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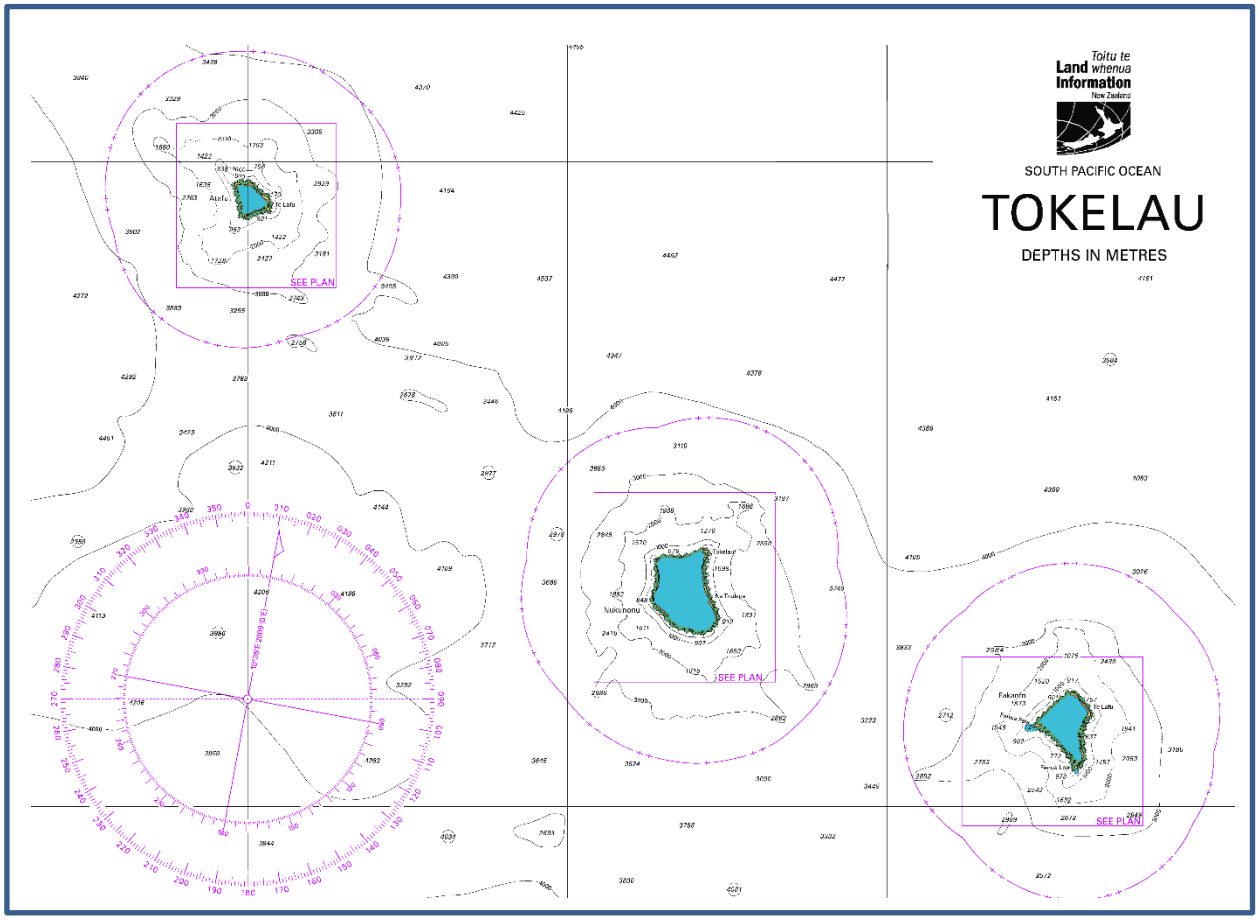
Hydrographic Authority

PACIFIC REGIONAL NAVIGATION INITIATIVE

TOKELAU Hydrographic Risk Assessment



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PACIFIC REGIONAL NAVIGATION INITIATIVE

TOKELAU Hydrographic Risk Assessment

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Satellite AIS data under licence from ORBCOM (augmented by IHS Global Pte Ltd)

FOREWORD

This report details the hydrographic risk assessment of the waters around Tokelau, based on the Land Information New Zealand (LINZ) Hydrographic Risk Assessment Methodology as published in Report Number 15NZ322 Issue 03[1]. The inability to conduct an in-country visit limited the data collection to desktop research only. Accordingly, no numerical assessment has been made and the risk observations are based on ship traffic patterns and existing charts.

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, Niue and Samoa, which are available from the International Hydrographic Organization website at this link.

The intent of these assessments, has been to conduct them using the same methodology, in order to 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 provide economic benefit and improve safety of navigation. This aim has not been fully achieved in this brief assessment.

[1] This report utilises aspects of LINZ Risk Methodology: South West Pacific Regional Hydrography Programme – Marico Marine Report No. 12NZ246, Issue 3 - February 2013, as further developed by later risk assessments.

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EXECUTIVE SUMMARY

0.1 Tokelau is a group of three coral atolls of Atafu, Nukunonu, and Fakaofo. It has a total land area of approximately 12km2 but an EEZ of 318,990km2. Tokelau is located in the southern Pacific Ocean between latitude 8° and 10° South and longitude 171° and 173° West. Situated mid-way between Hawaii and New Zealand, Tokelau is approximately 480km north of Samoa.

0.2 **The current nautical charting** consists of one 1:500,000 scale general chart, NZ 885 covering the three atolls and surrounding territorial seas. The three atolls of Tokelau are also covered by larger 1:100,000 scale plans. The territorial seas and the route between the atolls has been surveyed to a scale of either 1:50,000 or 1:100,000 but the remaining areas of the EEZ have only been charted from reconnaissance scale survey or general passage soundings. The Tokelau EEZ is charted on small scale ocean navigation charts NZ 14629 (INT 629) scale 1:1,500,000; NZ 14605 (INT 605) scale 1:3,500,000; NZ 14060 (INT 60) scale 1: 10,000,000; NZ 14061 (INT 61) scale 1: 10,000,000; and NZ 14052 (INT 52) scale 1: 10,000,000.

0.3 **Hazards to navigation**. The majority of the EEZ is very deep-water and there are no offshore features and dangers apart from: a shoal patch reported (1977) some 190 km north east of Fakaofo (in position 7° 43'.3 South, 170° 22.7 West), and reported breakers (1966) west of Atafu towards the outer limits of the EEZ (in position 8° 46'.9 South, 176° 25'.8 West). Considering the amount of fishing vessel traffic near these reported features, and the general depths of 5,000m, neither of these are considered likely to exist or present dangers to surface navigation.

0.4 There is substantial **maritime traffic** that traverses the Tokelau EEZ, these vessels include tankers, general cargo, fishing, passenger, and occasional recreational and military vessels, however most of this traffic traverses in deep water, generally keeps well clear of the Tokelau atolls and does not pass within Tokelau territorial seas. Occasionally a recreational vessel visits a Tokelau atoll and the current charting is adequate to meet this requirement, especially given the shallow draught of such vessels.

0.5 The only regular ships visiting Tokelau are: a Tokelauan Government general cargo and passenger re-supply vessel on a two-weekly cycle, and a chartered resupply vessel from Apia, operated by the Samoan Shipping Corporation. These vessels utilise local knowledge to augment the charted information and **are able to navigate safely with the existing chart coverage**.

0.6 As no in-country visit was undertaken during this assessment, there was no opportunity to assess the need for charting of the internal atoll lagoons to support domestic purposes. However, as there are no navigable passages for international vessels into these lagoons there is no international obligation to provide nautical charts of them.

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Glossary and Definitions[2]

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

[2] 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 of laser light 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 that length. 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 The report comments on the maritime and domestic circumstance of Tokelau and makes observations in relation to hydrographic data and nautical chart coverage of Tokelauan waters, based on existing chart coverage and an analysis of vessel traffic using geospatial techniques.

1.1 Aim

1.1.1 The aims of this report are:

a. to produce GIS derived plots showing the spatial distribution of shipping traffic that enables the Government of Tokelau and LINZ to identify priority areas for focussing hydrographic survey and charting improvements, and

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

1.2 Methodology[3]

1.2.1 The method employed uses risk assessment in a comparative way, to identify areas within the Tokelau EEZ that are more susceptible to an incident involving either a large SOLAS vessel or smaller cargo, fishing or recreational vessels.

1.2.2 The types of accident that can occur to vessels are related to the type of vessel transiting Tokelauan waters, as well as their size and cargo/passenger capacity. Details of vessel transit information is thus key to the methodology, and was supplied from satellite AIS data (S-AIS). As no in-country data gathering visit to Tokelau has been undertaken, there is no additional information on domestic, inter-island vessel movements.

1.2.3 Vessel traffic analysis was undertaken using satellite derived AIS data for January – December 2016, to build a model of shipping movements through Tokelauan waters. Ship traffic was analysed in a Geographic Information System (GIS), the details of how the tracks were created

[3] This report applies the same methodology described in (Marico Marine Report No. 14NZ262 – TM, Issue 1, 27 November 2014), the text is reproduced here with minor adjustments to apply to Tokelau.

and processed to remove anomalies is provided at Annex B. As Tokelau has no domestic commercial vessels of any significant GT, no additional non-AIS data was added to the ship traffic plot.

1.2.4 Event Trees (see Annex A) were generalised from the type of traffic and proximity to navigational dangers of that traffic. These event trees could be further refined were an in-country visit to take place and a numerical GIS-based risk assessment proceeded with. The expected types of navigational incident that could occur include: grounding, foundering or collision, and their consequences are driven by 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 Tokelau.

1.2.4 There was little information available regarding tourist destinations, dive sites, biological or cultural importance of specific areas in Tokelau. Therefore, it was not feasible to populate layers for these data.

2. COUNTRY INFORMATION AND ECONOMY

2.1 Atafu, Nukunonu, and Fakaofo Atolls

2.1.1 Comprising the three coral atolls of Atafu, Nukunonu, and Fakaofo, Tokelau is located in the southern Pacific Ocean between latitude 8° and 10° South and longitude 171° and 173° West. Situated mid-way between Hawaii and New Zealand, Tokelau is approximately 480km north of Samoa. Formerly known as the Union Islands, Tokelau adopted its current name in 1976.[4]

Figure 1 South West Pacific (Source: Encyclopaedia Britannica)

2.1.2 The island chain extends some 160km in length in a northwest/southeast alignment with a total land area of approximately 12 km^2. Nukunonu is the largest of the three atolls (*nukus*).[5]

- Atafu – land area 3.5km^2
- Fakaofo – land area 4.0km^2
- Nukunonu – land area 4.7km^2

[4] Generally known as the Tokelau Islands from 1946.

[5] (Tourism, Travel, & Information Guide to the New Zealand Territory of Tokelau, 2015). There exists a fourth island that is considered culturally, historically, and geographically part of the Tokelau chain but not politically. Located south of Fakaofo between Tokelau and Samoa, Swains Island is administered as part of American Samoa.

Figure 2 The islands of Tokelau (Source: SPC)

2.1.3 Atafu, the most northern island, lies 92km north-west of the central atoll, Nukunonu. The chain's southern atoll, Fakaofo, is 64km south-east of Nukunonu. The three atolls comprise a combination of calcium carbonate coral reefs, sand and rock and are uniformly low lying; no part of the land is more than three to five metres above high water.[6]

2.1.4 Each atoll is surrounded by deep water and comprises a number of reef-bound islets (*motu*) enclosing a large shallow lagoon;

- Atafu has 42 islets enclosing a small lagoon of just 17km^2
- Fakaofo comprises 62 islets encompassing a slightly larger lagoon (50km^2)
- Nukunonu is made up of 24 islets with its lagoon having an area of 98km^2

2.1.5 The islets across each atoll are of various sizes and dimensions ranging from 90m up to 6km in length and from only a few metres to about 200 metres in width. Tokelau's total coastline measures 101km.

[6] (Pacific Climate Change Portal - Tokelau, 2017)

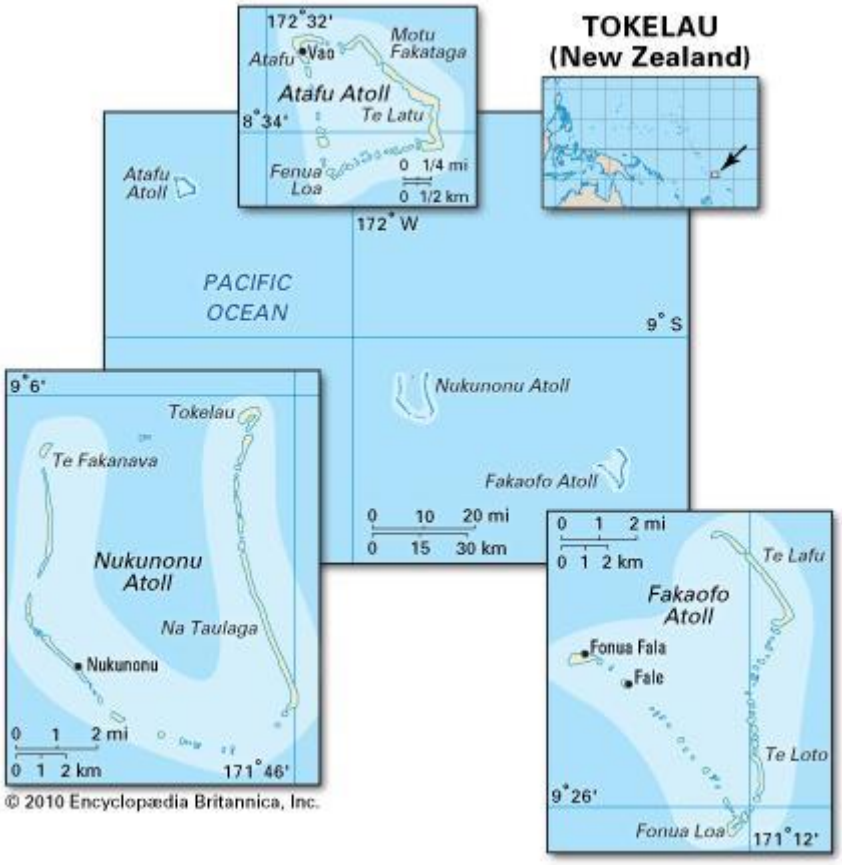

Figure 3 Tokelau (Source: Encyclopaedia Britannica)

2.1.6 Like many Pacific Island countries, the oceanic seabed around Tokelau rises sharply from several kilometres depth from a relatively short distance offshore. Each atoll can be circumnavigated in deep water exceeding 100 metres at a distance of one to two nautical miles from the reef.

2.1.7 **Exclusive Economic Zone (EEZ).** Tokelau's EEZ covers some 318,990 km^2 and is one of the larger EEZs in the Polynesia region.[7] Given the country's reliance on its marine resources as a source of income the preservation of economic interests throughout the EEZ is of paramount importance to the people of Tokelau.

2.1.8 The EEZ borders five other Pacific Island nations; the Republic of Kiribati to the north, the Cook Islands to the east, American Samoa and Samoa to the south, and Wallis and Futuna to the southwest. Around 15% of the total EEZ area lying in the northeast and west regions, borders international waters.

[7] (New Zealand Foreign Affairs and Trade, 2017)

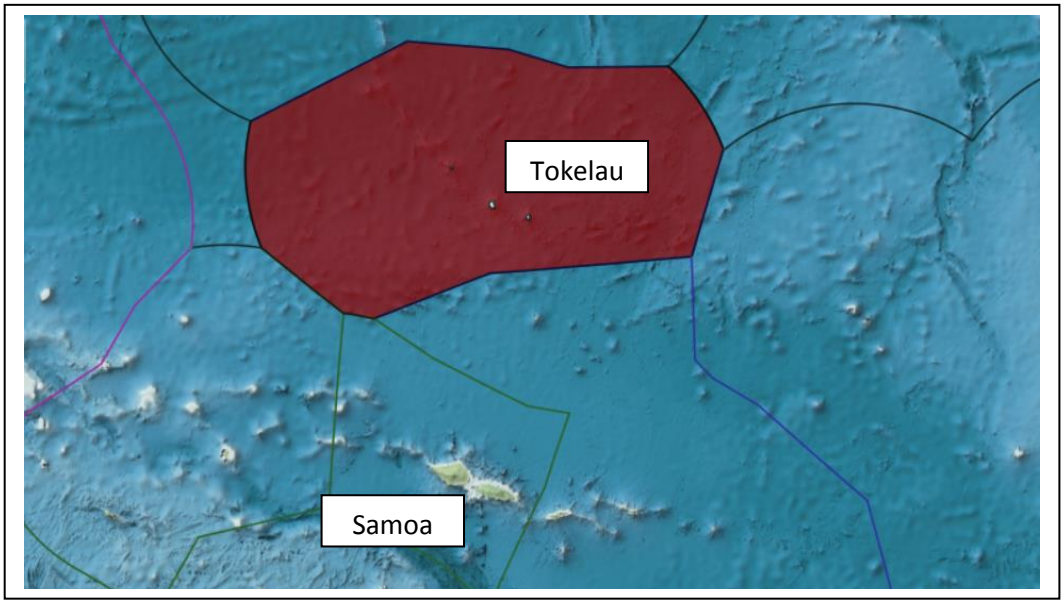

Figure 4 Tokelau EEZ (Source: Marine Regions)

2.1.9 There are no offshore islands or reef areas in the EEZ, nor are there any significant submarine features, apart from a shoal patch reported (1977) some 190 km north east of Fakaofo (in position 7° 43'.3 South 170° 22.7 West) and reported breakers west of Atafu towards the outer limits of the EEZ (in position 8° 46'.9 South 176° 25'.8 West). The EEZ is otherwise uniformly deep and featureless.

2.1.10 **Climate.** Tokelau is located in the easterly trade wind zone; from May to October the east-south-easterly trade winds dominate climatic conditions. During the wet season (November to April) rainfall can be heavy, although erratic in terms of frequency; the mean annual rainfall can be as much as 2,800mm, although distinct seasons tend to impact the amount of rainfall received. The period between October and March accounts for about 60% of the total annual rainfall, while outside this period the months of December and January account for approximately 25%.[8] Cyclones, tsunamis, and droughts are the most common natural hazards likely to affect Tokelau.

