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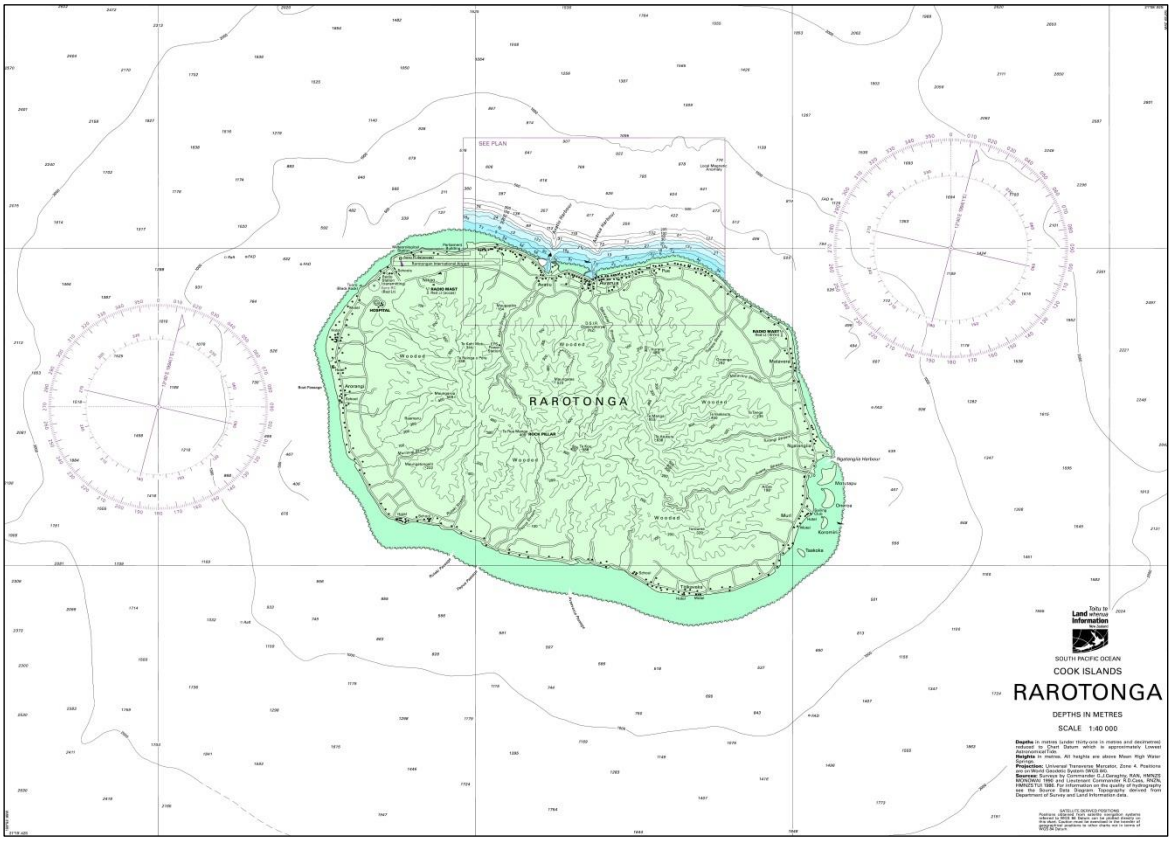
SOUTH WEST PACIFIC REGIONAL HYDROGRAPHY PROGRAMME

COOK ISLANDS RISK ASSESSMENT



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LAND INFORMATION NEW ZEALAND

SOUTH WEST PACIFIC REGIONAL HYDROGRAPHY PROGRAMME

COOK ISLANDS RISK ASSESSMENT

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The views expressed in this publication do not necessarily reflect those of the New Zealand Government.

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PROLOGUE

This report covers the detail of a hydrographic risk assessment of the Cook Islands' waters. It is divided into two documents, a synopsis and the main report (this document).

This main report provides a detailed record of the work performed with explanatory text and detail as appropriate. More importantly, the report gives objective and useful information which will allow the Cook Islands Government to consider which action to take in light of the results.

The study uses spatial data, using a comparative risk technique to define where official nautical charts should be upgraded to modern standards. The risk report contains ten main sections, which are briefly described below.

Section 1 introduces the scope of the hydrographic risk assessment and presents summary methodology. Section 2 gives a brief description of the Cook Islands: the nation's profile and an overview of its economy. Section 3 provides a description of the key items that partially influence the risk results.

Section 4 draws a more detailed picture for each island group, with a focus on its geographical characteristics, port infrastructure and domestic vessel trade, key sites of environmental and cultural significance, tourism, and the local economy. This information was taken into consideration when preparing the GIS risk model.

Based on records supplied by the Avatiu Harbour, Section 5 presents an analysis of shipping showing trends for all types of SOLAS (international trading) vessels for the Avatiu Harbour (Avatiu Harbour), as well as an analysis of domestic coastal vessel shipping. Section 6 presents further marine traffic analysis for SOLAS vessels, using S-AIS data. This analysis provides the base layer of the GIS risk model in order to evaluate the cumulative risk derived from 31 distinct criteria. Section 7 shows detailed risk results obtained from the work performed in section 6. Section 8, the economic analysis, identifies and estimates the economic value, or projected cost, that would be generated through charting upgrades where necessary. This section also takes into account the risk reduction derived from charting improvements. The economic data was supplied by the Cook Islands.

Section 9 presents the conclusions and recommendations for moving forward with the hydrographic survey. This section also lists any economic factors and risks that need to be considered before proceeding with the project. This ensures that the government has all the information at its disposal to make the best possible decision.

Section 10 provides information about the data confidence used to establish the risk model. This risk assessment also contains six Annexes of supporting material of importance to the study contents.

CONTENTS

FIGURES

TABLES

ANNEXES

Annex A	**Event Trees**
Annex B	**Traffic Analysis Plots (All)**
Annex C	**Chart CATZOC Plots for Each Island**
Annex D	**Risk Model Results**
Annex E	**Summary of Benefits of Hydrography Survey Data for the Cook Islands**
Annex F	**Assumptions for Hydrographic Cost Benefit Methodology**

GLOSSARY

Abbreviation or name	Explanation
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).
S-AIS	Satellite (received) Automatic Identification System
ALARP	As Low as Reasonably Practicable
AToN	Aid to Navigation. A shore based light or mark that may be lit, 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. It is an important differentiation.
CATZOC	Category of Zone of Confidence CATZOC is a system used by many (but not all) hydrographic authorities to advise mariners of the confidence a hydrographic authority has in chart quality, as well as the standard of survey that different areas of the same chart are based on. Hydrographic data is 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). It is attached to the electronic chart metadata as an attribute of the M_QUAL object.
CBA	Cost Benefit Analysis

Abbreviation or name	Explanation
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.
ECDIS	Electronic Chart Display Information System (Mandatory Carriage on some SOLAS vessels)
EEZ	Exclusive Economic Zone
ENC	Electronic Navigational Chart
Event	Unwanted or unplanned occurrence with consequential harm (i.e. accidents).
Frequency	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.
Ha	Hectare
HW	High Water
IMO	International Maritime Organisation
Kt	Knot (unit of speed equal to nautical mile per hour, approximately 1.85km/hr or 1.15 mph)
Km	Kilometres
LINZ	Land Information New Zealand
LW	Low Water
M	Metre
NPV	Net Present Value
NM	International Nautical Mile
VHF	Very High Frequency (radio communication)
WC	Worst Credible

Abbreviation or name	Explanation
ML	Most Likely
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.
Forms of Risk Assessment	**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). **Comparative Risk Assessment (CRA):** 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 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.
Hydrographic Risk	This form of risk assessment has recently been developed. Hydrographic risk, by its nature, must rely 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 are combined in a GIS using Risk Terrain Modelling (RTM) to output a spatial result.
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.
Risk management	Decision making on the implementation of measures stemming from risk assessment, then monitoring the efficacy of the controls.
SPREP	Secretariat of the Pacific Regional Environment Programme. This is an intergovernmental organisation co-ordinating environmental projects across the whole Pacific region.

1 INTRODUCTION

The SW Pacific Islands have experienced increases in commercial vessel traffic operating through their waters. Much of this growth is related to the numbers of large cruise ships operating in the SW Pacific. This trend of growth is projected to continue. This is coupled by a slow but steady growth in coastal trade within the various SW Pacific nations; small vessels in international terms, but these are domestic vessels that can be licenced to carry a significant number of passengers.

A disparity now exists between the size of SOLAS vessels, the growing volume of domestic coastal traffic and the quality of nautical charting used for navigation. Many of the charts date to the 1800s, some to the mid-1900s, and are in need of updating to modern standards.

This study uses a top-down approach to risk assessment to prioritise areas for chart improvement surveys in the Cook Islands waters, based on a combination of vessel transit risk and economic growth. The risk-based result is designed to aid decision-making by the Cook Islands Government, with the assistance of the hydrographic professionals with regard to updating nautical charts.

It is important to understand there are two different types of risk that need to be considered when reading this report, Inherent Risk and Hydrographic Risk.

Inherent risk is easy to understand, in that a harbour may present a difficult entrance (e.g. narrow, shallow, cross currents and poor aids to navigation). This provides an inherent heightened risk for a vessel wishing to transit the entrance. Hydrographic risk, on the other hand measures traffic by volume, type and size, as well as a range of other factors assessing consequence impacts.

Thus the inherent risk of a single transit into a harbour can be high for a vessel individually, but a hydrographic risk result may be lower, simply because the numbers of transits per annum are low and/or the vessels involved are small.

1.1 AIMS AND OBJECTIVES

The aims of this document are to describe:

- An application of a robust and previously developed, risk based methodology for the prioritisation of hydrographic surveys in the Cook Islands waters;
- To investigate the comparative risk of a shipping incident in the Cook Islands; and
- To produce GIS derived output plots clearly showing the spatial distribution of shipping risk that enables the Government of the Cook Islands to identify priority areas for chart improvement surveys.

1.2 SUMMARY METHODOLOGY

The method deployed uses risk assessment in a comparative way, to identify areas of the Cook Islands that are more susceptible to an incident involving either a large SOLAS vessel or a smaller domestic coastal trader. This is in terms of the range of most likely and worst credible potential for loss of life, damage to the environment, damage to economic development and impact to areas that are culturally important to the Cook Islands people.

The types of accident that can occur to vessels are related to the type of vessel transiting the Cook Islands 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), together with port pilotage records, obtained during a data gathering visit to the Cook Islands. Further information was obtained from cruise vessel operators and agents about cruise-calls, including future aspirations throughout the Cook Islands archipelago. Details of the fleet of coastal domestic vessels were obtained and rough schedules. Ship traffic was analysed in a Geographic Information System (GIS) and domestic shipping routes and associated volume added to this. Event Trees were used to derive the realistic types of grounding or foundering incident that could occur, and their outcomes related to the vessel types and the size of those vessels. The event trees were translated into consequence criteria for a risk matrix to be used in the GIS analysis. Event Trees are attached at Annex A and Annex B present the results of traffic analysis plots from both AIS transmissions and data gathering (for domestic vessels).

With both analysis of vessel traffic volume and information known about the more vulnerable locations of the Cook Islands, the traffic analysis was linked to location, and thus the risk criteria being used in a matrix form for any layer of information in the GIS.

The use of a GIS technology allowed a large number of factors (all of which were geospatial in nature) to each be considered in terms of their risk contribution and linked to the most dense

traffic areas, taken from the traffic analysis. The resulting risk levels, comparative in nature, could be displayed in the GIS as a coloured overlay “heatmap". This made the end result visual and easy to interpret. A detailed description of the GIS Analysis and Hydrographic risk assessment methodologies has been published by LINZ[1].

Use of a GIS was vital to accommodate the multitude of datasets, undertake the analysis and present the results. This approach was used after determining the large amount of environmental research undertaken in relation to climate change, and datasets obtained, (e.g. corals or mangrove datasets) could be verified for the Cook Islands by using the information obtained during in-country data gathering visits.

The method used is advantageous as it is data driven (i.e. reducing opinion-based input), using expert judgement only where necessary (e.g. event tree outcomes and risk criteria), and identification of the relevant risk factors.

In summary, vessel traffic analysis was undertaken on satellite derived AIS data for a six month period of 2013, including December and January 2014 (summer) to build a model of shipping movements through the Cook Islands Waters. A number of factors related to maritime risk were then identified and scored on a five point scale (i.e. Risk Matrix) across the study area. Each risk factor was then weighted in terms of its relative importance to the final model and combined with the traffic analysis to produce a final cumulative plot of hydrographic maritime risk in the Cook Islands, which took account of the accuracy of the current charting quality. Against this a cost effective hydrographic and charting upgrade programme could be developed for The Cook Islands, solidly based on risk and data analysis.

The risk results are presented in Section 7, with geographic risk plots presented at **Annex D**. Risk Criteria used throughout the main analysis is common with similar work undertaken in Tonga and Vanuatu.

A Cost Benefit Analysis of the risk result was then added, Section 8, taking account of the risk in each cell and using other referenced work to establish the risk reduction available from chart improvements. Other costs, such as pollution clean-up, economic impact out of accidents, Cook Islands GDP, etc., were also used to determine a Net Present Value of charting

[1] http://www.linz.govt.nz/hydro/projects-programmes/improving-maritime-safety-in-the-pacific (Marico Report Number 12NZ246)

improvements (+Ve or –Ve) throughout the EEZ study area. This is presented at section 8 and **Annex F** presents the criteria used in the CBA model.

2 COOK ISLANDS – INFORMATION AND ECONOMIC OVERVIEW

2.1 COOK ISLANDS – INFORMATION OVERVIEW

The Cook Islands is a nation archipelago located in the South Pacific Ocean between French Polynesia and Samoa. The country comprises 15 small islands with a total land area of 240 square kilometres and a combined coastline length of 120km (see Figure 1). The islands are widely spread between latitudes 8° 50'S and 21° 58'S and longitudes 157° 17'W and 165° 58'W. The Northern Cook Islands are mainly low coral atolls, while the southern group are predominantly volcanic in origin, with more elevation. Beyond their fringing reefs, all islands are surrounded by deep water. The country's Exclusive Economic Zone covers almost 2 million square kilometres. Population of the Cook Islands in 2011 was 17,794. In the same year, 13,095 residents lived on the main island of Rarotonga, which is the location of the capital, Avarua (Cook Islands Statistics Office, 2013).

The Cook Islands is an independent parliamentary democracy in free association with New Zealand. The Queen is head of state. Parliament serves for a four year term with ten MPs representing the main island of Rarotonga, and another 14 elected by each of the outer islands. The cabinet comprises six Ministers. In addition to Parliament, the House of Ariki is a separate assembly of hereditary chiefs, elected annually to represent particular islands or districts. This group deals with issues referred to it by Parliament, mainly related to land use and traditional customs. Local government functions are carried out by island councils, district councils and village committees. Individual islands are described in detail in Section 4.

The Cook Islands archipelago consists of 15 small islands in a vast area of ocean. Most of the islands have a small number of inhabitants. Sea transport will always be important here.

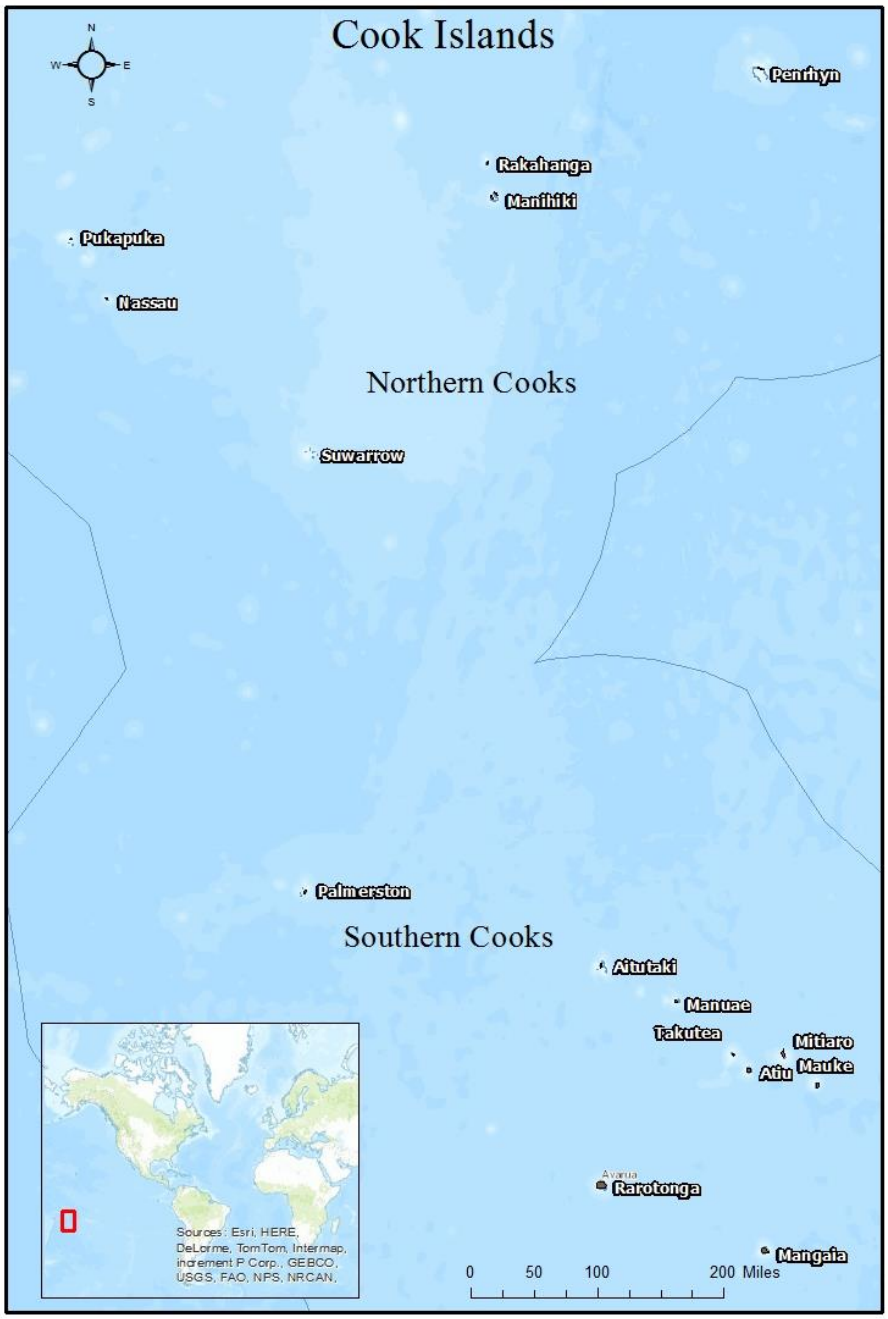


Figure 1: Map of Cook Islands

2.1.1 INTER-ISLAND SHIPPING

While most inter-island passenger travel is now conducted by air, the majority of freight still has to be delivered by sea. The combined challenges of large distances between many of the islands, small freight volumes, limited harbour facilities and a significant cyclone risk mean

that inter island shipping is an expensive and hazardous undertaking, conducted mainly by small vessels. A number of shipping accidents involving local traders have occurred in the past.

2.1.2 INTERNATIONAL SEAFREIGHT

Almost all of the Cook Islands' international seafreight passes through the port of Avatiu in Rarotonga. Regular freight callers include container/multipurpose vessels, LPG tankers and product tankers. Avatiu is the only port in the country which can handle these vessels safely at alongside berths.

2.1.3 CRUISE VESSELS AND CRUISE TOURISM

As an adjunct to the Cook Islands' popular inbound air tourism operations, cruise ships have been calling at Rarotonga for many years. Given the general increase in interest for new cruise destinations, it seems likely that demand for port visits will grow in the future. The trend towards larger cruise vessels will inevitably continue. Occasional calls have been made at other islands of the Cooks Group such as Aitutaki, Palmerston, Mauke and Atiu in the past.

2.1.3.1 Potential for Cruise Development

There appears to be considerable scope for development of the cruise industry in the Cook Islands. There are a number of islands in the Southern Cooks that have harbour developments which remain uncharted, which could be utilised for the landing of passengers from cruise vessels. There appears to be too many cruise vessels aborting calls to Rarotonga, yet there are always other islands in the Cooks Group that have sheltered landings when sea conditions off Rarotonga are unsafe to disembark passengers. The Northern Cooks have natural attractions to the discerning cruise traveller, and expedition cruise operations pass these by every year. More frequent outer island visits should be possible in the future if infrastructure and safety issues are addressed. As the majority of modern cruise vessels are too large to enter any of the Cook Islands' harbours, they will continue to lie to seaward of the landing places while passengers are ferried ashore by tender. Fundamental to such development are the development of accurate and adequate charting, of a scale that allows local harbour layouts to be understood by cruise planners.

2.1.4 Other Sea Traffic

Foreign fishing vessels are active in the northern part of the Cook Islands EEZ and significant numbers of large international vessels use their right of innocent passage to transit through the area in the course of a year. The Cook Islands are also a destination for cruising yachts which call at several of the islands, notably Penrhyn, Palmerston, Suwarrow and Rarotonga.

2.1.5 Marine Charts

A key requirement for safe sea transport is the availability of accurate and adequate up to date marine charts and related information. These should be considered as basic infrastructure to island nations, in the same way that roads are considered by countries with larger land masses. SOLAS vessels such as cruise ships visiting the Cook Islands navigate using ECDIS and need to navigate close to unfamiliar shorelines. They need assurance that coastlines, anchorages, shallows, channels and harbours are as they appear on the charts. Cruise ships in particular are likely to be the largest ships ever to have called at some of the Cook Islands. This means a higher standard of charting accuracy is required to ensure charted features are positionally accurate on the WGS84 datum and no shallows or other hazards remain undiscovered.

As is the case in some other Southwest Pacific states, marine charts of the Cook Islands tend to be based on a local or regional datum, obtained using outdated position fixing and hydrographic technologies.

2.1.6 Electronic Charts (ENCs)

ECDIS is progressively becoming mandatory on SOLAS vessels. As paper charts are phased out, it is important that the ENCs which replace them are developed with accurate, verified data. The current ENCs are significantly out of position on the WGS84 datum, when compared to modern satellite imagery. For example, Pukapuka in the Northern Cooks is greater than 200m in error; Suwarrow and Nassau are 300m in error and parts of Aitutaki are some 400m in error.

2.2 IHO TECHNICAL VISIT

The Cook Islands has received assistance from the International Hydrographic Organisation's (IHO) capacity building strategy in 2011. This programme is designed to support developing nations in their need to build hydrographic capacity, aligned with the agreed development goals of the United Nations Agencies. A technical visit to the Cook Islands has been funded and the visit report provides a technical assessment of the charting development needs of the country and recommended the governmental institutions needed to support a Cook Islands hydrographic committee to develop and maintain maritime charting.

2.3 COOK ISLANDS ECONOMIC OVERVIEW

Drivers of GDP	
Capital	Avarua, Rarotonga
Population	17,794 (Last Census)
Land Area	240 km²
Exclusive Economic Zone	1,830,000 km²
Key employment industry	Tourism
Key GDP industry	Tourism
Major Ports	Avatiu Harbour, Rarotonga
Climate	Tropical Maritime, SE trade winds dominate with a regular cyclone season

Table 1: Key Drivers Creating Cook Islands GDP

Cook Islands is characterised by a small land area and an extensive Exclusive Economic Zone (EEZ). Tourism dominates the economy. In 2011 Real GDP was $276m and GDP per capita was $13,410 *(Cook Islands Statistics Office, 2013).*

The country is reported to have one of the more vigorous economies in the South Pacific. Tourism is by far the major contributor to the economy, but significant revenues are also generated through exports of fish and cultured pearls.

In 2011 the unemployment rate was recorded as 8.2% of the population. Subsistence and unpaid workers (a relatively small proportion of the total workforce) were not classified as unemployed in the statistics.

2.3.1 TOURISM

Cook Islands tourism continues to grow. This growth is almost exclusively related to visitors arriving by air, but potential exists to increase visits by cruise ships also. There is concern that Rarotonga in particular is approaching the limit of its capacity to accommodate tourists. Growth potential exists in the outer islands, but increased travel costs and limited amenities on some islands have limited growth in this area to date.

122,000 visitors travelled by air to Cook Islands in 2012, as well as an additional 4,500 who visited by cruise ship. Cruise numbers were reduced due to a relatively high number of cancelled calls as a result of strong winds/heavy seas at the passenger disembarkation point offshore form Avatiu Port. An overwhelming majority of visitors are from Australia and New Zealand.

2.3.2 FISHING

Fishing in the northern part of the Cook Islands EEZ has significant scope for expansion, both through licensing of foreign vessels and the development of a local deep sea fishing industry.

2.3.3 AGRICULTURE

Agricultural output is mainly consumed locally. Out of a total land area of 240 km², 25% is, or has been used for agriculture *(SOPAC, 2007).* Much of the land of the Cook Islands is either atoll sands or makatea (uplifted coral), with limited agricultural potential. Anecdotal evidence gathered on site visits indicates that viable agricultural land on some outer islands is untended due to a lack of labour and irregular freight connections to Rarotonga for export products.

2.3.4 MINERALS

The mining of seabed minerals offers the possibility for significant wealth generation in the future for Cook Islands. While work is still to be done on deep water mining methods, the seabed within the Cook Islands EEZ is reported to hold many millions of tonnes of mineral

nodules. These are rare-earth metals, including manganese nodules, Cobalt, Nickel, titanium, copper and molybdenum. They accumulate below 5000 metres of sea depth. The Cook Islands best quality mineral reserves lie to the North of Aitutaki and are presently undeveloped.

Seabed reserves are very significant, but difficult to extract. Techniques for mining at such depth have not been developed, but proposals are expected by 2020. The offshore development potential is similarly significant, especially for the adjacent Island of Aitutaki, where the port facilities could be used for the support services to a continuous mining operation offshore.

2.3.5 FINANCIAL SERVICES

Financial services provide the second largest element of the Cook Islands economic growth strategy (Cook Islands Government, 2013). Although part of the NZ realm, in free association with New Zealand, the Cook Islands banking system is independent and the country is *"well-known and respected in the US as an offshore financial centre" (NZ Lawyer, 2013)*. Significant financial services relate to international trusts, foundations and captive insurance. The country also operates a ship registry, which is presently small, but attempting to grow.

2.4 NATURAL HAZARDS AFFECTING THE COOK ISLANDS

The Cook Island Group comprises a number of low lying atolls, especially those in the northern group. It makes them vulnerable to natural events. A short section on this is included in this hydrographic risk assessment, because of their influence on the seabed profile close to an island, or through inundation of a lagoon.

2.4.1 VOLCANO/EARTHQUAKE/TSUNAMI

The Cook Islands are located in a relatively benign area of the SW Pacific with respect to seismic activity (see Figure 2). While no major seismic events have affected the archipelago recently, their relative proximity to an active tectonic plate boundary means that strong earthquakes are a possibility and a tsunami risk is present (but with warning). From a hydrographic perspective, this does mean that rapid changes of the sea floor within the Cooks

group are less likely than in other SW Pacific island groups. However a number of low lying Atolls in the northern waters are vulnerable.

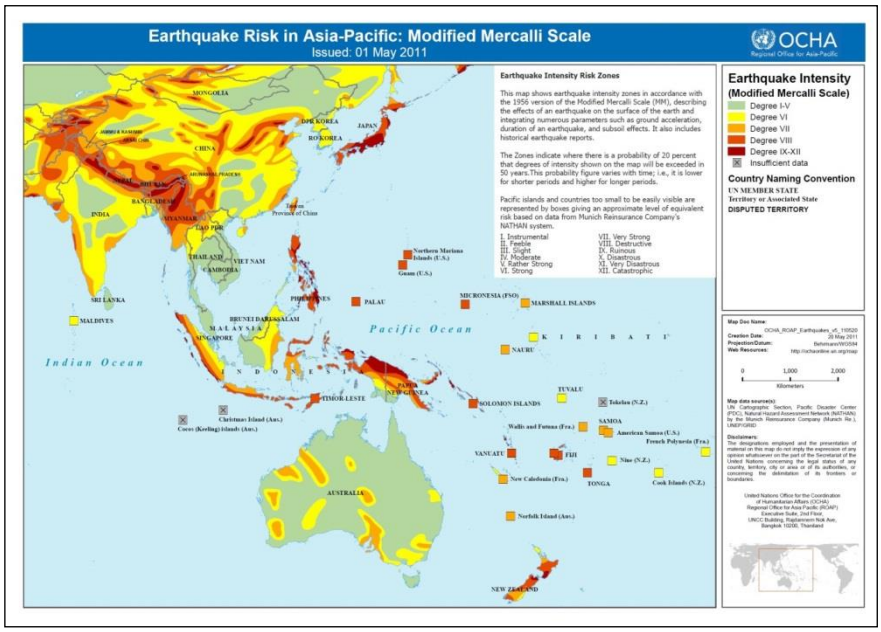


Figure 2: Cook Islands Earthquake Risk (OCHA, 2011)

2.4.2 CYCLONES

Cyclones occur regularly in the Cook Islands. It is raised in this hydrographic risk assessment as residents of the low lying northern atolls are particularly at risk. Coastal areas of Rarotonga have been inundated in past storms, including the port facilities. Throughout the Cooks group, the frequency of cyclones during the period 1970 to 2011 was 1.8 per season *(de Scally, 2008)*. The southern islands are most frequently affected. The international Aid system has already constructed emergency cyclone shelters on most of the Cook Islands.

Because of limited places of refuge, port facilities and the vessels in or attempting local shelter frequently suffer cyclone damage.

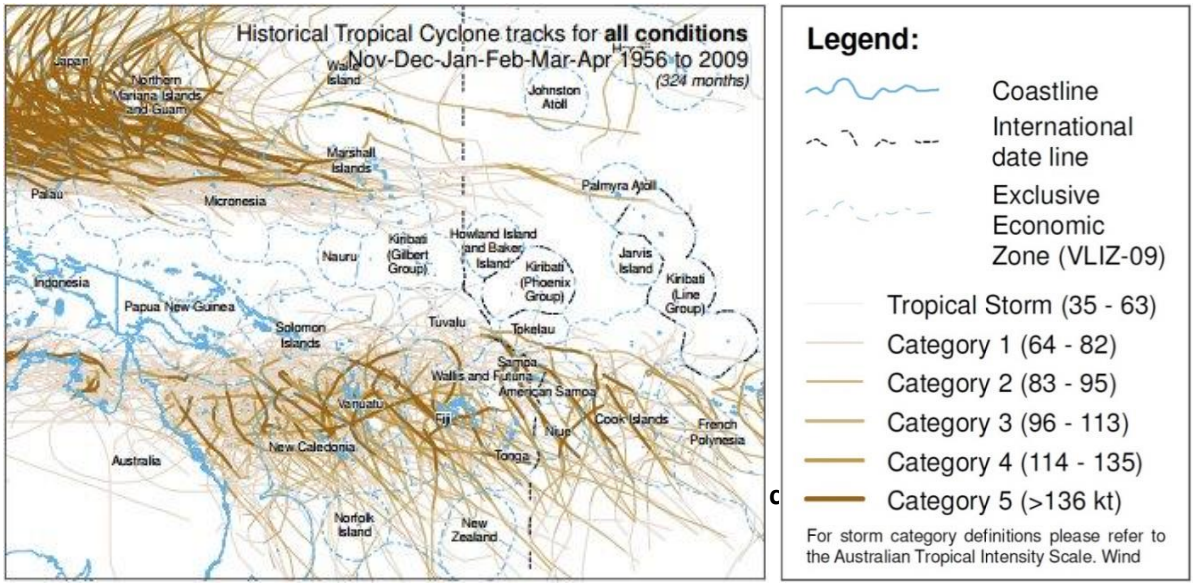


Figure 3: Cook Islands – Frequency of Cyclones (OCHA, 2009)

Cyclone Occurrences for the Country as a Whole and by Group

Area	1820–2006 Total Cyclones	1820–2006 Average Cyclones per Season	1820–2006 R.I.[a]	1970–2006 Total Cyclones	1970–2006 Average Cyclones per Season	1970–2006 R.I.[a]
Cook Islands	143	0.8	1.3	65	1.8	0.6
Southern Group[b]	119	0.6	1.6	58	1.6	0.6
Northern Group[b]	42	0.2	4.4	25	0.7	1.4
Group unknown	6	—	—	0	—	—
Palmerston	53	0.3	3.5	25	0.7	1.4

[a] Recurrence interval (yr).
[b] Each group's tally includes cyclones that affected both groups.

The cyclone season from November to April also coincides with most South Pacific cruise ship activity (Northern Hemisphere winter – see Figure 3). While these storms naturally present a risk for the cruise industry, good regional information on storm development/tracking and a high level of skill within the cruise industry, both on board and ashore, is critical in dealing with any developing threats. Due to the exposed location of Avatiu Harbour in Rarotonga, a significant number of cruise vessel calls are aborted due to heavy swells.

2.4.3 CLIMATE CHANGE

Climate change is an important, long term natural hazard for Pacific Island nations in general. Some of the Cook Islands, especially the Northern Cooks may be severely affected in time. Rising sea level (up to half a metre predicted by 2055) is not the only outcome. Rising air and

seawater temperatures (almost 2^{o}C by 2055 predicted)*(SPC, 2012)*, increasing acidification of seawater and increasing rainfall are also expected (SPC,2012).

3 KEY ITEMS OF RELEVANCE TO THE RISK ASSESSMENT

3.1 COOK ISLANDS PORT AND HARBOUR FACILITIES

The capacity of Cook Islands ports is limited by trade volumes and geographical factors. The main port of Avatiu in Rarotonga is the biggest in the country. It has two berths, a maximum depth in the channel of 8 metres and has handled ships of 130m length. The port is exposed to heavy weather from the north.

The atolls of Suwarrow and Penrhyn have access channels into their lagoons and anchorages which can accommodate yachts and other small vessels. Most of the other inhabited islands have landing places and/or small harbours which allow for the transfer of freight and passengers by small boat while the mother vessel remains drifting or anchored offshore.

However, many of these harbour facilities are not charted, yet the breakwater facilities are substantial and designed to reduce surge (which they do effectively). These harbour enclosures would provide safe access for cruise vessel tenders to land passengers. Examples of Islands with good harbour enclosures that remain uncharted are Mauke and Mitiaro.

3.2 COOK ISLANDS CHARTED POSITIONS

Many of the islands of the Cooks Group have positional information on charts that is no longer correct when displayed on nautical charts to the WGS84 datum. This is quite a serious safely issue for vessels wishing to approach such coastlines. For example, the position of Pukapuka is some 200 metres in error and that of Suwarrow is some 300m in error. The Arutanga Passage, Aitutaki, is charted some 400m in error.

Notwithstanding the outcome of the hydrographic risk assessment, these are important areas to correct in charts. There are often no illuminated aids to navigation along island coastlines and a vessel arriving during hours of darkness (or stationary offshore awaiting sea conditions to improve) has to rely on radar to maintain position. This is against best practice where vessels a recommended to navigate using more than one means of positional fixing. Without positional correction a vessel (or yacht) using GPS during hours of darkness as a means of positional fix would be faced with a confusing contradiction of information between radar and GPS.

3.3 WEATHER CONDITIONS

No port in the country provides effective protection for large vessels from cyclones or other severe weather events. The Pacific Islands Pilot[2] for the Cooks advises that "…there are no ports or anchorages which are sheltered."

In addition to the landing places mentioned under "Port Facilities" above, most islands have alternative landings on their lee sides. Depending on sea conditions, these landings may allow for limited transfer of freight and/or passengers when the main landings/boat harbours are untenable due to heavy swell.

On the approach of cyclones, anecdotal evidence indicates that large vessels are obliged to leave port, proceed to sea and avoid the heavy weather on the open ocean.

3.4 ECONOMICS OF INTER-ISLAND TRADING

Investigations suggest that small cargo volumes, declining return (export) cargoes, limited port facilities and large distances between islands combine to render inter-island shipping marginal or possibly uneconomic. A factor in this is vessel losses. Cargo volumes are also unreliable, partly because the sailing schedules are similarly unreliable. This appears to result in the use of small, old and unsuitable vessels for the inter-island trade. Working cargo in an open roadstead in heavy swells in close proximity to coral reefs is a high risk activity which has seen numerous accidents, casualties and loss of cargo.

3.5 ANNUAL INDEPENDENCE CELEBRATIONS

The Cook Islanders have an annual celebration and games, when representatives from all islands of the Cooks Group attend The Cooks Islands' national Independence celebrations, Te Maeva Nui, are considered one of the most important events in the Cook Islands.

Every year, dancers and performers from the islands gather at the National Auditorium in Rarotonga to present dances, songs, drum beats and costumes expressing the cultural theme chosen for that particular year.

[2] Admiralty Sailing Directions NP 62

This is organised by the Government, including free transit from an island home to Rarotonga. A vessel (normally a ferry/small cruise vessel operating in Tahiti) is chartered to bring nominated residents from each island to the celebrations.

3.6 CRUISE TOURISM PATTERNS

From 2003 through to early 2009, Princess Cruises' "TAHITIAN EXPRESS" called at Rarotonga throughout the year on a fairly regular cycle of around 10 days. Since the cessation of this service, a significant decline in cruise visits is recorded. Recent calls have been more in line with the northern hemisphere winter, occurring between November & April. This period also happens to be the cyclone season.

There are other regular cruise callers, the vessel PAUL GARGUIN calls about fortnightly in the season, cursing between Tahiti and the Cooks. Two sailing vessels, WIND SPIRIT and PICTON CASTLE also provide a cruise and, in part, cargo service.

Also of note is the relatively high number of cancelled cruise vessel calls (28% of scheduled calls were cancelled between 2002 and 2012). In these cases, ships' masters decided that sea conditions offshore were too dangerous for the safe disembarkation of passengers.

3.7 SEABED MINING

Mining of the seabed for minerals has the potential to become an important source of income for the Cook Islands. While the implementation of mining operations may still be some time away, the implications of increased shipping activity in the Cook Islands EEZ connected with seabed mining should be considered in this study. Mining vessels are likely to remain well offshore and will require support craft similar to those employed in the offshore oil industry. Cook Islands imports are likely to increase and port facilities will be required to transfer imported food and equipment to the support vessels.

3.8 FISHING

A number of foreign fishing vessels are licensed to fish in the Cook Islands EEZ. Currently these vessels are reported to use Pago Pago in American Samoa as a base for unloading fish and refuelling. From 2003 to 2013, foreign fishing vessels have averaged 8 calls per year in

Rarotonga. From 2006 to 2010 there were very few calls, but an increase to around 14 vessels per year was noted from 2011 onwards.

The local commercial fishing fleet in Rarotonga has dwindled from 37 vessels in 2003 to 3 vessels in 2013. This is reported to be a result of reduced catches.

3.9 COASTAL WRECKS

There are a small number of wrecks in the Cook Islands, most of which appear to be removed or reduced by the action of the sae. Some wrecks on the Rarotonga coastline provide benefit as diving reefs and fish habitat. The most recent wrecks are the remains of domestic inter-island traders.

3.10 TOURISM CAPACITY

The Cook Islands Government noted in 2012 that Rarotonga had limited capacity for further tourism without significant private investment. In particular, average utilised capacity of tourism accommodation on the island is expected to exceed 80 percent by 2014/2015. While this has few implications for the maritime sector, development of tourism facilities in other islands may influence an increase in seafreight volume from Rarotonga. The benefit is considered only marginal.

3.11 MARINE CHARTS

Only one small part of the Cook Islands coastline (Avatiu Harbour, 2012) has been surveyed to modern standards. The remainder was surveyed between 20 and 110 years ago. Notably, the anchorage at Manihiki Island was surveyed by HMS PLYADES in 1899 and the plan of Palmerston Island shows no survey information, merely a notation in the plan title: “Sources: Random track soundings”.

Many of the islands as currently charted are significantly out of position (by hundreds of metres), when compared to modern satellite imagery. Many small island harbour developments remain uncharted, which means that potential cruise operations do not know that there are harbour enclosures that could provide safe landing for their passengers.

Few persons interviewed during site visits had seen or knew of the nautical charts, which appeared not to be readily available for sale in the Cook Islands. Anecdotal evidence during

site visits highlighted numerous local anomalies with respect to charted information. For example, locals at Manihiki Island said that the anchorage surveyed by HMS Plyades in 1899 is never used.

3.12 CONCLUSIONS AND RECOMMENDATIONS – KEY ITEMS OF RELEVANCE

3.12.1 PORT FACILITIES

There are few places offering good sheltered harbour waters in the Cook Islands for large vessels. Avatiu Harbour, on main Island of Rarotonga has an upgraded wharf and superb facilities. It is let down by very tight (but necessary) restrictions on its entrance channel and its wharf is aligned with the final approach path of aircraft landing at Rarotonga international airport. With surge and swell problems affecting most Islands offshore, practical study and development of solutions to the port and shipping needs of the Cook Islands is likely to provide long term sustainable economic benefit.

3.12.2 ECONOMICS OF INTER-ISLAND TRADING

There are considerable distances between Islands of the Cooks Group which provide challenge for domestic trading links. As such, this is no different to the island communities of Greece, the isles of Scotland, the Philippines or Indonesia. Island nations need to trade with the main centre of population for domestic prosperity, especially in Island Groups where port infrastructure suitable for exporting is limited. A solution to domestic shipping has worked in Tonga, but it is a problem yet to be solved for the Cook Islands. To be fair, the distances involved make a solution difficult, but without reliable and regular shipping services, economic prosperity is difficult to deliver. This may well be a factor in Island population decline, which was the scenario faced by the Scottish Hebrides, Shetlands and Orkney Islands, before the facilitated shipping solution was delivered. Work is needed to understand and improve the Cook Islands' domestic trade; accuracy and adequate charting is of importance to this.

3.12.3 CRUISE TOURISM PATTERNS

The (relatively) high number of cancelled Cruise ship visits to Rarotonga, due to surge/swell off Avatiu Port, represents an important loss to the Cook Island's economy. An alternative

landing site has been developed at Arorangi on the west side of the island. As a result, cruise vessel masters are cautious to use it. However they are also cautious to embark passengers into their own tenders offshore in anything other than conditions of one metre significant swell and below.

3.12.4 MARINE CHARTS

Like other Islands countries, the availability of updated nautical charts for the Cook Islands is unclear. This is especially true of the remote islands. There is a need for clarity and availability of charting services in the distribution chain. In addition, islands are inaccurately charted (some many hundreds of metres out of their true position on the WGS84 datum). Some islands have substantial harbour structures that remain uncharted, that could be used by boutique cruise shipping operations to land passengers.

4 COOK ISLANDS OVERVIEW

4.1 INTRODUCTION

The 15 main islands which make up the Cook Islands are divided naturally into two groups, the Northern Group and the Southern Group. The Northern Group comprises six main islands, all of which have a common problem of distance to the main Island of Rarotonga, where both the seat of Government and the economic centre of the Cook Islands are located. With the exception of Penrhyn, all the Northern Group lie on the Manihiki Rise, a continental shelf the extents of which are under consideration for a Cook Islands international Extended Continental Shelf (ECS) territorial claim. All are relatively low lying coral atolls, vulnerable to sea rise. They have enclosed lagoons, except for Nassau, which is a sandy cay deposit on top of underlying Coral reef foundation. All of the Cook Islands have fringing coral reefs of varying widths.

The southern group lies in deeper water and has nine main islands, most are of volcanic origin and in most cases lie well above sea level, compared with those of the Northern Group. However, Manuae and Palmerston are coral atolls, sitting atop large seamounts, Manuae being raised further by volcanic activity.

The whole of the Southern Cooks Group (50% of the EEZ) was formalised into the world's largest marine reserve in 2013[3]. A marine reserve over such a large area has an influence on the hydrographic risk assessment.

The Islands visited during data gathering are referenced more comprehensively than those not visited.

4.2 NORTHERN COOK ISLANDS

4.2.1 PENRHYN

Penrhyn is the most northerly island of the Cook Island Group and is recognised internationally as a pristine and abundant island of high significance to environmentalists. It is

[3] Cook Islands Marine Park formal website - http://www.maraemoana.gov.ck/

also sometimes referred to in parallel by its old Polynesian name, Tongareva. It sits atop the highest submarine volcano in the Cook Islands EEZs, recorded at 4876 m above the ocean floor. It is composed of a ring of coral with an exceptionally large lagoon, some 15km across and of area about 233 kilometres^2. This compares with the land area of about 9.8 kilometres^2. Penrhyn at its highest point is little more than 5 metres above sea level and like many atolls is vulnerable to sea surges from passing cyclones and in the long term, faces the hazards of sea level rise.

Penrhyn is an official port of entry for the Cook Islands and a popular yachting destination, especially for those wishing to visit the other islands of the Northern Cooks. The Island Secretary is the customs and immigration officer.

The Population according to the 2001 census was 351 with a decrease to 219 inhabitants recorded in 2011[4]. During a 2013 data gathering visit, Islanders advised 184 people lived in the main village of Omoka, with a further 45 living at Te Tautua, a village lying almost on the opposite side of the lagoon (229 total). It appears the population loss recorded at 2011 had stabilised by 2013. Figure 5 shows a useful view of the whole of Penrhyn atoll from the air.

Penrhyn is charted in error by some 150m, when compared with satellite imagery on the WGS84 datum.

[4] Cook Islands 2011 Census of Population.

Figure 5 : The Approach to Penrhyn Viewed From Above the Takuua Passage

The coral ring provides for a number of Motu[5] around the lagoon. The lagoon is connected to sea by one relatively deep "harbour entrance" and two others. These are the Taruia Pass on the west, the Takuua Pass on the northeast and Siki Rangi pass on the northwest, which is too shallow for even yachts to transit. Figure 6 shows the location of Taruia Passage which is used by all commercial vessels and leads directly to the principal village of Omoka, shown in the foreground. Vessels of any size are supposed to take a marine pilot and there is a local appointed for this. However it is not mandatory and the Penrhyn Islanders report that the few vessels that access the lagoon do not use the service. Larger vessels (container) occasionally visit (rarely), but discharge offshore onto a community barge, provided by the Cook Island Government through NZ aid funding.

[5] A motu is a small island in the Pacific . The nautical charts for the Cook Islands usually reference small islets or islands located on circumference of a lagoon or an atoll.

Figure 6 : Taruia Passage, Penrhyn with the Relatively Close Village of Omoka Shown

Taruia Pass is reported to have about 7m depth, which is on the south side of the pass. The northern side has coral growth. There is always a current reported in this pass and "standing waves" are common with the flow. An estimate of one knot at almost slack water and three knots mid tide was provided. A requirement for pilotage appeared prudent. The KWAI has grounded inside the lagoon after negotiating the lagoon entrance.

Many yachts access the lagoon via Takuua Pass, which is reported to have a water depth of 6metres, but presents a single (uncharted) coral pinnacle almost to the surface of the water in the middle of the pass; this is located at the lagoon end. It was reported to be at 08.56.546 S and 157.55.857W. This is marked by a white pole; these are also used to mark a reef on the west side of the pass.

There is a (once-clear) channel through the lagoon to the wharfs at Omoka, which is marked on the chart. Coral grows rapidly in the Lagoon and the local pilot advised many areas of the channel were affected by growth of coral heads.

4.2.1.1 Location and Transport

Penrhyn is approximately 5 days sea transit (737 nautical miles) from Rarotonga and travel by sea is the primary transit method used by Cook Islanders. It is also accessible by a domestic airline, but mostly on a charter basis, which most Governmental, Aid, commercial or tourists use. Due to the large distances between Rarotonga and the furthest Northern Islands all forms of transport wait to secure either cargo or passengers before committing to the journey. Potential passengers often delay their own travel plans until a plane is chartered for another reason, at which time a seat is purchased.

4.2.1.2 Tourism Attractions

At best, the numbers of tourist visitors to Penrhyn are low, less than 20 per annum; it is an expensive flight over a significant distance, or a sea voyage of some 5 days in each direction. There are two homestays on the island, one of which offers lagoon and game fishing tours, although there are now few tourist visitors arriving. The natural Pipi pearl oyster is indigenous to the island and the sun coloured natural pearls are sought after and relatively expensive. The white Cook Islands “Bone fish” is plentiful in the lagoon, which is a fish that anglers value to catch and attracts tourists to the closer Island of Aitutaki.

There are now no marine farms operating in Penrhyn Lagoon, with pearl production solely focussed around the natural Pipi Oyster pearls. The value and uniqueness of these natural pearls appears to attract middle-eastern buyers, who are prepared to travel to Penrhyn by air to purchase stock directly to manufacture into Jewellery.

4.2.1.3 Ports and Harbours of Penrhyn

Table 2 shows the ports and harbours of Penrhyn. The main wharf is situated at Gudgeon Bay, close to Omoka village. Vessels and yachts capable of navigating Taruia Pass, a natural entrance into the lagoon, approach the wharf through a partially marked channel through the coral peaks.

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
Omoka Wharf, Gudgeon Bay	Penrhyn	NZ 945	1995	1:75K	D	Main Wharf	Domestic shipping and recreational
Te Tautau Wharf and anchorage	Penrhyn	NZ 945	1995	1:75K	D	Wharf	Yachts Penrhyn Barge

Table 2: Ports and Harbours of Penrhyn Island

The Penrhyn Island Secretary provides the Cook Island Government's port of entry services for Customs and Immigration, as well as clearance on depatrure. Visiting vessels/craft are obliged to visit Omoka before proceeding. Anchoring at Gudgeon Bay, close to Omoka Wharf, is said to be problematic beclause of a large number of developed coral heads, around which anchors and chain can be wrapped/fouled. Islanders advised anchoring can be achieved in the location of about 08.58.7S and 158.03.1W, where there is a sandy area. This is east of Omoka wharf and directly in front of a small boat basin, which lies to the north of the wharf.

On the west side of Penrhyn, there is an uncharted small wharf and an anchorage ground in close to Tautau village. After clearing in at Omoka, it appears that virtually all yachts transit the lagoon and anchor this location, due to the better holding ground.

There are plans recorded by the Ministry of Infrastructure project[6] for the upgrade of the existing facilities, including harbour, fuel depot and Taruia Pass.

Figure 7 shows the fuel depot used for the Northern Cooks Fisheries patrol boats. On a freight order basis, a domestic ferry will transport fuel drums from Rarotonga to Penrhyn. The fuel depot is located at Omoka Wharf; and was installed in 1995. There are three tanks maintained by the Minister of Fisheries, which contain diesel for use by the fisheries patrol vessel. A fourth is owned by the local community and in a state of disrepair.

[6] Cook Islands National Infrastructure Investment Plan – Draft Final Report

Figure 7: Fuel Depot at Omoka Wharf.

4.2.1.4 Status of Aids to Navigation (AToN)

The status of Aids to Navigation at Penrhyn is uncertain, especially within the lagoon. Inside the lagoon there are a large number of coral heads that are just at, or below, the water surface and coral growth is said to be rapid. There has been a minor grounding inside the lagoon, when the Tahitian sail assisted vessel KWAI reportedly grounded on clearing Taruia Pass, and turning to starboard over a coral shoal where a channel marker had been washed away. There is a charted channel leading form Taruia Pass to Omoka wharf, which is also now sparsely marked, and Islanders advised coral growth has reduced the charted water depths quite significantly.

The islanders regularly transit across the lagoon in hours of darkness and this is a transit of about 12km. Some of the coral heads have white markers, but by no means all, and there are no lights on any of the markers. The community barge transits cargo between Omoka and Tautau.

4.2.1.5 Domestic Coastal Vessel Trade

Small domestic vessels, such as LADY MOANA, can access Omoka Wharf, via Tururia Pass. The frequency of service is uncertain, but appears to be once in about three months, which is also cargo dependent. The small container vessel TIARE MOANA reportedly visits occasionally but discharges cargo onto a community barge which then transits to Omoka Wharf for discharge. It appears this international vessel may have been used due to vessel losses by the sole domestic vessel operator.

Local sources advised that it costs in the order of NZ$400 to ship a pallet of merchandise from Rarotonga to Penrhyn. This is merchandise for sale in the local store. Passenger transit from Rarotonga to Penrhyn costs around NZ$400, or $600 for a cabin.

4.2.1.6 Cruise Vessel Visits

There are few cruise vessels visiting Penrhyn and certainly not regularly. The tall-cruise ship PICTON CASTLE visited Penrhyn during 2013. This vessel carries both passengers and cargo and is operated by a Cook Island resident.

4.2.1.7 Visiting Yacht Activity

On average, twenty yachts per year call at Penrhyn, which as an official port of entry into the Cook Islands allows yacht owners to visit other islands of the group. The prevalent wind at Omoka is offshore and it is difficult to finds a safe anchorage on this side of the lagoon.

A considerable number anchor at the entrance of Taruia passage as well as the Tautau anchorage. Alternative access to the latter is also the Takuaa passage. It has also been reported the sailing ship KWAI using the aforementioned passage.

4.2.1.8 Key Sites of Environmental Significance

Penrhyn is home to an abundant population of turtles and there are a number of species regularly breeding, including the hawksbill which is critically endangered[7]. Interestingly, the

[7] IUCN Red List of Threatened Species. This turtle takes 50 years to reach maturity. Turtle numbers are recorded in the TREDS database, maintained by SPREP.

SW Motu Mangarongaro[8] is directly referenced as a highly important green turtle nesting area. Surveys by a researcher posted to the Island suggest that both seabirds and turtles can breed at most locations on the Atol. Penrhyn is recognised as the most important turtle breeding atol of the Cook Islands.

4.2.1.9 Key Sites of Cultural Significance

Although no international or national sites were identified, there are a number of historic reasons for the cultural importance of the Islands. The motu site of an old leper colony being one. For the Cooks hydrographic risk assessment, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is also partly based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

4.2.1.10 Summary of Economic Information

Black pearl farming was once of local economic importance to Penrhyn, but councillors advised this had all but ceased by 2013, in favour of the indigenous pipi pearl. This is a rare type of natural pearl[9] that grows in the lagoon. An overseas importer visits the island and it appears purchases a significant percentage of pearl production on an annual basis, which is exported to the middle-eastern markets. The quantity and value of natural pearls exported was not known to the risk assessment.

4.2.2 MANIHIKI

Manihiki is an atoll with a large lagoon, but significantly smaller than that of Penrhyn. It neighbours with Rakahanga Island which lies to the North. The lagoon is almost totally enclosed and unlike Penrhyn, there is no passage from the sea into the lagoon of any depth.

During the in-country visit, the population was reported to be about 150, a 39% reduction based on the 2011 census. There are two main villages, Tukao (the largest and adjacent to its airstrip) and Tauhunu.

[8] In country data gathering report.
[9] Golden Pearl oyster or poe pipi

Manihiki is charted in error by some 200m, when compared with satellite imagery on the WGS84 datum.

4.2.2.1 Pearl Farming

Manihiki has been a centre of excellence of the Black Pearl farming industry of the Cook Islands and one of the largest producers in the area. However, the water quality in the lagoon had deteriorated, possibly due to the need to manage water quality in relation to pearl production. The population decline in Manihiki can possibly be related to the reduction in the number of pearl farms that are now in operation. Pearl farms have fallen in number from about 100 at the beginning of the century to about 30 today. The nutrient levels in the lagoon water that are needed to feed growing pearl oysters had fallen, as had oxygen levels at depth.

Water quality has since improved dramatically, and there is a permanent environmental monitoring presence. Pearl quality is also returning as the level of farming has been rebalanced. However intense competition from Tahiti means earnings from Pearl Farming are now what they used to be.

4.2.2.2 Ports and Harbours

The North Manihiki passage can only be passed at high tide and it mainly used by the community barge and small boats. The community barge transits into and out of the lagoon without cargo, as it has, at least in part, to be manhandled across the reef passage[10]. A new wharf had been built on the seaward side of the lagoon reef, with a passage to it cut into the coral, so that the community barge can bring cargo to the wharf and not need to pass into the lagoon. This arrangement is effective, but it has limitations of weather. This is shown in Figure 8.

[10] Islanders wish for work to be done to assist the access into and out of the lagoon for the delivery of cargo.

Figure 8 : The Main Wharf at Manihiki, behind which is the Shallow Passage to the Lagoon

Most incoming freight is discharged on the barge offshore. Transfer to the main wharf occurs only with good weather conditions and HW tide.

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
Tukao Village	Manihiki	NZ 945	1995	1:75K	C	Uncharted Main Wharf	Barge and small boats
Power Station	Manihiki	NZ 945	1995	1:75K	C	Uncharted Jetty	Small boats
Manihiki Anchorage	Manihiki	NZ 945	1995	1:15K	C	Anchorage	Yachts

Table 3: Ports and Harbours of Manihiki Island

A second, small uncharted jetty (see Figure 9) is located close to one of the two power stations on the island (there is a power station close to each village). It lies on the other side of the lagoon to the main wharf, is open to the sea and almost solely used for offloading fuel

in drums supplying the station. It also provides an alternative landing for small craft in the event the main wharf is unusable because of swell.

Figure 9: Small Jetty Close to one of the Power Generation Stations (Fuel landed)

4.2.2.3 Domestic Coastal Vessel Trade

Domestic vessels are calling approximately every 6 six weeks based on the availability of the freight volume to/from Rarotonga. The cargo ship TIARE MOANA discharges cargo while drifting offshore onto the 9.5 metre community barge. Figure 10 shows the barge that is used for cargo offloads.

The ferry LADY LEAPATA transfers passengers between Rakahanga and Manihiki. The maximum capacity is 20 passengers.

Figure 10: The 9.5 Metre Community Barge Used for Cargo Transfer Ashore.

4.2.2.4 Cruise Vessel Visits

There are few cruise vessels visiting Manihiki, due to the difficulty of landing and certainly not regularly. Most, if not all, tourists arrive by air. There have been occasional visits in the past.

4.2.2.5 Cruise Yacht Activity

According to the S-AIS records, some visiting yachts have visited Manihiki Atol, but as there is no landing of safe anchorage in all weathers, it is not a popular destination for yachts.

4.2.2.6 Key Sites of Environmental Significance

There are two formal environmental reserves, a national and a regional both of high environmental significance. There are the Amoko reserve set up by the Ministry of Marine Resources and the Porea reserve established by the local government. There are also Turtle nesting sites reported on the island.

The Island Council declares reserves either permanently, or for a period of time, by local bylaw. These help to manage the local stocks of food. An example is show in Figure 11, showing the declaration for the Poera and Rahui reserves.

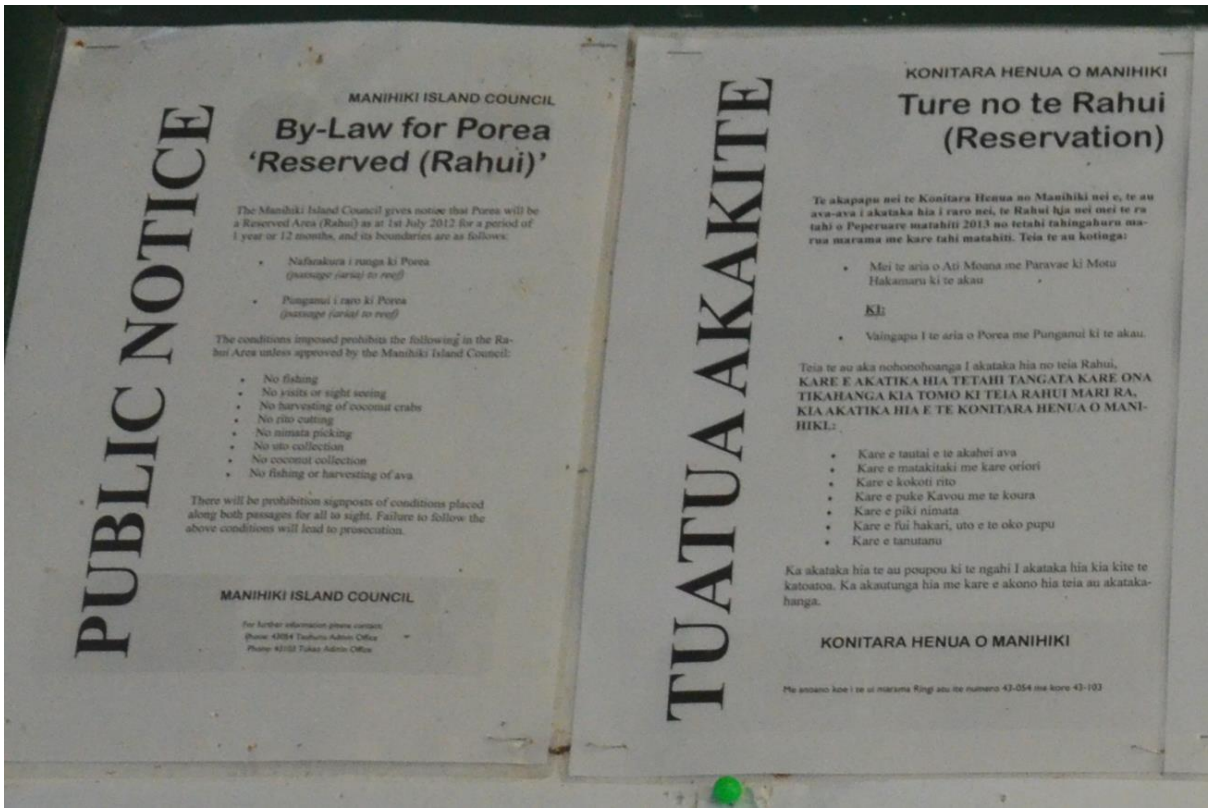


Figure 11 : Reserve and Catch Uptake Limitation Notices, Declared by Manihiki Council

On this basis, all of the Manihiki atoll was given a high significance score for the environmental significance GIS layer, in the hydrographic risk assessment

4.2.2.7 Key Sites of Cultural Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

4.2.2.8 Summary of Economic Information

Rich pearl farming is one of the major commercial activities in Manihiki Island. Presently, oyster volumes have been reduced due to overproduction and the number of black pearl farms has been decreased.

4.2.3 RAKAHANGA

Rakahanga is located north of Manihiki Island. It consists of two main islands and seven islets surrounding the Rakahanga lagoon. The first European to discover the island was Quiros in 1606. Rakahanga island remains pristine and unspoilt . The population lives at the main village of Nivano on the south-western side of the lagoon. From the 2011 census, the population had fallen to 77, from 141 in 2006, an important decrease related to migration of local residents overseas. The fishing grounds around Rakahanga are rich, especially in Tuna, according to Islanders living in Manihiki.

There were no records of tourist visits to this island, but accommodation is said to be available. The island was not visited as part of the in country-data gathering. Figure 12, below shows an aerial overview of this island.

Rakahanga is charted in error by some 150m, when compared with satellite imagery on the WGS84 datum.

Figure 12 : Overview of Rakahanga, taken from the North Eastern Quarter.

4.2.3.1 Ports and Harbours - Rakahanga

There is a small harbour basin which contains a landing stage suitable for the community barge. This landing place is also used by small boats and lighters (i.e. the community barge). It is located south west of the lagoon, close to the village. A cargo shed is located adjacent to the basin.

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
Rakahanga	Rakahanga	NZ 945	1995	1:50K	C	Landing place and basin. Cargo storage shed.	Community barge, Lighters and small craft

Table 4: Ports and Harbours of Rakahanga Island

4.2.3.2 Domestic Coastal Vessel Trade

There are irregular (rare) visits by domestic vessels reported. Rakahanga is relatively close to Manihiki and cargoes for this island are normally delivered to Manihiki, then transhipped to Rakahanga using a community barge.

4.2.3.3 Key Sites of Environmental Significance

Rakahanga Island is a pristine and abundant lagoon of high environmental significance. It has currently three formal marine reserves, which all are located west of the island. There are the Te Taha Ki Raro, the Paerangi and the Te Kainga Island reserves. A recorded turtle breeding ground has been considered in the risk assessment.

4.2.3.4 Key Sites of Cultural Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

4.2.3.5 Summary of Economic Information

Although its contribution to the economy is minor, Rakahanga Island is reported enjoys high quality fishing grounds, including reef fish and tuna offshore. It is also has been reported that there are some pearl farms on the atoll of Rakahanga with exports to Rarotonga. The status of pearl aquaculture farms is uncertain, with decline in production at Manihiki reportedly also affecting Rakahanga.

4.2.4 NASSAU

Nassau is a coral island which lies approximately 165 nautical miles North West of Suwarrow and 45 South East from Pukapuka. It is generally flat with fertile grounds. In 2011, the population of the island was recorded at 73. Nassau is charted in error by some 300m, when compared with satellite imagery on the WGS84 datum.

Nassau Island was not visited as part of the in-country data gathering visit.

4.2.4.1 Ports and Harbours

The best landing site[11] is located northwest of the island. The site is charted on NZ 945.

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
NW of Nassau Island	Nassau	NZ 945	1995	1:75K	C	Landing Site	Barges and small boat

Table 5: Ports and Harbours of Nassau Island

4.2.4.2 Domestic Coastal Vessel Trade

Nassau and Pukapuka are inter-connected by a small community owned boat providing links between the two populations.

4.2.4.3 Cruise Yacht Activity

Based on the S-AIS and hard copy records, no yacht activity of any significance has been recorded.

4.2.4.4 Key Sites of Environmental Significance

The data gathering did not note formal reserves, although it is recognised that customary management limits apply from time to time in a number of areas of the atoll.. As such the risk assessment recognised these as formal.

4.2.4.5 Key Sites of Cultural Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

[11] NP 62 Admiralty Sailing Directions

4.2.4.6 Summary of Economic Information

Nassau has a subsistence economy using the island's resources. There is some limited pearl farming reported and tuna fish stocks around the island are reported to be good.

4.2.5 PUKAPUKA

Pukapuka is an atoll located approximately 45 nm North West of Nassau and is the most westerly of the Cook Islands Group. It has a large lagoon with peripheral villages. In 2011, the population was 451 in the island.

The Island of Pukapuka is charted in error by some 200 metres on the WGS84 datum, when compared with satellite imagery.

4.2.5.1 Ports and Harbours

Pukapuka has a main landing site which is located west of the atoll. It has a pass through into the lagoon that was cut during the Second World War, but only small craft can use this. It has dangerous reefs in its approaches and offshore currents in the areas of reefs are reported to be high. There are a number of landings that can be used in different weather conditions.

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
West of Atoll	Pukapuka	NZ 945	1995	1:100K	C	Main Wharf	Domestic Shipping

Table 6: Ports and Harbours of Pukapuka Island

4.2.5.2 Domestic Coastal Vessel Trade

Likewise in other islands, cargo is transferred from domestic vessels onto the barges, west of Pukapuka. Figure 13 shows the two main barges landed along the site and used for cargo offloads. A domestic cargo ship calls once every three months. The island has suffered significantly from problems of domestic shipping services, in part due to the distance to Rarotonga. Trade from Samoa (international) is closer. Locals report there being a period of 9 months between freight services from Rarotonga at one time.

Figure 13: Barges on the Main Landing Pukapuka.

4.2.5.3 Cruise Vessel Visits

The vessel TAHITIAN EXPRESS reportedly visited Pukapuka on a frequent schedule (every 10 days) during 2008. Other vessels are also reported, but visits are infrequent.

4.2.5.4 Key Sites of Environmental Significance

There are four formal marine reserves which are of high significance. Fish, bird and turtle breeding grounds exist in these reserves. These are as below:

- Motu Niua – Marine Reserve 10ha
- Motu Uta – Marine Reserve 50ha
- Motu Kotawa – Marine Reserve 90ha
- Motu Ko – Marine Reserve 300ha

Informal protected areas are also maintained by the local chiefs where fishing is not allowed.

4.2.5.5 Key Sites of Cultural Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

4.2.5.6 Summary of Economic Information

The island is a net importer of produce, and its distance from Rarotonga, combined with lack of reliable and scheduled sea transport combine to deter any exports.

4.2.6 SUWARROW

Suwarrow is an atoll located 510 nm North of Rarotonga. The atoll is extremely vulnerable to storm surge and rise in sea level and all motu are low-lying. It has a high environmental significance and the whole of Suwarrow has National Park status. However, due to the danger of storm surge, it is uninhabited during cyclone season. This is confirmed in the 2011 population census. There are two government appointed officials living on the Island from May to November, which oversee visitors arriving by yacht. The season opens officially on 01 June and a Cook island flag is flown daily from the flagpole on the jetty when the officials are there.

Suwarrow is charted in error by some 300m, when compared with satellite imagery on the WGS84 datum

4.2.6.1 Ports and Harbours

Suwarrow has a charted jetty located at its Lagoon entrance. It is mainly used by yachts and is maintained by usually two wardens who also act as Park Rangers.

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
Suwarrow Lagoon Entrance	Suwarrow	NZ 945	1995	1:25K	D	Jetty	Yachts and small boats

Table 7: Ports and Harbours of Suwarrow Island

4.2.6.2 Domestic Coastal Vessel Trade

Domestic coastal vessel visits are not known to occur, but supplies for passing yachts may be (rarely) delivered by domestic vessel services. The island has no full time inhabitants. Supplies for the summer wardens are transported by air.

4.2.6.3 Cruise Vessel Visits

Cruise vessels do visit, although in low numbers annually, most of which appear to be "expedition cruises". As is the case with all of the Cook Islands cruise vessels need to transfer passengers into tenders offshore for transit to the landing stage. Suwarrow was reported to have received its first cruise ship with 2000 passengers in September 2014.

4.2.6.4 Cruise Yacht Activity

Suwarrow is a popular destination for yachts. Relatively high density is recorded, based on the S-AIS data and from records provided during data gathering. On average, 120 yachts visit Suwarrow annually.

4.2.6.5 Key Sites of Environmental Significance

Suwarrow is recognised as an environmental designated reserve. It was the first island to be established as National Park in 1978 as it has a rich biodiversity. Spear fishing and scuba diving are not permitted as part of the park rules. There is a recognised turtle breeding area. It is occupied by the wardens for approximately 6 months each year (wardens are removed for the cyclone season).

