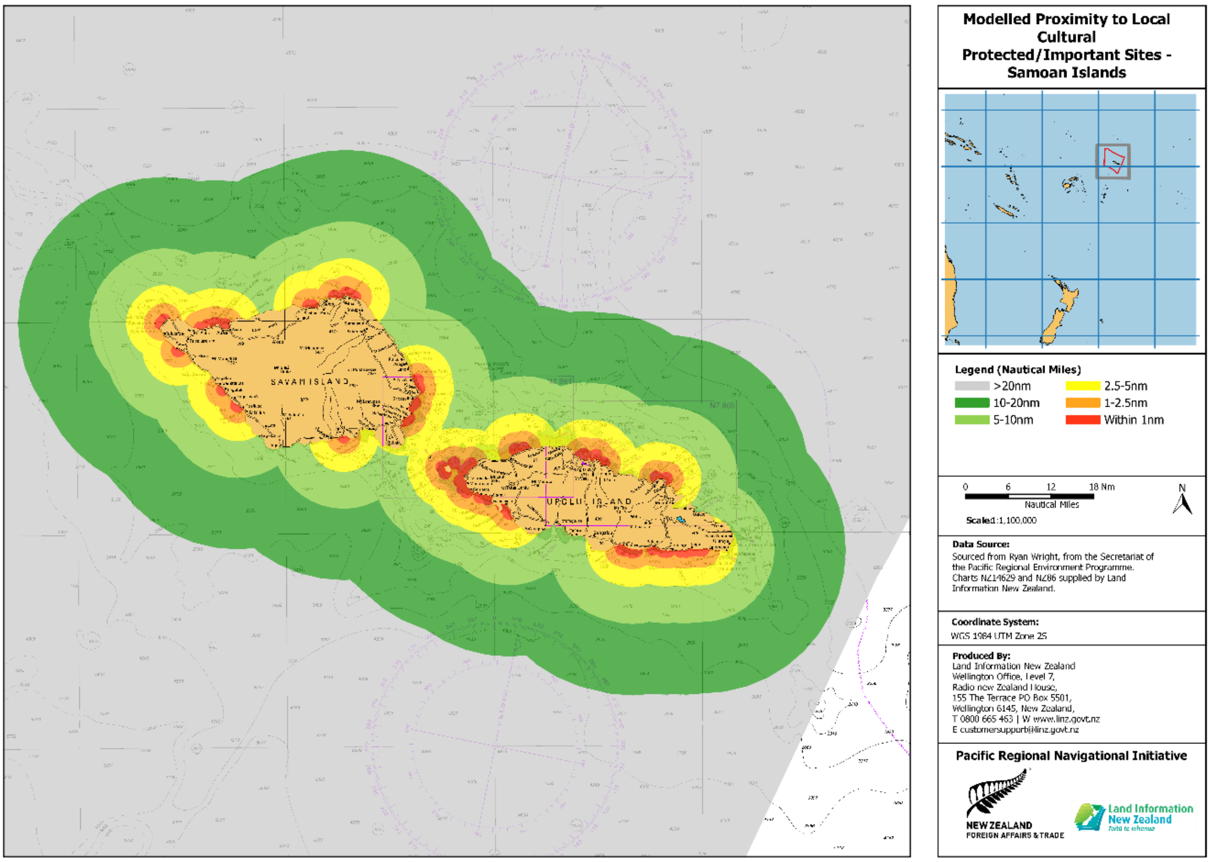
[179] (United Nations Environment Program (UNEP), 2015)

depending on the importance of a protection designation, such as World Heritage Site, or the size of the group for whom the site is important.[180]

3.2.1 Proximity to World/Regionally Cultural Protected/Important Sites

The study found that there were no formally recognised world or regionally protected cultural heritage sites across the study area, these factors were therefore both given a weight of 0 in the calculation of hydrographic risk and the cost or benefit of addressing the identified risk.

3.2.2 Proximity to Local Cultural Protected/Important Sites



Annex D Figure 18: Modelled Proximity to Local Cultural Protected Site

Figure 18 represents relative hydrographic risk due to the proximity to local cultural protected sites. This figure identifies the cultural sites linked to local villages and was compiled from data provided by SPREP.[181]

[180] For consistency, this explanation was taken from (Marico Marine Report No. 12NZ246-1, Issue 1, January 2013, D65).

[181] (United Nations Environment Program (UNEP), 2015) and interview with Ryan Wright.

