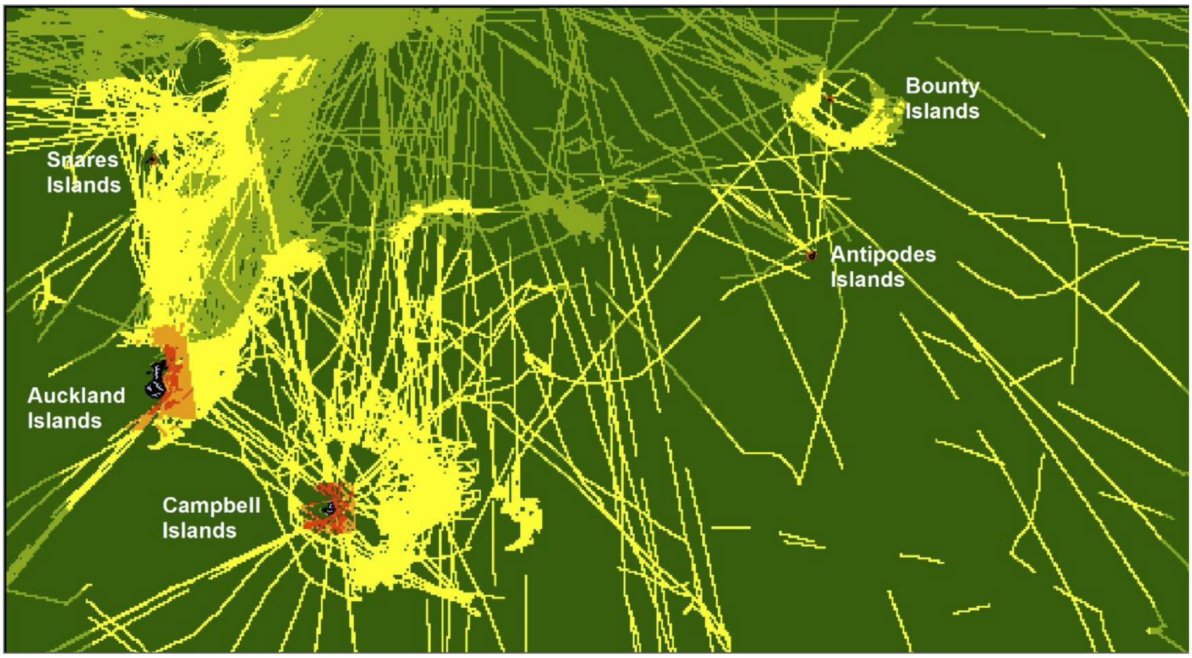
LAND INFORMATION NEW ZEALAND

SUB-ANTARCTIC ISLANDS HYDROGRAPHIC RISK ASSESSMENT



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MARICO MARINE NEW ZEALAND LTD

LAND INFORMATION NEW ZEALAND

SUB-ANTARCTIC ISLANDS HYDROGRAPHIC RISK ASSESSMENT

Prepared for: **Land Information New Zealand**

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ABBREVIATIONS AND GLOSSARY

Abbreviation	Detail and Definitions
ATBA	Area to Be Avoided. An IMO approved routeing tool, which is printed on the chart, where a sea area is close to SOLAS traffic in accordance with agreed criteria. ATBAs are normally used in sea areas of high ecological value to a coastal state, such as a marine reserve.
AIS	Automatic Identification System
ALARP	As Low as Reasonably Practicable
AtoN	Aid to Navigation
CATZOCCTL	Category of Zone of Confidence in data.
CTL	Constructive Total Loss (a point where hull underwriters decide it is uneconomic to repair the vessel and instead the owner is compensated in accordance with the hull policy. Third party insurers become responsible for pollution response and wreck removal
Causation Criteria	Causation criteria are reflective of the factors that may cause a vessel grounding incident to occur. These causation factors include Charting, Route Characteristics, Metocean conditions and Navigational hazards.
Chart Quality	Assessed using the CATZOC Rating of the chart
Chart Adequacy	The overall assessment of adequacy of the existing nautical charts to meet navigational purposes. Includes an assessment of three main components; Chart Quality (CATZOC), Survey Age and Chart Scale and Extents.
Cst	Conservation Status of Species determined by the New Zealand Threat Classification Index (Department of Conservation)
Consequence Criteria	The consequence criteria are reflective of the risk of a potential incident whereby specific local conditions may make impacts greater, these conditions represent consequence factors. Consequence factors include environmental impact, economic impact, response complexity (represented by loss of life), and salvage complexity.
DOC	Department of Conservation
ECDIS	Electronic Chart Display and Information System
EEZ	Exclusive Economic Zone
ENC	Electronic Navigational Chart
ESV	Ecological Subset Value – A measure of the Importance and Rarity of Endangered species
GIS	Geographic Information System
GRT	Gross Registered Tonnage
GT	Gross Tonnage
HFO	Heavy Fuel Oil
HW	High Water
Hydrographic Risk	Calculation of all risk contribution factors inclusive of traffic
IAATO	International Association of Antarctica Tour Operators

Inherent Risk	Calculation of all risk contribution factors without the application of traffic
IMO	International Maritime Organisation
ITU	International Telecommunications Union (Marine communication standards)
kt	Knot (unit of speed equal to nautical mile per hour)
LAT	Lowest Astronomical Tide
LOA	Length Overall
LW	Low Water
M	Metre
MDO	Marine Diesel Oil.
MCR	Maximum Continuous Rating (a measure of marine diesel engine power output)
MetOcean	The physical oceanography and meteorology inclusive of wind and wave conditions.
ML	Most Likely.
MMSI	Maritime Mobile Service Identity. Is a series of nine digits, uniquely identifying a vessel, sent in digital form by an AIS transponder.
nm	Nautical Mile
OPRC	International Convention on Oil Pollution Response Preparedness, Response and Co-Ordination. It uses a tiered system to categorise a response to a spill, based on tonnes of bunker fuel released into the marine environment.
pd	Population in decline determined by the population health detailed in NZ Threat Classification System (Department of Conservation)
RHIB	Rigid Hulled Inflatable Boat
Risk Matrix	The ranking and weighting of all Causation and Consequence factors are summed in the Risk Matrix.
Risk Model	The Risk Model is used to calculate risk and uses three resolution grid cells containing an attribute for each traffic component, causation factor and consequence factor.
S-AIS	Satellite (received) Automatic Identification System
SFOC	Specific Fuel Oil Consumption
STCW	Standards of Training Certification and Watchkeeping
SUI	Species Uniqueness Index determined by the endemism to the Sub Antarctic Islands
Traffic	Marine vessel traffic may include Fishing, Tanker, Passenger, Cargo, Research Vessel
UNCLOS	United Nations Convention on the Law of the Sea
VHF	Very High Frequency (radio communication)
VMS	Fishing Vessel Monitoring System
WC	Worst Credible
ZOC	Zone of Confidence

EXECUTIVE SUMMARY

A hydrographic risk assessment has been undertaken for the New Zealand Sub-Antarctic Islands using a GIS-based risk matrix, allowing a set of criteria that are common to the Sub-Antarctic region and Antarctica, to be used for risk calculations. The criteria integrated a large number of differing factors across a variety of data sources that combine to output mathematical values for each cell of a GIS system. Risk has been used relatively in the study, allowing direct comparison of hydrographic risk to be made between areas which might have quite different coastal and offshore characteristics.

In order to attribute risk to the region, the study area was turned into a grid of cells, with cell density increasing in the approach to a coastline or harbour. Both general spatial characteristics and individual vessel tracks were mapped to the cells for use in the mathematical risk model. The development of the risk model required a significant methodology development process to be undertaken. At an overview, the methodology proceeded as follows:

- Researching the history and ecology of each island group, their relative importance and diversity. This included detailed species descriptions and distributions for the development of ecological risk components.
- Developing draft risk criteria appropriate to the Sub-Antarctic Islands unique ecology, data, traffic volume and ship types. Subsequent refining of these as the project developed.
- Collecting records of ship visits to the islands, including passenger landing numbers. Decoding, cleaning and post-processing a representative traffic data set, made up from raw Satellite AIS records and VMS data. AIS is required to be transmitted by all vessels operating under the SOLAS Convention over 350 gross tons and passenger ships of any size. VMS, a positioning system that uses the SatCom C band, is a mandatory requirement for fishing vessels[1].
- Performing a traffic analysis of all SOLAS vessel types and domestic vessels, to determine traffic frequency, density, size and type.
- Undertaking a programme of data gathering from relevant parties with an interest in the Sub-Antarctic Islands, including DOC, NZ Navy and Cruise New Zealand.

The risk assessment methodology was modified in comparison to earlier studies performed by Marico Marine for LINZ (including SW Pacific and New Zealand). The concept of Inherent Risk was developed to take account of sparsity of vessel traffic and that the islands represent a unique and diverse

[1] **Large Fishing vessels operating internationally also carry AIS, so duplicate records need to be manually removed from the traffic database for analysis. A growing number of NZ domestic vessels of other types also carry AIS transponders.**

ecological landscape, with an array of distinct and endangered endemic species. Inherent Risk represents the product of Causation and Consequence factors relevant to a ship grounding, but without the actual traffic level being taken into account. The resultant Hydrographic Risk is derived by factoring in the traffic component. Thus:-

Causation × Consequence Factors = Inherent Risk

Traffic × Inherent Risk = Hydrographic Risk.

Inherent Hydrographic Risk presents a record of the locations which provide higher scores against the combinations of the criteria in the risk matrix, but without any contribution from traffic.

Figure 1 presents a plot of the inherent risk result, as derived for the entire study region. It is a method by which the varying importance (or vulnerability) of each island group can be compared. This concept was needed because vessel traffic to the region is low.

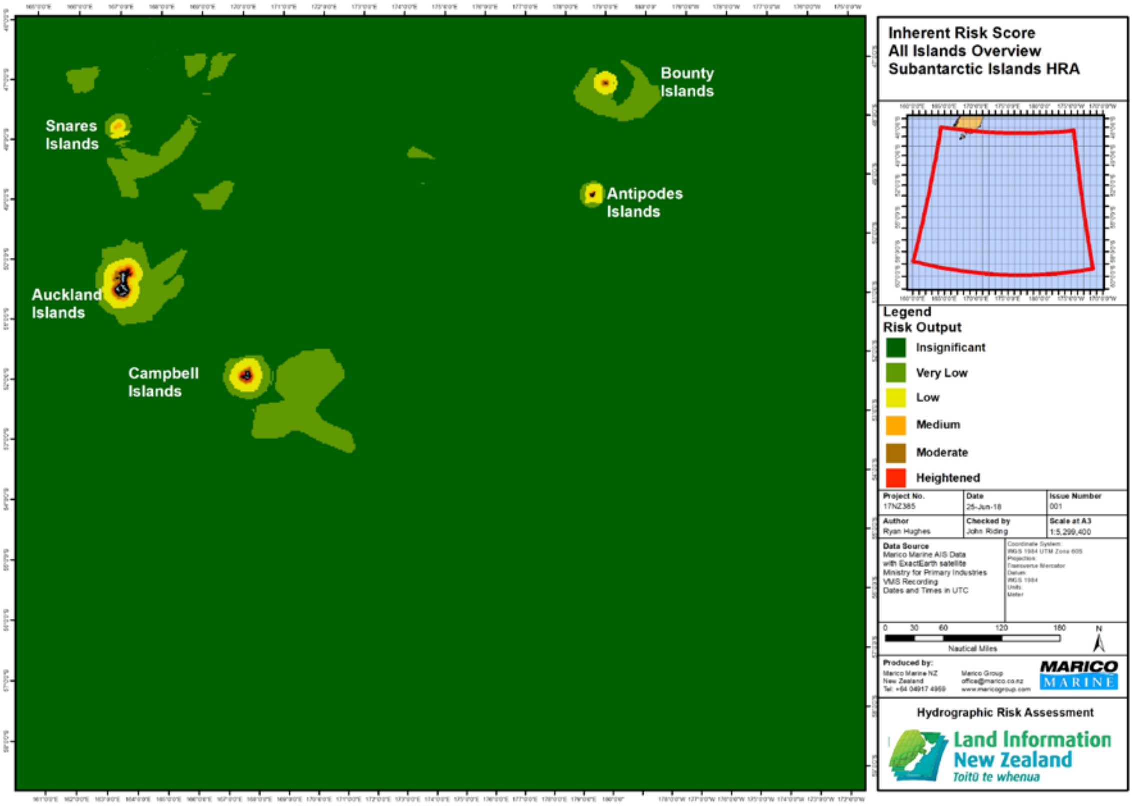


Figure 1 : Inherent Risk Plot - Sub-Antarctic Islands

It should be noted that as risk criteria have been tailored for the Sub-Antarctic and Antarctic regions, these risk results are not directly comparable to those of the SW Pacific in general or the waters of New Zealand's EEZ. However, the criteria are designed to allow the waters south of New Zealand to Antarctica to be compared for hydrographic risk.