4.2.6.6 Key Sites of Cultural Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

4.3 SOUTHERN GROUP

The Southern Cook Islands group has recently been designated as a Marine Park, extending south into the southern extents of the Cook Islands EEZ which covers 1,065 million square kilometres. It is the largest ocean park that hosts rich Pacific marine biodiversity.

4.3.1 RAROTONGA

Rarotonga is the main island in the Cook Islands archipelago and is the location of the capital and seat of Government, Avarua. In 2011 the population of Rarotonga was 13,095, which was 73% of the population of the whole country. It is the commercial centre and also the main focus of the tourism industry. The main export port facility of the Cook Islands is located at Avatiu, which is adjacent to Avarua.

Rarotonga is 11km across at its widest point and is characterised by a mountainous interior, fertile coastal strip, sandy shoreline with coral debris and a fringing coral reef.

4.3.1.1 Tourism Attractions

Rarotonga is surrounded by a unique blue lagoon with fringe of pearly white sand. It has warm temperatures and a relaxed ambience and is thus a top holiday choice, especially for New Zealanders and Australians.

The top tourism attractions for visitors are:

- Sailing
- Diving in blue lagoon sites around the island – A premier destination
- Cycling
- Trekking - Cross Island walk
- Aroa Marine reserve

4.3.1.2 Ports and Harbours

Table 8 records the harbours and landings of the island of Rarotonga. Avatiu Harbour, the main Cook Islands port, is located in the north of Rarotonga Island. The harbour was recently re-developed with the assistance of NZAID, which completed in 2013. The harbour has a 385m quay wall and a maximum draft (Outer Overseas Berth) of 8 metres. However, a turning

circle of limited size within the harbour prevents large vessels from using the Avatiu facilities. The harbour entrance channel is narrow, with a 15 knot cross wind limit. Because of the limited size of the turning circle, large vessels would be obliged to reverse either inbound or outbound through the channel.

Avatiu Harbour is exposed to prevailing conditions and heavy swell resulting in frequent occasions where international vessel cannot use the harbour.

During 2012/2013 the port handled approximately 85,000 RT of cargo, including 58,582 TEU.

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
Avatiu Harbour	Rarotonga	NZ 9558	1992	1:3K	B	Main Wharf	International and Domestic Visits
Avarua Harbour	Rarotonga	NZ 9558	1992	1:9K	B	Wharf	Fishing Vessels
Arorangi Jetty	Rarotonga	NZ 9558	1992	1:2K	C	Main Cruise Landing Facility	Cruise vessels visits

Table 8: Ports and Harbours of Rarotonga

4.3.1.3 Domestic Coastal Vessel Trade

Rarotonga is the main domestic cargo and passenger hub for the entire Cook Islands. There are four domestic vessels providing shipping services.

4.3.1.4 Cruise Vessel Visits

In 2012, 8 cruise ships visited Avatiu port. One cruise visit was recorded cancelled due to bad weather and the remaining 7 vessels lay off the port and disembarked passengers into tenders to be ferried ashore for excursions. Cruise lines own records suggest that other cruise vessels also cancel calls. The master of the regular cruise caller PAUL GAUGUIN advised that aborted calls to Rarotonga can be as high as 20%, as disembarking elderly passengers into tenders in anything greater than a one metre swell is not done.

An alternative landing place (with removable access-way) for cruise vessel passengers has been established at Arorangi on the west side of Rarotonga during 2012. This jetty can be

used if sheltered water can be found off Avatiu Port or further round the island to disembark cruise passengers into tenders.

The cruise stakeholders would benefit from a study of wave, swell and surge patterns around Rarotonga, to establish the best locations for tender operations, given sea conditions on the day.

Figure 14 : Arorangi Jetty, Rarotonga (Decking Removed)

4.3.1.5 Cruise Yacht Activity

Rarotonga has a separate yacht harbour, and as the main port has around 50-75 of yacht visits per annum. This is less that some of the northern group islands, especially Aitutaki and Palmerston.

4.3.1.6 Key Sites of Environmental Significance

Rarotonga has a variety of environmental protected areas that contribute to the risk assessment. There are four marine reserve areas, a national park, and a marine conservation area. These are described as below:

- Tokerau Ra'ui – A marine reserve area of 0.04km^2 located west of Rarotonga and was established in 2007.
- Aroa Ra'ui – A marine reserve area of 32.54ha situated SW of the island and was established during 2006.
- Aroko Ra'ui – A marine reserve site of 71.1ha which was set up in 1998.
- Popura Ra'ui – A marine reserve site of 5h.
- Nikao Social Centre – A formal national park designated in 2000.
- Tikioki Marine Sanctuary – A marine conservation area which covers 40ha.
- Takuvaine Water Catchment Area - A designated site which covers 228.66ha including species and habitat protection.

In addition to the above protected sites, there are also important turtle breeding grounds.

4.3.1.7 Key Sites of Cultural Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

4.3.1.8 Summary of Economic Information

Rarotonga International Airport is the arrival point in Cook Islands of all international passenger flights. In 2012, 11,000 arriving passengers were returning Cook Islands residents and 122,000 were visitors. Tourists in the main will stay at resorts in Rarotonga, some will travel on to Aitutaki and a small number will visit other islands.

4.3.2 AITUTAKI

Aitutaki is a popular tourist destination, lying conveniently close to Rarotonga. It has a beautiful lagoon and apparently unspoilt water areas, and quality hotel and resort capacity, making it the second top destination for Cook Island visitors. The island is of volcanic origin with fringing reefs located in the North of the island. It has a population of 2,038 recorded for 2011 census.

Parts of the island of Aitutaki are charted with significant error. The Arutanga Passage is in error by some 400m, when compared to satellite imagery on the WGS84 datum.

4.3.2.1 Tourism Attractions

As a pristine location the islands holds a number of diverse activities for every visitors. The main tourists' resorts are located in NW coast where white sand beach are dominant. There is a daily flight schedule connected with Rarotonga that makes the island more easy-accessible. Aitutaki is a recognised destination for weddings and is nicknamed "Honeymoon Island"[12]. There is a population of the native Bone Fish in its lagoon, which attracts tourists having an interest in angling.

Snorkelling and scuba diving is one a popular outdoor activity.

4.3.2.2 Ports and Harbours

Table below shows the main harbours of Aitutaki. The main wharf is at Arutanga which as located at the inner end of Arutanga Passage. The depth of the berth is 1.4m at LW. The harbour attracts mainly yachts and fishing vessels. Although a small harbour, it provides moderate economic value to the Cook Islands economy as well as development potential.

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
Arutanga Wharf, Orongo Port	Aitutaki	NZ 955	1993	1:60K	B	Main Wharf	Cargo barges ferrying containers to the wharf from larger vessels offshore. Domestic cargo vessels (18-22m).
Arutanga Anchorage, Orongo Port	Aitutaki	NZ 955	1993	1:15K	B	Anchorage	Cruise Vessels Domestic vessels SOALS vessels
Aitutaki Tautu public landing stage	Aitutaki	NZ 955	1993	1:60K	C	Small craft and cargo craft	Local base only.

Table 9: Ports and Harbours of Aitutaki Island

[12] Cook Islands Travel official website

A view of Arutanga Wharf, Opongo port is shown below, Figure 15

Figure 15: Arutanga Wharf, Port Opongo, Aitutaki

SOLAS vessels fitted with cranes need to discharge cargo offshore, which is then transferred to Arutanga Wharf by a large community barge, Figure 16. Cruise vessels are also too large to enter the port and need to deploy their tenders to transit passengers ashore.

Transit into the lagoon through the Aratunga passage can be difficult in conditions of offshore swell. The pass was cut during WW2, but is narrow. There are good AtoN markers that are lit, Figure 17. However night transit through the pass is not recommended by the official pilot sailing directions publication.

Figure 16 : The Aitutaki Community Barge is Capable of Transporting Containers.

Figure 17 : The Entrance to Port Orongo (also the Reef "Pass") is Narrow, but Well Marked

There is an ambitious port development plan to develop both a marina and support facilities, as well as provide access for medium sized SOLAS vessels (general cargo) to upgraded port wharf facilities. This would enable cargo to be discharged directly ashore. An initial phase was underway at time of the risk assessment visit, comprising a marine reception complex under construction. This was funded by NZAID. Given the geographical location of Aitutaki, relatively close to Rarotonga, port development is logical and Aitutaki may have the potential to provide a Cook Island port when Avarua in Rarotonga cannot be used safely.

It takes place in the main harbour of Aitutaki that consists of the harbour's channel dredging, and a yacht marina.

4.3.2.3 Domestic Coastal Vessel Trade

The island is served by the domestic vessel fleet and importation cargo demand is regular, due to the resorts and homestays requiring produce for their visitors. It appears that much fresh produce arrives by air from Rarotonga, but the relatively short sea distance would allow sea transport by domestic vessels fitted with reefer capacity.

There is a new tug and barge operation between Rarotonga and Aitutaki.

4.3.2.4 Cruise Vessel Visits

Cruise ships visit regularly Aitutaki and lagoon trips can be booked in advance. It is uncertain how often cruise vessels have to weather off Aitutaki. However, the Master of the cruse vessel PAUL GAUGUIN expressed an opinion that Aitutaki could almost always be successfully visited, with Rarotonga being the more unreliable destination.

4.3.2.5 Cruise Yacht Activity

For 2012 there were 56 yachts visiting Aitutaki; if the new port development plans progress, this number is likely to rise.

4.3.2.6 Key Sites of Environmental Significance

There are four marine reserves in Aitutaki which all were established during 2000. These are as below:

- Maina Ra'ui 1 – Area of 128.1ha which is mainly reef-flat
- Maina Ra'ui 2 – Area of 81.4ha where entry is restricted in lagoon
- Motukitiu Ra'ui – Area of 407ha. The 210ha is mainly reef-flat and entry is prohibited. The 230ha has restricted entry in lagoon.
- Ootu Ra'ui – Area of 220ha

The extents of each marine reserve were included in the risk assessment as of the highest significance. The reefs of Aitutaki have been assessed as in relatively poor health, when compared to those of the other islands of the Cooks Group.

4.3.2.7 Key Sites of Cultural Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

4.3.2.8 Summary of Economic Information

Aitutaki appears to be a net importer of produce and goods to support the resorts and homestays providing services to visitors. As an attractive tourist destination, it has a need for regular delivery of fresh and other produce.

4.3.3 ATIU

Atiu is situated 10 nautical miles southeast of Takutea. The Island is of volcanic origin and mainly consists of flat-topped hills. The island has risen out of the sea by volcanic upsurge, and although fertile, the coast line is surrounded by raised coral cliffs, which are difficult to negotiate. In 2011, the population was 480 and at the time of the data gathering visit, this appeared stable.

Atiu is charted in error by some 100m, when compared with satellite imagery on the WGS84 datum.

4.3.3.1 Tourism Attractions

There are a number of homestays on this island. The island is a haven for birds and has a number of rare species that are indigenous to Atiu. Visitors are mainly from those with interest in ornithology. There is a ranger/guide who can show visitor nesting areas and sighting locations of the wildlife population.

Visitors mostly arrive by air and there are a viable number of visitors per annum. Domestic trading vessels report that up to 10 transits from Rarotonga are made by passengers per year, but it was unclear if this was a reference to locals or visitors.

4.3.3.2 Ports and Harbours

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
Taunganui Landing	Atiu	NZ 955	1993	1:75K	B	Harbour Basin with entrance design to dampen surge	Domestic landing by Community Barge

Table 10: Ports and Harbours of Atiu

The main landing is a small harbour basin, the design of which includes a small spending beach adjacent to the entrance, which is effective at dampening the offshore surge.

It was originally developed with the help of NZ defence force personnel. The harbour development is a substantial structure which remains uncharted.

Figure 18 : The Main Landing at Taunganui

Domestic vessels discharge cargo offshore into the community barge, which then lands cargo ashore into the harbour enclosure.

There are some alternative landings for cargo, which are used sheltered when the waters of the main harbour are exposed to heavy swells. The second best landing is via a steep concrete ramp. All of the other landing options involve a crossing of the reef.

Figure 19 : The Steep Concrete Ramp Comprising the Second Landing at Aitu

4.3.3.3 Domestic Coastal Vessel Trade

Like the other islands of the Southern Group, Atiu receives a domestic trader either fortnightly or monthly. The island is said to take a significant cargo volume. There are old wrecks adjacent to the harbour basin, and a recent wreck of a domestic trader was noted to be located further down the coastline.

4.3.3.4 Cruise Vessel Visits

Occasional cruise calls are reported, but only by small "boutique" cruise vessels. There have been regular cruise calls by expedition vessels, and these appear to occur approximately bi-annually.

4.3.3.5 Cruise Yacht Activity

There are few visits by cruising yachts as the surge is significant and the harbour landing is difficult to negotiate. However, once inside the harbour basin is safe.

4.3.3.6 Key Sites of Environmental Significance

Atiu has a significant Bird population some of which are indigenous to the island. This attracts a lot of interest from ornithologists. There are also turtle breeding areas, where sand is deep. Beaches are remote, but the surf is significant; islanders report that turtles do breed annually.

4.3.3.7 Key Sites of Cultural Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

4.3.3.8 Summary of Economic Information

Atiu is an organised Island with a useful specialist tourist attraction. This islanders used grow and export fruit (including oranges), but this has ceased in recent years. Local domestic trading vessels advise it has the highest cargo volume of the islands south of Rarotonga.

4.3.4 PALMERSTON

Palmerston is an atoll located in the Southern Group. In 2011 the population is recorded as 60. It is a popular staging island for cruising yachts transiting the SW Pacific. The island was not visited during the data gathering.

Palmerston is charted in error by some 100m, when compared with satellite imagery on the WGS84 datum.

4.3.4.1 Tourism Attractions

Palmerston is visited by yachts, and is a popular destination. There are some facilities and supplies provided by the islanders, which attract long range cruising yachts. Its lagoon is reported to be straight forward to enter, and it provides a good anchorage for small craft. Visits have been made by members of the UK Royal Family, which helps with the attraction of Palmerston to tourists.

The development of the Island by Tom Masters is a colourful story of history with the islanders mostly comprising of relatives. There are places to stay and regular services, both shipping by sea and by air.

4.3.4.2 Ports and Harbours

The atoll has six islets which are lying on the periphery of the reef. The diameter of the lagoon is 6 nautical miles.

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
Palmerston	Palmerston	NZ 955	1993	1:75K	D	Main Wharf	Domestic Visits

Table 11: Ports and Harbours of Palmerston Island

4.3.4.3 Domestic Coastal Vessel Trade

Palmerston enjoys regular calls from the domestic coastal service, due to its ability to provide outbound cargo. The local population catch reef fish and freeze the fillets for their shipment to Rarotonga. The fish are stored in freezers originally supplied by the government, allowing product to be stored and amassed ready for the next ship. Reef fish are a local delicacy which can be eaten from the remote islands as the water environment is pristine and coral health is excellent. Reef fish cannot be safely eaten from the reef of Rarotonga, due to bloom and bacteria levels that accrue. Up to 8 tonnes of fish are shipped per vessel visit, with a freight cost of NZ$6000.00.

Palmerston is thus a good example of how coastal trade between islands could develop, as it is the level of two way trade that has secured a reliable shipping service to this particular island, of between 2 weeks and one month.

4.3.4.4 Visiting Yacht Activity

Palmerston is a popular destination for yachts that are transiting the SW Pacific. It offers both a lagoon in which yachts can safely anchor and facilities as well as stores. Its ability to trade and its location relatively close to Rarotonga also makes it a propriety destination of the domestic coastal traders. Anecdotally, about 200 visiting yachts a year are expected.

4.3.4.5 Cruise Vessel Visits

Occasional cruise calls are reported, mostly by small "boutique" cruise vessels. There have been regular cruise calls by expedition vessels, and these appear to occur approximately bi-annually. IN the season regular calls are made by the cruise vessel PAUL GAUGUIN, approximately every three weeks.

The unique history of Palmerston makes it an attractive option for any increase in cruise calls.

4.3.4.6 Key Sites of Environmental and Cultural Significance

Although no international or national sites were identified, Palmerston is acknowledged as a pristine destination, with a low population. Every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

4.3.4.7 Summary of Economic Information

Palmerston was not visited during the data gathering exercise and it is not possible to be definite about economic output. However, the coastal vessel trading operation advised that Palmerston is the one Island of the Cooks Group that stands out for its ability to trade, and enjoys a better cargo vessel service because of this (fortnightly service). The islanders catch reef fish, gut and freeze them[13]. The frozen cargo is taken by a domestic coastal vessel in its frozen condition to the markets of Rarotonga. All of the reef fish production from Palmerston is taken into the Rarotonga hotel trade, where reef fish are consumed as a local delicacy. Demand is reported to be greater than supply.

The value of an 8 tonne shipment of reef fish in the market at Rarotonga is said to be NZ$ 160,000.

[13] Like many of the Islands of the Cooks Group, the Government has provided "cargo" freezers, that can be used to fast freeze fresh fish, for transport to Rarotonga and its hotel tourist trade.

4.3.5 MANGAIA

Mangaia is a raised coral island with a volcanic core origin. In 2011 the populations was 572. The island was not visited during the data gathering exercise, but is the most southerly island of the Cooks Group.

Mangaia is charted in error by some 150m, when compared with satellite imagery on the WGS84 datum.

4.3.5.1 Tourism Attractions

Homestays, diving, fishing, scenery, bird life. There are a limited number of visitors to the island, but there is a regular air service, with three flights a week. Cost is said to be $500 for a flight to or from Rarotonga. By sea it is three days and $50, but only Islanders take that option.

4.3.5.2 Ports and Harbours

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
Mangaia	Mangaia	NZ 955	1993	1:75K	C	Main Wharf	Domestic Visits

Table 12: Ports and Harbours of Mangaia Island

4.3.5.3 Domestic Coastal Vessel Trade

As part of the Southern Group, the island will receive a cargo visit about once a month or once every two months. This is presumably both cargo and vessel availability dependant.

4.3.5.4 Cruise Vessel Visits

Unknown, but a visit within the last 5 years was suggested by Rarotonga agents.

4.3.5.5 Cruise Yacht Activity

Limited knowledge is available.

4.3.5.6 Key Sites of Environmental Significance

Mangaia is part of the Cook Islands southern Marine Park, and as such its status in the risk assessment was increased, as was the other islands of the Southern Cooks Group.

4.3.5.7 Key Sites of Cultural Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

4.3.5.8 Summary of Economic Information

The cooler climate is said to be good for the growth of a leaf plant providing "Lace Maire" which is used for weaving. The plant is harvested for 6 months and rested for 6 months, with export of the green leaf said to be freighted to Hawaii in a chilled condition (by air). Export values of circa NZ$ 46,000 were reported, at 2012 prices. Like other islands of the Southern Group, a small amount of food is exported to Rarotonga by sea, but the main trades are import related.

4.3.6 MITIARO

Mitiaro lies 21 nautical miles north east of Atiu. The population taken by the 2011 census was 189 and the island Council advised a population of 186 during the data gathering visit, with a drifting decline in population.

The charted position of Mitiaro is in error by about 100m on the WGS84 datum, when compared to satellite imagery

4.3.6.1 Tourism Attractions

There are three homestays and activities such as diving, fishing, scenery and ornithology. There are a limited number of visitors to the island, but there is a regular air service, with three flights a week. About 100 visitors visit per annum (Island Council advice).

Cost is said to be $500 for a flight to or from Rarotonga. By sea it is three days and $50, but only Islanders take that option.

4.3.6.2 Ports and Harbours of Mitiaro

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
Te Ao O Mutu	Mitiaro	NZ 955	1993	1:75K	C	Main Wharf (Uncharted)	Domestic Visits
North landing	Mitiaro	NZ 955	1993	1:75K	C	Beach	Beach

Table 13: Ports and Harbours of Mitiaro Island

The main harbour development at Te Ao O Mutu remains uncharted and is shown in Figure 20; its facilities are modern and safe.

Figure 20 : Te Ao o Mutu Harbour

Figure 21 : The Harbour at Mitiaro is NZ Aid Funded and Opened in May 2013

4.3.6.3 Domestic Coastal Vessel Trade

As part of the Southern Group, the island receives a cargo vessel either once a month or once every two months. It costs $50 per person by sea for the three day journey, but there are reportedly few who use this option, with the last sea transit by Islanders being reported as 4 years ago.

4.3.6.4 Cruise Vessel Visits

No cruise calls were recorded. This may change once the harbour development and the island position is correctly and adequately charted.

4.3.6.5 Cruising Yacht Activity

Limited knowledge. There are some visitors, but also there have been yacht casualties. There are relatively strong currents offshore which can carry the unwary navigator ashore.

4.3.6.6 Key Sites of Environmental Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

Mitiaro has some active turtle breeding beaches, with the deep and sheltered sandy areas favoured by turtles. Breeding sites close to the airport were visited.

This island lies in the Southern Cooks and is now within a marine reserve affecting the whole of the Cook Islands EEZ south of Rarotonga. This affects the hydrographic risk result for the whole area.

4.3.6.7 Key Sites of Cultural Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

4.3.6.8 Summary of Economic Information

Like Mangia, the cooler climate (southerly location) is said to be good for the growth of a leaf plant providing “Lace Maire” which is used for weaving. The plant is harvested for 6 months and rested for 6 months, with export of the green leaf said to be freighted to Hawaii in a chilled condition (by air). Export values of circa NZ$ 46,000 were reported, at 2012 prices, which is about the same value as that from Mangaia, with the trade from both islands being shipped as one consignment . There is an abundance of Coconut crabs. Like other islands of the Southern Group, a small amount of food is sometimes exported to Rarotonga by sea, but the main trades are import related.

Mitiaro Council charges a 10% levy on food and building material imports to fund council services to the island. This is a common method of assisting with Council funding in the Cook Islands.

4.3.7 MANUAE

Manuae is a coral atoll located 50 nautical miles south east of Aitutaki. It is known previously as Hervey Islands including the Te Au O Tu (Auotu) and Manuae Island. The island is reported to be uninhabited. It is administratively part of Aitutaki, which lies some 100km away, but does not belong to any district or tapere of Aitutaki.

Manuae is charted in error by up to 100m, when compared with satellite imagery on the WGS84 datum.

4.3.7.1 Ports and Harbours

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
Manuae	Manuae	NZ 955	1993	1:75K	C	Main Wharf	Domestic

Table 14: Ports and Harbours of Manuae Island

4.3.7.2 Domestic Coastal Vessel Trade

None, due to depopulation.

4.3.7.3 Cruise Vessel Visits

None known.

4.3.7.4 Recreational Yacht Activity

Unknown.

4.3.7.5 Key Sites of Cultural Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant.

4.3.7.6 Summary of Economic Information

None.

4.3.8 MAUKE

Mauke is located 23 nautical miles south east of Mitiaro. The island is generally flat with fertile soils of volcanic origin. The island is surrounded by coral formations. The population has been decreased by 34% in 2011 compared to 470 residents in 2001.

4.3.8.1 Tourism Attractions

There are a number of homestays as well as self-accommodation. Various outdoor activities are offered, including deep sea fishing and cave tours. Mauke has fertile soils and deep sandy beaches in sheltered coves, which also attract turtles during the breeding season. The islands volcanic soils are fertile and produce attractive forest cover.

4.3.8.2 Ports and Harbours

The Community barge is loaded offshore from the domestic trading vessel, and transit to the Taunganui Harbour enclosure to land cargo. Containerised cargos are generally devanned offshore and contents taken to the landing stage. Cargo is then distributed and Island Council dues are due.

Mauke Harbour remains uncharted, but is a substantial development with a design that includes a “spending beach”, which is effective at reducing surge within the harbour enclosure. The harbour wharf area leads off the entrance basin and provides a calm area for working cargo.

It provides a safe landing for the tenders of passenger cruise vessels, who have operations organisations that have learned of the development through their own enquiries.

Figure 22 –Mauke Harbour Entrance Basin includes a "Spending Beach" Limiting Surge

Figure 23 : The Harbour Wharf Area was Calm and Almost Without Surge

Figure 24 : An Overview of the Mauke Harbour Development

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
Taunganui landing	Mauke	NZ 955	1993	1:75K	C	Landing site	Barges
New Mauke Harbour	Mauke	NZ 955	1993	1:75K	C	Harbour (uncharted)	Coastal Shipping

Table 15: Ports and Harbours of Mauke (Uncharted)

4.3.8.3 Domestic Coastal Vessel Trade

The domestic coastal vessel trade is regular to all of the Southern Cooks, with a monthly or bi-monthly cargo service. Mauke is the location of a recent wreck of a domestic coastal vessel, which contacted the reef at night after pulling off cargo discharge and stooging offshore in a slow transit to the sheltered side of the island.

4.3.8.4 Cruise Vessel Visits

There have been up to 6 cruise vessel calls recorded by the Island Council to Mauke in 24 months.

4.3.8.5 Cruising Yacht Activity

The difficulty in accessing the harbour basin in offshore swell conditions is a barrier to growth of such visits. Little yacht activity is recorded.

4.3.8.6 Key Sites of Environmental Significance

Mauke Island is an important breeding site for turtles, as it has deep sand in sheltered coves. The turtle nesting season lasts from October to December. The island also has a large population of coconut crabs.

The island provided a high risk score for its environmental importance.

4.3.8.7 Key Sites of Cultural Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

4.3.8.8 Summary of Economic Information

Mauke Island has an organised local economy of economic significance. High-yielding crops of taro, cassava, kumara and bananas are cultivated for local consumption. Capsicum, courgettes, broccoli, sweet corn and snow peas are exported via air transport to Rarotonga. It has potential for tourism development due to the unspoilt and attractive nature of its woodlands, as well as deep sandy beaches in sheltered coves.

4.3.9 TAKUTEA

Takutea lies 11 nm North West of Atiu and is surrounded by a beach of white coral sands. It is reported as almost uninhabited. It is charted about 50 meters in error, when compared to satellite imagery on the WGS84 datum.

4.3.9.1 Tourism Attractions

Due the environmental importance of Takutea (see paragraph 4.3.9.4 below), there are regular day visits from local islanders of Atiu who manage the conservation area. International visitors require special permission from High Chief in order to explore the pristine island. Eco tours[14] and diving activities can be arranged from Rarotonga.

4.3.9.2 Ports and Harbours

The only landing site[15] is located on the NW of the Takutea Island. Caution is required when navigating in the area due to strong currents.

Location	Island	Chart	Year	Scale	ZOC	Facilities	Shipping
NW of Takutea	Takutea	NZ 955	1993	1:75K	D	Landing site	Small domestic Craft

Table 16: Ports and Harbours of Takutea Island

4.3.9.3 Cruise Yacht Activity

Based on satellite AIS records, and local advice, there are a small number (about 30) yachts visiting Takutea annually.

4.3.9.4 Key Sites of Environmental Significance

Takutea Island is designated as a Wildlife Sanctuary with bird breeding grounds of high significance. It is one of the first conservation areas in Cook Islands that was established since

[14] Online reference Takutea – Cook Islands Tourism Official Website
[15] The landing site is charted on NZ 955.

1903. The traditional Chiefs of Atiu are responsible for the management of this unique sanctuary. Visitors are not allowed to visit the island without authorization from the Chiefs.

4.3.9.5 Key Sites of Cultural Significance

Although no international or national sites were identified, every coastal area and shore line is included in the risk assessment criteria as culturally significant. This is based on the fact that the scale of the Cook Islands and the isolation of each island create a great reliance of the small communities upon the marine environment.

5 ANALYSIS OF SHIPPING IN COOK ISLANDS FROM LOCAL RECORDS

5.1 INTRODUCTION

This section of the report provides a statistical and seasonality analysis of the vessel traffic using Avatiu Harbour, Rarotonga, which is the most significant trade hub for the Cook Islands, based on its ship-traffic volume and port infrastructure. A high-quality movement database was kindly provided by the harbour master of the Cook Islands Port Authority. This provided information about commercial, cruise and domestic port movements at Avatiu Harbour, which includes the alternative Cruise landing jetty, Arorangi Jetty.

5.2 COOK ISLANDS TRAFFIC ANALYSIS – METHODOLOGY OVERVIEW

The movement database received was electronic, with both vessel details as well as port movements. Hard copies of pilotage act records were also supplied, allowing the database to be verified and any duplicates deleted[16]. Pilotage certificates were useful as they recorded each SOLAS vessel visiting Avatiu Harbour, from 2010 to 2013.

Cruise vessel calls at Rarotonga were compared with some feedback from local travel agents, as well as research of Web based itineraries for future planned schedules (2014–2015). A new database was manually created and statistical analysis was undertaken based on the port-call records. In the case of international vessels, this allowed merging of the factual marine traffic with satellite received data. This both verified shipping routes and allowed vessel tracks to be updated to record any port visits that were missing in the data because of the satellite refresh period.

The same three core vessel types were used for the traffic analysis as other studies, which allows for direct comparison with other SW pacific hydrographic risk assessments. There were passenger vessel (cruise), dry cargo vessel and bulk liquid vessels (tankers). “Dry cargo” vessels include general cargo, bulk carriers, containers and Ro/Ro vessels. The “bulk liquid” category includes tankers, LPG (chemical) and gas.

[16] Duplicate entries in movement databases are common in many port databases

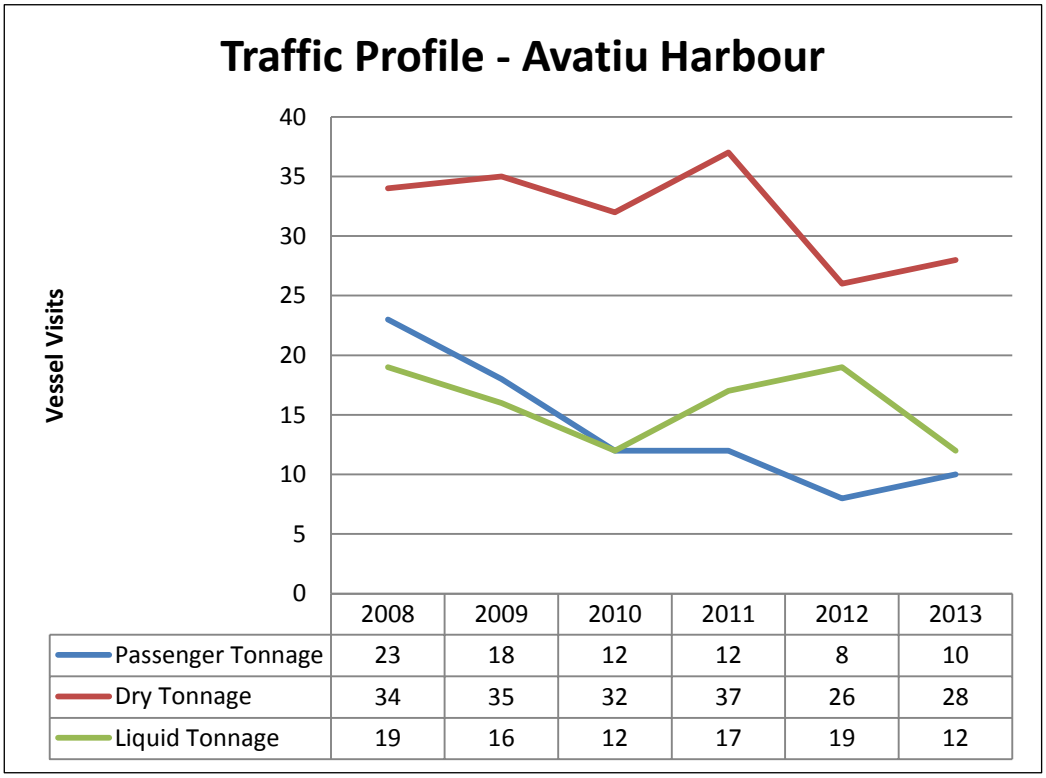
The Analysis used 2008 as a baseline year for graphical representation of change.

In the case of domestic coastal shipping, two of the vessels in service were found in the AIS dataset, but data records were limited to the last quarter of 2013 –January 2014. This is because AIS devices were fitted soon after the data gathering visit to the Cook Islands[17]. Analysis of domestic shipping routes was thus based on a combination of AIS and information about schedule and frequency service information given by the domestic shipping service provider. As the domestic traders were reportedly not being charged wharfage or berthing costs, accurate records of cargo volumes were not available. Cargo estimates were thus based on recorded vessel data (GT, length) from the Cook Islands Registry. Further information about cargo volumes moved as well as passengers making the sea transit to/from Rarotonga was obtained during the data gathering visits to the Northern and Southern Cooks.

[17] The Cook Islands Registry had discussed the option to require AIS on domestic vessels in their registry during the data gathering visit.

5.3 AVATIU HARBOUR (RAROTONGA) TRAFFIC ANALYSIS – OVERVIEW

An overview of the traffic analysis is provided in this section. A graphical representation of the port movement data is shown in Figure 25 , below.



	2008	2009	2010	2011	2012	2013
Passenger Tonnage	23	18	12	12	8	10
Dry Tonnage	34	35	32	37	26	28
Liquid Tonnage	19	16	12	17	19	12

Figure 25: Traffic Profile for Avatiu Harbour Showing Vessel Movement Trends

Both dry and bulk liquid vessel port calls fluctuated during the period 2008-2012. In the case of dry cargo vessels there was a short-period decline between 2011 and 2012. However, vessel visits increased in 2013, which may be the result of the commissioning of a new wharf and cyclone resistant cargo-shed development project concluded. This project was Aid funded.

Cruise vessels visits have been declining since the 2008 base year. There is quite some uncertainty for cruise vessels visiting the Cook Islands and aborted visits regularly occur. It is not possible for a cruise vessel to berth at Avatiu Habrour, due to swinging length limitations and the width of the entrance channel. Passengers are offloaded offshore and sea state parameters for embarkation of elderly passengers into launches are understandably conservative. A new jetty at Arorangi on the predominantly sheltered side of Rarotonga has improved the ability to land passengers ashore, but local seastate offshore still provide the

limiting criteria. It appears that the cruse passenger industry would benefit from a project to analyse wave conditions off Rarotonga in different weather directions. This would help in the on-board cruise vessel decision-making for the best location to disembark passengers offshore. .

5.3.1 CRUISE VESSELS VISITS – AVATIU HARBOUR

The data in Table 17 shows that the total number of port calls for Avatiu Harbour from 2008 to 2013. The table contains both completed and cancelled cruise vessel visits.

Cruise Vessel Visits 2008 – 2013													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2008	2	4	4	4	2	1	1	0	0	3	1	1	23
2009	2	4	1	3	0	2	0	0	1	1	3	1	18
2010	2	1	1	2	2	0	1	0	0	0	2	1	12
2011	3	1	2	0	1	1	0	1	0	2	0	1	12
2012	3	0	3	0	1	0	0	0	0	0	0	1	8
2013	5	0	1	1	0	1	0	1	0	0	1	0	10
Total	**17**	**10**	**12**	**10**	**6**	**5**	**2**	**2**	**1**	**6**	**7**	**5**	**83**

Table 17 : Cruise Vessel Visits at Avatiu Harbour (Rarotonga)

Overall, since 2008 there has been a year on year decline. From 2008 to 2013, approximately 29% of the total cruises vessels did not stop at Rarotonga for a variety of reasons, including swell and NW/NE wind conditions. The forecasted figure for 2014[18] shows the total number of 11 cruise vessels calling at Rarotonga. That means a 55% increase compared to 2013, which only had five completed port calls (excluding the cancelled calls). Given the economic benefits of this increase, the data demonstrate that the completed port infrastructure projects will put forth the tourism industry at Rarotonga. These are the Avatiu wharf redevelopment work and the Arorangi jetty[19]. Arorangi has been identified as an alternative location for cruise ships

[18] The figure is based on web itinerary.

[19] Based on the Cook Islands Government Budget Estimates, Avatiu Redevelopment Harbour is funded by the Asian Development Bank Economic Recovery Support Program and the Arorangi Jetty is sponsored by the New Zealand Government.

because weather patterns west of Rarotonga were different to those that affect Avatiu Harbour.

5.3.2 DRY CARGO VESSELS – AVATIU

Avatiu Harbour is the main trade centre for dry cargo goods**.** Table 18 shows the total number of the dry cargo vessels which includes container ships and other types of cargo carriers.

Dry Cargo Vessel Visits 2008 -2013													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2008	6	3	2	3	3	2	5	4	2	1	1	2	34
2009	1	1	1	2	2	7	2	2	5	6	2	4	35
2010	3	4	2	2	3	2	4	3	2	0	5	2	32
2011	2	2	1	2	4	5	4	3	3	3	4	4	37
2012	1	2	2	2	1	1	4	4	2	3	0	4	26
2013	3	2	4	2	4	3	3	4	3	0	0	0	28
Total	**16**	**14**	**12**	**13**	**17**	**20**	**22**	**20**	**17**	**13**	**12**	**16**	**192**

Table 18: Cargo Vessel Visits at Avatiu Harbour (Rarotonga)

During 2008, a total of 34 ports calls were made, which had decreased to 28 by 2013. Although a 17% decline, the vessel size data indicate a 31% growth. The percentage increase suggests that the current redevelopment of Avatiu Wharf, which is able to accommodate vessels up to 120m in length, has affected positively the port movements. However, vessels with an air-draft more than 24m cannot visit the port. There is an air draft restriction due to the Rarotonga International Airport.

For 2013, there are two international shipping lines operating through the Cook Islands. They run on an approximately two week's cycle and TIARE MOANA and OLOMANA are the two key container ships dominating the liner service, averaging 4500GT. The container vessels operate on a South West Pacific liner route, calling on a monthly basis to Fiji, Samoa, Tonga and the Cook Islands. Cargo statistics from 2009 to 2012 given by the Cook Islands Port Authority indicate that the container volumes kept constant averaging approximately 2400 TEU per year.

5.3.3 BULK LIQUID VESSEL VISITS – AVATIU HARBOUR

Table 19 presents the monthly frequency of Bulk liquid vessels for the period 2008-2013.

Bulk Liquid Vessel Visits 2008-2013													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
2008	1	2	2	0	2	2	3	1	2	0	2	2	19
2009	2	2	1	1	1	3	0	1	1	2	1	1	16
2010	1	1	0	2	0	2	1	2	0	2	0	1	12
2011	2	1	1	1	2	2	1	2	1	2	0	2	17
2012	1	3	0	2	2	2	0	3	1	2	1	2	19
2013	1	2	2	1	1	2	1	1	1	0	0	0	12
Total	**8**	**11**	**6**	**7**	**8**	**13**	**6**	**10**	**6**	**8**	**4**	**8**	**95**

Table 19: Bulk Liquid Vessels Visit at Avatiu Harbour (Rarotonga)

Oil and gas vessels had shown a reduction in calls since 2008; from 19 during 2008 to 12 during 2013. However, the liquid gross tonnage has been increased to 30% in 2012. During 2013, Avatiu Harbour is only served by two gas vessels averaging 3700GT compared to an average 2100GT during 2008. The data suggest that for this growth on vessel's size is the completed infrastructure project at Avatiu Harbour.

5.4 DOMESTIC COASTAL SHIPPING

Inter-island shipping has long been its most important structural supports to the national economy providing the backbone for national and regional trade. The main trade centre is Avatiu Harbour where export produce and commodities are being transported to the outer islands.

The data provided by the Cook Islands Port Authority did not include passenger capacity data, and hence, a limitation for this analysis.

Table 20 shows the frequency and routes of the domestic coastal shipping services.

Domestic Coastal Services – Port of Rarotonga					
Vessel	**GRT**	**Length**	**Type**	**Route**	**Frequency**
MAUNGAROA II	153	35	Cargo/Pass	Northern and Southern Cooks	Intermittent
LADY MOANA	163	27	Cargo/Pass	Northern and Southern Cooks	Intermittent
LADY MARY	34	16	Fishing vessel	Southern Cooks	Intermittent

Table 20: Domestic Coastal Services – Avatiu Harbour

There are 3 vessels providing both freight and passenger services. Two domestic vessels hold a Certificate of Registry Cook Islands Flag and the third vessel is a fishing type that can carry small volumes of freight. The domestic fleet is typically old and shipping operators have difficulties in accessing finance for the maintenance or replacement of their vessels. Although, the domestic fleet gross tonnage has been reduced to 63% compared to 2008, the number of port calls is relatively stable but intermittent.

The data suggests that domestic shipping has historically been sporadic in nature. There does not appear to have been a regular schedule from 2008 to 2013. The majority of remote islands, especially the Northern Group, are located a considerable distance from Avatiu Harbour. The timing of a ship visit appears to be based on waiting until sufficient cargo volume have been aggregated for the vessel's capacity, and thus fund both the voyage as well as the necessary profit. Another obstacle for the domestic service is the fact that most of the islands do not have the appropriate berthing facilities. The inter-island vessels stooge and transfer passengers and cargo to shore by barge.

The analysis suggest that a review could secure potential improvement on the fleet, bearing in mind the successful example of the Aid assisted ferry service introduced into Tonga.

5.5 CONCLUSIONS – ANALYSIS FROM PORT CALL RECORDS

1) Avatiu Harbour is the most significant port by ship traffic-volume. It has a relatively steady trade in containerised imports.

2) Two SOLAS general cargo vessels visit Avatiu Harbour, Rarotonga on a regular basis, including Arutanga Harbour, Aitutaki. These vessels represent the Pacific trade route connecting the Cook Islands with New Zealand, Australia, Tahiti and Samoa.

3) The Avatiu port development project is an important milestone for the Cook Islands shipping industry, completing 2013. The same year, dry cargo and liquid bulk tonnage increased, on average, by 30%. This growth is likely to be a positive result of the port development.

4) Cruise vessel visits have decreased over the last five years. Avatiu Harbour is small for modern cruise vessels and adverse weather conditions make entry transit dangerous. Cruise vessels mostly land passengers from offshore using their tenders. The development of Arorangi jetty provides a sheltered landing for cruise tenders. The jetty may also be an answer to an airdraft restriction at Avatiu Harbour for aircraft final landing approach which affects cruise vessels.

5) Arutanga, Aitutaki, also benefits cruise and dry cargo vessel calls, being the second Cook Island port in terms of SOLAS movements. Other Islands do occasionally experience cruise vessel calls, although these are one off visits by the smaller “boutique” section of the cruise market.

6 SHIPPING ANALYSIS – AIS TRANSPONDER DATA

6.1 INTRODUCTION

This section analyses the traffic movements of SOLAS and domestic vessels carrying AIS transponders and domestic vessel movements, geocoded by the project team. It also includes yachts and fishing vessels fitted with AIS transponders. There are some plots of the traffic in this section, which are supplemented by all of the traffic plots, which are presented at **Annex B**.

6.2 DATASETS SOURCES

The principle input for the identification of shipping routes is data from the Automatic Identification System (AIS). Satellite derived AIS provided by ExactEarth for the entirety of the South Pacific has been used to complete this project. Data was analysed for the following periods:

- 1st January 2012 to 31st March 2012;
- 14th July 2013 to 30th September 2013; and
- 1st December 2013 to the 31st January 2014.

It should be noted that the 2013-2014 datasets is additional to that obtained and analysed in the Vanuatu pilot project.[20] Therefore, in total seven and a half months of AIS data was analysed that was representative of the seasonality over a number of recent years. Later data periods contained a much larger pool of Class B transponders, representing the transmissions from yachts, recreational craft and some fishing vessels.

Satellite AIS data requires frequent satellite sweeps and so there can be an interval between received reports of up to 6 hours. To overcome this limitation, it was necessary to undertake post-processing to augment the AIS data, with port visit records taken from in country data gathering. Marico Marine report for the Vanuatu risk hydrographic assessment (12NZ246, 2013) detailed the full methodology, and its inherent limitations, that were employed to

[20] It should also be noted that the exactEarth algorithms were updated to "EV1" in late 2012. This significantly increased the amount of data that could be collected by the satellite constellation as well as increasing the proportion of Class B AIS messages. There was therefore a noticeable improvement in both the amount and quality of supplementary data that was used in this study.

process the AIS data into useful vessel tracks. The methodology has been published in full by LINZ.

6.3 ANALYSIS BY VESSEL TYPE

Figure 26 shows all vessel tracks recorded during the study periods and a density plot is created in Figure 27 that highlights the dominant routes.

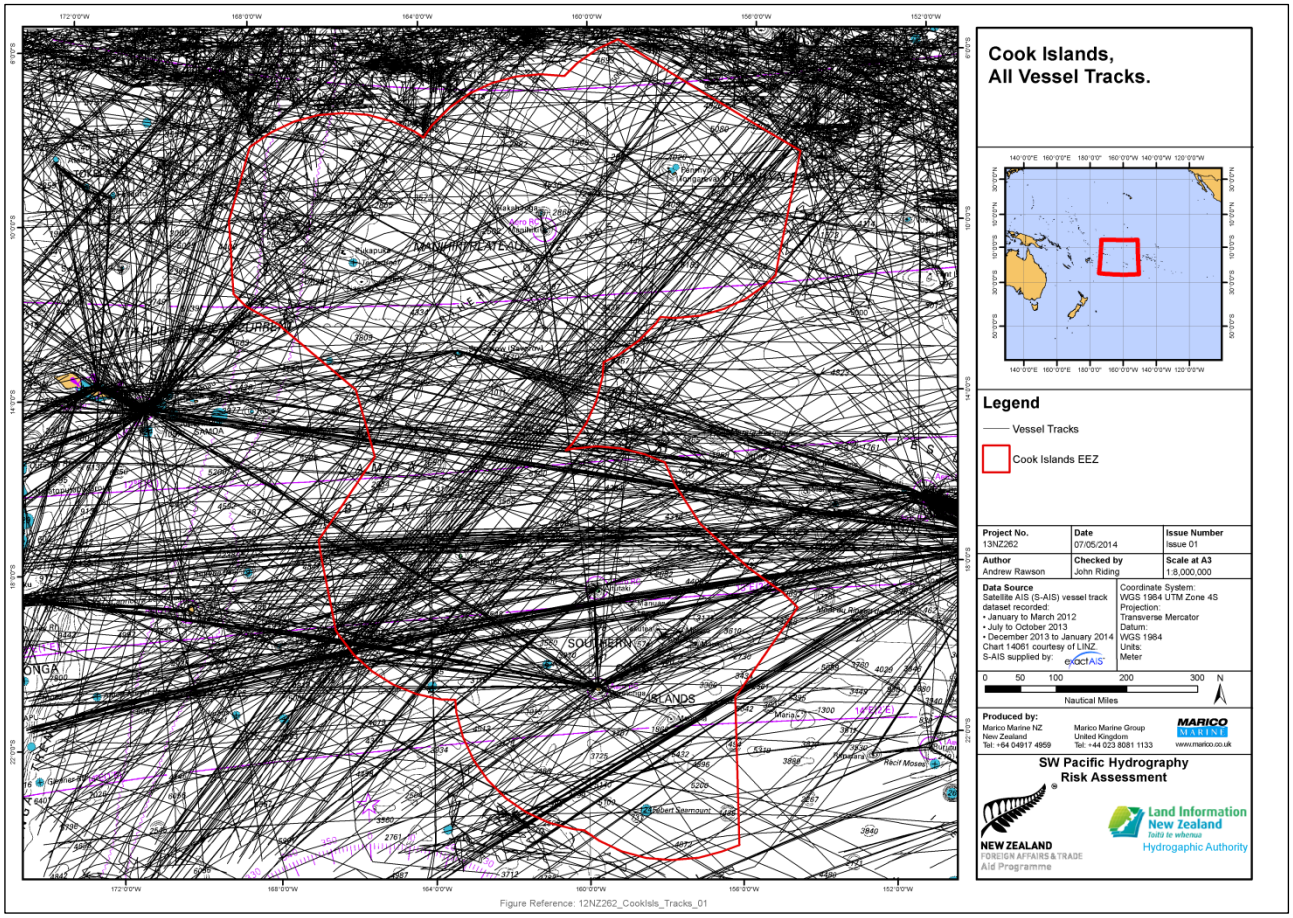


Figure 26: All Vessel Tracks

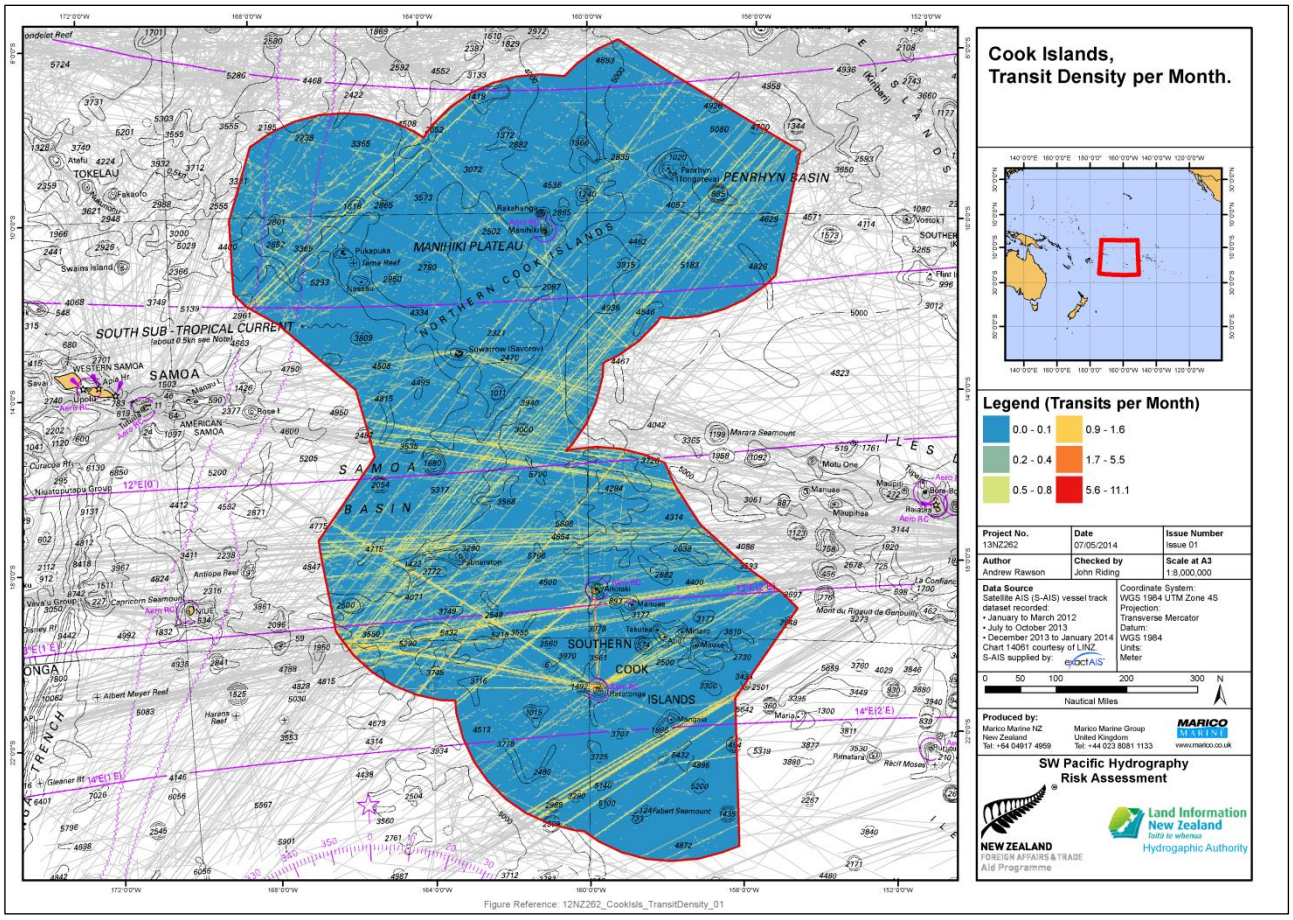


Figure 27: Transit Density Per Month.

The Cook Islands covers a vast area and therefore the majority of vessel movements within the EEZ are through traffic, either between the Americas and South East Asia or Australasia or else traffic moving between other island groups. In particular, large numbers of vessels are tracked to the west of the Cook Islands, in Samoa and also to the east near Tahiti. Furthermore, there seems to be a north-east, south west transit route across the Cook Islands that links the United States with New Zealand and Australia.

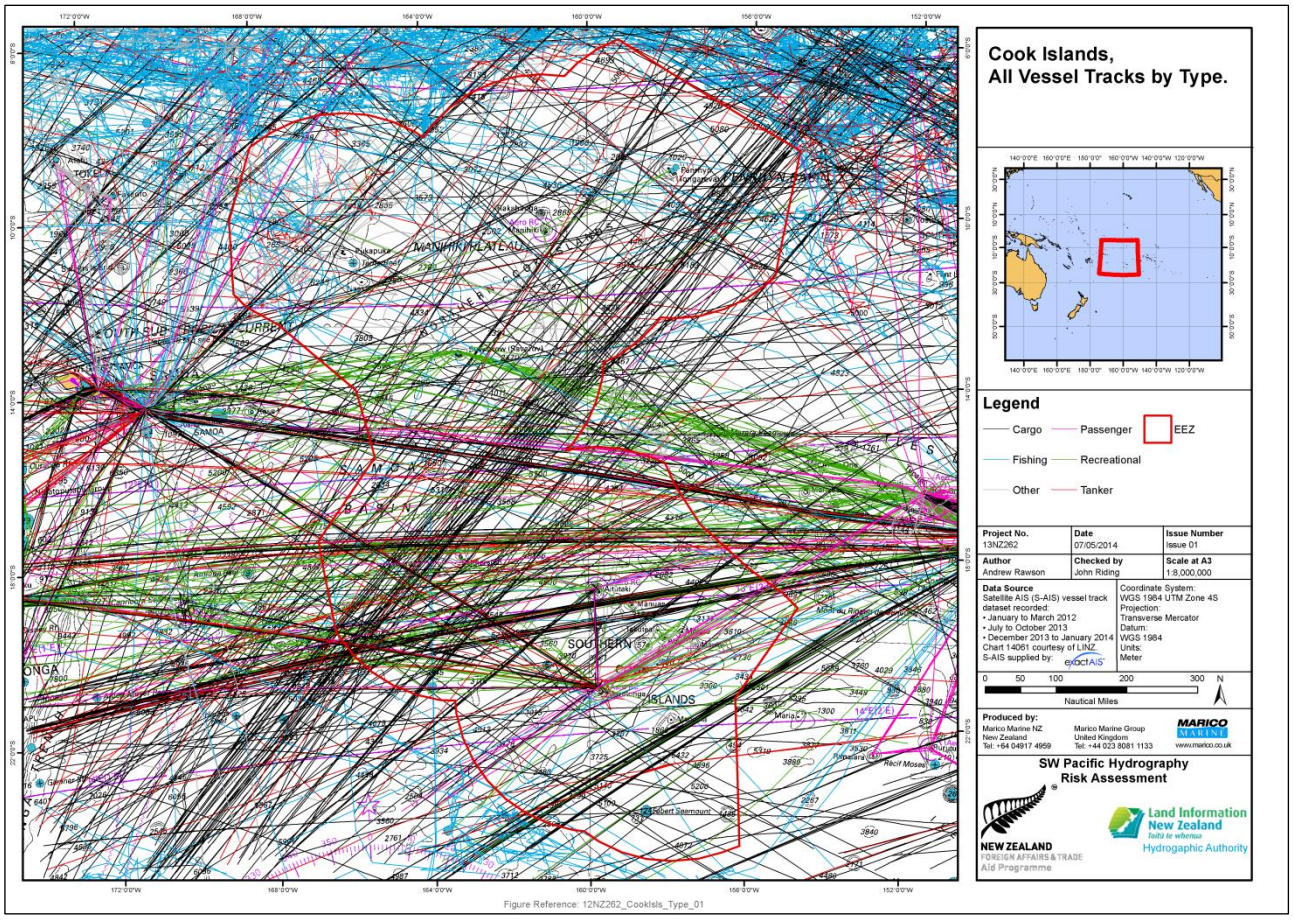


Figure 28: All Vessel Tracks by Type.

Figure 28, expanded in Figure 29 to Figure 34, show the tracks of all vessels by vessel type. Each vessel was classified into six categories:

- Dry cargo (bulk, container, reefer, Ro-Ro etc.);
- Liquid tankers (oil, chemical, gas etc.);
- Passenger vessels (cruise vessels);
- Recreational craft (sailing yachts, motor yachts and tall ships);
- Fishing vessels (commercial fishing vessels and trawlers); and
- All others.

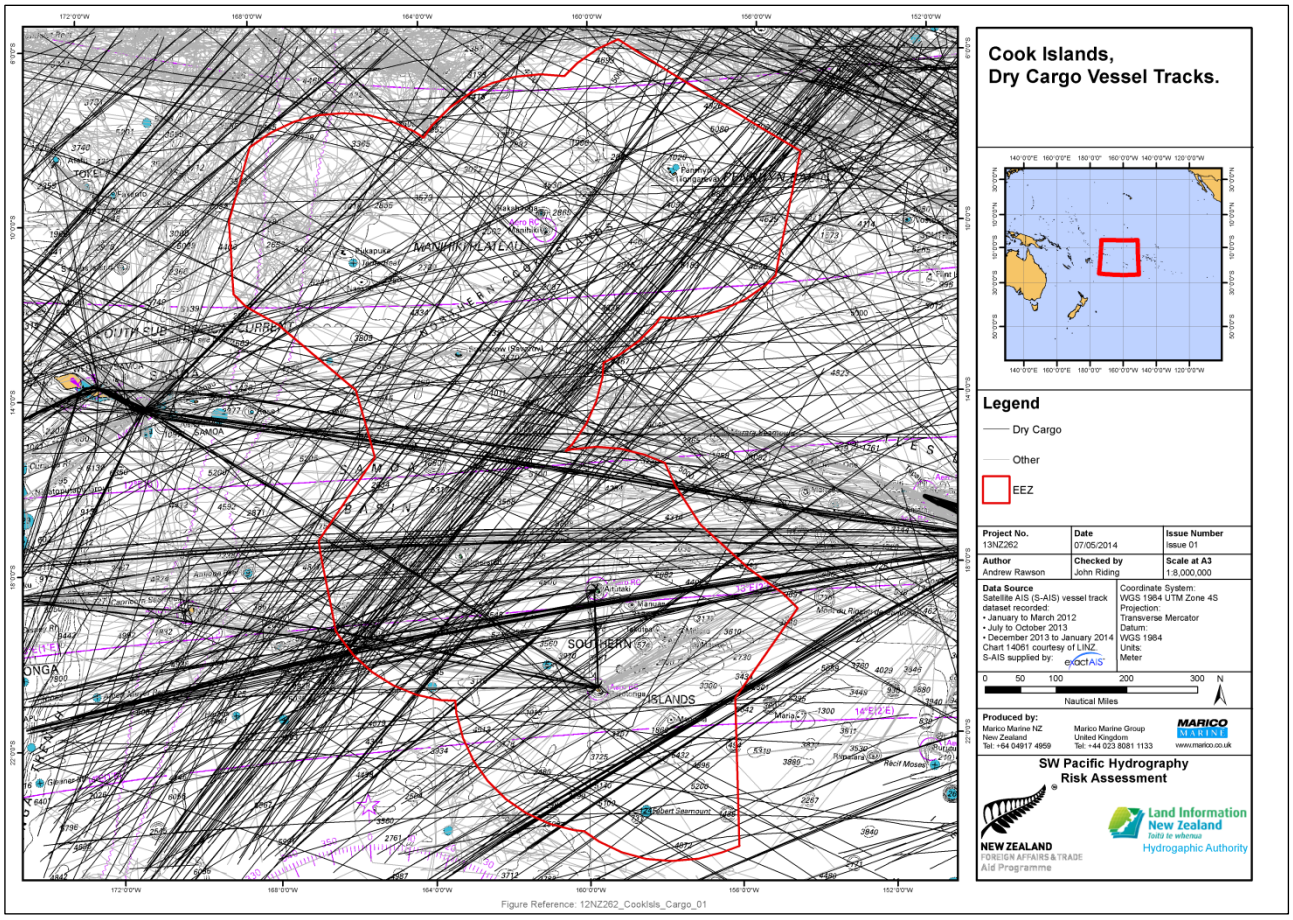


Figure 29: Dry Cargo Vessel Tracks

Figure 29 shows the movements of all dry cargo vessels in the Cook Islands. 192 unique cargo vessels were recorded inside the Cook Islands during the analysis periods. These include some of the largest container ships in the world such as the MSC INES (107,551 GT) as well as small reefers and cargo ships under 5,000 GT. The majority of cargo vessels are transiting across the Cook Islands, however where they do stop it is exclusively at either Rarotonga or Aitutaki.

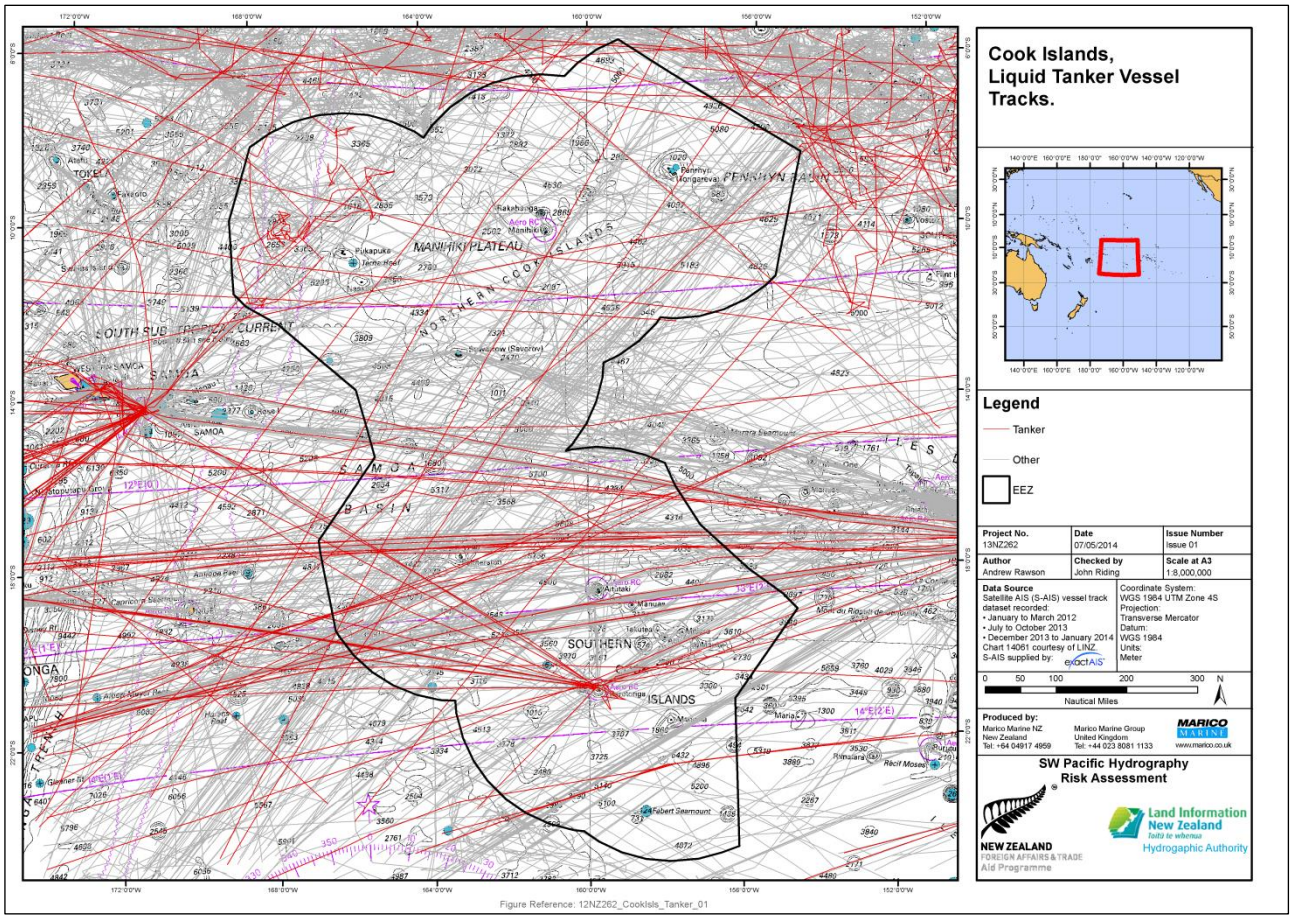


Figure 30: Liquid Tanker Vessel Tracks

The movements of liquid tanker vessels are shown in Figure 30. The pattern is similar to that of cargo vessels however there are far fewer of them, with only 36 unique vessels identified. Whilst two were Aframax size (80,000 to 120,000 DWT), the *Barcelona Knutse* and the *Methane Spirit*, the majority were Panamax or smaller. Tanker vessels were only recorded stopping at Rarotonga.

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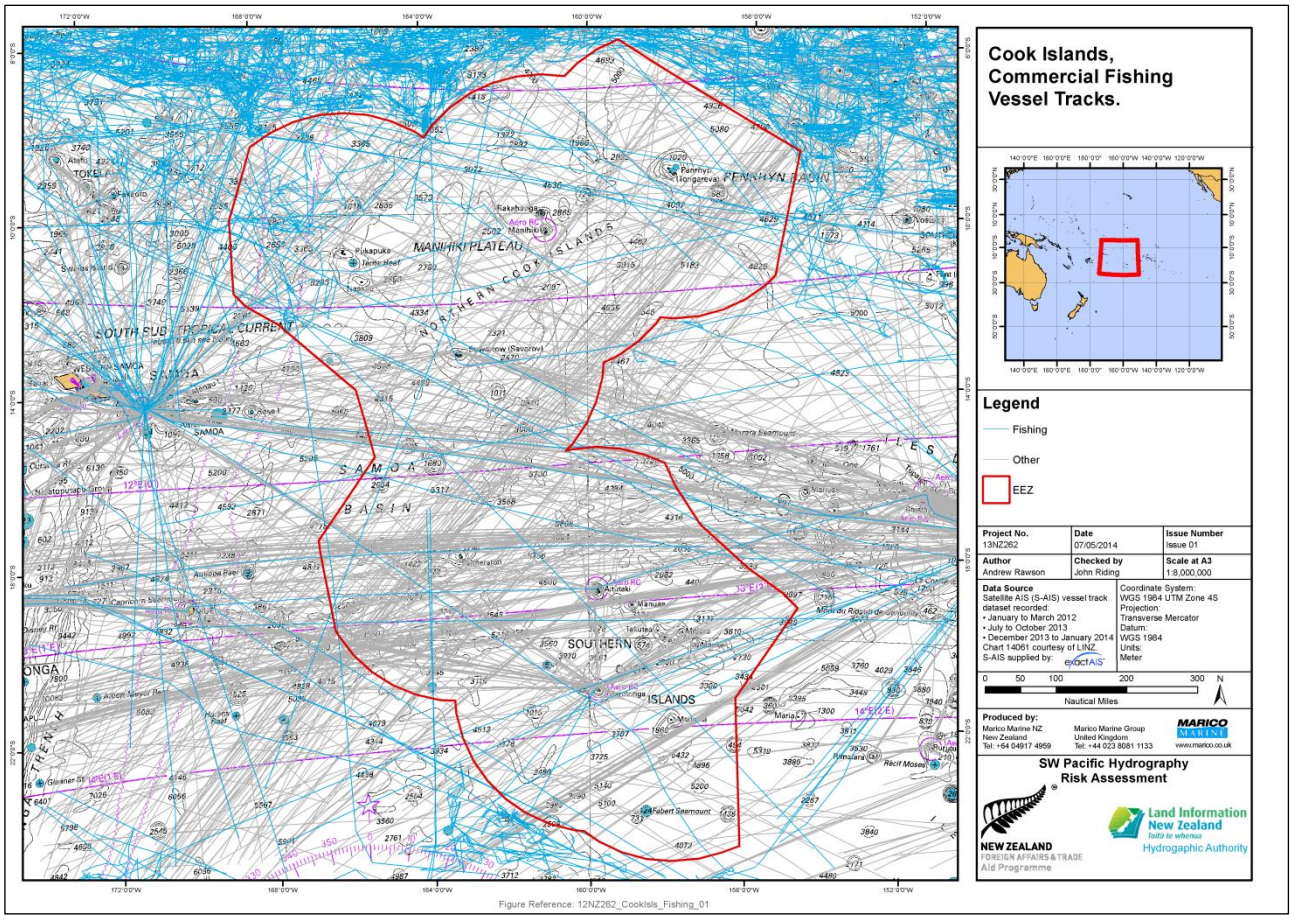


Figure 31: Fishing Vessel Tracks

Figure 31 shows fishing vessels near to the Cook's EEZ. It is immediately apparent that large commercial fishing vessels do not regularly operate in the Cook Islands EEZ and instead fish north of the border. Very few vessels transit through the Cook Islands and only a handful stop at any of the islands, mostly Rarotonga. There appears to be some fishing activity in the north west of the Cooks, near to Samoa

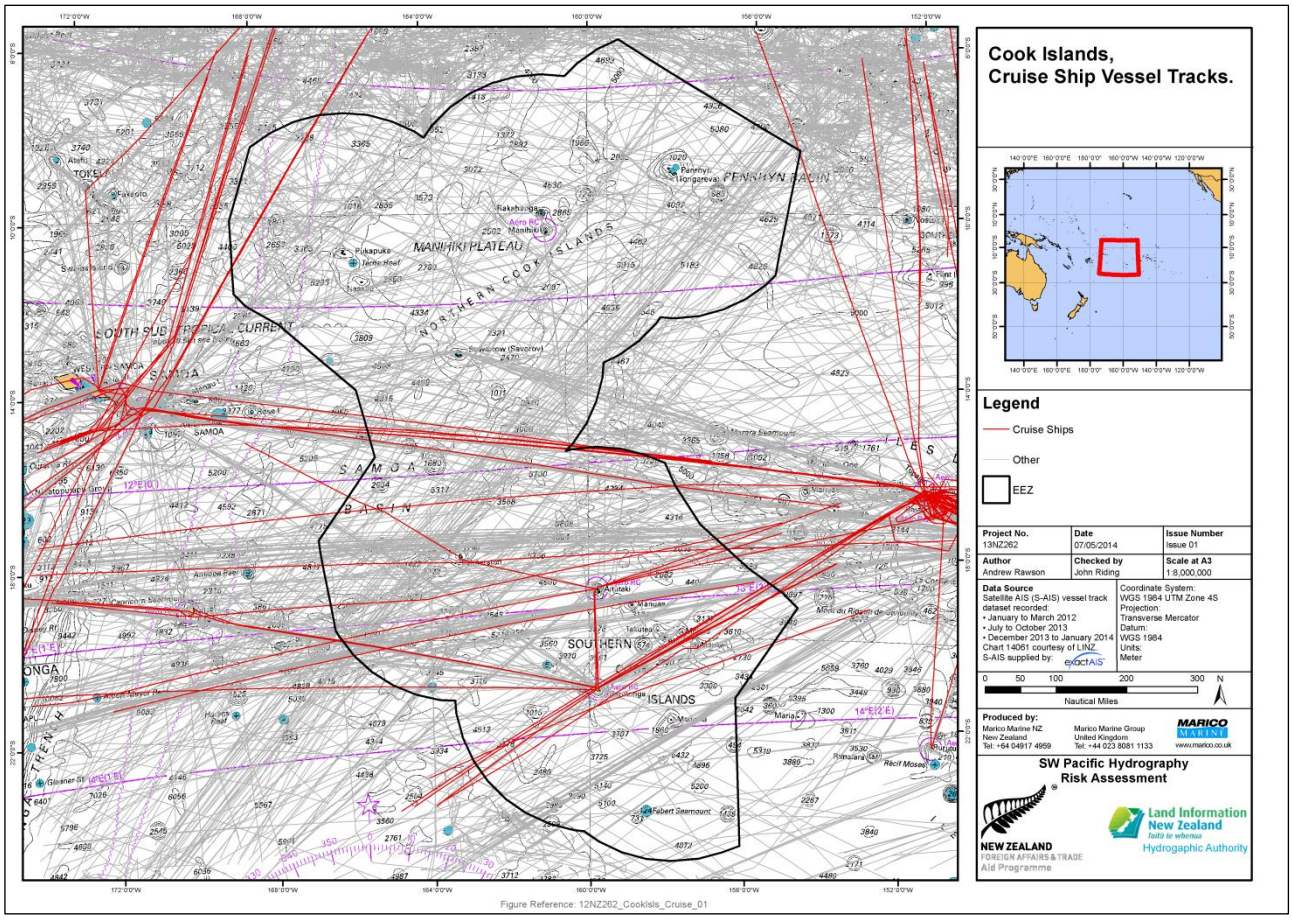


Figure 32: Cruise Vessel Tracks

Figure 32 shows the tracks of all cruise ships with the Cook Islands. Cruise ships stop at the Cook Islands infrequently, and exclusively in the Southern Cooks. Several transit directly between Tahiti and Samoa, or elsewhere. Those vessels that regularly stop include the *PAUL GAUGUIN* and the *HANSEATIC*.