2.1.11 Tokelau sits on the edge of the cyclone belt and is therefore susceptible to tropical storms and importantly, any associated storm surges. The cyclone season is between December and April. It has been reported that Tokelau has experienced the effects of more tropical cyclones and storm surges in the last ten years, relative to the situation some two or three decades ago.[9] While actual tropical cyclones in the vicinity of Tokelau may not be as common as the frequency of tropical storms in more southern parts of Polynesia, because Tokelau comprises low lying coral atolls any resulting storm surge and wind associated with a tropical cyclone, that may well be many hundreds of kilometres away, can still have a significant and devastating effect on the population.[10]

[8] (Tokelau: A True Small Island Developing State, n.d.)
[9] (Pacific Climate Change Portal - Tokelau, 2017)
[10] In 2005 Tokelau, Tropical Cyclone *Percy* caused substantial damage to property and food crops and resulted in Fakaofo and Nukunonu being inundated with over a metre of seawater.

2.1.12 **Heritage.** The islands were initially settled some 1,000 years ago, with the original Polynesian settlers arriving from surrounding island groups including Samoa, the Cook Islands and Tuvalu. While the people of Tokelau can relate to those communities in Tuvalu, culturally and linguistically, Tokelau maintains strong links with Samoa.

2.1.13 The first contact with Europeans was during the mid-1700s. Christian missionaries started to arrive between 1845 and 1860, resulting in a range of different denominations being embraced across the atolls; Atafu for example, was converted primarily to Protestantism, Nukunonu to Catholicism, while Fakaofo converted to both faiths. The religious situation on Atafu and Nukunonu today remains largely unchanged, while on Fakaofo much of the population (approximately 70%) still identifies with the Congregational Christian faith, with the remainder being aligned with Catholicism.[11]

2.1.14 Peruvian slave traders arrived in Tokelau in 1863, kidnapping nearly all of the able-bodied men to work as labourers. This was a defining moment from both a political and ethnic perspective. Over subsequent years, immigrants from across Polynesia and from surrounding island groups, along with American and European beachcombers, started to settle on Tokelau, filling this void by marrying local women and gradually repopulating the atolls. While the people of Tokelau are considered to be of Polynesian heritage, with virtually all residents being of Tokelauan ancestry, the population comprises a degree of mixed ethnicity as a direct result of these historical interactions.

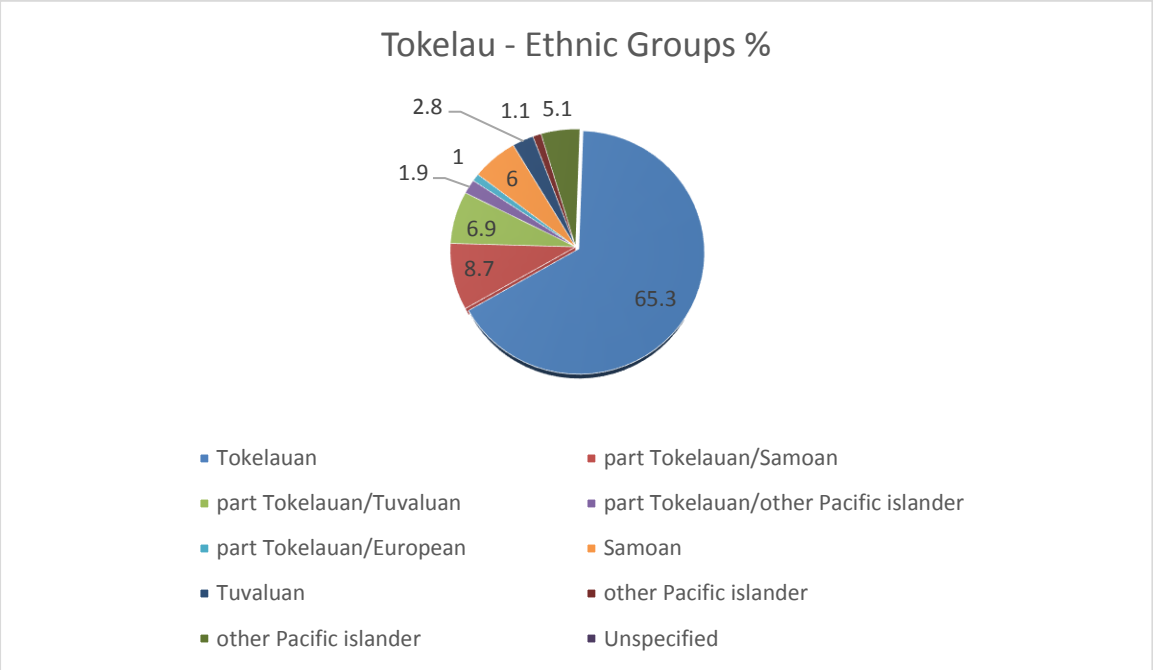

Figure 5 Ethnic groups in Tokelau (Source: The World Fact Book)[12]

2.1.15 **Population.** In terms of population, Tokelau is the second smallest country in the world. In 2013, the population count listed 1,383 inhabitants, while an estimate the following year recorded approximately 1,337 people living across Tokelau's atolls. Having experienced a general decline

[11] (Government of Tokelau, 2014)
[12] (CIA Factbook, 2017)

since 1961 when the population was at a high of 1,860, the population today remains in the order of 1,499 permanent residents.

2.1.16 The Tokelau Islands Act (1948) gave Tokelauans New Zealand citizenship and the opportunity to migrate. More than 8,000 Tokelauans live elsewhere in the Pacific region, mainly in Samoa and New Zealand. Increased migration to New Zealand was encouraged under the Tokelau Islands Resettlement Scheme, which was introduced in 1966 to address increasing overpopulation across Tokelau itself.[13] While Tokelau's population has stabilised in recent years it remains at risk of further decline as people continue to emigrate 'beyond the reef'.[14]

2.1.17 In terms of dispersal of people across each of the three atolls, the 2016 Census in Tokelau suggests a relatively even spread of population (see Figure 6).

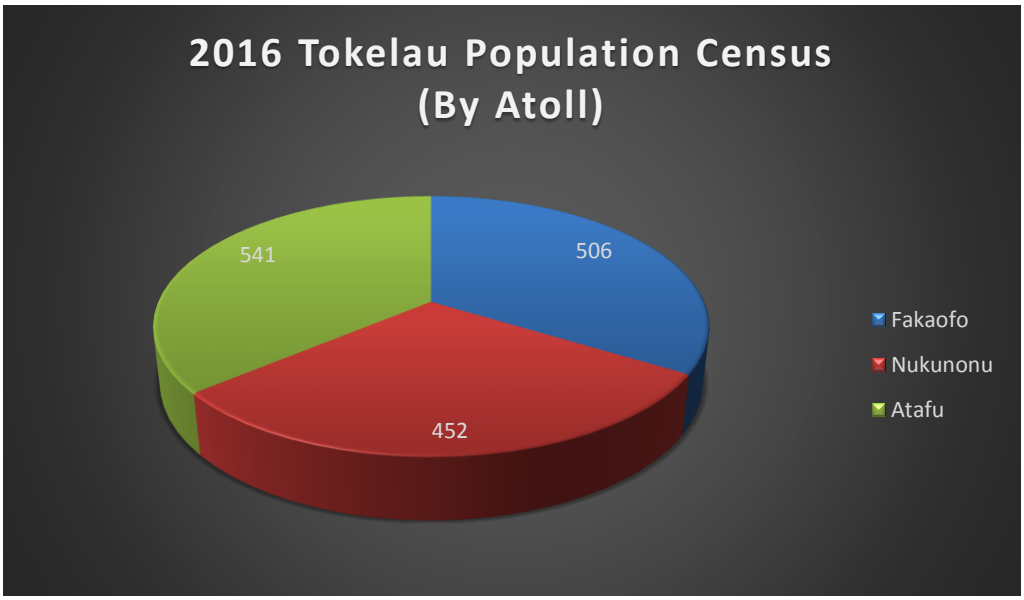

Figure 6 Population spread across Tokelau - by atoll (Source: Government of Tokelau)

2.1.18 Tokelauans reside in four main island communities, which are located on selected islets making up the leeward side of each atoll. The availability of land in Tokelau ensures that each population centre tends to be densely settled.

- There are two settlements on Fakaofo with Fale being the main settlement towards the western side of the atoll, and which accommodates most atoll inhabitants. A short distance to the north-west is Fenua Fala, which was established in 1960 to relieve the atoll's growing population.
- There is a single settlement on Nukunonu on the south-western corner of the atoll, Nukunonu Village and Motuhaga, which are connected by a 'concrete bridge.'

[13] The 2013 New Zealand population census recorded 7,176 people living in New Zealand who identified with Tokelau. (National Strategy For The Development of National Statistics Roadmap – Tokelau , 2015)
[14] (The World CIA Factbook, 2017)

- The only community on Atafu is Atafu Village, which lies on the north-western corner of the atoll.

2.1.19 **Government.** The most striking feature about the governance arrangements on Tokelau is the adherence to traditional power (*pule*), which is exercised by village authorities. There is no national capital in Tokelau; rather, each of the three atolls maintains its own administrative centre, an arrangement that can be directly linked back to the South American slave trader period, which resulted in the need to shift the manner in which the islands were governed. With the loss of island chiefs and most of the able-bodied men, Tokelau was forced to adopt a governance system based around a Council of Elders (*Taupulega*). Tokelau today, remains governed as a parliamentary democratic dependency by this system that embraces village engagement and leadership.

2.1.20 Tokelau has been administered by New Zealand since 1926. The statutory position of Administrator in New Zealand maintains technical responsibility for the administration of Tokelau's executive government. The Administrator is represented on Tokelau by three headmen (F*aipule*), one for each atoll. Each atoll has its own *Taupulega* comprising village elders and the heads of all village families. The administrative and legislative powers of the Administrator are formally delegated to the three *Taupulega*; the *Taupulega* therefore remains the source of local village *pule* with members assuming key local positions, including village mayor (*Pulenuku*), Law Commissioner and Police Sergeant.

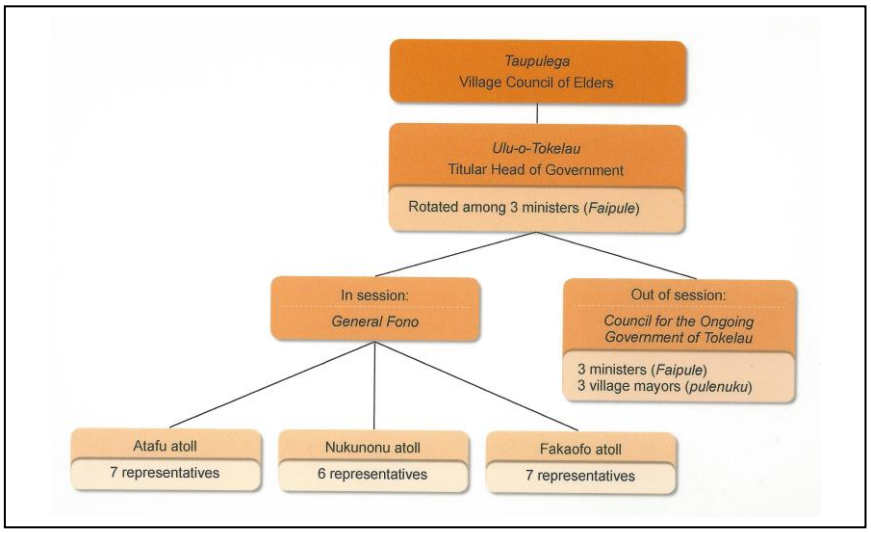

Figure 7 Governance structure in Tokelau (Source: World Health Organization)

2.1.21 Each *Taupulega* elects six to seven representatives to sit on the General Fono. The authority for national issues is delegated to this body which focuses its attention on issues normally falling outside the remit of each *Taupulega*. As a result, the General Fono has almost complete control of national and regional affairs. When the General Fono is not in session Tokelau is governed by an executive council, the Council of the Ongoing Government of Tokelau, which is based in Apia in Samoa. This Council effectively acts as Tokelau's cabinet and comprises the three *Faipule* and the three *Pulenuku* who between them, manage eight ministerial portfolios. The position of Titular Head of State (*Ulu o Tokelau*) is rotated annually between the three elected *Faipule* members of this council.

2.2 Economic Overview

2.2.1 Tokelau is the fifth smallest country in the world, with its economy being the smallest. In terms of development, the economy remains extremely vulnerable because of the country's size, its isolation, access to a limited resource base, a lack of infrastructure, and an inability to attract foreign investment. Tokelau is therefore almost fully reliant on international development aid to prop up the economy which remains susceptible to international currency and fiscal shock, along with the effects of natural disasters.

2.2.2 Tokelau's economy is largely one of subsistence agriculture and fishing; few attempts have been made to date to implement meaningful economic initiatives.[15] There is virtually no cash economy operating in Tokelau although with the formation of the Tokelau Public Service, this is starting to change. Tokelau's main sources of national revenue come from exporting copra, the management of international fishing licences, and the sale of stamps and coins and internet domain registrations. Some revenue is also generated by locally imposed duties and taxes, freight and boat fares, and a small market for handicrafts.[16]

2.2.3 Substantial revenue continues to be generated under the current US Tuna Treaty and from the licensing of foreign vessels to fish Tokelau's EEZ and offshore waters. The management of fishing licences for example, generates 99% of the country's revenue, with purse seine licences alone accounting for 90% as part of the US Tuna Treaty. Revenue in 2016 from the fishing sector has been estimated to be US$13.5 million.[17]

2.2.4 Notwithstanding, the country is still heavily dependent on foreign aid from countries like New Zealand. Between 1999 and 2000 New Zealand financial aid accounted for 80% of Tokelau's budgetary resources. Today, New Zealand provides about 60% of Tokelau's annual Government budget.[18] Similarly, Australian aid is based around contributions to the Tokelau International Trust Fund, which supports the country's long-term economic stability. Australia's total contribution to this fund since 2005 has been AS$8.8 million.[19]

	2010-14	1970-79	1980-89	1990-99	2000-09	2010-14	2012	2013	2014
	Oceania Share (%)	*Annual Averages (US$m)*					*Annual Amounts (US$m)*		
Tokelau	1	4	7	8	15	20	19	24	18

Table 1 Overseas development aid - 2013 (Source: OECD)

[15] Notwithstanding, some initiatives have been introduced. For example, a fish processing plant has been in operation on Atafu since 1990, funded under the FFA/US Tuna Treaty. The Kileva Factory processes fresh tuna into marinated, sun-dried tuna jerky, primarily for domestic consumption. Such village-based projects are however, difficult to sustain given Tokelau's relative isolation, access to meaningful regional and international markets, limited infrastructure and transport constraints.

[16] Stamps and commemorative coins continue to provide a dependable source of income for Tokelau. In 2015/2016 sales exceeded NZ$70,000. (Stamps and Coins Providing a Growing Income For Tokelau, 2015)

[17] (Tauafiafi, 2016)

[18] (New Zealand Ministry of Foreign Affairs and Trade, 2017)

[19] (Australian Department of Foreign Affairs and Trade, 2017)

2.2.5 An additional source of income for the economy are family remittances, which are sent back from Tokelauans living abroad. Some 7,000 currently live in New Zealand[20] while smaller communities can be found in Samoa, American Samoa, Australia and Hawai'i. However, the emergence of the Tokelau Public Service as a new source of income has reduced the importance of remittances to helping sustain the economy.

2.2.6 **GDP.** The most recent GDP figure for Tokelau covers the 2015/16 Financial Year and has been determined to be NZ$14 million. This equates to US$6,275 per capita.[21]

	2012/2013	2013/2014	2014/2015	2015/2016
GDP (NZ$m)	10.38	11.24	11.97	14.04
Per Capita (US$)	5,678	6,224	6,116	6,275

Figure 8 Tokelau GDP figures - FY 12/13 to FY 15/16 [22]

2.2.7 **Trade.** Tokelau's location and international standing, along with the size of the economy means there are few established trade patterns associated with the country. To emphasise this point, the lack of trade means there is little in the way of contemporary trade-related data to draw on, particularly any information regarding Tokelau's imports and exports and the extent of any trading partners. Apart from exporting a small amount of copra, Tokelau does not have any established export markets, since the country currently has no proper means for mass export. Nor are there any internal market opportunities for local products. What trade that does exist is primarily conducted with New Zealand and Samoa. In 2014 imports from Samoa, for example, averaged NZ$432,000 per month or NZ$5.2 million per annum.[23]

2.2.8 The lack of regular and efficient transport to expedite delivery of fish to external markets, for example, remains a key challenge which limits potential earnings and development in the fisheries sector. On the other hand, Tokelau imports the vast majority of its household and commercial goods, including foodstuffs, building materials, and fuel (petrol). Imported essentials such as petrol, kerosene, soap, tobacco, cloth, flour, rice, and sugar tend to be purchased from the cooperative village store located on each atoll.

2.3 Economic Sectors

2.3.1 Agriculture

2.3.1.1 The coral nature of each atoll means the land is generally alkaline, highly porous, and nutrient-deficient. The soil is characterised as having low humus content, with a high surface salinity. Poor soil characteristics, the lack of available land, and limited access to fresh water, remain significant factors in Tokelau's capacity to develop any sort of agricultural sector. Accordingly, what agriculture there is remains restricted to supporting the local population at a basic subsistence level.

[20] (Government of Tokelau, 2017)
[21] (Tokelau's Gross Domestic Product determined for first time this century, 2017)
[22] (Tokelau's Gross Domestic Product determined for first time this century, 2017)
[23] (Jasperse, 2015)

2.3.1.2 In general, no fresh fruit and vegetables are grown; potatoes, onions and carrots for example, are imported. Cultivated food crops are generally limited to breadfruit, various forms of taro, two varieties of bananas, papaya, pandanus, pumpkins, and coconuts. The latter is harvested both for subsistence purposes and to support Tokelau's small commercial copra export industry. Swamp taro is cultivated on Fakaofo, in the satellite village of Fenuafala, which does have access to underground freshwater sources. Food imports tend to be cheap, which tends to negate any effort to build competitive small-scale domestic agricultural production. This results in a situation where even commodities that could probably be grown/cultivated locally, are also imported (eg. tinned tuna, mackerel, and bananas).