A plot of the total hydrographic risk result for the Sub Antarctic Islands area is presented at **Figure 2**.

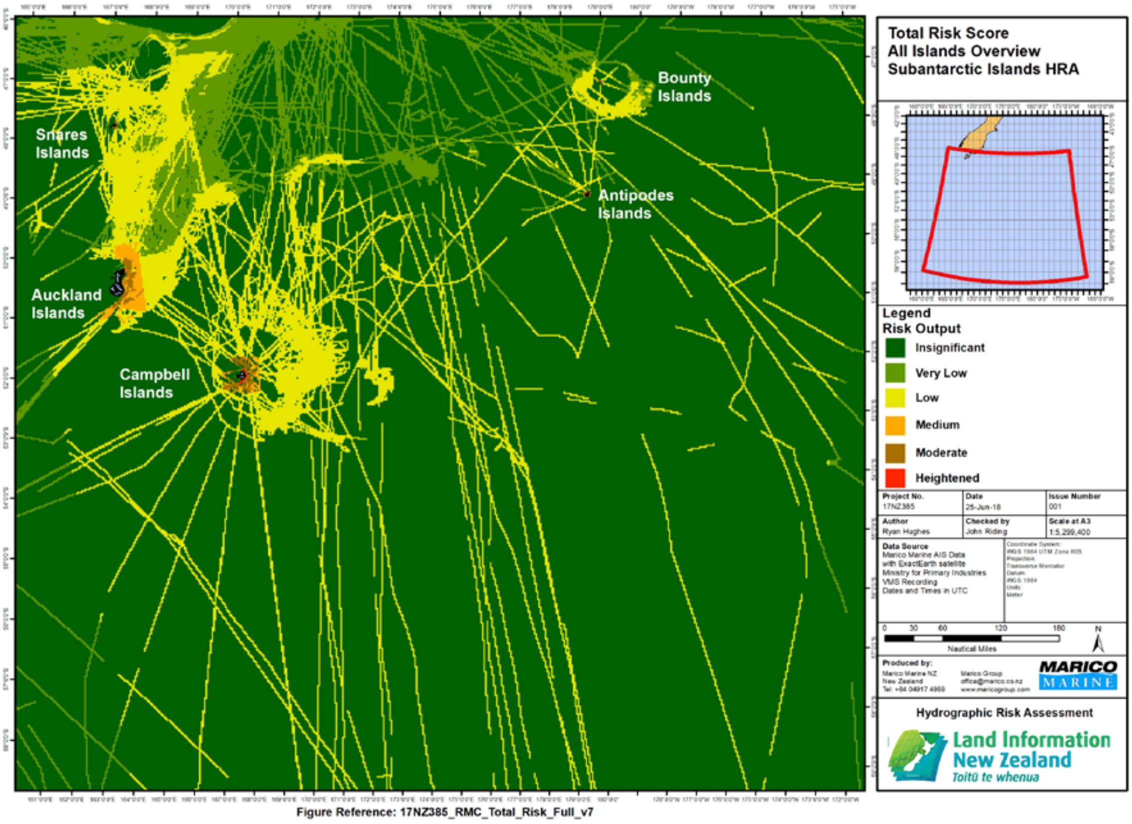


Figure 2: Hydrographic Risk Result - Sub-Antarctic Islands

Offshore regions present lower risk, which is primarily the result of traffic related to offshore fishing grounds and the occasional use of great circle routes by large vessels. The most influential criteria in the risk assessment are those representing abiotic/biotic factors, which are clustered around the Island groups where endangered colonies reside. The fact that these offshore areas produce a risk result, albeit low, suggests that the risk criteria have a balance and are working well for the project result.

Heightened risk is evident around each of the Island groups, in particular around Campbell, Auckland and Snares Islands. At a summary, areas of note for heightened risk include:

- **Auckland Island:** Port Ross and Carnley Harbour;
- **Campbell Island:** Entire eastern coast;
- **Antipodes Islands**: Northwest coast;
- **Snares Islands:** Eastern and Southern coasts.

The Bounty Islands present an interesting special case due to their very wide biodiversity, producing a risk driver that is sensitive to the level of traffic. A single track-record from a small cruise vessel visiting these waters provided a moderate risk result.

Given the nature of heightened risk in nearshore waters of some islands, it is recommended that consideration be given to a Charting Benefit Assessment, as was done for the whole of NZ hydrographic risk project. This is because charting adequacy is one criteria amongst many used to derive hydrographic risk. This risk assessment is also strongly influenced by ecological criteria, with low traffic levels, also affecting charting influence. The Charting Benefit module is designed to assess the cost-effectiveness of charting upgrades and achieves this using the detail of the present charting standard. Some of the official charting inserts have areas where surveys are modern, but equally contain unsurveyed areas. A chart benefit assessment would provide information of assistance to the hydrographic decision-making needs of this work.

It is also noted that while many of the Sub-Antarctic Islands have moderate charting accuracy, the western sides of most islands are less well surveyed. This is a reflection not only of the predominant weather conditions in the region, with strong westerly winds and associated long period swell, but also because natural harbours open from the east. Historically, the vessels mostly operating in the areas are those engaged in fishing, but cruising is becoming important. With fishing grounds to the east of islands, this vessel type seek shelter to the east, even during onshore wind conditions. Whilst the probability is lower, strong winds from other directions do occur throughout the region. With the potential for larger, high windage cruise vessels to start visiting the islands, the possibility of one needing to seek shelter on either side of the islands will increase. This though is only relevant to islands such as Campbell and Auckland, where land height is available to provide some lee shelter in an easterly. Thus, it is recommended that the western side of these islands, in particular, are given some priority for charting upgrade.

The Chart Adequacy for each of the island groups was determined using a compilation of input criteria; available chart scales, the distribution of CATZOC scores and chart survey age. An assessment of charting adequacy was made, taking into account the type of marine traffic using the islands. The prevalence of a criteria, as well as where it is located, is also taken into account. For example, if the harbour approaches score well in both survey age and CATZOC, this contributes to a higher Chart Adequacy score. However, if all surrounding areas are unsurveyed, this affectively lowers the overall Chart Adequacy score. This has affected adequacy scoring in some of the chart inserts for harbours, where charting improvements have been made.

Conclusions are presented at **Section 15** (**Page 130**) and Recommendations at **Section 16** (**Page 133**).

1 INTRODUCTION

This report documents a Hydrographic Risk Assessment for a sea area encompassing New Zealand's Sub-Antarctic Islands (Auckland, Campbell, Bounty, Antipodes and Snares Islands) and was carried out at the request of Land Information New Zealand (LINZ). This Risk Assessment uses Geographic Information System (GIS) spatial analysis techniques to identify areas of hydrographic risk using data-based evidence.

The study uses this risk comparative technique to assist LINZ with the effective prioritisation of future hydrographic surveys and charting improvements throughout the Sub-Antarctic Islands.

This Hydrographic Risk Assessment provides recommendations and conclusions for prioritising charting improvements, based on the needs of contemporary shipping for the provision of accurate and adequate nautical charts.

More detailed information on the Risk Criteria Matrix, Consultation Meetings and Event Trees can be found in the accompanying Annexes (bound separately).

Marico Marine would like to acknowledge and thank those Stakeholders who contributed to this study, especially the Department of Conservation (DOC), Heritage Cruises and the New Zealand Cruise Association. Thanks are also expressed to the Ministry for Primary Industries, who released VMS data for the study area, which provided transit information about fishing vessels not using AIS transponders.

1.1 BACKGROUND

This section can only be a summary of the hydrographic risk approach, the methodology surrounding which is the subject of a separate LINZ document. Deriving hydrographic risk for any area allows prioritisation of locations where hydrographic survey or charting upgrade would provide the most benefit and be the most cost effective. The risk approach takes into account the traffic using the sea areas, the coastline locations that are more vulnerable than others to a shipping accident, as well as the standard of the existing charting.

In the Sub-Antarctic Islands the environmental and ecological significance of the area are important factors in themselves. This often dictates the ship types and sizes that visit the area and the ongoing protection of this unique environment by DOC may be a significant biggest factor in limiting future growth in vessel numbers and passenger capacity (cruise is the most important trade in this region).

Locations sensitive to environmental damage require special consideration and focus. In the case of this study, the ecological importance is such that vulnerability to damage from a ship grounding can provide a risk result in itself – the newly-formed concept of Inherent Hydrographic risk. Environmental damage in an area with economic activity linked to environmental utility provides further consequence impact. Grounding consequence in both environment and economics is related to the release of bunkers or cargo.

Thus, there are three key components (risk, ship types and sizes; environmental sensitivity) that, when combined, provide the evidence required to promote one area over another for hydrographic survey prioritisation.

The maritime activity around the Sub-Antarctic Islands, has changed significantly in recent decades. There has been a reported increase in both cruise ship calls as well as interest from the cruise industry for future bookings. There is also an ongoing trend for larger vessels wishing to visit, which are at the end of the already tight DOC limits for vessel size. Visits by large vessels to remote locations is becoming increasingly common place. This trend of growth is projected to continue (DOC advice).

The risks associated with the use of older or outdated charts have therefore increased significantly in recent years. There is a practical as well as a budgetary need, though, to prioritise. This report presents the results of the deployment of a methodology designed to enable prioritisation. It is risk based, but combines the economic and environmental drivers with the risk considerations. This process is a crucial base for survey planning, as comprehensive statistical data was available in few areas.

The prioritisation process is not only risk based, but transparent against set criteria. It also needs to be clearly documented, systematic and recorded in a uniform manner. To achieve this, the methodology and required input data was uniformly applied across the candidate harbours, coastal and ocean areas.

The overall severity of impacts from a marine accident on a coastal zone is dependent on a large number of factors. Areas of environmental importance can be severely affected, but severity of impact is dependent on their distance from the casualty. Longer term impacts, especially to the environment and tourism, are also lessened the greater the distance from the event.

Severity of consequence are thus geographically relevant and the best way to assess such impacts is to employ a Geographical Information System to evaluate the risk. This risk-based result will significantly benefit hydrographic decision-making and will identify the areas that are priority candidates for charting improvements.

1.2 PROJECT SCOPE

The geographical scope comprises the development of a Hydrography Risk Assessment for the Sub-Antarctic Islands. In more detail, this comprises:

- Decoding, cleaning and post-processing to prepare a fused AIS data set, made up from raw Satellite AIS and VMS data. AIS data is transmitted by all SOLAS ships in service over 350 gross tons and some NZ domestic registered vessels, while VMS is most commonly used by fishing vessels.
- Undertaking a programme of data gathering from relevant parties with an interest in the Sub-Antarctic Islands, including DOC and Cruise New Zealand.
- Provision of traffic analysis of all SOLAS vessel types and domestic vessels, including traffic frequency, density and type.
- Developing risk criteria appropriate to the Sub-Antarctic Islands and Ross Sea data volume and ship traffic types.
- Developing a hydrographic risk model using the developed risk criteria.

1.3 DATA USED IN THE PROJECT

1.3.1 Satellite Automatic Identification System Data (S-AIS)

A 6-month record of shipping traffic in the Sub-Antarctic Island waters was specified as a core input into this Hydrographic risk assessment. However, in order to deliver a robust result, Marico Marine took an internal project decision to continue with a policy of using a full 12 months of traffic data to drive the risk assessment. This data set has thus been added-to by Marico Marine in order to provide a full year of data for analysis. Reasoning for this is the fact that traffic in the Sub-Antarctic Islands is low anyway, but that a portion of the traffic record transits onwards to Antarctica, which on its return may provide transit records outside of the 6 month traffic record specified for the project.

Traffic has been broken down into ship types as transmitted by AIS transponders fitted to all internationally trading vessels ("SOLAS" vessel) and most fishing vessels.

As most of the study area is not covered by terrestrial AIS recording, Satellite recorded AIS (S-AIS) data was used. The S-AIS data was sourced from the exactEarth satellite constellation, used because of its frequency of data update as well as its tested superiority in the recording of transmission time in relation to the vessel's transmitted positional data. This is an important consideration, as AIS transmissions received by satellite suffer some delay in timestamping, which is added only when the data is downloaded to a ground station. The relationship between the written timestamp and the actual time associated with a vessel position is important to the risk assessment record[2].