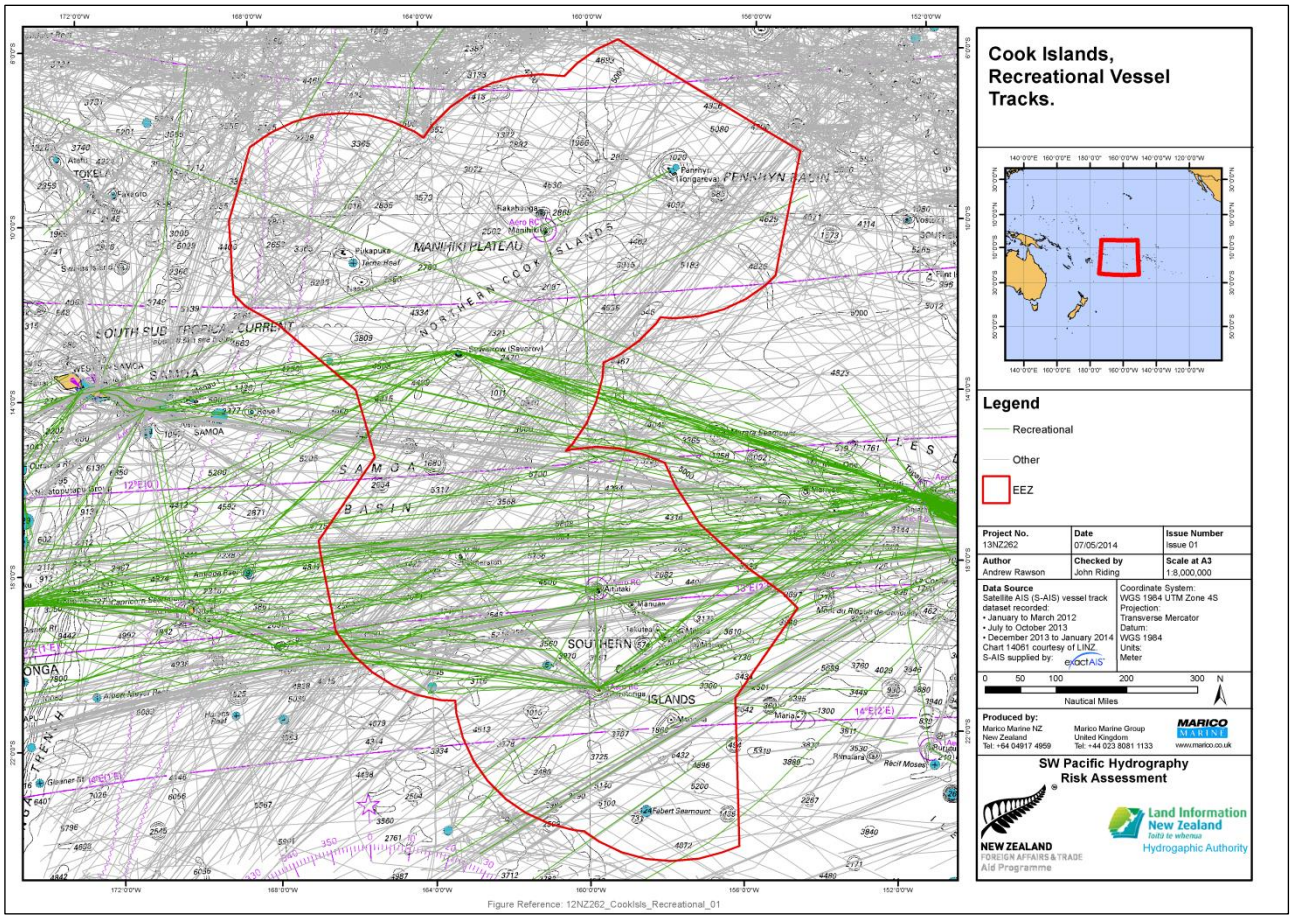


Figure 33: Recreational Vessel Tracks

Recreational vessel tracks are shown in Figure 33. Recreational vessels constitute a large proportion of the total number of movements within the Cook Islands. In particular it is apparent that these vessels rarely visit the Northern Cooks, with the exception of Suwarrow and Palmerston, and use the Cooks as a stopping point between Samoa, Tonga and Tahiti. The islands of Rarotonga and Aitutaki are most regularly visited.

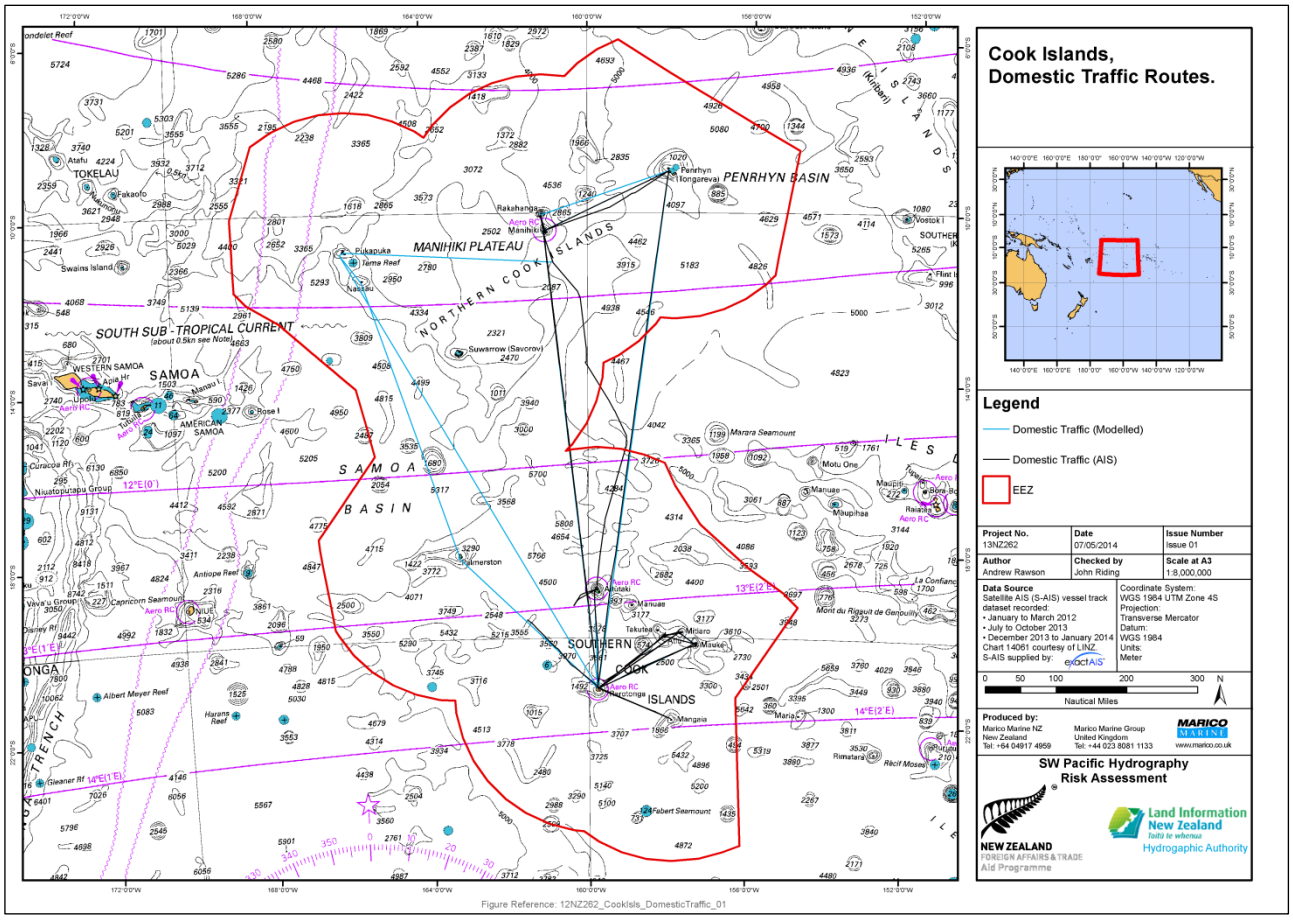


Figure 34: Domestic Vessel Tracks.

Domestic vessels are those vessels that fulfil a regular inter-island passenger of cargo service. These vessels are generally of a smaller size and would therefore not often be equipped with AIS. To include these vessels in the risk assessment their routes and frequency are geocoded into the GIS. Figure 34 shows the tracks of these domestic vessels, principally the *PICTON CASTLE* and *MAUNGAROA 2*, both of which carried AIS. The service offered by these vessels is much less frequent when compared to domestic traffic in other Pacific Island groups.

6.4 ANALYSIS BY VESSEL CHARACTERISTIC

Figure 35 and Figure 36 show the tracks differentiated by their gross tonnage and lengths respectively. It is immediately apparent that the largest vessels that transit through the Cook Islands are through traffic only.

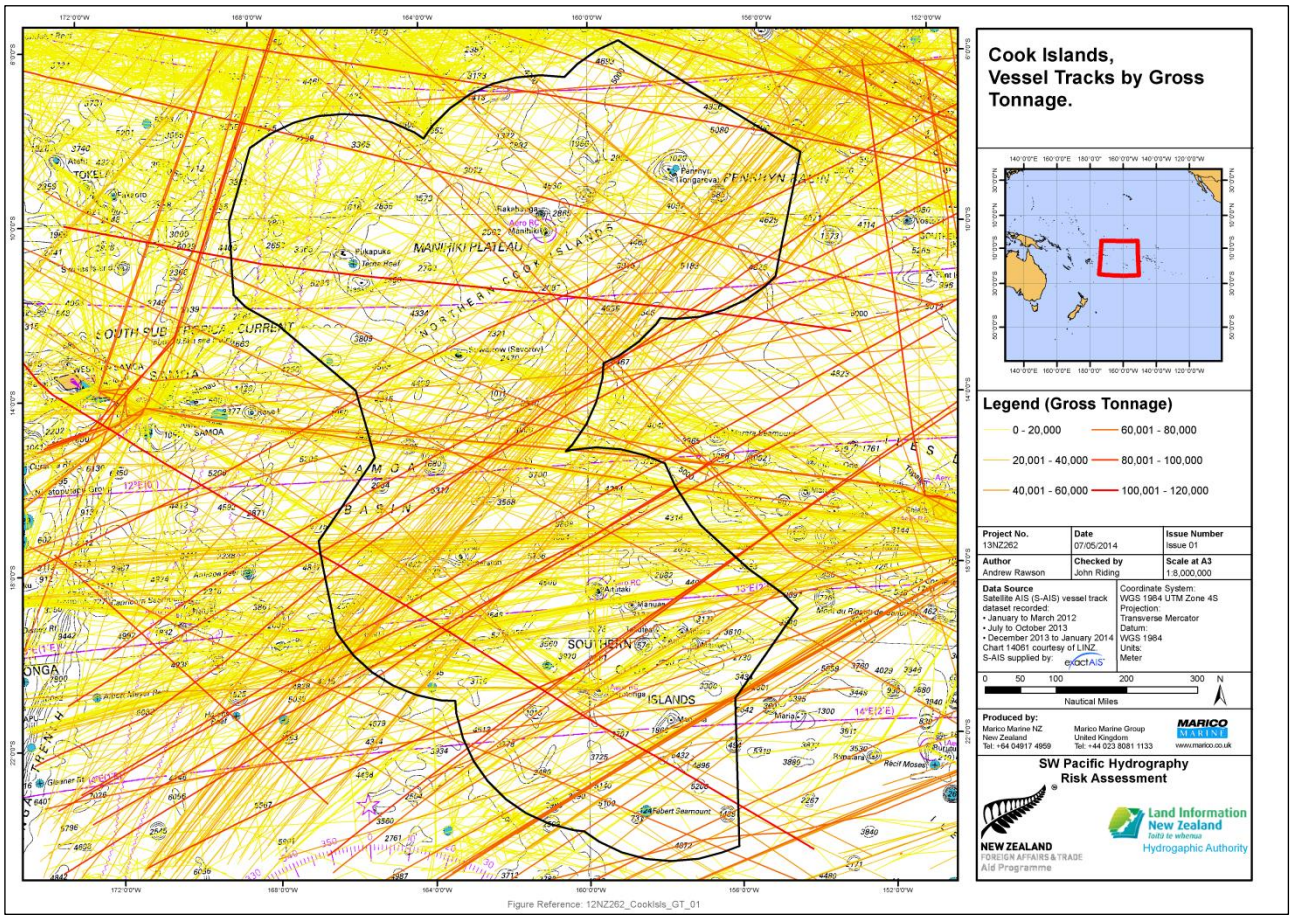


Figure 35: Vessel Tracks by Gross Tonnage

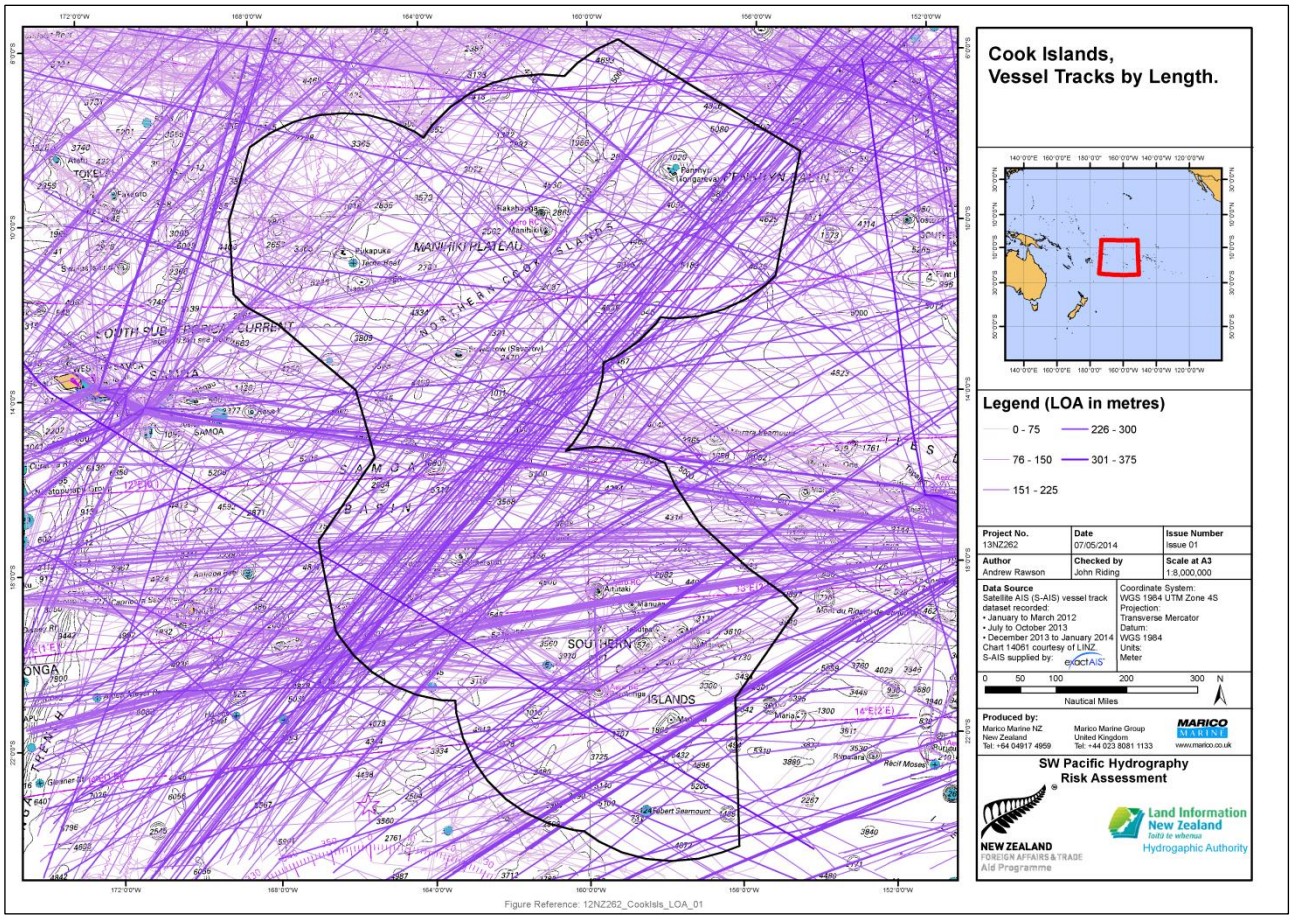


Figure 36: Vessel Tracks by Length

6.5 CONCLUSIONS – INTERNATIONAL VESSEL TRAFFIC ANALYSIS

1) The majority of vessel movements within the Cooks EEZ are through traffic, either between the USA and South East Asia or Australasia, or else traffic moving between other island groups. Dry Cargo vessels were recorded calling at Rarotonga or Aitutaki and tanker vessels only at Rarotonga.

2) Cruise ship calls to the Cook Islands do occur and there are some regular traders, based on the satellite AIS records. Those vessels that regularly stop include the PAUL GAUGUIN and the HANSEATIC. Sail assisted cruise vessels such a PICTON CASTLE and Windstar Cruises are also regular callers.

3) There is quite a high percentage of Cruise Vessels that abort calls to Rarotonga. The problem is the offshore sea conditions, which make landing passengers into cruise tenders difficult. This needs further work, perhaps a wave analysis over a period of time. A new Jetty has been installed on the shelters side of the Island, but this will only help matters if cruise passengers can be disembarked safely offshore.

4) There is considerable scope of further development of the cruise industry in the Cook Islands group, especially Aitutaki.

6.6 CONCLUSIONS – DOMESTIC VESSEL TRAFFIC

1) When compared to domestic traffic in other Pacific Island groups, the Cook Islands coastal shipping service provision is much less frequent. There have been problems of grounding in the domestic fleet, and losses resulting. Domestic vessels of over 350 gross tonnes and those carrying passengers carry AIS transponders.

2) The development of domestic trading is quite seriously hindered by the sporadic nature of domestic vessel trade schedules. Services to many islands of the Northern Group only occur if cargo is committed and only Palmerston is accumulating trade cargo ready for the next scheduled visit. Other islands that used to produce goods for consumption on Rarotonga, have mostly ceased trading. One minor exception is coffee.

3) Given the long transit distances between islands, domestic trade would benefit from an approach used by other Governments to support marginal ferry services in remote areas

to be regular. In these systems, a service is contracted by the Government, and cargo shipped is discounted from the assistance as trade develops.

7 RISK ANALYSIS RESULTS

7.1 INTRODUCTION

This section presents the result overlays for the Cook Islands, as well as for the entire Cook Islands EEZ overall. It highlights the areas that decision makers need to consider for hydrographic surveys, from a risk perspective. It should be noted that the risk results should be considered in conjunction with the Cost Benefit Analysis results, as both provide complementary information for decision makers to consider.

Conclusions and recommendations for this part of the report are presented in Section 9.

7.2 RISK MATRIX AND TRAFFIC

The derived risk matrix used in the GIS overlay analysis is shown in Figure 37, which is the same as that used for the other studies of this series. The risk derived is a combination of traffic, likelihood criteria and consequence criteria. This is the key feature of the methodology as the model depends on the presence of shipping traffic for there to be a risk.

In the risk assessment, the traffic type, size and volume are evaluated by a grid of geographic cells in the GIS. The traffic profile (ship type, size and density in relation to the grid) then influences the risk levels associated with each of the 31 criteria. The criteria are each held on a separate layer in the GIS.

The matrix also shows the influence each of the GIS overlays has on the risk results, Figure 37. Review of the matrix shows the emphasis placed on chart quality within the risk assessment, measured in the risk assessment by the CATZOC M_QUAL attribute recorded by LINZ as metadata to their charts. The CATZOC system was also used to determine the available risk reduction from chart improvements from a lower ZOC rating to a higher one. The CATZOC system is explained at the beginning of this report. Plots of the Cook Islands, showing the ZOC ratings as interpreted for potential risk contribution, for each of the key sea areas surrounding the Cook Islands, are presented at **Annex C.** The matrix also shows the influence each of the GIS overlays on the risk results, which follow.

Figure 37: Risk Matrix for Cook

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

7.3 COOK ISLANDS HYDROGRAPHIC RISK - OVERALL

Figure 38 shows the cumulative risk model taking into account all risk factors. The following areas that have a significant or a heightened risk level are:

- Rarotonga Island, Avatiu Harbour Entrance and Approaches
- Penhryn Island, Taruia Passage and West Coast of Penhryn
- Aitutaki Island, Arutanga Harbour Entrance and Approaches

Compared to the risk results of other completed hydrographic risk studies[21], the Cook Islands present a reduced hydrographic risk score. This is because the Cook Islands are dispersed and isolated islands and atolls and therefore the vast majority of the EEZ is absent of a number of the risk factors, consequently exhibiting a lower risk score. Within approximately 20nm of each island, the risk scores increase. Table 21 shows the proportion of grid cells in the Cooks EEZ that are in each risk category. It can be seen that the vast majority of the study area has a low modelled risk score, reflecting the vast sea areas between each island group.

Category	Count	Percentage
Significant	1	0.0003%
Heightened	21	0.0066%
Moderate	217	0.069%
Low	4585	1.45%
Insignificant	311753	98.48%
Total	316577	100%

Table 21: Risk Model Categories

7.3.1 DECISION MAKING CRITERIA

If a recommended criterion to act on areas that evince moderate, heightened or significant risk is accepted, it is possible in broad terms to specify recommended areas for either charting and AToN review or hydrographic survey to improve charts. In a number of areas providing a

[21] Tonga Hydrographic Risk Assessment and Vanuatu Hydrographic Risk Assessment.

heightened risk result, charting may have already been updated because past expert judgement had recommended this. In such areas it is appropriate to review charting to confirm that scales are appropriate and that aids to navigation and channel use remain appropriate.

Although the risk assessment has determined areas where the accuracy and adequacy of charting should be reviewed against modern standards, risk results for the Cook Islands are subdued, due to the low level of traffic overall and the rapid increases in ocean depth close to each island. Accordingly the results should be treated with caution as the risk assessment makes comparison to other areas of the SW Pacific that enjoy increased volumes of traffic.

Improvements to charts, including improvements to charted island positions are needed as almost all islands are out of position, some significantly, when compared with modern satellite imagery on the WGS84 datum. For example Pukapuka is some 200m in error; Suwarrow and Nassau are some 300m in error and parts of Aitutaki some 400m in error.

A number of islands have benefitted from substantial harbour enclosure developments, which remain uncharted. This hinders cruise penetration into the Cook Islands as voyage planners are unaware that potentially safe landing arrangements are present for their passengers; examples of these are Mauke and Mitiaro. Consideration needs to be given to adequacy of scale for practical use of harbour developments.

This following part of this section presents in more detail the hydrographic risk for Northern and Southern Cook Islands.

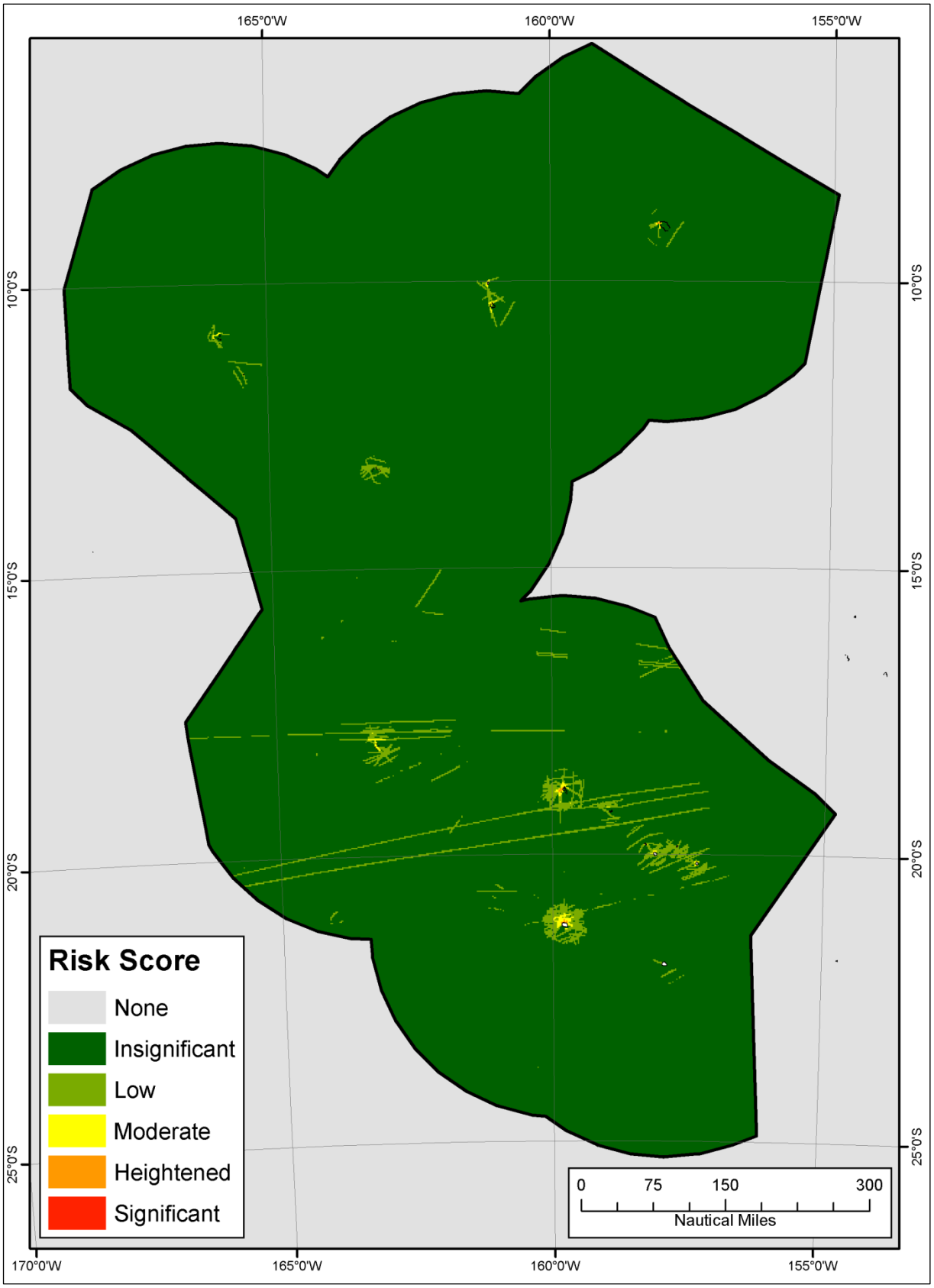


Figure 38: Risk Model Results

7.4 NORTHERN COOK ISLANDS

The risk scores in Penrhyn are shown in Figure 39. The heightened level of hydrographic risk is driven by a small number of visiting craft calling at Omoka Wharf, which are mostly recreational or domestic traders, and where cargo is worked. However the lagoon is poorly charted with missing AtoNS, exposed with little shelter and surrounded with hazardous reefs. The atoll has the highest environmental risk score in the entire Cook Islands with pristine and significant reserves of ecological resources which provides some economic value as a tourist asset.

The risk scores for Rakahanga and Manihiki in the Northern Cooks are displayed in Figure 40. Both of these atolls offer significant high value environmental resources but are isolated and so there is very little tourist activity. Both have complex navigational channels through breaking reefs and offer little shelter. Whilst only domestic traffic regularly stops at these islands, a significant number of SOLAS international vessels, including tankers and cargo ships transit within 20nm of these islands.

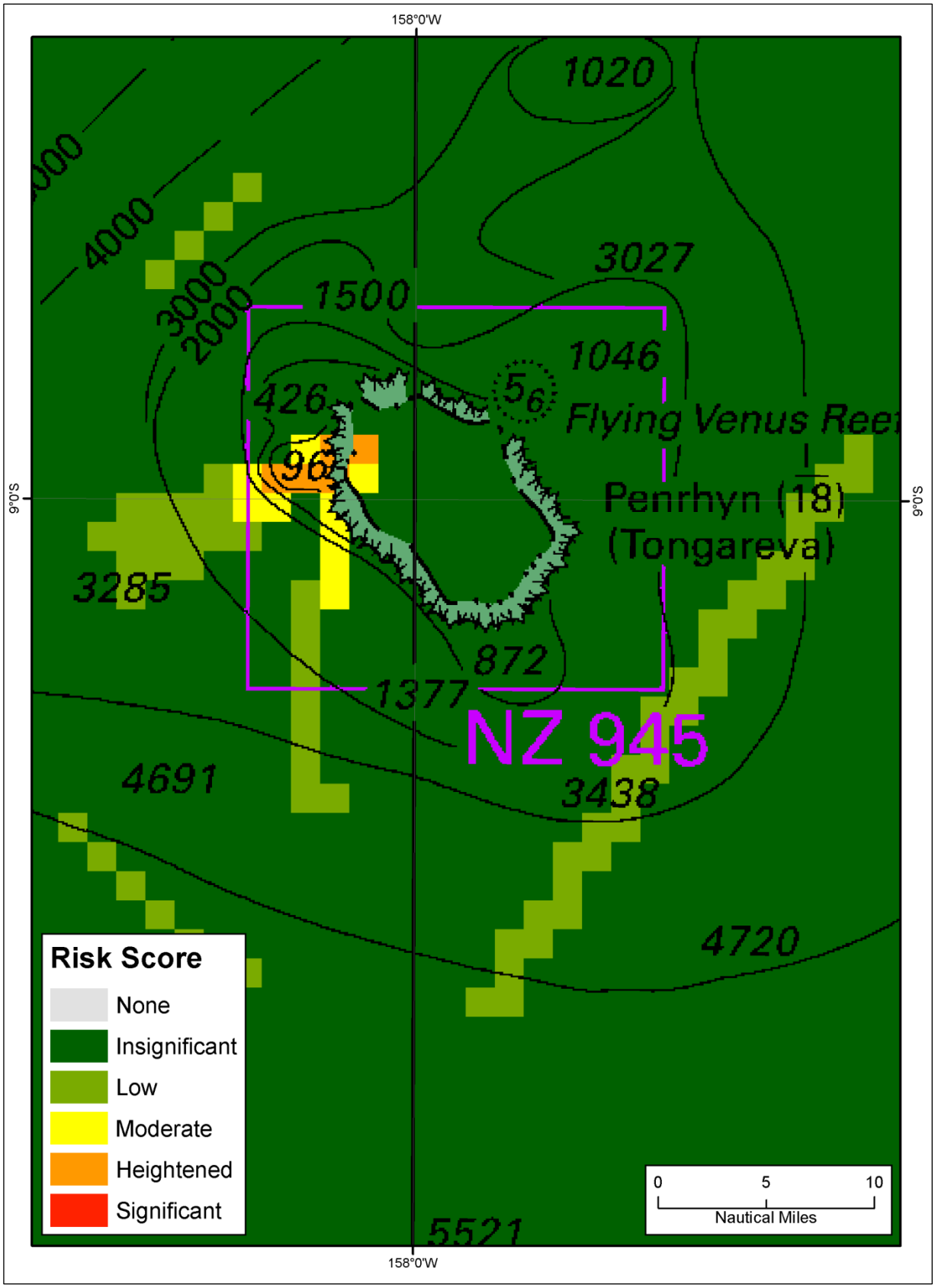


Figure 39: Risk Model Results in Penrhyn.

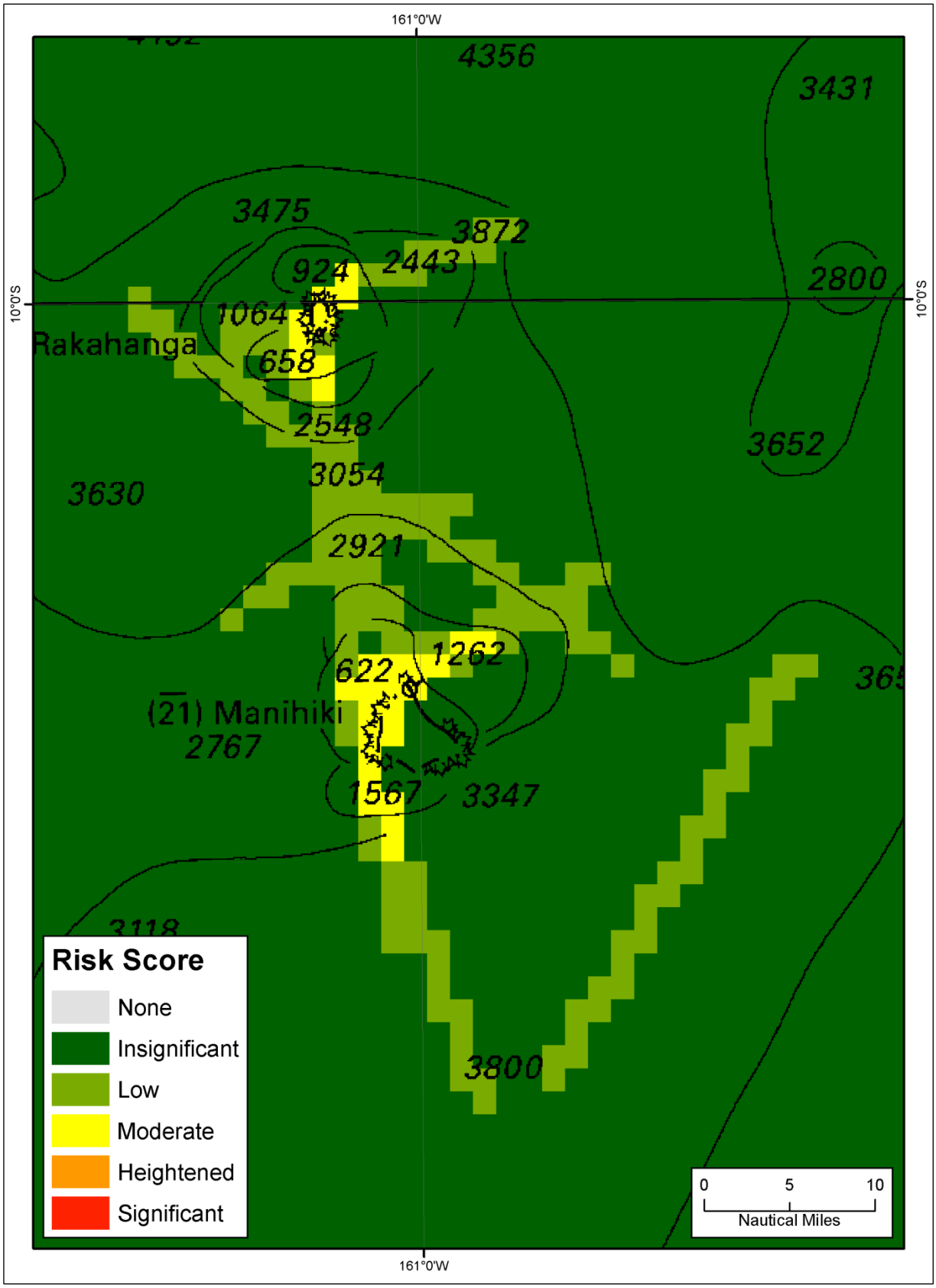


Figure 40: Risk Model Results in Rakahanga and Manihiki

7.5 SOUTHERN COOK ISLANDS

Only a single cell, namely the entrance to Avatiu Harbour, Rarotonga, is scored as having a significant risk (Figure 41). This site is the most concentrated area of shipping activity in the Cook Islands and therefore has the highest potential for loss of life or pollution. Furthermore, the navigational complexity in a constrained channel, shallow water and proximity to breaking reefs increase the likelihood of an incident. The environmental significance combined with the economic importance with a major tourist trade and infrastructure drive high consequence values. The risk scores are notably higher on the northern coast of the island than the southern coast with areas of heightened risk in the approaches to Avatiu.

Aitutaki holds the third highest risk values in the Cook Islands a heightened risk (Figure 42). The atoll receives the second highest traffic volume, all of which must anchor close to a breaking reef with little shelter, or else navigate a very narrow passage, in the approaches of Arutanga Harbour. The reef and lagoon have significant amounts of high quality coral and is home to both ecological sanctuaries and breeding grounds. As one of the regularly cruise ship destinations the island also is a significant tourist destination.

Figure 43 shows the risk scores near Palmerston. Palmerston has a number of recreational vessels stopping and during the analysis period a single cruise ship, the *Hanseatic*, was recorded. However there are a significant number of large international traders transiting near to the island. Palmerston, like many of the other atolls, offers little shelter and shallow breaking reefs. The site exhibits a number of environmental risk factors and some economic significance.

Figure 44 shows the risk model results for a number of islands in the Southern Cooks. The islands of Manuae, Takutea, Atiu, Mitiaro and Mauke all exhibit similar risk scores that are moderate to low. Almost exclusively, only domestic vessels were recorded at these sites; however a number of recreational craft are known to infrequently visit.

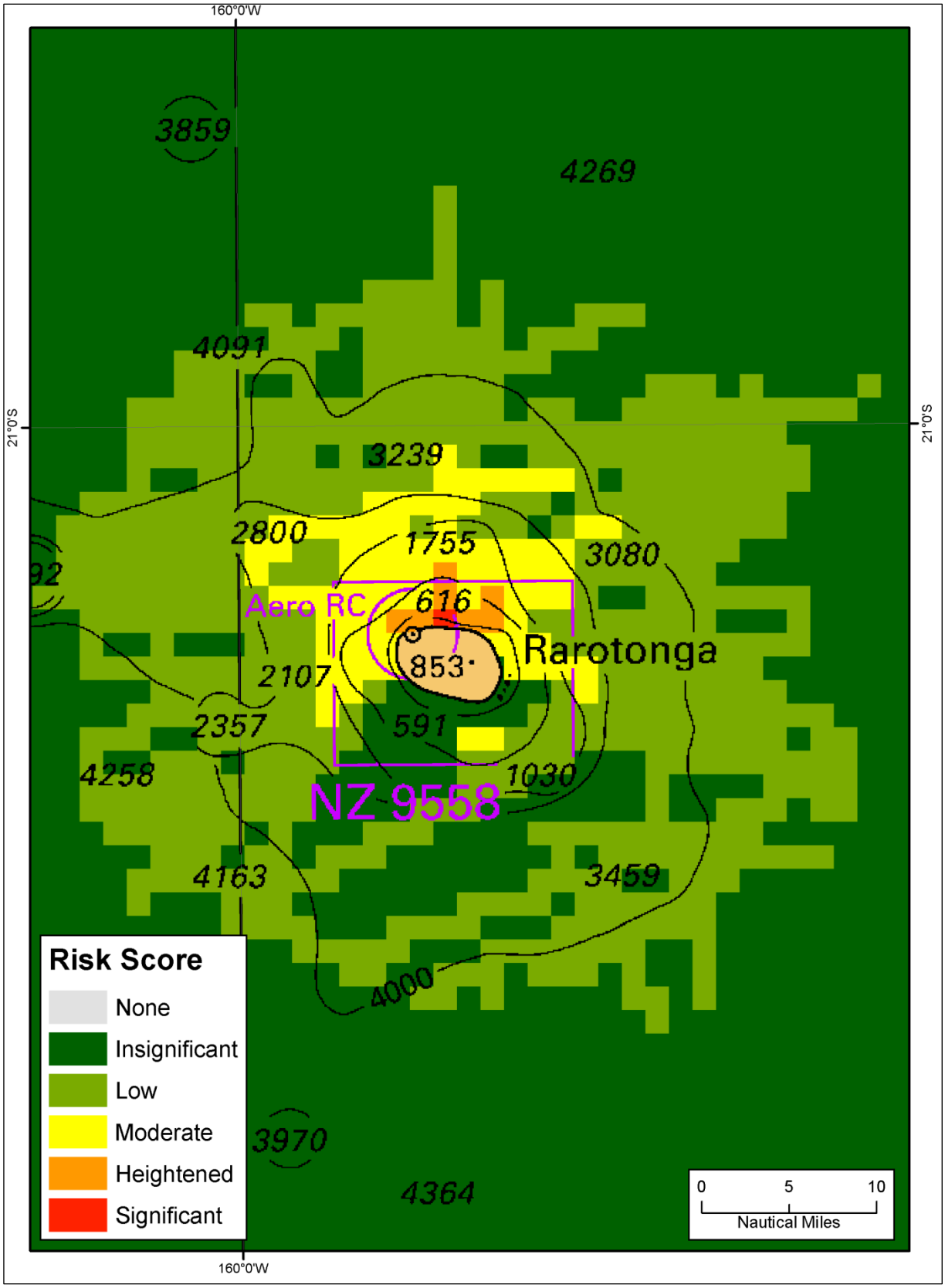


Figure 41: Risk Model Results in Rarotonga.

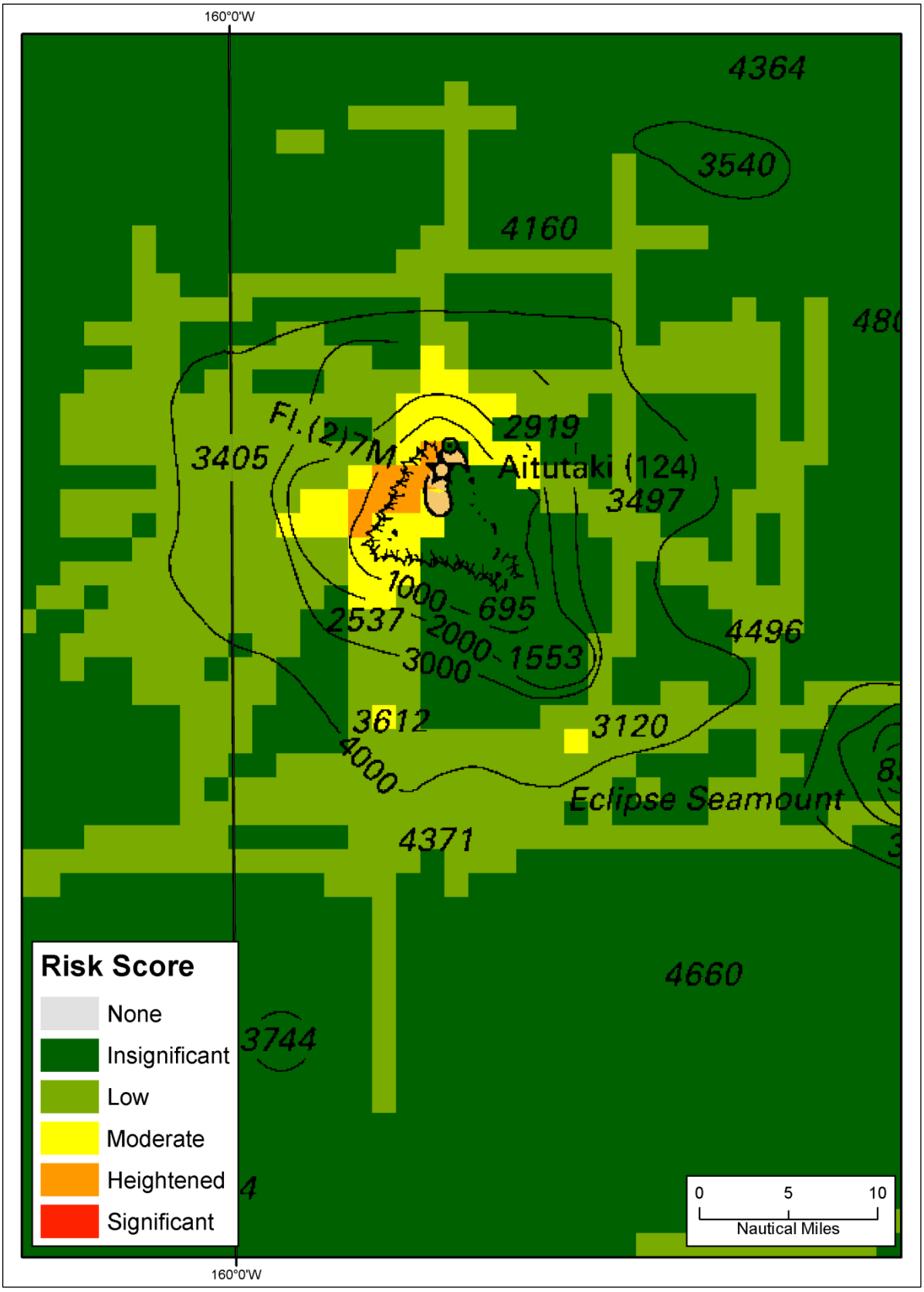


Figure 42: Risk Model Results in Aitutaki.

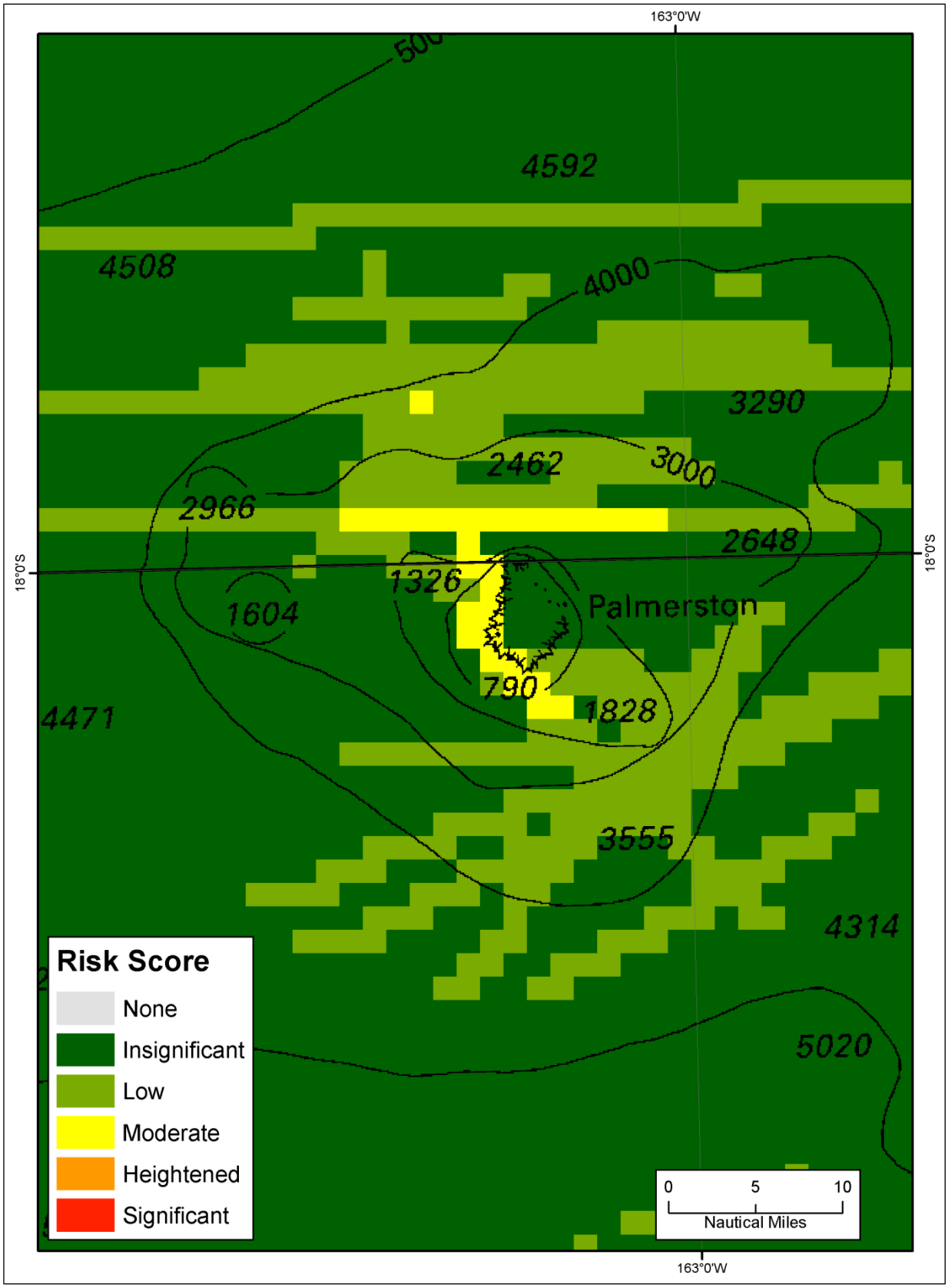


Figure 43: Risk Model Results in Palmerston.

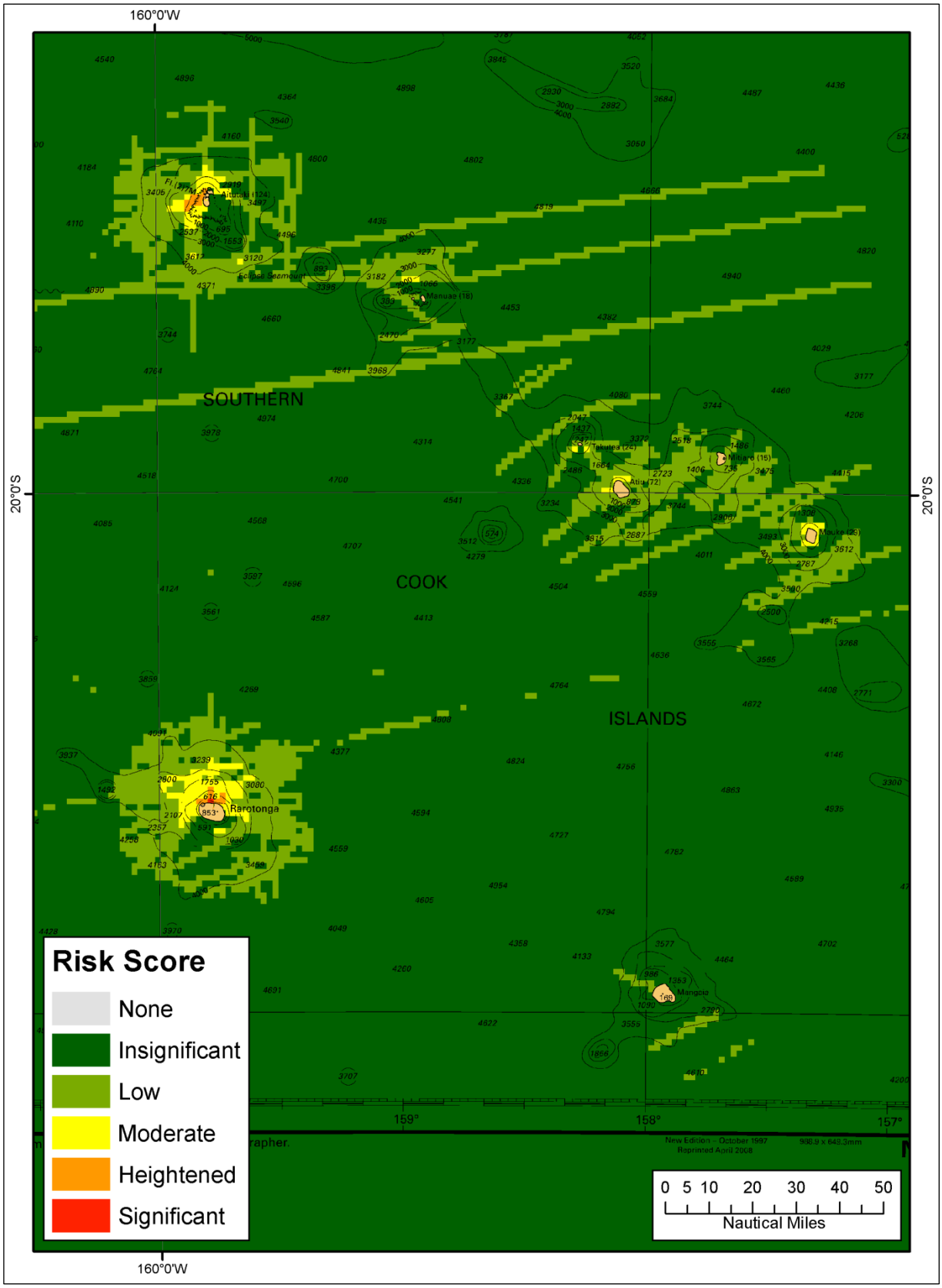


Figure 44: Risk Model Results in the Southern Cooks

7.6 COOKS ISLANDS HYDROGRAPHIC RISK – INTERNATIONAL DOMESTIC COASTAL VESSELS

Figure 45 shows the risk profile for the international fleet. The highest risk scores are generated around the islands of Rarotonga and Aitutaki where large numbers of vessels converge. Also evident is the significant numbers of large vessels crossing the Southern Cook Islands EEZ which was recently designated as a National Marine Park.

Figure 46 shows the risk level associated with domestic coastal vessel transits. As this is a risk associated with just one layer of the GIS against the risk matrix criteria for that level, the scale of risk for this individual layer is not the same as that for the risk assessment.

The licensed passenger capacity of the domestic fleet and the regularity of transits, both with respect to the routes always taken and the volume of transits is a driver of domestic vessel risk. The domestic fleets are far smaller and follow defined routes. This means many of the Northern Cook Islands exhibit higher domestic risk than international risk.

For the domestic fleet, the main difference in risk levels is because of the greater volume of traffic in Rarotonga associated with the service to Aitutaki.

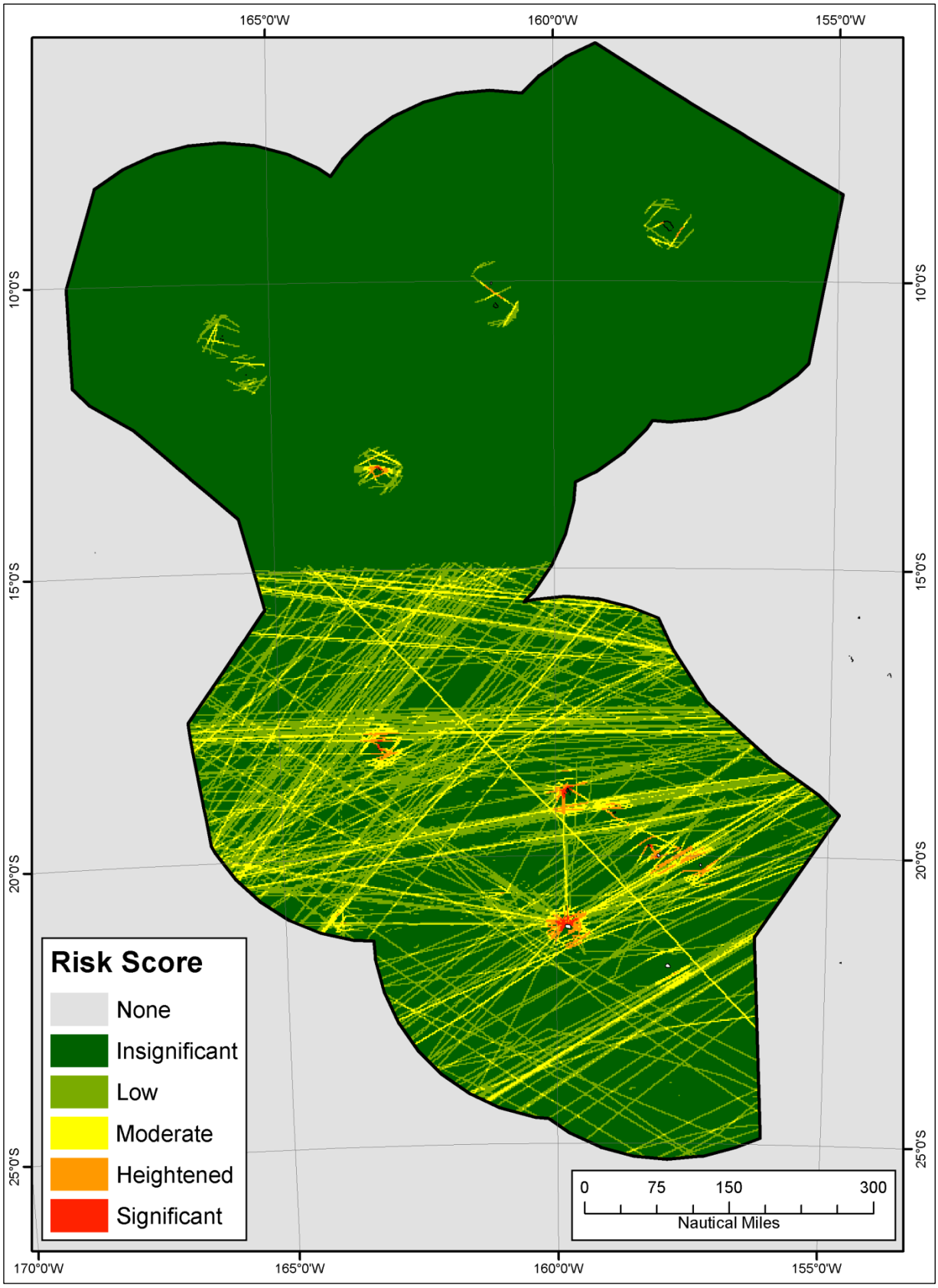


Figure 45: Modelled SOLAS Vessel Risk

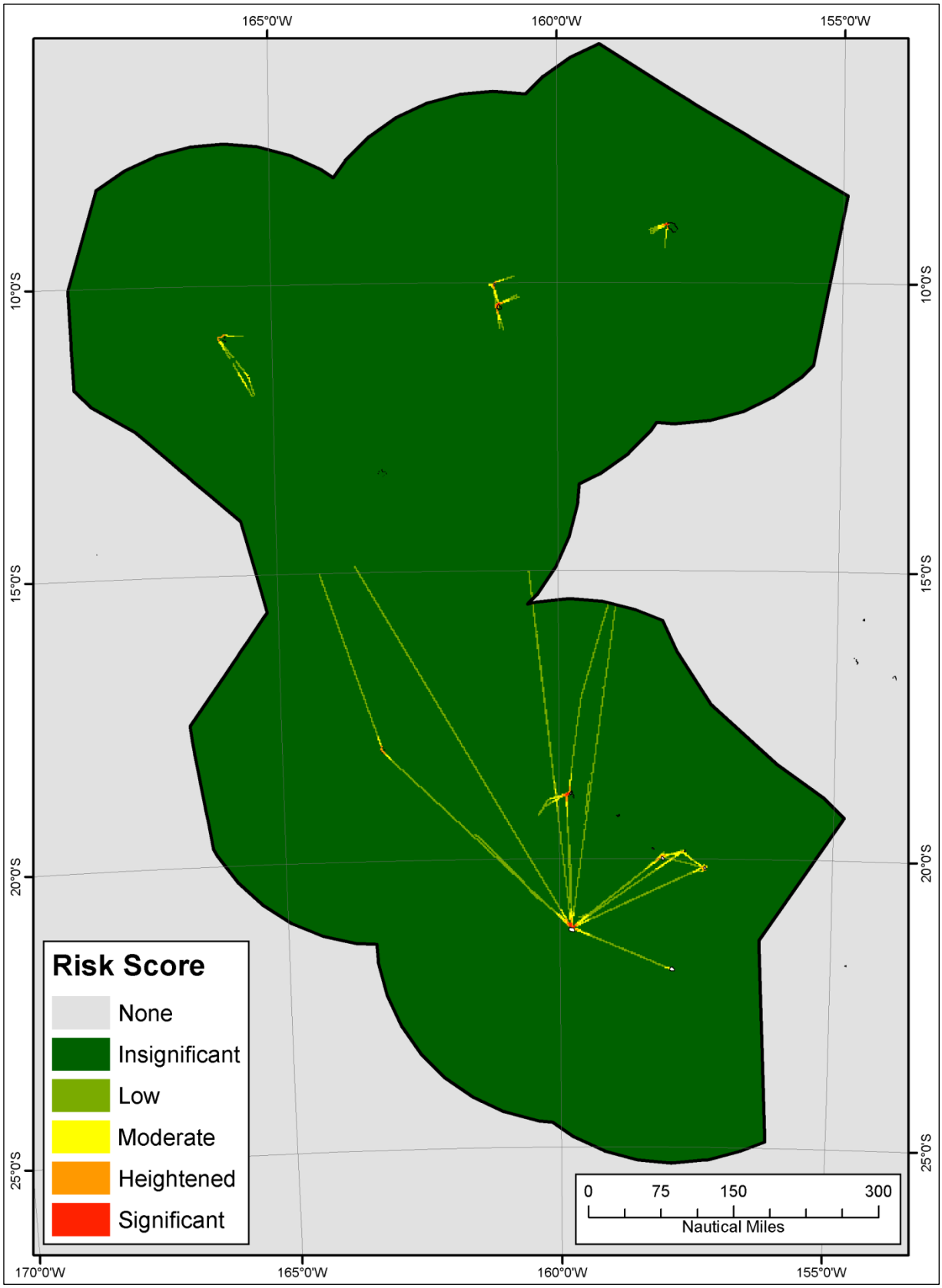


Figure 46: Modelled Domestic Vessel Risk

8 ECONOMIC ANALYSIS – COST BENEFIT ANALYSIS (CBA)

8.1 INTRODUCTION

The hydrographic risk methodology relies on evidence of economic growth, combined with ship transit risk (traffic volume, vessel type and size) in order to conclude a need for improved charting. The combination of economic increase and ship activity provides the body of evidence for trade growth on the basis of adequate and accurate charting.

In this section, the economic analysis does two things:

- It identifies and estimates the economic value (if not a benefit, the cost) that would be generated through charting upgrades, where needed.
- It takes account of the risk reduction obtained by charting improvements.

Subsequently, this analysis also determines the potential economic risks of no improvement to these charts. The net result is a measure of the cost benefit payback (or cost) of the surveys to improve charting. The results are presented in the same GIS format as the risk assessment.

8.1.1 CBA METHODOLOGY - OVERVIEW

To facilitate the above scenarios, the economic analysis delivers a cost benefit analysis (CBA) overlaid, cell by cell, onto the GIS risk model that quantifies the balance between maritime costs and benefits of a hydrographic survey, mathematically linked to the risk reduction achieved. It is based on the passenger and freight data of the Cook Islands, as well as survey costs, taken as an average of the various studies that report such costs.

The methodology identifies the net present values associated with charting upgrades and survey. It evaluates these against the safety benefits for SOLAS international and domestic coastal vessels. The safety benefits translate into a risk reduction, which itself is based on referenceable work from around the globe that has evaluated available risk reduction associated with charting improvements.

The derived cost of survey is calculated in the GIS CBA model and applied to each grid cell. The risk reduction available is then taken from the risk result in each grid cell. The overall benefit (or net costs) is calculated based on the difference between the risk results in Section 7, which

assumes no improvements to charts, when compared with a risk reduction available if charts are improved.

Finally, the net present function is employed to give an estimate of monetary return (or overall cost) on the investment needed in each grid cell to bring charting up to modern standards. The investment is based on independent work that established that ECDIS, used with accurate and adequate ENCs reduces grounding likelihood and improves situational awareness by about 36%[22] overall. The risk reduction benefit available by a charting upgrade from such a standard is higher.

It has to follow that the available risk reduction from charting improvements will vary, depending on the status (quality) of the chart that is to be resurveyed and upgraded (or indeed reorganised. LINZ are one Hydrographic Office employing the CATZOC categorisation of chart and data quality, which is a useful attribute for both the assessment of risk, as well as CBA calculations that need to establish a risk benefit for the CBA calculation.

A varying range of available risk reduction was developed, using the work by DNV as a benchmark. This is shown in Table 22, below.

Charting Upgrade Risk Reduction Available	
ZOC A	2.5%
ZOC B	5%
ZOC C	10%
ZOC D	20%
ZOC U	30%
Fathom Charts	45%

Table 22 : CBA Risk Reduction Relationship to ZOC Category

Annex C presents CATZOC plots for each of the islands of relevance to the CBA.

[22] DNV 2010 – Technical Data Report - Marine Shipping QRA: Enbridge Northern Gateway Project

A 10 year life cycle was assumed for CBA costing purposes. **Annex F** presents assumptions used in support of calculations for the scenarios derived, together with other supporting information.

8.1.2 CBA Data Sources (Key Data)

To successfully undertake a CBA as a GIS layer, linked to the risk result in each cell, required data in new areas that previous hydrographic risk projects had not needed. Some of this data varies considerably and was not readily available. Two key examples are:

- the cost of hydrographic survey, and
- the risk reduction that can be expected from a charting upgrade.

For the former, an internet search was undertaken, which served to emphasise the range of costs that occur, taking into account the fact that different technologies have different costs. One reference from SHOM, the French Hydrographic Office, provided formally referenceable data, suggesting surveys using singlebeam technology cost about 450 Euros per square kilometre. The internet provided data similar to that from SHOM. The following costs were averaged and singlebeam costs chosen for the CBA model.

- Low cost (satellite): 35 dollars per km squared;
- Low Medium Cost (single beam): 500 dollars per km squared;
- Medium cost (Multibeam): 1633.3 dollars per km squared Modelled cost; and
- Highest cost (Lidar): 2381.9 dollars per km squared (although LIDAR cost varied enormously).

Further information is attached as **Annex F**.

For the latter (risk reduction available from charting upgrade), work undertaken by Det Norske Veritas was reviewed, from a study originally undertaken to estimate the benefits of the introduction of ECDIS. This concluded that a risk reduction of 36% could occur from charting upgrades. Further work was then done in 2010 for a Canadian shipping channel, again referencing the same 36% value.

8.2 ECONOMIC ANALYSIS

8.2.1 BENEFITS OF HYDROGRAPHIC SURVEYS

Hydrographic survey data is a facilitator. Classically the data is integrated into ships' charts as a navigational aid; to provide the wherewithal for the ship to safely plan and undertake a voyage avoiding such hazards as dangerous shoals. The quality of hydrographic data determines the extent to which investors are prepared to undertake 'the shipping adventure', and insurers to underwrite the risk, to supply essential transportation services to nations such as the Cook Islands. 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 substandard shipping.

However, particularly 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 and development. It is now widely accepted that these benefits of hydrographic survey data, which are mostly unquantifiable in financial terms, outweigh those derived from its classic application, hence the common assessment that hydrographic data should be viewed as a public rather than private good. This is particularly so for the Cook Islands where the development of deep sea mining would not be practicable without such surveys one of the most important elements clear delineation of EEZ boundaries, to ensure the revenue secured is for the benefit of the Cook Islands.

Across the three shipping sectors hydrographic survey data delivers benefits in different ways. For the international shipping of freight, the principal benefit is assessed to be the maintenance of market stability with the opportunity to lever significant reductions in transportation costs. For domestic shipping, with a poor record historically – and recently – improvements in safety will flow from hydrographic data. Finally, for cruise tourism, hydrographic data arms planners with the information they require to identify suitable sites for future development, to access in particular the burgeoning Australian cruise market.

For the Cook Islands, a small population, thus limited commercial shipping – international and domestic – means, in purely financial terms, the benefits of hydrographic surveying to safety

are minimal and would not outweigh the costs. However, the ALARP test is one of disproportionate expense set against the benefit. On this measure, the investment is justified. Notwithstanding, hydrographic surveys have the potential to deliver significant financial returns for Cook Islands' cruise tourism sector subject, that is, to the establishment of an accommodating fiscal regime.