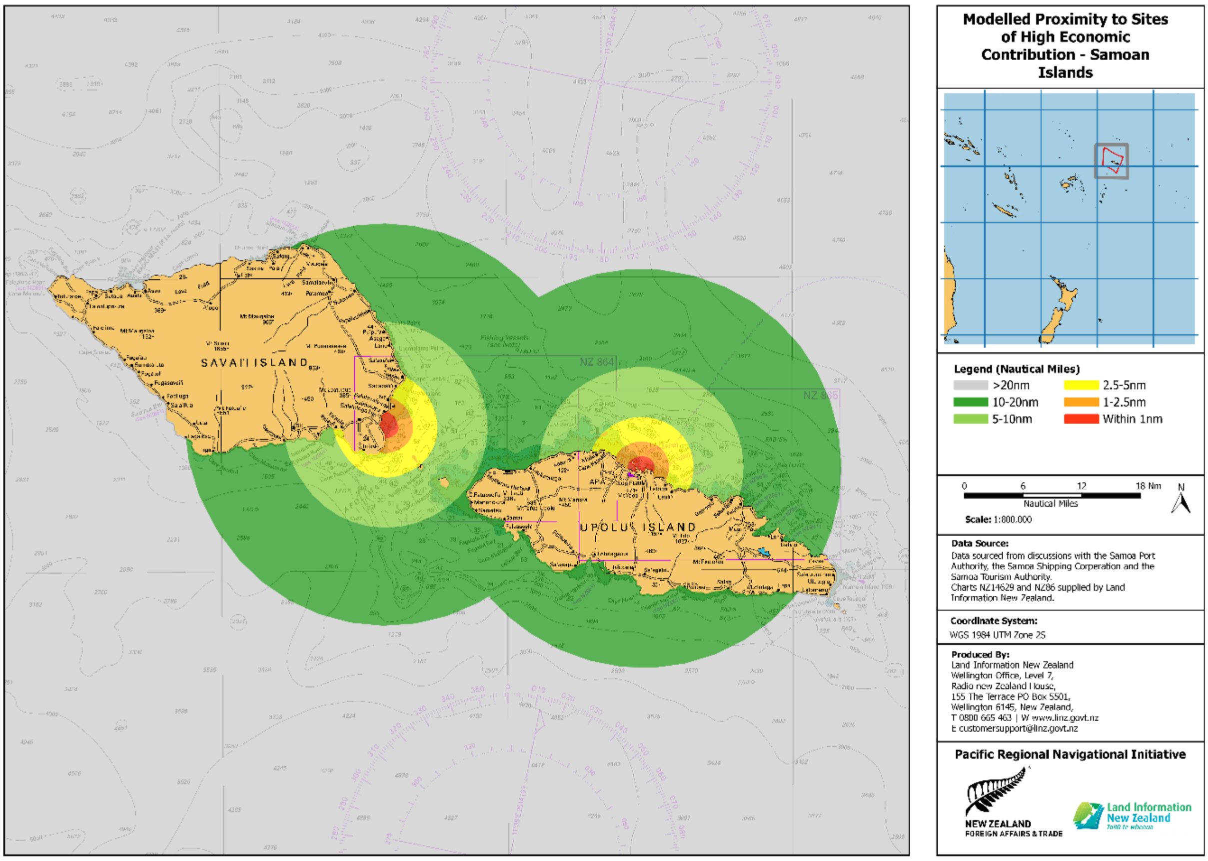
ANNEX D – Likelihood and Consequence Factors

3.3 Economically Sensitive Areas

The economic consequence of a shipping incident refers to the impact upon the local economy and not to the ship operator. The economic consequence is in most cases a denial of access problem with the loss of a resource, tourist potential or in the extreme a closure of a business.[182]

3.3.1 Proximity to Site of High Economic Contribution

The study found that Samoa's international trade was completely dependent on the operation of the port of Apia and rated Apia as a site of high economic contribution. Similarly, the port of Salelologa is the only commercial port on the island of Savai'i and the island's economic survival is completely dependent on the port for imports (including all fuel) and exports. The majority of tourist also transit through here, thus this port is identified as a site of high economic contribution.