As S-AIS data is not recorded real time and is intermittent in nature, tracks were linked together by a computer based on time and the recorded positions, thus reproducing the exact track taken by a vessel where data exists, but not necessarily reproducing the tie at which the vessel passed through the recorded location. Where data showed tracks in obvious error (e.g. crossing land due to connection of discrete data points), or with an obvious misalignment to other data received, these were manually corrected. Thus, the final track database used for the project will contain some inaccuracies, which do not materially affect the risk result, but vessel tracks should not be relied on as an exact record of the track taken by any vessel.

1.3.2 Fishing Vessel Monitoring (VMS) Data

Fishing Vessel VMS data for a 12 month period was provided by the New Zealand Ministry of Primary Industries. This is a system where registered fishing vessels are tracked periodically by the regulator as part of the fishing quota management system. VMS data provides a periodic record of such vessels positions and identity, but it is not as comprehensive a dataset as is provided by the AIS transponder transmission. A majority of fishing vessels in the study area were fitted with AIS transponders in addition to VMS and the data was combined to ensure that double counting of fishing vessels did not occur. VMS data did add fishing vessel records to the data base of smaller fishing vessels that were not fitted with an AIS transponder.

1.3.3 Species Descriptions and Distributions

Information on key species present at the Sub-Antarctic Islands was gathered and allocated numerical values based on their associated ecological attributes. The underlying information on these species distributions and a general description of their population status can be seen in **Table 1.** The Ecological Subset Value (ESV) score is shown in the table, as used in the Risk Assessment. The ESV is a concept developed for this risk assessment by Marico Marine and has been vetted by DOC specialists. It takes the established system of threat assessment for endangered species and links it to a system using risk.

[2] **Transmitted AIS data packets do have time included within the transmission, but this is a time breakdown within a second to allow two AIS transponders in an area to synchronise transmission and reception (and thus avoid data collisions). AIS "time" within transmission does not include minutes (or hours), so remote reception needs to add those time elements when the data is received. The significance of any delays from transmission to reception affects positional accuracy.**

Type	Name	Status	ESV	Location				
				Auckland	Campbell	Bounty	Antipodes	Snares
Mammals	NZ Sealion	Threatened, Nationally Critical	9	✓	✓			
	Southern Elephant Seal	Threatened, Nationally Critical	6				✓	
	Southern Right Whale	Threatened, Nationally Vulnerable	2	✓	✓			
Penguins	Erect-crested Penguin	At Risk, Declining	6			✓	✓	
	Rockhopper Penguin	Threatened, Nationally Vulnerable	5	✓	✓		✓	
	Snare's Crested Penguin	At Risk, Naturally Uncommon	4					✓
	Yellow-eyed Penguin	Threatened, Nationally Endangered	8	✓	✓			
Albatrosses	Antipodean Albatross	Threatened, Nationally Critical	10				✓	
	Buller's Mollymawk	At Risk, Naturally Uncommon	1					✓
	Campbell Albatross	Threatened, Nationally Vulnerable	5		✓			
	Gibson's Albatross	Threatened, Nationally Vulnerable	6	✓				
	Light Mantled Sooty Albatross	At Risk, Declining	4	✓	✓		✓	
	Salvin's Mollymawk	Threatened, Nationally Critical	9			✓		✓
	Southern Royal Albatross	At Risk, Naturally Uncommon	4	✓	✓			
	White-capped Mollymawk	At Risk, Declining	4	✓			✓	
Snipes, Shags, Teals	Antipodes Island Snipe	At Risk, Naturally Uncommon	4				✓	
	Auckland Island Shag	Threatened, Nationally Vulnerable	5	✓				
	Auckland Island Snipe	At Risk, Naturally Uncommon	4	✓				
	Auckland Island Teal	Threatened, Nationally Vulnerable	5	✓				
	Bounty Island Shag	At Risk, Naturally Uncommon	4			✓		
	Campbell Island Shag	At Risk, Naturally Uncommon	4		✓			
	Campbell Island Snipe	Threatened, Nationally Critical	10		✓			
	Campbell Island Teal	Threatened, Nationally Vulnerable	5		✓			
	Snares Island Snipe	At Risk, Naturally Uncommon	4					✓
Other Birds	Antarctic Prion	At Risk, Naturally Uncommon	1	✓	✓			
	Auckland Island Dotterel	Threatened, Nationally Vulnerable	6	✓				
	Auckland Island Rail	At Risk, Naturally Uncommon	4	✓				
	Burrowing Petrel	At Risk, Naturally Uncommon	4	✓	✓		✓	
	Fulmar Prion	At Risk, Naturally Uncommon	1			✓		
	Northern Giant Petrel	At Risk, Recovering	3				✓	
	Sooty Shearwater	At Risk, Declining	5	✓	✓			

Table 1: Sub-Antarctic Islands - Key Species Distributions and Population Status

1.3.4 Additional Data Collected

A key component of the risk assessment was the gathering of location specific information to support the identification of risk areas and provide input to assist with prioritising future hydrographic surveys.

The more significant vessel operators who visit the Sub-Antarctic Islands were researched and input from Cruise New Zealand as well as the predominant cruise operator to the Sub-Antarctic Islands, Heritage Line, was provided during data gathering visits. Information about vessel movements, vessel types and sizes were compiled from data supplied by stakeholders, augmented with data available from records posted to the internet.

Where GIS shapefiles of sensitive sites and other data sets were available from stakeholders, these were uploaded directly into the GIS risk model. Shapefiles of Marine Reserves were kindly supplied by the Department of Conservation (DOC), identifying areas where breeding habitats we located for the varying species, some of which are critically endangered, which reside on each Sub-Antarctic Island. The files had, in some cases, confidential information attached as to critically endangered species and in each case contained information about other important areas for specific species.

The resulting information was used to design the risk criteria to be used across the Sub-Antarctic and Antarctic regions for the Hydrographic Risk Assessment process. The detail of how the input layers were derived into the risk criteria for the risk assessment can be found in the methodology report (Marico Marine NZ reference 17NZ305-1). The resulting risk matrix used for this hydrographic risk assessment is presented at **Annex A.**

1.4 OFFICIAL NAUTICAL CHARTS AND PUBLICATIONS

The Official Nautical Charts used for this risk assessment are published by LINZ. All coastal states have an international obligation to provide hydrographic services to survey and deliver depth data from their waters in areas where navigation is needed. Where a State does not have the resources for a national Hydrographic Office, they supply the data to another State which has agreed to provide the services of a charting authority. LINZ is a charting authority for a large area of the South West Pacific, as well as the Hydrographic Office and Charting Authority for the EEZ waters of New Zealand and south to and including the Ross Sea. It is thus the charting authority for an exceptionally large area of sea in relation to the NZ landmass. LINZ thus provides an important NZ role representing both NZ and a significant charting area in its membership role of the International Hydrographic Organisation (IHO). The charting used as input criteria for this risk assessment were constructed in accordance with the IHO recommendations.

In addition to nautical charts, LINZ provides nautical publications, such as light lists, notices to mariners, tide tables and other nautical publications necessary for any intended voyage, are required to be carried by vessels to remain compliant with the SOLAS Convention[1].

1.4.1 NEW ZEALAND CHARTING DEFINITIONS

The recording of clear definitions is critical to the understanding of the hydrographic risk assessment. Hydrographic charts have two functions: the facilitation of safe navigation ***and*** the provision of accurate information resources for marine activities in general. The following sections record the relationships used by the risk process in deriving the criteria used to deliver this hydrographic risk assessment.

1.4.2 CHART ADEQUACY

Charting scales, extents of coverage, and quality-ratings (CATZOC) all combine to denote chart adequacy. The overall assessment of adequacy of nautical charts is complex but the components overall that contribute to the LINZ measure of charting adequacy can be represented by the diagram below.

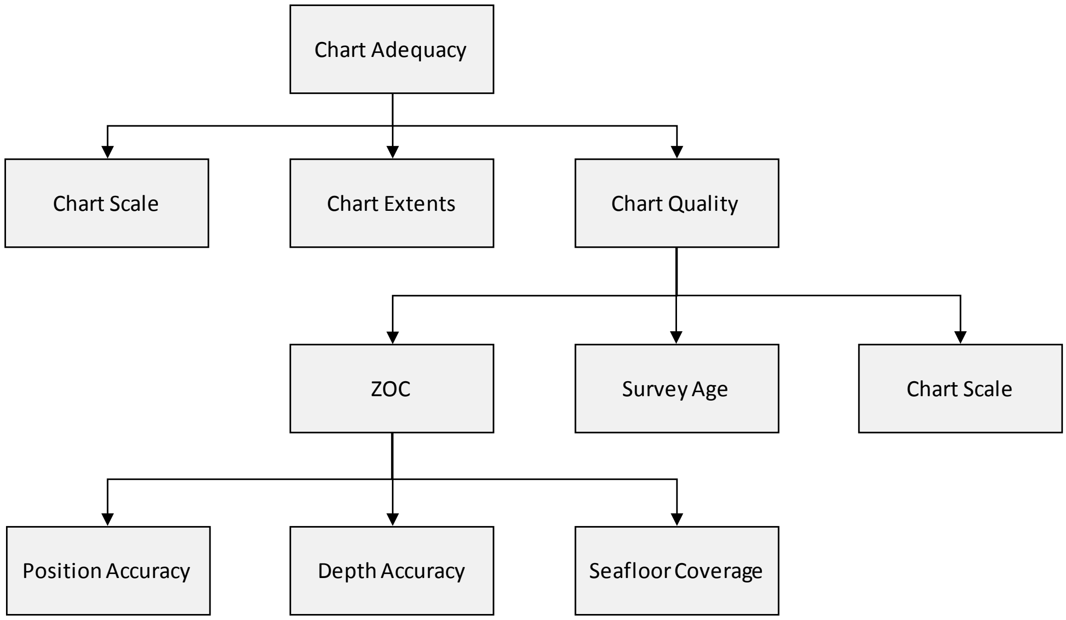


Figure 3: Components of Chart Adequacy

1.4.3 NZ Chart Scales

The LINZ chart series was developed to meet the needs of shipping over time. Shipping traffic, vessel types and sizes have changed considerably since many of the NZ charts were schemed and they may need revision for todays or future needs.

National nautical chart series usually encompass the largest scale publications available, showing the detailed configuration of the seabed offshore. Information about the shape of the seabed is used by a variety of users other than navigation: port developers, dredging contractors, offshore developers and construction engineers, defence organisations and so on.

The combined effect of the requirements of marine navigation and providing an information source has caused the national chart series to cover national waters in varying detail, dependant on usage. For example, port plans have large scales, but there are in existence two continuous coastal series, one on a relatively large scale, the other slightly smaller.

With the advent of ECDIS (Electronic Chart Display Information System), the IHO members agreed recommended scale ranges for the needs of different navigational usage:

- Offshore charting
- Coastal charting
- Harbour Approach charting

- Berthing charting

The New Zealand charting area under consideration includes overview, ocean, approach and harbour charts of scales from 1:75,000-1:4,000,000 for planning, ocean passage and coastal navigation, to 1:2,500-1:75,000 for large scale or harbour charts. These charts are all published on the WGS 84 geodetic datum. All New Zealand Charts for the area inside the EEZ now have depths and heights in metres. Previous versions with depths in fathoms and heights in feet have all been withdrawn.

A range of different scales are recommended for the stated type of navigational use, which sets the scales for printed charts. By policy, LINZ use the following guidance for the scales of their NZ chart portfolio, which is in accordance with the IHO recommendations for navigation type[3].

LINZ Navigational Purpose Scale Ranges (Paper Charts)			
Subfield	**Navigation**	**Purpose**	**Available Compilation Scales for ENC charts**
1	Overview	>=3,000,001	1:3,000,000
2	General	800,001 – 3M	1:3,000,000 1:1,500,000 1:700,000
3	Coastal	80,001 – 800K	1:700,000 1:350,000 1:180,000 1:90,000
4	Approach	25,001 – 80K	1:90,000 1:45,000 1:22,000
5	Harbour	8,001 –25K	1:22,000 1:12,000 1:8,000
6	Berthing	>=8K	1:8,000 1:4,000

Table 2: LINZ Paper Chart Compilation Scale

A ship's ECDIS will comply with the standard scale table (**Table 3**) when a charting range is selected on the ECDIS system. Setting the range on an ECDIS will select the chart data scale nearest to the chosen setting. For harbour approaches, the system should automatically change scale to the charting scale as recommended. This provides the mariner with a paper chart scale to ENC scale

[3] Regulations of the IHO for International (int) charts and chart specifications of the IHO (2013)

conversion. The paper chart compilation scale is rounded down to the nearest ENC Compilation Scale (e.g. Paper Chart 20,000 = ENC 12,000).