Commercial shipping relies on current hydrographic survey data. A hydrographic survey undertaken to the latest International Hydrographic Organization (IHO) standards[23] provides the following benefits:

- 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.
- Critical new shallows or shallows shallower than previously may be identified and appropriate actions taken.
- Facilitate revisions of fairways or routes, and planning of modified or new Traffic Separation Schemes.
- Enabling changed practices in navigation with new ECDIS[24] functionality (e.g. 3D navigation with real time dynamic water level in formation, precise warnings), with consequential reduction in environmental harm and insurance premiums.

These factors have been identified as causal to shipping companies using less efficient and capable vessels that are more likely to be involved in a maritime accident in areas with poor hydrographic data (Connon and Nairn, 2011).

Further, the International Convention for the Safety of Life at Sea (SOLAS) requires signatory states ensure current electronic navigation charts (ENCs) are available for ships navigating coastal waters[25]. Should a member state not fulfil this obligation, in addition to being a violation of international law, and the diplomatic ramifications thereto, insurers may decline to provide cover to vessels wishing to navigate its coastal waters, including ports.

[23] IHO S-100 Universal Hydrographic Data Model
[24] Electronic Chart Display and Information System
[25] Regulation 9 of SOLAS Chapter 5

8.2.2 ENC CHARTS

All ENC's are based on the World Geodetic System 84 (WGS84 datum) and are organized in so called Cells. The cells are allocated to defined scale ranges with a different degree of generalization or usage bands.

To comply with IMO requirements, a member state should develop accurate and adequate ENCs for all its waterways, including ports.

Beyond shipping, reflecting its 'public good' nature[26], hydrographic survey data delivers a wide range of additional benefits to maritime stakeholders as illustrated in the table below.

Indeed, the largest users of hydrographic data are typically developers, notably in the Cook Islands context the proponents of deep-sea mining, and planners.

Indeed, the largest users of hydrographic data are typically developers, notably port developers, and planners. The specific benefits of charting improvements to shipping in the Cook Islands are summarised at **Annex E.**

In summary, hydrographic data is a facilitator and should be considered as vital infrastructure, servicing exactly the same purpose as a mapped highway on land. Like all other types of infrastructure, it is a key to the door most likely to lead to economic prosperity. Put another way, without hydrographic data it would not be possible to efficiently conduct the activities shown in the table below.

Benefiting Activity	Hydrographic Data Type									
	Coastline	Coordinates	Current	Depth	Geo Description	UNCLOS Boundary Definition	Aids to Navigation	Sea Bottom Contours	Tide Levels and Datum	Wrecks
Aquaculture	X	X	X	X		X		X	X	
Cable / Pipe Laying	X	X	X	X	X	X		X	X	X
Coastal Zone Management	X	X	X	X	X	X	X	X	X	

[26] 'Public goods' are services in the public interest which would not be supplied at optimal levels by market forces alone

Benefiting Activity	Hydrographic Data Type									
	Coastline	Coordinates	Current	Depth	Geo Description	UNCLOS Boundary Definition	Aids to Navigation	Sea Bottom Contours	Tide Levels and Datum	Wrecks
Defence	X	X	X	X	X	X	X	X	X	X
Dumping		X	X	X	X	X			X	
Coastal Engineering	X	X	X	X	X	X		X	X	X
Environment	X	X	X	X	X	X		X	X	
Fisheries, Living Resources	X	X	X	X	X	X	X	X	X	X
Health: 'Red Tides'	X	X	X	X	X	X	X		X	
National Boundaries	X	X		X	X			X	X	
Scientific Research	X	x	X	X	X	X	X	X	X	X
Maritime Transport / Navigation	X	X	X	X	X	X	X	X	X	X
Natural Hazard Modelling	X	X	X	X	X	X	X	X	X	
Deep Sea Mining	X	X	X	X	X	X		X	X	X
Ports	X	X	X	X	X	X	X	X	X	X
Real Estate	X	X	X	X	X	X			X	
SOLAS	X	X	X	X	X	X	X		X	X
Sports	X	X	X	X	X	X	X	X	X	X
Tourism	X	X	X	X	X	X	X		X	X

Table 23: Beneficiaries of Hydrographic Survey Data (Source: FIG 2011)

Nevertheless, as highlighted above, the principal benefit derived from hydrographic surveying is mitigation of navigational risk, particularly vessel grounding, through the effective application of bathymetric (chart) data.

Figure 47 is a bow-tie representation of risk related to the vessel grounding hazard. Two potential causal events are identified: 'Powered Grounding', which includes human error due

to poor passage planning and / or loss of awareness – possibly due to deficiencies in the navigational information available; and, 'Unpowered Grounding' typically the result of propulsion and / or steering failure.

The consequence of vessel grounding is determined by a number of factors ranging between a 'most likely' – usually, but not always, a minor incident - and 'worst credible' outcome. The factors influencing consequence include vessel design, for example damage stability and maintenance; the competence of the crew (to manage an emergency situation); the nature of the seabed; and, environmental conditions.

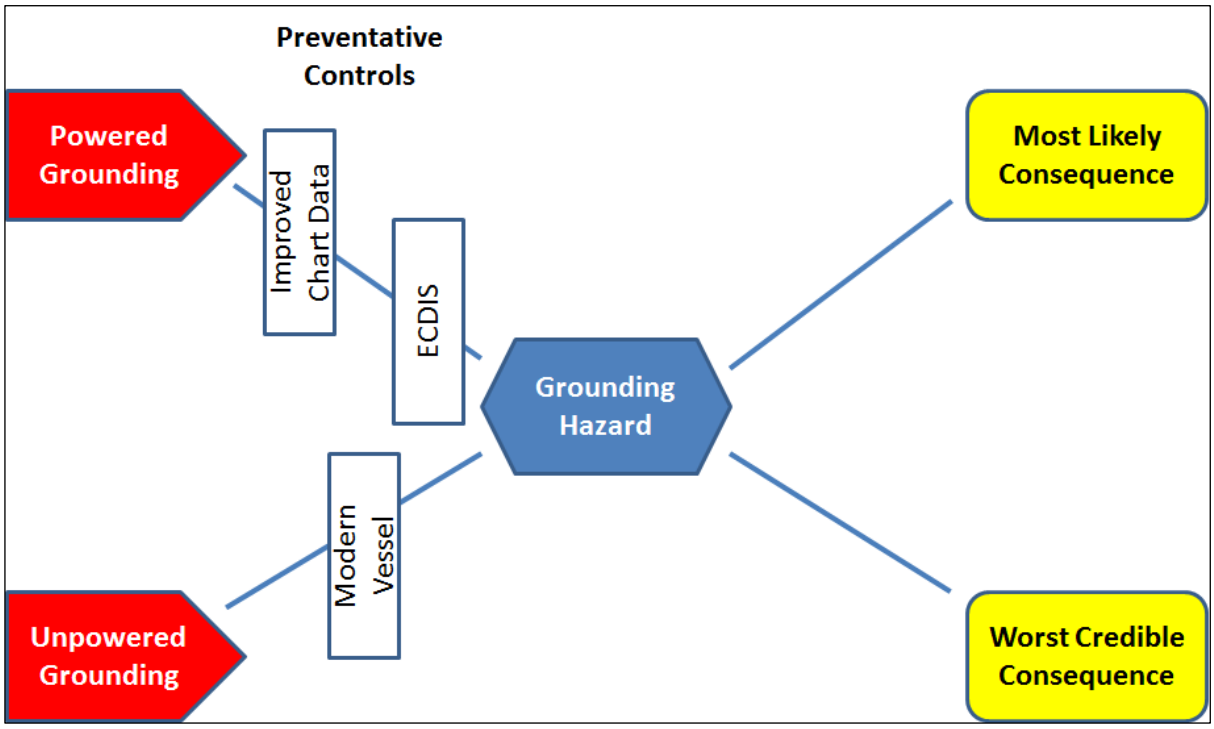


Figure 47: Bow Tie Representation of Grounding Risk

As shown on Figure 47, improved chart data is a risk control that directly mitigates the likelihood of a powered grounding, i.e., through facilitating ships' navigators' access to the most appropriate charts for the area of operation. Further mitigation may be achieved through application of ECDIS; a technology that reduces the probability of grounding related

to human error through provision of due warning if the vessel is standing into danger[27]. Carriage and use of ECDIS for ships' navigation is a requirement of SOLAS, as is the obligation on coastal states to deliver ENCs as referenced above. The reduction in grounding likelihood through used of ENCs and ECDIS is estimated to be 35% (DNV 2008).

It is important to note that the full benefits of ECDIS can only be realised if ENCs conforming to the latest IHO standards are used; and for navigation in near coastal waters, at least Usage Group 5. To produce ENCs best international practice suggests it is often more feasible and productive to completely re-survey sea areas where old survey data exists than try to use old data and estimate where it will be useful. Old datasets are in many cases inhomogeneous and partial re-surveys are inevitable (HELCOM 2013).

There are additional indirect benefits to navigational safety from a hydrographic survey. As previously remarked, areas that are poorly surveyed are assessed to be more likely served by old, unreliable vessels with a higher probability of propulsion failure. Conversely, as shown on Figure 47, modern vessels reduce the likelihood of unpowered grounding incidents.

8.3 COOK ISLANDS SHIPPING: EXISTING SITUATION

8.3.1 GEOGRAPHY

The Cook Islands comprises 15 small islands scattered over 1.8 million square kilometres of the South Pacific Ocean with a population of 14,974, the majority in Rarotonga (Cook Islands 2011).

The environment is one of the Cook Islands' major assets. The climate, topography, vegetation, reefs and lagoons make the country a popular tourist destination.

8.3.1.1 Economy

The Cook Islands' economic development is hindered by the isolation of the country from foreign markets, the limited size of domestic markets, lack of natural resources, periodic devastation from natural disasters, and inadequate infrastructure. Agriculture, employing more than one-quarter of the working population, provides the economic base with major

[27] ECDIS will not prevent a human violation, i.e., a deliberate act by an individual, usually the vessel master, to circumvent the safety controls in place to prevent (e.g.) vessel grounding.

exports of copra and citrus fruit. Black pearls are the Cook Islands' leading export. Manufacturing activities are limited to fruit processing, clothing, and handicrafts. An economic summary for the Cook Islands is shown in Table 24, below. The average wage is NZ$15,028 (Cook Islands 2011).

Economic Activity	2009-10	2010-11	2011-12
Nominal GDP ($'000)	345,380	356,960	377,540
Real GDP (at 2006 Price, $'000)	285,310	293,450	3030,040
GDP per capita	15,282	15,795	16,705
Productive Sector Indicators			
Visitor Arrivals	99,400	106,000	111,500
Est. Visitor Expenditures ($'000)	209,900	225,100	241,500
Total Exports ($'000)	5,827	5,746	5,717
Total Imports ($'000)	349,936	361,674	382,526
Containers Handled (TEU)	2,406	2,455	2,438

Table 24: Cook Islands Economic Summary

Source: Ports Authority Cook Islands

8.3.2 MARITIME TRANSPORT - INTERNATIONAL

The Cook Islands are primarily served by two small general cargo vessels operated by the US-based Matson Shipping[28]. The vessels sail every four weeks from New Zealand to Rarotonga and Aitutaki via a number of other Pacific islands including Tonga[29]. Freight rates are estimated to be similar to other Pacific islands.

Petroleum, liquefied and gas, is delivered to Rarotonga about once every six weeks typically in chemical tankers (Asian Development Bank 2013).

There is no significant demand for the shipment of dry cargoes in bulk to or from the Cook Islands. Nonetheless, there is the potential for deep-water mining within the Cook Islands EEZ.

[28] OLOMANA and LILOA
[29] Only the *OLOMANA* serves Aitutaki

8.3.3 DOMESTIC SHIPPING

As reported by the Ports Authority, domestic shipping operations in Cook Islands provide an unacceptable service to the outer islands from the main capital Rarotonga. Ensuring adequate, efficient and reliable domestic shipping services is seen one of the most difficult and perplexing challenges facing the nation (Tau 2013).

The Cook Islands has no dedicated, modern vessel for inter-island passenger and freight trades. The only licensed vessel, *TE KOUMARU II*, is a 37-year old 326 GRT[30] cargo vessel; the vessel bears some similarity to the *TYCOON* introduced above, but could reasonably be judged far worse. The servicing schedule is irregular due to infrequent and insufficient cargo volume to make advance shipping schedules.

This irregularity and poor quality of domestic shipping has an inevitable economic impact on the viable sustainability of the outer islands. The outcome is depopulation, regressive economic development and growth, and failing tourism. This is a major concern for the Cook Islands Government and will become a matter of priority for the immediate to long term future (APHoMSA 2010). Securing finance for new vessels would be dependent upon, amongst other things, investor confidence in their safety not least compliance with international requirements such as the availability of ENCs fulfilling IHO standards, and the carriage and use of ECDIS.

8.3.4 CRUISE SHIP TOURISM

Tourism is vital to the sustainable growth of the Cook Islands contributing 34.1% of its GDP (PIFS 13). Tourists must either arrive by air or sea. As noted previously, cruising is increasingly popular, providing the opportunity to visit multiple locations within a relatively short period.

Rather bucking the international trend, cruise ship tourism to the Cook Islands is in decline as shown in Table 25 below.

[30] Gross registered ton

	2007	2008	2009	2010	2011	2012
No. of Visiting Cruise Vessels	27	19	13	7	9	8
Passenger Numbers	21,512	17,736	13,870	4,362	6,632	4,532

Table 25: Cook Islands Cruise Arrivals

Source: PIFS 2013

The reasons for this are unclear although press reports suggest there is hostility amongst cruise lines to the Cook Islands' departure tax policy.

Those vessels continuing to visit the Cook Islands are predominantly 'boutique' liners on round-the-world cruises. Vessels exceeding 200m LOA can be accommodated at Rarotonga although this appears to be an increasingly rare event[31].

8.4 FUTURE DEVELOPMENTS

8.4.1 OVERVIEW

The economic drivers shaping the development of international commercial shipping are complex. The market is highly competitive and freight rates notoriously volatile.

Nonetheless, there are constants. Notably these include further penetration of containerisation into specialist trades and the wider adoption of hub-and-spoke operations referenced previously.

8.4.2 INTERNATIONAL TRADE

Trade to the Cook Islands is constrained by the dimensions of Rarotonga Port, which limits the maximum length of vessel that can be safely accommodated. Without major reconstruction, presumably through land reclamation, in all probability both financially unviable and environmentally undesirable – if practicable, there is no possibility that the Cook Islands will benefit from container feeder services, typically vessels of around 2800 TEU. Other than for specialist operations, vessels smaller than this are now rarely constructed[32].

[31] Cruise liners do not necessarily have to berth on a quay. They may anchor and use their launches to transport passengers ashore
[32] Less than 1% of new ship builds in 2013 were for vessels <1000 TEU (BV 2014)

In the short to medium term, the existing Matson service is assumed to operate to the Cook Islands. However, such services are under increasing pressure from dedicated container operators, whose rates are invariably less than niche operators such as Matson. To remain viable, Matson is assumed to have little option but to increase freight rates well in excess of general inflation to ports where it continues to exercise a de facto monopoly.

Furthermore, if existing charts are deleted or otherwise ENCs of appropriate Usage Groups are not developed, it is assumed Matson is forced to withdraw services from the Cook Islands, due to the unavailability of insurance cover. The by now ageing Matson vessels may be sold to an owner prepared to accept the risk of operating without insurance or, alternatively, a vessel similar to the *TE KOUMARU II* undertakes voyages to / from The Cook Islands in addition to its domestic programme.

Either way, the outcome is old, unreliable vessels with an increased likelihood of grounding amongst other potential hazards associated with such ships (see Figure 47). *TYCOON* incident at Christmas Island, December 2012, illustrates the practical risks faced by small island economies reliant on sub-standard ships: the port was closed for three months, the cost of wreck removal and pollution clean-up estimated to be AU$8.2 Million.

For the petroleum sector, the developments outlined previously, which have seen growth in product tanker size and consolidation of refining, are anticipated to escalate. Given recent opposition to the development of a tanker terminal at Rarotonga (Cook Islands News 2013), it can be concluded that firm proposals for new facilities are in existence for handling medium range tankers in the Cook Islands. It is uncertain if this will remove the continued reliance on small tankers drawn from the chemical trades, at inflated freight rates for shipment of fuel. In due course, if charts are withdrawn and / or ENCs of the appropriate Usage Group not developed, as for general cargo, it is reasonable to assume lack of insurance will render these tankers unavailable. In such circumstance, the Cook Islands may be forced to rely on the delivery of fuel by general cargo ship, as deck cargo, with the consequential risks this brings.

8.4.3 OTHER VESSEL OPERATIONS

Deep water mining is now seen to be economically viable (SPC-EU 2014). Extensive deposits of gold and similar high value commodities have been discovered within the Cook Islands Exclusive Economic Zone (EEZ), with licenses for development granted or in the process so

being. One full mining operation is estimated to produce export revenues of up to US$500m per annum and taxes / royalties of up to US$50m per annum (SPC-EU 2014).

Offshore mining requires suitable ports; to transport the recovered ore to markets; to provide service bases, and shelter, for the support vessels deployed; and, to serve as hubs for the movement of equipment and personnel to / from the mining sites.

Although there are many other factors / issues to resolve to successfully develop deep-sea mining in the Cook Islands, it is reasonable to infer that a hydrographic survey, to identify suitable sites for port development and develop ENCs, would be an essential requirement. Consequently, at least in some part, the potential economic benefits from deep-sea mining would directly attributable to the hydrographic survey.

8.4.4 DOMESTIC VESSEL OPERATIONS

The safety benefits of hydrographic surveys to domestic shipping in the Pacific islands were alluded to above. Should chart data decline in quality, it is reasonable to assume risk to navigation will increase beyond what are already elevated levels, particularly in port approaches. Noting that the existing vessel operating the service may be doing do without insurance, the development of appropriate ENCs will not materially improve matters. Nevertheless, it would be key to securing investment for a suitable replacement similar to the *'OTUANGA'OFA* presently operating in Tongan waters although it would be sensible to ensure the vessel has the capability to undertake voyages to / from The Cook Islands to fill the gap left by the envisaged loss of the Matson service.

8.4.5 CRUISE TOURISM

As noted above, in contrast with other markets, Cook Islands cruise tourism is at best stagnant, at worst in serious decline. If charts are withdrawn and / or not replaced by appropriate ENCs, it is reasonable to assume the remaining vessels will leave the islands. Conversely, with provision of ENCs, the existing trade will further develop.

As also noted above, the physical constraints of Cook Islands ports mean that only 'boutique' size vessels may visit, typically carrying around 420 passengers and crew. What hydrographic surveys potentially offer, however, is the opportunity to open up additional Cook Islands'

ports for ship visits, with pro-rata increases in revenue. Table 27, below, references the assumptions made for Economic Analysis.

Scenario Assumptions			
Sector		**Status Quo**	**Survey to IHO Standards**
General Cargo	**Short Term (5 Years)**	Continued use of small, ageing vessels by Cargo Liner Lines. Freight rates increase twice rate of inflation.	As for status quo
	Medium Term (5-10 Years)	Cargo Liner Lines forced to increase rates four times rate of inflation	Confidence returns to market Proposals to develop new vessel to term Cook Islands domestic and international trades Deep sea mining develops
	Long Term (>10 Years)	Cargo Liner Lines terminate management contract Increased use of airfreight *Te Koumaru II* switched to trade to / from The Cook Islands as well as serving islands Vessel suffers catastrophic failure on approach to Rarotonga carrying petroleum as deck cargo. Port closed for extended period, high clear-up costs Severe food and fuel shortages across the islands	Regular service to The Cook Islands and outer islands on specialist vessel carrying general freight and petroleum in ISO containers Deep sea mining commences

Scenario Assumptions			
Sector		**Status Quo**	**Survey to IHO Standards**
Petroleum	**Short Term**	Continued use of small chemical tankers Freight rates increase three times rate of general inflation	As for status quo
	Medium Term	Freight rates continue to escalate at up to 5 times general rate of inflation Warning issued that tanker operators will withdraw service if suitable ENCs are not provided	As for status quo
	Long Term	Tanker service withdrawn Service switches to deck cargo on replacement general cargo vessel Incident scenario as for general cargo	Fuel shipment switched to ISO container ISO containers readily transportable to outer islands to address fuel crises and meet needs of deep-sea mining
Domestic Shipping	**Short Term**	Passenger – no service Freight reliant on irregular service	As for status quo
	Medium Term	Vessel suffers catastrophic mechanical failure/wrecked/scrapped Finance for replacement cannot be secured as insurance cannot be secured Accelerated decline of outer islands' economies	As for general cargo
	Long Term	No effective service other than by air Outer islands' economies in further decline	As for general cargo – passenger and freight service with new vessel Extensive operation by offshore support vessels, for deep-sea mining
	Short Terms	Continued decline sees maximum 3 or 4 'boutique' vessels visiting, who are reluctant to due to lack of ENCs; increased insurance costs	As for short term

Scenario Assumptions			
Sector		**Status Quo**	**Survey to IHO Standards**
Cruise Tourism			
	Medium Term	No cruise tourism	Two new ports identified Departure tax withdrawn Each port served by ten vessels spending minimum of two days in each of three ports
	Long Term	No cruise tourism	Cruise visits increase to twenty per annum, each spending minimum two days in each of three ports

Table 26: Assumptions for Economic Analysis

8.5 INTERNATIONAL SHIPPING

8.5.1 SAFETY BENEFITS

Most vessels recorded exercise the right of innocent passage through Cook Islands waters; given the very deep water surrounding the Cook Islands, the existing ENCs with higher CATZOC are broadly adequate to ensure the safety of these vessels, although they may benefit from island positions being more accurately recorded. Consequently only a smaller subset of vessels, those visiting and of the Cook Islands would secure benefit from ENCs of higher CATZOC rating, therefore the benefits are marginal.

Noting also the physical constraints imposed by Rarotonga port, improved charts would have no material impact on the *type* of vessel delivering freight to the Cook Islands, whether this freight is of a general nature or petroleum.

8.5.2 ECONOMIC BENEFITS

For international shipping the principal economic benefit derived from hydrographic survey data is market stability. In other words, more certainty that the Cook Islands will continue to be served by quality operators particularly if insurance is forthcoming through use of modern

ENCs. In the long term, however, the Cook Islands will need to secure investment for a suitable vessel covering both domestic and international trades. This is assessed to be possible only if suitable and adequate paper charts and ENCs have been developed.

8.6 DOMESTIC SHIPPING

In the short to medium term, Hydrographic data (ENCs) is envisaged to deliver little direct economic benefit for Cook Islands domestic shipping, both passenger and freight. The existing vessels, despite limitations are likely to remain in continued use.

For quantification purposes, a risk model was developed based on published research data. The detail of the assumptions used in the model is included at Annex F. From the model the risk, in financial terms, without ENCs has been estimated for each $1km^2$ within the Cook Islands Extended Economic Zone (EEZ) and compared with the estimated (reduced) risk with ENCs; to an approximation, ENCs are estimated to reduce grounding probability depending on the status (quality) of the chart that is to be resurveyed and upgraded (or indeed reorganised (CATZOC categorisation). No significant benefits to safety are identified.

However, as outlined in the introduction, there is a positive correlation between the quality of hydrographic data and shipping, and vice versa. With suitable ENCs there is a higher probability of securing investment in modern vessels and, with that, a reduced likelihood of incidents.

Quantification of this benefit in financial terms is problematic. Nonetheless, taking into account the extent of harm to the Cook Islands' pristine environment should a worst credible incident occur involving, e.g., *TE KOUMARU II,* it is difficult to argue that investment in hydrographic surveying would be disproportionate to the potential benefit secured, the 'classic' test for determining whether risk is being maintained As Low As Reasonably Practicable (ALARP).

Above this, there is the anticipated development of deep sea mining, facilitated in some part by hydrographic surveys. The direct benefits to the economy of deep sea mining were alluded to previously.

8.7 CRUISE TOURISM

Notwithstanding the increase in cruise tourism worldwide, the number of cruise passengers visiting the Cook Islands has decreased in recent years. There are a number of factors underpinning this situation including, for example, the reportedly unpopular imposition of a departure tax on vessels. There would appear to be little likelihood of the situation improving in the short to medium term. In the longer term, without suitable ENCs, and lack of insurance cover, it is reasonable to assume all cruise liners will withdraw from the Cook Islands market.

Taking into account the above, the safety benefits of hydrographic survey are minimal. With few ships visiting, the existing risk is low and likely to decrease to zero with the loss of the remaining trade.

As previously highlighted, whilst not ensuring the future of cruise tourism in the Cook Islands, hydrographic surveys – and the resulting high Usage Band ENCs – are a key facilitator of such development. Planners may objectively seek to develop new port opportunities for cruise liners in the knowledge that suitable channels previously only suspected as existing can be proven and appropriately provided with aids to navigation (buoys and beacons), optimally located through access to the necessary data[33]. On the basis of that assumption, noting the expenditure of both passengers and crew in each port, and the estimate of employment generated (Worley and Akehurst 2013), are shown in Figure 48. Two scenarios are modelled post 2018. The 'low growth' scenario assumes, from 2018, and the publication of new ENCs, each visiting liner – of 'boutique' size – visits three ports for one day only. The 'high growth' scenario assumes increased ship visits with the removal of the departure tax, thereafter each ship staying in each port for two days.

[33] For a given length and breadth, the draught of a cruise liner is far less than that of a cargo ship or tanker. Further, cruise liners are far more manoeuvrable and may therefore safely enter restricted areas unsuitable for cargo ships. Finally, as noted above, cruise liners are provided with suitable launches and do not require a berth alongside, thus, full port facilities are not required.

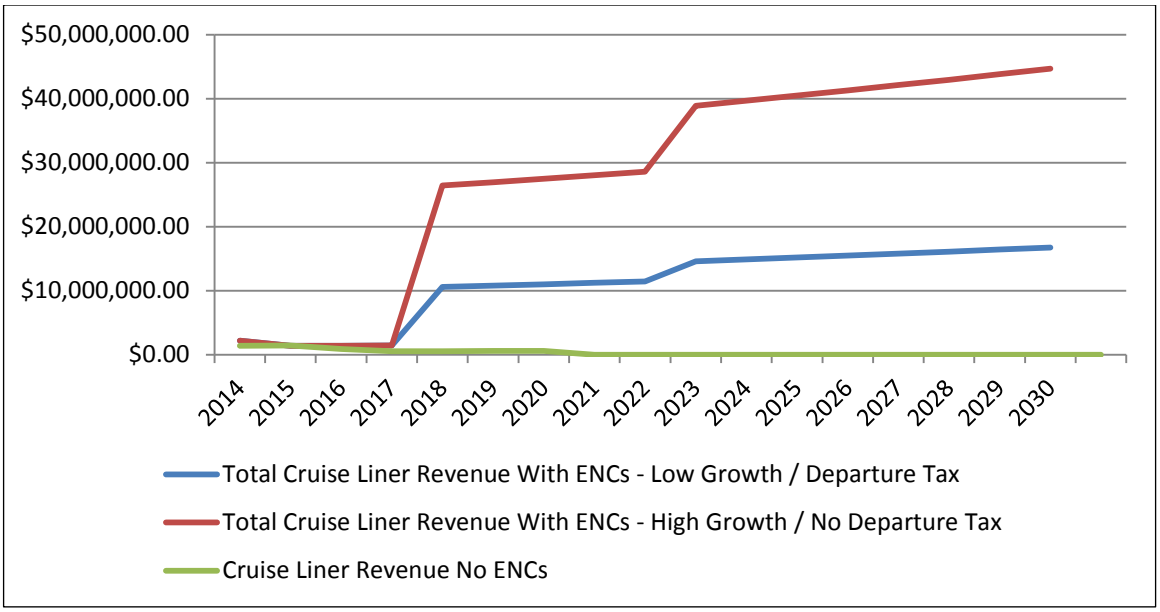


Figure 48: Estimated Revenue Generation for Cruise Tourism in the Cook Islands

8.8 OTHER BENEFITS OF CHARTING IMPROVEMENTS

There are a number of other areas where charting improvements are in the wider public interest. The first is Aid Relief after a significant natural event. Accurate charting allows planning for cargo delivery into areas other than designated ports, which may be inaccessible following a natural event. Aid can also be delivered directly to where it is needed by e.g. landing craft, if charting is accurate throughout a coastline. The second area is sea level inundation from climate change. Accurate high quality hydrographic survey data is of significant value in measuring sea level change over a considerable period of time.

8.9 COST BENEFIT ANALYSIS RESULTS

8.9.1 COOK ISLANDS COST BENEFITS RESULTS

Figure 47 presents the maritime cost-benefit result for the Cook Islands, overall, followed by further plots to detail the result. The model assumes single beam hydrographic survey costs and a percentage grounding risk reduction related to the ZOC rating of the chart as shown below:-

Charting Upgrade Risk Reduction Available	
ZOC A	2.5%
ZOC B	5%
ZOC C	10%
ZOC D	20%
ZOC U	30%
Fathom Charts	45%

Table 27: Risk Reduction Available in Relation to Existing Charting Standard

The period of benefit assessment is ten years. Each grid cell in the GIS outputs a Net Present Value (NPV).

Overall, the Cook Islands present an average negative NVP return. This is explained by only modest vessel movement numbers in the coastal and harbour water areas, when compared to other areas of the SW Pacific. The cost-benefit from an economic perspective is marginal both for the Southern and the Northern Cook Islands. The only areas where the Net Present Value is positive are the deep sea traffic routes around Rarotonga, Aitutaki and Atiu islands. This is the result of a "slight concentration" of traffic (SOLAS and domestic vessels), when compared to the other areas.

Although there is no clear financial benefit, there are some significant safety benefits to be gained by improvements to the accuracy and adequacy of charting. These are not necessarily measured by cost benefit analysis, which takes account of the lower volume of shipping in this part of the South West Pacific, when compared with other areas of study. Increasing safety

margins for cruise as well as domestic vessels needs to be undertaken despite it appearing to be less cost effective, when compared to other areas of the SW Pacific that enjoy higher ship traffic volumes.

The following subsections investigate the Northern and Southern Cooks cost-benefit analysis. A sensitivity analysis is also provided based on the different hydrographic survey costs that are publically recorded.

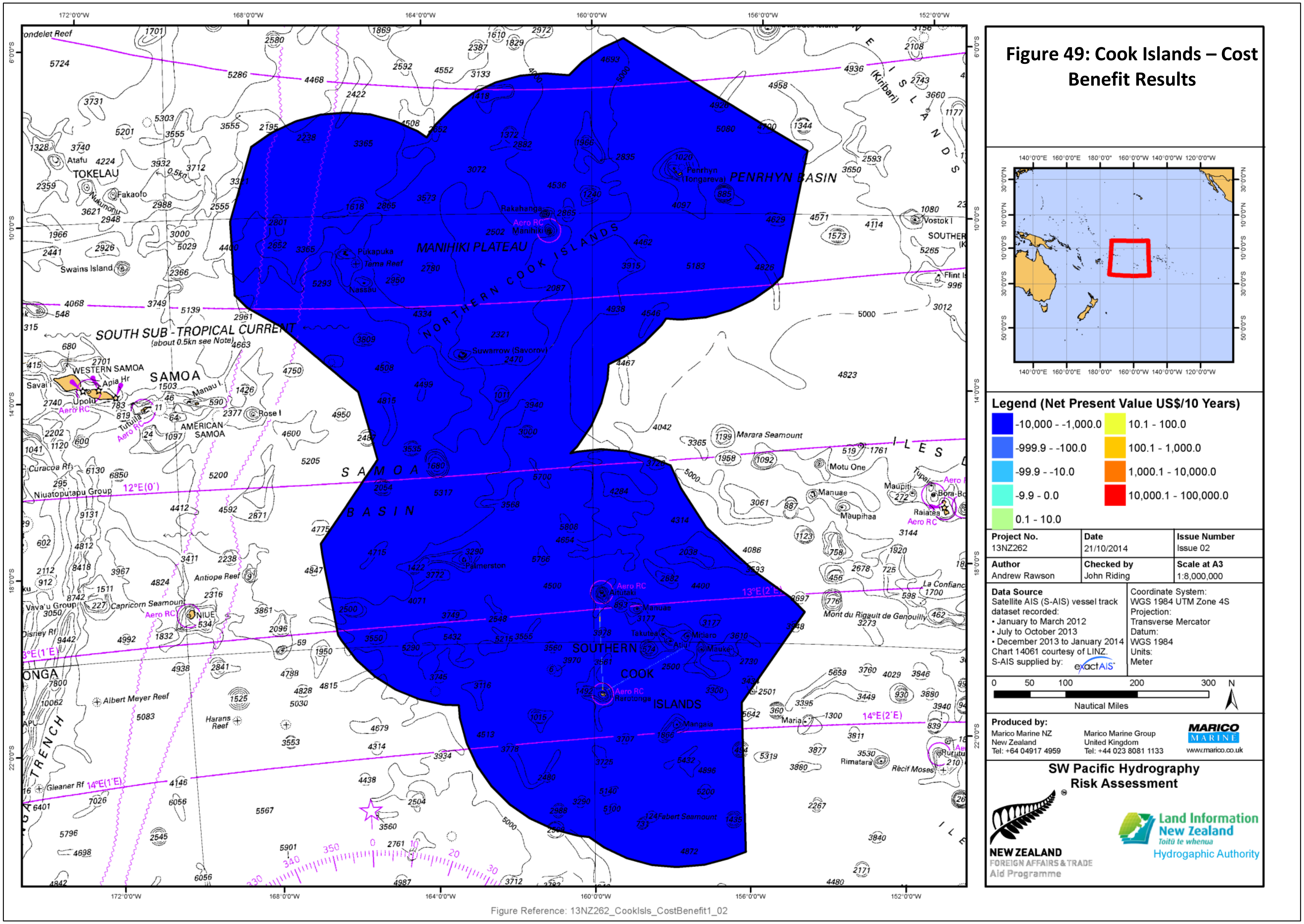


Figure 49: Cook Islands – Cost Benefit Results
Legend (Net Present Value US$/10 Years)
-10,000 - -1,000.0
-999.9 - -100.0
-99.9 - -10.0
-9.9 - 0.0
0.1 - 10.0
10.1 - 100.0
100.1 - 1,000.0
1,000.1 - 10,000.0
10,000.1 - 100,000.0
Project No. 13NZ262
Date 21/10/2014
Issue Number Issue 02
Author Andrew Rawson
Checked by John Riding
Scale at A3 1:8,000,000
Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
• January to March 2012
• July to October 2013
• December 2013 to January 2014
Chart 14061 courtesy of LINZ.
S-AIS supplied by: exactAIS
Coordinate System: WGS 1984 UTM Zone 4S
Projection: Transverse Mercator
Datum: WGS 1984
Units: Meter
Nautical Miles
Produced by:
Marico Marine NZ
New Zealand
Tel: +64 04917 4959
Marico Marine Group
United Kingdom
Tel: +44 023 8081 1133
www.marico.co.uk
SW Pacific Hydrography Risk Assessment
NEW ZEALAND FOREIGN AFFAIRS & TRADE Aid Programme
Land Information New Zealand Toitū te whenua Hydrographic Authority
MANIHIKI PLATEAU
PENRHYN BASIN
NORTHERN COOK ISLANDS
SOUTHERN COOK ISLANDS
SAMOA BASIN
SOUTH SUB-TROPICAL CURRENT
TOKELAU
SAMOA
AMERICAN SAMOA
TONGA
NIUE
Rarotonga
Aitutaki
Palmerston
Suwarrow (Suvorov)
Pukapuka
Nassau
Manihiki
Rakahanga
Penrhyn (Tongareva)
Figure Reference: 13NZ262_CookIsls_CostBenefit1_02

8.9.2 NORTHERN COOK ISLANDS COST BENEFITS RESULTS

Figure 50 shows the cost-benefit results for the Northern Cook Islands. On average, the cost-benefit analysis produces negative NVP levels. The underlying factor driving this result is the low traffic density for both SOLAS and domestic vessels. The traffic risk input associated with the hydrographic risk model is minimal and does not produce a positive outcome.

The overall economic benefits of a hydrographic survey will not outweigh the costs of producing electronic charts. However, there are other reasons for updating the Cook Islands, meaning the financial attractiveness is marginal for the Northern Cooks. As the cost benefit assessment seeks to measure overall economic benefit to the Cook Islands economy, it is the economic return that is difficult to deliver. However this is different to the safety risk as measured by the hydrographic risk assessment. A criteria for any decision for aid funding is because there is a safety benefit (and the risk assessment shows there is), but no obvious financial return from the investment. The decision to invest in measures that will clearly improve safety is still valid in such circumstances.

There is an area of heightened risk result in the Northern Cooks waters; at Penrhyn. A review of the lagoon entrance and transit to Omoka wharf at Penrhyn does provide a safety benefit. The aids to navigation are also of relevance here, including the transit across the lagoon. The safety benefit accrues to domestic vessels and the fisheries protection service.

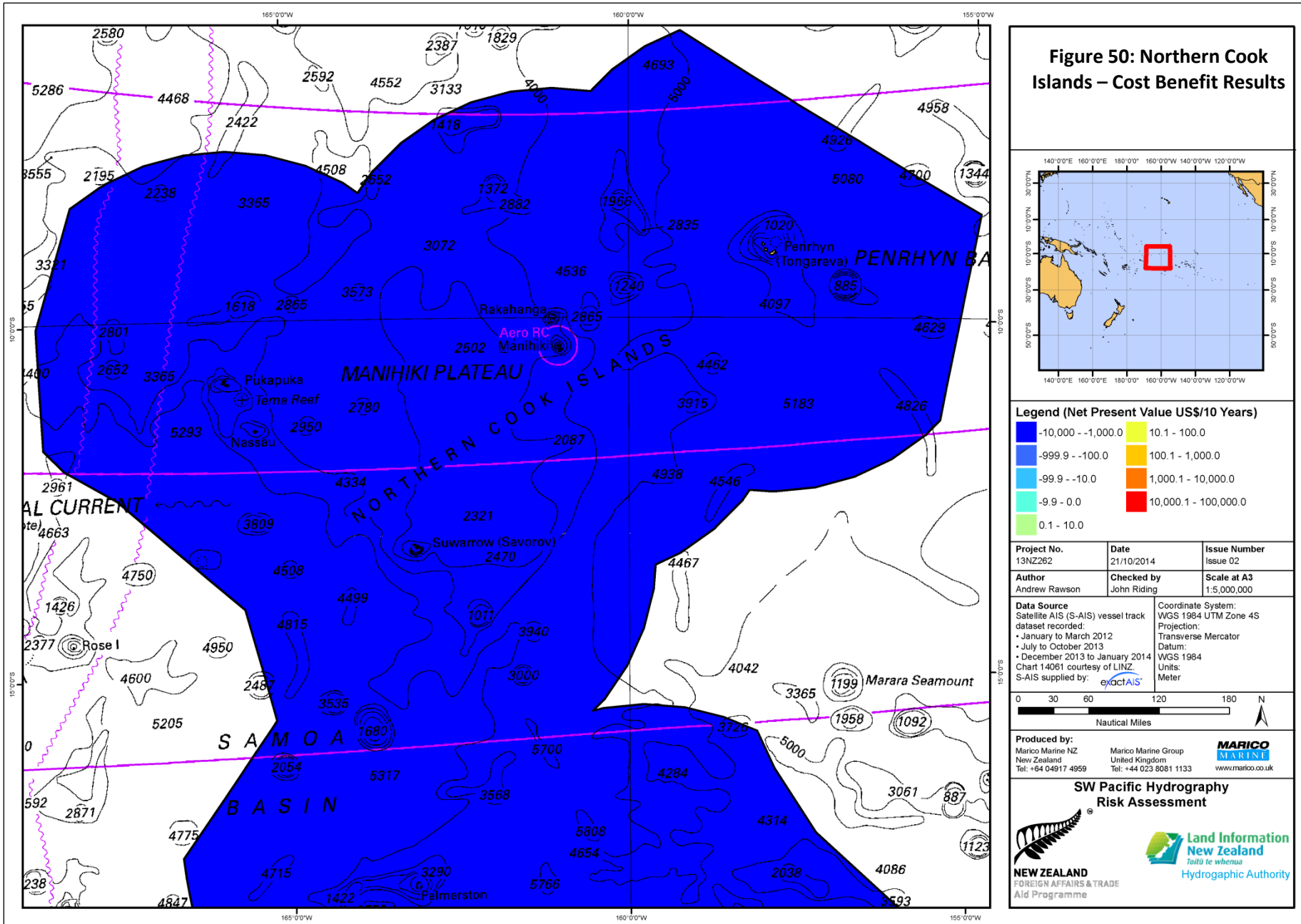


Figure 50: Northern Cook Islands – Cost Benefit Results

Figure Reference: 13NZ262_CookIsls_CostBenefit4_02

8.9.3 SOUTHERN COOK ISLANDS COST BENEFIT RESULTS

Figure 51 presents the cost-benefit results for the Southern Cook Islands. There is a minimal Net Present Value throughout the Southern Cooks. Given that traffic levels through the waters of the Southern Cooks are relatively higher than those found in the Northern Cooks, the only areas that show cost-effective returns from charting improvements are the following:-

- The deep sea shipping route between Rarotonga and Aitutaki.
- The deep sea shipping route between Rarotonga and Atiu.

Figure 52 shows that there are negative NVP cells around the coastline of Rarotonga. The nautical charts have a better quality of ZOC ratings for Rarotonga, as well as for Aitutaki and Atiu. This is attributed to the low likelihood of grounding in restricted or harbour water areas.

The cost benefit return from charting upgrade is low overall for the Southern Cook Islands. However, there are areas where safety benefit can be gained. Areas of notable risk result include Rarotonga and Aitutaki, both of which have the highest traffic levels in Southern Cooks. In the case of Aitutaki, the benefit to port development is also a factor.

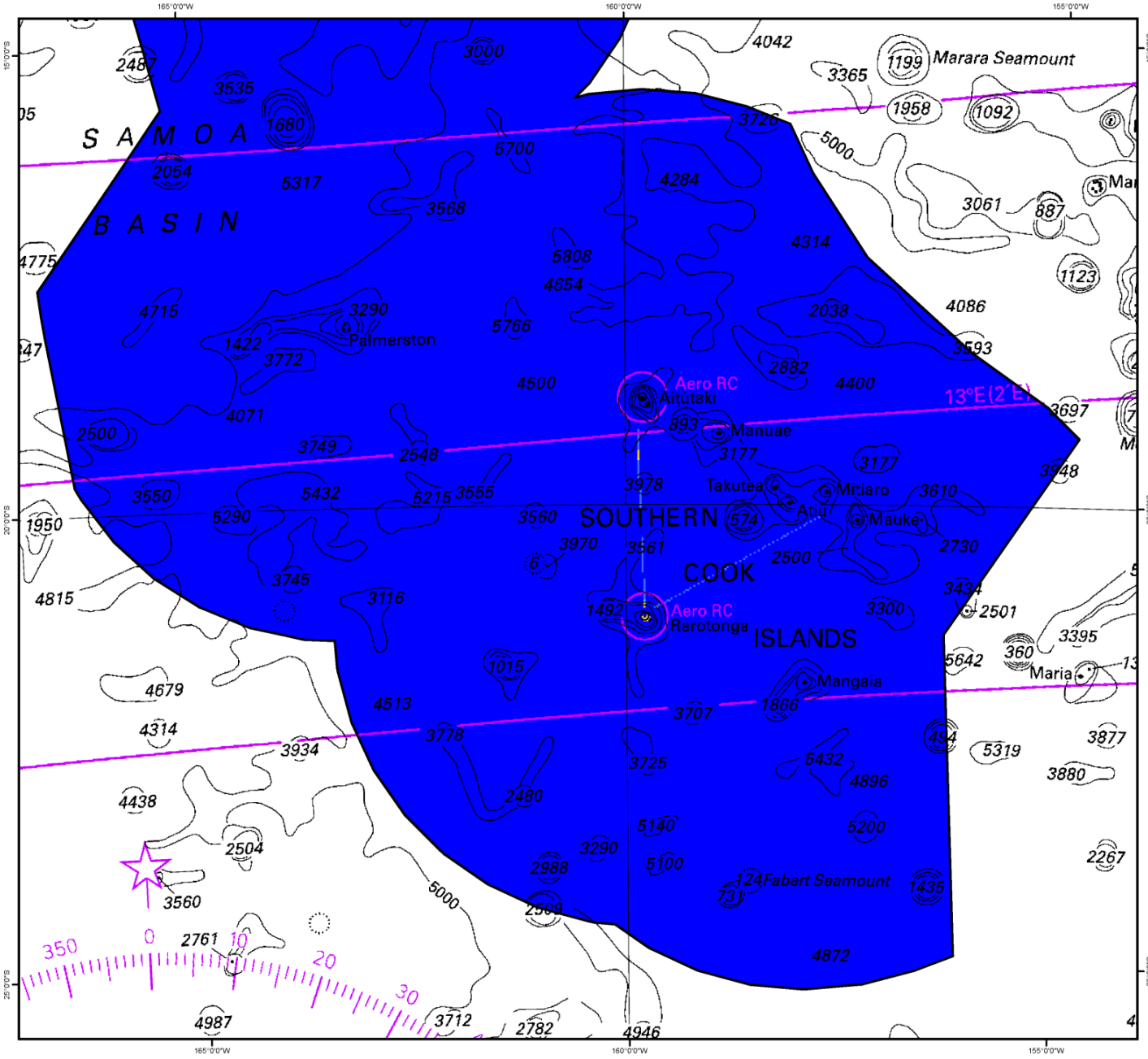
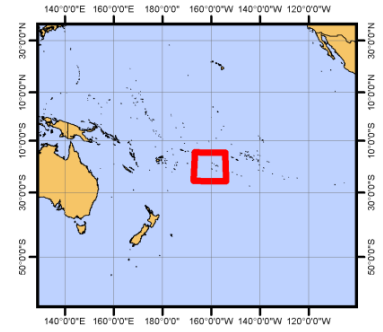


Figure 51: Southern Cook Islands – Cost Benefit Results



Legend (Net Present Value US$/10 Years)

- -10,000 - -1,000.0
- -999.9 - -100.0
- -99.9 - -10.0
- -9.9 - 0.0
- 0.1 - 10.0
- 10.1 - 100.0
- 100.1 - 1,000.0
- 1,000.1 - 10,000.0
- 10,000.1 - 100,000.0

Project No.	Date	Issue Number
13NZ262	21/10/2014	Issue 02
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:4,400,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
- January to March 2012
- July to October 2013
- December 2013 to January 2014

Chart 14061 courtesy of LINZ.
S-AIS supplied by: exactAIS

Coordinate System:
WGS 1984 UTM Zone 4S
Projection:
Transverse Mercator
Datum:
WGS 1984
Units:
Meter

0 25 50 100 150 N
Nautical Miles

Produced by:
Marico Marine NZ
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United Kingdom
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SW Pacific Hydrography Risk Assessment

NEW ZEALAND
FOREIGN AFFAIRS & TRADE
Aid Programme

Land Information New Zealand
Toitū te whenua
Hydrographic Authority

Figure Reference: 13NZ262_CookIsls_CostBenefit3_02

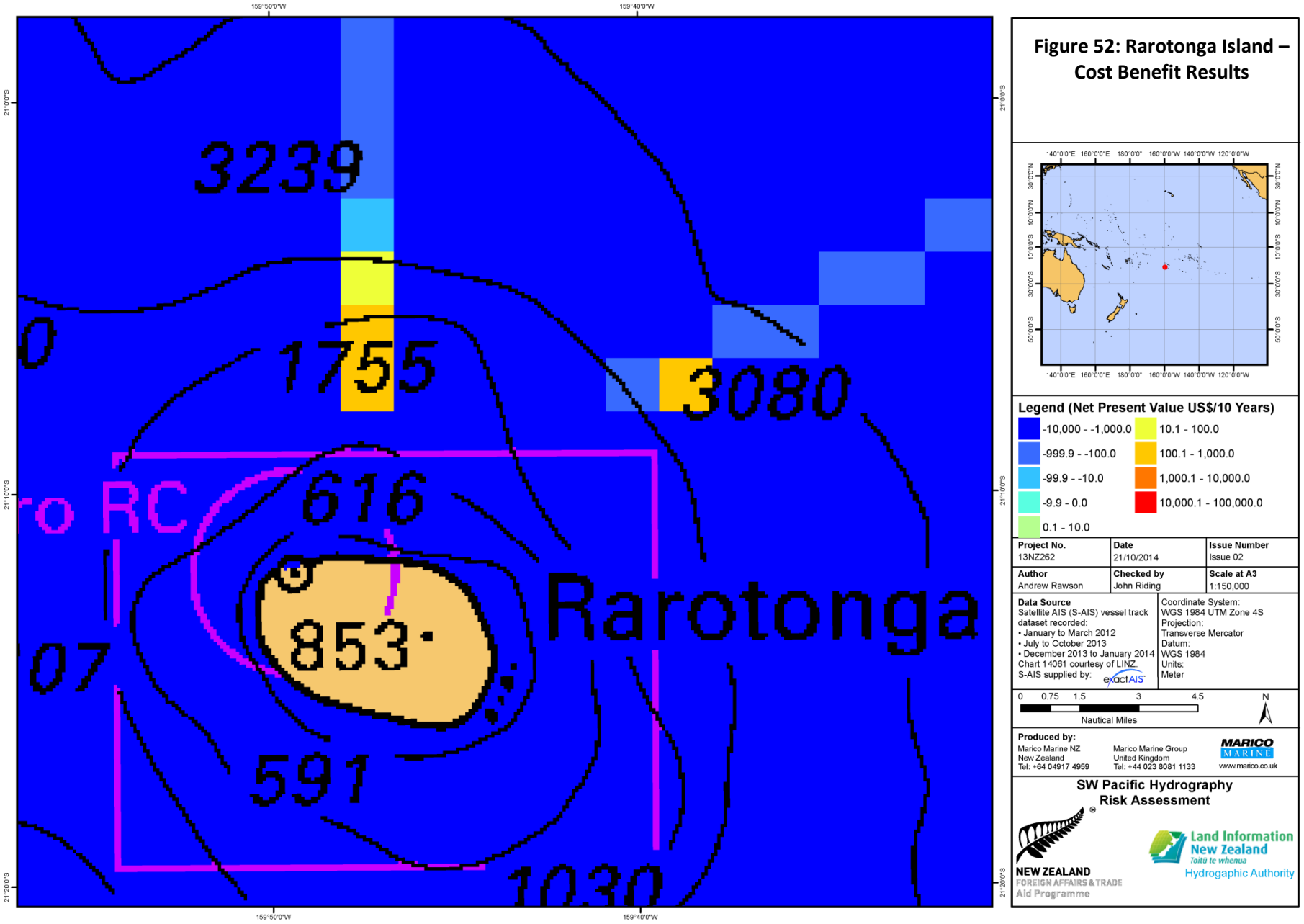

Figure 52: Rarotonga Island – Cost Benefit Results

Figure Reference: 13NZ262_CookIsls_CostBenefit2_02

8.9.4 SENSITIVITY ANALYSIS

Testing of the cost-benefit result was undertaken. The results were found to be highly sensitive to the type of hydrographic survey system used, which is, of course, a function of survey cost. The results are also sensitive to the cost of oil pollution clean-up, but more to the actual value of the risk reduction delivered by the introduction of improved charting. The latter result has been fixed at a percentage of risk reduction based on the four ZOC Categories (see Figure 53). However, the assessment of risk reduction, based on research work undertaken by Det Norske Veritas (a well-known classification society), is at best an estimate and at worst undefendable. This is because this work assumes that the sum of all grounding events in the world divided by the sum of all the shipping routes in the world and their traffic volume is a result that can be applied to any maritime location in the world. Clearly it cannot, but this is the best estimate of the risk reduction value that is currently available.

Figure 53 shows the change in the NPV result across the Cook Islands waters as the cost of the survey changes. The case assessed in the CBA model is that of a single beam survey; this decision is borne out as appropriate when the sensitivity analysis result is considered, as the chosen case lies in the centre of the result and not at one extremity or the other.

The sensitivity analysis clearly shows that the cost effectiveness of updating the charts using only satellite derived bathymetry survey will outweigh the costs.

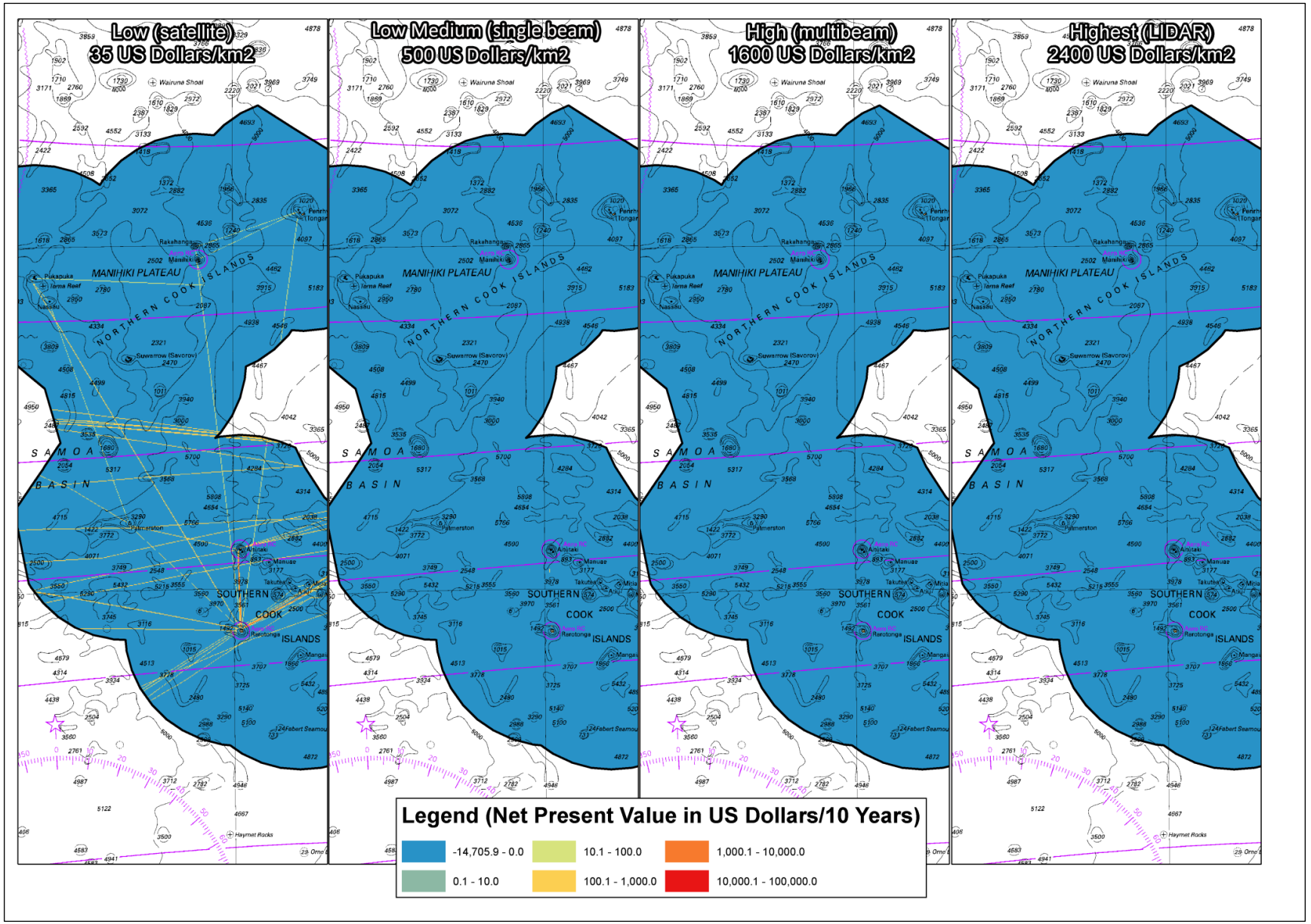

Figure 53: CBA Sensitivity Analysis – Results show Survey Cost Dramatically Affects NVP

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 OFFICIAL NAUTICAL CHARTS

1) The risk assessment has determined areas where the accuracy and adequacy of charting should be reviewed against modern standards. The risk results for the Cook Islands are subdued, due to the low level of traffic overall and the rapid increases in ocean depth close to each island.

2) Improvements to charts, including improvements to charted island positions are needed as almost all islands are out of position, some significantly, when compared with modern satellite imagery on the WGS84 datum. For example Pukapuka is some 200m in error; Suwarrow and Nassau are some 300m in error and parts of Aitutaki some 400m in error.

3) A number of islands have benefitted from substantial harbour enclosure developments, which remain uncharted. This hinders cruise penetration into the Cook Islands as voyage planners are unaware that potentially safe landing arrangements are present for their passengers; examples of these are Mauke and Mitiaro. Consideration needs to be given to adequacy of scale for use of harbour developments.

9.2 CONCLUSIONS FROM SOLAS TRAFFIC ANALYSIS

4) The majority of vessel movements within the Cooks EEZ are through traffic, either between the USA and South East Asia or Australasia, or else traffic moving between other island groups. Dry Cargo vessels were recorded calling at Rarotonga or Aitutaki and tanker vessels only at Rarotonga.

5) Avatiu Harbour is the most significant port by ship traffic-volume. It has a relatively steady trade in containerised imports.

6) A small number of SOLAS general cargo vessels visit Avatiu Harbour, Rarotonga on a regular basis, including Arutanga Harbour, Aitutaki. These vessels represent the Pacific trade route connecting the Cook Islands with New Zealand, Australia, Tahiti and Samoa.

7) The Avatiu port development project is an important milestone for the Cook Islands shipping industry, completing 2013. It is provides facilities that should be capable of supporting growth.

8) Cruise ship calls to the Cook Islands do occur and there are some regular traders. Those vessels that regularly stop include the PAUL GAUGUIN and the HANSEATIC. Sail assisted cruise vessels such a PICTON CASTLE and Windstar Cruises are also regular callers.

9) Avatiu Harbour is small for modern cruise vessels and adverse weather conditions make entry transit dangerous. Cruise vessels mostly land passengers from offshore using their tenders. The development of Arorangi jetty provides a sheltered landing for cruise tenders. The jetty may also be an answer to an airdraft restriction at Avatiu Harbour for aircraft final landing approach which affects cruise vessels.

10) Arutanga, Aitutaki, also benefit from cruise and dry cargo vessel calls, being the second Cook Island port in terms of SOLAS movements. Other Islands do occasionally experience cruise vessel calls, although these are one off visits by the smaller "boutique" section of the cruise market.

11) There is quite a high percentage of Cruise Vessels that abort calls to Rarotonga. The problem is the offshore sea conditions, which make landing passengers into cruise tenders difficult. This needs further work, perhaps a wave analysis over a period of time. A new Jetty has been installed on the shelters side of the Island, but this will only help matters if cruise passengers can be disembarked safely offshore.

12) There is considerable scope of further development of the cruise industry in the Cook Islands group, especially Aitutaki.

9.3 CONCLUSIONS – DOMESTIC VESSEL TRAFFIC

13) When compared to domestic traffic in other Pacific Island groups, the Cook Islands coastal shipping service provision is much less frequent. There have been problems of grounding in the domestic fleet, and losses resulting. Domestic vessels of over 350 gross tonnes and those carrying passengers carry AIS transponders.

14) There are two key domestic trade routes in the Cook Islands (freight and domestic passengers); Rarotonga to the Northern Cooks Group, and Rarotonga to the Southern Cooks Group. .

15) The development of domestic trading is quite seriously hindered by the sporadic nature of domestic vessel trade schedules. Services to many islands of the Northern Group only occur if cargo is committed and only Palmerston is accumulating trade cargo ready for

the next scheduled visit. Other islands that used to produce goods for consumption on Rarotonga, have mostly ceased trading. One minor exception is coffee.

16) A wider review of the trade, including routes, harbour facilities, as well as the option of a policy of development assistance to deliver regular scheduled services is required. Given the long transit distances between islands, domestic trade would benefit from an approach used by other Governments to support marginal ferry services in remote areas to be regular. In these systems, a service is contracted by the Government, and cargo shipped is discounted from the assistance as trade develops.

9.4 CONCLUSIONS GIS RISK ANALYSIS

9.4.1 NORTHERN COOK ISLANDS

17) Penrhyn presents heightened risk at the Taruia Pass into the lagoon, and moderate risk at Omoka Harbour. The key underlying influences are: the internationally recognised pristine and abundant nature of this atoll, which results in rapid coral growth as well as extensive turtle and rare species nesting areas. Negative to risk are the narrow lagoon entrance, uncertainty of depth and AtoNs of uncertain status. The wharf at Omoka is a critical location for the viability of the Northern Cooks fisheries patrol as it is *the* fuelling facility that provides patrols with the range necessary. There is potential for increased domestic vessel visits, as the present service levels are too low to encourage trading development. Penrhyn could be an attractive cruise destination. It is an important candidate for charting review on grounds of safety risk and guaranteeing the ongoing fisheries management missions.

18) Rakahanga shows a moderate risk at the west coastline of the island. This risk is mainly influenced by the high environmental and local economic importance of the island.

19) In Manihiki, the moderate risk level is scattered east and north of the island. Its economic and environmental importance, in combination with the moderate density of traffic, underlines this risk outcome.

20) Pukapuka presents a moderate risk result at the sea area east and west of the island. This arises from the domestic traffic coastal service and the SOLAS vessel transits, combined with a large numbers of marine reserves.

9.4.2 SOUTHERN COOK ISLANDS

21) Palmerston shows a moderate level of risk, scattered north of the island. Large SOLAS vessels pass in the vicinity, which underpins this result influenced by the environmental importance of the island (turtle nesting sites).

22) At Aitutaki, there is a localised heightened risk which is concentrated at Arutanga Harbour and its approaches. The small harbour attracts SOLAS international ships, including containers and cruise ships. The heightened risk is generated from the key environmental importance of the marine reserves and breeding grounds. Passing SOLAS vessels extend the risk profile to south of the island.

23) Takutea shows isolated moderate risk at the eastern and western coast of the island, influenced by passing SOLAS vessels. It is uninhabited, but has an important Wildlife Sanctuary, of cultural importance to the islanders. A moderate number of yachts and day visits from Atiu have an effect on the risk results.

24) Atiu depicts a moderate risk level at the North West coast. An underlying factor is domestic vessel transits from Rarotonga, with community barge transits to Takutea Island. An uncharted berth is located at Taunganui landing, without recorded AtoNs. A review of charting and Aids to Navigation is justified by the risk result for mitigation effectiveness.

25) For Mauke, a moderate risk level is attributed to the domestic vessel visits in combination with the turtle breeding grounds located on the island. The island has an economic importance in the supply of domestic fresh produce exports to Rarotonga. It has an organised economy.

26) Rarotonga has an isolated area of significant risk at Avatiu Harbour which is surrounded by heightened risk. The island has both economic and environmental importance and attracts SOLAS international port calls for all types of vessels. The harbour is also the domestic coastal hub and therefore, a trade centre for the Cook Islands. The recent port development could possibly have improved tonnage capacity of the port, including larger tankers and dry cargo vessel port calls. These factors accumulate to deliver a localised significant risk result at the harbour entrance. However, it is exposed to heavy swell and weather limits for transit are low.

27) Cruise vessels mostly use their tenders to disembark passengers offshore and transit to a landing stage. Regular aborted visits occur due to conditions offshore. A second landing

option in more sheltered waters (Arorangi Jetty) has recently opened, which may assist matters. This jetty also avoids airdraft restrictions if alongside Avatiu Harbour.

9.5 CONCLUSIONS - ECONOMIC ANALYSIS

28) The Cost Benefit Analysis (CBA) for the Cook Islands is based on singlebeam survey costs. Even for (cost effective) hydrographic survey method, most of the Cook Islands will produce minimal NPV economic returns, because of low vessel traffic levels. Therefore, the safety *and* economic benefits of charting improvements would not outweigh the costs of survey. This is not a negative finding; it is the type of scenario on which a case is made for Aid funding to improve safety and efficiency.

29) Hydrographic surveys do, though, have the potential to deliver significant financial returns for the Cook Islands' cruise tourism sector, subject to the establishment of an accommodating fiscal regime.

30) The Cook Island's leading exports are black pearls and, to a lesser extent, copra and fresh produce. On average, import cargo volumes remain stable in terms of container numbers handled.

31) A potential benefit derived by practicable hydrographic surveys is the development of the deep mining industry in the Cook Islands.

32) A long-term cruise strategy could help to facilitate expansion of cruise calls to the Cook Islands. Rarotonga and Aitutaki do enjoy regular cruise calls, but occasional visits only occur at Atiu, Manihiki and Penrhyn. This is based on in-country records.

33) Regular and scheduled domestic shipping services are needed if economic trade between all of the remote islands is to be facilitated.

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10.1 DATASET CONFIDENCE – RISK MODEL

Dataset	Confidence	Reason
Vessel traffic patterns	Moderate/High	7.5 months of AIS data was analysed, representing traffic patterns over two years, both summer and winter. This was supported by port movement records obtained during the site visits. Domestic traffic routes and frequency were also obtained during the site visit and geocoded into the risk model.
Prevailing conditions	Moderate	Absence of a universal and accurate digital dataset of The Cook Islands' meteorological conditions required approximation using other sources. Modelled conditions are basic without wave propagation or refraction.
Tidal conditions	Low	No dataset available, therefore charted tides and the South Pacific sailing directions were used to identify sites of significant tidal flow. Other potential sites were identified but could not be accurately included I the risk model.
Navigational complexity	N/A	Qualitative judgement.
Chart quality assessment	High	CATZOC ratings extracted from LINZ S-57 charts. The Cook Islands charts all present ZOC ratings. In the event any were missing, those charts would automatically have the lowest rating applied for the risk assessment.
Fixed aids to navigation	Moderate/High	It was not possible for all aids to navigation to be checked by the project team on the site visit.
Depth	Moderate	Depth map created from S-57 data but is therefore inherently limited by the source data of that chart.
Bottom Type	Low	Use of a global geological dataset will not accurately reflect localised geological features.
Significant charted reefs	Moderate/High	Most significant reefs are charted and a number of datasets were drawn upon to support this information.
Seamounts	Moderate	Seamount locations drawn from a number of different sources, however it is not possible to model the locations of seamounts which have yet to be identified.
WW2 military sites	High	Considerable literature research to support the assertion that no records of WW2 munition dumping or mined areas exist for the Cook Islands.

Dataset	Confidence	Reason
Sites of volcanic activity	Low	Few datasets could be found to identify volcanic sites.
Tidal hazards	Moderate	Charted tidal hazards were extracted from the S-57 charts or were geocoded based upon their description in the South Pacific pilot book.
Coral reefs	High	Coral reefs have been widely studied and mapped and so a number of high quality datasets were available on their locations.
Wetlands resource	High	Traditional wetlands resources are based on both literature review and marked during local consultation.
Breeding grounds	Moderate	Multiple studies were provided to the project team regarding the locations of significant breeding grounds. However only those sites for selected species were included.
Environmental protected sites	Moderate	Global protected sites are well marked however local informal sites are only obtainable from consultation with local communities.
Culturally protected sites	Moderate	Global protected sites are well marked however local informal sites are only obtainable from consultation with local communities.
Key infrastructure	High	Rarotonga is the Cook Islands only major port.
Tourist sites	Moderate/High	The routes of cruise ships and recreational craft were combined with sites identified during consultation.
Sites of economic contribution	Moderate	Qualitative judgement supported with research and local consultation.
Cruise ship destinations	High	Over 12 months of cruise ship movements were analysed and supplemented with consultation during site visits and historic schedules.