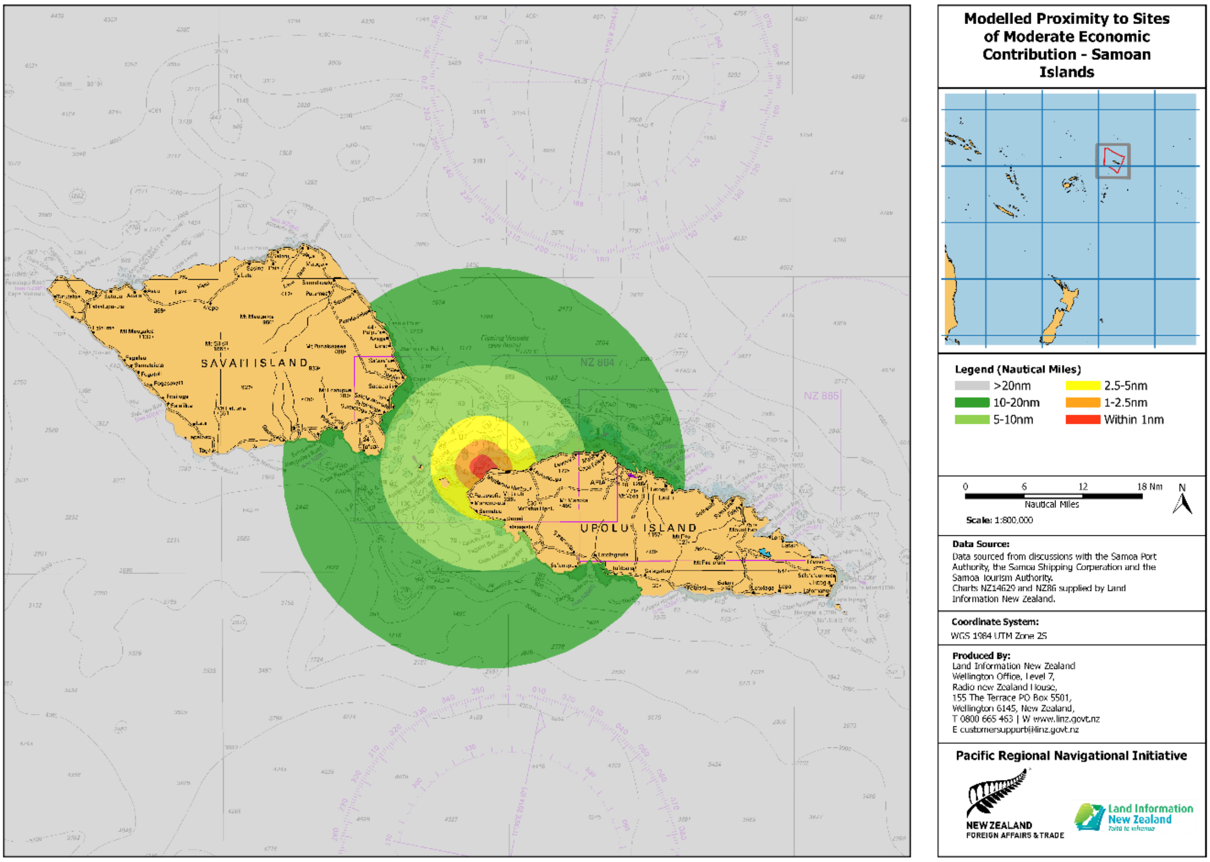


Annex D Figure 19: Proximity to Site of High Economic Contribution

[182] For consistency, this explanation was taken from (Marico Marine Report No. 12NZ246-1, Issue 1, January 2013, D70).

ANNEX D – Likelihood and Consequence Factors

3.3.2 Proximity to Site of Moderate Economic Contribution

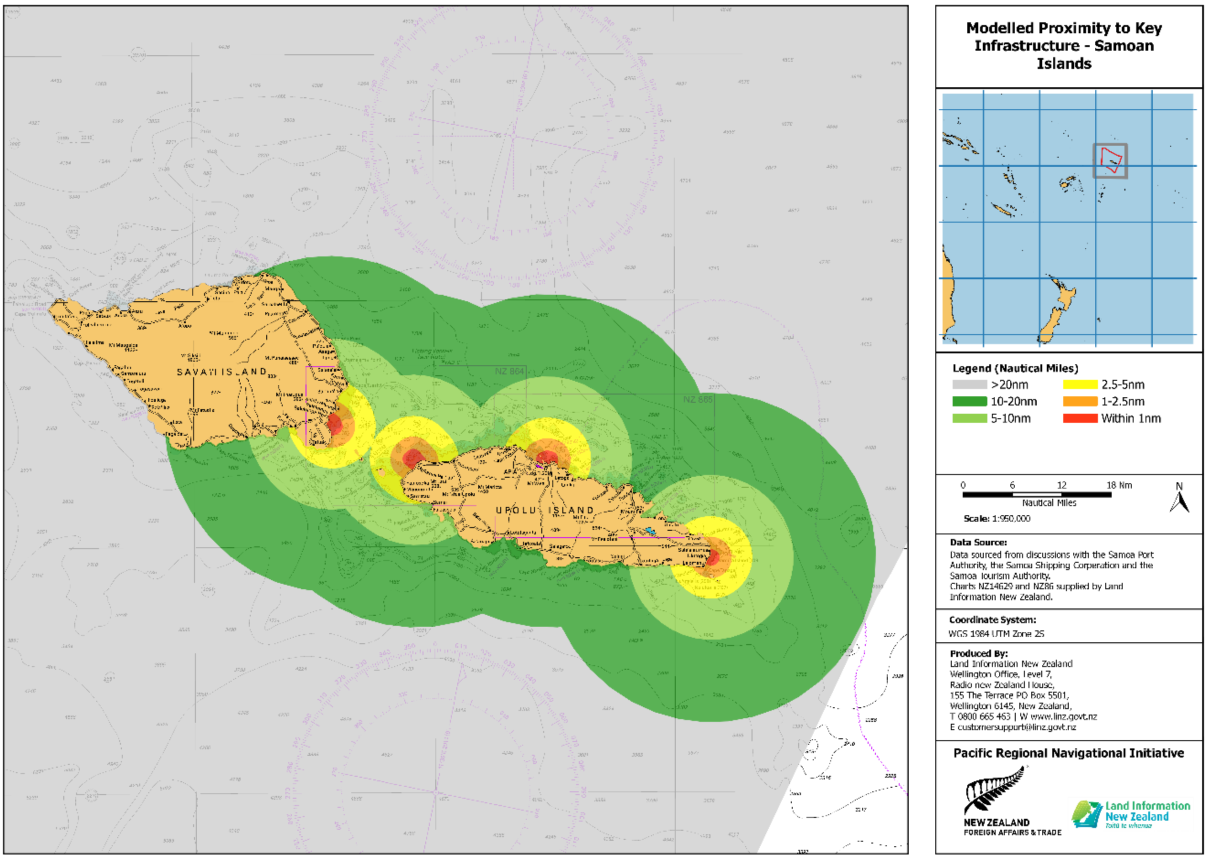


Annex D Figure 20: Modelled Proximity to Site of Moderate Economic Contribution

Figure 20 shows relative hydrographic risk due to the proximity to sites of moderate economic contribution. The port of Mulifanua provides the main connection to the island of Savai'i for inter-island trade and movement of passengers. Apia provides an alternative port and some fuel supplies and other cargo are routed from there directly to Salelologa, thus Mulifanua is classified as a site of moderate economic contribution.