One of the key tests in the charting benefit model is to determine if chart data is available at the right scale (as recommended by the IHO – see reference previous page) for the navigational purpose of the area in which a vessel was navigating.

Radar Range / Standard Scale Table (ENC)	
Selectable Range (in nautical miles)	ENC Compilation Scale (rounded)
200	1:3,000,000
96	1:1,500,000
48	1:700,000
24	1:350,000
12	1:180,000
6	1:90,000
3	1:45,000
1.5	1:22,000
0.75	1:12,000
0.5	1:8,000
0.25	1:4,000

Table 3: IHO ENC Compilation Scale

1.4.4 EXTENTS OF THE STUDY AREA

This hydrographic risk assessment covers a rectangular area extending from 47°S (including the southern end of Stewart Island) to 60° and from 164°E to 174°W.

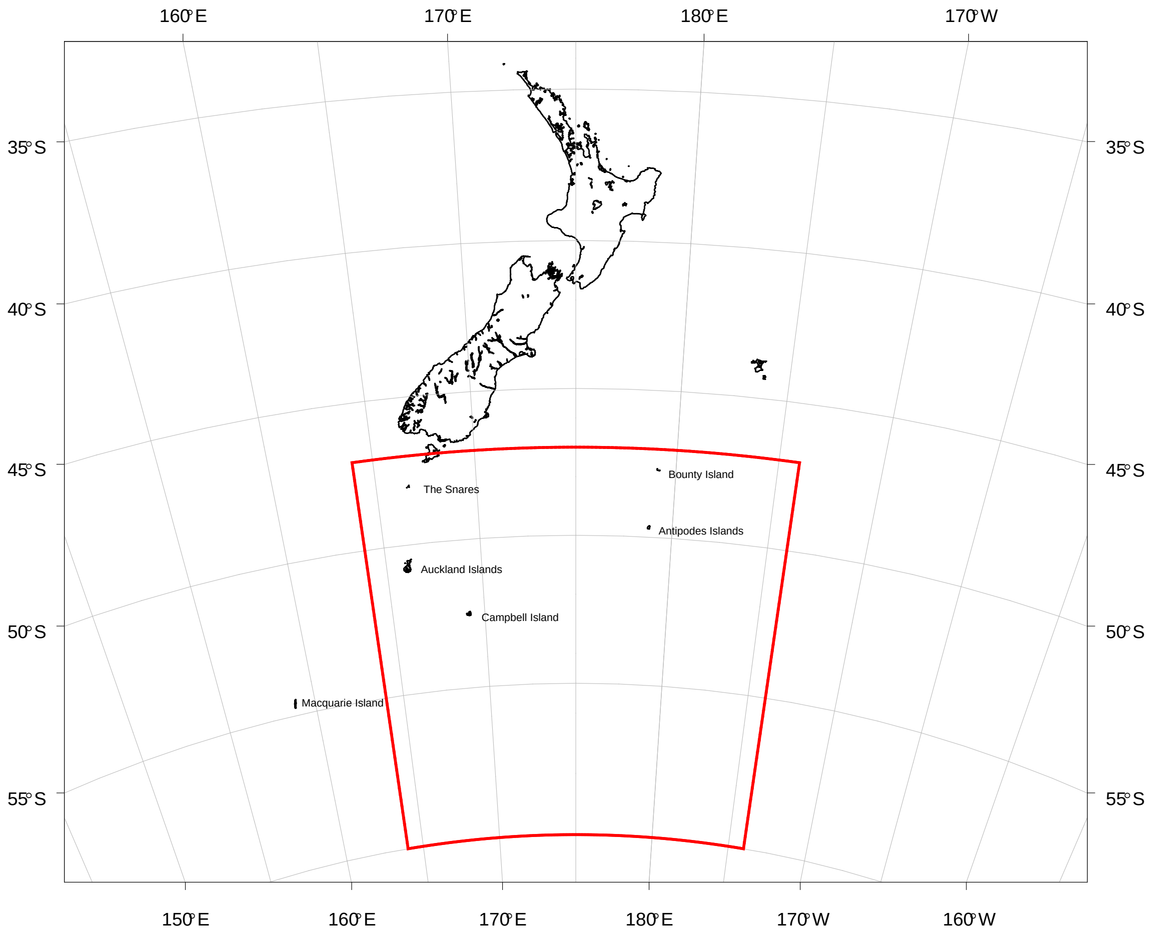


Figure 4: Sub-Antarctic Islands Hydrographic Risk Assessment Study Area

1.4.5 CHART QUALITY

Chart quality may be said to comprise three factors: Zone of Confidence (ZOC); survey age and survey scale/extents. LINZ has policy to add the MQUAL Charting Quality CATZOC rating to its charts (ENC) and has done this to almost all of its coastal charting series[4]. The CATZOC rating is of help to the navigator in understanding uncertainty in the underlying chart data and presently the rollout programme extends to all the LINZ Coastal Chart portfolios.

Quite some time ago, New Zealand, in common with other hydrographic authorities, added quality indicators on all its hydrographic charts using Source Data Diagrams and Diagrams of bottom sounding density.

[4] Not all Hydrographic offices have this policy, which makes LINZ a leader in this area; others are following. As Hydrographic Risk is much better informed by the ZOC rating of a chart, this LINZ policy is important.

1.4.5.1 ZONE OF CONFIDENCE

The IHO Data Quality Working Group (DQWG) developed the concept of the Zone of Confidence (ZOC) as a solution for the assessment and display of hydrographic data quality, which supports safe navigation by providing the mariner with additional information about the data underpinning the chart in use. Areas covered by hydrographic surveys are classified by identifying various levels of confidence with respect to depth accuracy, position accuracy, thoroughness of seafloor search, and the characteristics of the survey. Six ZOC have been developed - A1, A2, B, C, D and U.

To decide on a ZOC Category, all conditions outlined in columns 2 to 4 of **Table 4** must be met.

<table>
<tr><th>1</th><th>2</th><th colspan="2">3</th><th>4</th><th>5</th></tr>
<tr><th>ZOC</th><th>Position Accurancy</th><th colspan="2">Depth Accurancy</th><th>Seafloor Coverage</th><th>Typical Survey Characteristics</th></tr>
<tr><td rowspan="6">A1</td><td rowspan="6">± 5 m + 5% depth</td><td colspan="2">= 0.50 + 1%d</td><td rowspan="6">Full area search undertaken. Significant seafloor features detected[4] and depths measured.</td><td rowspan="6">Controlled, systematic survey high position and depth accuracy achieved using DGPS or a minimum three high quality lines of position (LOP) and a multibeam, channel or mechanical sweep system.</td></tr>
<tr><td>Depth (m)</td><td>Accuracy (m)</td></tr>
<tr><td>10</td><td>± 0.6</td></tr>
<tr><td>30</td><td>± 0.8</td></tr>
<tr><td>100</td><td>± 1.5</td></tr>
<tr><td>1000</td><td>± 10.5</td></tr>
<tr><td rowspan="6">A2</td><td rowspan="6">± 20 m</td><td colspan="2">= 1.00 + 2%d</td><td rowspan="6">Full area search undertaken. Significant seafloor features detected and depths measured.</td><td rowspan="6">Controlled, systematic survey achieving position and depth accuracy less than ZOC A1 and using a modern survey echosounder[7] and a sonar or mechanical sweep system</td></tr>
<tr><td>Depth (m)</td><td>Accuracy (m)</td></tr>
<tr><td>10</td><td>± 1.2</td></tr>
<tr><td>30</td><td>± 1.6</td></tr>
<tr><td>100</td><td>± 3.0</td></tr>
<tr><td>1000</td><td>± 21.0</td></tr>
<tr><td rowspan="6">B</td><td rowspan="6">± 50 m</td><td colspan="2">= 1.00 + 2%d</td><td rowspan="6">Full seafloor coverage not achieved; uncharted features, hazardous to surface navigation are not expected but may</td><td rowspan="6">Controlled, systematic survey achieving similar depth. But lesser position accuracies than ZOCA2, using a modern survey echosounder, but no sonar or mechanical sweep system.</td></tr>
<tr><td>Depth (m)</td><td>Accuracy (m)</td></tr>
<tr><td>10</td><td>± 1.2</td></tr>
<tr><td>30</td><td>± 1.6</td></tr>
<tr><td>100</td><td>± 3.0</td></tr>
<tr><td>1000</td><td>± 21.0</td></tr>
<tr><td rowspan="6">C</td><td rowspan="6">± 500 m</td><td colspan="2">= 2.00 + 5%d</td><td rowspan="6">Full seafloor coverage not achieved, depth anomalies may be expected.</td><td rowspan="6">Low accuracy survey or data collected on an opportunity basis such as soundings on passage.</td></tr>
<tr><td>Depth (m)</td><td>Accuracy (m)</td></tr>
<tr><td>10</td><td>± 2.5</td></tr>
<tr><td>30</td><td>± 3.5</td></tr>
<tr><td>100</td><td>± 7.0</td></tr>
<tr><td>1000</td><td>± 52.0</td></tr>
<tr><td>D</td><td>worse than ZOC C</td><td colspan="2">worse than ZOC C</td><td>Full seafloor coverage not achieved, large depth anomalies may be expected.</td><td>Poor quality data or data that cannot be quality assessed due to lack of information.</td></tr>
<tr><td>U</td><td colspan="5">Unassessed – The quality of the bathymetric data has yet to be assessed</td></tr>
</table>

Table 4: CATZOC Categories (IHO, 2014)

CATZOC categories in the Sub-Antarctic Islands region have mostly been rated as C/D for open ocean areas, increasing to ZOC A in areas where vessels approach the inlets and for navigation close to the eastern side of individual islands (the eastern side of islands are sheltered from the prevailing westerly winds). Notably, there are also U rated areas near some islands. The sections of the report presenting results for each island group include detailed plots showing CATZOC ratings.

1.4.5.2 Survey Age

Whilst the age of survey data in the charts for the Sub-Antarctic Islands is generally less than what is found in several locations in mainland New Zealand, there can be significant variations within each island group.

The source data plot from chart NZ 3111 for Campbell, Bounty and Antipodes Islands is shown in **Figure 5**. It can be appreciated that while there is a mix of recent LINZ (2005) and mid-Eighties Navy survey data, there are also very large areas that either consist of "random soundings" or are not surveyed at all.

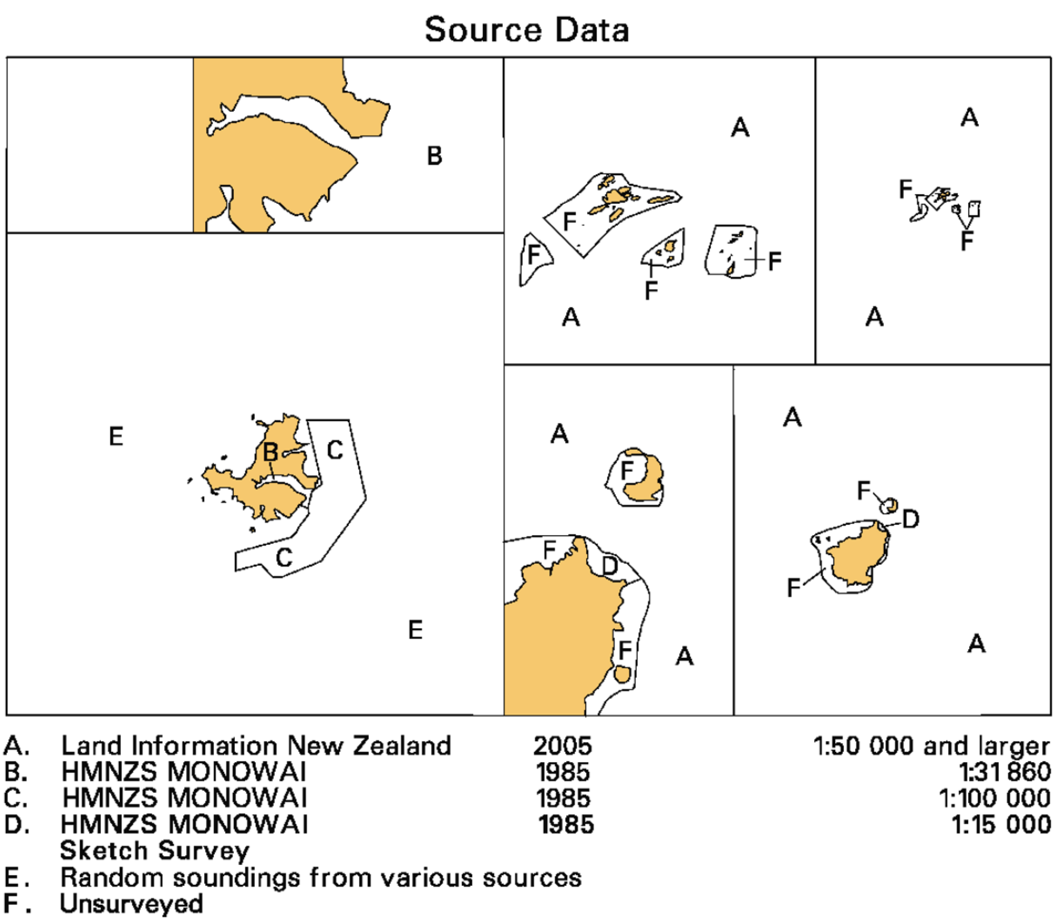


Figure 5: Chart NZ 3111 Campbell, Bounty and Antipodes Islands –Source Data

The size of vessels and the accuracy of navigation now possible using satellite derived positioning are significantly different from the original intended purposes for which many existing charts were derived. The mariner is advised accordingly, both during training and by remarks on the charts and source data advice. This mitigates liability risk by providing clarity of chart limitations.