ANNEXES

Table of Contents

List of Figures

List of Tables

Annex A
Event Trees

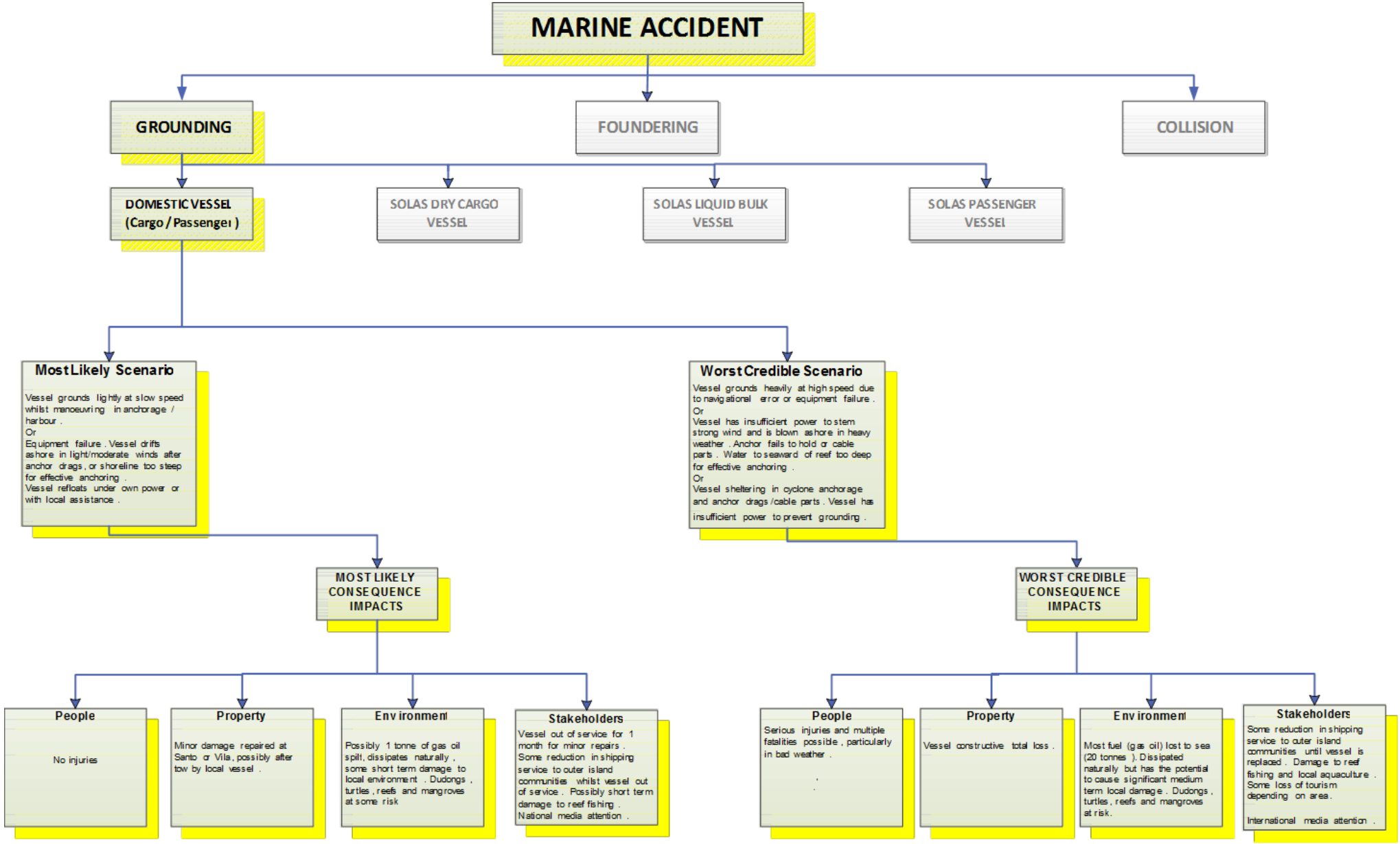


Figure 1: Domestic Vessel Grounding Scenario

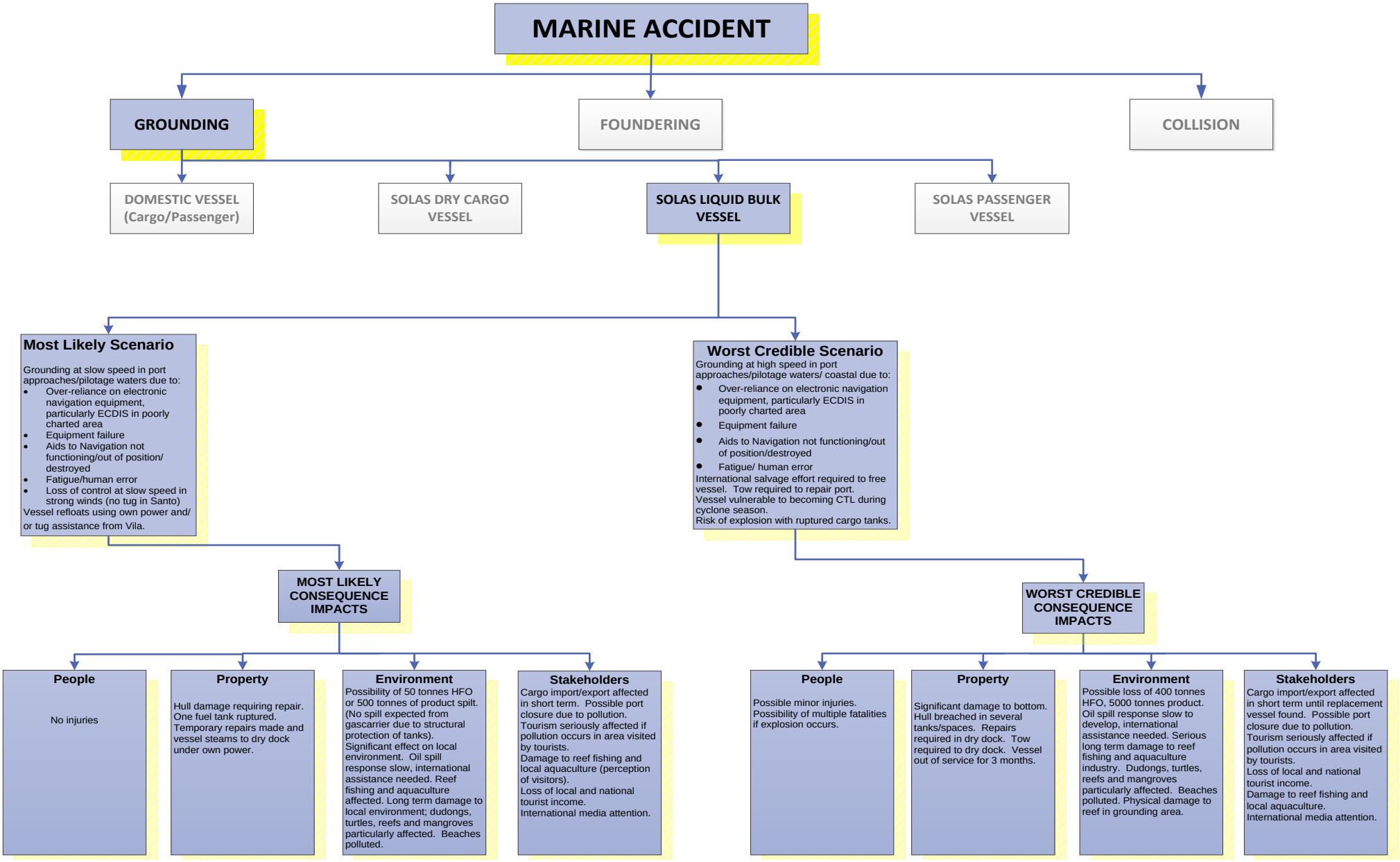


Figure 2: SOLAS Liquid Bulk Vessel Grounding Scenario

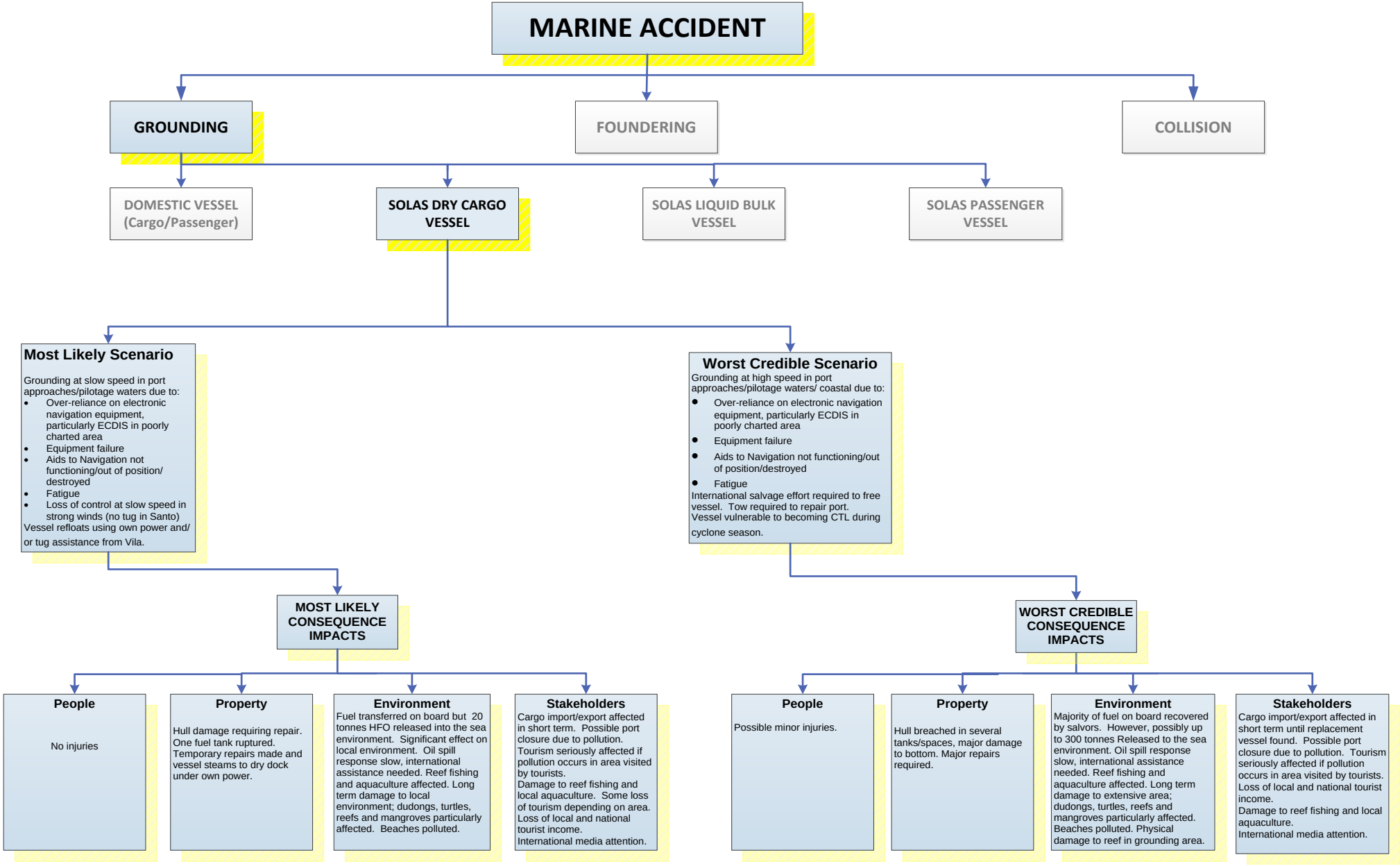


Figure 3: SOLAS Dry Cargo Vessel Grounding Scenario

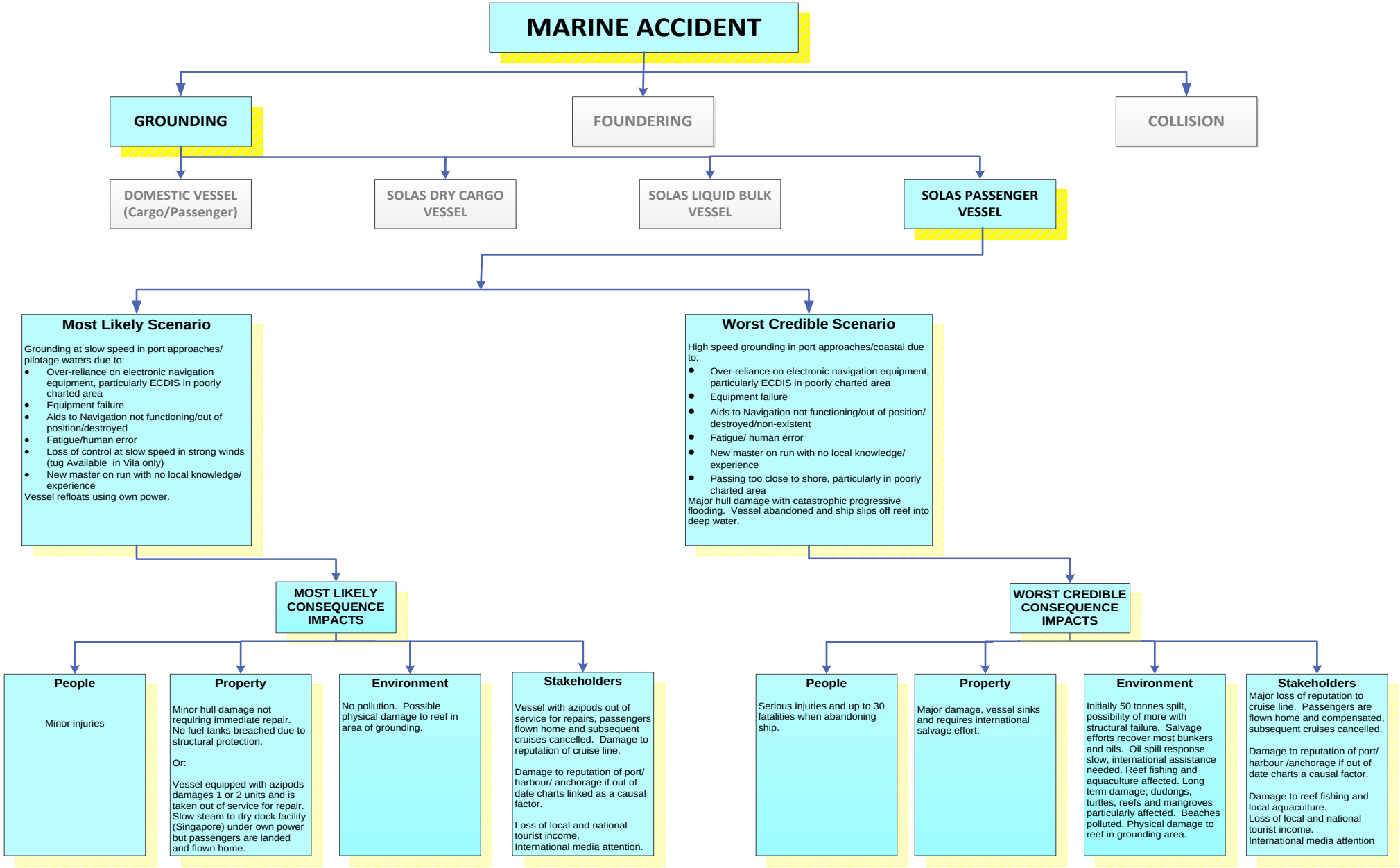


Figure 4: SOLAS Passenger Vessel Grounding Scenario

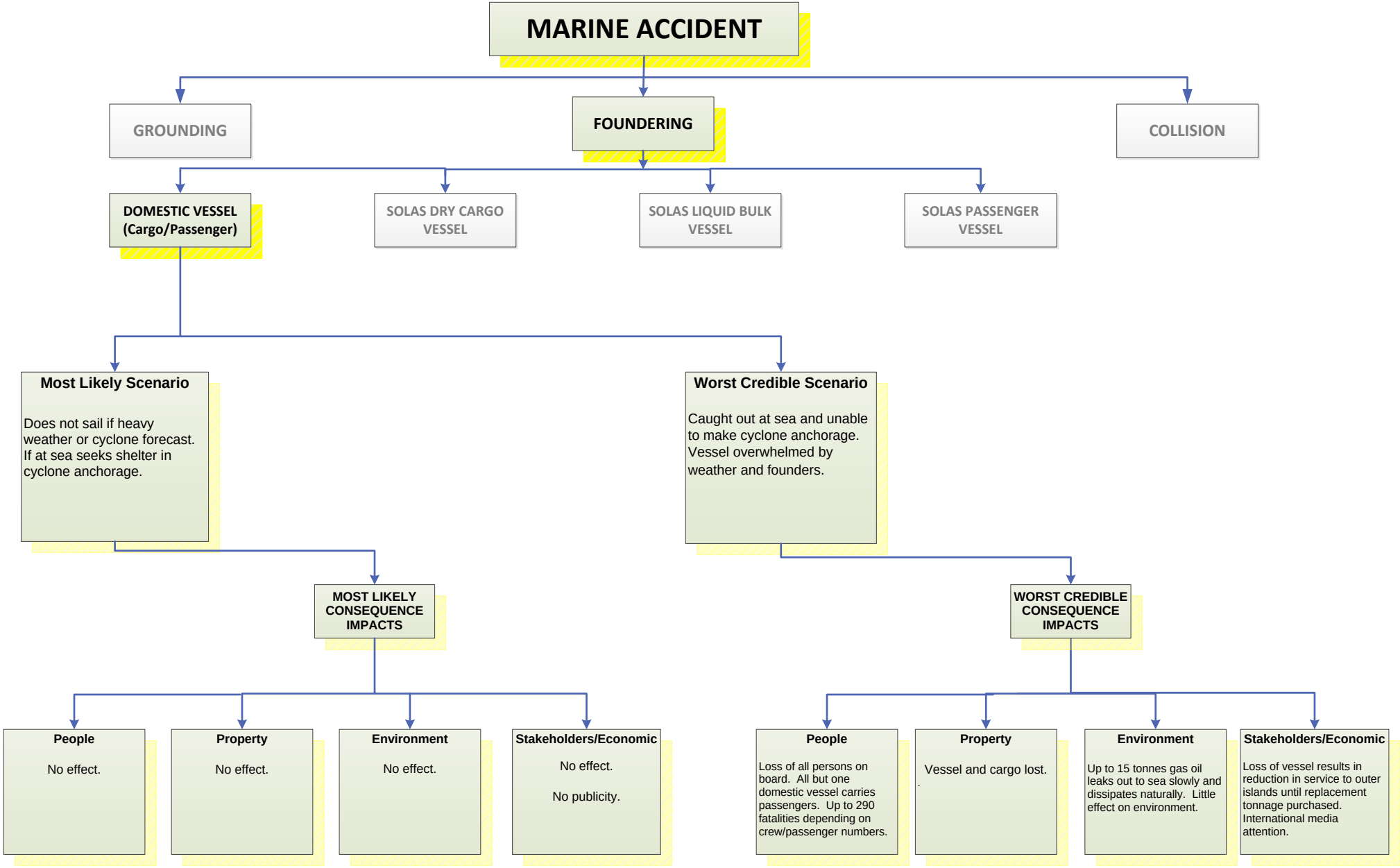


Figure 5: Domestic Vessel Foundering Scenario

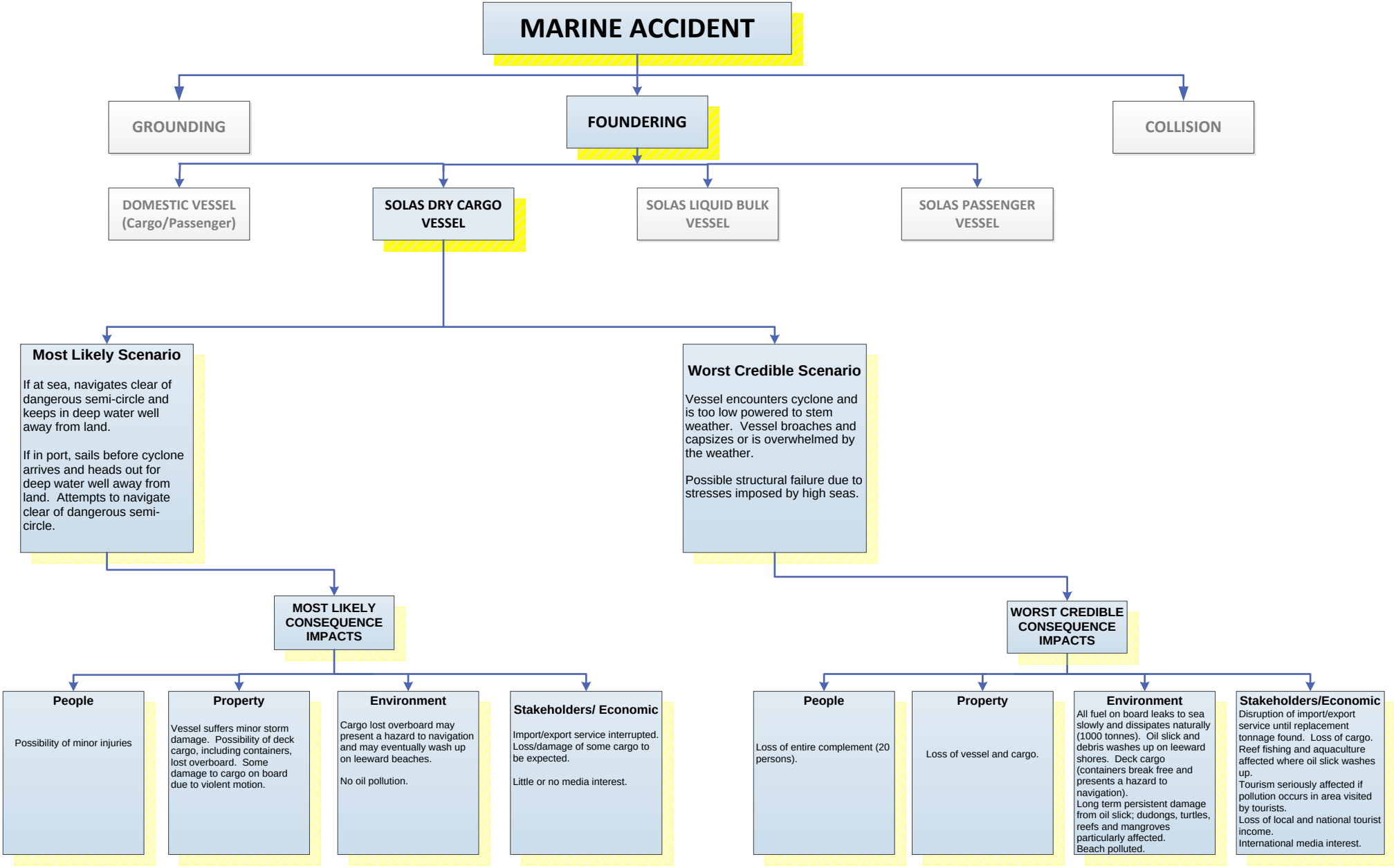


Figure 6: SOLAS Dry Cargo Vessel Foundering Scenario

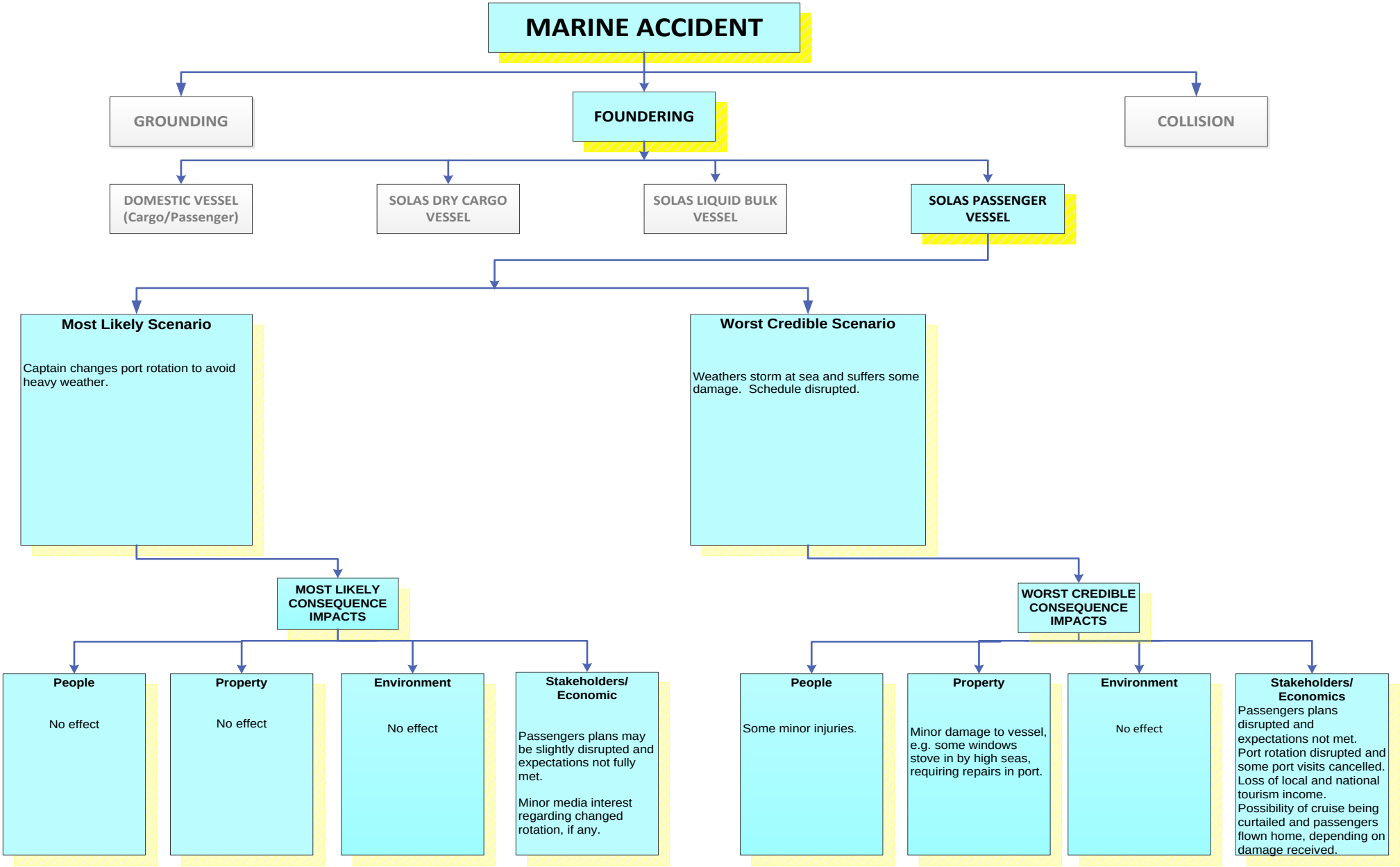


Figure 7: SOLAS Passenger Vessel Foundering Scenario

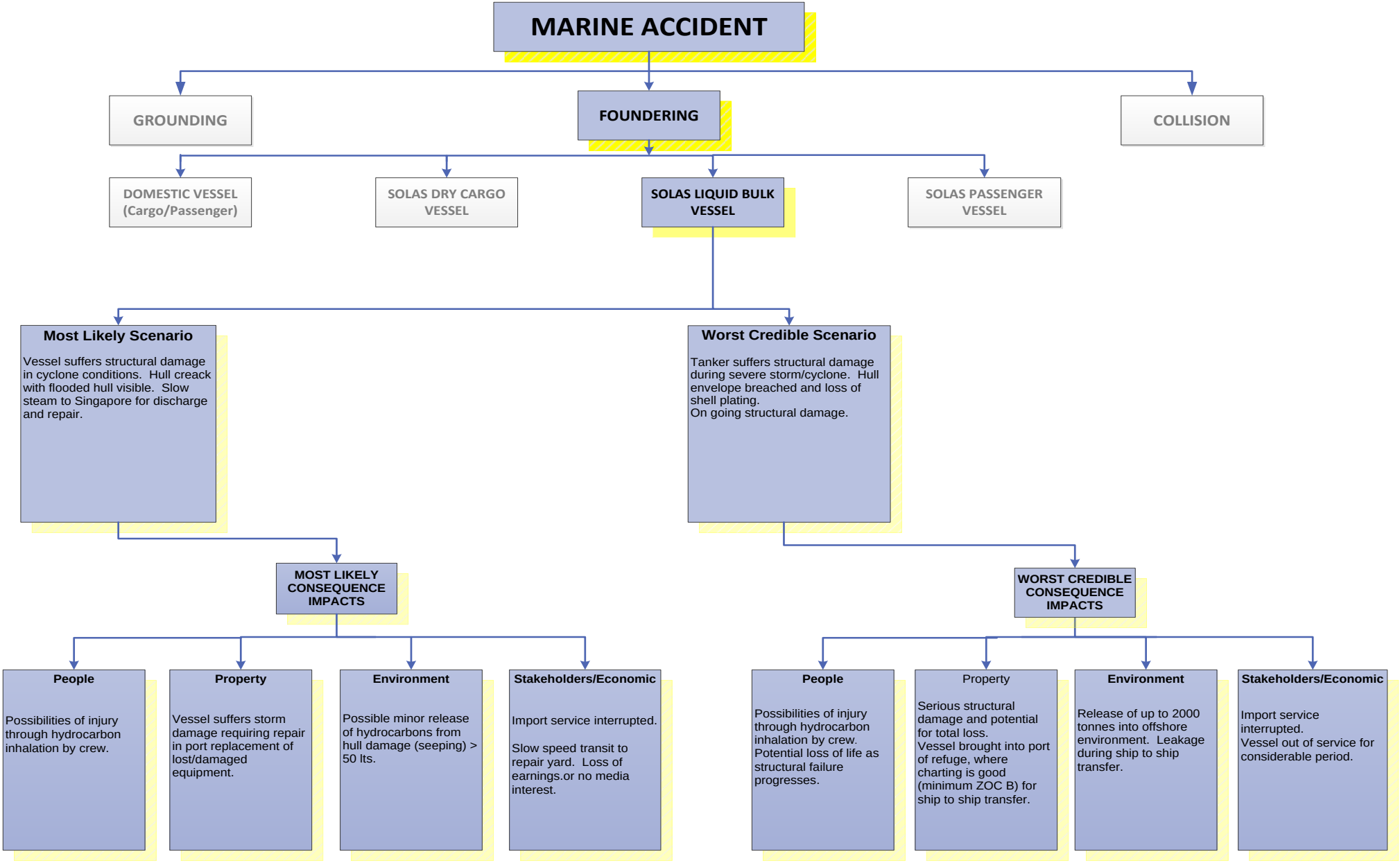


Figure 8: SOLAS Liquid Bulk Vessel Foundering Scenario

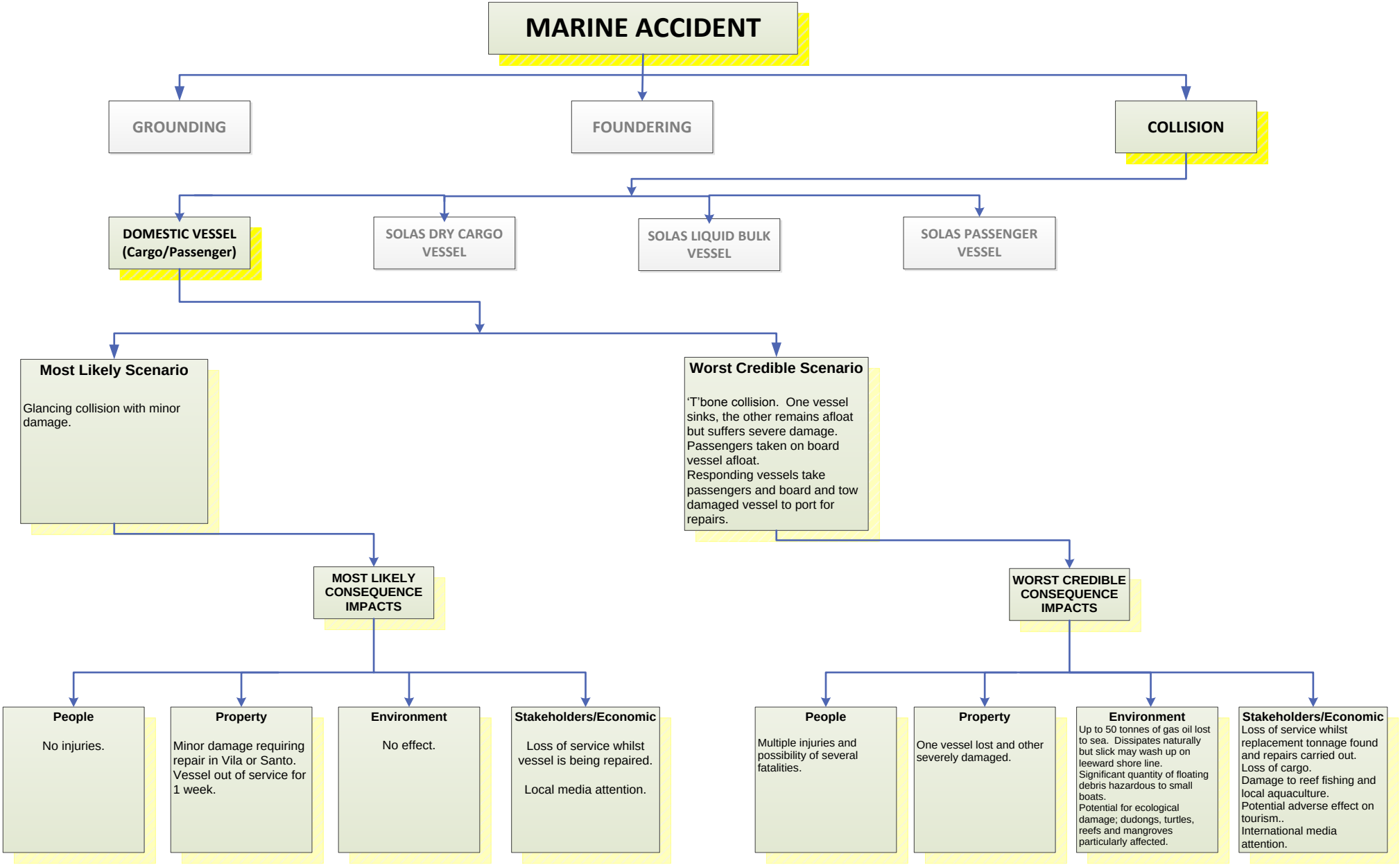


Figure 9: Domestic Vessel Collision Scenario

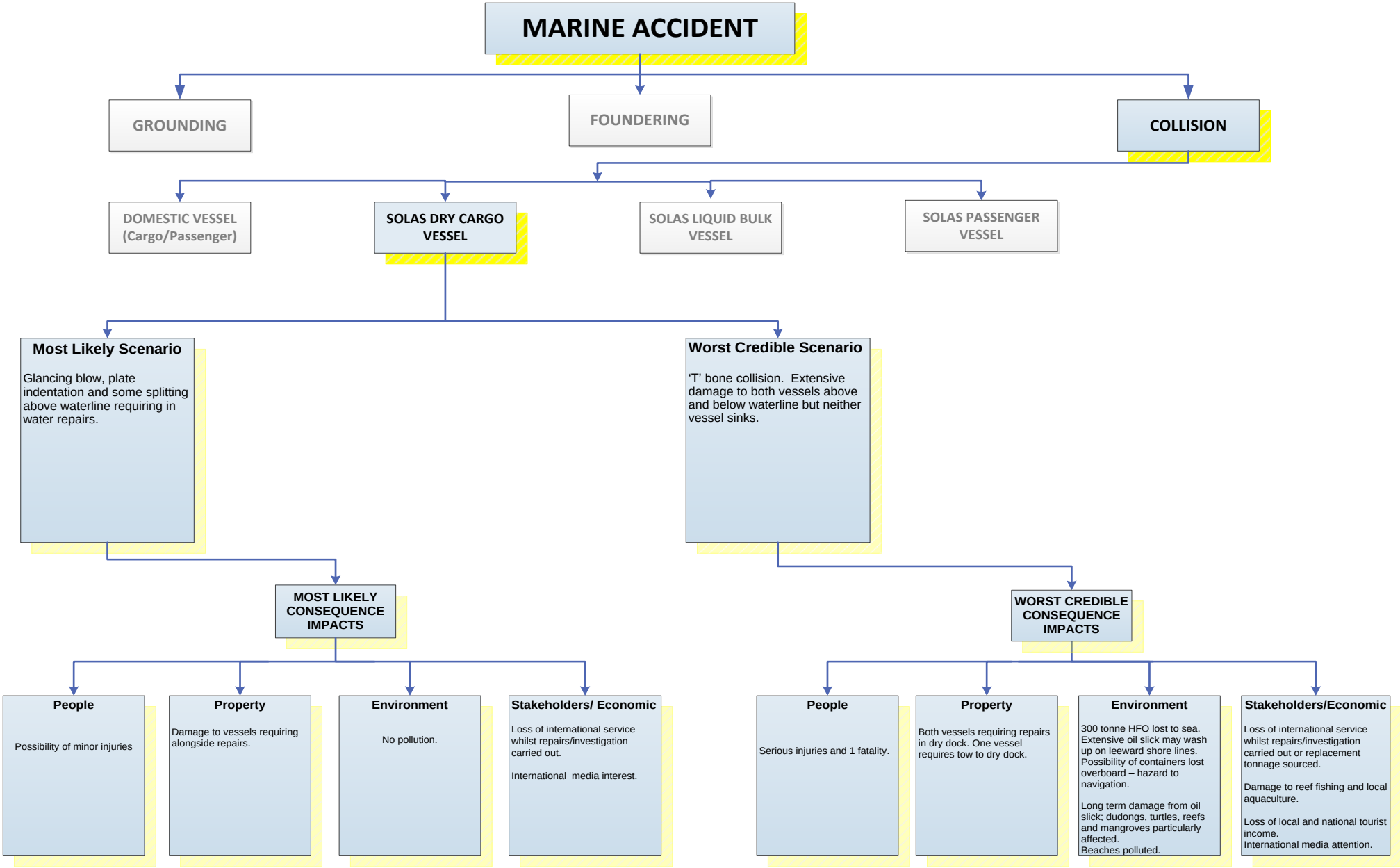


Figure 10: SOLAS Dry Cargo Vessel Collisions Scenario

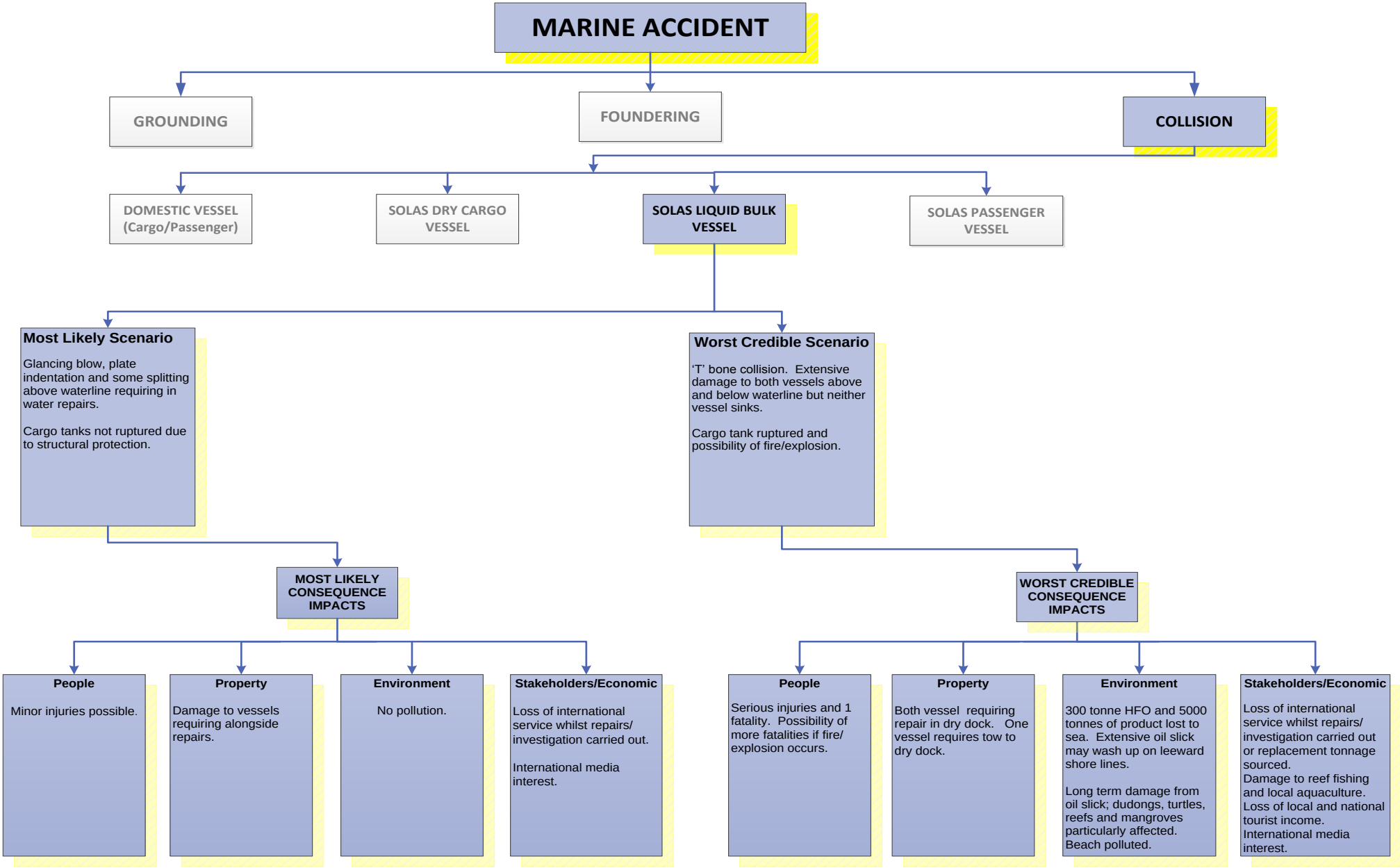


Figure 11: SOLAS Liquid Bulk Vessel Collisions Scenario

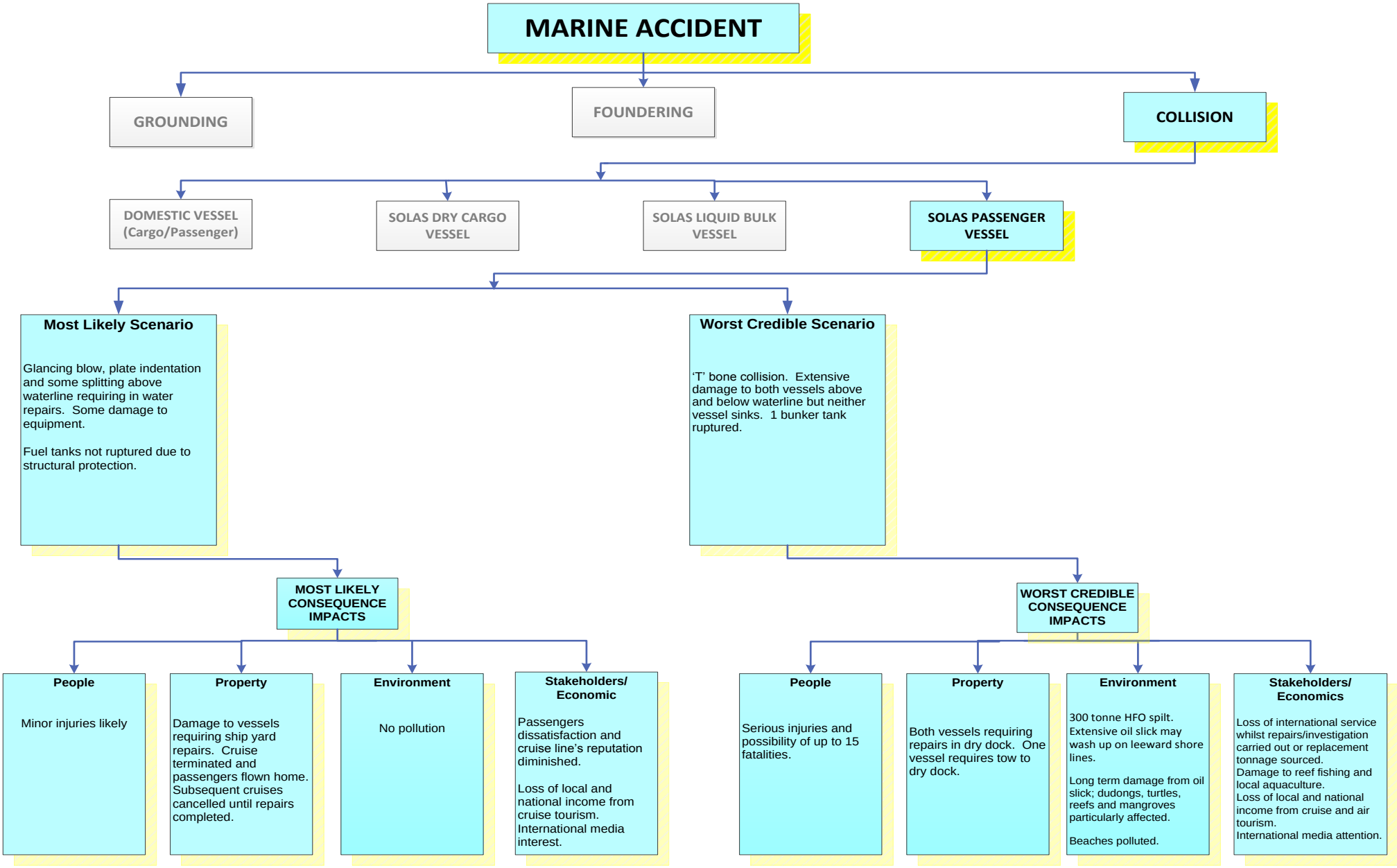


Figure 12: SOLAS Passenger Vessel Collision Scenario

Annex B
Traffic Analysis

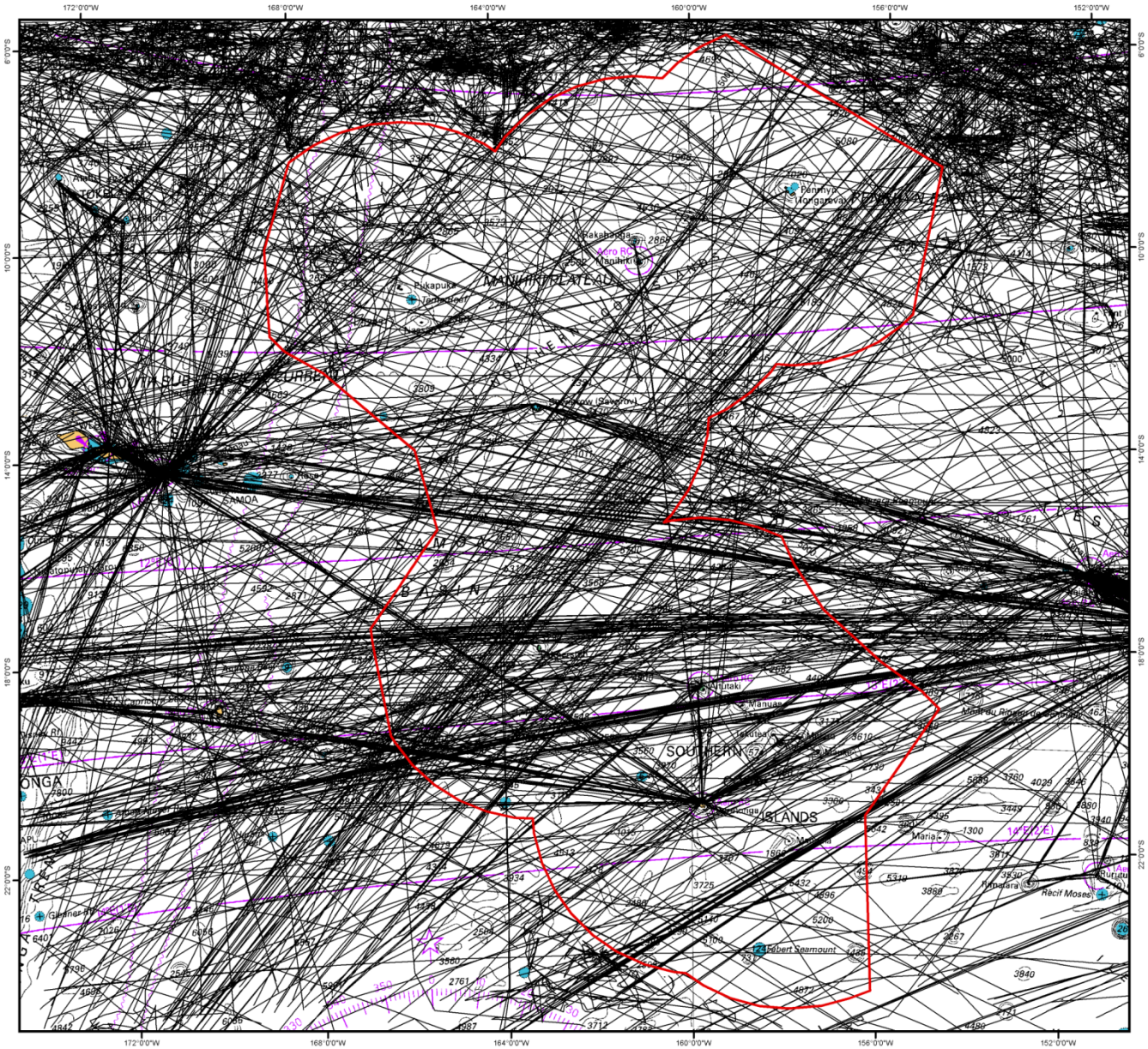
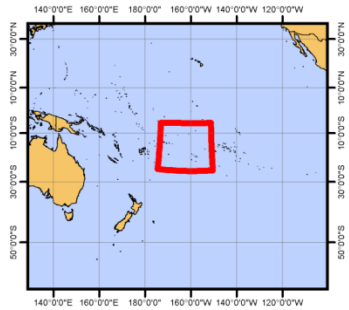


Figure Reference: 12NZ262_CookIsls_Tracks_01

Figure 13: All Vessel Tracks



Legend

Vessel Tracks

Cook Islands EEZ

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:8,000,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
- January to March 2012
- July to October 2013
- December 2013 to January 2014

Chart 14061 courtesy of LINZ.
S-AIS supplied by: exactAIS

Coordinate System:
WGS 1984 UTM Zone 4S
Projection:
Transverse Mercator
Datum:
WGS 1984
Units:
Meter

0 50 100 200 300 N
Nautical Miles

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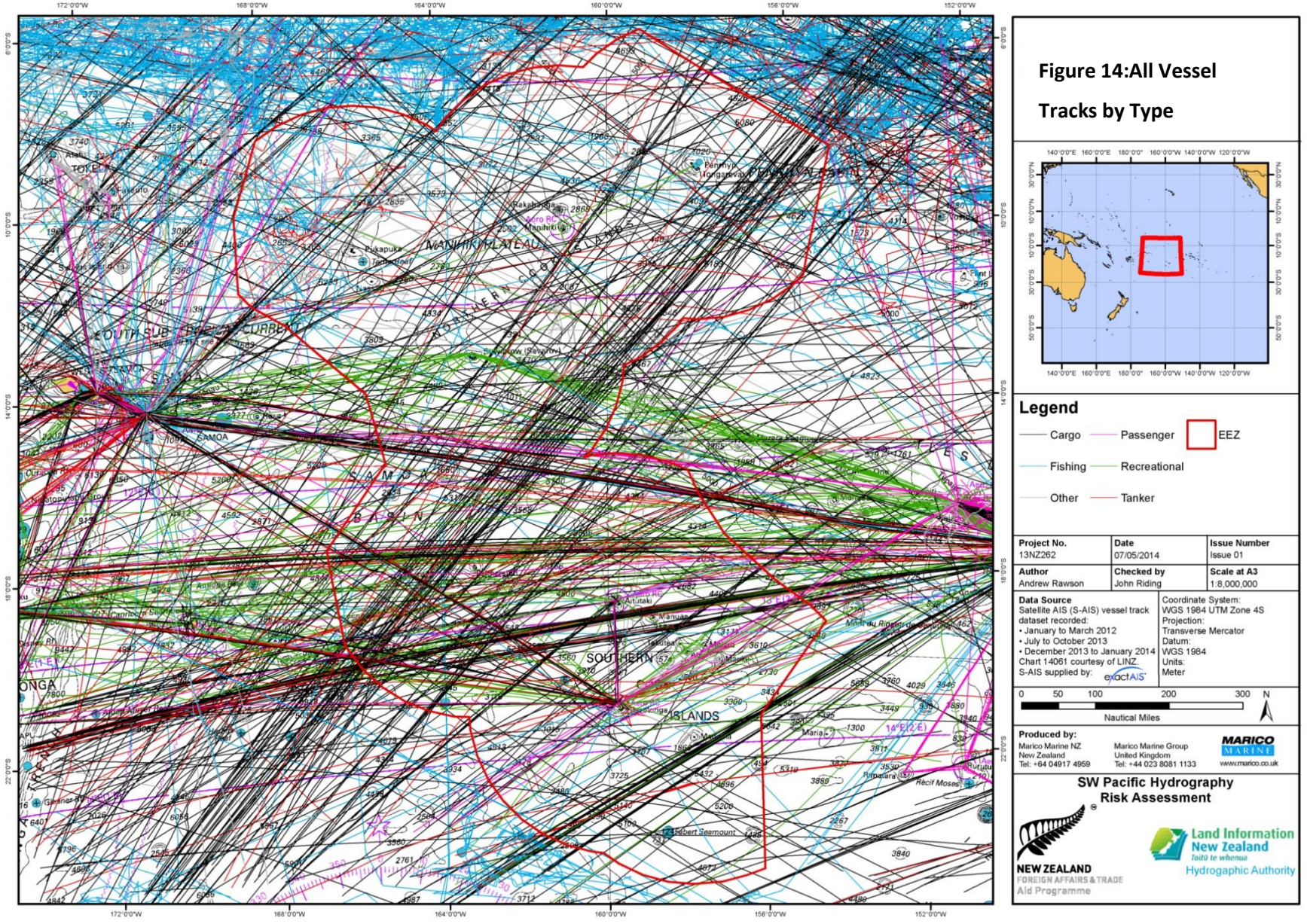

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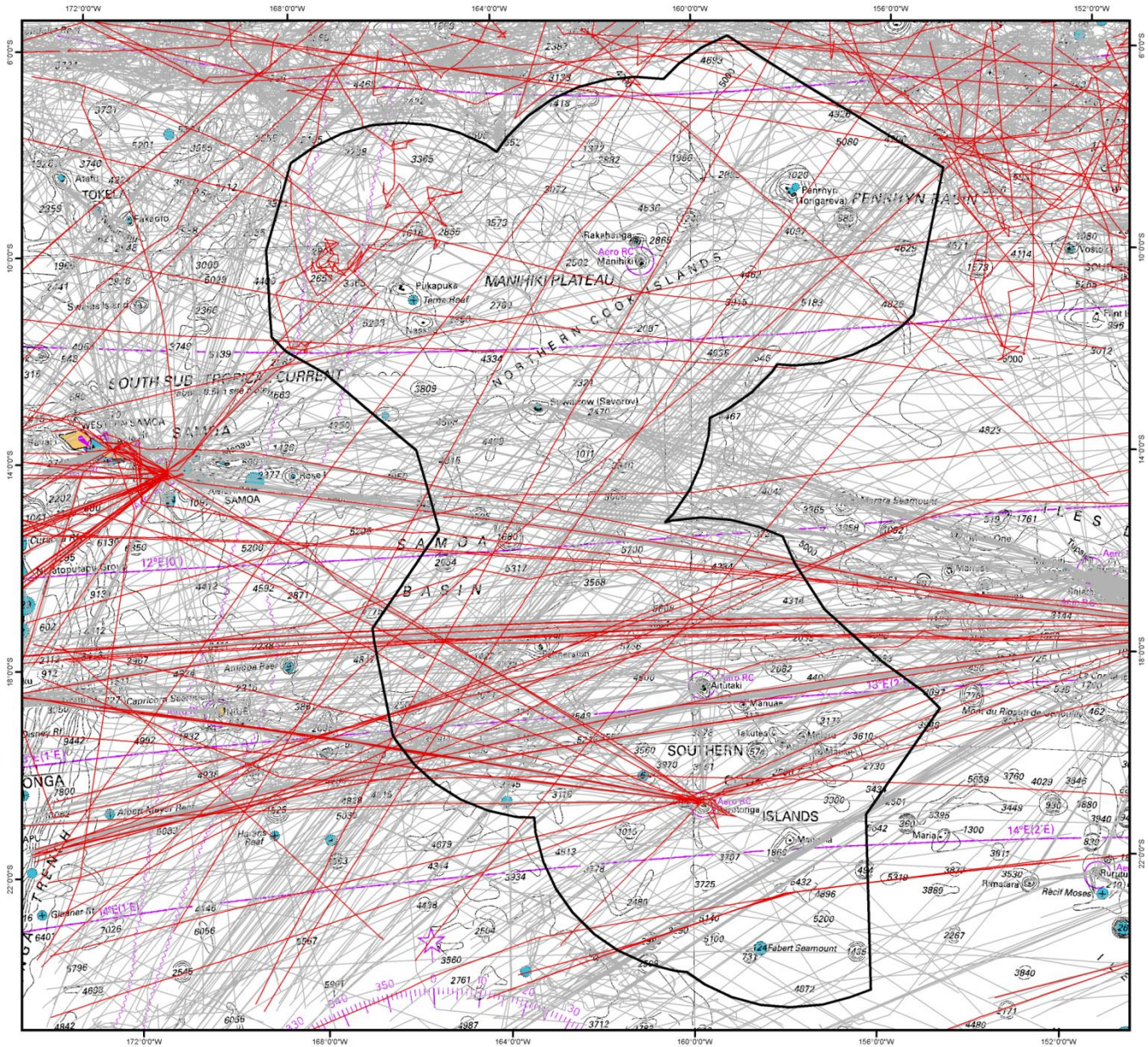
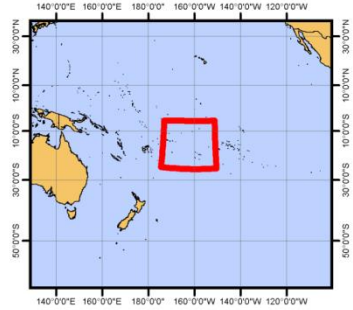


Figure Reference: 12NZ262_CookIsls_Tanker_01

Figure 15: Liquid Tanker Vessel Tracks



Legend

- Tanker
- Other
- EEZ

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:8,000,000

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Datum: WGS 1984
Units: Meter

0 50 100 200 300 N
Nautical Miles

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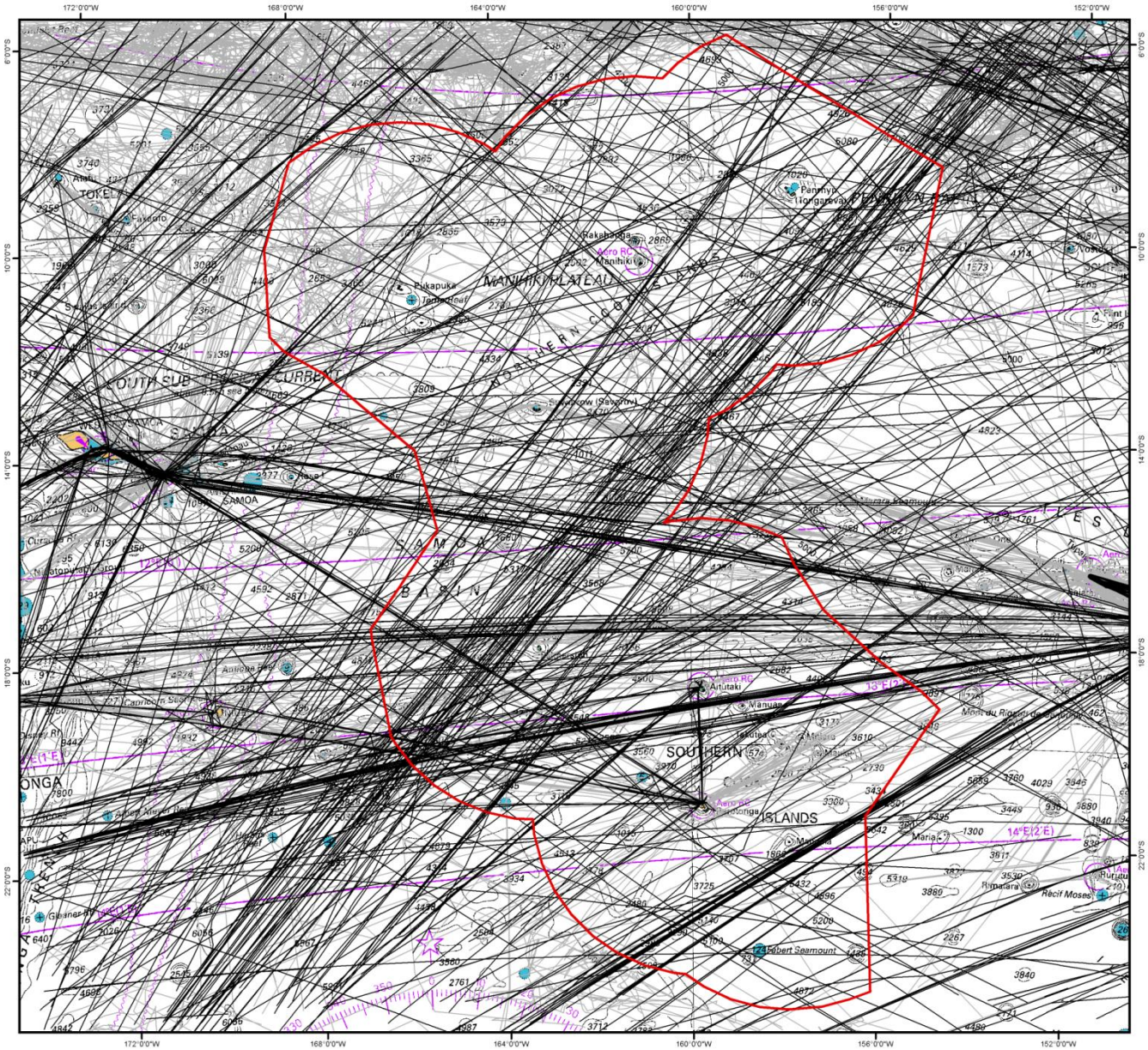
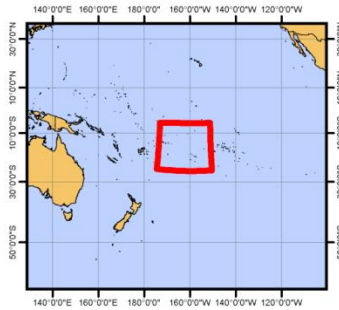


Figure Reference: 12NZ262_CookIsls_Cargo_01

Figure 16:Dry Cargo Vessel Tracks



Legend

- Dry Cargo
- Other
- EEZ

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:8,000,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
- January to March 2012
- July to October 2013
- December 2013 to January 2014

Chart 14061 courtesy of LINZ.
S-AIS supplied by: exactAIS

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Projection:
Transverse Mercator
Datum:
WGS 1984
Units:
Meter

0 50 100 200 300 N
Nautical Miles

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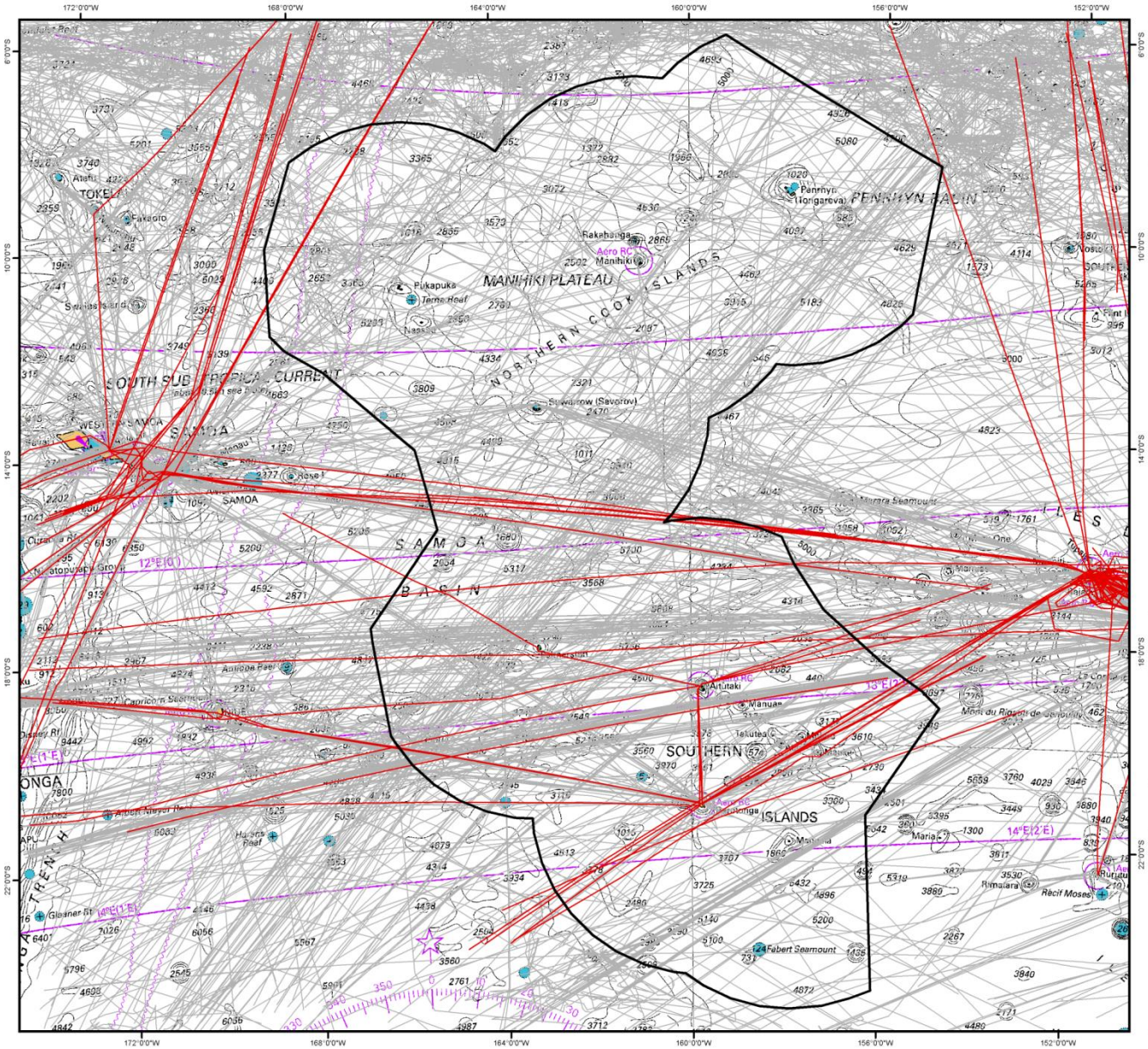
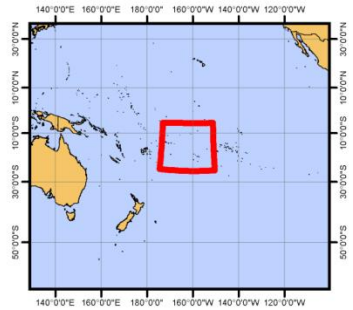


Figure Reference: 12NZ262_CookIsls_Cruise_01

Figure 17: Cruise Ship Vessel Tracks



Legend

- Cruise Ships
- Other
- EEZ

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:8,000,000

Data Source
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- December 2013 to January 2014

Chart 14061 courtesy of LINZ.
S-AIS supplied by: exactAIS

Coordinate System:
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Projection:
Transverse Mercator
Datum:
WGS 1984
Units:
Meter

0 50 100 200 300 N
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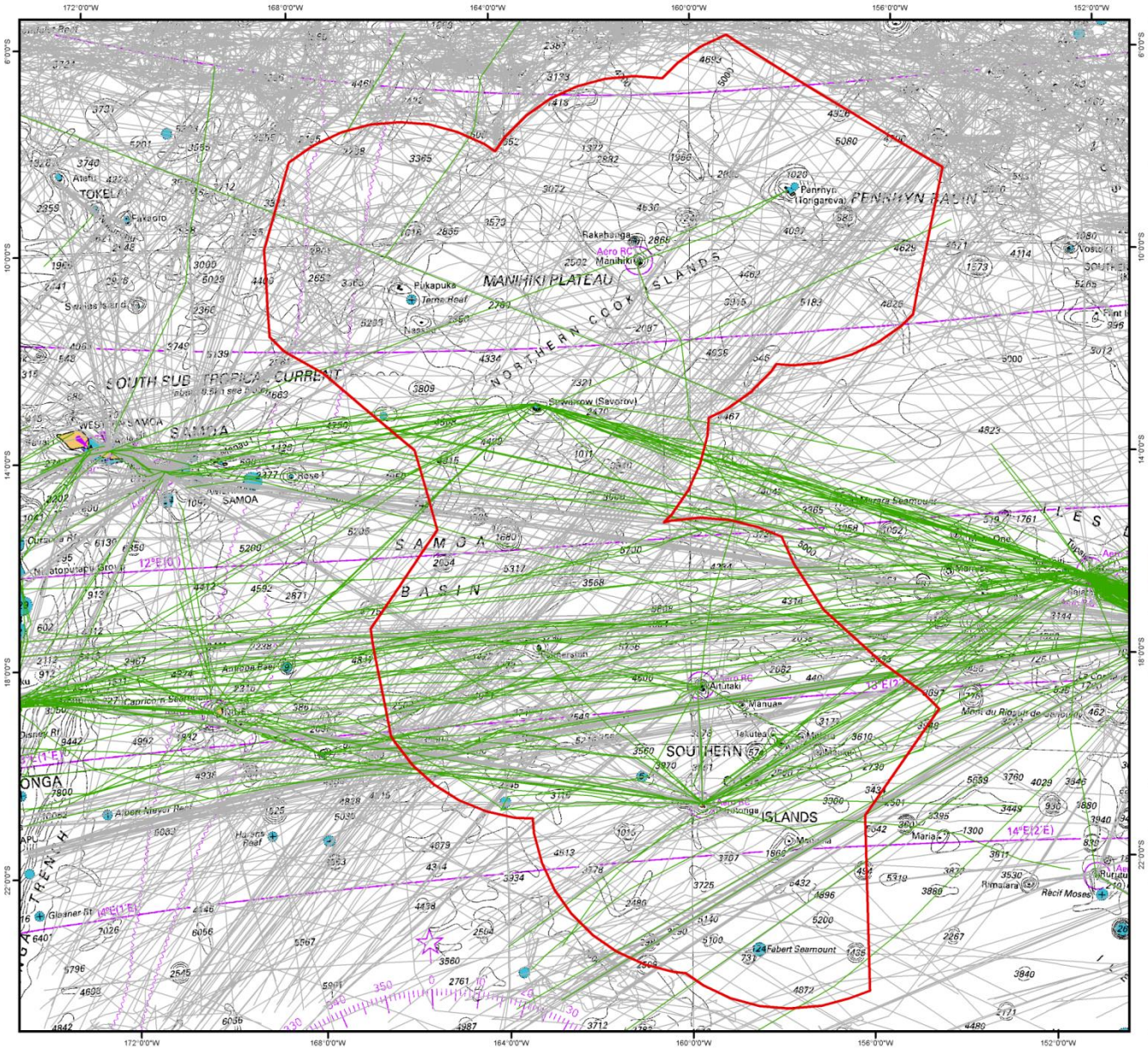
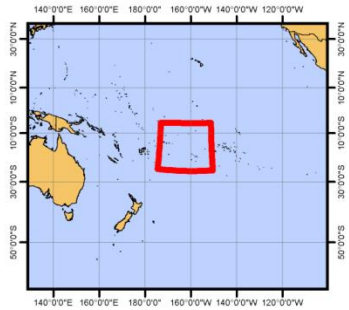