ANNEX D – Likelihood and Consequence Factors

3.3.3 Proximity to Key Infrastructure

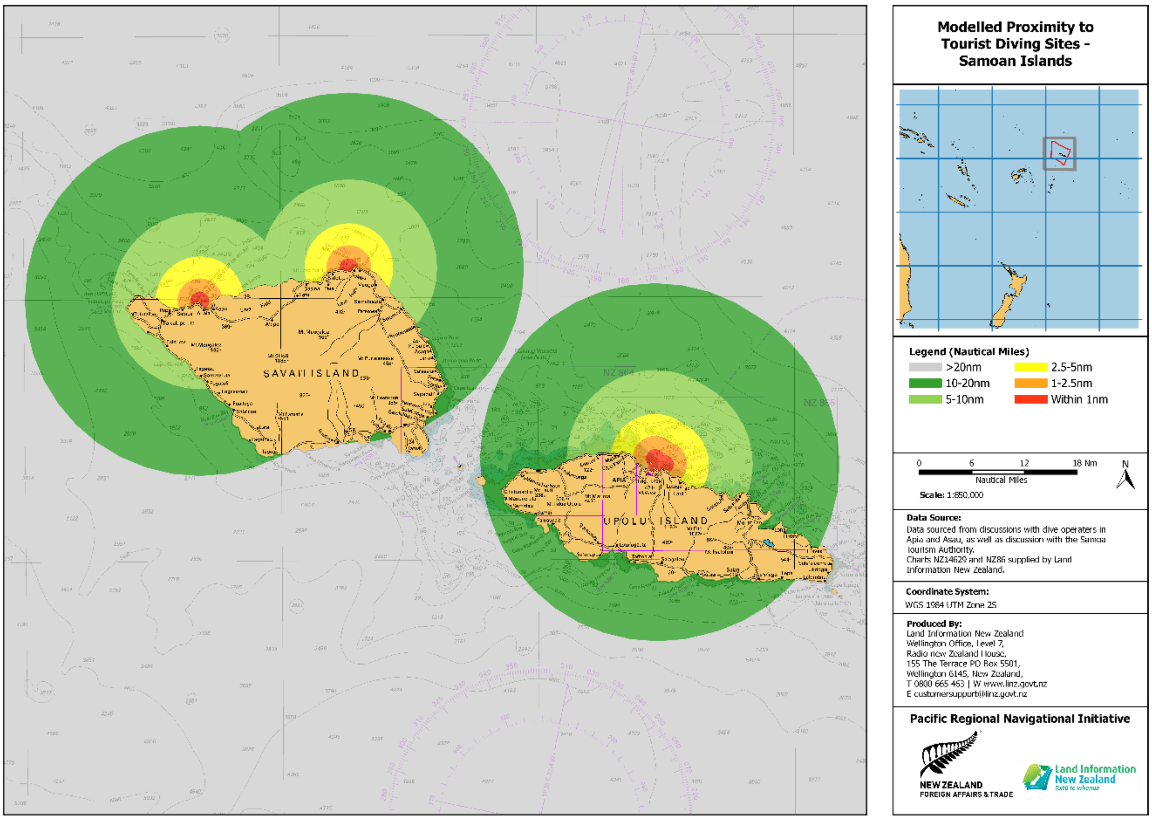


Annex D Figure 21: Modelled Proximity to Key Infrastructure

Figure 21 represents relative hydrographic risk due to the proximity to key infrastructure across the study area. This figure was created based on information gathered during the in-country visit. The port of Apia provides all the infrastructure enabling international maritime trade, the ports of Mulifanua and Salelologa provide the as the key infrastructure for domestic inter-island trade and the port of Aliepata (Satitoa) provides the only slipway in Samoa.

ANNEX D – Likelihood and Consequence Factors

3.3.4 Proximity to Tourist Diving Site



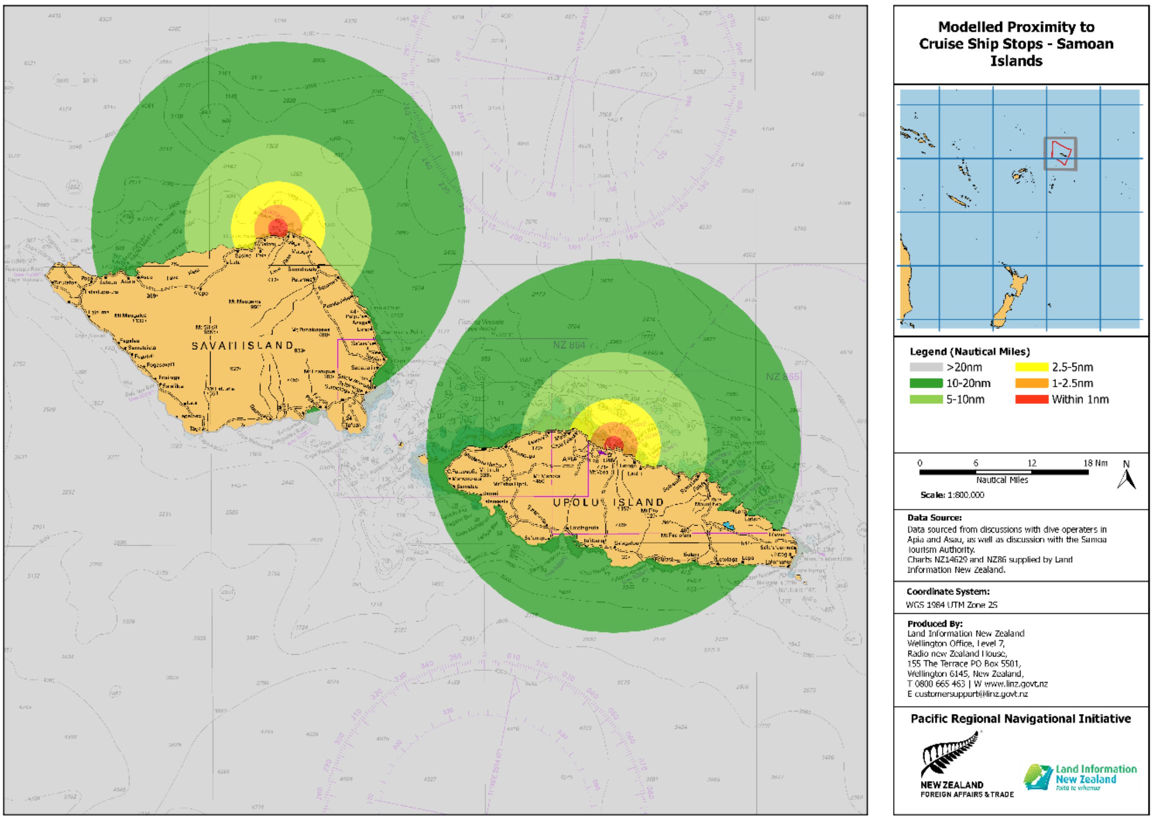
Annex D Figure 22: Modelled Proximity to Tourist Diving Site