2.3.1.3 Tokelauan communities also maintain some pigs, poultry, and goats.[24]

2.3.1.4 **Initiatives.** Beyond efforts to increase domestic marketing of agricultural products, no broader commercial agricultural export-orientated initiatives were outlined in Tokelau's National Strategic Plan 2010-2015.[25] However, the Government has recently launched 'Small Garden', a food project that aims to supply every household across the three atolls with specially selected seeds (assessed as having the best chance of success in the harsh island conditions) from which families can grow their own vegetables. Launched in October 2015, the longer-term intent is to reduce Tokelau's dependence on imported fresh produce.

2.3.2 Fishing

2.3.2.1 The 2012 Tokelau Fisheries Policy characterises the country's fisheries waters as follows:

- inshore fisheries – 0-12 nautical miles (territorial waters) – food security; and
- offshore waters – 12–200 nautical miles (EEZ) – revenue generation.[26]

2.3.2.2 The vast majority of households in Tokelau engage in fishing, primarily for subsistence purposes. While there is no domestic commercial fishing industry in Tokelau, offshore fishing activity provides a key opportunity for ongoing economic development.

2.3.2.3 **Inshore Fishing.** Subsistence fishing activities centre on lagoon and reef fishing, which are similar in extent and manner across each atoll and which comprise a range of techniques including: trolling, reef gleaning, gillnetting, mid-water fishing, bait fishing and bottom fishing. Across the three atolls, trolling is the main method used, followed by bottom fishing, reef fishing and gillnetting. The percentage of time attributed to each activity does differ depending on the area/atoll.

[24] Across Tokelau, pigs are kept in concrete pens at the edges of the villages on Atafu and Nukunonu. On Fakaofo, a special *motu* exists to accommodate pigs (the islet lies between Fale and Fenuafala).
[25] (Tokelau National Strategic Plan 2010-2015, 2010)
[26] (Ocean, 5-13 August 2015)

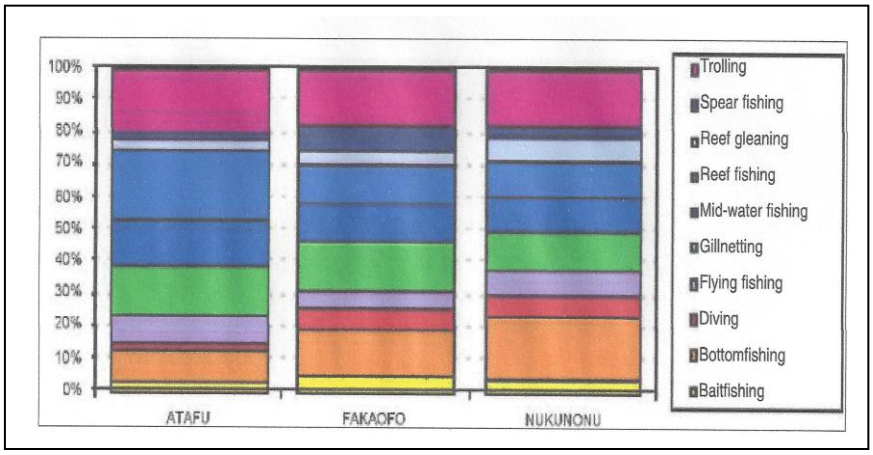

Figure 9 Fishing effort by method and atoll (%)[27]

2.3.2.4 While canoes and outriggers continue to be used as the preferred means for inshore and lagoon fishing, in more recent times there has been a move to utilise powered aluminium boats as an alternative means, primarily to facilitate fishing activities a little further offshore. Today, Tokealu's 'artisanal fleet' comprises 30-40 small open aluminium boats ranging from 4-5 metres in length, which are powered by 15 – 30hp outboard motors. Artisanal fishery efforts tend to occur within four nautical miles of the reef and are primarily aimed at supporting local consumption using troll and handline methods to target mainly skipjack and yellowfin tuna.

Figure 10 Four new aluminium boats being delivered to one of the atolls in Tokelau (Source: SPC)

2.3.2.5 **Offshore Fishing.** Offshore fishing throughout the EEZ focuses on pelagic and deep-ocean resources conducted by foreign fishing vessels from a range of countries and from neighbouring Pacific Island states. The licencing of these fleets provides an important source of domestic revenue for Tokelau. There are no Tokelau-flagged vessels and all tuna catches by foreign licenced vessels are offloaded outside Tokelau itself.

2.3.2.6 In 2016, a total of 31 purse-seine vessels were licenced to fish Tokelau's offshore waters, concentrating much of their effort in the northern and north-eastern parts of the EEZ.[28] The same

[27] (Lindsay Chapman, Kim Des Rochers, and Mose Pelasio, October/December 2005)

[28] By flagged state - 18 x Korea, 8 x Kiribati, 1 x Spain, 2 x El Salvador, 2 x New Zealand. (The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean, 2016)

year, Tokelau reached the country's longline license limit of 25 vessels with the majority of longline effort occurring in the south and south-east parts of the EEZ.[29]

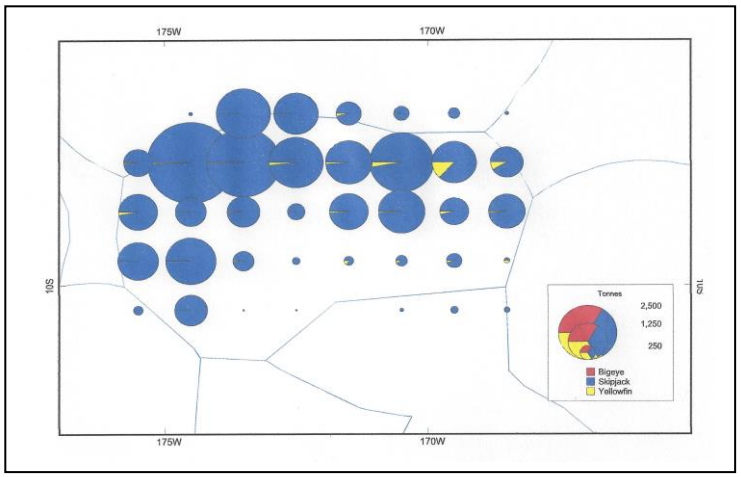

Figure 11 EEZ - Distribution of purse-seine catches by species (Source: SPC)

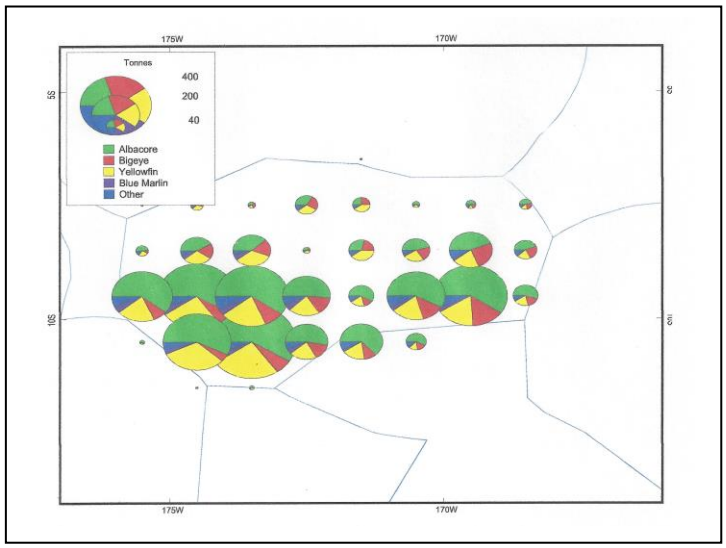

Figure 12 EEZ - Distribution of longline catches by species (Source: SPC)

2.3.2.7 **Initiatives.** Domestic fisheries development in Tokelau is severely constrained by limited market access and a lack of infrastructure. The Government however, remains committed to identifying opportunities for participation in small-scale commercial tuna fishery developments.

2.3.2.8 Further offshore, the ongoing protection of Tokelau's only sustainable revenue source is critical to the future of the country. The successful management of resources in the offshore estate continues to be undermined by illegal and unreported fishing, a situation that is compounded by the fact Tokelau does not have the means to exercise jurisdiction over its EEZ. To help mitigate this, Tokelau is now working in partnership with New Zealand and regional fishing agencies to increase

[29] By flagged state – 18 x Vanuatu, 4 x Taiwan, 2 x Cook Islands, and 1 x Kiribati. (The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean, 2016)

the penalties for illegal fishing in the EEZ, as part of a more robust and stringent penalty regime. The range of pecuniary penalties were initially agreed more than three decades ago. Today, these no longer provide an effective deterrent to illegal fishing.

2.3.2.9 Pelagic and deep-ocean fishing continues to be managed by the Government of Tokelau (through the Department of Economic Development Natural Resources and Environment) in collaboration with the New Zealand Ministry of Primary Industries (Fisheries Department) and Ministry of Foreign Affairs and Trade. Collaboration with New Zealand aims to help manage Tokelau's EEZ to 'increase the revenue that Tokelau earns from its international fisheries while protecting its food security.'[30]

2.3.2.10 In response to some specific challenges in the fisheries sector, the Government detailed a number of additional strategies in its National Strategic Plan 2010-2015, including the development and implementation of sustainable fishing regulations aimed at preventing excess catch. Part of this is an offshore resource management plan that includes the following strategies:

- management of the purse seine industry through a 'vessel day scheme' (VDS) that remains compatible with other VDS schemes under the Parties to the Nauru Agreement;[31]
- collaboration with regional countries to establish and manage country limits in the albacore longline sector and to develop a management regime that maximises the value obtained from leasing harvesting rights;
- management and ongoing review of neighbouring country limits for yellowfin and bigeye and explore tropical longline fishing management options to give effect to these limits; and
- continuing to manage the number of licenses issued across each fishing sector.[32]

2.3.2.11 The plan also supports the Government's efforts in working collaboratively with other Pacific Island nations, as part of the Niue Treaty and the TeVaka Toa Arrangement in terms of fisheries law enforcement activities. A key strategy is to identify and put in place MOUs or arrangements with neighbouring Pacific nations for EEZ surveillance.[33]

2.3.3 Tourism

2.3.3.1 Tokelau has no established tourism industry and annual tourist numbers are difficult to obtain.[34] For the most part tourism is almost non-existent largely due to the lack of infrastructure, the challenges associated with getting people to/from the atolls, and the need to adhere to local regulations. There are no port or airport facilities, little tourist accommodation, and limited passenger shipping services to/from Tokelau,[35] (which is the only means of getting to and from Tokelau).

[30] (New Zealand Ministry of Foreign Affairs and Trade, 2017)
[31] The 'vessel day scheme' is a scheme where vessel owners can purchase and trade days fishing at sea in places subject to the Parties to the Nauru Agreement.
[32] (Department of Economic Development Natural Resources and Environment of Tokelau, 2017)
[33] (Tokelau National Strategic Plan 2010-2015, 2010)
[34] (Tourism, Travel, & Information Guide to the New Zealand Territory of Tokelau, 2015)
[35] A seaplane service was suspended in 1993. There has recently been talk of establishing an airport on Fakaofo.

2.3.3.2 There are few suitable anchorage sites throughout Tokelau for large cruise vessels, the only charted location being close off Atafu on the western side. There are no deep-water passages into any of the inner lagoon areas, and few ships attempt to anchor off the atoll reefs for any extended period because of the steep drop off and the lack of shelter and protection from the prevailing sea and swell.

Figure 13 Ship to shore - Fakaofo (Source: Government of Tokelau)

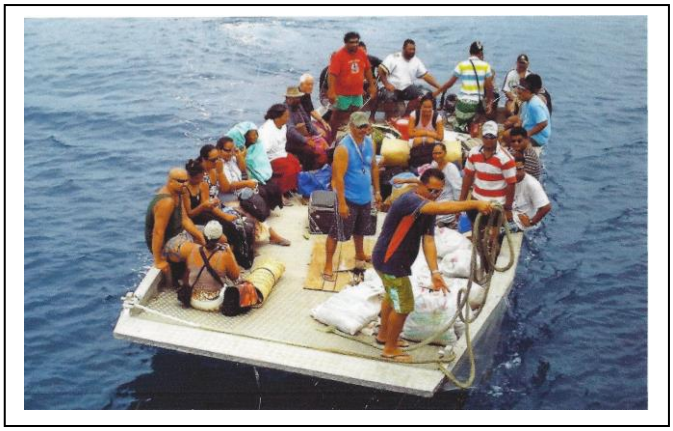

Figure 14 Transporting passengers ashore in Tokelau (Source: Government of Tokelau)

2.3.3.2 Those tourists that do get the opportunity to visit Tokelau have to be transported by outboard-powered barge/boat. Before departure however, particular governance and customary regimes need to be followed once a visitor permit is obtained. For example, consent to visit must be given by the *Taupulega* and accommodation pre-arranged, which can be problematic given there are only two places to stay on Nukunonu (the Luana Liki Hotel) and one resort (the Falefa Resort). There are also a few guesthouses on Fakaofo and Atafu, of which range from good to very poor with three new guest houses on Fakaofo (Fenua Fale) being the subject of claims of suspect construction and questionable workmanship.

Figure 15 Nukunonu (Source: www.turkey-visit.com)

2.3.3.3 **Cruise shipping and recreational vessels**. There is limited information about the extent of cruise ship visits to Tokelau. Because there is no port or harbour and few suitable long-term anchorages close offshore for large vessels, Tokelau does not appear to feature as a priority destination for the cruise industry in compiling South Pacific itineraries. Any vessel that does visit Tokelau is required to anchor off and can only risk this for a short period.

2.3.3.4 The extent of recreational vessel and international yacht visits to Tokelau is unknown. There are a few anchorage sites in Tokelau suitable for smaller vessels, including sites close off Fale and Nukunonu but these can only be used under favourable weather conditions.

2.3.3.5 **Initiatives.** As part of its long-term national strategic planning effort Tokelau continues to progress plans to establish eco-tourism and cultural tourism, implement hospitality training programmes to cater for future increases in the tourism sector, explore opportunities to increase the number of quality accommodation and hospitality services that are necessary to support any tourist increase, and reconcile village by-laws and national rules that will be necessary to regulate a developing tourist sector in line with Tokelau's environmental and traditional requirements.[36]

2.4 Energy/Fuel Security

2.4.1 Prior to 2012, Tokelau relied wholly on diesel-power generation. Through collaborative funding from the Government of Tokelau, the New Zealand Ministry of Foreign Affairs and Trade, and the UN Development Programme Bank, Tokelau's Renewable Energy Project saw a gradual shift towards solar power usage from 2010 onwards. Becoming the first country in the world to produce

[36] (Tokelau National Strategic Plan 2010-2015, 2010)

Figure 16 Solar Array on Nukunonu atoll (Source: IPT Renewables)

all its electricity needs from renewable energy, today Tokelau is now fully powered by three solar photovoltaic systems, one on each atoll (which are managed by respective *Taupulega)*. A total of 4,032 solar panels (with a capacity of around one mega-watt) make up the entire national system which provides 150% of Tokelau's current electricity demand. Diesel generators, which operate using local coconut oil, provide backup power.[37]

2.4.2 The only fossil fuel used in Tokelau is petrol, which is used for the country's all-terrain vehicles, tractors, and light trucks. Petrol is imported through the fortnightly Samoa/Tokelau shipping service and is delivered ashore in 44 gallon drums. Fuel is stored, managed, and distributed by the cooperative/bulk store on each atoll.

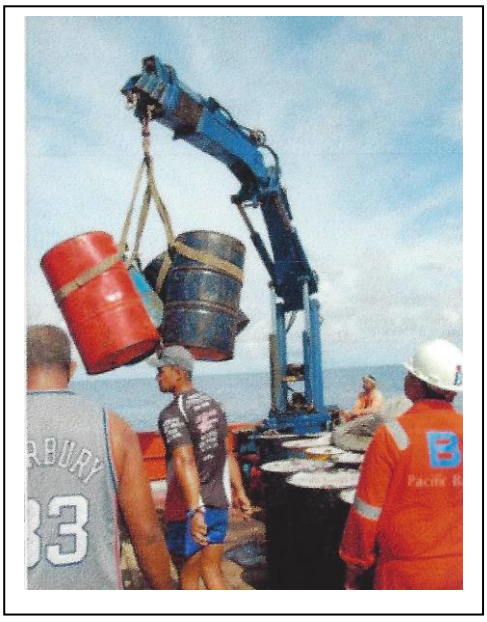

Figure 17 Landing petrol drums ashore in Tokelau[38]

2.4.3 In a region where hardly a day goes by without a sea breeze coming up, Tokelau is also embracing wind power, with a project currently underway for each atoll to have a wind generator capable of producing 50-55kW each. The adoption of wind turbines aims to supplement the existing

[37] (Guevara-Stone, 2013)
[38] (Jasperse, 2015)

solar network across the three atolls, while also ensuring a reliable alternative back-up energy source when days are overcast, at night, or when components of the solar network go off-line due to maintenance. The first wind turbine will be situated and trialled on Fakaofo this year.

2.5 Economic Summary

- Tokelau is a dependency of New Zealand.
- The country's EEZ is the largest of all Pacific Island Countries in the South Pacific.
- Tokelau's economy is largely one of subsistence agriculture and fishing, and is the smallest in the world.
- The economy is susceptible to external factors, including natural disasters and broader international economic developments and events.
- Tokelau does not have any established trade markets and is reliant on food and material imports.
- The fisheries sector is important to the Tokelauan economy, primarily through the administration and management of international fishing licences.
- The economy is dependent on international development aid primarily from New Zealand.
- Tokelau does not have an established tourist sector.
- Tokelau's power needs are fully met through renewable energy sources.

3 CULTURAL ASPECTS AND TRADITIONAL RESOURCE MANAGEMENT

3.1 Cultural Aspects

3.1.1 The guiding principal of Tokelau cultural values is *Maopoopo* ('a unity of a common purpose that encompasses both body and spirit.') *Maopoopo* can be seen in the communal activities Tokelauans participate in (including fishing expeditions, village construction, sports competitions, music, and dance) and underpins the notion of *Faka Tokelau*.