Figure 18: Recreational Vessel Tracks



Legend

- Recreational
- Other
- EEZ

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:8,000,000

Data Source
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Projection:
Transverse Mercator
Datum:
WGS 1984
Units:
Meter

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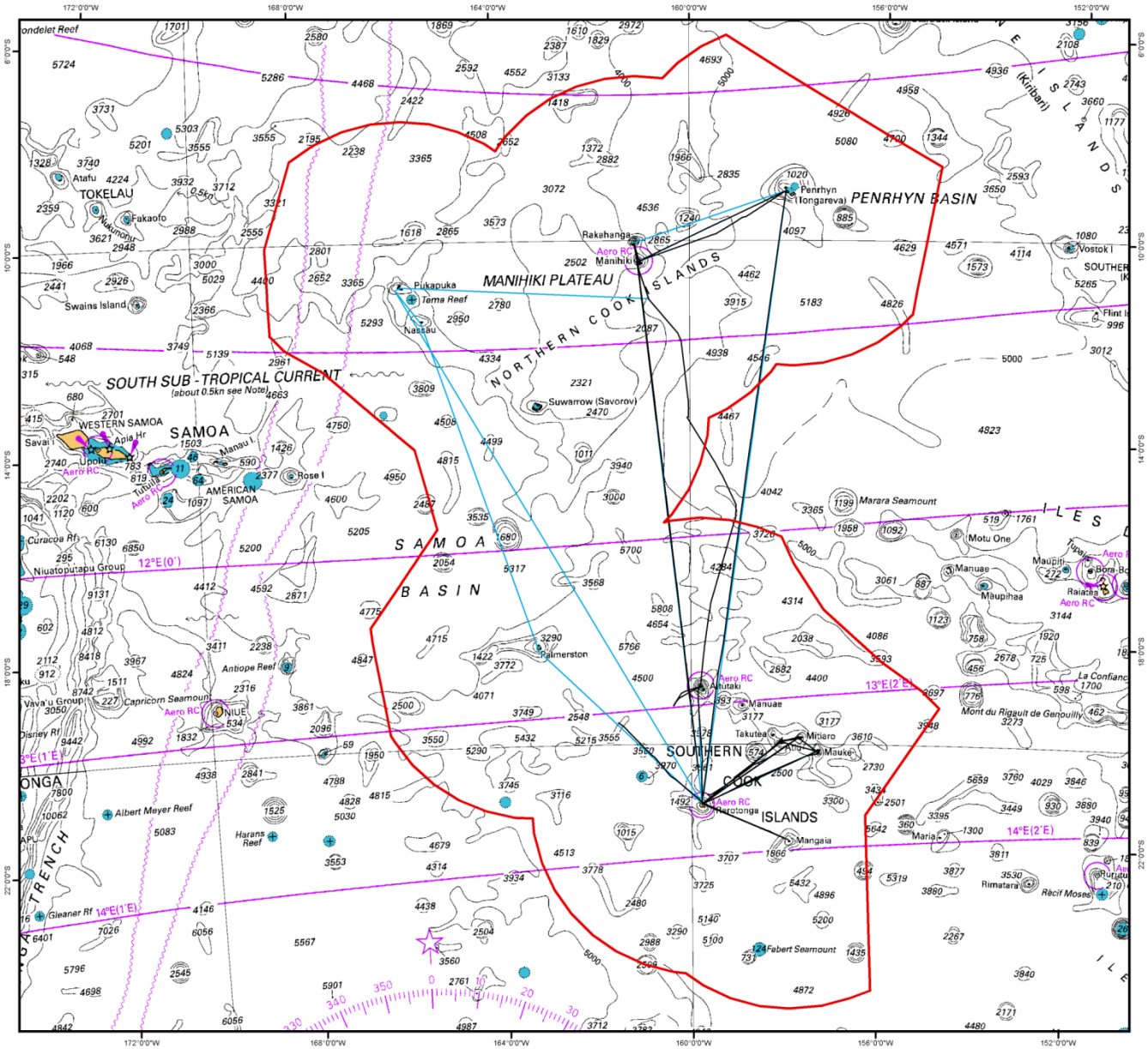
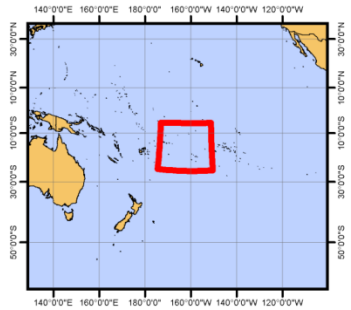


Figure Reference: 12NZ262_CookIsls_DomesticTraffic_01

Figure 19:Domestic Traffic Routes



Legend

- Domestic Traffic (Modelled)
- Domestic Traffic (AIS)
- EEZ

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:8,000,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
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Projection: Transverse Mercator
Datum: WGS 1984
Units: Meter

0 50 100 200 300 N
Nautical Miles

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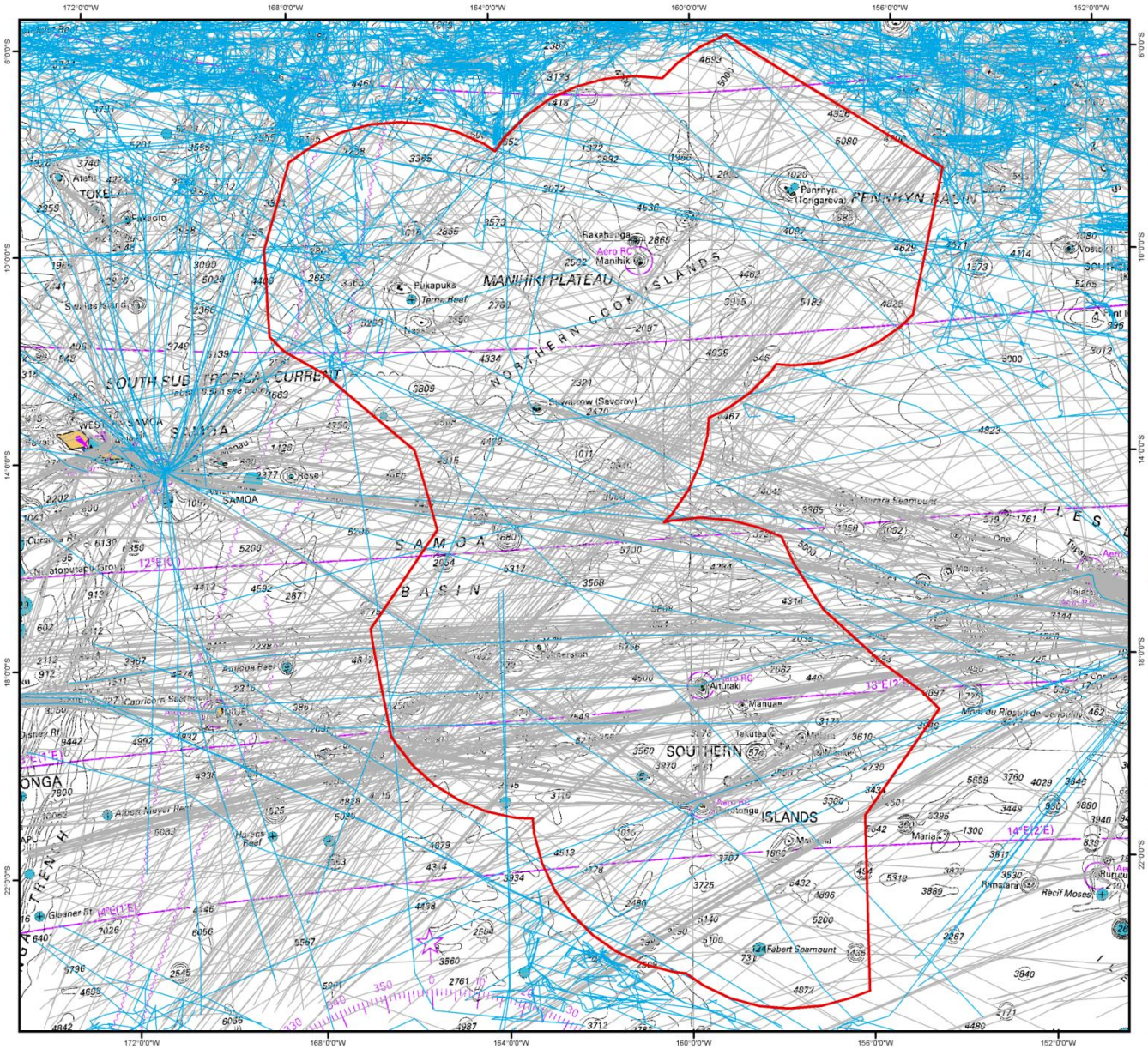
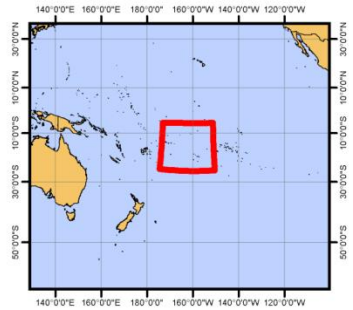


Figure 20: Commercial Fishing Vessel Tracks



Legend

- Fishing
- Other
- EEZ

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:8,000,000

Data Source
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Datum:
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Units:
Meter

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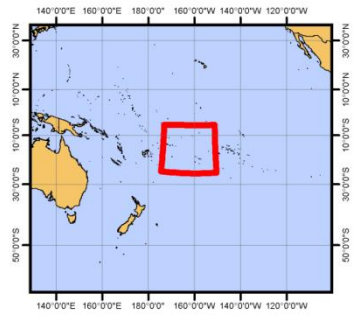
Figure Reference: 12NZ262_CookIsls_GT_01

Figure 21: Vessel Tracks by Gross Tonnage



Legend (Gross Tonnage)

- 0 - 20,000
- 20,001 - 40,000
- 40,001 - 60,000
- 60,001 - 80,000
- 80,001 - 100,000
- 100,001 - 120,000

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:8,000,000

Data Source
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- December 2013 to January 2014

Chart 14061 courtesy of LINZ.
S-AIS supplied by: exactAIS

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Projection: Transverse Mercator
Datum: WGS 1984
Units: Meter

0 50 100 200 300 N
Nautical Miles

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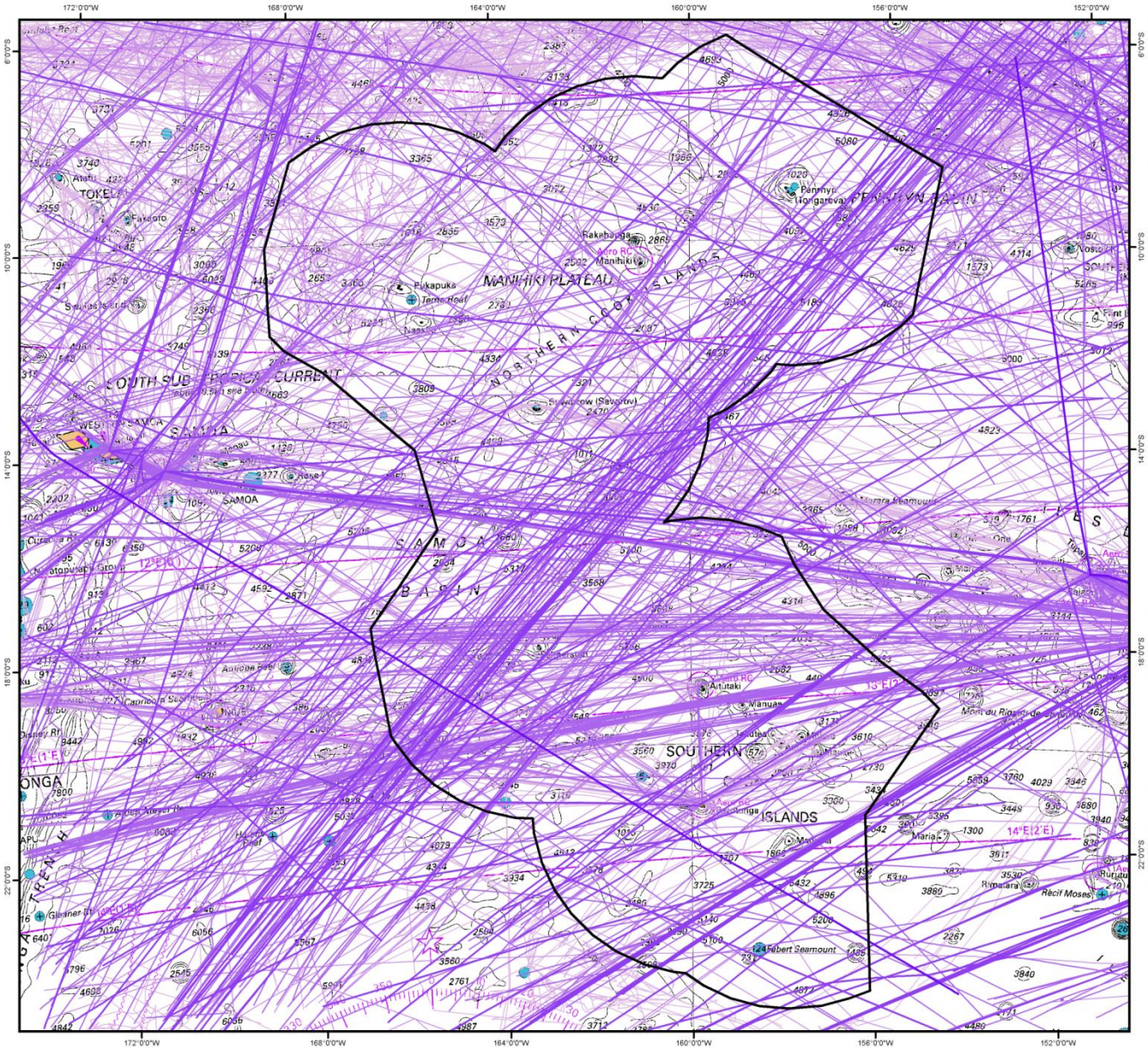
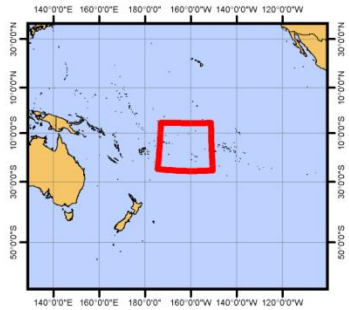


Figure 22: Vessel Tracks by Length



Legend (LOA in metres)

0 - 75	226 - 300
76 - 150	301 - 375
151 - 225	

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:8,000,000

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Datum:
WGS 1984
Units:
Meter

0 50 100 200 300 N
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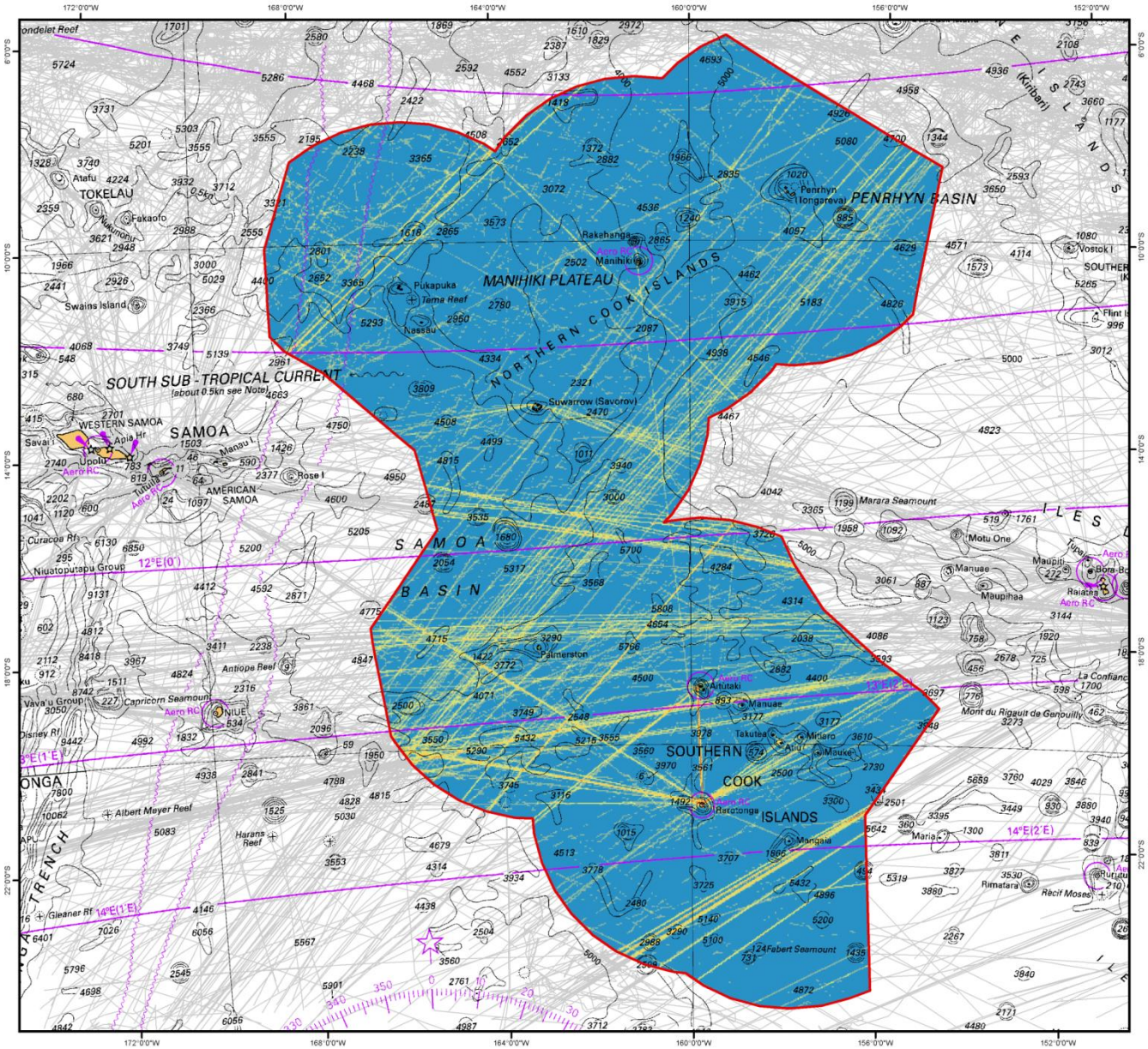
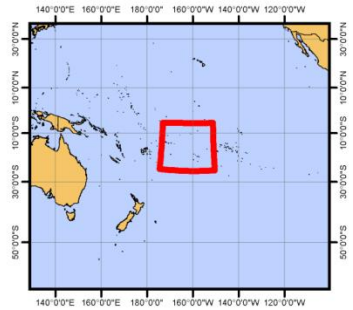


Figure Reference: 12NZ262_CookIsls_TransitDensity_01

Figure 23: Transit Density per Month



Legend (Transits per Month)

0.0 - 0.1	0.9 - 1.6
0.2 - 0.4	1.7 - 5.5
0.5 - 0.8	5.6 - 11.1

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:8,000,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
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- December 2013 to January 2014

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Datum:
WGS 1984
Units:
Meter

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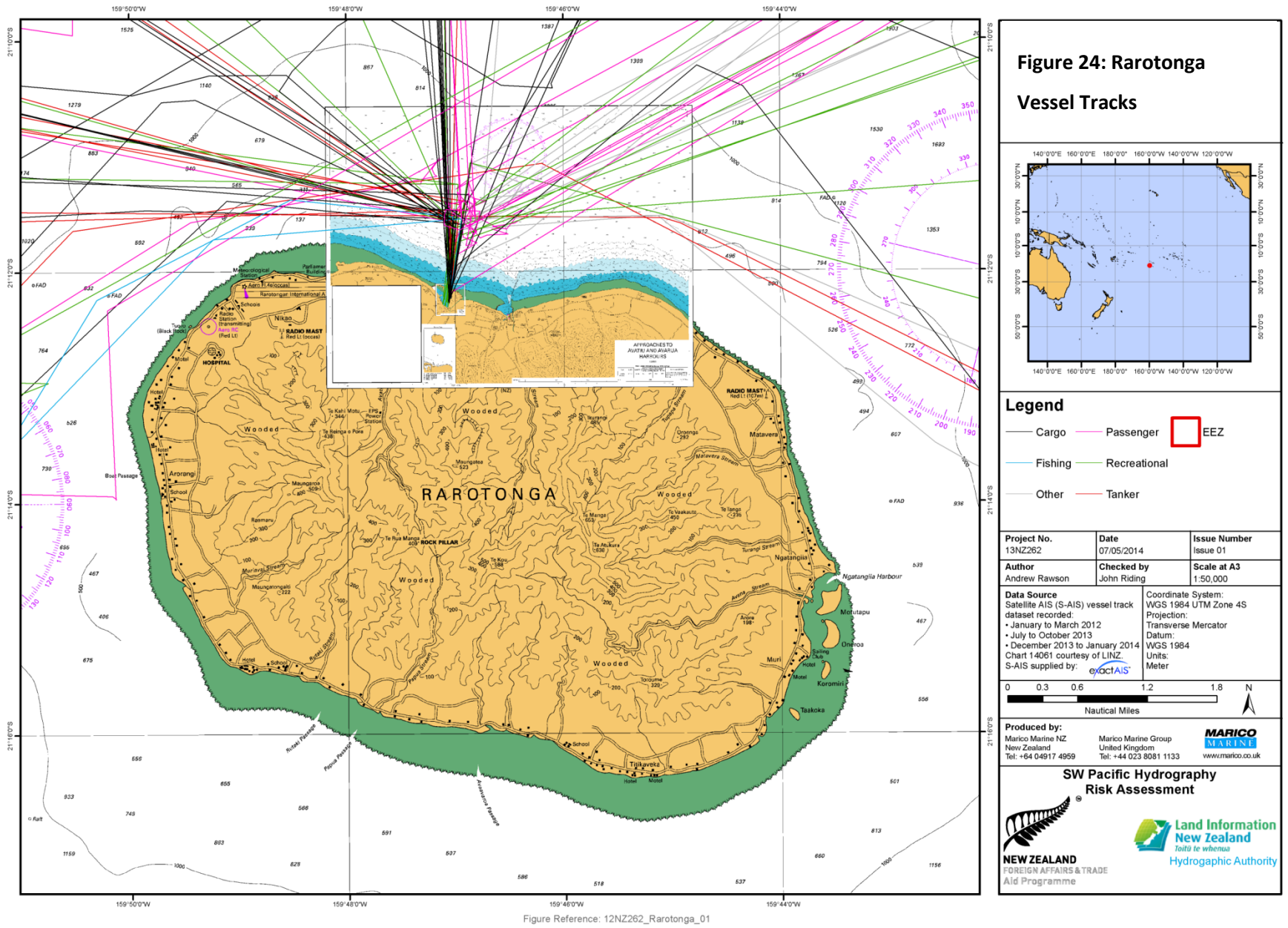

Figure Reference: 12NZ262_Rarotonga_01

Figure 24: Rarotonga Vessel Tracks

Legend

Cargo — Passenger — EEZ
Fishing — Recreational
Other — Tanker

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:50,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
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- December 2013 to January 2014

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S-AIS supplied by: exactAIS

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Projection:
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Datum:
WGS 1984
Units:
Meter

0 0.3 0.6 1.2 1.8 N
Nautical Miles

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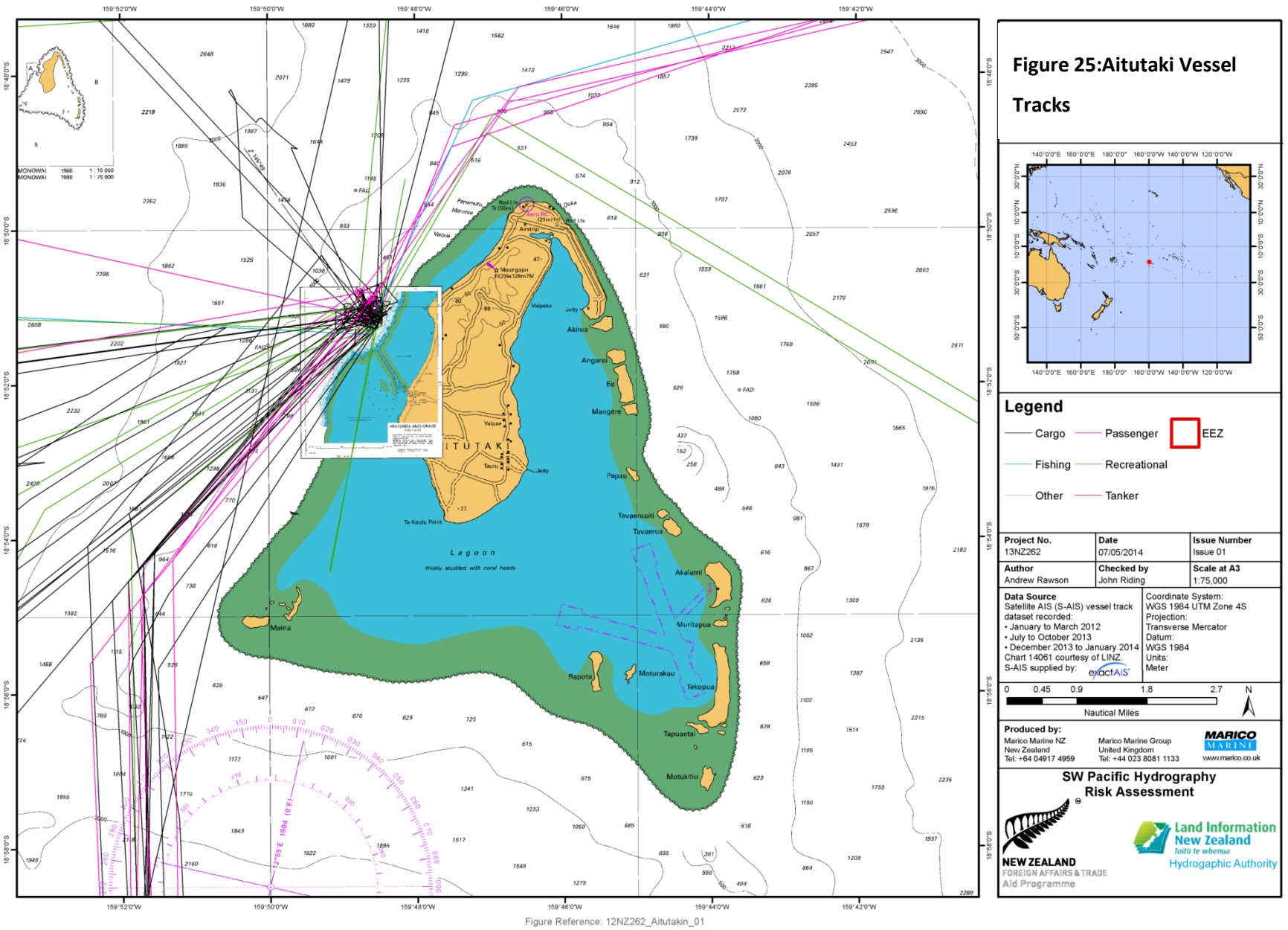


Figure Reference: 12NZ262_Aitutakin_01

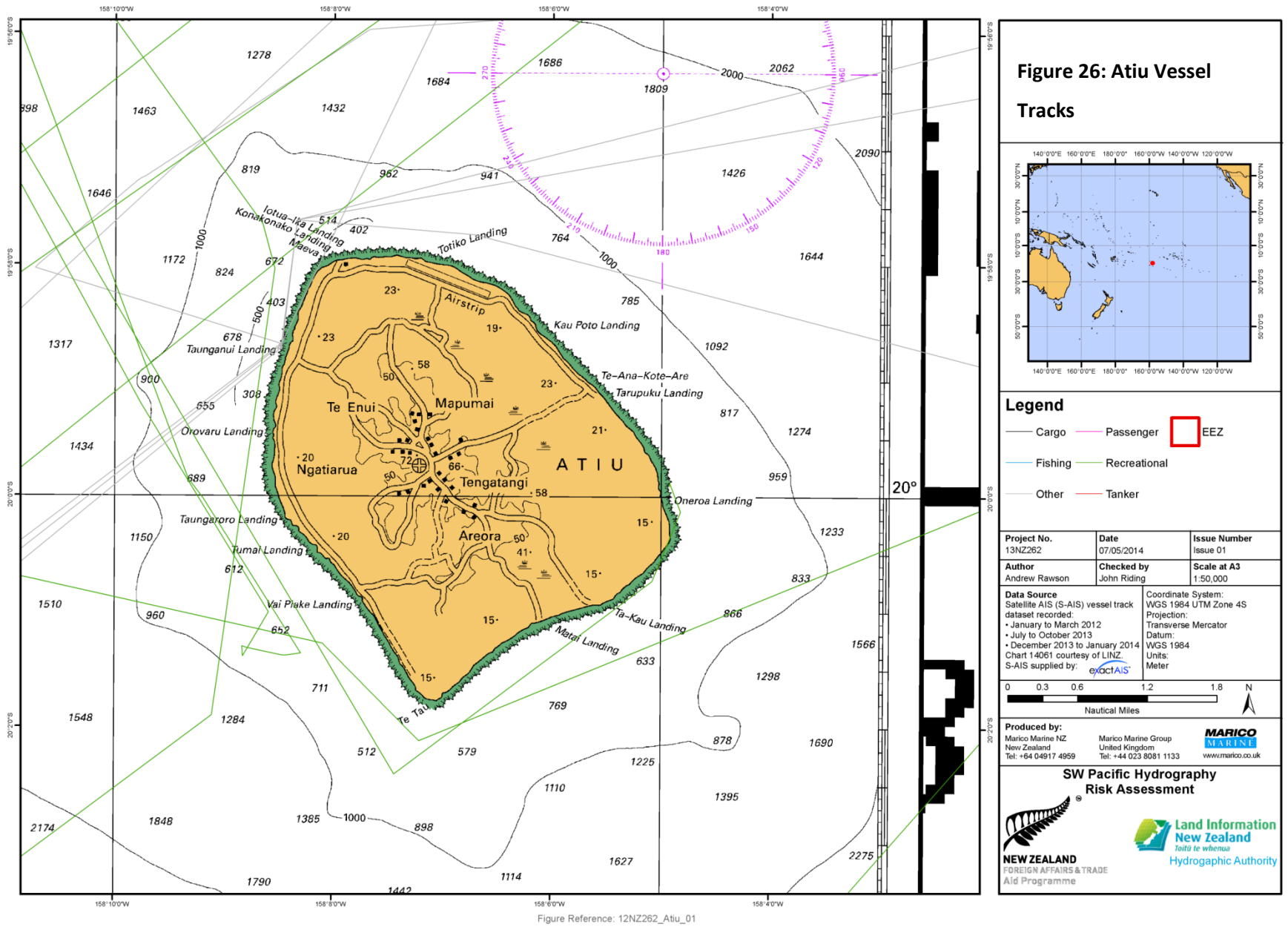


Figure Reference: 12NZ262_Atiu_01

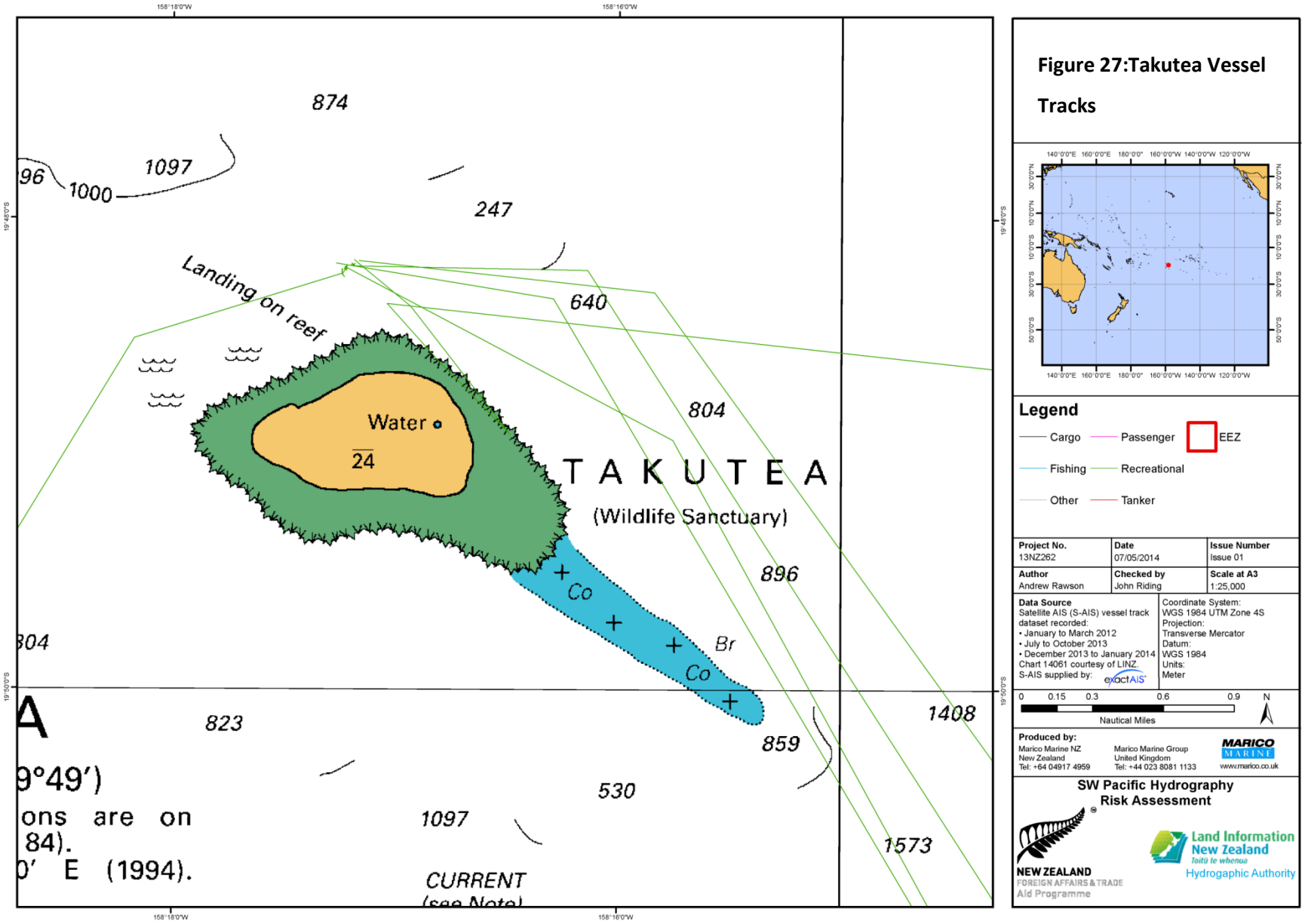


Figure Reference: 12NZ262_Takutea_01

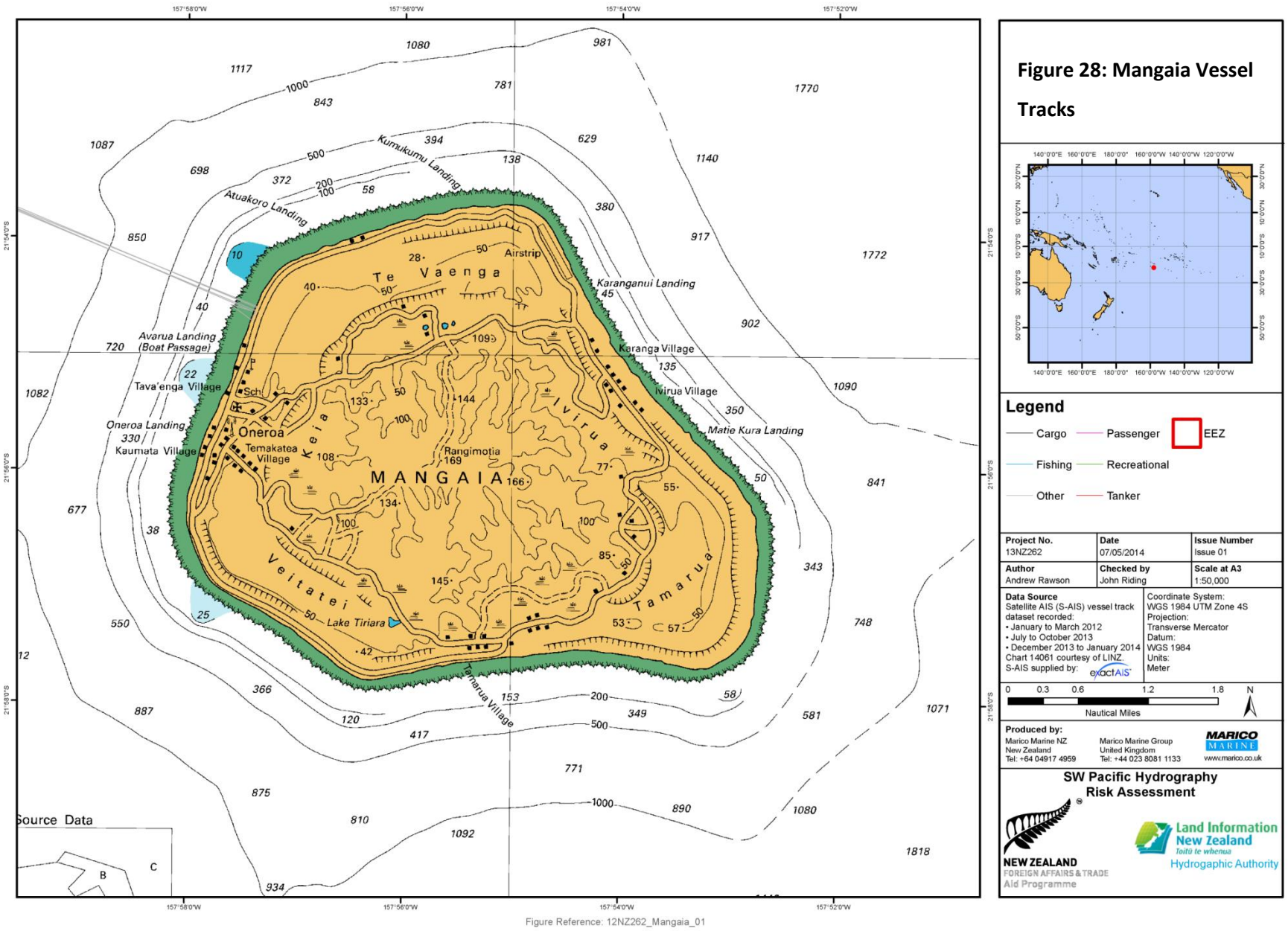


Figure Reference: 12NZ262_Mangaia_01

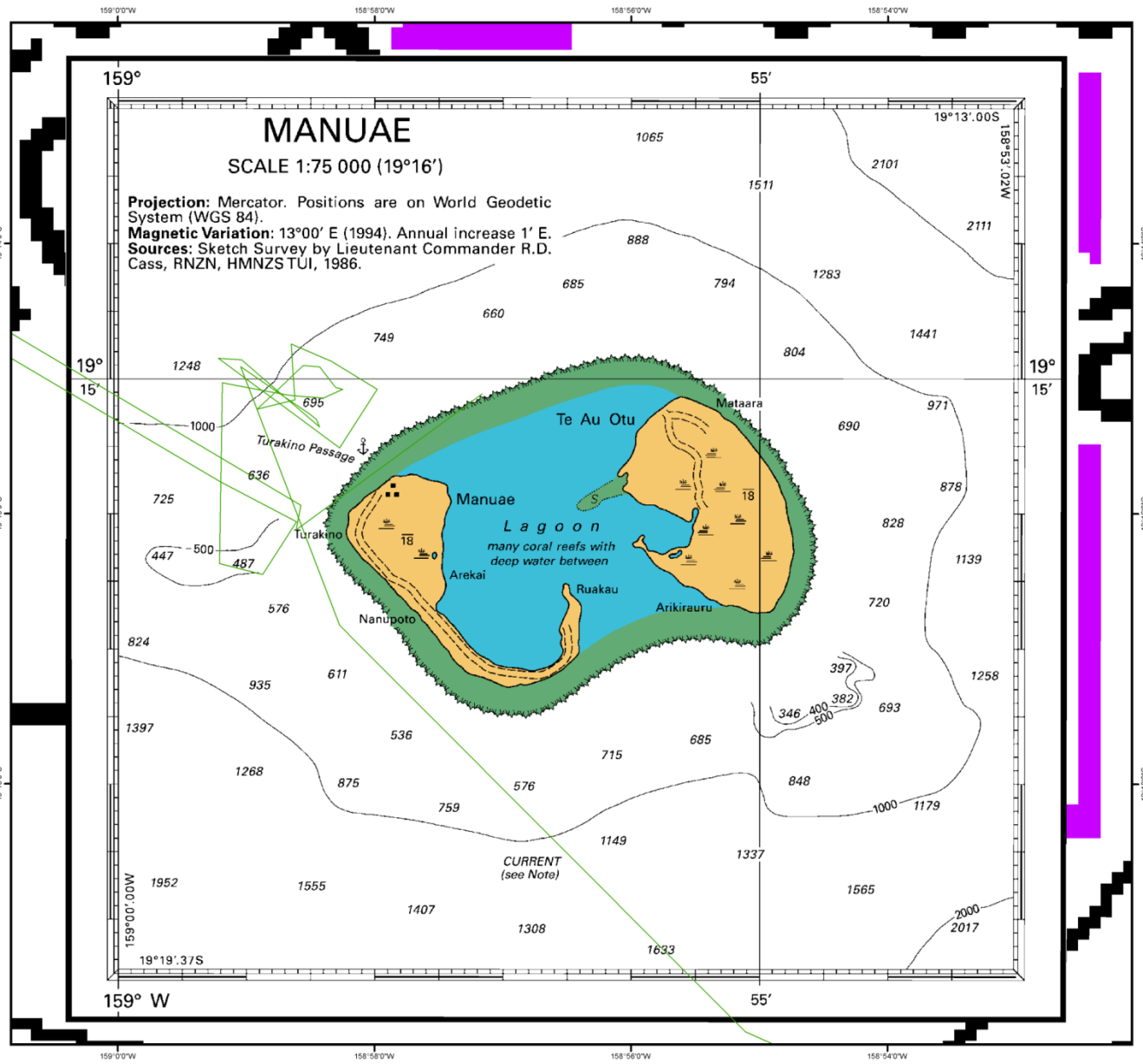
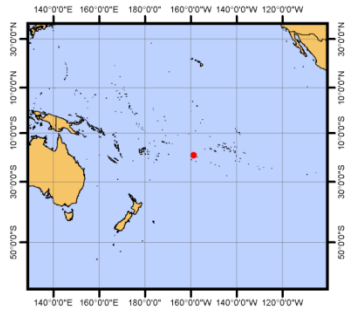


Figure Reference: 12NZ262_Manuae_01

Figure 29:Manuae Vessel Tracks



Legend

Cargo — Passenger — EEZ
Fishing — Recreational
Other — Tanker

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:50,000

Data Source
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Projection: Transverse Mercator
Datum: WGS 1984
Units: Meter

0 0.3 0.6 1.2 1.8 N
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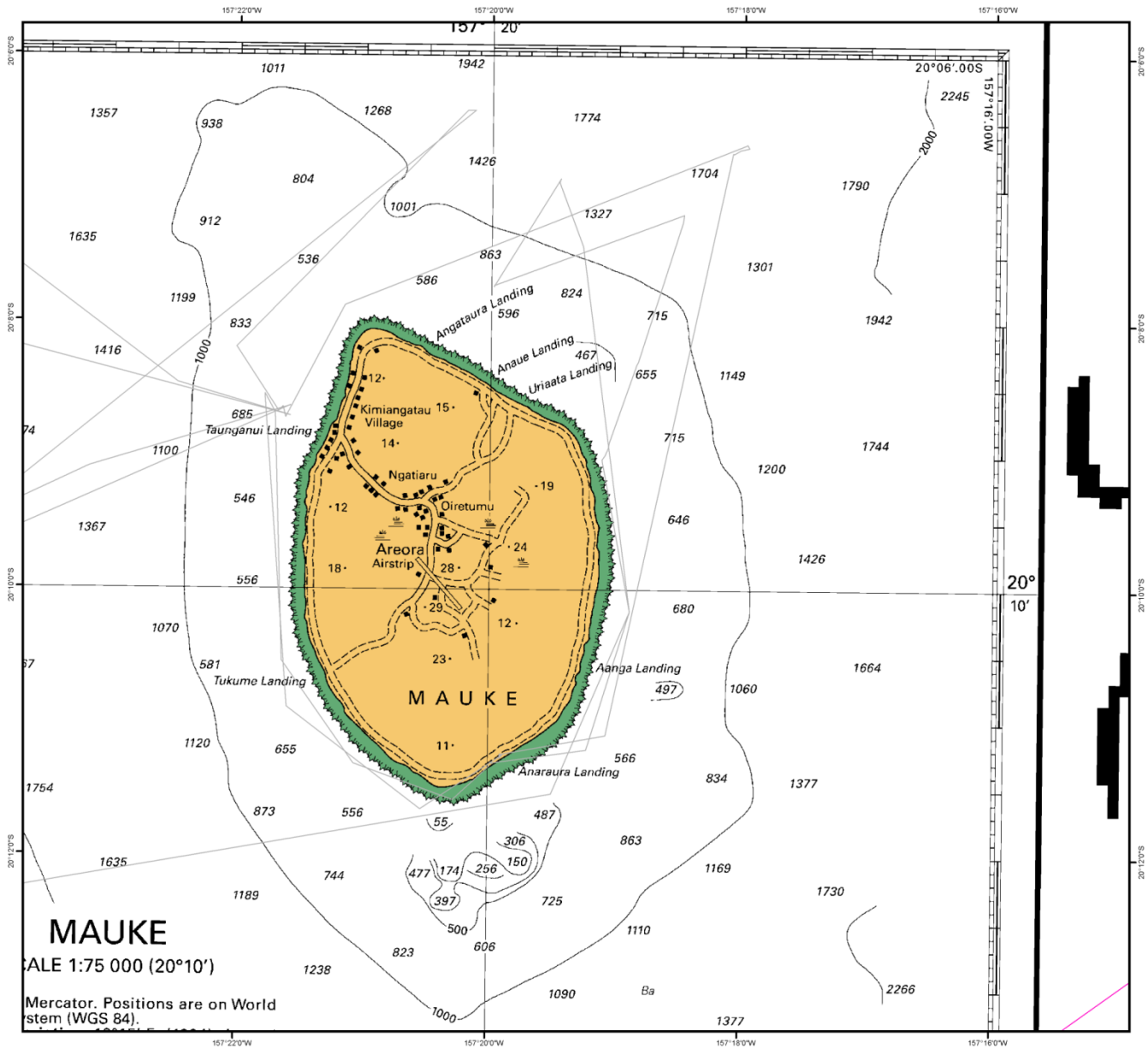
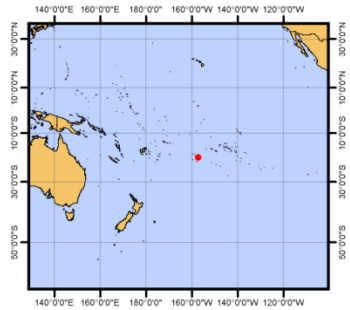


Figure Reference: 12NZ262_Mauke_01

Figure 30: Mauke Vessel Tracks



Legend

Cargo — Passenger — EEZ

Fishing — Recreational

Other — Tanker

Project No.	Date	Issue Number
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Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:50,000

Data Source
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Projection:
Transverse Mercator
Datum:
WGS 1984
Units:
Meter

0 0.3 0.6 1.2 1.8 N
Nautical Miles

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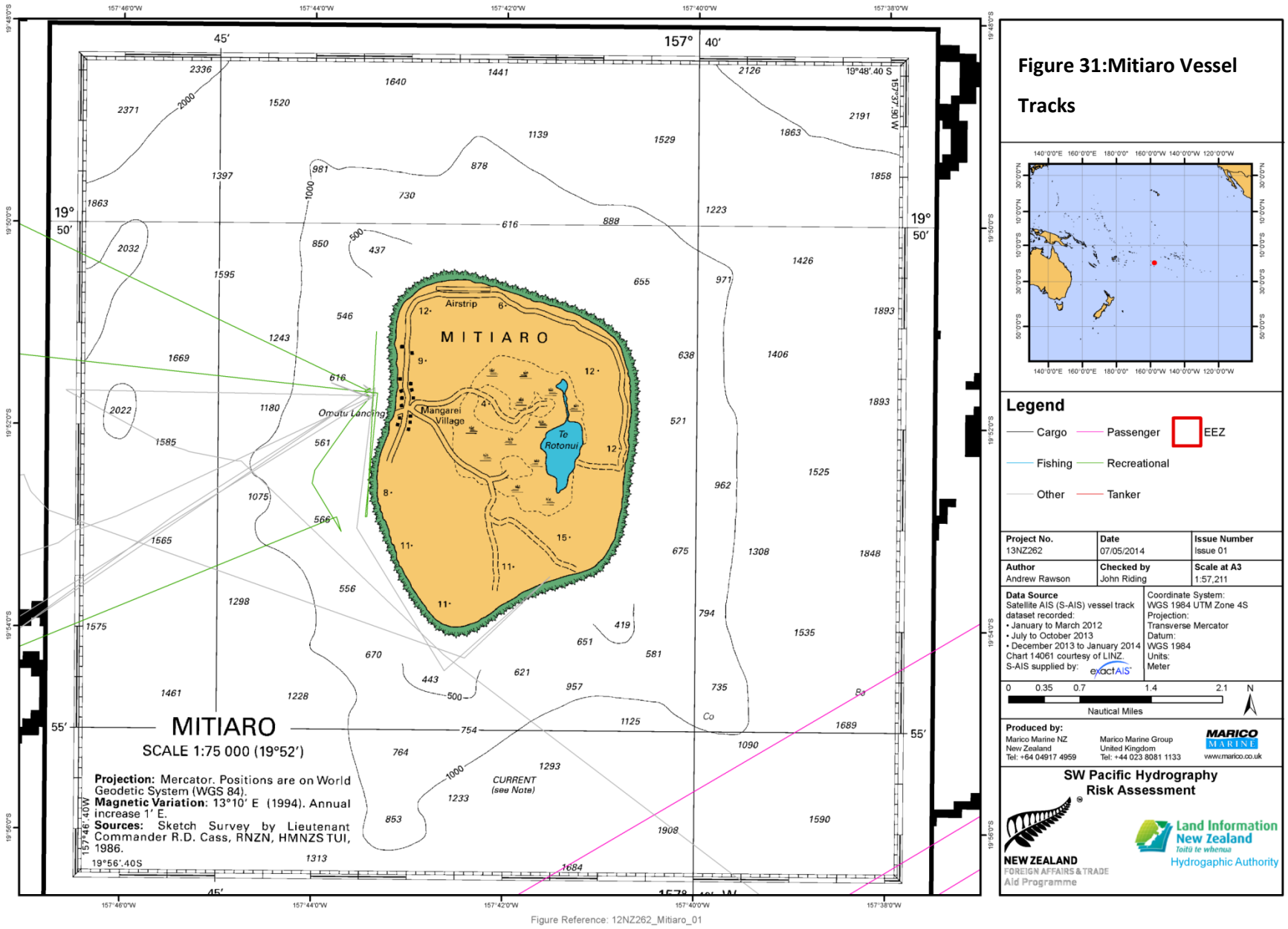

Figure Reference: 12NZ262_Mitiaro_01

Figure 31:Mitiaro Vessel Tracks

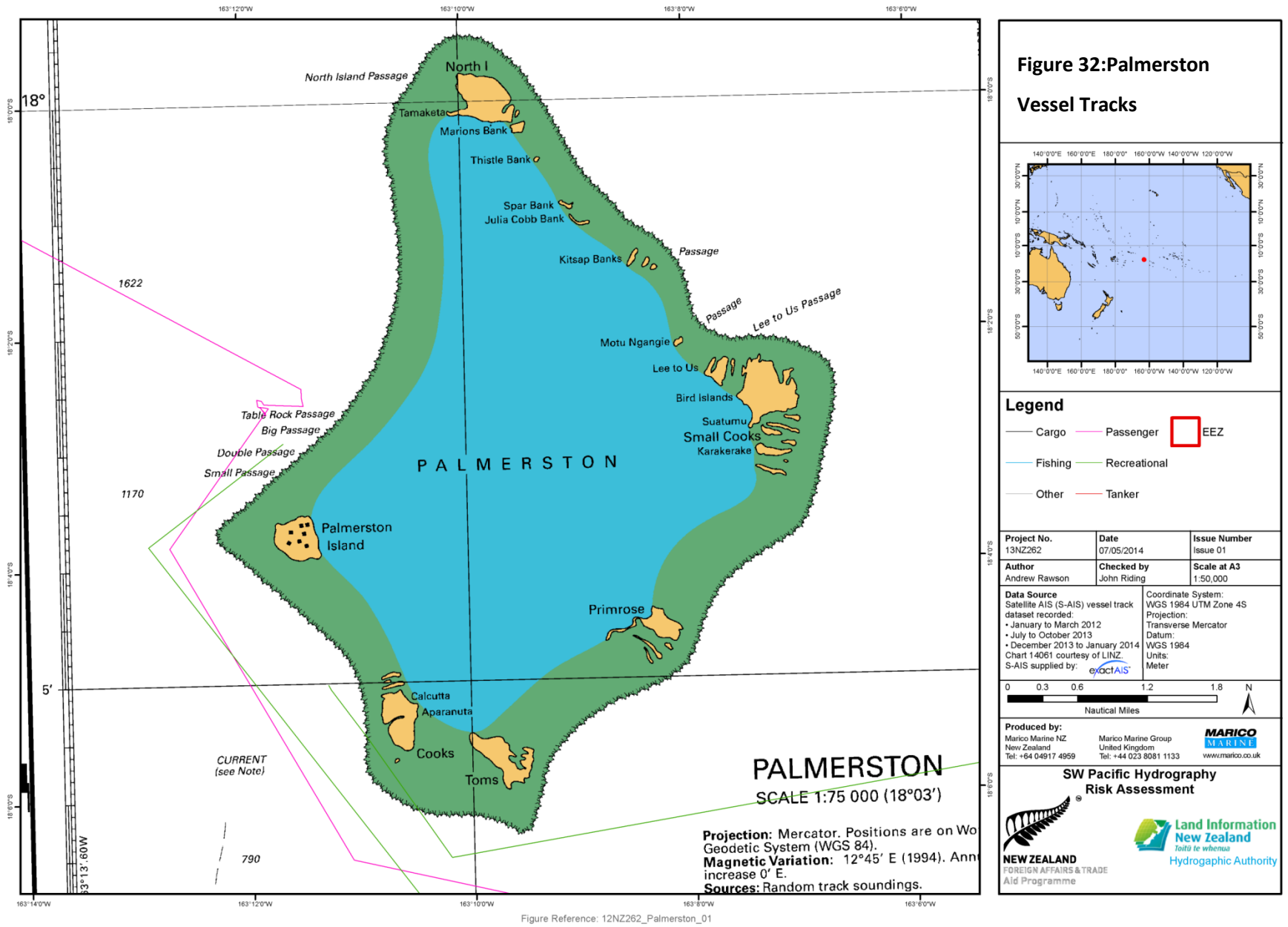

Figure Reference: 12NZ262_Palmerston_01

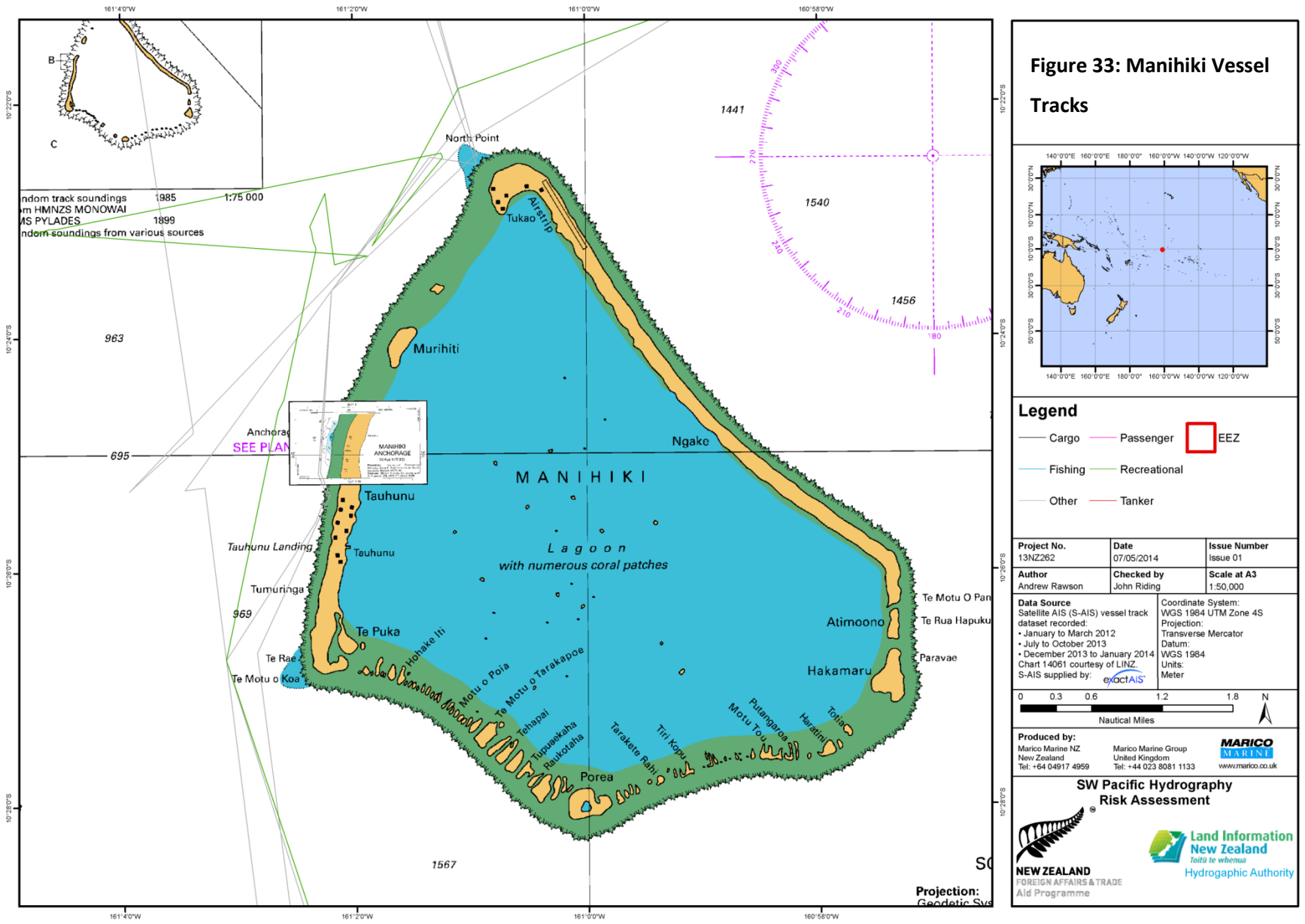

Figure Reference: 12NZ262_Manihiki_01

Figure 33: Manihiki Vessel Tracks

Legend

Cargo — Passenger — EEZ
Fishing — Recreational
Other — Tanker

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:50,000

Data Source
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- December 2013 to January 2014

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Projection:
Transverse Mercator
Datum:
WGS 1984
Units:
Meter

0 0.3 0.6 1.2 1.8 N
Nautical Miles

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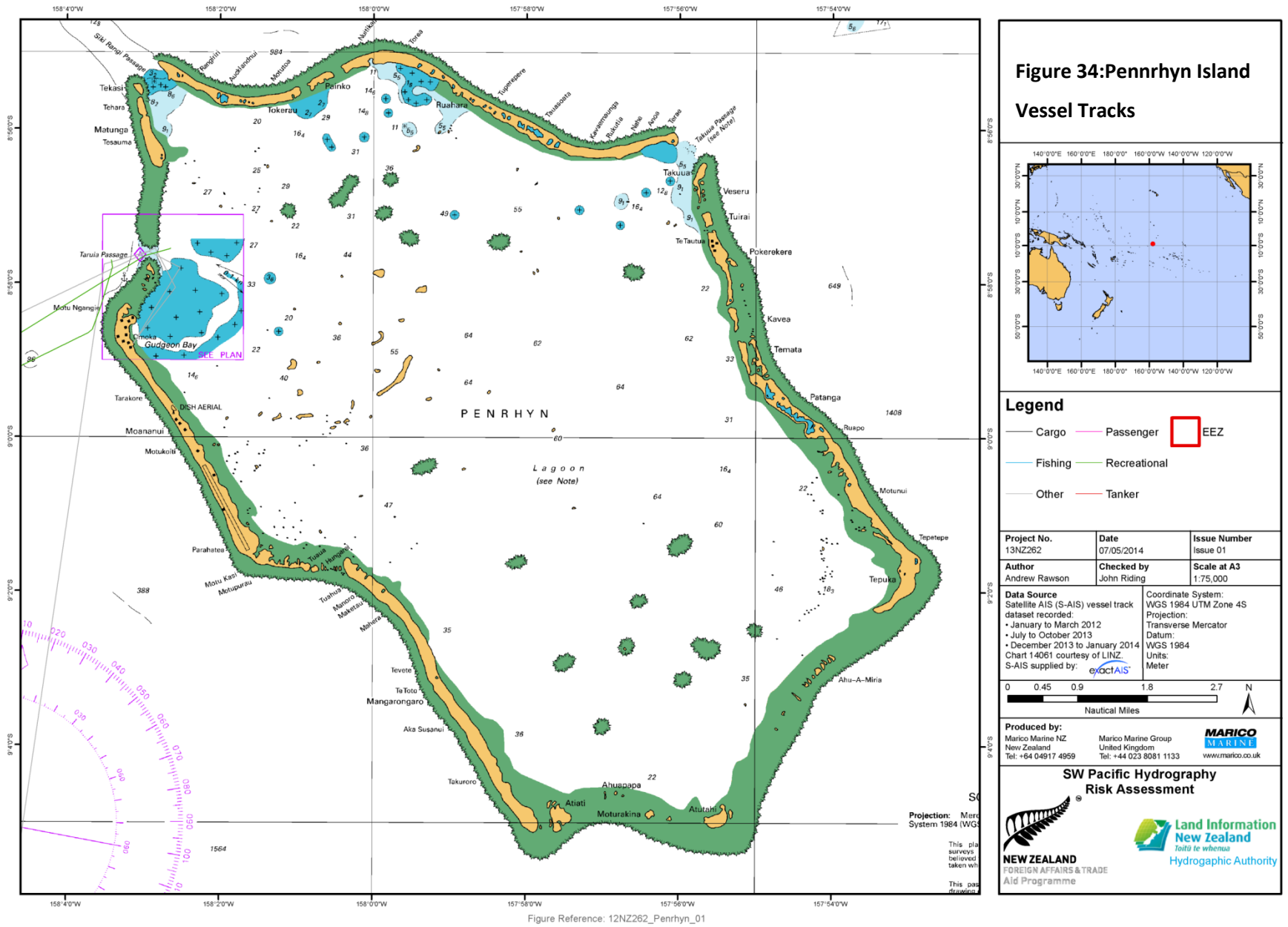

Figure Reference: 12NZ262_Penrhyn_01

Figure 34:Pennrhyn Island Vessel Tracks

Legend

Cargo — Passenger — EEZ
Fishing — Recreational
Other — Tanker

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:75,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
- January to March 2012
- July to October 2013
- December 2013 to January 2014

Chart 14061 courtesy of LINZ.
S-AIS supplied by: exactAIS

Coordinate System:
WGS 1984 UTM Zone 4S
Projection:
Transverse Mercator
Datum:
WGS 1984
Units:
Meter

0 0.45 0.9 1.8 2.7 N
Nautical Miles

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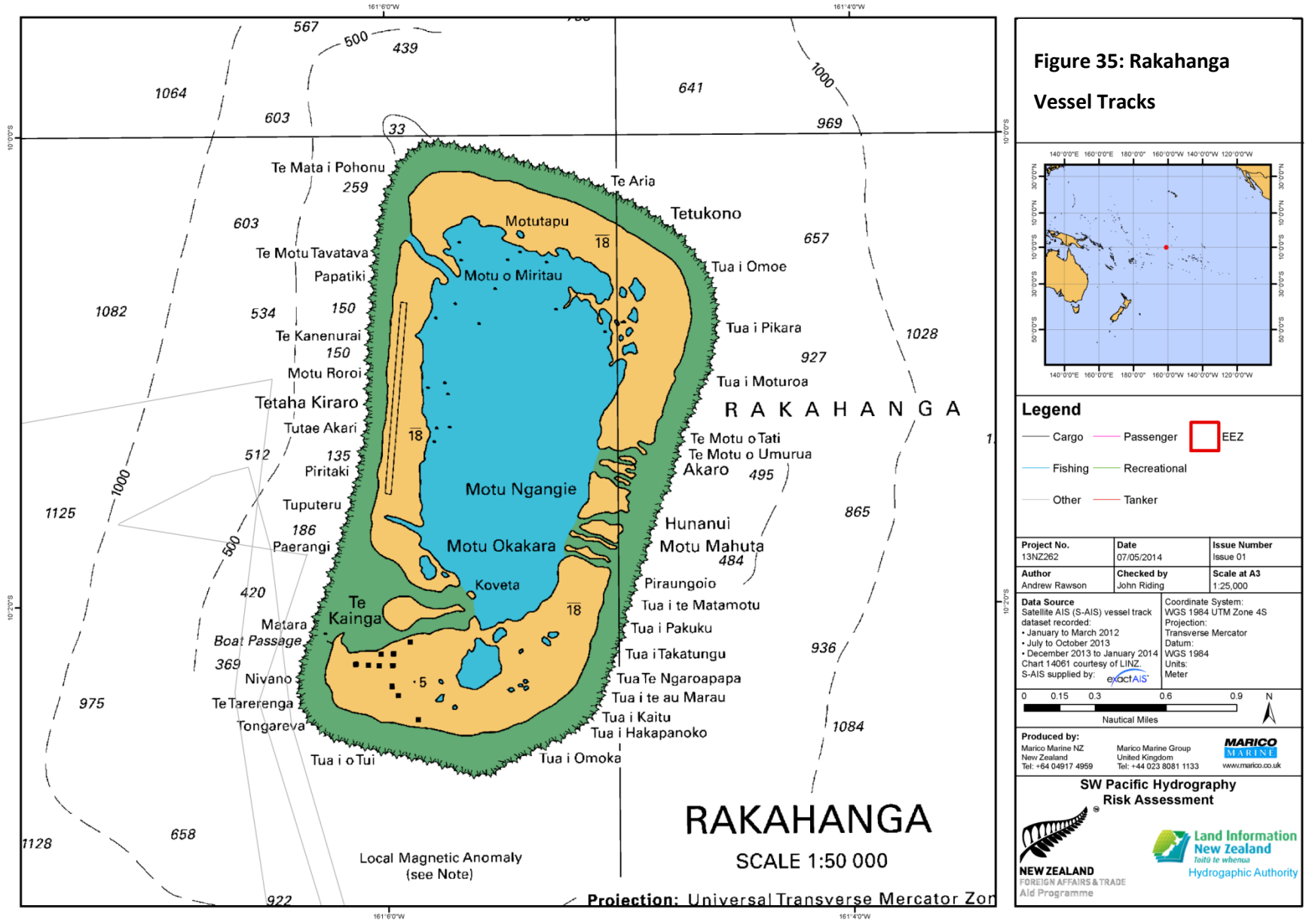

Figure Reference: 12NZ262_Rakahanga_01

Figure 35: Rakahanga Vessel Tracks

Legend

Cargo — Passenger — EEZ
Fishing — Recreational
Other — Tanker

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:25,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
- January to March 2012
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- December 2013 to January 2014

Chart 14061 courtesy of LINZ.
S-AIS supplied by: exactAIS

Coordinate System: WGS 1984 UTM Zone 4S
Projection: Transverse Mercator
Datum: WGS 1984
Units: Meter