Figure 22 shows relative hydrographic risk due to the proximity to tourist diving sites across the study area. This figure was created based on interviews with the operators of “AquaSamoa” and “Dive Savai’i” and corroborated by Samoa Tourism Authority.[183]

[183] Interview with Sonja Hunter, CEO.

ANNEX D – Likelihood and Consequence Factors

3.3.5 Proximity to Cruise Ship Stop



Annex D Figure 23: Modelled Proximity to Cruise Ship Stop

Figure 23 represents relative hydrographic risk due to the location of cruise ship stops across the study area. This figure was created based on AIS data and confirmed by interviews with Captain Lotomau Tomane,[184] Sonja Hunter[185] and Feagaima'alii Nanai M. Sua[186]

[184] Samoa Port Authority
[185] Samoa Tourist Authority
[186] Ministry of Revenue - Customs

ANNEX E – Hydrographic Risk Factor Weighting Matrices

Overview

1. The risk matrix shown on page E-2 below provides both:

   a. the generic low traffic risk matrix developed by LINZ/Marico Marine[187] used in previous regional South West Pacific risk analyses, and

   b. a slightly modified "in-country" weighting factor adopted for this Samoa risk assessment (last three columns).

2. While the overall aim of this risk assessment is to provide results comparable with those conducted in the Cook Islands, Tonga and Niue, the specific circumstances of Samoa are such that some of the likelihood and consequence criteria do not exist in Samoa. Thus, an adjustment was made to provide the best risk discrimination between local.

3. An amended "in-country" Samoa risk matrix was created by setting irrelevant likelihood criteria to zero so that other criteria within the category received higher weighting and the overall category retained its relative importance. Those set to zero were: proximity to sub-sea volcanic activity, proximity to WW2 military sites, and proximity to charted tidal hazards.

4. Additionally, the following consequence criteria were set to zero and other criteria within the category received higher weighting so that the overall category retained its relative importance: proximity to world biologically protected sites, proximity of world culturally protected sites and proximity to regional culturally protected sites.

5. While it could be argued that the redistribution of these criteria results in biasing the overall risk towards the remaining criteria, it is considered that the overall result is more representative of the absolute hydrographic risk for the Niue "in-country" region than that calculated from the South West Pacific regional risk matrix.

6. Risk results were calculated using both of these sets of weightings and a discussion of the differences is included in Section 7 of the main report (Risk Results).

[187] (Marico Marine Report No. 15NZ322 Issue 03, 5 August 2015, p. D2)

ANNEX E – Hydrographic Risk Factor Weighting Matrices

Risk Matrix showing - SW Pacific Regional Risk Weightings (fixed Scales) & amended Samoa "in-country" weightings (right 3 columns)