Despite this, there remains a reasonable concern that inadequate and inaccurate nautical charting could adversely affect safety of life at sea and the protection of the marine environment. It may also inhibit maritime trade, thereby adversely affecting the economy of some regions. There remains a potential for pollution and other environmental damage associated with a vessel grounding in areas where charting is poor.

2 SUB-ANTARCTIC ISLANDS – OVERVIEW AND ECOLOGY

The New Zealand Sub-Antarctic Islands consist of five island groups; the Auckland Islands, Campbell Islands, Bounty Islands, Antipodes Islands and Snares Islands. The islands are recognised as a unique ecological landscape for an array of distinct endemic species. The remote and unique nature of the Sub-Antarctic Islands makes this location particularly attractive to the tourism industry.

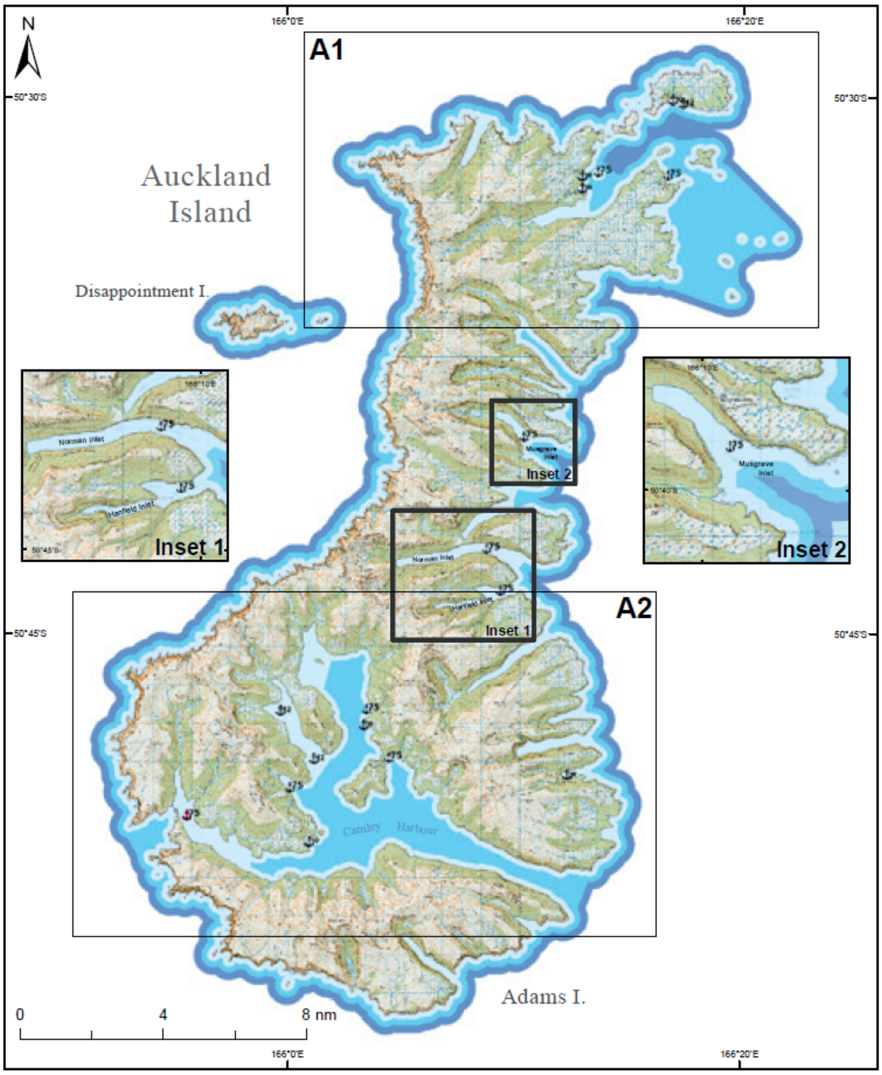
Recognised as a UNESCO World Heritage Site in 1998, the islands are home to 40 species of seabird as their principal breeding grounds. The islands are the breeding site of approximately 11% of all seabird species in the world and 30% of the world's petrels, as well as 14 species of endemic land birds. The Islands also feature many species of marine mammals throughout the year, acting as important seasonal breeding grounds for migratory cetaceans, in particular Southern Right Whales.

2.1 AUCKLAND ISLANDS

The Auckland Islands are the largest of the Sub-Antarctic Islands with a combined area of 62500 Ha and are 465 km southeast of the South Island of New Zealand (**Figure 6**). This group, lying between 50° 26' and 50 56' S, and between 165° 52' and 166 22' E, is approximately 200 miles SSW of Stewart Island. In the group are one large and five smaller islands, with several detached islets and rocky pinnacles. The main island is some 24 miles long and from 3 to 16 miles wide, with Adams Island in the south and Enderby Island in the north, with Disappointment Island off the west coast. All the islands are of volcanic origin with a maximum height of just over 610m. The east coast of the main island has long, narrow inlets, but the west coast is mostly unbroken lines of high, steep cliffs. Auckland Island offers good sheltered anchorages in the east, notably in Carnley Harbour, which divides Adams Island from the mainland. The climate is cool, humid, cloudy, and windy. Nevertheless, most of the area is clothed with shrubby forest at lower levels. Above 100m this gives way to open patches of tussock and Sub-Antarctic meadowland.

Whist the largest of the Sub-Antarctic Islands, the Auckland Island group also has the most diverse and rarest flora and fauna. The group is the principal breeding grounds for the New Zealand Sea Lion, the most threatened sea lion species in the world. Like all the Sub-Antarctic Islands, there is a no-fishing zone extending to 12nm which acts as both a marine mammal sanctuary and marine reserve. A seasonal exclusion zone for vessels >75m in Port Ross, a principal breeding ground for the Southern Right Whale, is enforced from June-October.

The group was discovered by Abraham Bristow, master of a whaling ship, in 1806. Little notice is reported in the islands until ships sailing the great circle route from Australia to Cape Horn were wrecked there. The *General Grant*, was wrecked there in 1866, carrying passengers and gold.



Distance to MHWS (metres & nautical miles)	Vessel Class (metres)			
	Ancillary Craft	Up to 30 m	Between 30 - 125 m	Large (> 125 m)
Up to 300 m (0.162 nm)	Permitted	Discretionary	Discretionary	Prohibited
300 m to 600 m (0.162 nm - 0.324 nm)	Permitted	Permitted	Permitted	Prohibited
600 m to 1000m (0.324 nm - 0.540 nm)	Permitted	Permitted	Permitted	Discretionary
Excess of 1000m (0.540 nm)	Permitted	Permitted	Permitted	Permitted

NOT TO BE USED FOR NAVIGATIONAL PURPOSES *MHWS: Mean High Water Springs

The Master of any vessel entering any of the waters of the Subantarctic Islands needs to be aware of the risks – such as age and nature of hydrographic survey data (potential for uncharted hazards) coupled with the effect of strong winds - and be mindful that rapid and severe changes in weather conditions can occur.

Anchorages

Vessels of the length specified below do not require a permit to anchor at the designated locations only (Anchor at own discretion)

- 30 For Vessels up to 30 metres
- 42 For Vessels up to 42 metres
- 75 For Vessels up to 75 metres
- 75 For Vessels up to 75 metres (if wind speed is <35 knots)

Island Topography Sources from Topographic Map - Auckland Islands. Crown Copyright Reserved.

Figure 6: Auckland Islands (Port Ross Southern Right Whale Exclusion Zone, Right)

2.1.1 Species of Note in the Auckland Islands

There are quite a number of species endemic to the Auckland Islands that are of note and threatened[5]:

- **New Zealand Sea Lion:** Threatened - Nationally Critical. The population is currently estimated at around 12,000 individuals. The New Zealand Sea Lion is the most threatened species of Sea Lion in the World.
- **Southern Right Whales**: Threatened - Nationally Vulnerable. The population is currently estimated at around 10,000 individuals. Their principal breeding grounds are in Port Ross, Auckland Island, from June-October and has resulted in an exclusion zone to vessels >75m in this area during their breeding season.
- **Rock Hopper Penguin:** Threatened, Nationally Vulnerable. The population amongst the Auckland Islands is estimated at less than 3000 breeding pairs, comparable to that at the Antipodes Islands and roughly 1/10 the population size estimated amongst the Campbell Islands.
- **Yellow-eyed Penguin**: Threatened - Nationally Endangered. Around 1000 breeding pairs are estimated to be living amongst Auckland and Campbell islands.
- **Gibson's Albatross:** Threatened - Nationally Vulnerable. The population is estimated at 6000 breeding pairs amongst the Auckland Islands.
- **Light Mantled Sooty Albatross:** At Risk - Declining. Approximately 5000 pairs breed on the Auckland Islands.
- **Southern Royal Albatross:** At Risk - Naturally Uncommon. Approximately less than 100 pairs breed on the Auckland Islands.
- **White-Capped Mollymawk**: At Risk – Declining. Current population estimates vary widely, with aerial surveillance estimating 75000-117,000 breeding pairs. However, these estimates are based on annual counts, and as the species breeds biennially the actual number may be somewhat larger.
- **Auckland Island Shag:** Threatened – Nationally vulnerable. The population is estimated at around 4500 mature individuals.
- **Auckland Island Snipe:** At Risk - Naturally Uncommon. Population estimates vary and are usually based on available space, though have been estimated as stable.
- **Auckland Island Teal:** Threatened – Nationally vulnerable. The population is estimated to exceed 1000 following an increase seen on Enderby and Rose Islands.
- **Antarctic Prion:** At Risk – Naturally Uncommon. Breeds on the Auckland Islands, but is widely distributed throughout the South Pacific. Population estimated at 100,000 to 1,000,000 breeding pairs.
- **Auckland Island Banded Dotterel:** Threatened – Naturally endangered. The population is estimated at 50,000 individuals and is thought to be declining.

[5] **Department of Conservation, (2009, 2012, 2013, 2017)**

- **Auckland Island Rail:** At Risk- Naturally Uncommon. The population is estimated at around 1500 on the Auckland Islands.
- **Burrowing Petrel**: At Risk – Naturally Uncommon. The population is estimated at 53,000 breeding pairs.
- **Sooty Shearwater:** At Risk – Declining. There are no accurate estimates of the total New Zealand population. However, recent data estimate the population at about 21 million birds.