0 0.15 0.3 0.6 0.9 N
Nautical Miles

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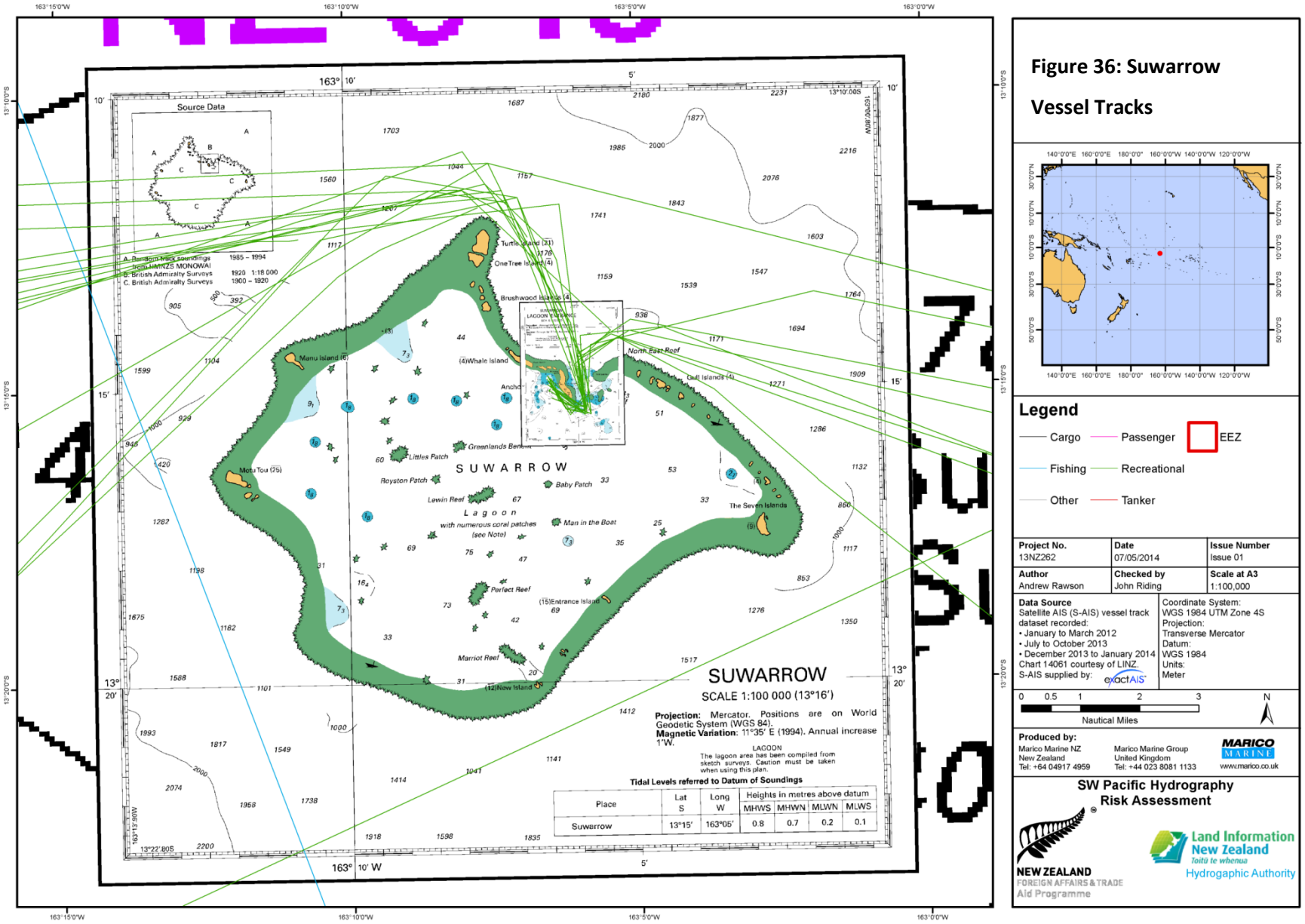

Figure Reference: 12NZ262_Suwarrow_01

Figure 36: Suwarrow Vessel Tracks

Legend

Cargo — Passenger — EEZ
Fishing — Recreational
Other — Tanker

Project No.	Date	Issue Number
13NZ262	07/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:100,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
- January to March 2012
- July to October 2013
- December 2013 to January 2014

Chart 14061 courtesy of LINZ.
S-AIS supplied by: exactAIS

Coordinate System: WGS 1984 UTM Zone 4S
Projection: Transverse Mercator
Datum: WGS 1984
Units: Meter

0 0.5 1 2 3 Nautical Miles
N

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Annex C
Chart CATZOC for Each Island Group