3.1.2 *Faka Tokelau* (the traditional Tokelauan family and community-oriented way of life) is a strong guiding influence in Tokelau and is centred on family and community. Respect for the land and the sharing of resources according to need, together with respect for elders, are integral characteristics of this Polynesian culture. The following aspects of *Faka Tokelau* are of particular note:

- Families are very close and there is a system of sharing and obligation to care and assist all family members.
- However, through the institutionalised system of sharing (*inati*), where each member of the community receives equal shares or portions of harvested resources and where every member of society has responsibilities and equal rights, the main responsibility is not to the family but to one's community (i.e. their village on their atoll).
- Villages are tightly controlled and egalitarian; order tends to be achieved by a dominating age hierarchy based on the 'precept that wisdom is acquired with years and therefore elderly people should decide, direct, and supervise.'[39]
- Everyone in Tokelau has rights to land. Apart from parcels being given over to village activities or assigned to the church, all land (*nukus*) in Tokelau is controlled by recognised 'cognatic' kin groups, who collaboratively engage in its management and harvest. Emphasising the importance of what land there is and the role it plays in Tokelauan culture, the Tokelau Amendment Act 1967 clearly laid out the rules of land ownership; land can be transferred to other Tokelauans but it cannot be transferred to foreigners.

3.1.3 The church also plays a significant part in *Faka Tokelau* with Christianity having played a central part of life in Tokelau since the latter half of the nineteenth century. While Tokelauans can attend church several times a week, Sunday is traditionally devoted to church attendance, with all work being forbidden.

3.2 Culture and Resource Management

3.2.1 Customary marine tenure is important in Tokelau and can be considered the primary and enabling conservation strategy, most notably for marine areas. In a society where there exists a strong traditional institution and resource-use ethic, a prohibition (*fakahao or lafu*) system where reefs, lagoons or general fishing areas are closed off for certain lengths of time, has existed for generations.

[39] (Government of Tokelau, 2017)

3.2.2 Under *Faka Tokelau* and the concept of resource sharing, all marine resources in Tokelau are generally accessible for community use. The management of each atoll's marine and corresponding land resources remains the responsibility of the respective *Tapulega* who, in exercising their traditional powers, make rules on usage and exploitation as part of in-shore coastal marine management plans.

3.2.3 *Lafu* over particular areas is sometimes implemented, particularly during periods of adverse weather, while a *Tapulega* may decide to impose more enduring spatial or temporal prohibitions on fishing on the outer reef slope or open ocean off the atoll for periods ranging from a few days to several months for the purpose of marine conservation, to preserve resources for future community fishing activities. The *Tapulega* on Nukunonu for example, prohibits the harvesting of elongated giant clams for export during March to October each year, while on Atafu *lafu* exists over the harvesting of clam. Importantly, anyone wishing to harvest reef resources for commercial purposes must first seek the approval from the *Tapulega*.

3.3 Cultural Summary

- The guiding principal of Tokelau cultural values is *maopoopo* which means 'a unity of a common purpose that encompasses both body and spirit.'
- *Faka Tokelau* means the 'Tokelauan Way' and describes the socio-political and traditional-customary way of life underpinning Tokelauan culture.
- The Tokelauan Way is centred on family and community along with respect for the land and the sharing of resources.
- Tokelau is a deeply religious society.
- Tokelauans 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 *Faka Tokelau*.
- Customary marine tenure is the primary and enabling marine conservation strategy.
- Each *Tapulega* maintain a strong cultural association with the land and with the sea, primarily for subsistence and conservation reasons.

4 MARITIME OVERVIEW

4.1 Description of Atolls

4.1.1 **Fakaofo.** The atoll rises from a surrounding depth exceeding 2,000 metres and is almost entirely surrounded by an extensive fringing reef, which dries. This reef affords very limited access to the inner lagoon area which is un-surveyed, largely unnavigable by any sort of substantial vessel, and is reportedly shallow in nature, with numerous coral heads and shoal patches. There are no deep-water passages for large vessels to enter the lagoon. Outside the lagoon, the only two notable shoal areas that exist are the 12m patch extending offshore from Fenua Fale (which breaks in a swell) and the 11.9m shoal area that extends out from the atoll's most southern *motu* (Fenua Loa).

4.1.2 There are two passages through the fringing reef which are marked on the chart, the first servicing Fenua Fale and the second in the vicinity of Fale. Neither passage is marked, although a special mark showing a yellow light is located near the entrance to the channel into Fale. At low water you can walk between the two villages.

4.1.3 There are no safe havens for large vessels in or around Fakaofo, nor are there any lights on the atoll to aid offshore navigation. Even in comparatively calm conditions the sea can break heavily in the entrance to both passages. A number of buildings exist in the two villages but the low evaluation of the land and the extent of coastal vegetation means many structures are unlikely to prove useful to the mariner when making landfall or navigating close offshore. The administration building however, can be readily seen from seaward. The wreck of the Fijian trading freighter *Ai Sokula* lies on the northern part of the reef, is also conspicuous and is a useful point of reference for the mariner.

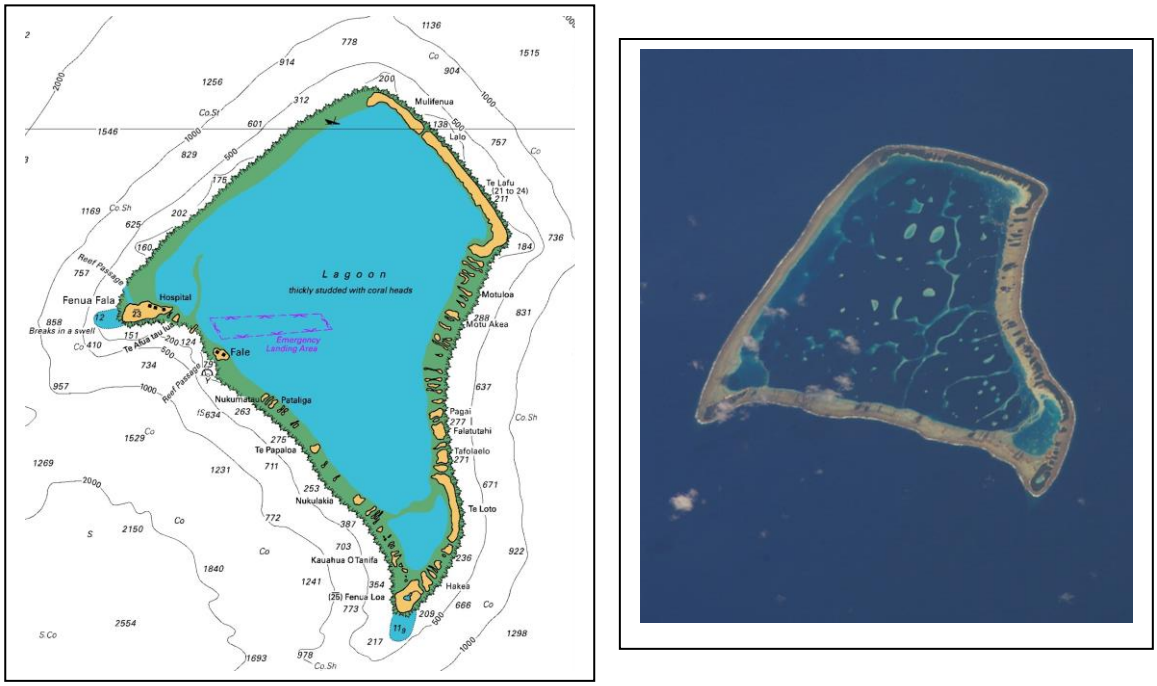

Figure 18 Fakaofo (Source: LINZ and GoogleEarth)

4.1.4 **Nukunonu.** This atoll is almost identical to that of Fakaofo in terms of its fringing reef, lagoon access, general characteristics and surveyed state, and deep-water surrounds. Nukunonu however, has more land mass and its lagoon appears either slightly deeper or equally shallow but with less obvious shoal areas/patches. The northern part of the atoll is often awash and the sea can break heavily over the reef.

4.1.5 There is one boat passage into the lagoon (between Te Tauhunu and Te Kamu midway along the western side of the atoll) and one reef passage into the village of Nukunonu itself. Neither passage is marked.

4.1.6 Like Fakaofo, there are no safe havens for large vessels in or around Nukunonu. Similarly, there are no lights or navigation aids on Nukunonu. A number of buildings make up the village, including the church (with its red roof) and the hospital. These buildings may be visible from seaward and may well aid the mariner when making landfall or when navigating close offshore in the vicinity.

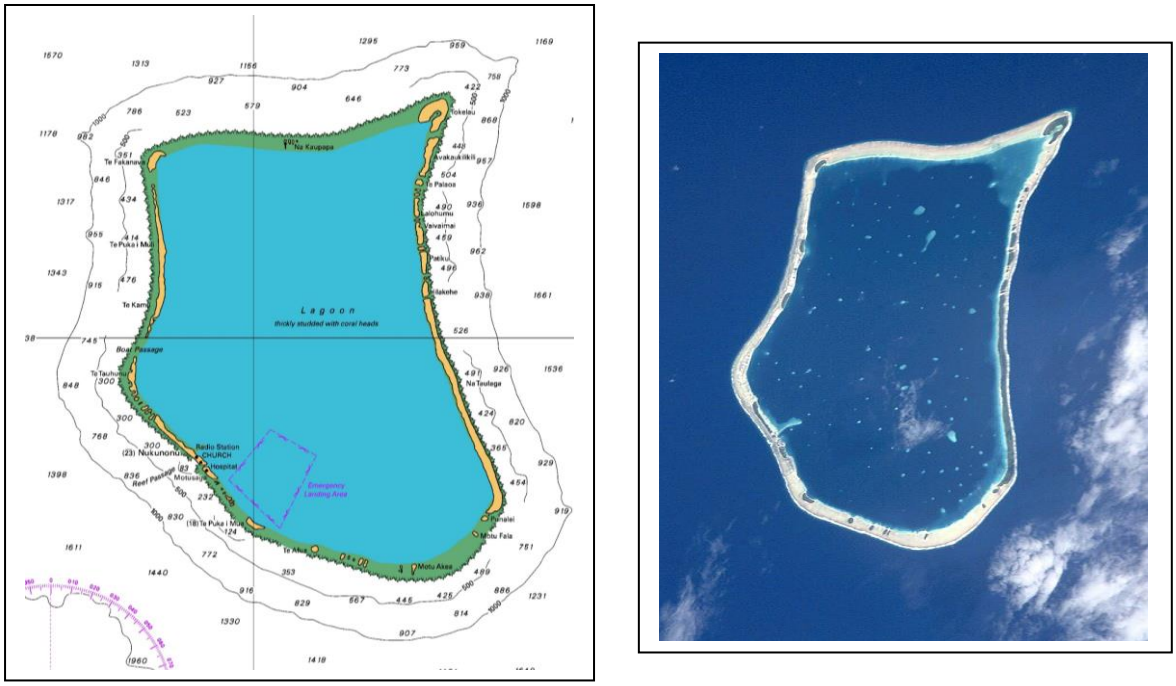

Figure 19 Nukunono (Source: LINZ and GoogleEarth)

4.1.7 **Atafu**. This atoll is the smallest of the three but again, is similar in many respects. Its fringing reef surrounds the atoll and is generally larger in extent than that of the other two atolls. The atoll may be circumnavigated in deep water at a distance of two nautical miles from the reef.

4.1.8 There is only one passage through the reef servicing Atafu itself; there are no charted boat passages into the lagoon itself, which is also shallow and which appears to have signifinicant areas of shoal water and coral bommies, perhaps more-so than the lagoons in Fakaofo and Nukunonu. Like Fakaofo, the reef passage is marked to seaward with a special mark near its entrance showing a yellow light.

4.1.9 The only notable shoal features outside the lagoon in the vicinity of the fringing reef are two 12 metres patches, one extending out for Atafu on the northwest corner and the other towards the south off Fenualoa. A charted anchorage is shown immediately south of the shoal area off Atafu; this is the only charted anchorage shown for any of the atolls.

4.1.10 A number of buildings and structures are visible from seaward, including the village church and some radio masts on the *motu* itself. There are no other navigational lights or aids.

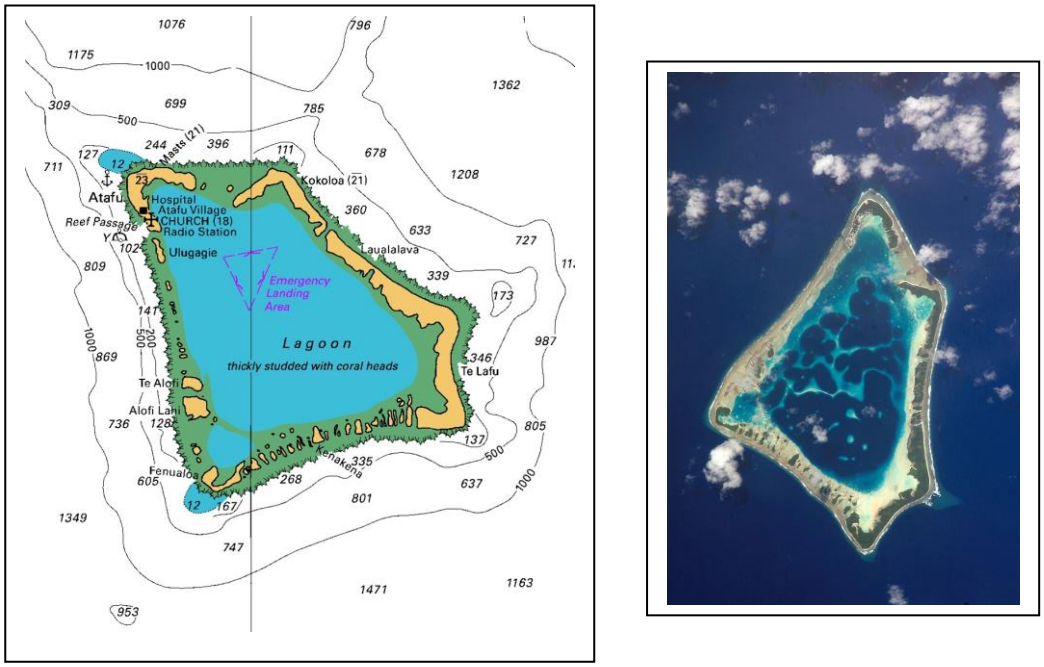

Figure 20 Atafu (Source: LINZ and GoogleEarth)

4.2 Nautical Charting and Navigation

4.2.1 The three atolls of Tokelau feature on the largest scale chart of the area NZ885 (1:500000). The immediate vicinity of each atoll has been surveyed at a scale of 1:50,000, which supports the 1:100,000 scale plans of the atolls themselves. The remainder of the territorial seas, and the route between the atolls has been surveyed to a scale of 1:100,000, but the remaining areas of the EEZ have only been charted from reconnaissance scale survey or general passage soundings. The majority of the EEZ is very deep-water and there are no offshore features and dangers apart from a shoal patch reported (1977) some 190km north east of Fakaofo (in position 7° 43'.3 South 170° 22.7 West) and reported breakers west of Atafu towards the outer limits of the EEZ (in position 8° 46'.9 South 176° 25'.8 West). Considering the amount of fishing vessel traffic near these reported features, neither of these are considered likely to present dangers to surface navigation.

4.2.2 **Currents and Tidal Streams.** There is little if any tidal stream data shown on existing nautical charts. However, as a rule the South Sub-Tropical Current in the vicinity of Tokelau flows predominantly from east to west throughout the year and generally sets at 05 to 1 knot. Between June and September, the current sets in a westerly direction at about 1 knot. The tidal range in the vicinity of Tokelau is around 0.7m.

4.3 Main Harbours, Ports and Anchorages

4.3.1 There are no sea ports, harbours or permanent large vessel anchorage areas in Tokelau. Each atoll has a small concrete hardstand area located at the end of an artificial passage through the reef, which is used by each village to embark/disembark passengers and load/unload cargo. There are no established wharves in the traditional sense, in Tokelau. When larger vessels do call in to Tokelau they tend to anchor about 360 metres from the passage entrances to load and off-load cargo by barge. These anchorages are exposed to both the sea and swell at the best of times and afford little if any protection.

Figure 21 MV *Mataliki* anchoring off Fakaofo (Source: Government of Tokelau)

Figure 22 Barge operations on Nukunonu (Source: Government of Tokelau)

Figure 23 Off-loading cargo in Tokelau (Source: Government of Tokelau)

4.3.2 The movement of cargo and passengers to and from the shore is the direct responsibility of each *Taupulega* which delegates its management to the village General Manager. Respective *aumaga* (work force) provide the stevedoring effort in Tokelau. What cargo loading equipment exists on each atoll (usually in the form of mounted/tractor cranes) is either unserviceable or not fit-for-purpose. This means much of the cargo handling has to be undertaken manually by the *aumaga,* which is both labour intensive, time consuming, and presents various workplace health and safety issues, particularly when working within the small and often slippery, confines of each hardstand area.

Figure 24 Unloading cargo by truck (Source: Government of Tokelau)

4.3.3 **Initiatives.** Along with the need to maintain each channel to keep them clear to support barge movements to/from the wharves (an operation that is usually achieved through blasting), the need to upgrade the wharf area and associated infrastructure on each atoll has been identified as a priority in the Government's current Asset Management Plan 2015-30. Upgrade plans include:

- tracked cranage for each atoll/wharf area;

- a minimum seven metre by 14 metre concrete hardstand area;
- a six metre wide access area between the hardstand and the land;
- navigation aids for each passage/channel; and
- seawalls and wave 'dissipation structures' to reduce the hazards of wave action at each wharf location.[40]

4.3.4 Under this plan, the Government is also looking to upgrade and construct new seawalls across the three atolls to mitigate the short and longer term risks of cyclone storm surge inundation. Seawall construction and composition across each atoll varies and is in various states of repair. Repair efforts are currently focussing on those areas across Tokelau assessed as being most vulnerable. Public invitation to register interest in providing marine construction services on Atafu and Nukunonu closed 1 March this year.

4.4 Regional Shipping Movements

4.4.1 The only connection Tokelau has with the world is through the regional passenger and cargo service provided by the Government-owned MV *Mataliki*. There are no other established shipping services to Tokelau.

4.4.2 Built with funding from New Zealand by the south east Asian shipbuilder Western Shipyard (Bangladesh) the 500 GRT *Mataliki* vessel entered service with its maiden voyage to Tokelau in March 2016. The vessel can carry up to 60 passengers and 50 tons of cargo and supplies making the trip from Apia in Samoa in about 24 hours.