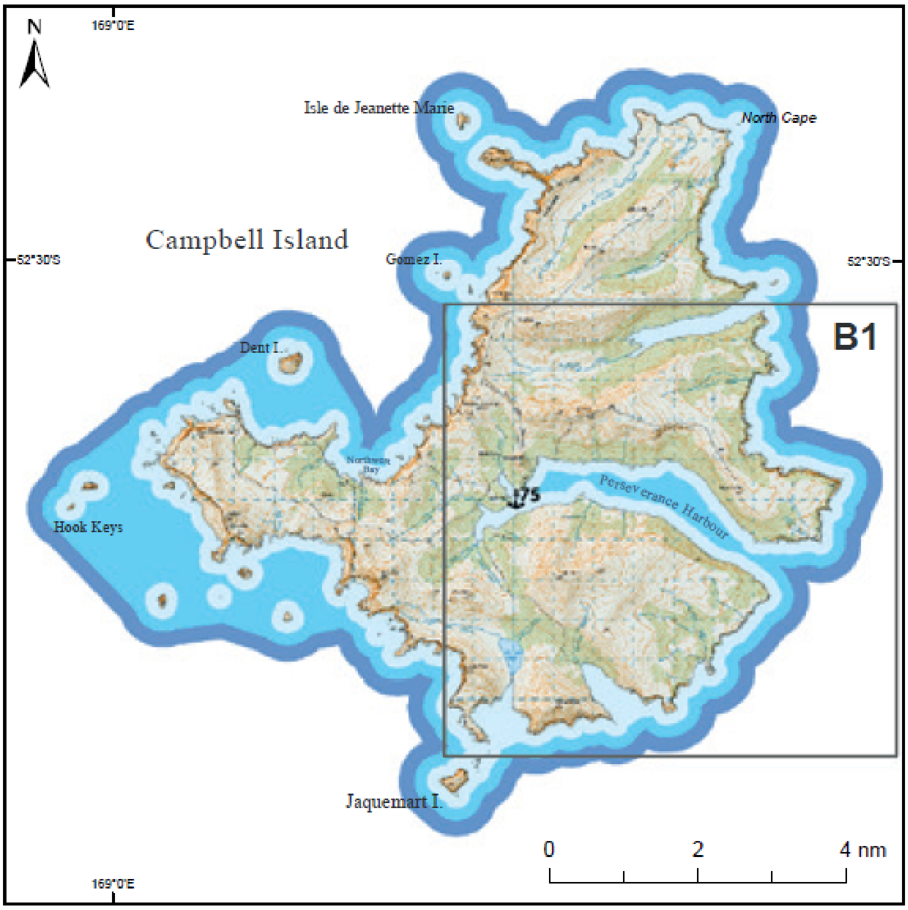
2.2 CAMPBELL ISLANDS

The Campbell Islands are the most southern group of the Sub-Antarctic Islands, lying around 700 km south of the South Island. The main island is Campbell Island and is surrounded by a series of steep, rugged Islands and rocks, in particular Dent Island, Folly Island, Isle de Jeanette Marie and Jacquemart Island (**Figure 7**). The main island is some 4400 Ha in area, lies in latitude 52° 30' S and longitude 169° 8' E and is some 150 nm ESE of the Auckland group.

High and rugged in the south (up to 570m), it slopes off more gently to the north with smoothed ridges and open valleys are reported to be the result of recent glaciation. The east coast is broken by the two long, narrow, sheltered inlets of Perseverance and North-east Harbours. There are three harbours overall - North East Harbour; South East Harbour and North West Bay.

The island was discovered in 1810 by F. Hasselburgh, Master of the sealing ship *Perseverance*, owned by the Sydney firm of Campbell and Co. The climate of Campbell Island is similar to that of the Auckland group; though a little colder, it has less cloud and more sunshine.

The Campbell Islands are known as the ‘home of the albatross’, with six species, including the world’s largest.



Distance to MHWS (metres & nautical miles)	Vessel Class (metres)			
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Up to 300 m (0.162 nm)	Permitted	Discretionary	Discretionary	Prohibited
300 m to 600 m (0.162 nm - 0.324 nm)	Permitted	Permitted	Permitted	Prohibited
600 m to 1000m (0.324 nm - 0.540 nm)	Permitted	Permitted	Permitted	Discretionary
Excess of 1000m (0.540 nm)	Permitted	Permitted	Permitted	Permitted

NOT TO BE USED FOR NAVIGATIONAL PURPOSES *MHWS: Mean High Water Springs

Figure 7: The Campbell Islands

2.2.1 SPECIES OF NOTE IN THE CAMPBELL ISLANDS

The species endemic to the Campbell Islands that are of note and threatened are as follows[6] :-

- **New Zealand Sea Lion -**Threatened - Nationally Critical. The population is currently estimated at around 12,000 individuals. The New Zealand Sea Lion is the most threatened species of Sea Lion in the World.
- **Southern Right Whales** – Threatened - Nationally Vulnerable. The population is currently estimated at around 10,000 individuals. While their principal breeding grounds are found off of Auckland Island, they are also known to breed in Northwest Bay off of Campbell Island.
- **Rock Hopper Penguin:** Threatened, Nationally Vulnerable. The Rock Hopper Penguin population found amongst the Campbell Islands is 10 times the size of the populations

[6] **Department of Conservation, (2009, 2012, 2013, 2017)**

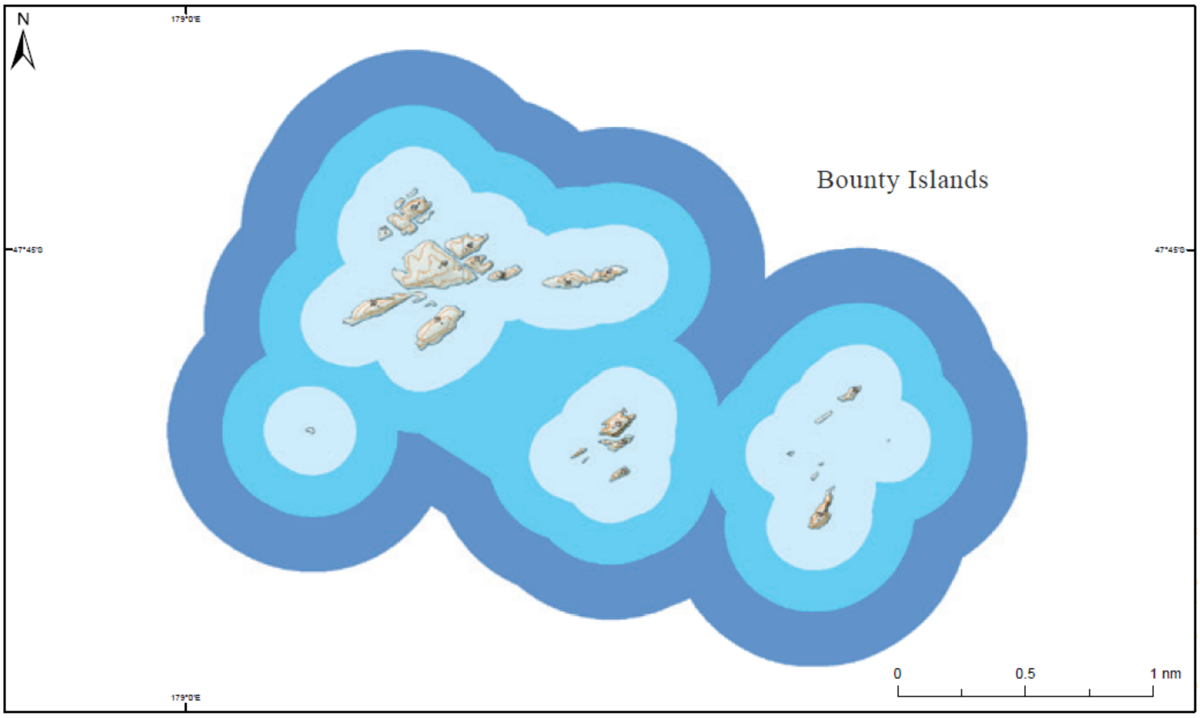
found at the Auckland/Antipodes Islands, although it suffered a major population crash during 1942-2012 from 800,000 to a now estimated 33,200 breeding pairs.

- **Yellow-eyed Penguin**: Threatened - Nationally Endangered. Around 1000 breeding pairs are estimated to be living amongst Auckland and Campbell islands.
- **Campbell Albatross**: Threatened - Nationally Vulnerable. Endemic to Campbell Islands. The current population is estimated at around 21,000 breeding pairs.
- **Light Mantled Sooty Albatross:** At Risk - Declining. Approximately 1600 pairs breed on the Campbell Islands.
- **Southern Royal Albatross:** At Risk - Naturally Uncommon. The world's largest Albatross, around 99% Endemic to Campbell Island (small population $\leq$100 on Auckland Islands). The current population is estimated at around 8500 breeding pairs.
- **Campbell Island Shag**: At Risk - Naturally Uncommon. Endemic to the Campbell Islands. The current population is estimated at around 8000 individuals, though this is thought to have increased since the last survey.
- **Campbell Island Snipe:** Threatened - Nationally Critical. Endemic to the Campbell Islands. Population estimates vary, though is thought to be critically low.
- **Campbell Island Teal**: Threatened - Nationally Vulnerable. Endemic to the Campbell Islands. The current population is estimated at around 100 adults.
- **Burrowing Petrel**: At Risk – Naturally Uncommon. The population is estimated at < 100 breeding pairs on Campbell Island.
- **Sooty Shearwater:** At Risk – Declining. There are no accurate estimates of the total New Zealand population. However, recent data estimate the population was about 21 million birds.

2.3 BOUNTY ISLANDS

The Bounty Islands are approximately 640 km off the Southeast of the South Island, New Zealand. This archipelago consists of three main Island groups being the Main, Centre and East groups (**Figure 8**). The Islands have a total land mass of 135 ha with Depot Island the largest at approximately 800m in length and 88m at the highest point. There is no safe anchorage or easy landing sites within the Bounty Islands.

There is virtually no vegetation above the high tide mark on the Bounty Islands, due to them being so steep that nutrients provided via guano wash down into the water. Soil development of any kind on the islands is nonexistent. Despite these factors, they are an important breeding ground for seabirds, which use sea weed and penguin feathers for nest building rather than traditional vegetation. The nearshore terrestrial environment of the islands receives a significant level of marine-derived nutrients, and hence is heavily dependent on the health of surrounding waters.



Distance to MHWS (metres & nautical miles)	Vessel Class (metres)			
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Up to 300 m (0.162 nm)	Permitted	Discretionary	Discretionary	Prohibited
300 m to 600 m (0.162 nm - 0.324 nm)	Permitted	Permitted	Permitted	Prohibited
600 m to 1000m (0.324 nm - 0.540 nm)	Permitted	Permitted	Permitted	Discretionary
Excess of 1000m (0.540 nm)	Permitted	Permitted	Permitted	Permitted

NOT TO BE USED FOR NAVIGATIONAL PURPOSES *MHWS: Mean High Water Springs

The Master of any vessel entering any of the waters of the Subantarctic Islands needs to be aware of the risks – such as age and nature of hydrographic survey data (potential for uncharted hazards) coupled with the effect of strong winds - and be mindful that rapid and severe changes in weather conditions can occur.

Figure 8: The Bounty Islands

2.3.1 Species of Note in Bounty Islands

The species endemic to the Bounty Islands that are of note and threatened are as follows[7] :-

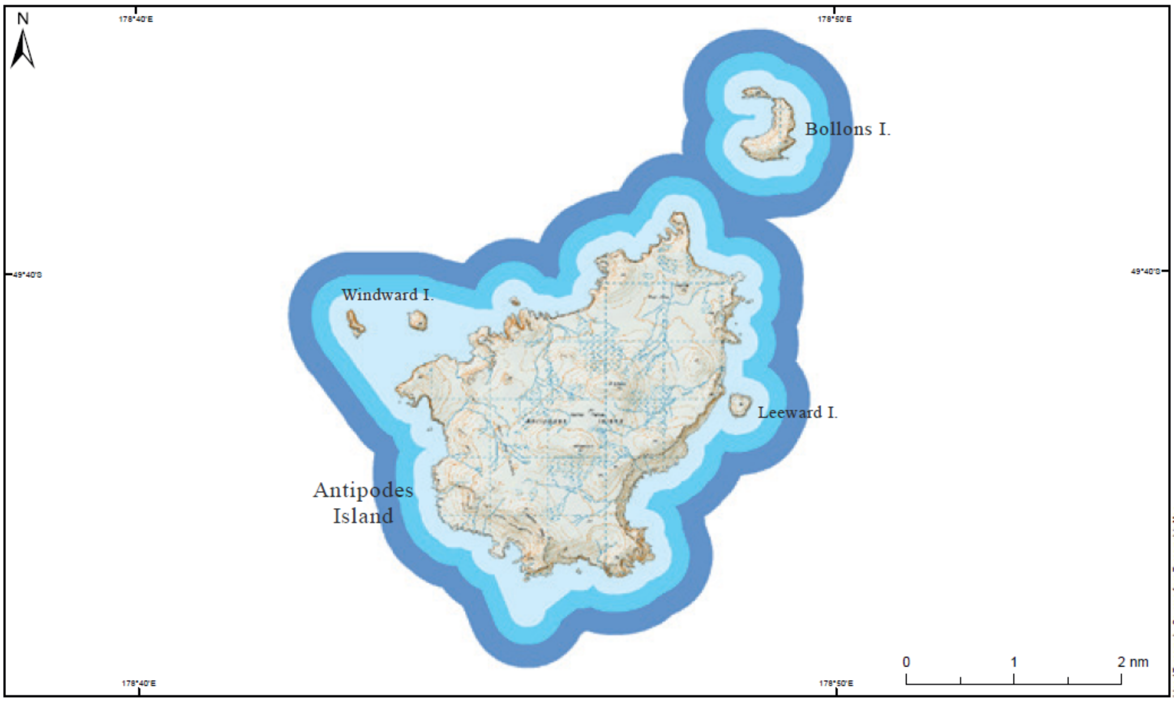
- **Erect-crested Penguin**: At Risk –Declining. Endemic to the Bounty and Antipodes Islands. The current population is estimated at 26,000 breeding pairs on the Bounty Islands, compared to 42,500 breeding pairs on the Antipodes Islands (total of 68,500 breeding pairs).
- **Bounty Island shag:** At Risk - Naturally Uncommon. Endemic to the Bounty Islands. The current population is estimated at < 1000 adults.
- **Salvin's Mollymawk:** Threatened – Nationally Critical. Breeds on the Bounty and Snares Islands. The current population is estimated at 41,000 breeding pairs on the Bounty Islands.
- **Fulmar Prion:** At Risk – Naturally Uncommon. The current population is estimated at 30,000 breeding pairs on the Bounty Islands.