		Risk Scores						Weightings of Regional Risk Assessment			Weightings of Samoa In-country Risk Assessment		
		0	1	2	3	4	5	Factor	Category	Total Model	Factor	Category	Total Model
		Increasing Risk ----------------->											
Traffic	Vessel Traffic												
	Potential Loss of Life (Vessel Type + GT Weighed)		Insignificant	Low	Moderate	High	Catastrophic			0.5000			0.5000
	Pollution Potential (Vessel Type + GT Weighted)		Insignificant	Low	Moderate	High	Castastrophic			0.5000			0.5000
Likelihood Risk Criteria	MetOcean Conditions												
	Prevailing Conditions Exposure		Sheltered at most times	Mainly Sheltered	Moderate Exposure	Mainly Exposed	Exposed on most days	3	0.3	0.1500	3	0.3	0.1500
	Spring Mean Current Speed	Open Sea (Current insignificant)	1-2 knots	2-3 knots	3-4 knots	>5 knots	>5 knots	2		0.1000	2		0.1000
	Visibility	Unknown	Poor Visibility Very Unlikely	Poor Visibility Unlikely	Occasional Poor Visibility	Often Poor Visibility	Poor Visibility Common	1		0.0500	1		0.0500
	Navigational Complexity												
	Type of Navigation Required		Open Sea >10nm	Offshore Navigation (5-10nm)	Coastal Navigation (1-5nm)	Port Approaches	Constrained Navigation (Within 1nm)	3	0.15	0.1500	3	0.15	0.1500
	Aids to Navigation												
	ChartZoc		A	B	C	D	U	3	0.3	0.1800	3	0.3	0.1800
	Proximity to Non Working AToNs (Nav Lights)	No Lights	100% effective range	80% effective range	70% effective range	60% effective range	Within 50% effective range	2		0.1200	2		0.1200
	Bathymetry												
	Depth of Water 15m Contour	>10nm	5-10nm	2.5-5nm	1.5 to 2.5nm	1 to 1.5nm	Within 1nm	3	0.1	0.0600	3	0.1	0.0600
	Bottom Type		Soft				Hard/Rocky	2		0.0400	2		0.0400
	Navigational Hazards												
	Proximity to Known Reefs	>10nm	5-10nm	2.5-5nm	1.5 to 2.5nm	1 to 1.5nm	Within 1nm	2	0.15	0.0333	2	0.15	0.1000
	Proximity to Sub-Sea Volcanic Activity	>10nm	5-10nm	2.5-5nm	1.5 to 2.5nm	1 to 1.5nm	Within 1nm	2		0.0333	0		0.0000
	Proximity to Known SeaMounts	>10nm	5-10nm	2.5-5nm	1.5 to 2.5nm	1 to 1.5nm	Within 1nm	1		0.0167	1		0.0500
	Proximity to WW2 Military Sites	>2.5nm	2-2.5nm	1.5-2nm	1-1.5nm	500m-1nm	Within 500m	1		0.0167	0		0.0000
	Proximity to Charted Tidal Hazard (Overfalls/Race)	>2.5nm	2-2.5nm	1.5-2nm	1-1.5nm	500m-1nm	Within 500m	3		0.0500	0		0.0000
Consequence Risk Criteria	Environmental Impact												
	Proximity to Large Reef (High Quality / or Isolated Shoreline	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	3	0.5	0.0789	3	0.5	0.0938
	Proximity to Key Offshore Reef (Cooks Reef or Rowe Island)	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	2		0.0526	2		0.0625
	Proximity to Large Wetlands Resource (Mangroves) (Large Volume or Small Volume)	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	3		0.0789	3		0.0938
	Proximity Small Wetlands Resource (Mangroves) (Large Volume or Small Volume)	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	2		0.0526	2		0.0625
	Proximity to Important Breeding Grounds	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	3		0.0789	3		0.0938
	Proximity to World Biological Protected Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	3		0.0789	0		0.0000
	Proximity to Regional Biological Protected Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	2		0.0526	2		0.0625
	Proximity to Local Biological Protected/Important Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	1		0.0263	1		0.0313
	Culturally Sensitive Areas												
	Proximity to World Cultural Protected/Important Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	3	0.15	0.0750	0	0.15	0.0000
	Proximity to Regional Cultural Protected/Important Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	2		0.0500	0		0.0000
	Proximity to Local Cultural Protected/Important Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	1		0.0250	1		0.1500
	Economically Sensitive Areas												
	Proximity to Sites of High Economic Contribution	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	3	0.35	0.1000	3	0.35	0.1000
	Proximity to Sites of Moderate Economic Contribution	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	1		0.0333	1		0.0333
	Proximity to Key Infrastructure (Ports)	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	3		0.1000	3		0.1000
	Proximity to Tourist Diving Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	1.5		0.0500	1.5		0.0500
	Cruise Ship Stops	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	2		0.0667	2		0.0667

ANNEX F – Hydrographic Risk Calculations

Overview

1. Risk can be calculated as the product of probability of an undesirable event happening and the expected consequences, i.e. Risk = Probability x Consequence. However, when assessing hydrographic risk the shipping traffic comprises the predominant factor. Previous risk assessments note that "Risk requires the co-existence of three variables. Traffic must transit through an area, there must be a likelihood of that traffic to have an incident and there must be a consequence of that incident."[188] Clearly, if any one of these three factors is not present there is no risk.

2. Each of these factors is calculated from a number of different input variables which are all listed in the risk matrix.[189] The risk matrix is the core document upon which the implementation of the risk model depends. Due to each island group having slightly different risks there is some variance between the risk models used in each of the separate assessments.

3. The hydrographic risk model has three main components:

(1) Spatial definitions of the input data showing vessel traffic and the distribution of likelihood and consequence factors.

a. In the case of likelihood and consequence inputs these are areas defined in the GIS attributed with scores of 1-5 representing relative risk. For example, CATZOC areas can be represented in the GIS as polygons with a 1 to 5 score assigned to each. The definition of each input variable's 1 to 5 scoring is in the risk matrix. For CATZOC, a rating of "A" gets a score of 1 (low risk), "B" gets a score of 2, and so on to "Unassessed" which has the maximum score of 5.

b. Traffic inputs are either satellite AIS tracks from vessels, and if needed, estimated tracks for non-AIS vessels which have been manually digitised in the GIS. Each track has vessel type and gross tonnage (GT) attributes from which a relative score representing potential loss of life and pollution for "most likely" or "worst case" accidents. Section 4.1.4 of the Vanuatu Risk Assessment Annexes explains the detail of how this is done. The end result is a raw but representative score for each vessel track indicating how much potential risk is associated with that particular vessel. All the 'raw' scores are then translated to a 1-5 score using the Jenks Natural Breaks statistical method.

(2) Grid of the study area.

a. The study area (Samoa EEZ) is covered by a grid comprising cells 1.0 km by 1.0 km. This grid is the common framework that combines all the inputs and is used to map the computed risk scores. Previous risk South West Pacific risk

[188] (Marico Marine Report No. 12NZ246-1, January 2013, p. D.10)
[189] See Annex E

ANNEX F – Hydrographic Risk Calculations

assessments have used a 2.5 km grid but better processing power has enabled higher resolution to be used in this instance.

b. Inputs are combined by assigning each cell the input scores for those inputs that spatially intersect each particular cell. This allows all traffic, likelihood and consequence scores to be combined in one layer where the model calculations can be made.