Figure 25 MV *Mataliki* (Source: Western Marine Shipyard Limited)

4.4.3 Although the ferry is owned by the Government, the New Zealand company Transport and Marine Ltd currently operates the vessel on a fortnightly sailing schedule. A typical voyage will see the vessel depart Apia and transit to Tokelau spending time at Fakaofu, then Nukunonu, and finally Atafu before returning via Nukunonu and Fakaofu and on to Apia. The duration of the round trip varies between four and ten days depending on passenger movements and the extent of any inter-

[40] (Waugh Infrastructure Management Ltd, 2014)

atoll and national/village activities (e.g. Council and General Fono meetings). Any unplanned medical evacuation to Apia has priority, which occasionally sees passengers temporarily stranded in Tokelau until the MV *Matalik*i returns

APIA/TOKELAU/APIA SHIPPING SERVICE - Sailing Schedule from 25 April 2017 to 30 December 2017

Reference: 2016-0

Voyage	Vessel	Apia (APW)	Fakaofo (FF)	Nukunonu (NN)	Atafu (AA)	Nukunonu	Fakaofo	Apia	Activities
Apr-17									
	Charter	25-Apr-17	26/04/2017	27/04/2017	28/04/2017			30/04/2017	Dangerous Goods Sailing
May-17									
V050	Mataliki	2-May-17	3/05/2017	4/05/2017	5/05/2017	6/05/2017	6/04/2017	7/05/2071	Consultation sailing
	Charter	3-May-17	4/05/2017	5/05/2017	6/05/2017			7/05/2017	Statistic Consultation
V051	Mataliki	14-May-17	15/05/2017	15&16/05/2017	16&20/05/2017	20/05/2017	21/05/2017	22/05/2017	Consultation sailing
	Charter	27/05/2017			29/05/2017	30/05/2017	31/05/2017	01/06/2017	Dangerous Goods Sailing
V052	Mataliki	30-May-17	1/06/2017	1/06/2017	2/06/2017			3/06/2017	Pax & Cargo sailing
Jun-17									
V053	Mataliki	1-Jun-17	2/06/2017	2/06/2017	3/06/2017			4/06/2017	Pax & Cargo sailing
	Norfolk	11-Jun-17			13/06/2017	14/06/2017	15/06/2017		DG Run/Bulk/Coop Sailing
V054	Mataliki	14-Jun-17	15/06/2017	15/06/2017	16/06/2017			17/06/2017	Pax & Cargo sailing
V055	Mataliki	29-Jun-17	30/06/2017	30/06/2017	1/07/2017			2/07/2017	Pax & Cargo sailing
Jul-17									
	Charter	8-Jul-17			10/07/2017	11/07/2017	12/07/2017	13/07/2017	General Fono Run
V056	Mataliki	13-Jul-17	14/07/2017	14/07/2017	15/07/2017	15/07/2017	16/07/2017	17/07/2017	General Fono sailing
V057	Mataliki	20-Jul-17	21/07/2017	21/07/2017	22/07/2017	22/07/2017	23/07/2017	24/07/2017	Drop off General Fono
Aug-17									
V058	Mataliki	1-Aug-17	2/08/2017	2/08/2017	3/08/2017			4/08/2017	Pax & Cargo sailing
	Charter	8-Aug-17			10/08/2017	11/08/2017	12/08/2017	13/08/2017	Dangerous Goods Sailing
V059	Mataliki	22-Aug-17	23/08/2017	23/08/2017	24/08/2017			25/08/2017	Pax & Cargo sailing
Sep-17									
	Charter	2-Sep-17			4/09/2017	5/09/2017	6/09/2017	7/09/2017	Dangerous Goods Sailing
V060	Mataliki	5-Sep-17	6/09/2017	6/09/2017	7/09/2017			8/09/2017	Pax & Cargo sailing
V061	Mataliki	19-Sep-17	20/09/2017	20/09/2017	21/09/2017			22/09/2017	Pax & Cargo sailing
Oct-17									
V062	Mataliki	3-Oct-17	4/10/2017	4/10/2017	5/10/2017			6/10/2017	Pax & Cargo sailing
	Charter	4-Oct-17			6/10/2017	7/10/2017	8/10/2017	9/10/2017	White Sunday Sailing
V063	Mataliki	17-Oct-17	18/10/2017	18/10/2017	19/10/2017			20/10/2017	White Sunday Sailing
Nov-17									
V064	Mataliki	1-Nov-17	2/11/2017	2/11/2017	3/11/2017			4/11/2017	Pax & Cargo sailing
	Charter	4-Nov-17			6/11/2017	7/11/2017	8/11/2017	9/11/2017	Dangerous Goods Sailing
V065	Mataliki	14-Nov-17	15/11/2017	15/11/2017	16/11/2017			17/11/2017	Pax & Cargo sailing
V066	Mataliki	28-Nov-17	29/11/2017	29/11/2017	30/11/2017			1/12/2017	Pax & Cargo sailing
Dec-17									
	Charter	2-Dec-17			4/12/2017	5/12/2017	6/12/2017	7/12/2017	DG &Christmas Run
V067	Mataliki	5-Dec-17	6/12/2017	6/12/2017	7/12/2017			8/12/2017	Pax & Cargo sailing
V068	Mataliki	12-Dec-17	13/12/2017	13/12/2017	14/12/2017			15/12/2017	Christmas Run
	Charter	16-Dec-17			18/12/2017	19/12/2017	20/12/2017	21/12/2017	Christmas & New Year Run
V069	Mataliki	19-Dec-17	20/12/2017	20/12/2017	21/12/2017			22/12/2017	Pax & Cargo sailing
V070	Mataliki	27-Dec-17	28/12/2017	28/12/2017	29/12/2017			30/12/2017	Pax & Cargo sailing

Figure 26 MV *Mataliki* Schedule - Samoa to Tokelau - April to December 2017 (Source: Government of Tokelau)

4.4.4 In addition to the regular MV *Mataliki* service, Samoa Shipping Company vessels are often called upon to provide dedicated charters between Apia and Tokelau to accommodate peak travelling times and to facilitate the movement of special cargo to support Government-sponsored or village projects (eg. renewable energy projects, channel blasting and maintenance). Additional charters are also engaged when there are national activities which necessitate the movement of large groups and families between the atolls.

4.4.5 On average over the past five years, there have been between 10-12 additional charters arranged to Tokelau each year.[41]

4.5 Inter-Island Movements

4.5.1 For safety reasons, the General Fono prohibits private/family-related movements between each atoll. The only authorised way to travel between atolls is through the fortnightly MV *Mataliki* service. Each atoll is wholly dependent on this shipping service for regional and domestic passenger movement, cargo transfer, and medical and emergency evacuation. The *Matalik*i can carry up to 120 passengers on its inter-atoll schedule. Passage time between Fakaofo and Atafu is about nine hours.

[41] (Government of Tokelau, 2017)

4.5.2 Each atoll has a number of small fishing craft, aluminium boats, and pontoons. Each atoll also has a number of barges, powered by 40-60hp outboard engines, which are used to conduct ship to shore passenger and cargo transfers. Fakaofo has a number of other barges, which are used for solid waste management and hospital passenger services, and to transport school students, teaching staff and residents between Fale and Fenua Fale.

4.6 Other Maritime Assets

4.6.1 There are no other significant maritime assets in Tokelau. In addition to providing Tokelau's cargo and passenger service, the MV *Mataliki* is used on occasion either by the Government of Tokelau or by Samoan authorities, for dedicated search and rescue operations either off Tokelau itself or in the waters between Tokelau and Samoa. The vessel is also available to support any contingency activity or emergency event, including regional disaster relief and humanitarian assistance efforts.

4.6.2 Surveillance operations in Tokelau's EEZ are provided by New Zealand Defence Force air and maritime platforms or through the Forum Fisheries Agency, with similar support also being provided by New Zealand as part of New Zealand's regional surveillance programme.

4.7 Maritime Summary

- Without an airport, Tokelau's prosperity and economic future is fully dependent on maritime transportation.
- There is only one regular passenger and freight service to Tokelau, this being the fortnightly shipping service from Apia.
- There is no other dedicated international shipping that services Tokelau.
- There are no harbours in Tokelau nor are there any wharves or permanent anchorage areas. All passenger and cargo movements to/from shore are conducted over the shore by motorised barge.
- The atolls of Tokelau are considered 'closed'; there is no deep-water passage reaching into any of the lagoons.
- A priority for the Government of Tokelau is to upgrade existing wharf and channel infrastructure across each atoll.
- Much of Tokelau's surrounding waters appear to have been adequately surveyed although the lagoon areas are either un-surveyed or are considered sufficiently unnavigable to not warrant bathymetric detail being shown on the current chart.

5. KEY SITES OF SIGNIFICANCE

5.1 Sites of Environmental Significance – Overview

5.1.1 There exists a natural affinity, community engagement, and spiritual connection with what land exists in Tokelau and the surrounding marine environment. The environment and in particular the ocean, continues to play an important part of Tokelau's cultural heritage. Tokelauans see the ocean as being 'us, our cultural identity' to the extent that people's lives and community activities continue to be intertwined with the ocean in many respects – economy, subsistence, culture and language.

5.1.2 The entire coastal and reef margins and lagoon waters remain important to Tokelau's village communities. This importance is best demonstrated by concerted efforts to strengthen resilience against the effects of climate change through the Tokelau Climate Change Strategy '*Living With Change*' where the protection and preservation of the ocean features as a high priority. It can also be seen through Tokelau's community-based management approach, which has been in existence in a formal sense since 2004 and which is based around traditional institutions for the implementation of local laws and regulations to govern and monitor resource use.

5.1.3 While Tokelau may not have too many tangible monuments, the entire land and reef system can be considered environmentally significant as well as important from a cultural heritage and subsistence perspective.[42]

5.2 Sites of Cultural Significance – Marine Reserves

5.2.1 Since the mid-1990s there have been three areas afforded some form of marine protection in Tokelau, one area for each atoll.[43]

Area	Type	Date Designated	Location
Atafu Marine Conservation Area	Marine Reserve	1995	Southern tip Atafu - east of Fenualoa and south of Alofi Lahi and Alofi
Fakaofo Conservation Area	Reserve	1992	Southern tip of Fakaofo - northeast of Fenua Loa and southwest of Metu.
Nukunonu Marine Conservation Area	Marine Reserve	1998	Northeastern tip of Nukunonu - a wildlife reserve west of Tokelau and east of Fakanava.

Table 2 Marine Conservation Areas in Tokelau

[42] One notable site of significance is an 'ancient coral slab' erected to personify the god Tui Tokelau. It stands in the meeting house in Fale on Fakaofo and is supposed to be able to exercise supernatural powers.
[43] (Tokelau, n.d.)

5.2.2 In these marine reserves there are no markers. However, people are familiar with any *tabu* areas since the boundaries tend to be the islets themselves, along with the divide between the ocean and lagoon sides of each *motu* and reef area.

5.2.3 **Initiatives.** A 2013 report by the Department of Economic Development, Natural Resources and Environment of Tokelau and the Secretariat of the Pacific Community, recommended the establishment of more enduring marine protected areas covering some 50 to 200 hectares to mitigate the effects of climate change and fishing pressure and to improve the resilience of marine resources:

- *Nukunonu* - the section of the reef/lagoon from the *motu* Te Afua to the *motu* Fala (including the Te akau loa coral patch reef) and the south-east section of the reef/lagoon to the east and south of the *motu* Tokelau, including *motu* Tokelau itself.
- *Atafu* - the reef/lagoon area around the *motu* Te Alofi to Ava o te Puka and the southern section or reef/lagoon adjacent to the *motu* Na Utua (including all coral patch reefs in the lagoon); and
- *Fakaofo* - the section of the reef/lagoon south of Nukutakia to Akegamatu, together with one or two selected large coral patch reefs inside the lagoon itself.[44]

Whether there has been any movement to establish permanently protected areas across any of these recommended areas is unknown.

5.3 Significant Site Summary

- All of Tokelau's coastline and coastal and lagoon waters can be considered either environmentally and culturally significant or considered important from a biodiversity perspective.
- There are only three formally recognised marine areas of significance in Tokelau.
- The coastal and lagoon waters of each atoll are administered through community-based management plans.

[44] (The Status of Reef Invertebrate Resources and Recommendations for Management at Tokelau, 2013)

6. INTERNATIONAL SHIPPING TRAFFIC DATA (AIS)

6.1 Introduction

6.1.1 This section discusses the results of the traffic data analysis for Tokelau EEZ. Raw ship S-AIS data for the periods: January–December 2016 were used for the ship traffic analysis. This is the same period used for the 2017 Samoa risk assessment but differs from previous assessments of the Cook Islands and Tonga. 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 traffic results.

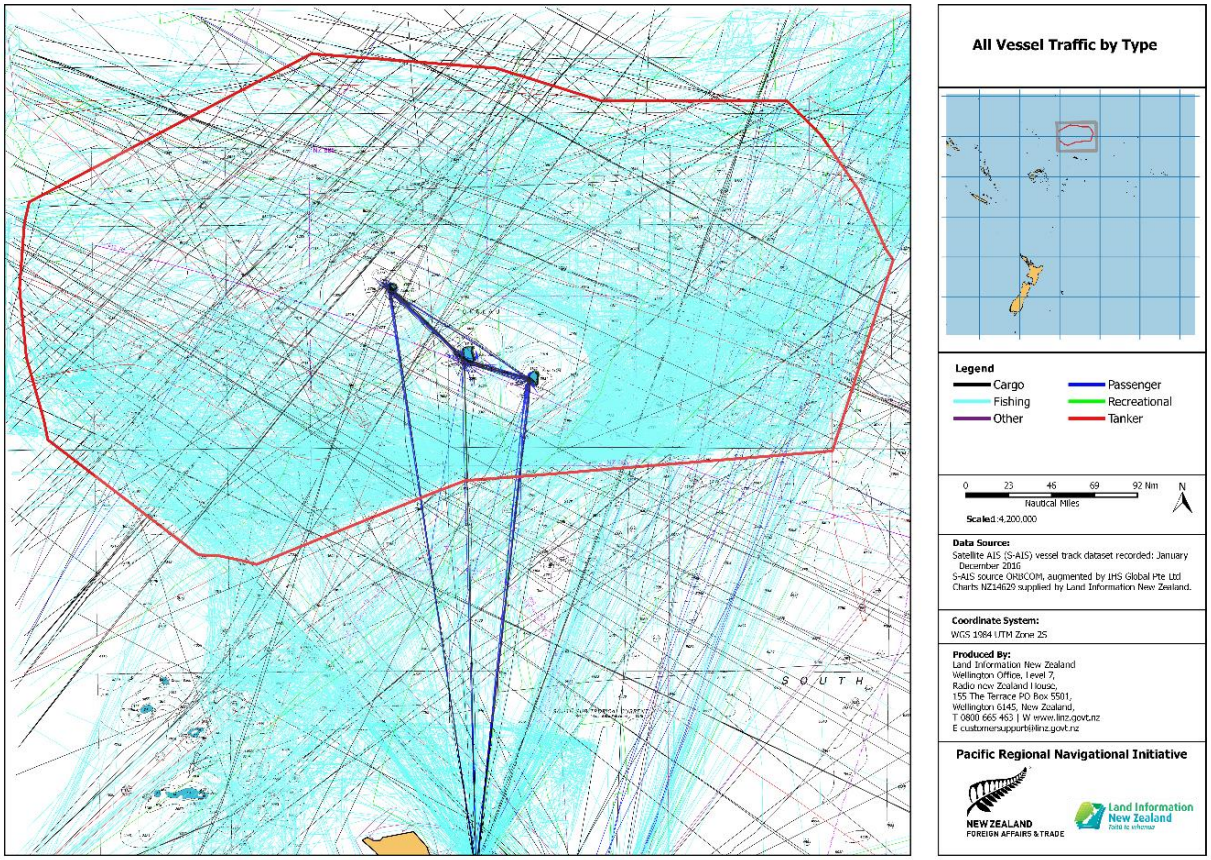

Figure 27: All vessel tracks Tokelau EEZ to Samoa, for the analysis period

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

- Cargo;
- Fishing;
- Passenger;
- Recreational;
- Tankers; and
- Other

6.1.3 This plot provides an overview of traffic through the Tokelau EEZ. While there are very few port calls to Tokelau atolls, the black lines indicate that there is regular general cargo ship traffic

crossing the area in a north-east/south-west direction and in a north-west/south-east direction. The number of tracks over the 12 months of data indicate that these vessels generally transit on a weekly basis. There are a small number of tanker tracks also crossing the EEZ.

6.1.4 The most notable observation is the large amount of fishing vessel activity in in the Tokelau EEZ, almost exclusively outside of the 12nm territorial seas of the three atolls. The fishing vessel traffic in the north-west sector is generally straight lines indicating transiting, however the random patterns of the fishing vessels in the south-west, south, south-east and north-east indicate very active fishing in these areas. Note also that most of this fishing activity is limited to inside the Tokelau EEZ, with the only significant spill-over being to the north-east beyond the EEZ boundary into the uncontrolled high seas region.

6.1.5 The density of fishing vessel traffic crossing the reported shoal area (1977) in approximate position 7° 43'.3 South, 170° 22.7 West, indicates that this reported feature, in general depths of 5000m is likely to have been a disturbance caused by schools of fish and unlikely to present a danger to surface navigation.