[7] **Department of Conservation, (2009, 2012, 2013, 2017)**

2.4 THE ANTIPODES ISLANDS

The Antipodes Islands are the most remote of New Zealand's Sub-Antarctic Islands and around 750km southeast of the South Island. The Antipodes Island group consist of the main 'Antipodes Island', Bollons Island and several smaller Islands and rocks (**Figure 9**). The main Antipodes Island is around 2000 ha, and is relatively low lying, such that they afford little shelter from adverse weather conditions to vessels lying off their coastlines.

The Antipodes Islands are covered in an endemic tussock grass that relies on nutrients deposited by the guano of local seabirds. The Islands have been recognised as the principal breeding grounds for several seabirds, two of which are endemic to the Islands.



Distance to MHWS (metres & nautical miles)	Vessel Class (metres): Ancillary Craft	Up to 30 m	Between 30 - 125 m	Large (> 125 m)
Up to 300 m (0.162 nm)	Permitted	Discretionary	Discretionary	Prohibited
300 m to 600 m (0.162 nm - 0.324 nm)	Permitted	Permitted	Permitted	Prohibited
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Excess of 1000m (0.540 nm)	Permitted	Permitted	Permitted	Permitted

NOT TO BE USED FOR NAVIGATIONAL PURPOSES

*MHWS: Mean High Water Springs

The Master of any vessel entering any of the waters of the Subantarctic Islands needs to be aware of the risks – such as age and nature of hydrographic survey data (potential for uncharted hazards) coupled with the effect of strong winds - and be mindful that rapid and severe changes in weather conditions can occur.

Figure 9: The Antipodes Islands

2.4.1 SPECIES OF NOTE IN THE ANTIPODES ISLANDS

The species endemic to the Campbell Islands that are of note and threatened are as follows[8] :-

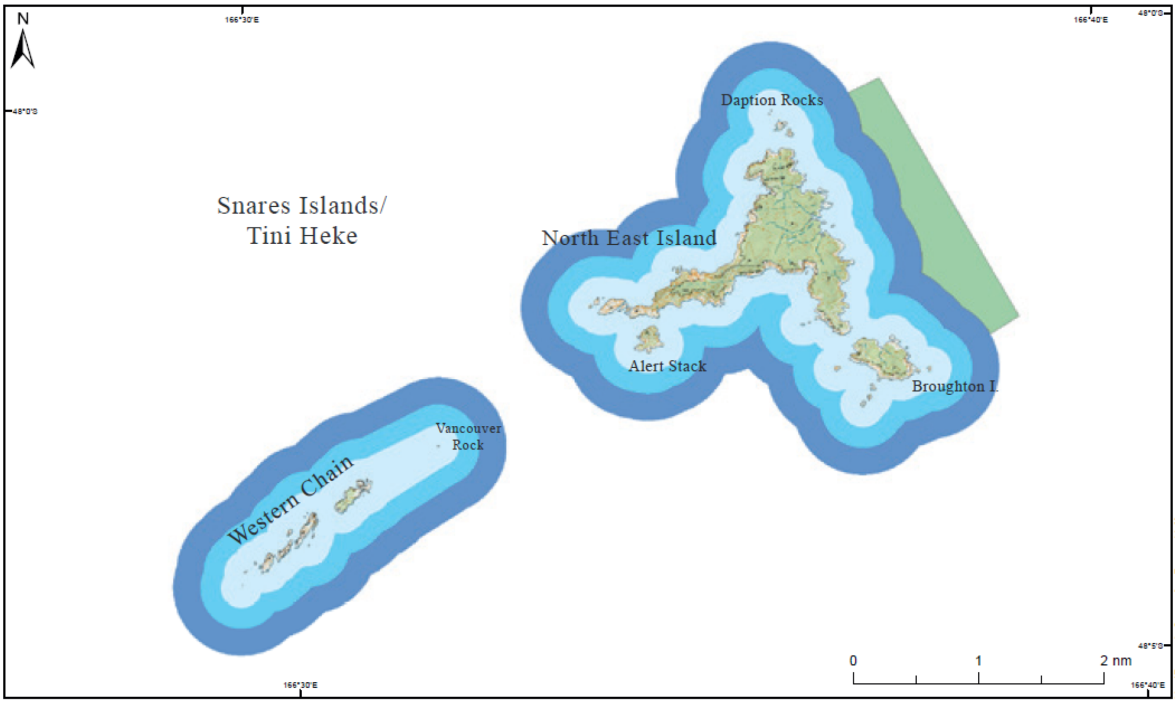
- **Southern Elephant Seal**: Threatened – Nationally Critical. The current population is estimated at < 250 mature individuals on the Antipodes Islands – though the population outside of New Zealand waters is thought to be secure.

[8] **Department of Conservation, (2009, 2012, 2013, 2017)**

- **Erect-crested Penguin**: At Risk –Declining. Endemic to the Antipodes and Bounty Islands. The current population is estimated at 42,500 breeding pairs on the Antipodes Islands, compared to 26,000 breeding pairs on the Bounty Islands (total of 68,500 breeding pairs).
- **Rock Hopper Penguin:** Threatened, Nationally Vulnerable. The population amongst the Antipodes Islands is estimated at less than 3000 breeding pairs, comparable to that at the Auckland Islands and roughly 1/10 the population size estimated amongst the Campbell Islands.
- **Antipodean Albatross:** Threatened - Nationally Critical. The population is currently estimated at 3700 breeding pairs amongst the Antipodes Islands.
- **Light Mantled Sooty Albatross:** At Risk - Declining. Approximately 250 pairs breed on the Antipodes Islands.
- **White-Capped Mollymawk**: At Risk – Declining. The main breeding population can be found on the Auckland Islands 75,000-117,000 breeding pairs), although it is estimated that 20 pairs breed on Bollons Island amongst the Antipodes Island group.
- **Antipodes Island Snipe:** At Risk – Naturally Uncommon. Endemic to the Antipodes Islands. The population is currently estimated at around 8000 individuals.
- **Burrowing Petrel**: At Risk – Naturally Uncommon. The largest population of Burrowing Petrels can be found on Antipodes Island and is estimated at 53,000 breeding pairs.
- **Northern Giant Petrel:** At Risk – Recovering. The population is currently estimated at 230 pairs on the Antipodes Islands.

2.5 SNARES ISLANDS

The Snares lie approximately 200 km off the South Island of New Zealand. The Snares Islands are broken up into two distinct Island groups; the Western Chain, and North East Islands (**Figure 10**). The Islands cover an estimated total area of 340 Ha. The highest point is 130 metres above sea level and is low lying in comparison with the larger Sub-Antarctic Islands. There are no landing areas on the Island, meaning viewing of native birds is only possible by small craft. An exemption zone for cruise ships using any fuel type can be found on the eastern side of North East Island to allow for cruise ships to engage in penguin watching from aboard the ship. The Snares Islands are often noted for being home to over 5 million breeding pairs of seabirds. However, the Snares are the only Island group without a marine reserve.



Distance to MHWS (metres & nautical miles)	Vessel Class (metres)			
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Up to 300 m (0.162 nm)	Permitted	Discretionary	Discretionary	Prohibited
300 m to 600 m (0.162 nm - 0.324 nm)	Permitted	Permitted	Permitted	Prohibited
600 m to 1000m (0.324 nm - 0.540 nm)	Permitted	Permitted	Permitted	Discretionary
Excess of 1000m (0.540 nm)	Permitted	Permitted	Permitted	Permitted

NOT TO BE USED FOR NAVIGATIONAL PURPOSES *MHWS: Mean High Water Springs

Snares Islands Discretionary Exemption Zone

Vessels may be granted consent to access this zone while using heavy fuel oil - see rules 33 and 35

The Master of any vessel entering any of the waters of the Subantarctic Islands needs to be aware of the risks – such as age and nature of hydrographic survey data (potential for uncharted hazards) coupled with the effect of strong winds - and be mindful that rapid and severe changes in weather conditions can occur.

Figure 10: The Snares Islands.

2.5.1 SPECIES OF NOTE IN SNARES ISLANDS

The species endemic to the Snares Islands that are of note and threatened are as follows[9] :-

- **Snares crested penguin:** At Risk – Naturally Uncommon. Endemic to the Snares Islands. The population is currently estimated at around 25,000 breeding pairs.
- **Buller's Mollymawk:** At Risk – Naturally Uncommon. Around 9000 breeding pairs can be found on the Snares Islands, with 4500 breeding pairs also found on the Solander Islands near Fiordland.
- **Salvin's Mollymawk:** Threatened – Nationally Critical. Breeds on the Snares and Bounty Islands. The current population is estimated at 1,200 breeding pairs on the Western Chain of the Snares Islands.
- **Snares Island Snipe:** At Risk – Naturally Uncommon. Endemic to the Snares Islands. The population is currently estimated at around 400 breeding pairs.

[9] **Department of Conservation, (2009, 2012, 2013, 2017)**

2.6 PEST ERADICATION

The remote nature of the Sub-Antarctic Islands has allowed for some of the most highly sensitive, endemic species on earth. As a result, pest control is paramount to preserving the unique flora and fauna that persist within the Islands. Most notably, the 'million-dollar mouse' project aimed at eradicating mice from the Antipodes Islands. The first published reference to the mice on Antipodes was in 1899 and was thought to have been induced from a ship wreck. The highly successful project began in 2016 where the New Zealand public raised $250,000, WWF gave $100,000, the Morgan Foundation matched their donations with the rest of the cost funded by DOC. The project successfully eradicating the mouse population in 2018.

Other projects within the Sub-Antarctic's have also resulted in the successful eradication of rabbits and mice in the Auckland Island group from both Enderby and Rose Islands in 1993, the eradication of goats from the main Auckland Island by 1992 and the eradication of rats from Campbell Island in 2001.

The expenditure on pest eradication within the Sub-Antarctic's is particularly significant and could be used for a charting benefit assessment using the output of this hydrographic risk assessment.

3 DATA GATHERING

3.1 DATA COLLECTION - INTRODUCTION

Data gathering meetings were held with the Department of Conservation (DOC) and with Cruise New Zealand. For consultation DOC was met with at their Wellington Headquarters, for input into the risk matrix criteria and then at their Invercargill Office, where the co-ordination of visits to the Sub-Antarctic Islands are managed and visitor number records are held. DOC further provided information about the nature of the wildlife colonies that exist on these islands, ultimately providing the key information that allowed risk criteria to be developed around the ecology and diversity of the island groups.

Cruise New Zealand were met with in Auckland, where the ongoing wish for cruise operations to expand in the Sub-Antarctic Islands was tabled. The cruise-market view of the ability for large cruise vessels to take advantage of the Great Circle Route (Summer) from Australian ports and allow an offshore call to the Snares, followed by the Chatham's was referenced. Overall viewpoints of the cruise industry towards cruising into the Sub-Antarctic Islands, as represented by Cruise New Zealand were also covered.