(3) Model calculation and synthesis

a. Each input variable has a weighting applied to it so the relative importance of inputs can be factored in. A final weighting number for each input is calculated from its relative importance to other inputs in its sub-category, then that category's weighting in the overall category and finally the weighting for traffic vs likelihood vs consequence. All these weightings are documented in the risk matrix at Annex E.

b. The risk is calculated by multiplying the weighted scores for traffic (T), likelihood (L) and consequence (C) together taking into account the following:

- Risk =T x L x C

- All T, L and C scores are divided by 5 to normalise the scores to the commonly used probability range of 0-1 rather than the 0-5 range the input variables were initially classified as.

So the calculation becomes **Risk = T/5 x L/5 x C/5**

- Although risk is equal to T x L x C, consequence is also a product of likelihood and traffic: C = T x L.

Adding in this consideration we get **Risk = T/5 x L/5 x C/25** (because if C =T/5 x L/5 then C becomes C/25.

c. Using this formula, hydrographic risk is computed for each cell in the grid and the results are classified using Jenks Natural Breaks into five risk categories of insignificant, low, moderate, heightened and significant for display as a heat map.

4. A Word of Caution – Interpreting Heat Map Results

4.1 The use of Jenks Natural Breaks to allocate the colour mapping for the final "in-country" risk plots has the effect of converting the risk results into a relative risk heat map across the Samoa study

ANNEX F – Hydrographic Risk Calculations

area. This is because this method will represent the lowest risk as *insignificant* (green) and the highest risk as *significant* (red), across the numerical range of calculated risk values.

4.2 To normalise the results and thus allow a level of comparison with the heat map results of other South West Pacific hydrographic risk assessments, a further "regional" heat map was produced using the same colour mapping to risk scores as the final heat map colour groups of the Tonga and Cook Islands and Niue assessments. These values used are shown below.

Regional Risk Colour Map Break Values	
0.00000 – 0.01007	insignificant
0.01007 – 0.03891	low
0.03891 – 0.08772	moderate
0.08772 – 0.17805	heightened
0.17805 – 0.38684	significant

4.3 Due to the Samoa risk assessment utilising a full 12 months of AIS and domestic traffic data whereas the previous assessments have only used 9 months of traffic data, the final cell risk values were multiplied by 0.75 before applying the colour mapping (this is feasible because risk is directly proportional to GT).

4.4 The other difference in this assessment is the cell size. The 1 km square cells used in this assessment are 6.25 times smaller in area than previous 2.5 km square cells. However, as vessels can be assumed to generally travel in straight lines over small distances in open waters (this is not true for pilotage waters), it is the difference in the length of cell sides and diagonals that determine the difference in traffic intersecting the cells. This value is 2.5 times. This would indicate that the total cell traffic risk calculated for Samoa needs to be multiplied by 2.5 times to normalise it with previous assessments.

4.5 A complicating factor is that when traffic is constrained by a narrow channel or by choosing the most efficient (shortest or safest) route, the same amount of traffic may pass through a 1 km cell as would have passed through a 2.5 km cell. This is certainly the case for the narrow entrance channels at Apia, Mulifanua and Salelologa and also in the narrow part of Apolima Strait near Apolima Island. Thus, to avoid overstating the risk in confined areas and accepting that comparative risk may be understated in open ocean areas, **the Samoa risk values have not been adjusted to compensate for the small grid squares.**

4.3 This "regional" heat map shows that Samoa has significantly higher risk around its coastal areas, particularly Apolima Strait and the approaches to Apia, than the "regional" result for Niue, but similar risk levels to those in the higher traffic areas of the Tonga and Cook Islands assessments. These results are consistent with the high level of traffic in these areas, the proximity to navigational dangers and sensitive coastal reef areas, but taking into account the high CATZOC values that result from good quality of hydrographic survey and charting. The quality of charting in these areas is the principal factor that results in the "regional" risk result in these areas being generally lower than in Tonga and Cook Islands.

ANNEX G – Benefits of Hydrographic Surveys to SAMOA

Benefits of Hydrographic Surveys[190]

1. Hydrographic survey data is an enabler that underpins all maritime activities. Classically, the data is integrated into ships' charts to enable the safe planning and execution of a voyage. The quality of hydrographic charts is an important factor in determining the risk of undertaking voyages and the cost of insurance to underwrite that risk. Good quality hydrographic information is an enabler for all other maritime activities and therefore a pre-requisite for maritime infrastructure development to boost the economy. It influences decisions on the cost effectiveness of providing essential transportation services. If the hydrographic data and, in the modern context, the relevant ENCs are of high quality, there is an increased likelihood the marine transport service will be of high quality as well, with competition ensuring no excess freight rates. Conversely, poor quality data brings with it the risk of higher costs or substandard shipping.

2. With the advent of Geographical Information Systems (GIS) underpinned by powerful computer processing, and integration with satellite and other remote sensing technologies, hydrographic data delivers a wide range of additional benefits to multiple marine stakeholders, notably planning, management and development in the maritime domain. It is widely accepted that these benefits of hydrographic survey data, difficult to quantify in financial terms, outweigh those derived from its classic application, hence the common assessment that hydrographic data should be viewed as a public good[191]. It is relatively expensive to acquire because it requires ships or aircraft to transit the ocean and cannot be properly obtained by satellite remote sensing, but the overall benefits of hydrographic survey from a national perspective are considered to outweigh the costs.