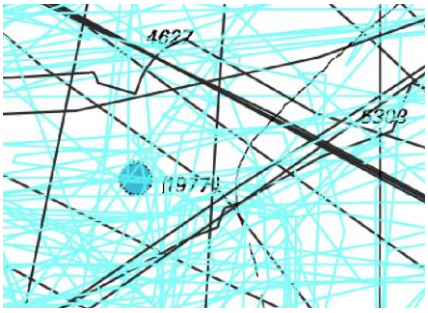

Figure 28: Reported shoal area (1977)

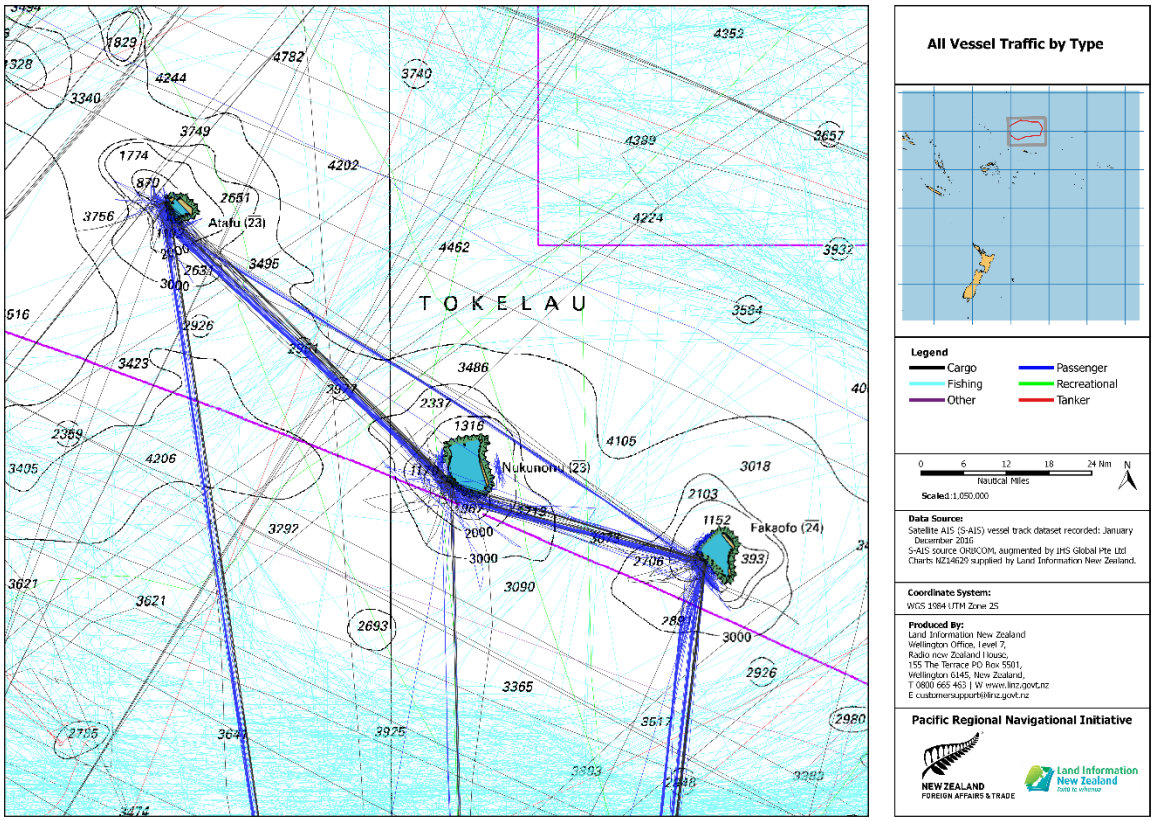

Figure 29: All vessel tracks near Tokelau atolls, colour coded by type

6.1.6 The port calls to Tokelau are shown above. There is a regular pattern of passenger and cargo ship visits to the three atolls and Apia (Samoa). These are undertaken by the Tokelauan vessel *MV Mataliki* and chartered vessels operated by the Samoan Shipping Corporation. These vessels normally remain underway or anchor off the protected ends if each atoll, nearest the population centres, where landing areas for barge transfer of passengers and cargo is possible. While a larger scale chart would make navigation in the vicinity of the atolls safer and more convenient, the fact that only two or three vessels and masters visit the islands ensures that local knowledge is maintained at a high level. Considering this fact, it is assessed that the current charting coverage is sufficient to support safe navigation.

6.1.7 One tanker track passes between the Atafu and Nukunonu atolls remaining outside the territorial sea limit. All other tanker tracks pass well clear of the atolls.

6.1.8 Five cargo vessel tracks pass close north-west of Atafu in a north-east/south-west direction. Nine other cargo vessel tracks in a similar direction pass between Atafu and Nukunonu atolls, all but four remaining outside the territorial sea limits. No cargo vessels pass between Nukunonu and Fakaofo atolls.

6.1.9 Numerous fishing vessels tracks do pass between the atolls. Forty-two between Atafu and Nukunonu atolls and 20 between Nukunonu and Atafu atolls. Almost all of these tracks remain outside the 12nm territorial seas. Those that do intersect the territorial seas are generally straight lines, indicating that these vessels are most likely in transit and not engaged in fishing.

6.1.10 Four recreational vessels have passed through the Tokelau group but only one appears to have called at Tokelau (Nukunonu) during the 12 month data collection period.

6.1.11 As the Tokelau Government does not permit domestic transit between the atolls in private vessels, there is no additional domestic vessel traffic to add to this plot. Small fishing dinghies operate locally generally close to the atolls and within the lagoons.

6.2 Conclusion - International Shipping Traffic Data (AIS)

6.2.1 Large commercial cargo and tanker vessels transiting the Tokelau EEZ generally keep well clear of the Tokelau atolls, which are correctly charted on small scale ocean navigation charts. Smaller commercial fishing vessels generally remain outside the Tokelau territorial seas, where there appear to be no dangers to navigation. Occasionally, a recreational vessel visits a Tokelau atoll and the current charting is adequate to meet this requirement, especially given the shallow draught of such vessels.

6.2.2 Routine passenger and cargo vessels servicing the Tokelau atolls from Apia utilise local knowledge to augment the charted information and are able to navigate safely with the existing chart coverage.

6.2.3 As no in-country visit was undertaken during this assessment there was no opportunity to assess the need for charting of the internal atoll lagoons to support domestic purposes. However, as there are no navigable passages for international vessels into these lagoons there is no international obligation to provide nautical charts of them.

7. RISK ANALYSIS

7.1 Introduction

7.1.1 No spatial or numeric risk assessment has yet been conducted for Tokelau. This may be undertaken in the future if demand warrants.

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ANNEXES

ANNEX A - Event Trees

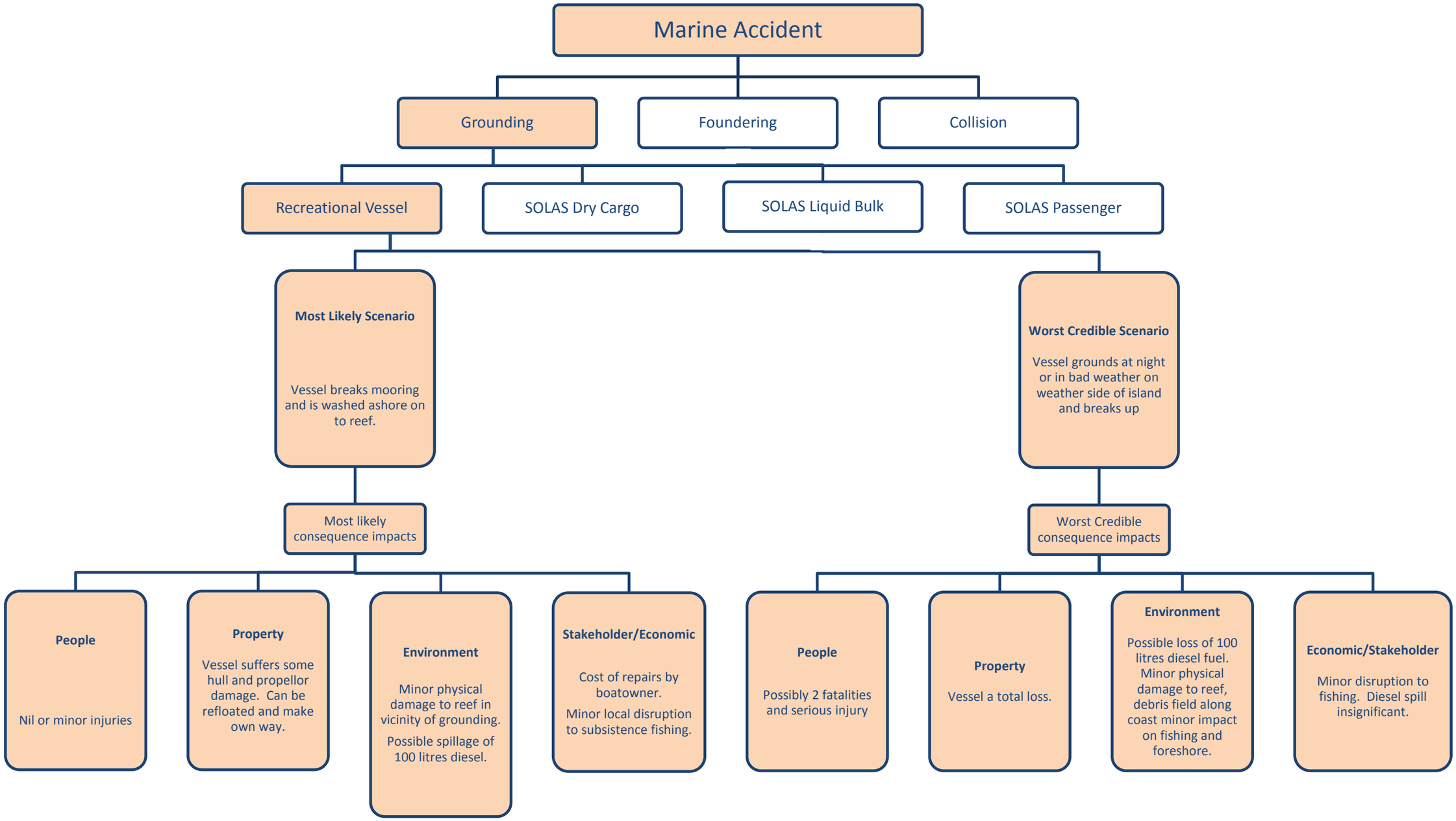
1. Event trees were used to determine the most likely and worst credible impacts of defined unwanted navigation events. For consistency and commonality across the south-west Pacific hydrographic risk assessment area, the event trees in this Annex are based on the generic event trees in the Risk Assessment Methodology[45] and those used in the Cook Islands[46] and Tonga,[47] which were subsequently modified for Niue[48] and Samoa.[49] These have been further adapted for the general risks to Tokelau.

2. Tokelau has no domestic cargo or passenger vessels of any recordable GT, all domestic movements are undertaken by international vessels.

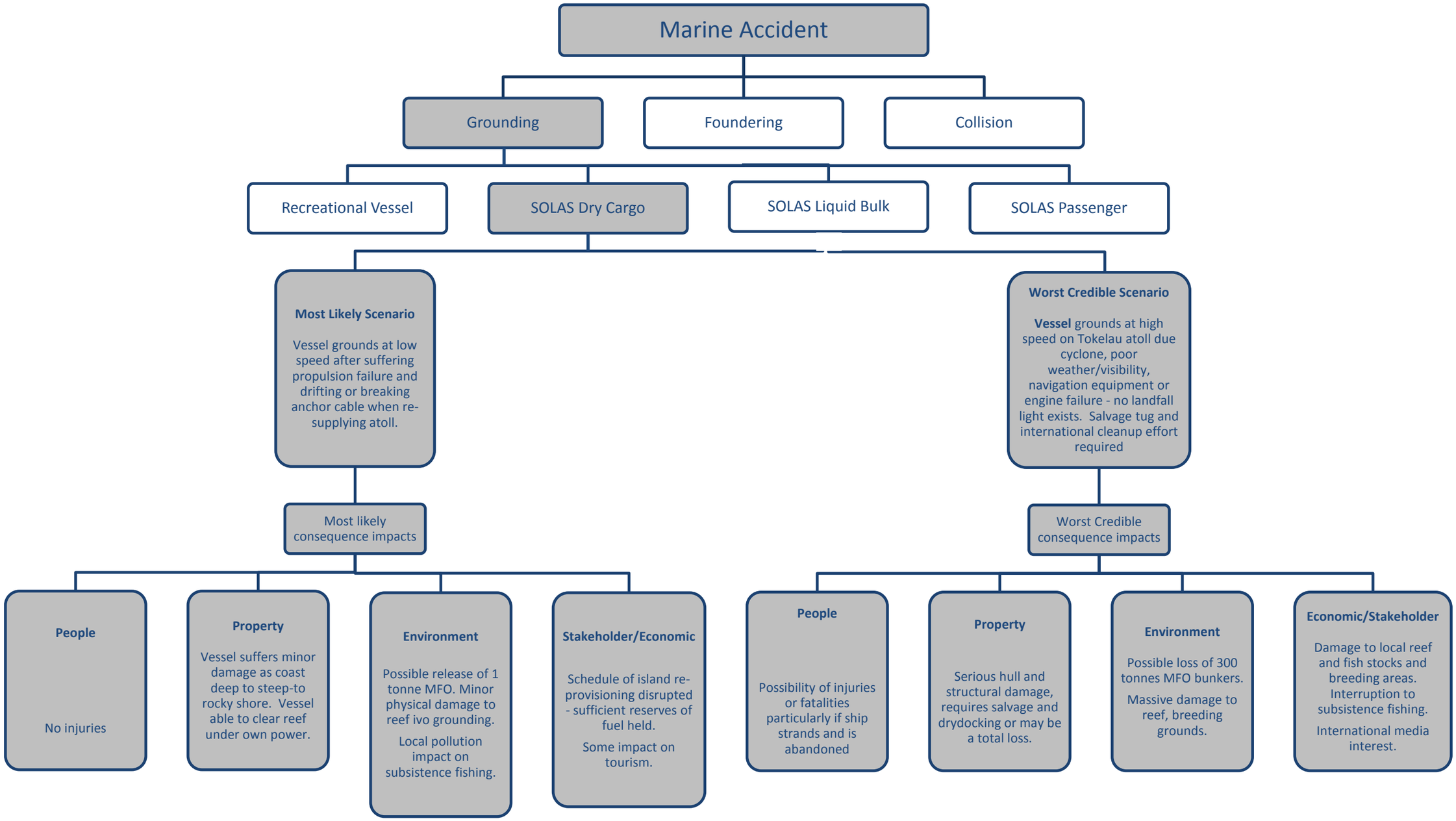
3. These event trees are for general information only and have not been used to amend the generic South West Pacific risk consequence factors weightings which are included for information at Annex E.

[45] (Marico Marine Report No. 15NZ322 Issue 03, 5 August 2015)
[46] (Marico Marine Report No. 14NZ262MR Issue 02, 20 January 2015)
[47] (Marico Marine Report No. 14NZ262 – TM, Issue 1, 27 November 2014)
[48] (RNAPL16002 - NIUE Hydrographic Risk Assessment, 2016)
[49] (RNAPL17001 - SAMOA Hydrographic Risk Assessment, 2017)

ANNEX A - Event Trees



ANNEX A - Event Trees



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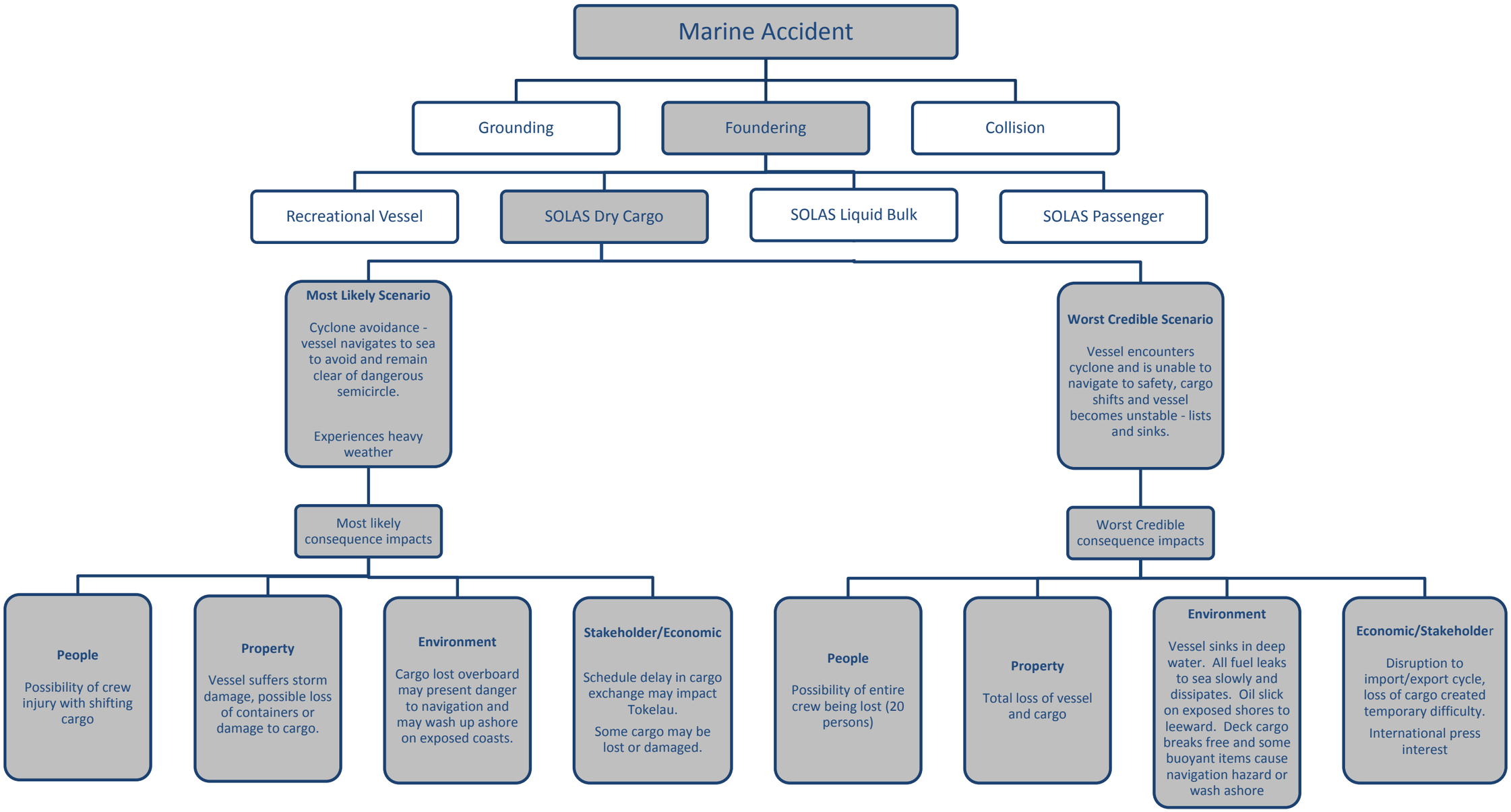