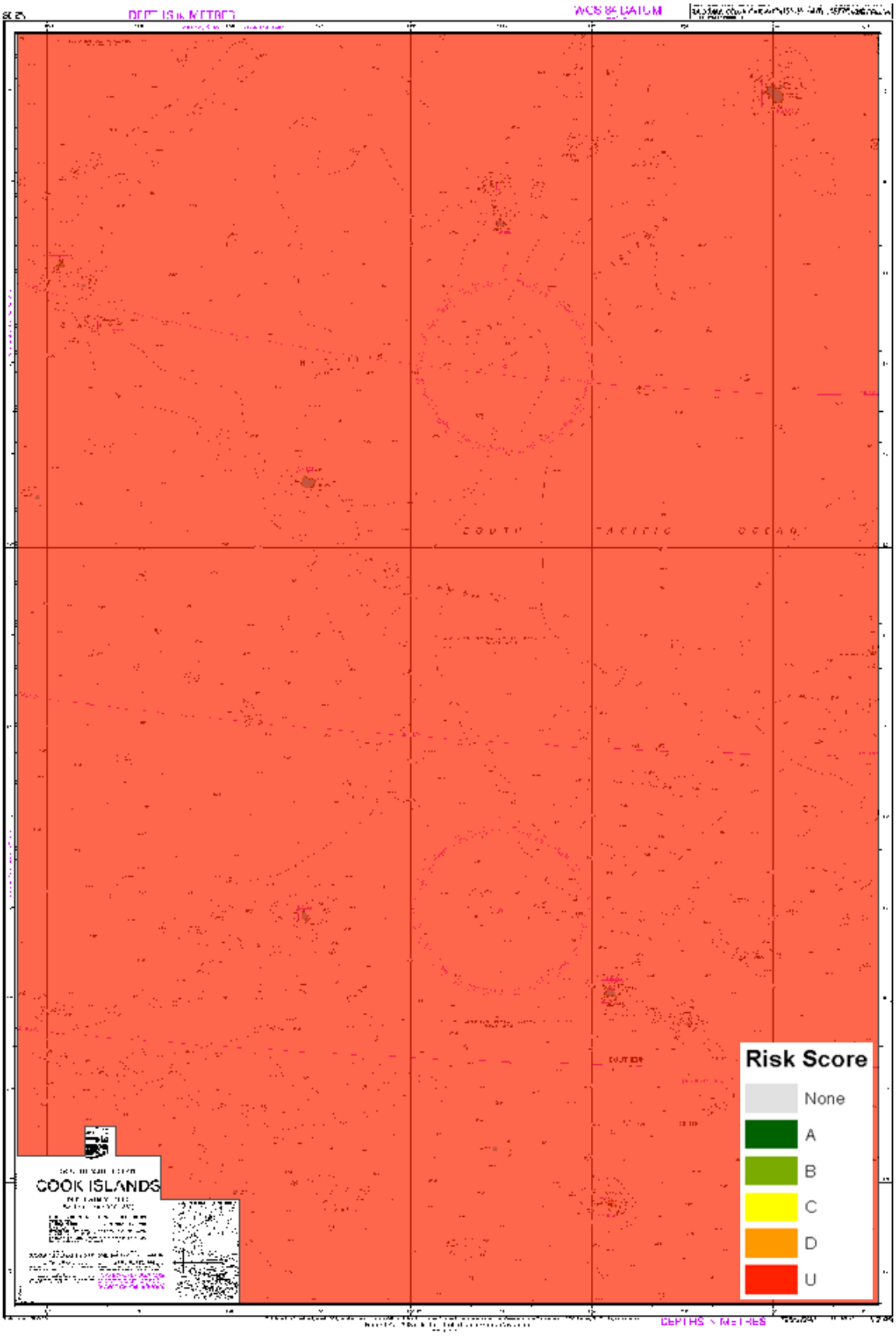


Figure 38: CATZOC Categories for Cook Islands

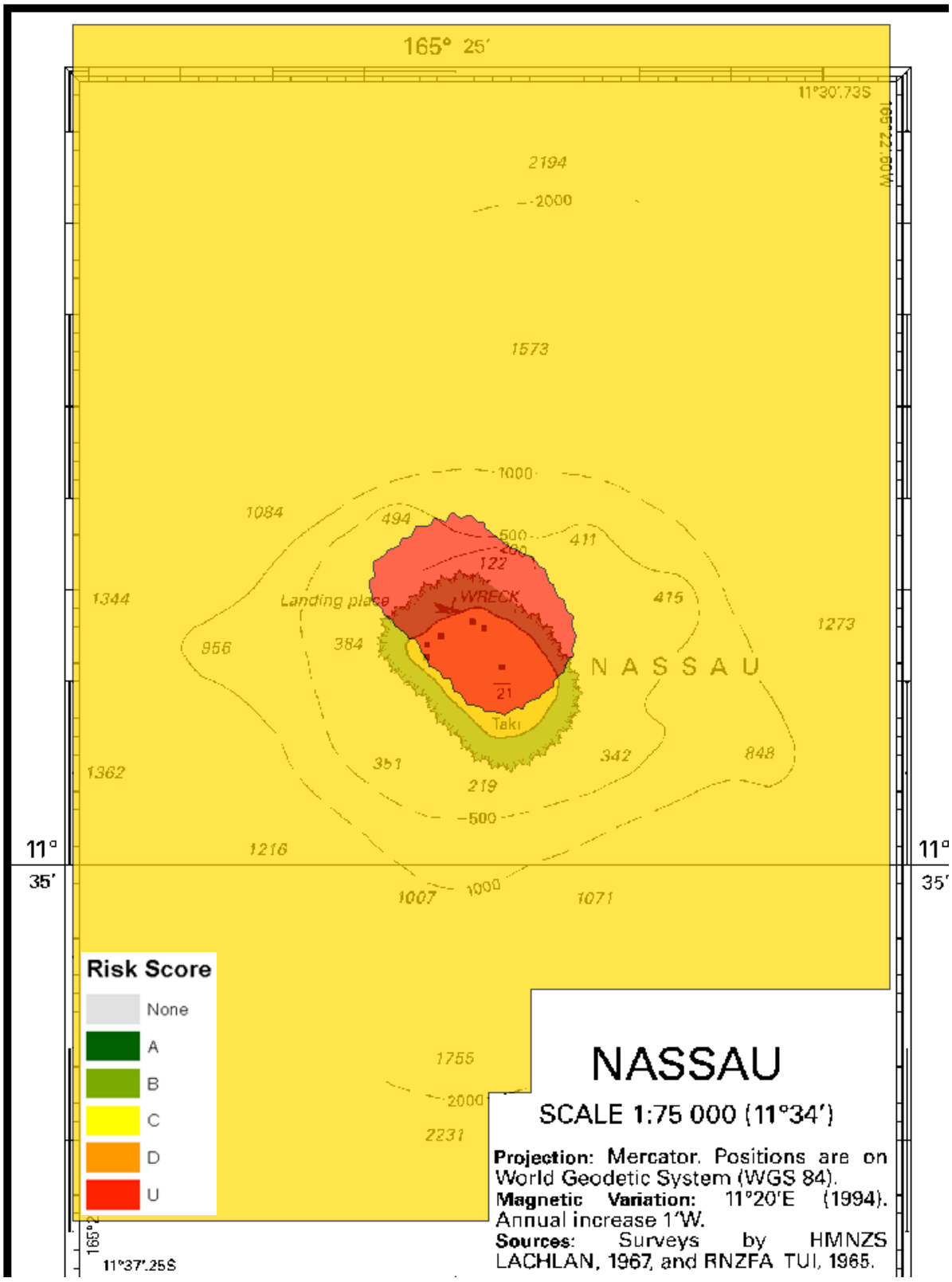


Figure 39: CATZOC Categories for Nassau Island

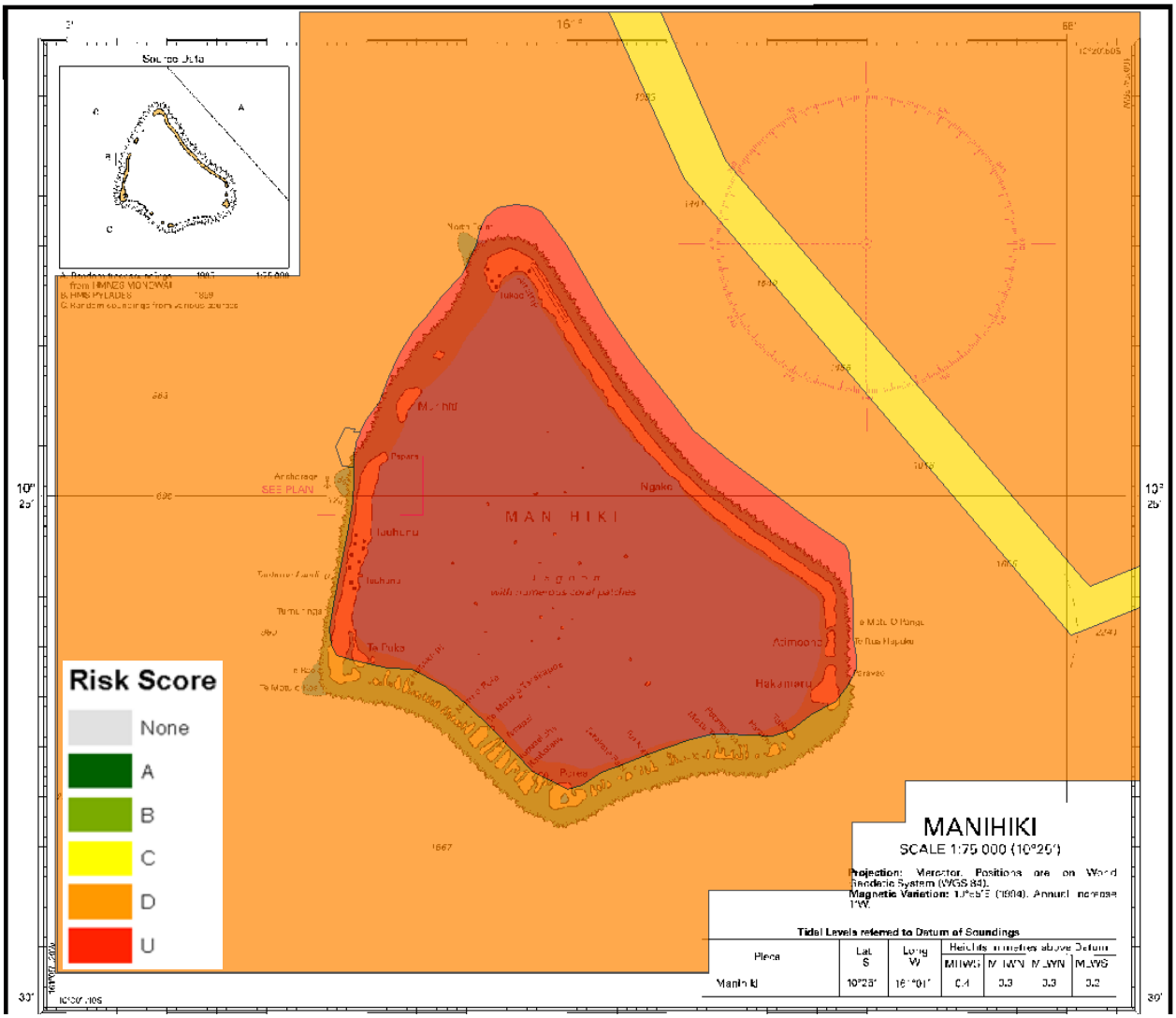


Figure 40: CATZOC Categories for Manihiki Island

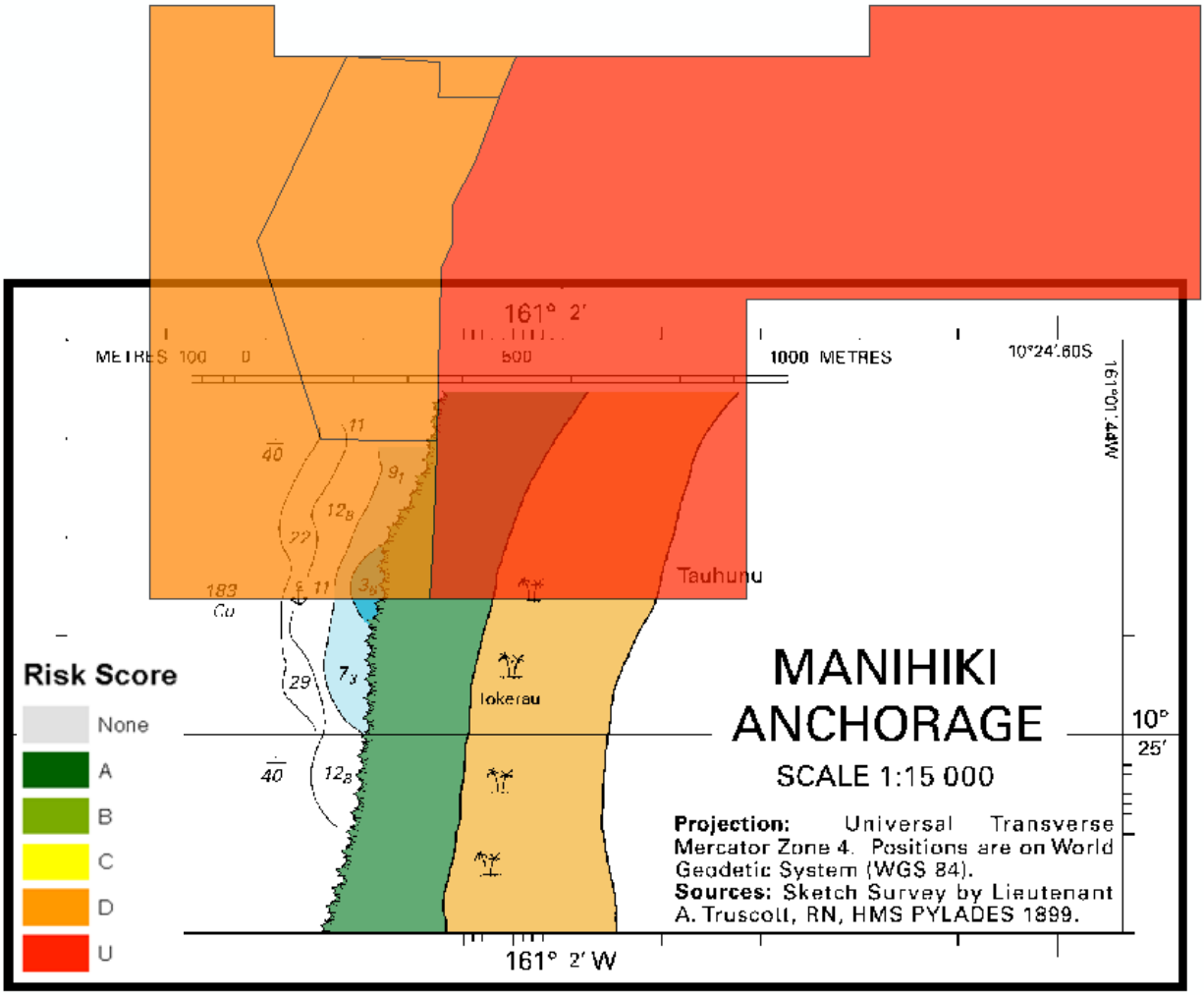


Figure 41: CATZOC Categories for Manihiki Island

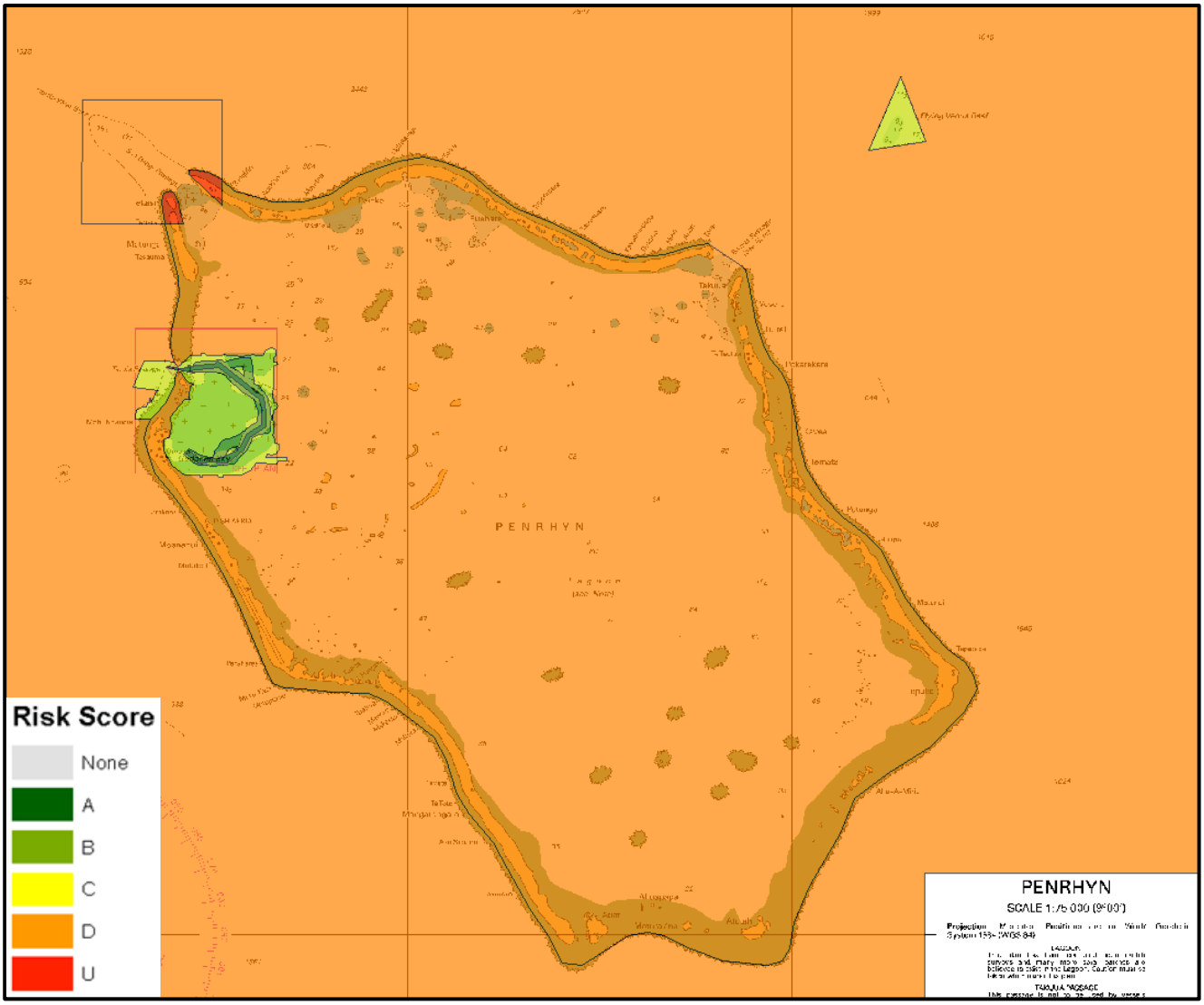


Figure 42: CATZOC Categories for Penrhyn Island

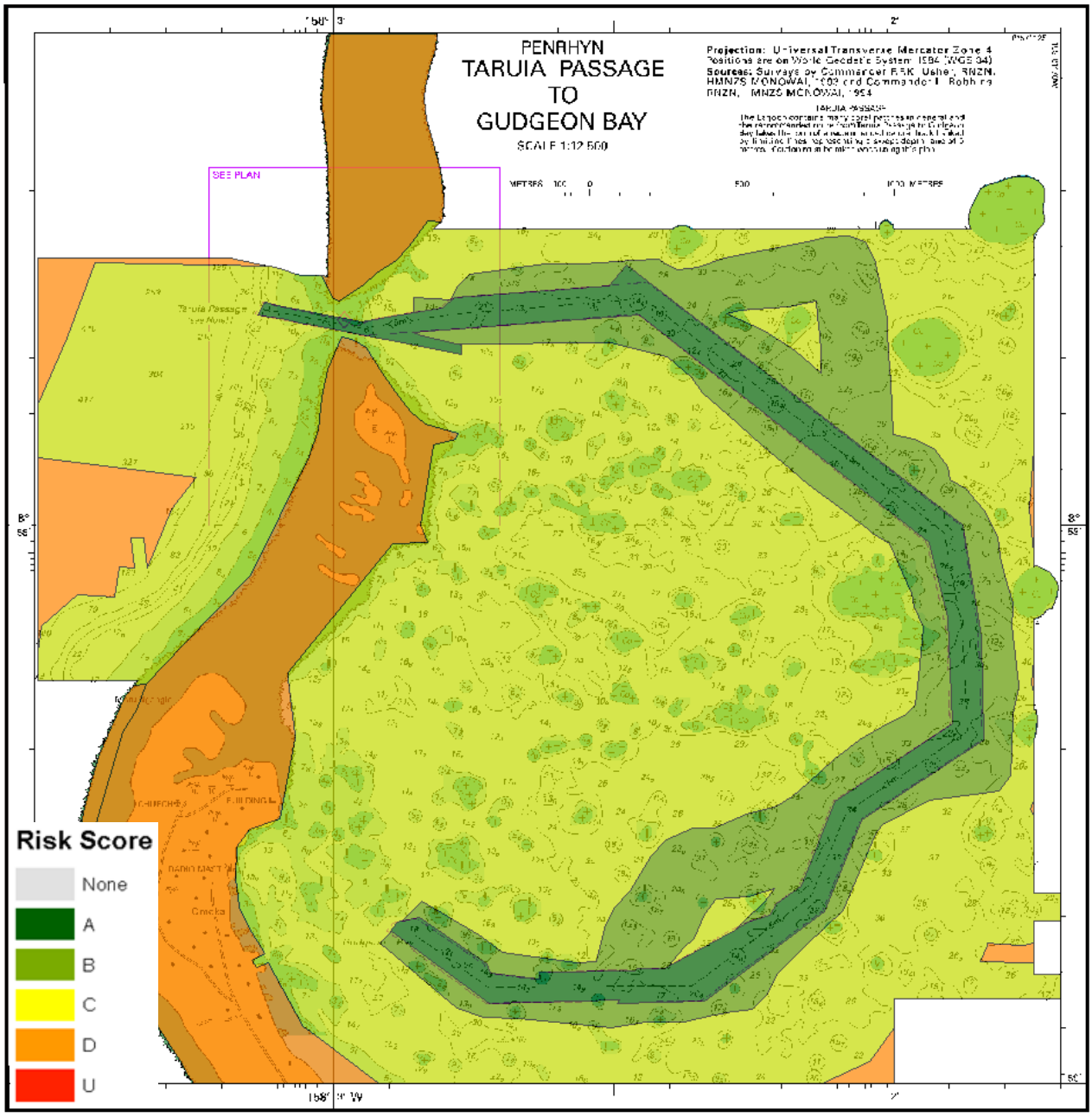


Figure 43: CATZOC Categories for Penrhyn Taruia Passage to Gudgeon Bay

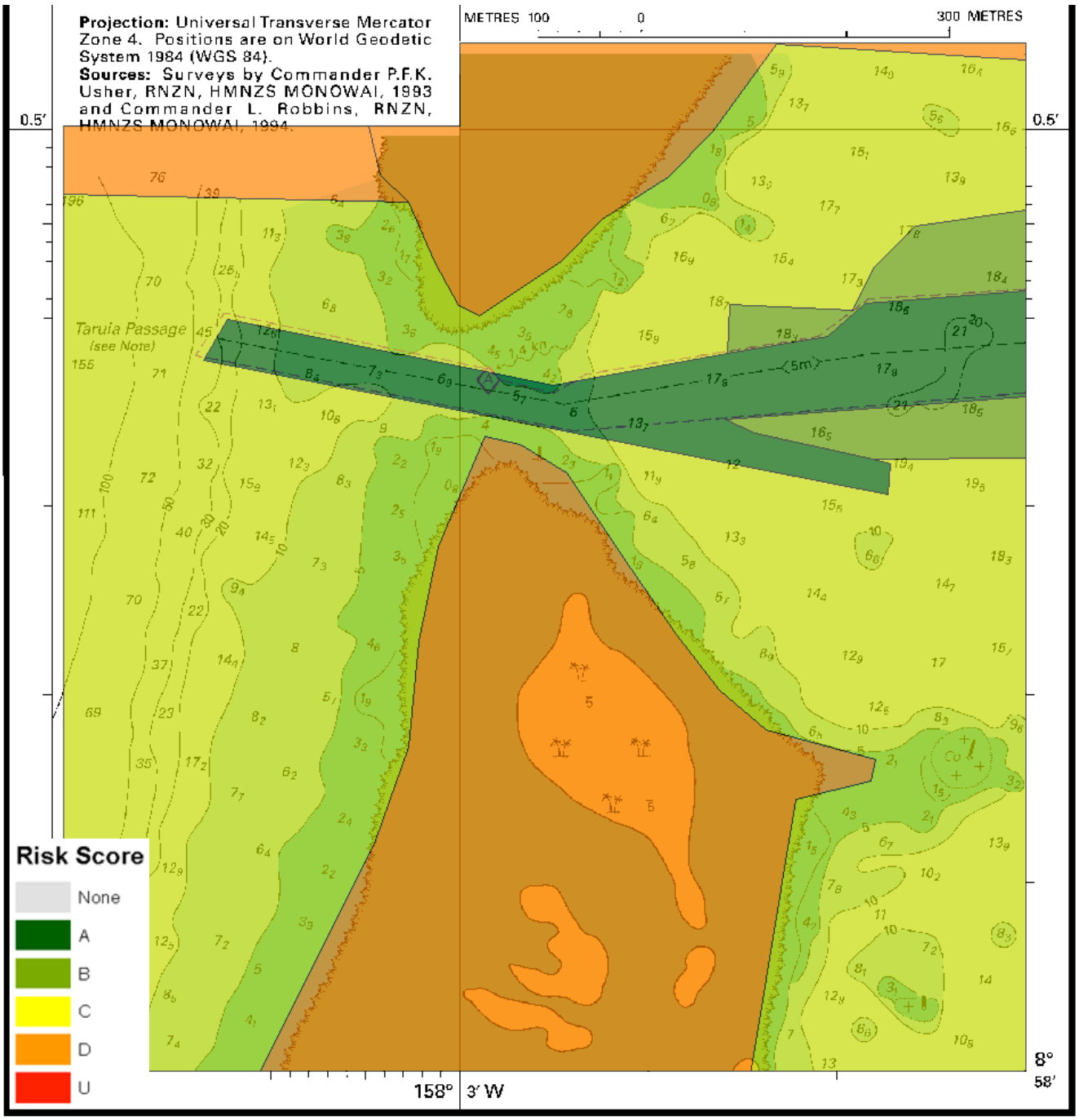


Figure 44: CATZOC Categories for Taruia Passage

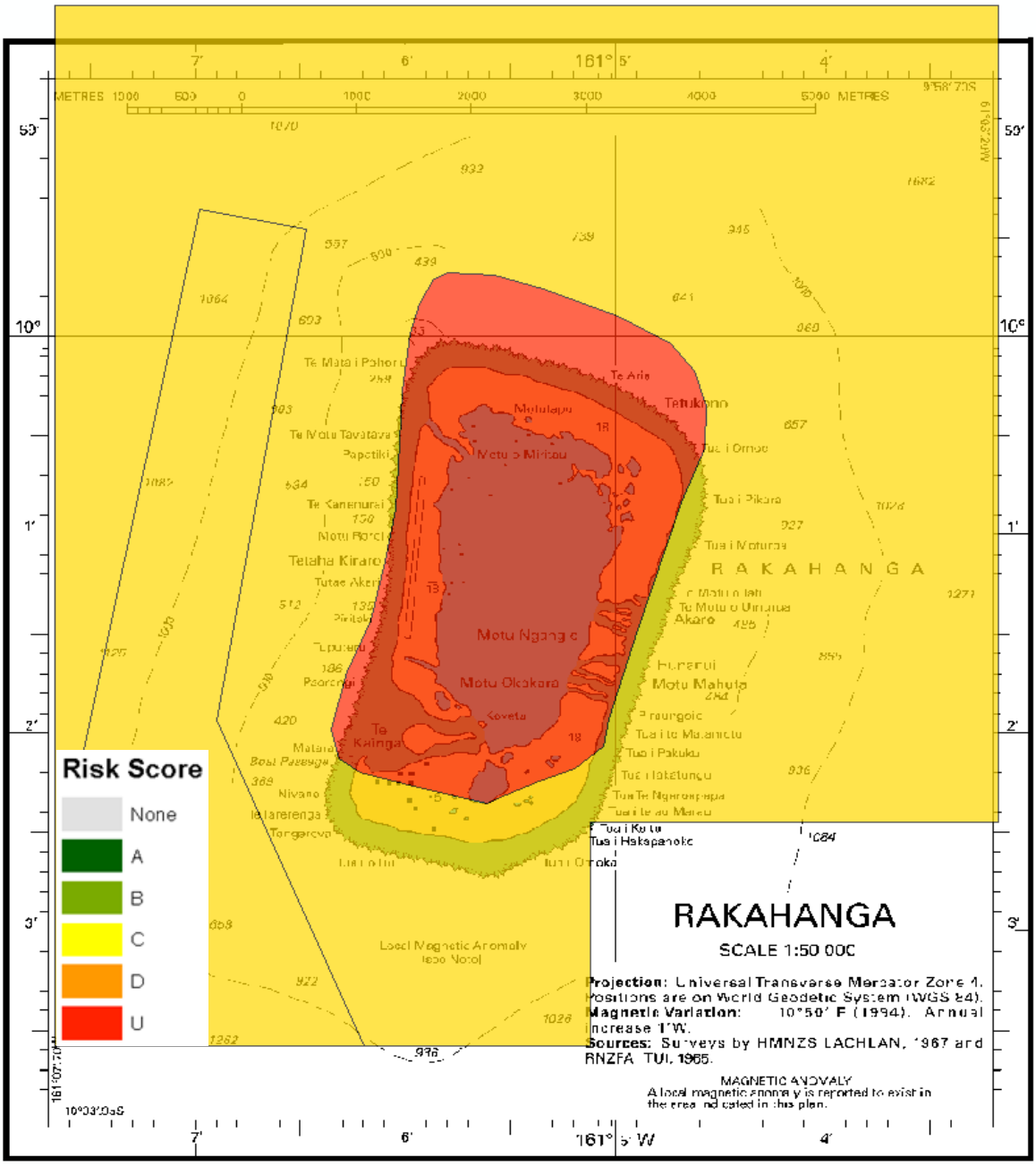


Figure 45: CATZOC Categories for Rakahanga Island

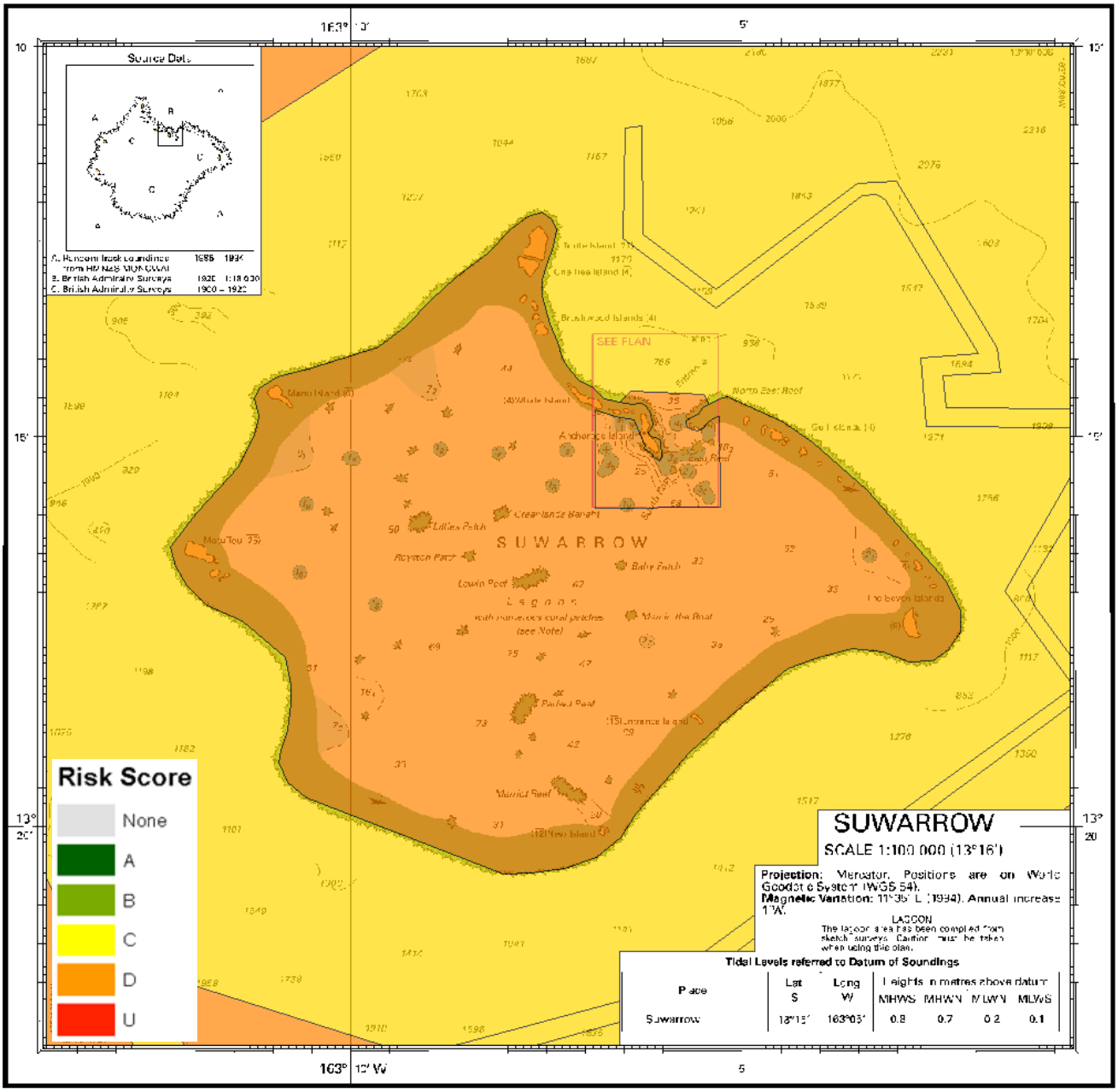


Figure 46: CATZOC Categories for Suwarrow Island

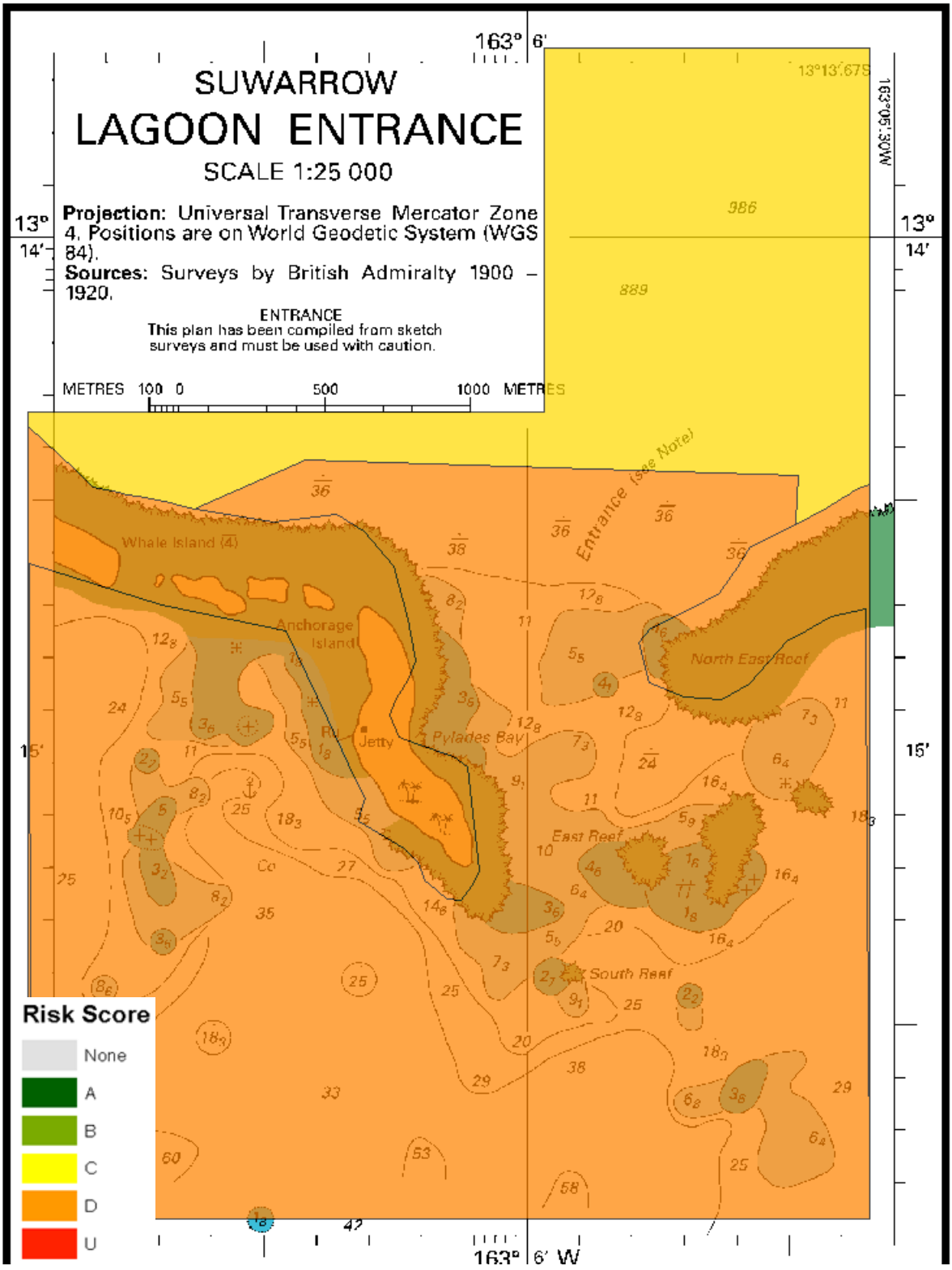


Figure 47: CATZOC Categories for Suwarrow Lagoon Entrance

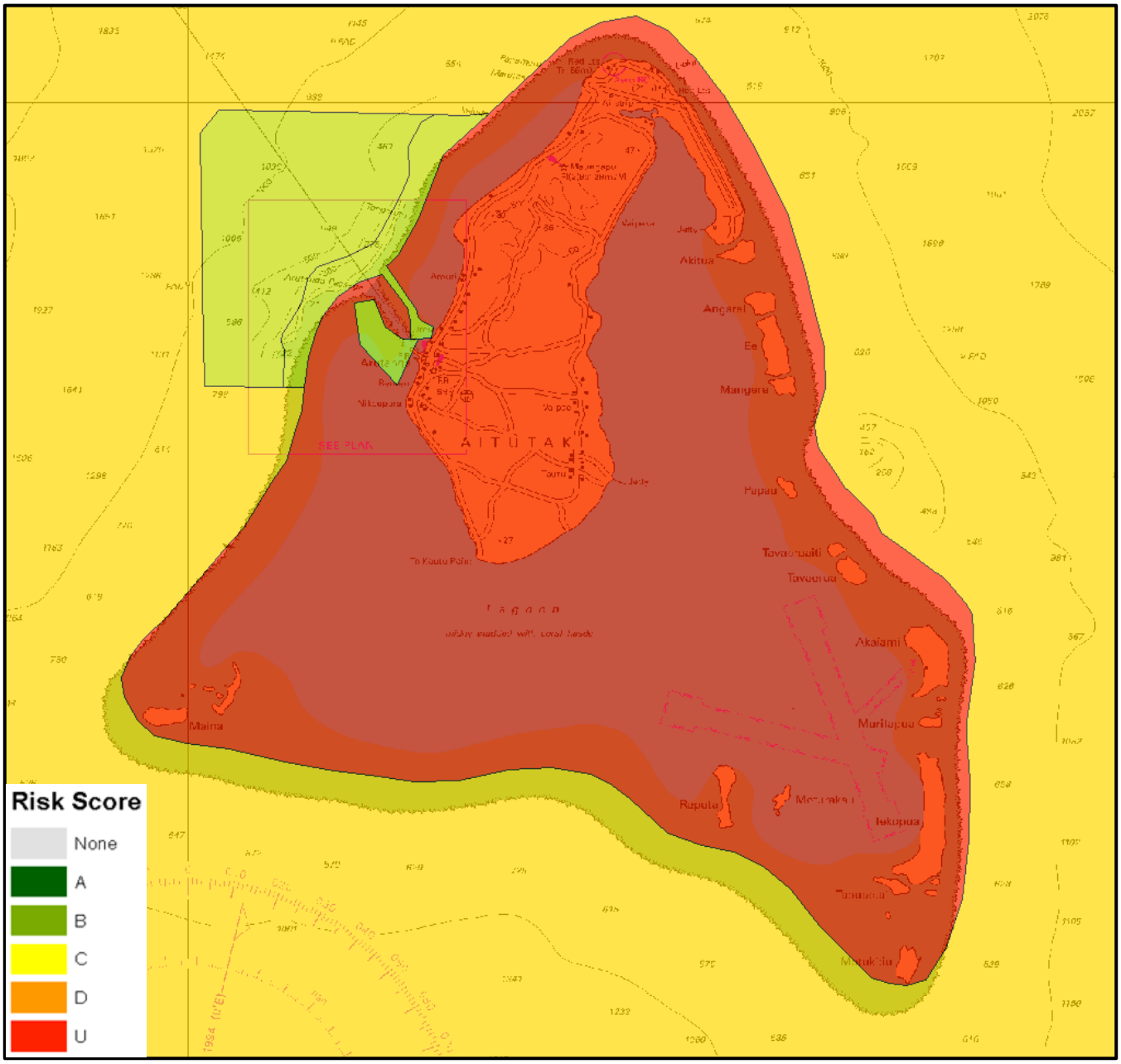


Figure 48: CATZOC Categories for Aitutaki Island

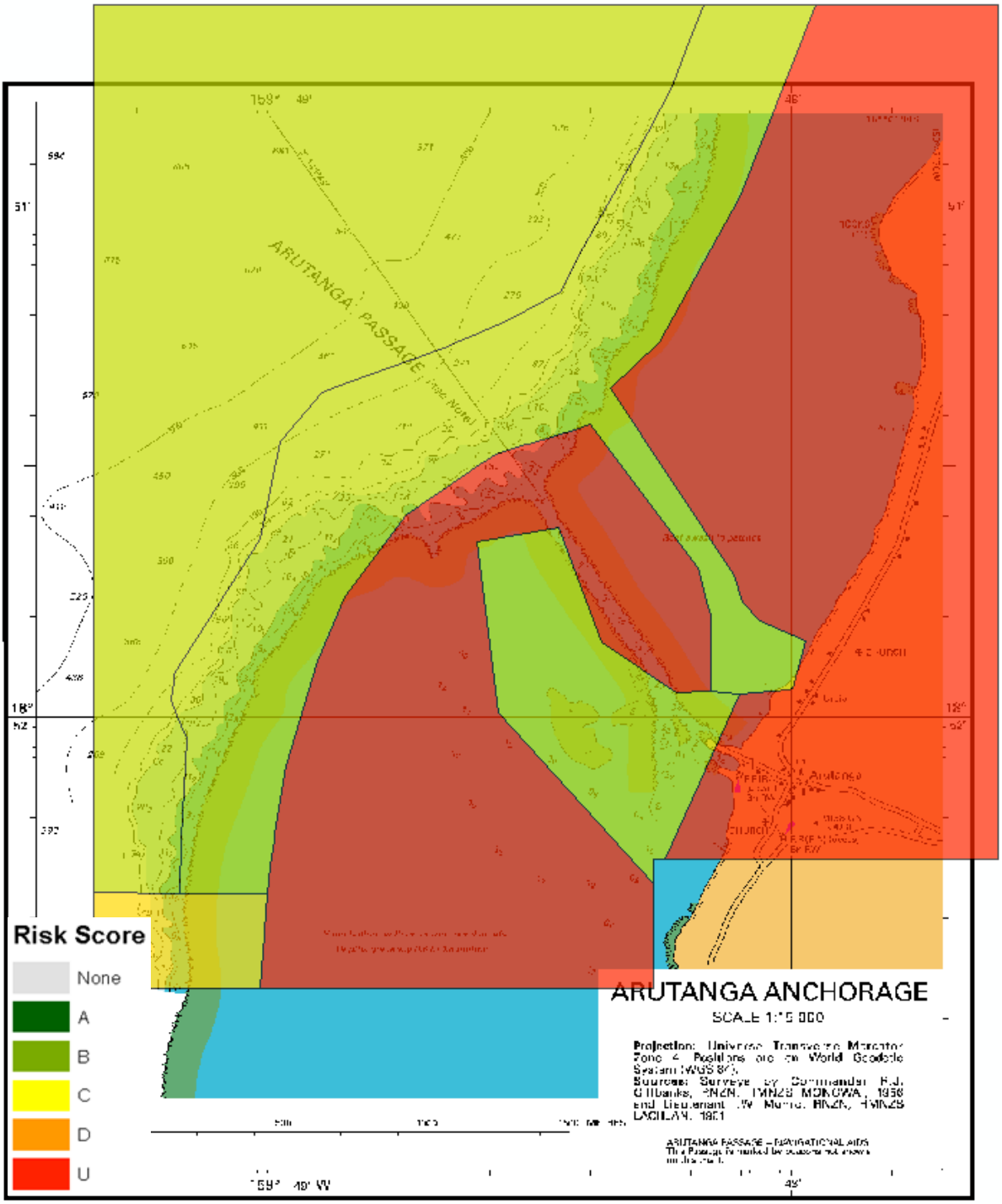


Figure 49: CATZOC Categories for Arutanga Anchorage

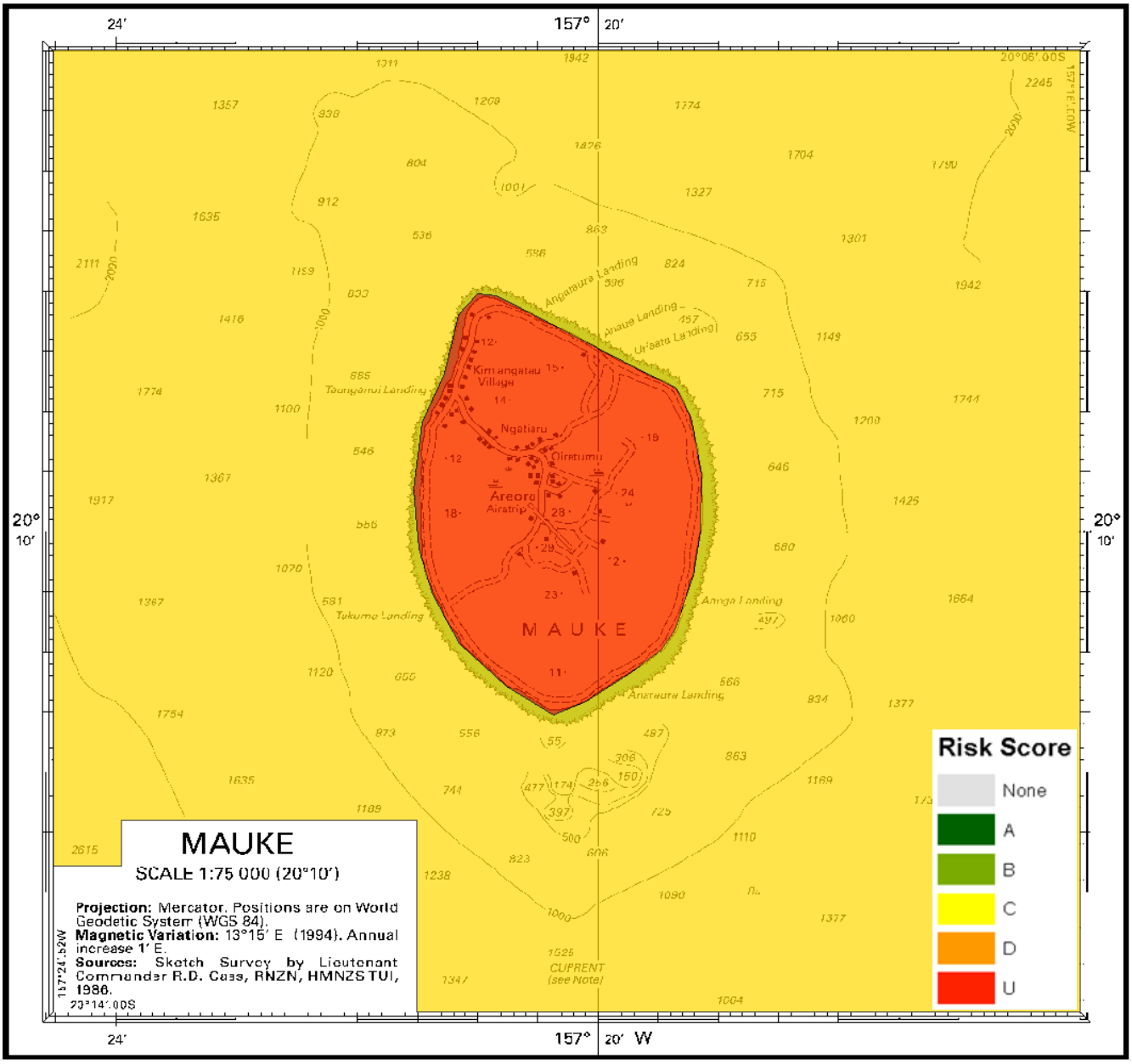


Figure 50: CATZOC Categories for Mauke Island

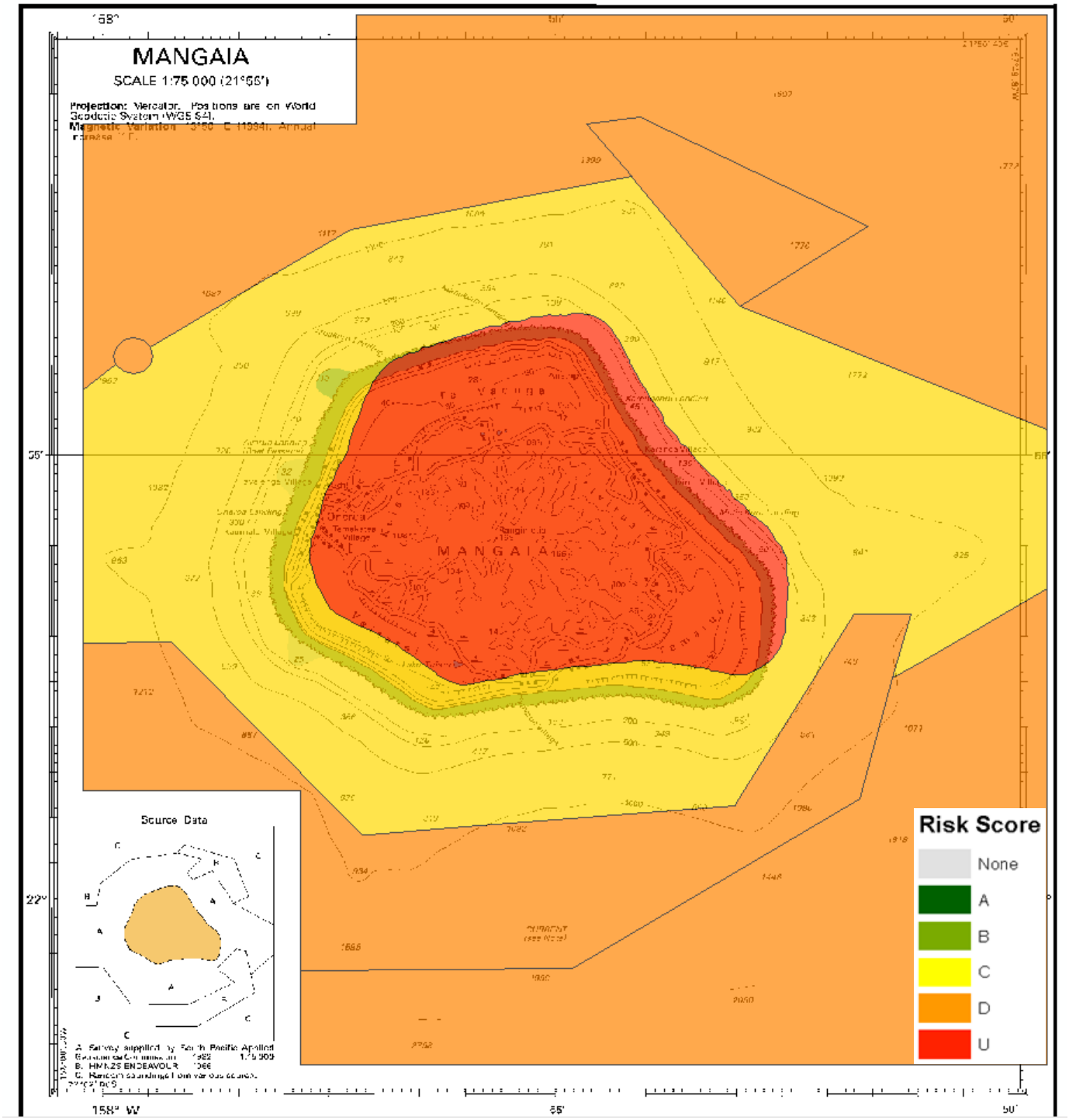


Figure 51: CATZOC Categories for Mangaia Island

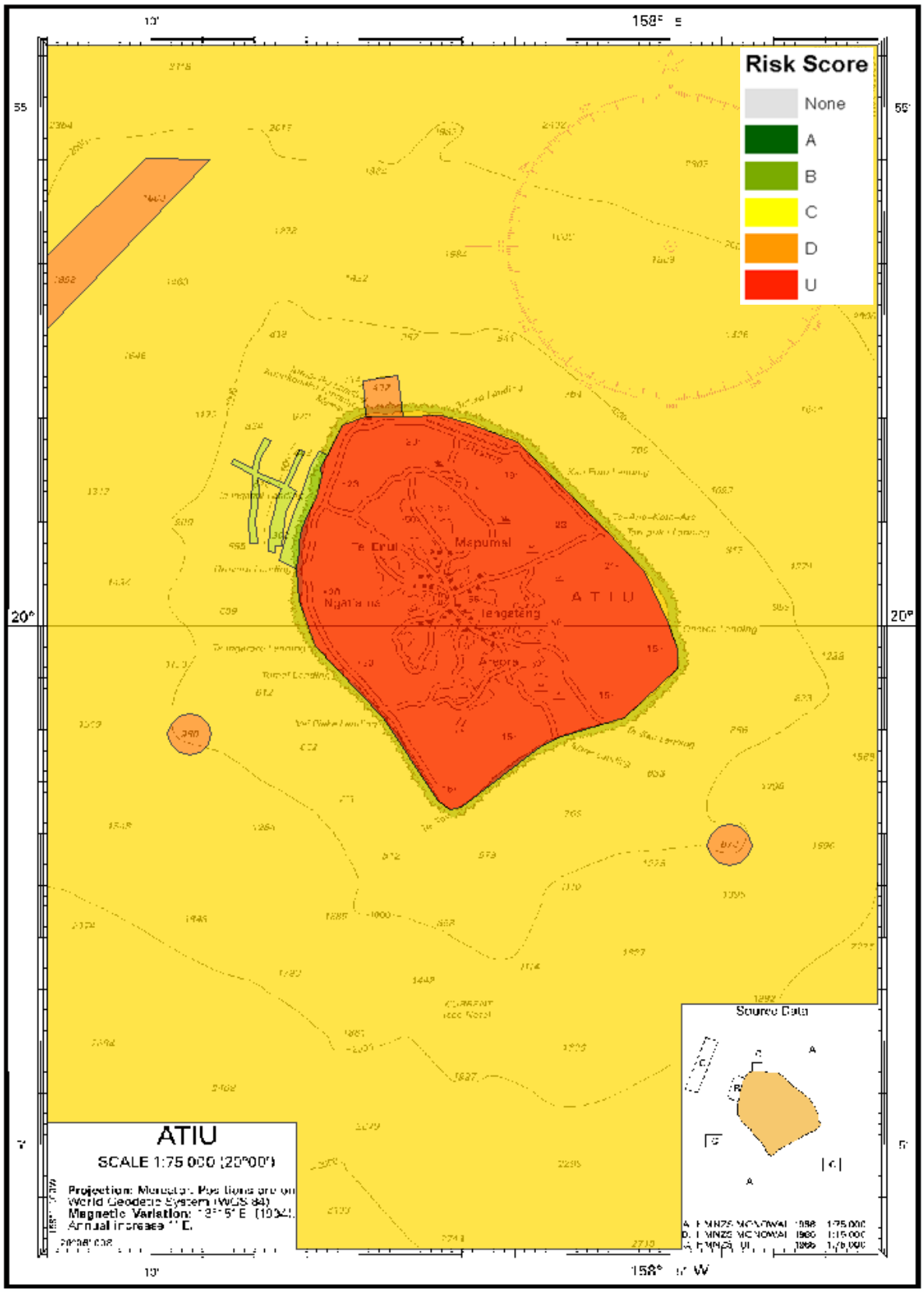


Figure 52: CATZOC Categories for Atiu Island

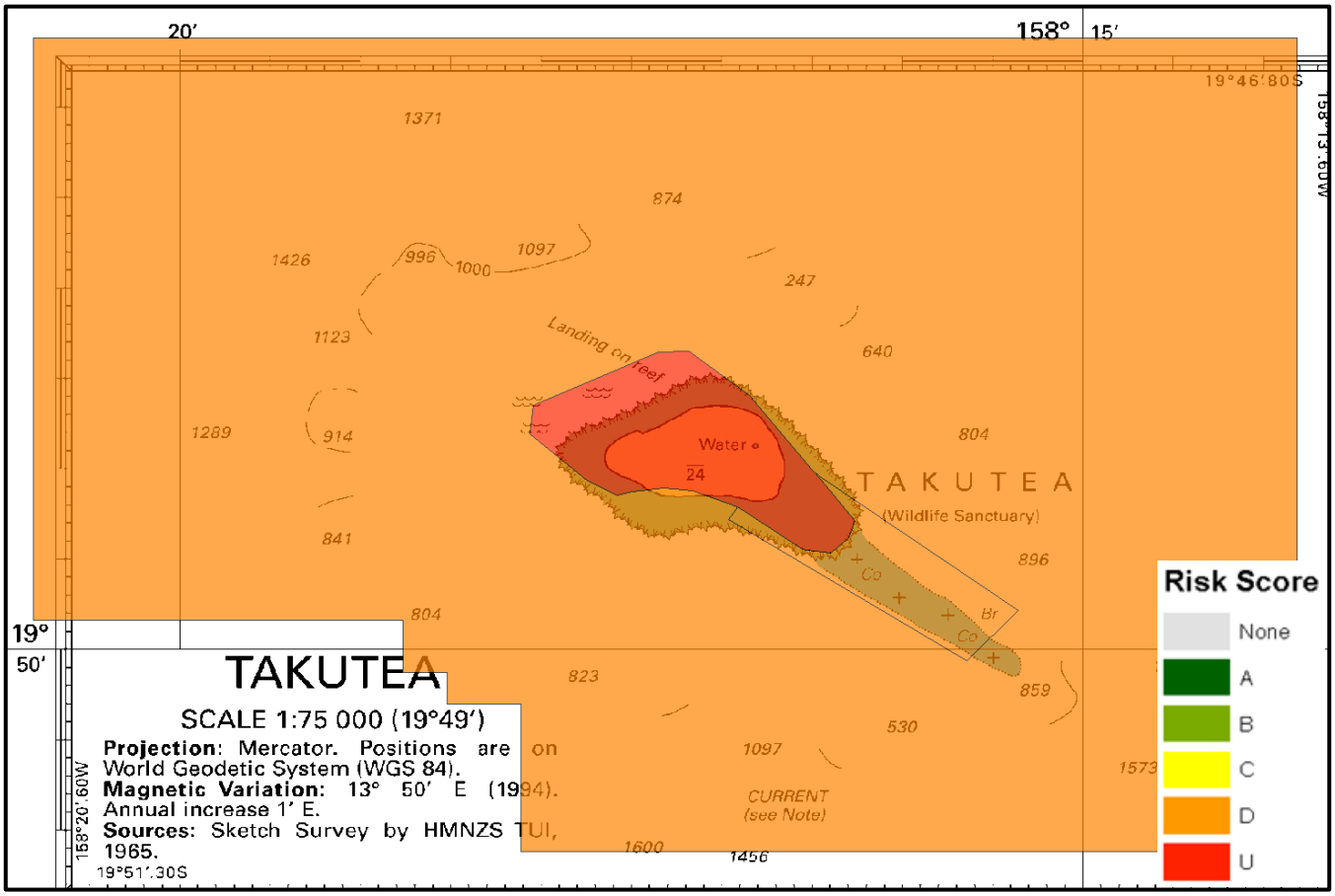


Figure 53: CATZOC Categories for Takutea Island

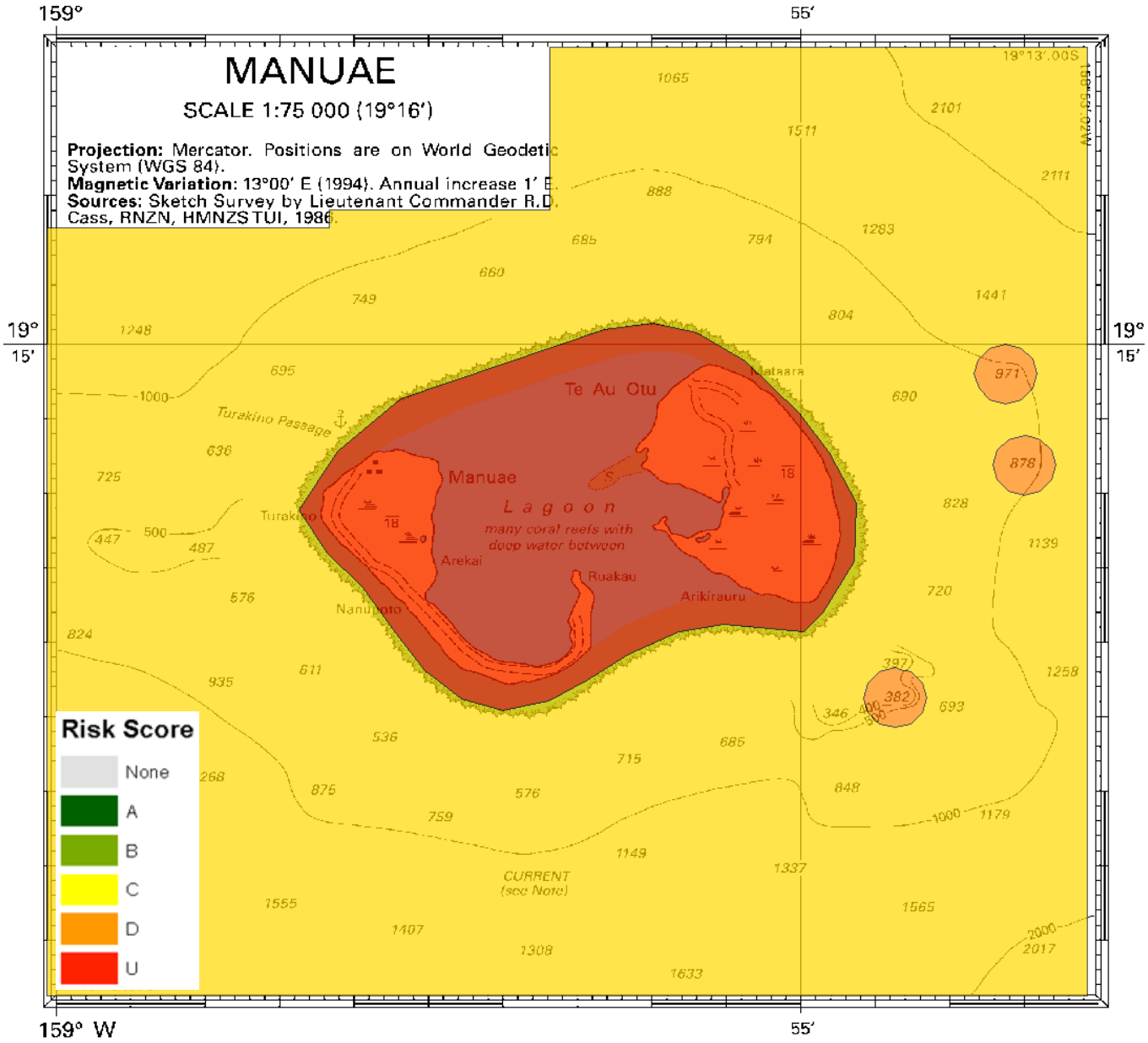


Figure 54: CATZOC Categories for Manuae Island

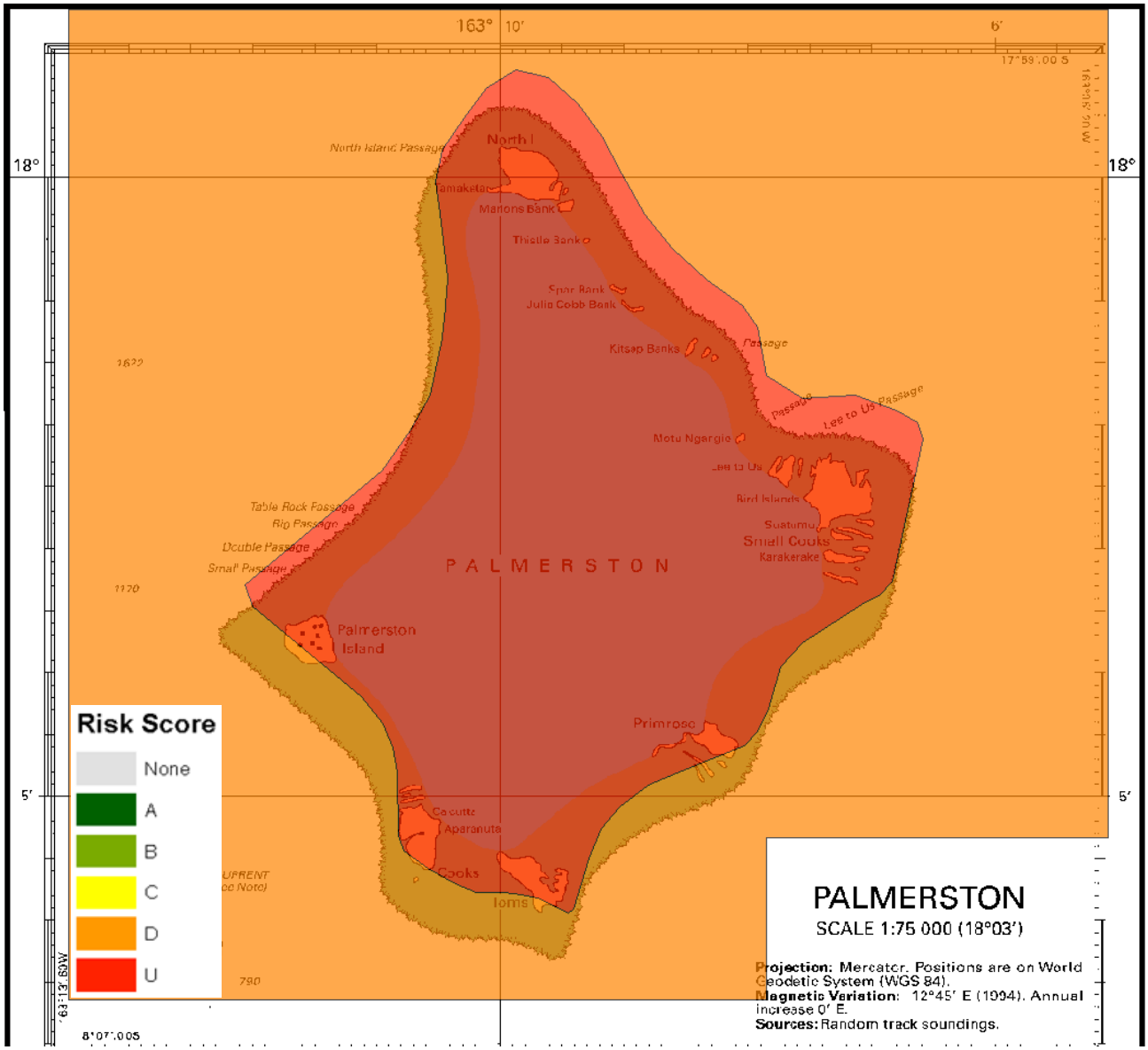


Figure 55: CATZOC Categories for Palmerston Island

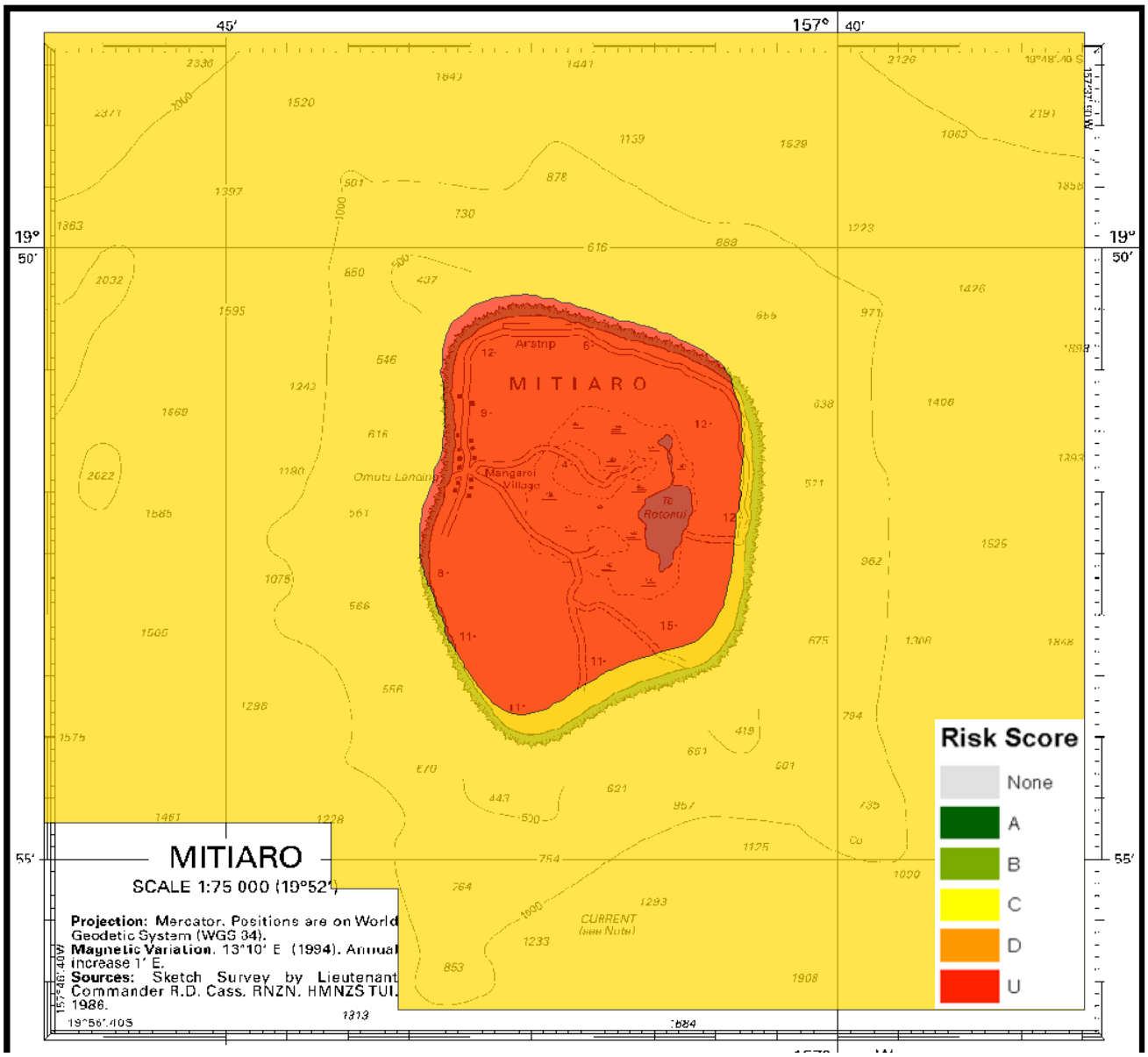


Figure 56: CATZOC Categories for Mitiaro Island

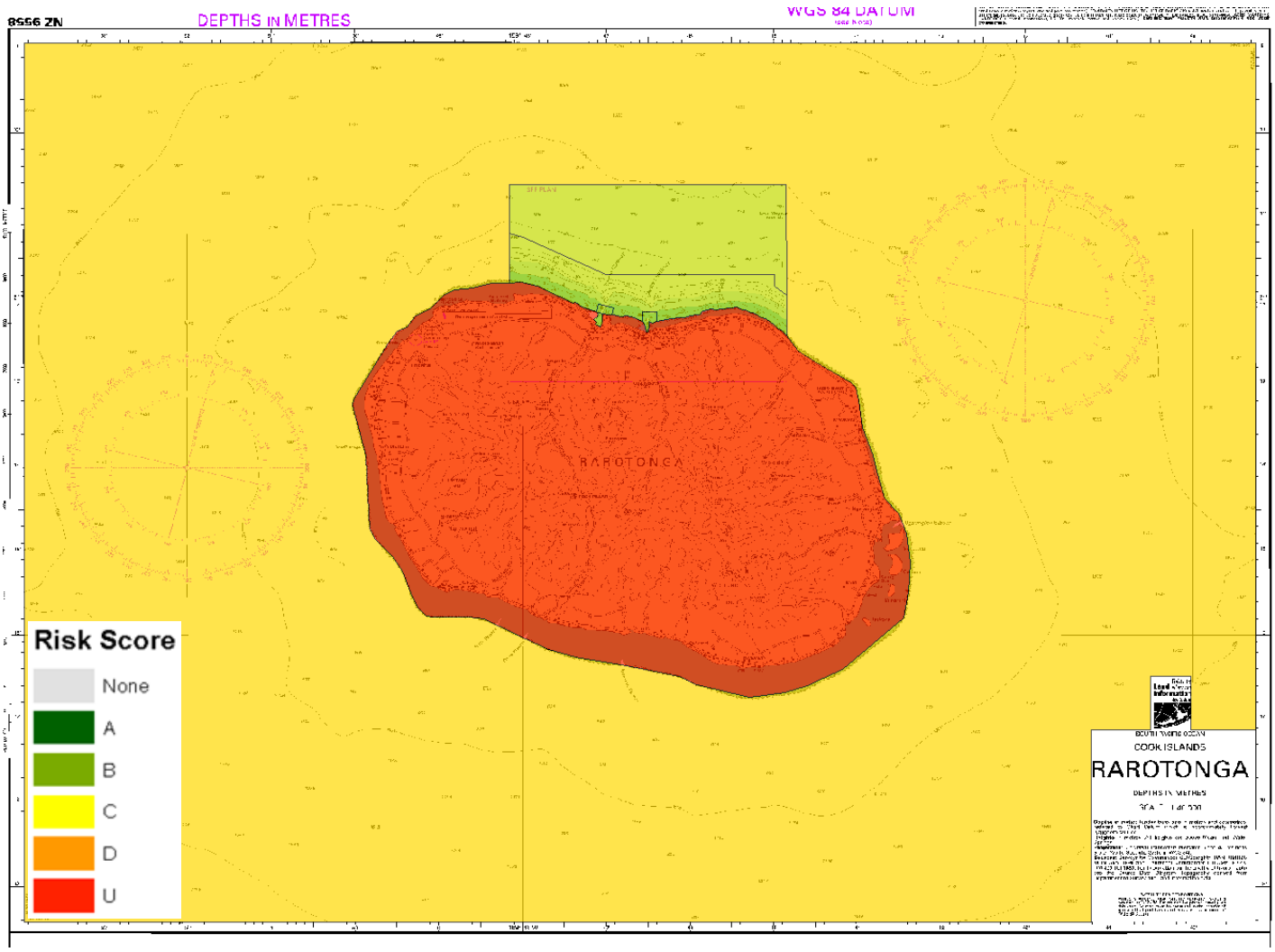


Figure 57: CATZOC Categories for Rarotonga Island

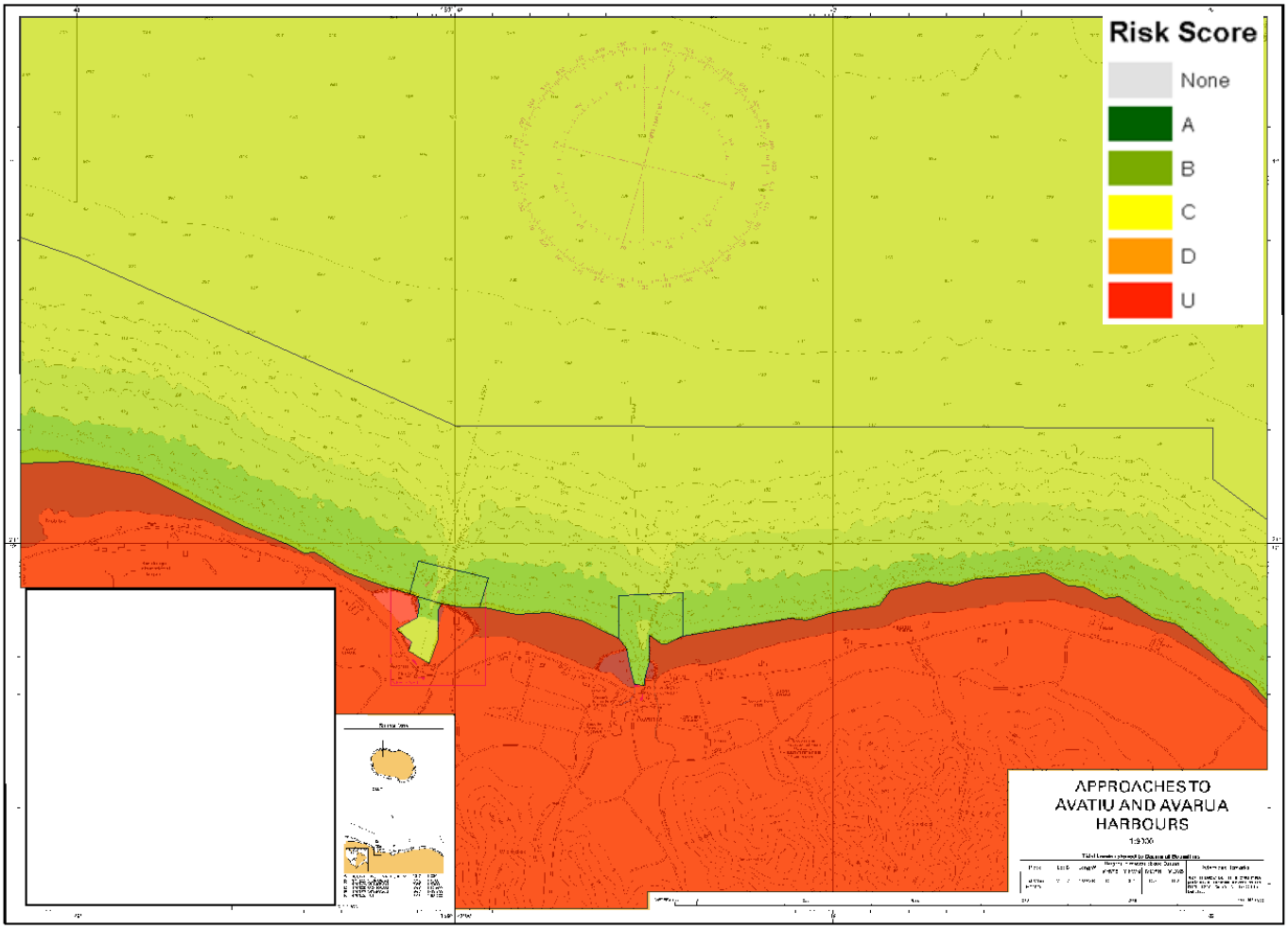


Figure 58: CATZOC Categories for Approaches to Avatiu and Avarua Harbours

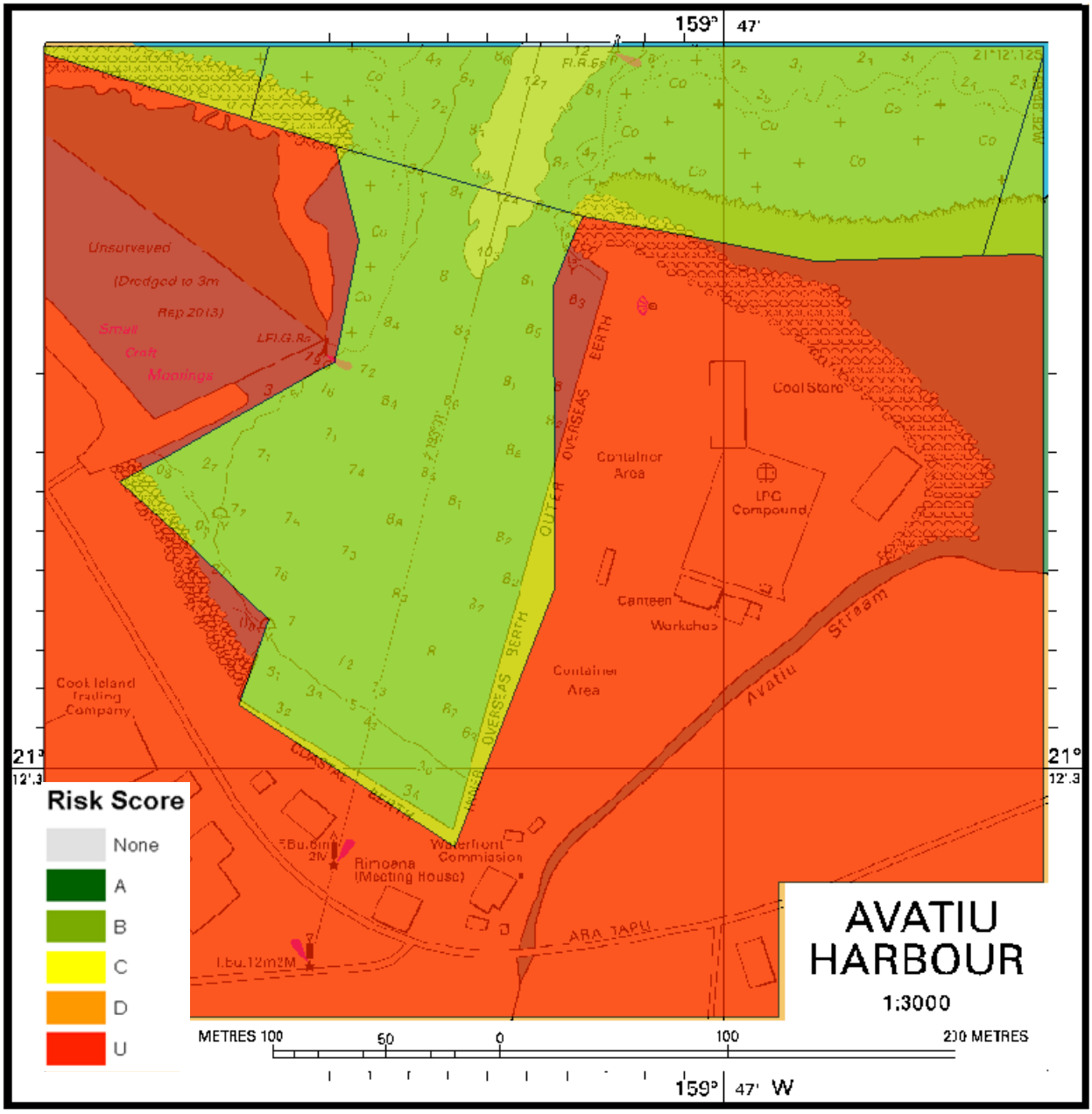


Figure 59: CATZOC Categories for Avatiu Harbour

Annex D
Risk Model Result

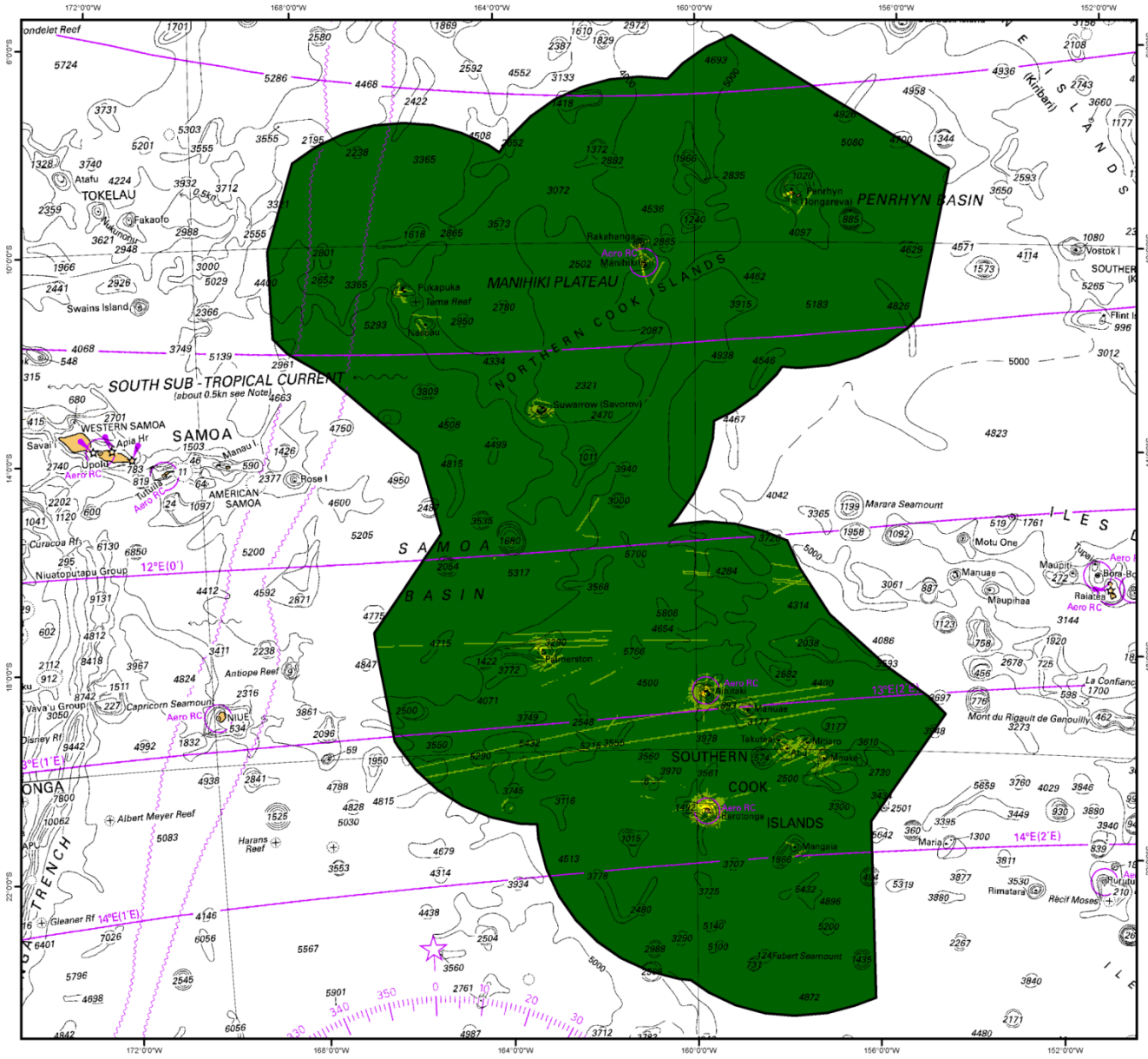
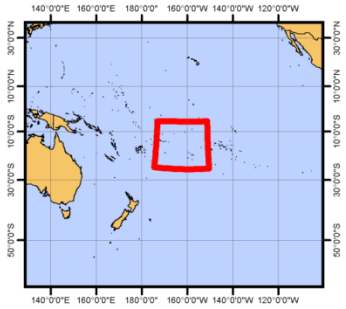


Figure Reference: 13NZ262_CookIsls_RiskModel1_01

Figure 60: Cook Islands Risk Model Results



Legend

- Insignificant
- Heightened
- Low
- Significant
- Moderate

Project No.	Date	Issue Number
13NZ262	09/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:8,000,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
- January to March 2012
- July to October 2013
- December 2013 to January 2014

Chart 14061 courtesy of LINZ.
S-AIS supplied by: exactAIS

Coordinate System:
WGS 1984 UTM Zone 4S
Projection:
Transverse Mercator
Datum:
WGS 1984
Units:
Meter

0 50 100 200 300 N
Nautical Miles

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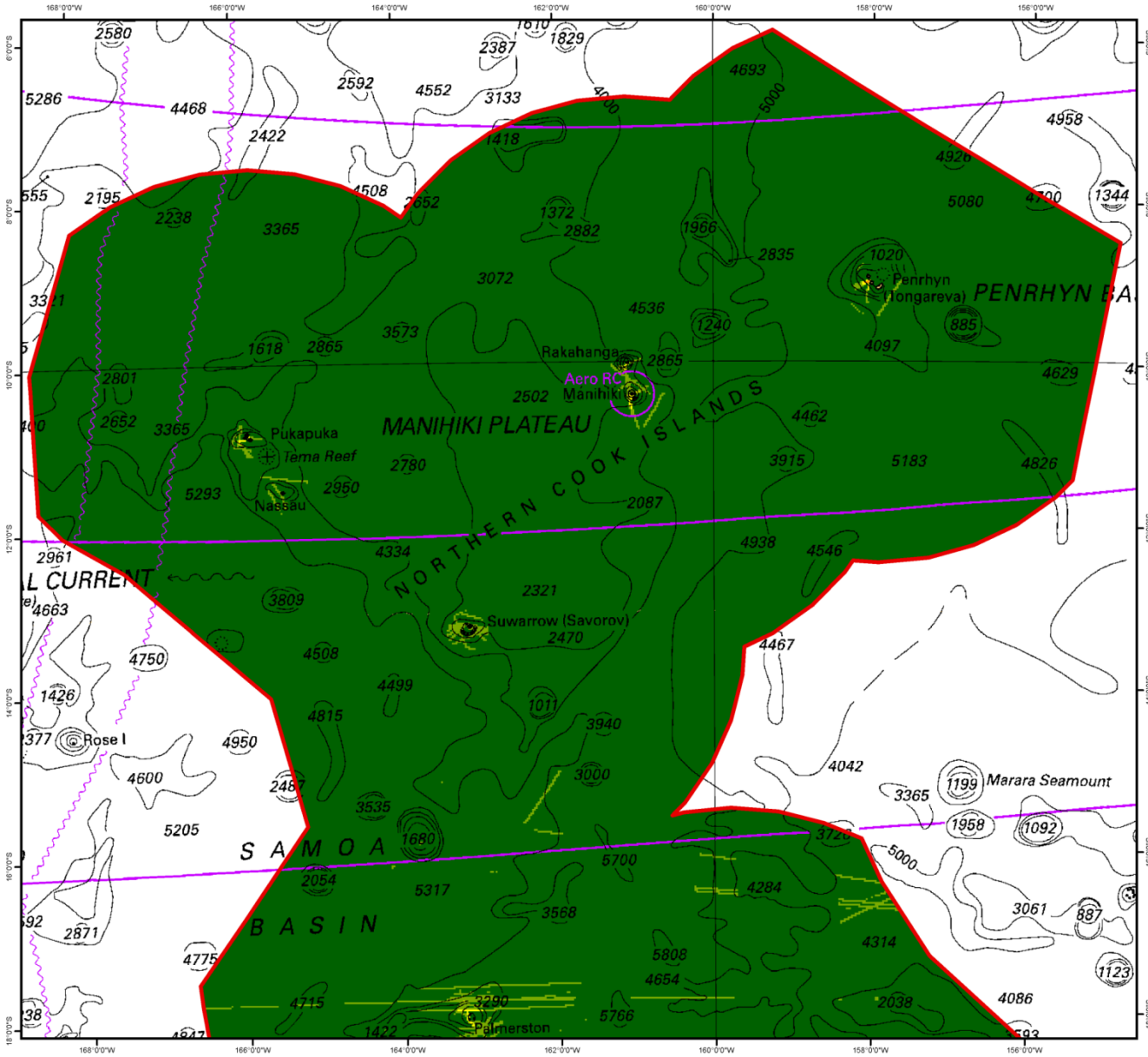
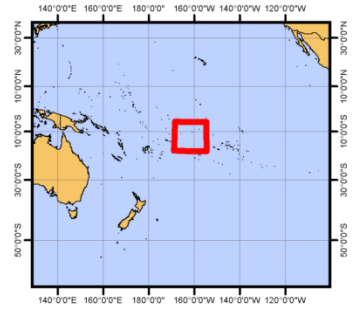


Figure 61: Northern Cooks Risk Model Results



Legend

- Insignificant
- Heightened
- Low
- Significant
- Moderate

Project No.	Date	Issue Number
13NZ262	12/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:5,000,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
- January to March 2012
- July to October 2013
- December 2013 to January 2014

Chart 14061 courtesy of LINZ.
S-AIS supplied by: exactAIS

Coordinate System: WGS 1984 UTM Zone 4S
Projection: Transverse Mercator
Datum: WGS 1984
Units: Meter

0 30 60 120 180 N
Nautical Miles

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Figure Reference: 13NZ262_CookIsls_RiskModel7_01

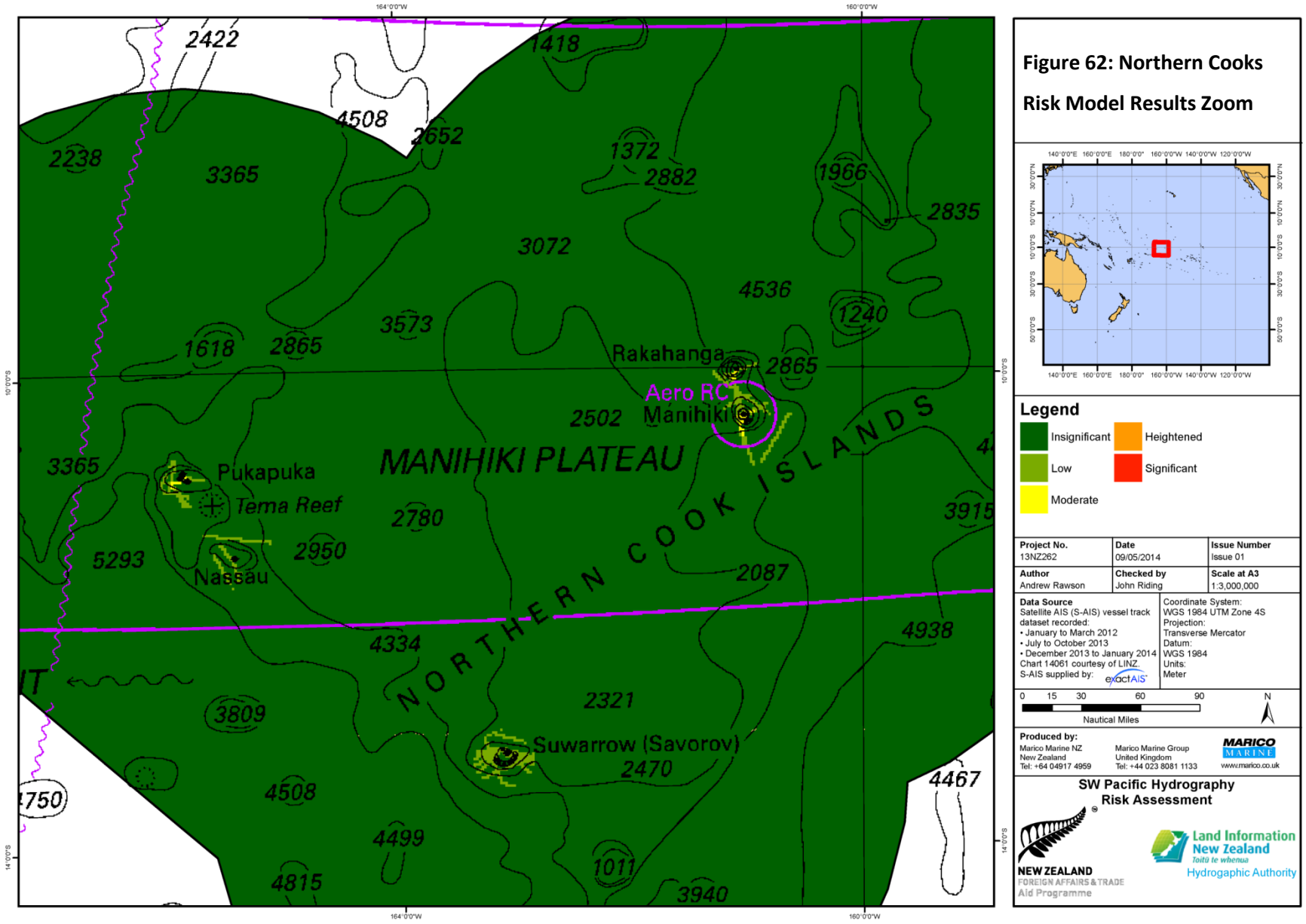


Figure Reference: 13NZ262_CookIsls_RiskModel3_01

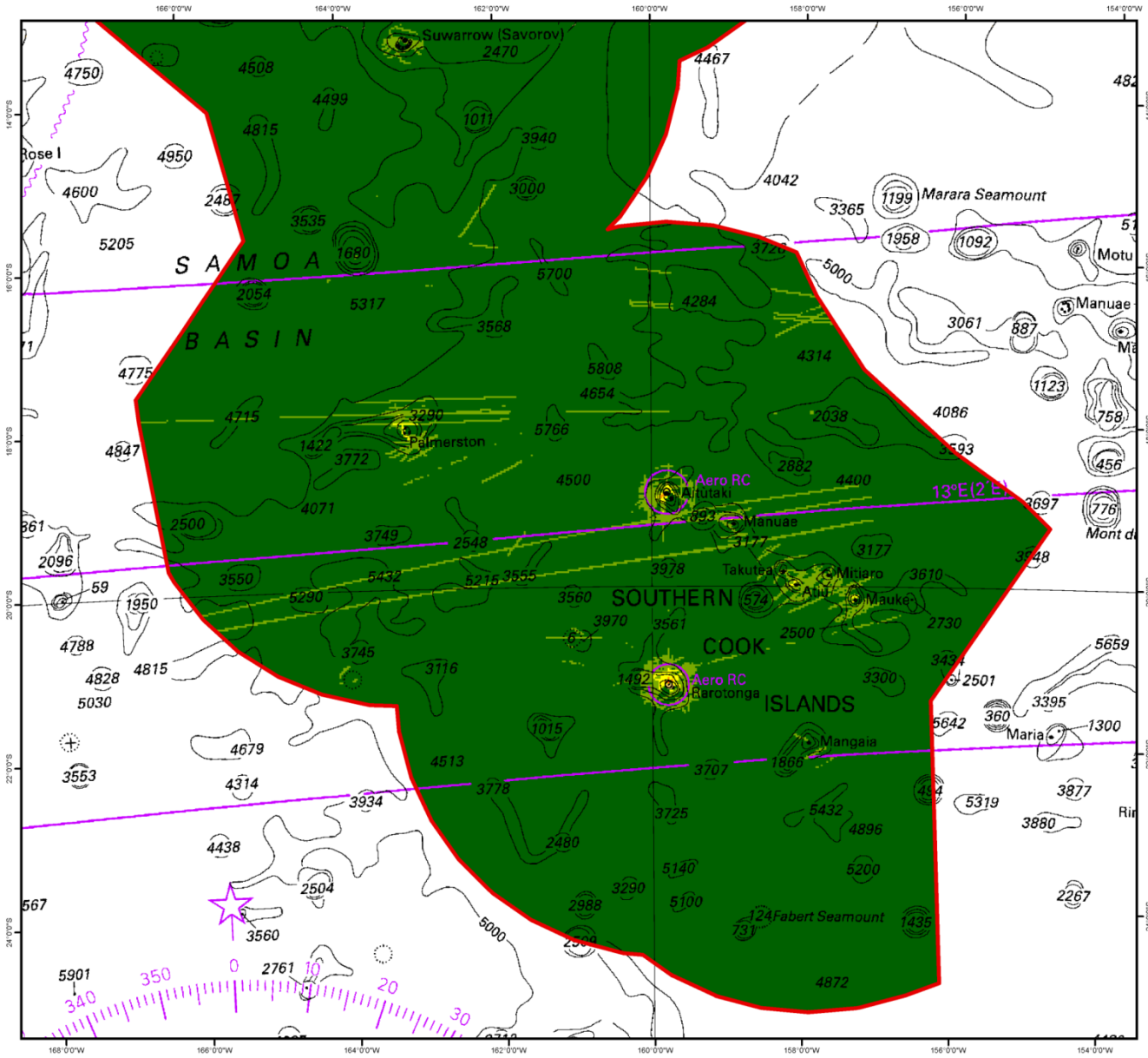
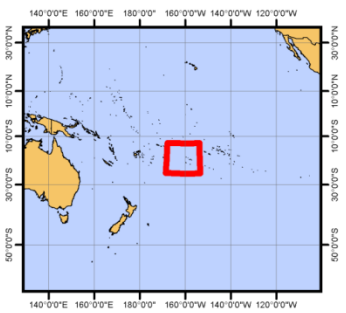


Figure Reference: 13NZ262_CookIsls_RiskModel8_01

Figure 63: Southern Cooks Risk Model Results



Legend

- Insignificant
- Heightened
- Low
- Significant
- Moderate

Project No.	Date	Issue Number
13NZ262	12/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:5,000,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
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- December 2013 to January 2014

Chart 14061 courtesy of LINZ.
S-AIS supplied by: exactAIS

Coordinate System:
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Projection:
Transverse Mercator
Datum:
WGS 1984
Units:
Meter

0 30 60 120 180 N
Nautical Miles

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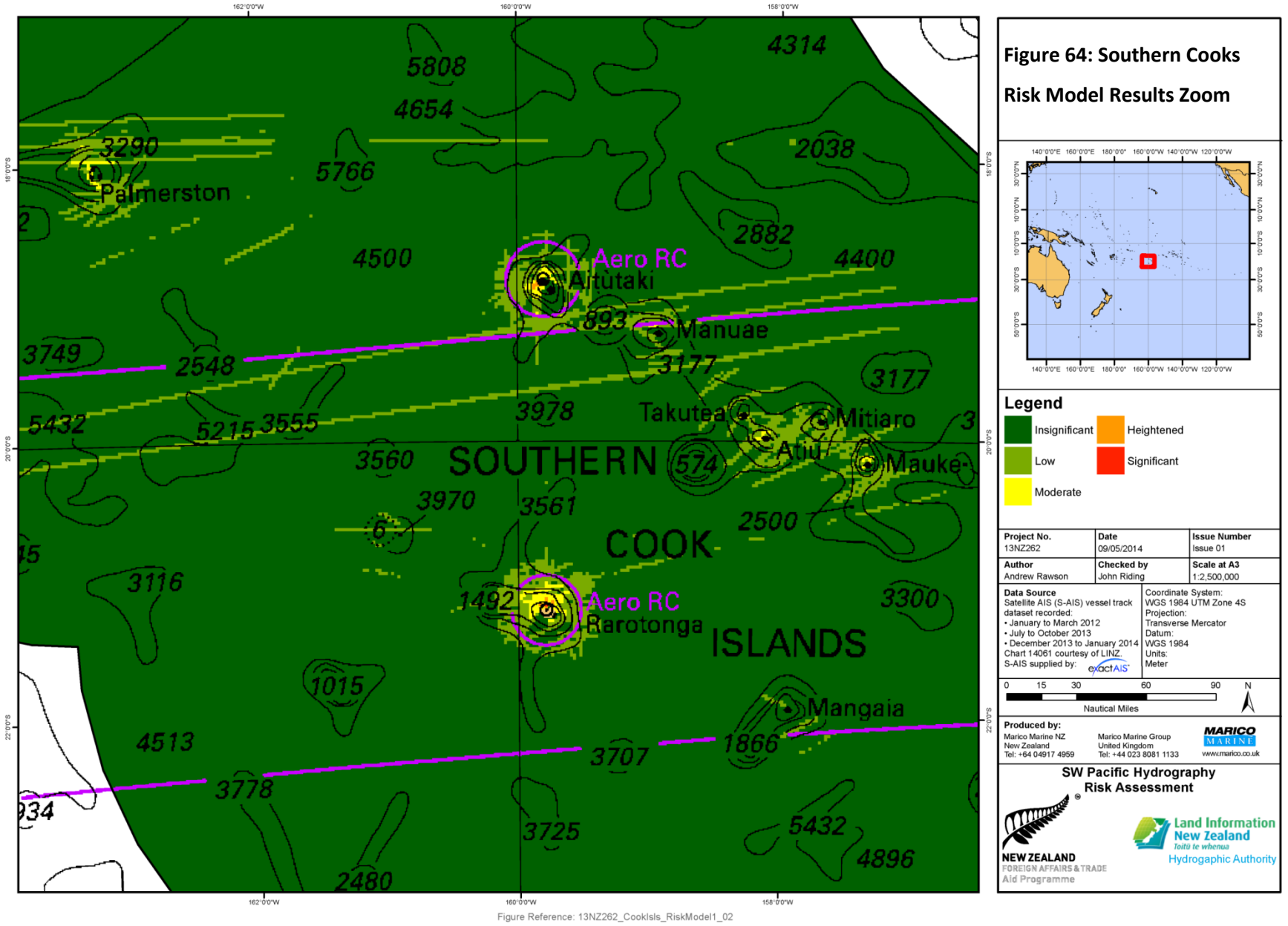

Figure Reference: 13NZ262_CookIsls_RiskModel1_02

Figure 64: Southern Cooks Risk Model Results Zoom

Legend

- Insignificant
- Heightened
- Low
- Significant
- Moderate

Project No.	Date	Issue Number
13NZ262	09/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:2,500,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
- January to March 2012
- July to October 2013
- December 2013 to January 2014

Chart 14061 courtesy of LINZ.
S-AIS supplied by: exactAIS

Coordinate System: WGS 1984 UTM Zone 4S
Projection: Transverse Mercator
Datum: WGS 1984
Units: Meter

0 15 30 60 90 N
Nautical Miles

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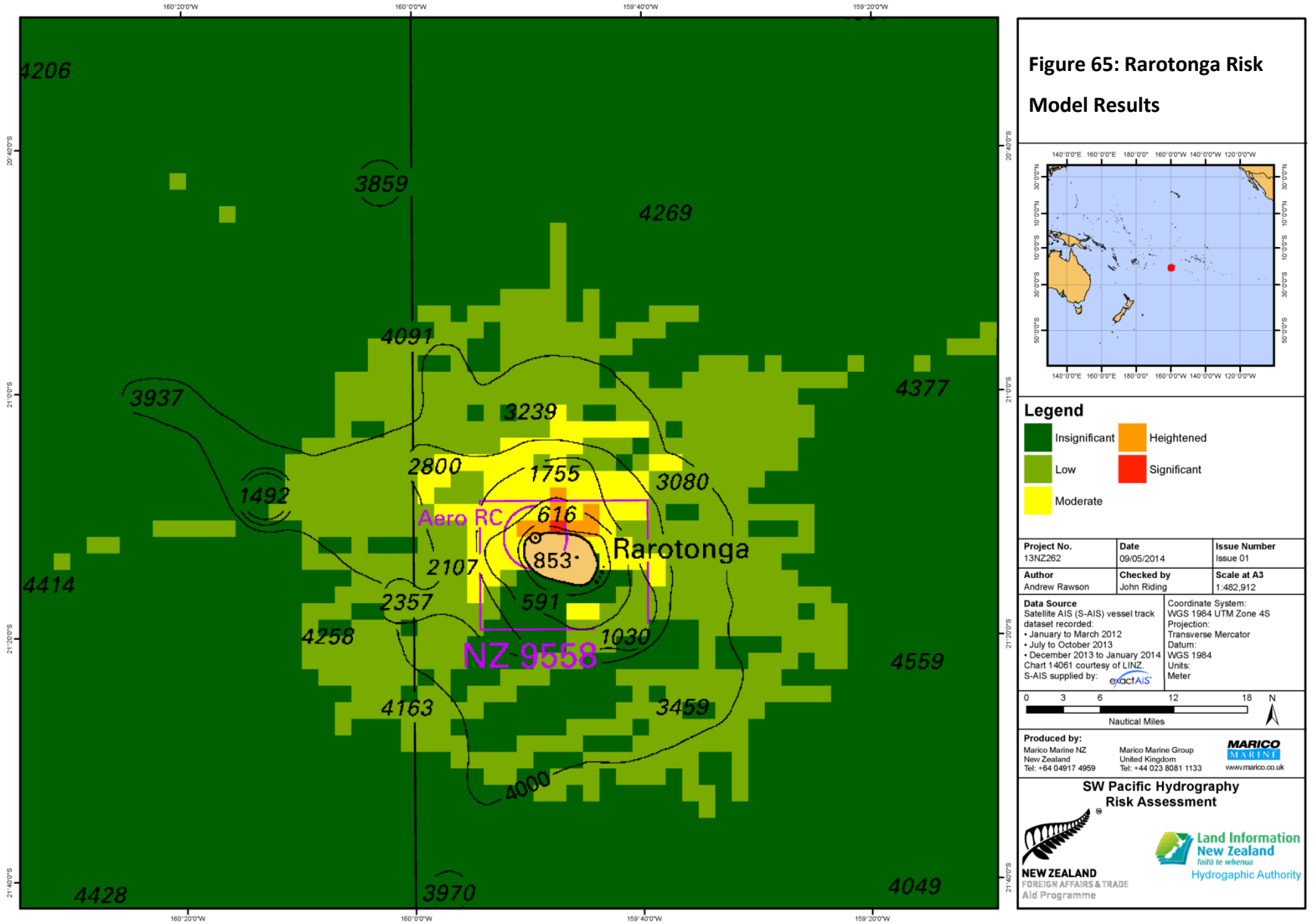


Figure Reference: 13NZ262_CookIsls_RiskModel4_01

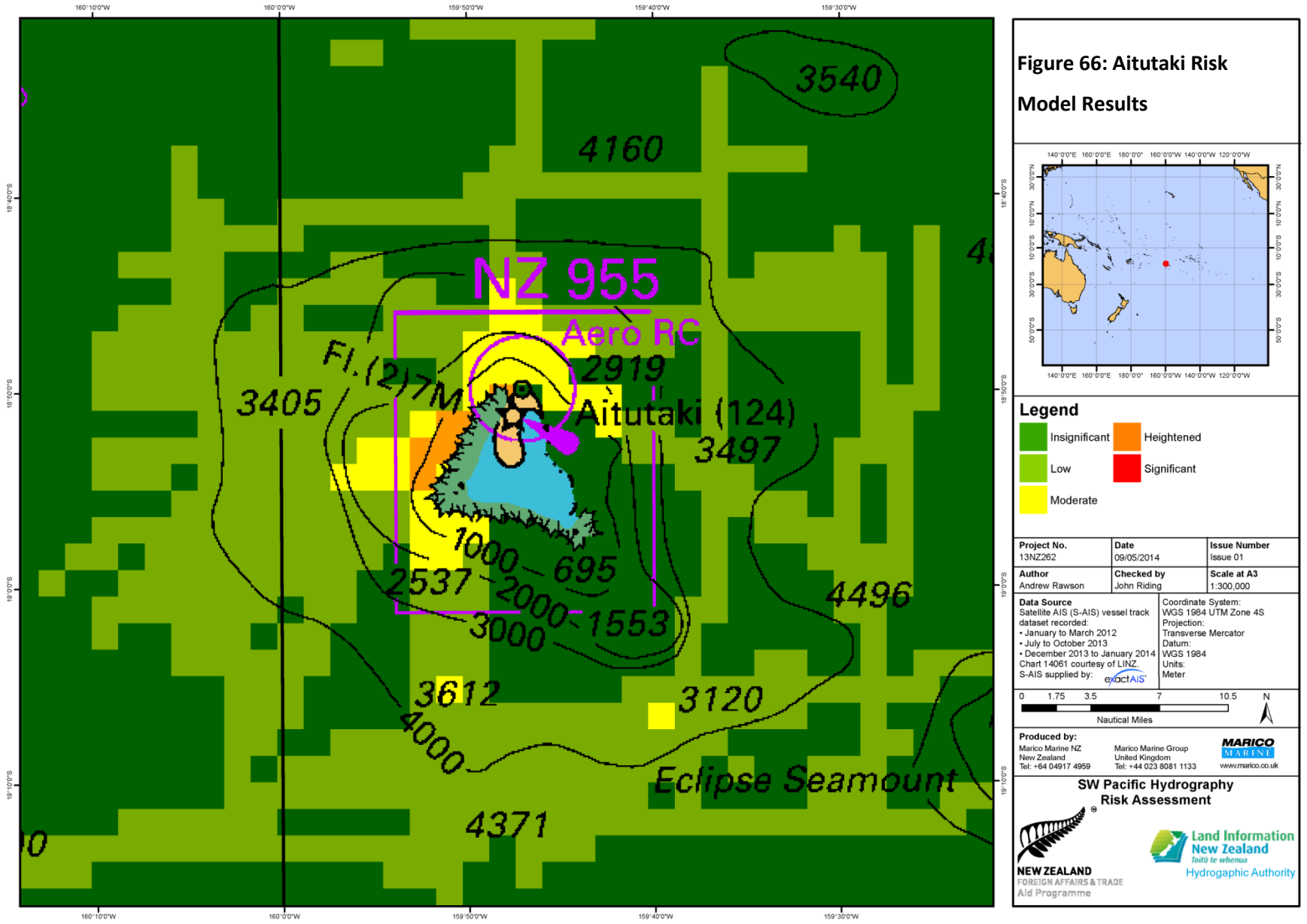


Figure Reference: 13NZ262_CookIsls_RiskModel5_01

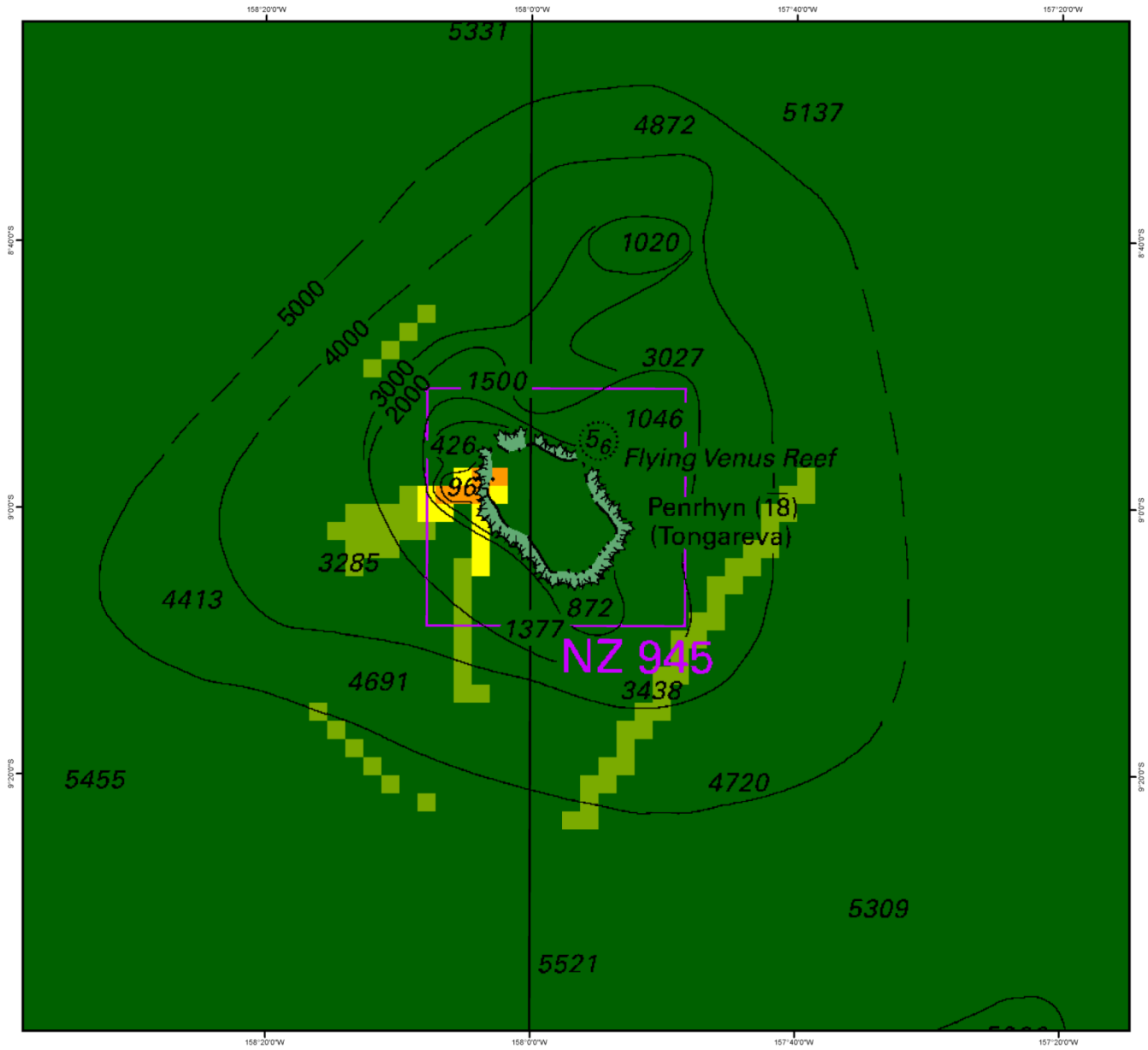
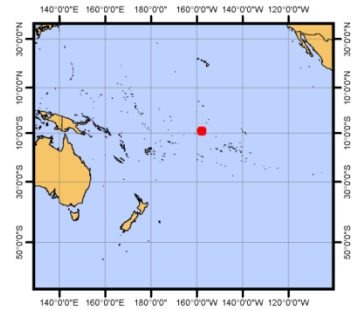


Figure Reference: 13NZ262_CookIsls_RiskModel6_01

Figure 67: Penrhyn Risk Model Results



Legend

- Insignificant
- Heightened
- Low
- Significant
- Moderate

Project No.	Date	Issue Number
13NZ262	09/05/2014	Issue 01
Author	**Checked by**	**Scale at A3**
Andrew Rawson	John Riding	1:500,000

Data Source
Satellite AIS (S-AIS) vessel track dataset recorded:
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Projection:
Transverse Mercator
Datum:
WGS 1984
Units:
Meter

0 3 6 12 18 N
Nautical Miles

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Annex E
Summary of Benefits of Hydrographic Survey Data for Cook Islands

Cook Islands				
Table of Benefits Associated with Charting and Hydrographic Services Upgrades				
Economic Analysis Sector	**No.**	**Status Quo**	**Benefits of Charting Improvements**	**No Improvements to Charts**
Port Infrastructure	1	The Avatiu Harbour Development Project was completed in 2013. The project has expanded the harbour's capacity to handle larger SOLAS vessels.	Improvements in charting standards for Avatiu Harbour create shipping confidence and the potential for new trade opportunities. Cheaper transport costs encourage the growth of Cook Islands exporting companies.	Port and channel maintenance discontinues and international shipping reduces calls to Avatiu Harbour. There is no viable option to increase productivity as port movements decline. Transportation costs and port/customs charges increase disproportionately over time.
	2	Some domestic harbours are uncharted and of uncertain depth, experiencing, in many cases, rapid coral growth. Examples are the harbours of Penrhyn and Manihiki.	Clarity of lagoon transit and approaches to the remote harbours of the Cook Islands reduce the grounding risk for domestic vessels. Changes in harbour infrastructure status circulate more rapidly. Further improvements to entrance channel capacities become more likely.	The grounding risk increases, despite low vessel visit numbers and any resulting oil spills have disastrous consequences to the marine environment and the local economy. The Oil Spill Emergency Response team experiences delays while navigating the difficult approaches to the remote harbours. Uncertainty continues to exist with regards to depth.
	3	Charting in Penrhyn needs updating and chart corrections are required for AtoNs and channel locations. Omoka Harbour, a port of international entry to the Cook Islands, is a domestic port with sheltered waters.	Lagoon transit channel capacity becomes clearer, allowing cargo and vessel operators to understand options. Omoka Harbour has a development plan to improve its port facilities and continues to improve the entrance and channel approaches.	Charts are no longer updated and navigational safety becomes an ongoing issue. Omoka Harbour, Penrhyn, is no longer served by scheduled shipping and used only by locals. Cargo transportation depends solely on costly flights.

Cook Islands				
Table of Benefits Associated with Charting and Hydrographic Services Upgrades				
Economic Analysis Sector	**No.**	**Status Quo**	**Benefits of Charting Improvements**	**No Improvements to Charts**
	4	Surveys are anticipated to show the need for further channel deepening.	The need for deepening of domestic harbours is accurately identified as depth restrictions are accurately recorded. The planning of ongoing hydrographic work and its scope is improved. Safety benefits accrue as more reliable information allows vessels to access ports with minimal risk. Port infrastructure in the Cook Islands other than Rarotonga has the potential to grow. Local employment options improve in the long term and the decline in population is reduced.	Deep draught vessels navigate in shallow waters with difficulty as manoeuvring is restricted. Safety and environmental concerns increase. Inter-island freight distribution diminishes due to ineffective port operations. Poor port maintenance increases unwillingness to invest in an agile supply chain system.
	5	The majority of Aids to Navigation are either not marked or their status is incorrectly promulgated on charts or by Notices to Mariners. Examples are the AtoNs located at the pristine lagoons of Penrhyn and at uncharted harbour basins at a number of islands.	The status of leads and other Aids to Navigation (AToNs) improves as information for chart corrections becomes more readily available. This information is added to the charts on a regular basis. A functioning system with regular Notices to Mariners improves the confidence of shipping interests in the Cook Islands and increases the Cook's value as a trading destination.	During cyclone season, a majority of AToN's become defective and there is no proper maintenance. Thus, the probability of a grounding accident increases during this period. Such an accident would result in a major economic impact to the local economy.

Cook Islands				
Table of Benefits Associated with Charting and Hydrographic Services Upgrades				
Economic Analysis Sector	**No.**	**Status Quo**	**Benefits of Charting Improvements**	**No Improvements to Charts**
International Cargo Shipping Sector	6	International trade to the Cook Islands waters is presently focussed around Avatiu Harbour. With the exception, in part, of fuel transhipments, only occasional calls occur to Aitutaki, whose deliveries rely on transhipment or air.	Charting improvements allow shipping operators to reduce the grounding risk of vessels providing existing services. Options for discharge at other international port destinations in the Cook Islands become viable, as flexibility improves along with the potential for cost efficiencies derived from direct calls. The economic benefits of reduced freight costs lead to an increase in cargo shipments in and out of the Cook Islands overall.	No further charting improvements lead to a higher risk of maritime accidents. There are no alternative trade routes for vessels which now provide shipping services in the Cook Islands. It is difficult for shippers to achieve economies of scale. Freight rates remain high as transportation costs increase for South Pacific container services in the Cook Islands.
	7	The Cook Islands Hydrographic Committee has not yet been established with clarity of roles.	Confidence in the charting system increases as the flow of navigational safety information from operators to the Cook Islands Hydrographic Committee is introduced and communication of information is maintained.	The charting system is inefficient as it fails to respond to maritime safety standards and hydrographic best practices. As a result, the Notice to Mariners is not reliable. Commercial vessels do not receive nautical chart and publication updates. The probability of an accident is high, and is certain to increase over time; therefore commercial shipping is increasingly likely to withdraw operations at a future date.
Cruise Tourism	8	There is pressure from cruise interests for the Cook Islands to open up more cruise destinations which, in turn, increase the number of cruise visits to the islands.	The development of accurate and appropriate scale charts into the Northern Cooks and the Southern Cooks, as well as certain isolated islands, result in increased cruise vessel penetration. Port calls other than Rarotonga become viable, which result in the increased popularity of the Cook Islands as a cruise destination. The increased number of passenger visits brings income into the local economy.	The cruise sector shrinks because nautical charts are not reliable. Cruise shipping operators are reluctant to send their vessels to remote or isolated islands. Cruise port calls decrease and economic development stagnates. The recent grounding of the WORLD DISCOVERER, a cruise ship that struck an uncharted reef at Sandfly Passage, Solomon Islands, serves as an example of the possible consequences.

Cook Islands				
Table of Benefits Associated with Charting and Hydrographic Services Upgrades				
Economic Analysis Sector	**No.**	**Status Quo**	**Benefits of Charting Improvements**	**No Improvements to Charts**
	9	At present, the number of visitors to the Cook Islands arriving on cruise ships is on the decline, with a by cruise drop in the number of visitors to Rarotonga and Aitutaki.	An increase in cruise line passengers results in more tourists choosing to return to the Cook Islands by air for longer stays, thereby increasing the demand for hotel and home-stay accommodations. Companies catering to large numbers of tourists, such as diving and whale watching tours, enjoy increased revenues.	Currently, tourism contributes to almost 60% of the gross domestic product of the Cook Islands. This figure is likely to drop substantially in the years to come as the number of cruise passengers declines. Accommodation suffers high vacancy rates, holiday market rates fall and international tourism revenues suffer, leading to an increase in the rate of unemployment.
	10	During 2012/2013, the number of cruise vessels visiting Avatiu Harbour decreased (mostly due to adverse weather conditions). An alternative destination located at Arorangi provides safe disembarkation of cruise passengers.	Improved charting provides cruise ship operators with the confidence that Cook Islands destinations other than Rarotonga are able to accommodate cruise vessels of increasing size. Infrastructure and economic development is driven by the need to accommodate larger vessels and trade as well as larger passenger numbers.	There is no return on investment from cruise vessel visits because navigational charts do not provide accurate and updated hazard information. Although aid donors provide substantial funding, it may not be targeted and infrastructure projects are likely to be abandoned in the long-term.
Domestic Shipping Service and Training	11	Demand for cargo transportation – Aquaculture products from the Northern Cook Islands.	Charting improvements facilitate the growth of domestic trade to export ports (including airports) as well as increase the availability of gourmet fish and marine based produce.	Export and domestic trade remain static or go into decline. An aged fleet is used to transport local products in order to cut costs further.

Cook Islands				
Table of Benefits Associated with Charting and Hydrographic Services Upgrades				
Economic Analysis Sector	**No.**	**Status Quo**	**Benefits of Charting Improvements**	**No Improvements to Charts**
	12	Coastal navigation depends on the master's knowledge of local features, rather than on nautical charts.	Ongoing advances in awareness and confidence in navigational safety together with improvements in chart-related practices, such as passage planning and positional monitoring, reduce the risk of vessel groundings and other marine accidents in the Cook Islands waters. The quality standard of the domestic fleet improves as safety awareness grows and owners gain confidence in the new navigational systems being put into place.	Current maritime charts are inaccurate, therefore they are, and continue to be, a poor tool for use as a preventative measure to avoid an accidental oil spill or similar incident. Discrepancies in mapping also hinder emergency response teams or search and rescue operations in the event of grounding. The Cook Islands have a total of 15 islands with a plethora of corals and shallow depths which increase the risk of accidents.
ENCs	13	The geographic location of electronic charts in the Cook Islands is not aligned with the actual position of the islands. As a result, ENCs depicting the Cook Islands are unreliable.	Further amendments and updates to ENCs for the Cook Islands have a positive impact both on SOLAS and domestic coastal shipping.	Though flag states enforce the SOLAS amendment for all vessels to carry ECDIS on-board, the Cook Islands ENCs remain unreliable. SOLAS vessels, especially liner shipping, reduce or withdraw their operations from the Cook Islands.
Cook Islands Hydrographic Committee	14	The Cook Islands has not formed a National Hydrographic Committee. Under the IMO Convention SOLAS V/9, the Government of the Cook Islands has an obligation to collect hydrographic data and keep it up-to-date with all the nautical information necessary for safe navigation.	The Cook Islands Hydrographic Committee is established and they become a member state of the IHO. The Committee becomes more effective and the Cook Islands interests are better represented in the work of the IHO. New options for further grant funding accrue.	The Cook Islands does not appear to meet its international treaty obligations to ensure that appropriate hydrographic services are in place. This has a negative safety and financial impact, both for domestic and international shipping.

Cook Islands				
Table of Benefits Associated with Charting and Hydrographic Services Upgrades				
Economic Analysis Sector	**No.**	**Status Quo**	**Benefits of Charting Improvements**	**No Improvements to Charts**
	15	The Cook Islands has only a limited government agency mandate to undertake hydrographic activities.	Hydrographic services and surveys are performed on a regular basis. New nautical charts are produced and are kept up–to-date.	The current state of nautical charting and the lack of coherent Maritime Safety Information (MSI) services are likely to have a significant adverse impact on the economy of the Cook Islands. This negative result puts the safety of life at sea and protection of the marine environment at risk.
Chart and ENC Distribution Services	16	The distribution of new or replacement charts in the Cook Islands is fragmented. Published ENCs difficult to obtain within the Cooks.	An effective Chart distribution service with ENC updates for ECDIS/ECS systems using Cook Island waters is established as part of port infrastructure development. Cook Islands' agents are established outside of Rarotonga, improving usage and promulgation to users. Improved charting extends into the recreational and visiting yacht markets. Employment and benefits accrue.	The fragmented replacement chart system in the Cook Island remains fragmented. Interest in charting by navigational stakeholders and usage declines.

Table 1: Summary of Benefits of Hydrographic Survey Data for the Cook Islands

Annex F
Assumptions for Hydrographic Cost Benefit Methodology

Model Assumptions	Data Value Used	Detail
Survey Cost/km^2	US$1,633 – Multibeam Hydrographic Survey	There are a wide range of Hydrographic Survey Costs worldwide, even for the same technology. An average value was used, based on the cost of the popular technology, Multibeam Technology.
		Internet Derived Costs: Queensland Govt: Baythymetric LIDAR: $500-1000 per km^2 Single Beam at 50x50m resolution is $1500 per km^2 Canadian Hydrographic Service Bathymetric survey $1700 per sq km^2 Marine Electronic Highway Working Group Multibeam survey - 120km^2 (60 survey days) – request for US$1.2million (1mill for survey and processing and 200k for ENC production) - $10k/km^2 Fugro Norway survey in Offshore Magazine $4.95 million for 13,200 km^2 – 375$ per km^2 (this record appears unlikely)
		Costs per Square km - Published by Hydrographic Office - SHOM – Laporte 26/9/2012 Based on 2011 values): Bathymetric Lidar: from 1,500 to 2,000€ - Greatly variable and depends on survey and quality of post-processing. MBES (Multibeam Echo Sounders) Survey: from 1,000 to 1,400 – Up to 10 times the figures in the worst cases Satellite Survey: from 25 to 45€ - Depends on the quality of product
Risk Reduction	Charting Upgrade Risk Reduction: • ZOC A 2.5%	The Net Present Value is based on independent work that established that ECDIS, used with accurate and adequate ENC reduces grounding likelihood and improves situational awareness by about 36% overall (DNV 2008 – Technical Report – DNV Research & Innovation, ECDIS and ENC Coverage – Follow up study).

Model Assumptions	Data Value Used	Detail
	• ZOC B 5% • ZOC C 10% • ZOC D 20% • ZOC U 30% • Fathom Chart 45% Probability of Grounding/nm is taken to be 5.98E-07 (DNV)	A varying range of available risk reduction was developed (Charting Upgrade Risk Reduction), using the work by DNV as a benchmark. DNV undertook a study to determine a global probability, using shipping volume and Grounding Incident data. The study provided values of both Grounding Probability and available risk reduction from Charting Improvements. This probability is modified by a factor dependent upon the complexity of navigation from 0.00001 to 1.94. To calculate this conversion factor, the highest and lowest likelihood scores are used from the Marico risk model; DNV score = (0.9358*Marico)-1.3028
Base Inflation	2%	Based on the Asian Development Bank inflation rate for The Cook Islands
A generic or representative SOLAS "ship"	700 TEU	Based on the size of a containership/general cargo vessel applicable to calling at Rarotonga.
GDP of The Cook Islands	US$ 815,286,000	Estimated 2013 value based on a 2.4% growth
Average GDP Increase	2.4% per annum	Real GDP growth has averaged 2.4% per annum since 2006/2007
Most Likely and Worst Credible Relationship	For every 10 accidents, 9 are most likely and 1 is worst credible.	Calculation: Weight ML/WC – SUMPPRODUCT (ML:WC,Weight1:Weight2). Average cost of grounding in range between most likely and worst credible outcomes: 80:20 weighting applied. This is a financial figure based on damage to vessel, value of preventing fatality,

Model Assumptions	Data Value Used	Detail
		pollution clean-up etc
Commercial Vessel Accident Consequences – Clean Up cost and GDP Impacts	ML is 2277895 WC is 17964786	Benchmark clean-up costs $6900 per tonne for Oceania – SKEMA Consolidation Studies – 2010 - Evaluation of methods to estimate the consequence costs of an oil spill.
	ML is 1 day of GDP lost WC is 28 days of GDP lost	GDP Impact (blocking port channel).
Clean up costs Annual Rise	4%	Clean up coasts assumed to rise at twice the rate of inflation
Commercial Vessel Accident Consequences - Damage to People and loss of life	Damage to vessel	
	People damage (days lost/fatalities)	
Cook Islands Median Wage	US$82.4	
ICAF	US$ 3,282,000 (EU/HSE figures of 2.4 million Euros)	Implied Cost of Averting a Fatality (ICAF) is expressed in terms of $ per statistical fatality averted
Survey Benefit.	Calculation Policy	Surveys undertaken in Year 1 assumed to provide no benefit until Year 3

Table 2: Model Assumptions Used for ArcGIS Hydrographic Cost Benefit Methodology

CBA METHODOLOGY CALCULATIONS FOR COMMERCIAL (SOLAS) VESSELS	
Description	**Detail**
Distance for each grid	Calculate the distance travelled in each grid cell using the GME sumlinelengthspoly tool, and convert to nm
Period /Time	Scale up the distance from 7.5 months to a year (multiply by 1.6)
Probability per year	The probability per year is base probability * derived factor * distance travelled per year
Total Cost	Total cost is the Consequence of clean up added to the consequence of GDP
Cost Per Year	The cost per year is the probability per year multiplied by the cost per accident
The cost without a survey over 10 years	Year 1 is the cost/year
	Year 2 is cost/year *1.02 (inflation)
	Year 3 is Year 2*1.02
	Etc.
The cost with a survey over 10 years	Year 1 is cost/year
	Year 2 is cost/year*1.02
	Year 3 is Year 2*1.02* ZOC (Charting Upgrade by ZOC Category)
	Etc.
The delta (without survey vs survey)	Year 1 (No Hydro) – Year 1 (Hydro)
	Etc
Economic Benefit	Net Present Value function of the GIS model

Table 3: CBA Methodology Calculations for Commercial (Cargo/Tanker) Vessels

CBA METHODOLOGY CALCULATIONS FOR COMMERCIAL (DOMESTIC) VESSELS	
Description	**Detail**
Distance for each grid	Calculate the distance travelled in each grid cell using the GME sumlinelengthspoly tool, and convert to nm
Period /Time	Scale up the distance from 7.5 months to a year (multiply by 1.6)
Probability per year	The probability per year is base probability * derived factor * distance travelled per year
Total Cost	Total cost is the Consequence of clean up added to the consequence of GDP
Cost Per Year	The cost per year is the probability per year multiplied by the cost per accident
The cost without a survey over 10 years	Year 1 is the cost/year
	Year 2 is cost/year *1.02 (inflation)
	Year 3 is Year 2*1.02
	Etc.
The cost with a survey over 10 years	Year 1 is cost/year
	Year 2 is cost/year*1.02
	Year 3 is Year 2*1.02*ZOC (Charting Upgrade by ZOC Category)
	Etc.
The delta (without survey vs survey)	Year 1 (No Hydro) – Year 1 (Hydro)
	Etc.
Economic Benefit	Net Present Value function

Table 4: CBA Methodology Calculations for Commercial (Domestic) Vessel