3. Hydrographic survey data delivers benefits to different sectors in different ways. For the international shipping of freight, the principal benefit is to enable safe and efficient navigation to minimise risk and provide reductions in transportation costs. For the Samoan economy it supports international trade, enables the safe access to the growing cruise tourism market, and for good governance it provides the underpinning data and framework for the effective environmental management of marine resources.

4. Commercial shipping relies on current hydrographic survey data. A hydrographic survey undertaken to the latest International Hydrographic Organization (IHO) standards[192] provides the following benefits:

   a. Accurate and reliable full bottom coverage allows for more flexible route planning, more precise navigation and more flexibility to utilise the increased loading of ships, thus increasing the economic efficiency of shipping.

[190] This Annex is a modified development of previous published work and (Land Information New Zealand and Rod Nairn & Associates Pty Ltd, 2016) and (Marico Marine Report No 14NZ262CS Issue 02, January 2015, pp. A1-A3).

[191] Public good – a good or service in the public interest which would not be supplied at optimal levels by market forces alone.

[192] IHO S-44 Standards for Hydrographic Survey

ANNEX G – Benefits of Hydrographic Surveys to SAMOA

b. Critical new shallows or water depth, less than previously charted, may be identified and appropriate action taken.

c. Facilitate revisions of fairways or routes, and planning of modified or new Traffic Separation Schemes or sea management areas (which could be applicable to Beveridge Reef).

d. Enabling modern practices in navigation with new ECDIS functionality (e.g. 3D navigation with real time dynamic water level in formation, precise warnings), with consequential reduction in potential environmental harm and insurance premiums.

e. Provision of quality information for training purposes.

5. The absence of good quality hydrographic information (accurate, up to date navigation charts) has been identified as causal to shipping companies using less efficient or less capable vessels that are more likely to be involved in a maritime accident.

6. Further, the International Convention for the Safety of Life at Sea[193] requires signatory states to facilitate the production of ENCs for ships navigating their coastal waters, including ports. Should an IMO member state not fulfil this obligation, insurers have the option to decline cover, or charge an additional risk premium, to vessels wishing to navigate its waters. It is therefore beneficial for Samoa to ensure that they establish an effective two-way information flow with the primary charting authority for Samoan waters, Land Information New Zealand.

7. Beyond shipping, hydrographic survey data delivers a wide range of additional benefits to maritime stakeholders. Indeed, the largest users of hydrographic data are typically port developers, planners and environment managers. Hydrographic data is an essential enabler for everything that takes place on, under or near the sea, it should be considered as vital infrastructure, servicing similar purposes as three-dimensional land mapping.

8. Samoa has recently completed a comprehensive LiDAR mapping project[194] which provides topographic land heights and general bathymetric coverage offshore to depths in the vicinity of 50m. While this information has not been collected to the highest IHO standards, the depth information can be used to make significant improvements to the current quality of Samoa's coastal nautical charting and help to identify specific areas that require further hydrographic survey examination.

[193] SOLAS Chapter 5, Regulation 9
[194] World Bank funded project "Enhancing the Climate Resilience of Coastal Resources and Communities Project for Samoa" (World Bank, 2014)

ANNEX H – List of Consultations

Samoa

	Organisation	Contributor	Position
1.	NZ High Commission	Measina Meredith	Development Programme Coordinator
		Situfu Salesa	Senior Development Programme Coordinator
3.	Ministry of Works, Transport and Infrastructure	Fepulea'i Faleniu Mark Alesana	ACEO Maritime Division
		Etuale Tolo	Senior Maritime Safety Inspector
		Makerita Atonio	Registrar of Vessels
4.	Ministry of Agriculture and Fisheries	Ueta Faasili	Acting ACEO
		Magele Ropeti	Operations Officer
5.	Ministry of Natural Resources and Environment	Safuta Toelau Iulio	ACEO Technical Division
		Petania Tuala	Principal Surveyor, Spatial Information Agency
		Samantha Kwan	Dept. of Environment & Conservation
		James Atherton	Consultant (by phone/email)
6.	Samoa Meteorology Division	Tumau Faasaoina	Acting ACEO, Principal Scientific Officer
7.	Ministry of Revenue – Customs	Feagaima'alii Nanai M. Sua	ACEO Border Operations
8.	Samoa Ports Authority	Capt. Lotomau Tomane	Port Master/ACEO Maritime
	Samoa Ports Authority	Capt. Tafaigata Toilolo	Port Operations Manager
9.	Samoa Shipping Corporation	Capt. Sam Phineas	Operations Manager
10.	Ministry of Police	Manusamoa Christine Saaga	Assistant Police Commissioner
11.	Maritime Police Unit	Sefo Hunt	Team Leader
12.	Maritime Police Unit Samoa Tourism Authority	Anthony Cooper	Australian Technical Advisor to Samoa Maritime Unit
13.	Samoa Tourism Authority	Sonja Hunter	CEO
		Kristian Scanlan	Events Coordinator
14.	Secretariat of the Pacific Region Environment Program (SPREP)	Ryan Wright	Spatial Planning Officer
15.	AquaSamoa	Ted Thompson	Owner
16.	Asau SPA Facility	Nese Tufuga	Caretaker
17.	Dive Savai'i	Olaf & Tina	Owners