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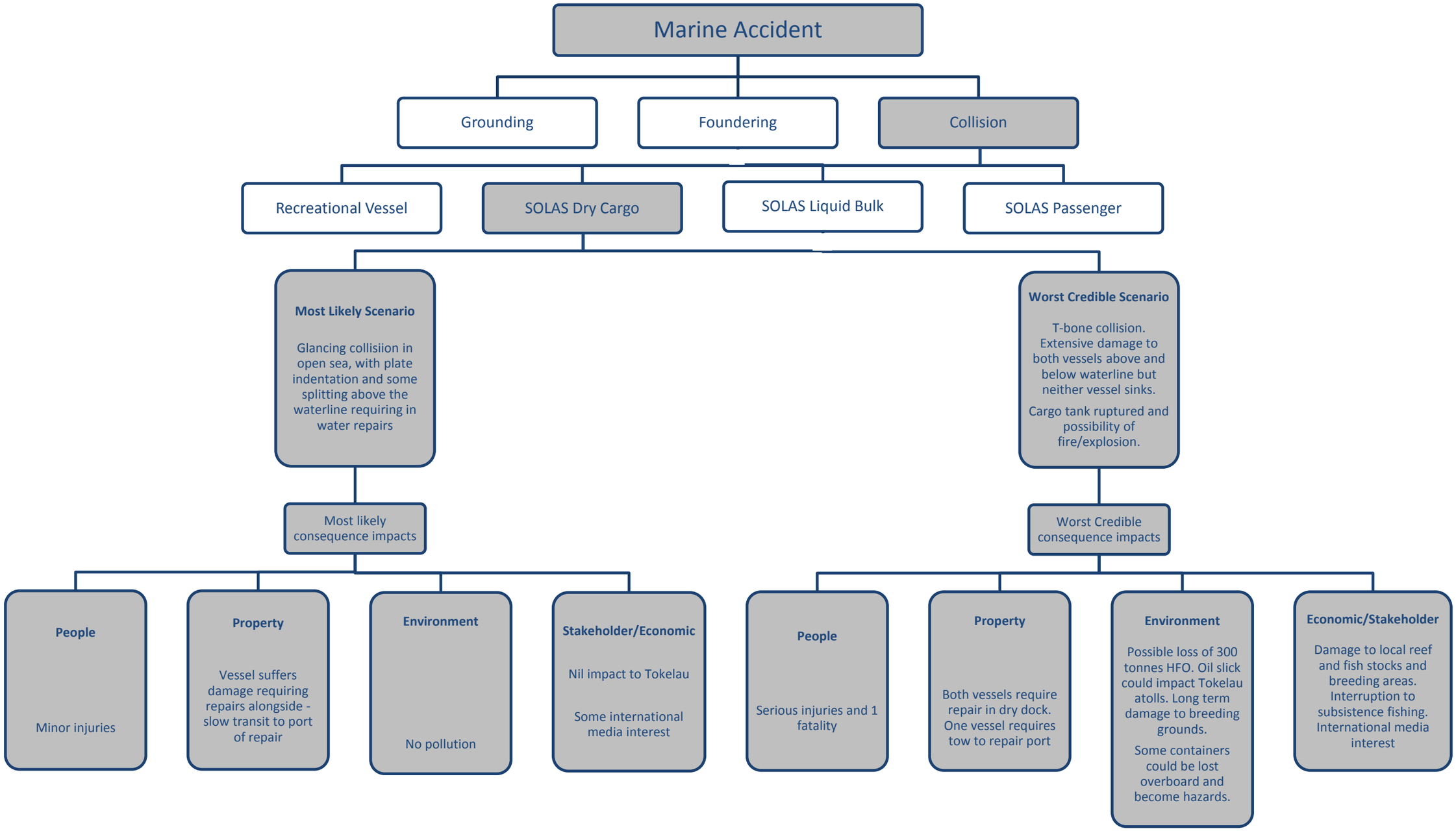
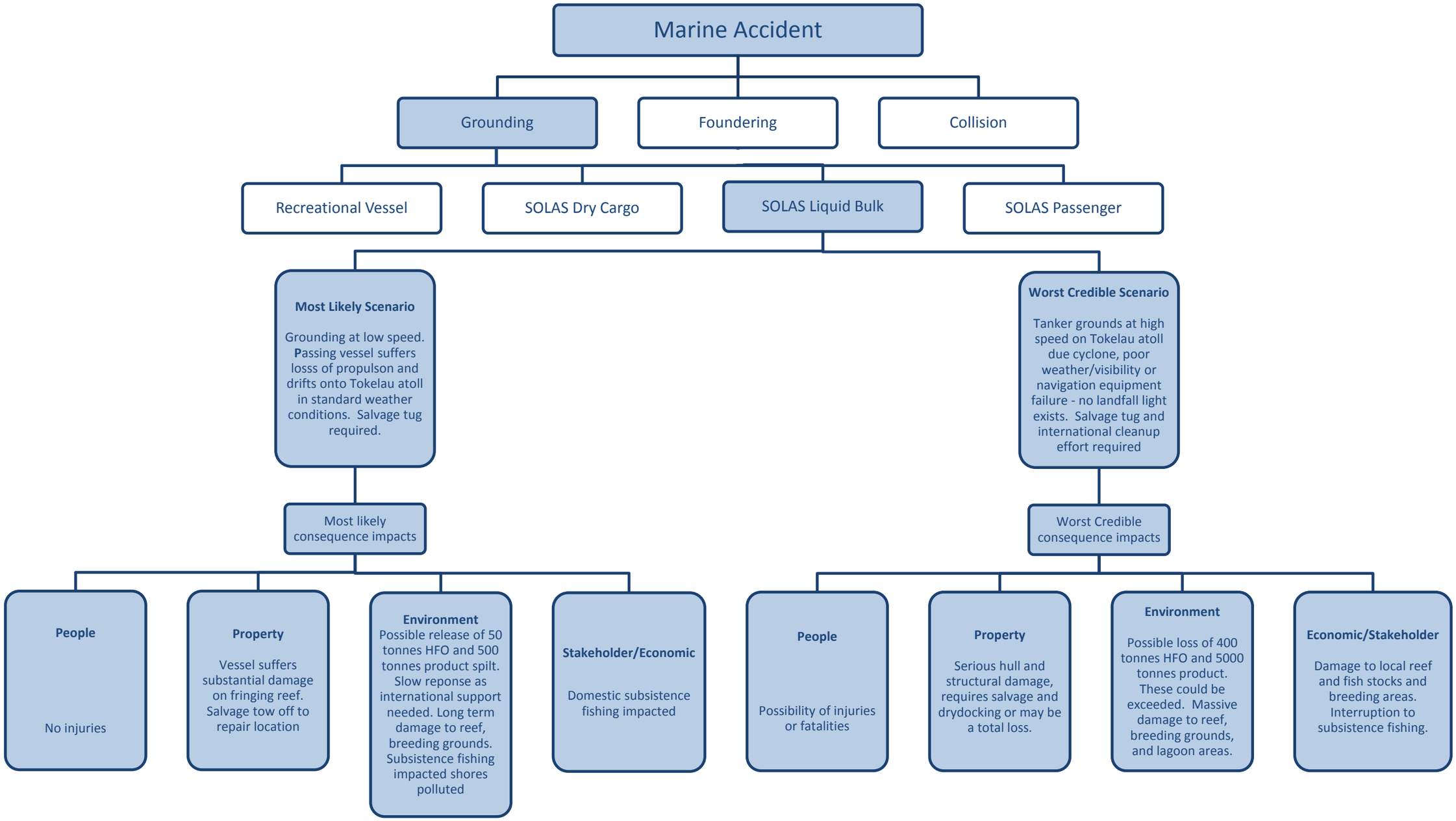
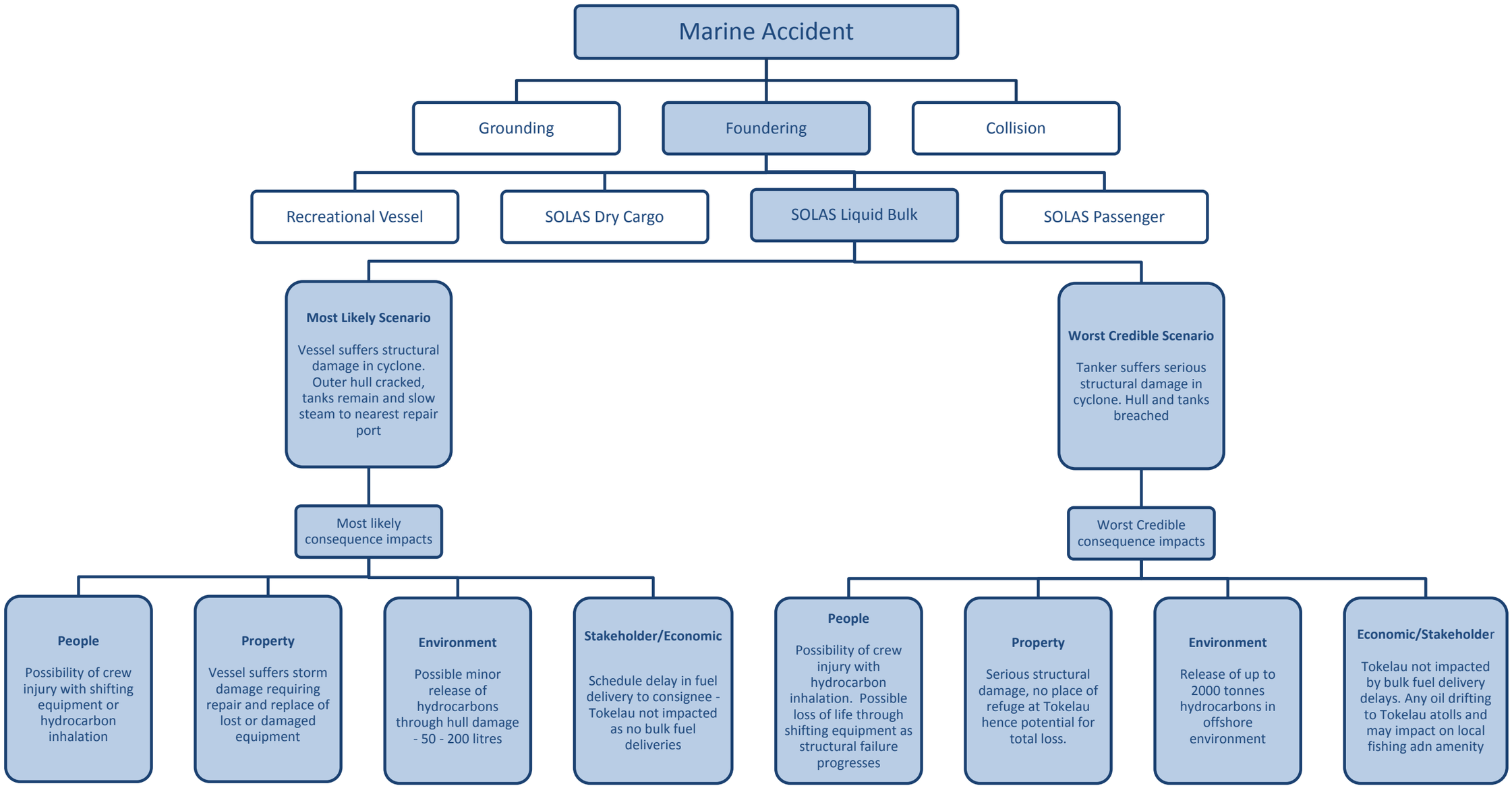


ANNEX A - Event Trees



ANNEX A - Event Trees



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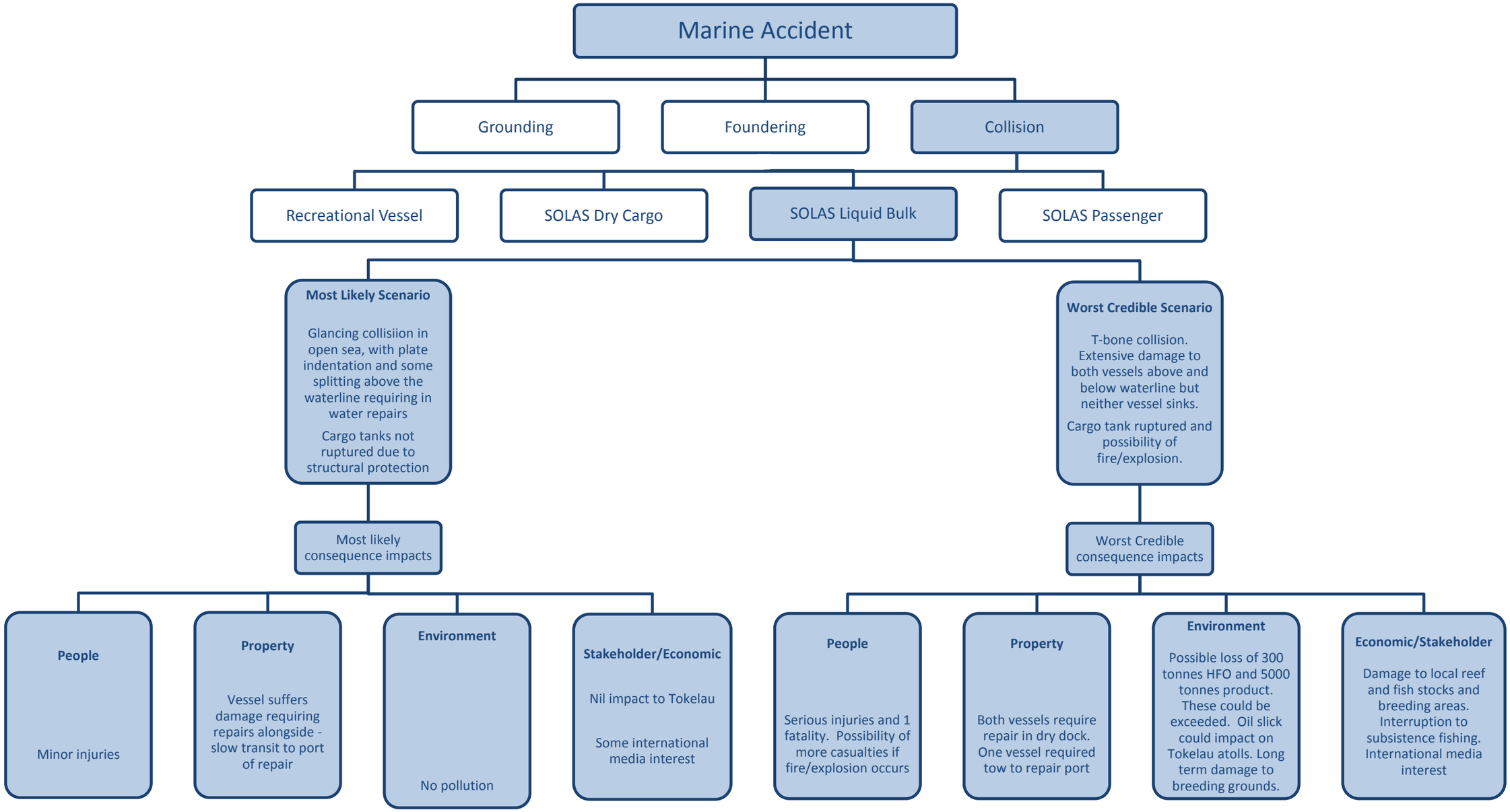
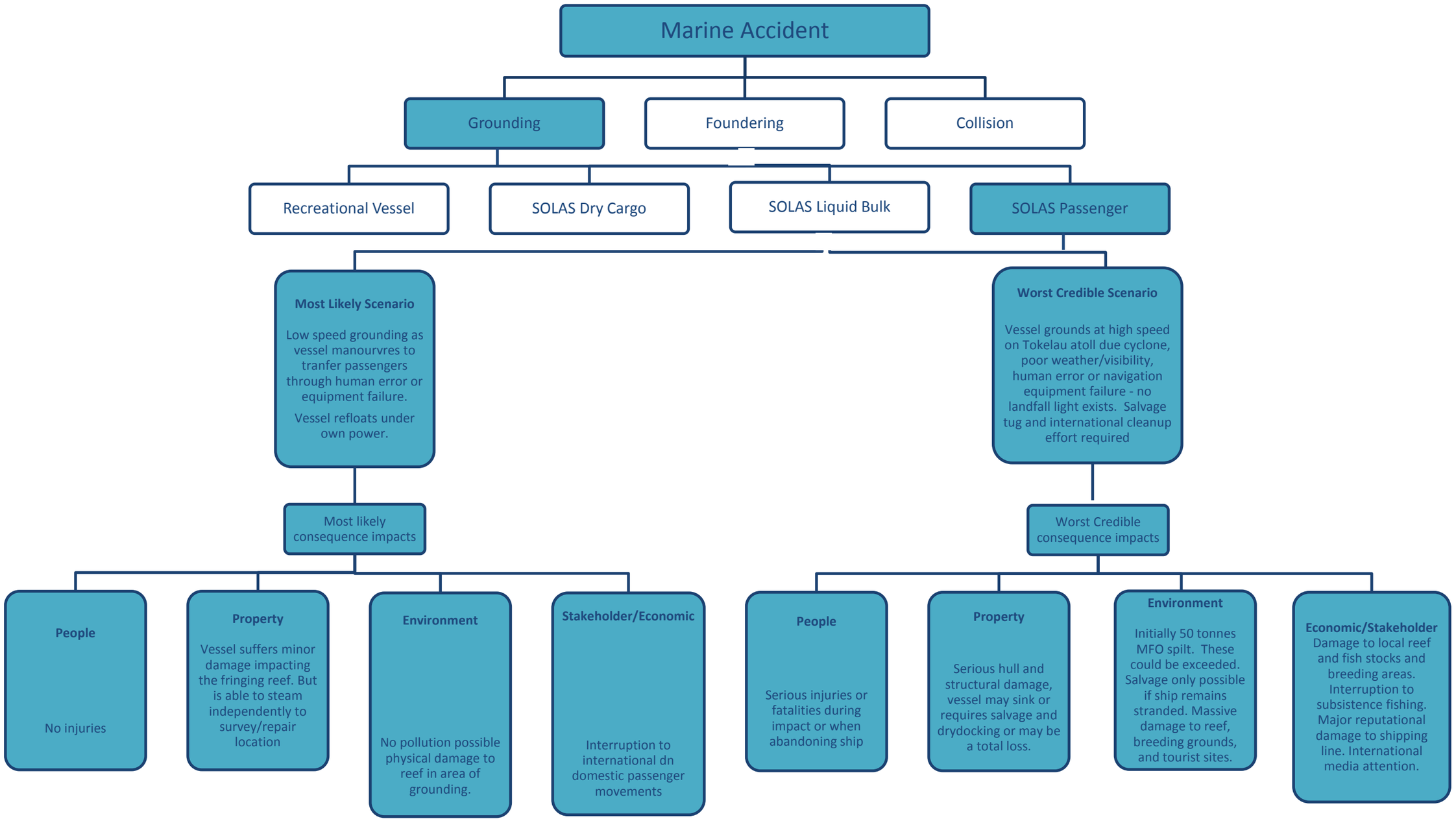
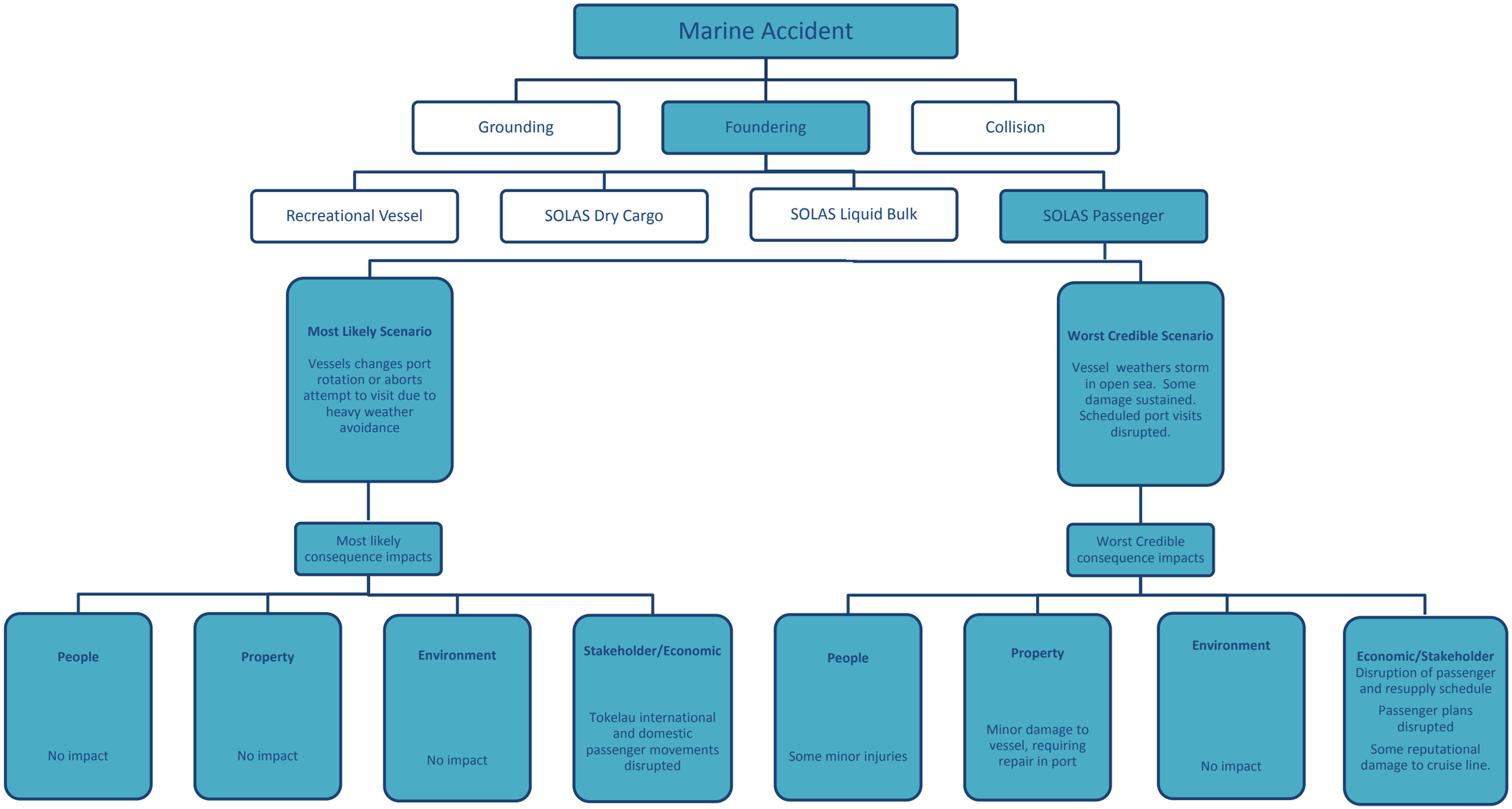


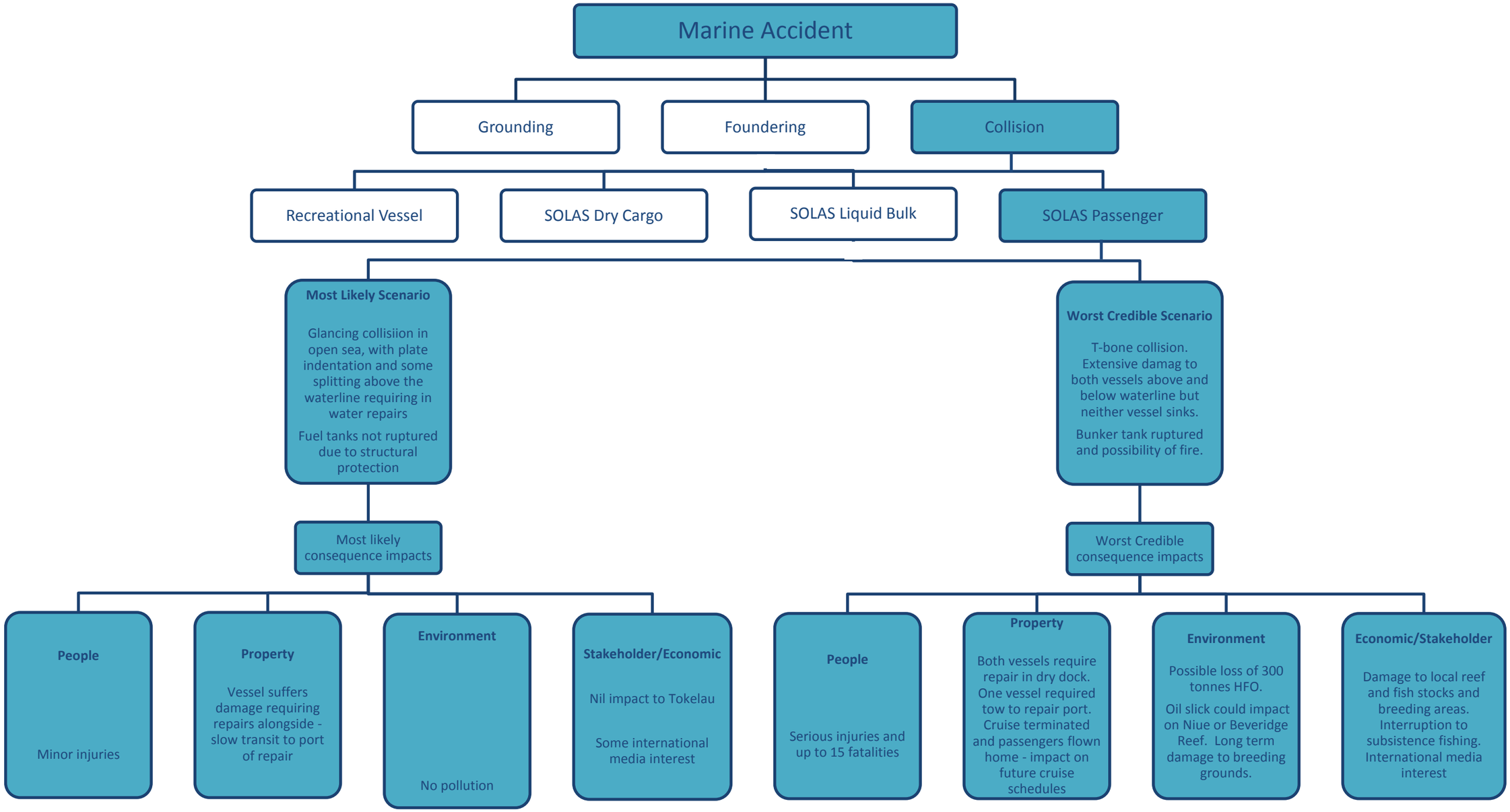
ANNEX A - Event Trees



ANNEX A - Event Trees



ANNEX A - Event Trees



ANNEX B - GIS Track Creation and Processing

1 Track Creation[50]

1.1 Raw AIS data was acquired from ORBCOM for the contiguous 12 month period from January–December 2016, this is the same period used for Samoa. 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

[50] 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 Tokelau.

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[51] 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 Vessel track lines were created using NOAA's Marine Cadastre Track Builder, such that each line connects multiple points for an individual vessel. The raw nature of tracks lead to some anomalies, 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; and
- There were multiple vessels shown as transiting across land or the reef and lagoon areas. 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.

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:

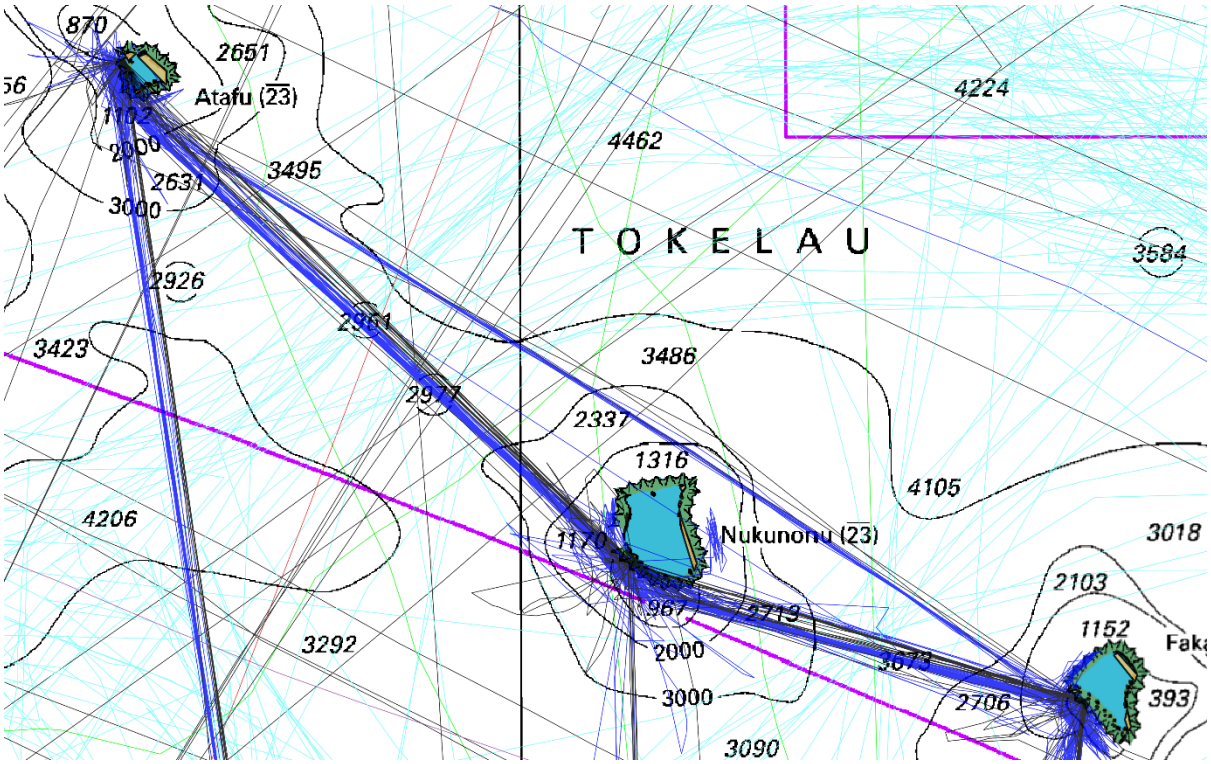
- Extrapolating track lines to the edge of the study area. This processing was based on visual assessment assuming that those vessels near the limits of the study area that have a steady track will maintain that track to the boundary of the EEZ;
- All tracks that crossed land or drying reefs were manually routed around the coast along their likely course based on:

[51] 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

- 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.

- 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).



Annex B: Figure 1 – Tracks plot showing some uncorrected tracks across Nukunonu lagoon

3 Non AIS Domestic Traffic

3.1 In previous risk assessments additional tracks have been added to account for domestic vessels not fitted with AIS. There were no additional tracks added for Tokelau as no information about domestic vessels was available.

ANNEX C – Traffic Risk Calculation

1 Traffic Risk Calculation

1.1 This Annex has not been compiled for this report.

ANNEX D – Likelihood and Consequence Factors

Overview

1.1 This Annex has not been compiled for this report

ANNEX E – Regional Hydrographic Risk Factor Weighting Matrix

	Risk Criteria		Risk Scores 0	1	2	3	4	5	Factor Importance (1st, 2nd or 3rd)	Derived Factor Importance	Importance of Category Contribution to Frequency and Consequence	Factor Weight in Model Category	Weighting Balance of Frequency and Consequence in Model	Derived Variable Weighting used in GIS Model
			Increasing Risk ---------->											
Traffic	Vessel Traffic													
		Potential Loss of Life (Vessel Type + GT Weighed)		Insignificant	Low	Moderate	High	Catastrophic				0.5	0.25	0.125
		Pollution Potential (Vessel Type + GT Weighted)		Insignificant	Low	Moderate	High	Castastrophic				0.5		0.125
Likelihood Risk Criteria	MetOcean Conditions													
		Prevailing Conditions Exposure		Sheltered at most times	Mainly Sheltered	Moderate Exposure	Mainly Exposed	Exposed on most days	3	0.5	0.3	0.15	0.25	0.0375
		Spring Mean Current Speed	Open Sea (Current insignificant)	1-2 knots	2-3 knots	3-4 knots	>5 knots	>5 knots	2	0.333333333		0.1		0.025
		Visibility	Unknown	Poor Visibility Very Unlikely	Poor Visibility Unlikely	Occasional Poor Visibility	Often Poor Visibility	Poor Visibility Common	1	0.166666667		0.05		0.0125
	Navigational Complexity													
		Type of Navigation Required		Open Sea >10nm	Offshore Navigation (5-10nm)	Coastal Navigation (1-5nm)	Port Approaches	Constrained Navigation (Within 1nm)	3	1	0.15	0.15		0.0375
	Aids to Navigation													
		ChartZoc		A	B	C	D	U	3	0.6	0.3	0.18	0.25	0.045
		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	0.4		0.12		0.03
	Bathymetry													
		Depth of Water 15m Contour	>10nm	5-10nm	2.5-5nm	1.5 to 2.5nm	1 to 1.5nm	Within 1nm	3	0.6	0.1	0.06		0.015
		Bottom Type		Soft				Hard/Rocky	2	0.4		0.04		0.01
	Navigational Hazards													
		Proximity to Known Reefs	>10nm	5-10nm	2.5-5nm	1.5 to 2.5nm	1 to 1.5nm	Within 1nm	2	0.222222222	0.15	0.033333333		0.00833333
		Proximity to Sub-Sea Volcanic Activity	>10nm	5-10nm	2.5-5nm	1.5 to 2.5nm	1 to 1.5nm	Within 1nm	2	0.222222222		0.033333333		0.00833333
		Proximity to Known SeaMounts	>10nm	5-10nm	2.5-5nm	1.5 to 2.5nm	1 to 1.5nm	Within 1nm	1	0.111111111		0.016666667		0.00416667
		Proximity to WW2 Military Sites	>2.5nm	2-2.5nm	1.5-2nm	1-1.5nm	500m-1nm	Within 500m	1	0.111111111		0.016666667		0.00416667
		Proximity to Charted Tidal Hazard (Overfalls/Race)	>2.5nm	2-2.5nm	1.5-2nm	1-1.5nm	500m-1nm	Within 500m	3	0.333333333		0.05		0.0125
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	0.157894737	0.5	0.078947368	0.5	0.03947368
		Proximity to Key Offshore Reef (Cooks Reef or Rowe Island)	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	2	0.105263158		0.052631579		0.02631579
		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	0.157894737		0.078947368		0.03947368
		Proximity Small Wetlands Resource (Mangroves) (Large Volume or Small Volume)	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	2	0.105263158		0.052631579		0.02631579
		Proximity to Important Breeding Grounds	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	3	0.157894737		0.078947368		0.03947368
		Proximity to World Biological Protected Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	3	0.157894737		0.078947368		0.03947368
		Proximity to Regional Biological Protected Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	2	0.105263158		0.052631579		0.02631579
		Proximity to Local Biological Protected/Important Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	1	0.052631579		0.026315789		0.01315789
	Culturally Sensitive Areas												0.5	
		Proximity to World Cultural Protected/Important Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	3	0.5	0.15	0.075		0.0375
		Proximity to Regional Cultural Protected/Important Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	2	0.333333333		0.05		0.025
		Proximity to Local Cultural Protected/Important Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	1	0.166666667		0.025		0.0125
	Economically Sensitive Areas													
		Proximity to Sites of High Economic Contribution	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	3	0.285714286	0.35	0.1		0.05
		Proximity to Sites of Moderate Economic Contribution	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	1	0.095238095		0.033333333		0.01666667
		Proximity to Key Infrastructure (Ports)	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	3	0.285714286		0.1		0.05
		Proximity to Tourist Diving Sites	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	1.5	0.142857143		0.05		0.025
		Cruise Ship Stops	>20nm	10-20nm	5-10nm	2.5-5nm	1-2.5nm	Within 1nm	2	0.19047619		0.066666667		0.03333333

ANNEX F – Hydrographic Risk Calculations

Overview

1.1 This Annex has not been compiled for this report.

Annex G – General Benefits of Hydrographic Surveys

General Benefits of Hydrographic Surveys[52]

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. 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 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[53]. 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 Tokelau economy it may support the safe access to the growing cruise tourism market, and for good governance it provides the underpinning data and framework for the effective management of marine resources and environmental monitoring.

4. Commercial shipping relies on current hydrographic survey data. A hydrographic survey undertaken to the latest International Hydrographic Organization (IHO) standards[54] 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.

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

[52] This Annex is a modified reproduction of previous published work (Marico Marine Report No 14NZ262CS Issue 02, January 2015, pp. A1-A3)
[53] Public good – a good or service in the public interest which would not be supplied at optimal levels by market forces alone.
[54] IHO S-44 Standards for Hydrographic Survey

Annex G – General Benefits of Hydrographic Surveys

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. These factors have 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 in areas with poor hydrographic data.

6. Further, the International Convention for the Safety of Life at Sea[55] requires signatory states to facilitate the production of ENCs for ships navigating their coastal waters, including ports. Should a 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.

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.

[55] SOLAS Chapter 5, Regulation 9