A significant interface with the DOC headquarters office in Wellington also occurred, especially for the development of the risk criteria, which are unique to this risk assessment. DOC were especially helpful in the development of methodology that led Marico to link the NZ threat classification system to identify areas of increasing coastal vulnerability, that was used in the risk matrix (**Annex A**). The help provided by DOC personnel over the nature of endangered colonies by island location, was if significant importance to this risk assessment result.

Details of contacts made for consultations can be found at **Annex B.**

3.2 AUTOMATIC IDENTIFICATION SYSTEM (AIS) AND VMS DATA

The project used both AIS data and VMS data. The AIS data was sourced from the exactEarth© satellite constellation, in polar orbit. In this location, significantly to the south of New Zealand, there is no terrestrial reception of AIS (T-AIS). S-AIS data was recorded at intervals whenever a satellite passes over the study area. The positional accuracy depends on the time taken from reception by satellite, to the time when the data is downloaded to a ground station. It is thus not as accurate as T-AIS data. The time period for the S-AIS updates in the Sub-Antarctic Islands region was around 2-3 hours, resulting in occasionally intermittent data records. However, this is a significant improvement on data periods in relation to other hydrographic risk work undertaken by Marico Marine in the SW Pacific.

To overcome this limitation and provide greater accuracy, processing was undertaken by Marico to decode, clean and post-process the raw AIS data. Post-processed vessel tracks were enhanced with port visit records where available from records provide by DOC and Cruise New Zealand Schedules.

Six months' worth of vessel tracks were initially developed using S-AIS for the summer period October 2016 – March 2017, thus being representative of the parts of the year when vessel activity in the Sub-Antarctic Islands is at its highest. Marico Marine elected to augment this with a further 6 months of S-AIS data (taking an analysis-only licence), to provide a record for a full year (June 2016-July 2017); this assisted with vessel records which occasionally transit through the area, either cruising earlier/later in the season or cargo vessels taking a great circle route South of New Zealand. There was also the possibility of some research vessels transiting south to Antarctica to arrive in those waters for summer research activities. Typical AIS data includes vessel name, details, location, speed and heading. Each vessel was modelled in the risk assessment by its type, size, passenger carriage and fuel carriage.

AIS vessel tracks do not represent all of the non-SOLAS vessels. These are not required to carry AIS. Typically, these comprise of smaller coastal vessels; smaller fishing vessels; tugs, barges and other workboats and recreational vessels. An increasing number of these are fitted with AIS, either voluntarily or due to company recognition of the collision avoidance advantages of AIS. Consequently, for the fishing vessel record, Vessel Monitoring System (VMS) data has been obtained from the Ministry of Primary Industries (MPI) for fishing vessels active in the region that do not necessarily carry AIS transmitters. A hybrid dataset was created which spliced together the large AIS dataset with the VMS data.

3.2.1 LIMITATIONS OF AIS DATA

The positional accuracy of AIS data as received can be within 10m of the vessel's position, depending on the GPS accuracy of the vessel and it's equipment. However, AIS data does not have a time record in full in the transmission as it was designed for vessels to be able to identify each other in a seaway and not for remote monitoring. When AIS data is collected by satellites, the time recorded is added only when the data has been downloaded from a satellite. As the time from data being received and downloaded can vary between satellite orbits, that data when plotted by time has inherent inaccuracies. Although the vessel passed through a point, the time at which it did so is not certain.

In remote areas such as the Sub-Antarctic Islands, polar satellites pass over the area relatively infrequently in comparison to other areas nearer the equator. The AIS data can also only be received when a satellite is passing, so the data recorded is sporadic, such that the vessel track lines often need to be corrected, based on marine assessment of a coastal transit. There are also some data records which suffer from transmission corruption.

For every hydrographic risk assessment, the track has been manually manipulated to correct for any errors due to transmission gaps (i.e. re-routeing through channels). This is done on the basis that a vessel is known to have transited a channel and improves the reliability of the risk results

The AIS information transmitted by a ship is of three different types:

- Fixed, or static information, which is entered into the AIS transponder on installation and need only be changed if the ship changes its name or undergoes a major conversion from one ship type to another;
- Dynamic information, which, apart from 'navigational status' information, is automatically updated from the ship sensors connected to AIS; and
- Voyage-related information, which might need to be manually entered and updated during the voyage.

Examples of manually input data, entered at start of the voyage and whenever changes occur, include:

- Ship's draught;
- hazardous cargo;
- destination and ETA;
- route plan (way-points);
- the correct navigational status; and
- safety related short messages.

Integrity of data that must be input by the vessel's operator is consequently not assured. The limitation of this part of the AIS data is thus related to the correctness of the manually input figures.

Automatic inputs, for example gyro heading input, may also be subject to errors or limitations. Poorly configured or calibrated ship sensors (position, speed and heading sensors) may lead to incorrect AIS information being transmitted.

In addition, some specified vessel types (e.g. warships, naval auxiliaries and ships owned/operated by governments) are not required to be fitted with AIS. The carriage requirements affect all vessels over 300 tons operating under the SOLAS convention that need to comply with radio regulations, as well as all passenger vessels.

Other inherent limitations of AIS data include the fact that leisure craft and small fishing boats, are also exempt from mandatory carriage of AIS transponders, although a growing number do. Even if some of these exempt vessels choose to carry AIS, accurate transmission of data may still be limited by the availability and suitability of vessel instrumentation – the AIS device is, after all, a transponder. Smaller vessels (including recreational) chose to fit Class B transponders, which transmit at low power (0.75w as opposed to 12w). Class B devices are designed for a small craft to be received locally by a larger vessel, thus assisting with detection, identification and collision avoidance. Class B transponders can be difficult to receive reliably by satellite, although exactEarth S-AIS data has been found in the past to deliver a good result from a data sampling exercise. This is provided that there are not a high volume of other more powerful AIS frequency transmitters in the adjacent sea areas

Furthermore, some vessels, fitted with AIS as a mandatory carriage requirement, may disable AIS under certain circumstances by professional judgement of the master (ISPS security concerns for example provide a reason). This commonly occurs for example with fishing vessels who are reluctant for other fishers to know where they are fishing at any given time.

Additional errors may be induced by the incompatibility or lack of integration with other electronic systems. Transmission errors may also occur if the transponder coverage is incomplete. Shipboard AIS transponders have a horizontal range that is highly variable but typically only about 74 km. They reach much further vertically, up to the 400 km orbit of the International Space Station (ISS).

Examples of raw AIS data that required post processing by Marico included:

- Missing or incorrect data - blank/unknown
- Wrong vessel name
- Wrong vessel type
- Inaccurate AIS time stamps
- Missing records

3.3 VESSEL USAGE RESEARCH : DOC, FISHING, IAATA AND CRUISE NEW ZEALAND

3.3.1 INTRODUCTION

This section records the findings of data research about the Islands -See **Section 4** for a traffic type breakdown of vessel tracks. The cruise industry provides the largest demand for people to visit the Sub-Antarctic Islands. Fishing operations provide by far the highest representation of traffic. However, unless seeking shelter, fishing operations remain well offshore to each of the Islands, with Campbell and Auckland providing the best shelter.

Cruise vessels mostly commence their visits in mid-November, but there are visits as late as mid-March in a season. The latter is always a vessel returning from Antarctica, which may have left early due to a safe-visitor season closing. It is uncommon for a vessel providing Antarctic tours to include Sub-Antarctic Island landings, but it does occur. Vessels visiting the NZ sector of the Sub-Antarctic Islands will generally also visit Macquarie Island in the Australian sector.

3.3.2 OVERVIEW OF THE CRUISE INDUSTRY

The remote and unique nature of the Sub-Antarctic Islands is particularly attractive to the tourism industry, but only to a specific and specialist sector; the Expedition Cruising market. This generally means smaller cruise vessels and operations which historically have been difficult vessel sizes for a cruise operation to deliver healthy returns for future expansion. However, this appears to be a sector of the market that is growing strongly in 2017-8, with a passenger following that seeks out destinations that are interesting to those who wish to learn more about the areas of the earth and associated wildlife and ecology that are off the "beaten track". These areas are very well represented by the Sub-Antarctic Islands and every consultee referenced the ongoing expansion and interest there is for a planned increase in passenger visits to these important islands. The main driver of such tourism to the Sub-Antarctic Islands is the global significance in the Islands biodiversity, their unspoilt remoteness, and the history they represent. There are, for example, colonies of endangered species (e.g. Yellow Eyed Penguins) which are genetically isolated, but may provide a pool of genetic resources to maintain populations elsewhere. Interest in these subjects has been growing rapidly as the present threats to the Earth's resources have begun to be understood. In short, the areas subject to this hydrographic risk assessment have significant drivers for an increase in vessel transits through the waters.

3.3.3 PRESENT CRUISE OPERATORS VISITING THE SUB-ANTARCTIC ISLANDS

There are five main cruise expeditions that currently operate to the Sub-Antarctic Islands. These are Carnival, Heritage Expeditions, Ponant Expeditions, Oceanwide Expeditions and Hapag-Lloyd. Heritage Expeditions are the dominant operator and presently use two vessels; one a passenger vessel with the capacity for 50 passengers and the other a 71 m research vessel allowing for quasi scientific cruise experience. Ponant's cruise vessel (L'Austral) has the capacity for 200 passengers, at a length of 142 m. Other vessels provide cruise expeditions that range to 100 m length with a capacity between 100 and 150 passengers.

3.3.4 DOC LICENCING

The Sub-Antarctic Islands are part of the New Zealand World Heritage Sites and are a nature reserve under the Reserves Act of 1977. Any vessel wishing to visit the limits of the Sub-Antarctic islands require a permit from DOC to land passengers on an Island. The only Islands presently suitable and licenced for passenger visitor landing in any volume are Campbell and Auckland Islands. Even then, landing is in set areas with limits on the number of people allowed at any one time. This is all laid out in the conditions of a DOC permit, which provide a limit on total access to the islands in any one year. Some permits allow landing to a location by a specific vessel only, on the basis of the history of knowledge and expertise of the islands possessed by the operators of such vessels.

3.3.4.1 LIMITS OF VESSEL SIZE

There is presently a size limit of 125 metres in length for a cruise vessel wishing to land passengers on the islands. This is a small vessel size and is suitable for organisations undertaking specialist or researcher type cruise operations, such as are supplied by Heritage Line – the largest operator visiting these islands regularly.

Cruise New Zealand advise that there is a growing demand for eco-tourism and are aware of the expansion plans of some of their member lines. The current projection is for vessel passenger capacity to continue to grow with an average around 100 m to 150 m for this type of cruising. In 2018, there are three additional cruise companies applying for permits - Lindblad, Arora Expeditions and Noble Caledonia.

It should be noted that the expedition type of cruise vessel that wishes to visit the Sub-Antarctic islands is today of average length of 150 metres. This is slightly larger than the 125 metre length limit of DOC (set in 2013). There is one vessel being built that is 165m and one of 180m. An increase in the DOC limit by 25 metres of length would improve sea keeping in the stormy waters of the Sub-Antarctic Islands. An increase of this limit would be unlikely to affect the utility of the DOC permit system for passenger landing, which limits the number of people per day in any event.

As time progresses, there will be pressure on the present DOC limits by length and an increase to 150 metres in length could be considered whist still limiting the number of visitors landing at any one time or location.

3.3.5 Visitor Landing by Island

In terms of visitor numbers to Islands, DOC guidelines for visitor numbers per island and per location form part of any permit to operate in these waters. The summary below provides a present upper limit based on the DOC criteria.

- The Snares – No Landing but 2 Hour Visits for Observing Colonies from offshore;
- Antipodes – No landing, but “Zodiac” trips around the Islands;
- Auckland Island – 400 people landing maximum per year, 200 per day;
- Enderby Island – 1100 people landing maximum per year, 200 per day;
- Campbell Island – 1100 people landing maximum per year, 200 per day.

Table 5 uses the limits of the DOC permit system to show where vessels can land passengers, by island and landing location (note Auckland Islands **Figure 11**, Terror Cove is a location where there are many landing sites and the DOC limits are location specific).

Island Group	Visitor Site	max visitors per day	Guideline Max Visitors per year
Auckland Island	Hardwicke	200	400
	Camp Cove	50	150
	Erlangen Clearing	50	150
	Epigwaitt	50	150
	Lake Hinemoa	50	150
	Ranui	50	150
	South West Cape	50	150
	Tagua	50	150
	Hill 360 Route	50	50
Enderby Island	Northern Cliffs	200	1100
	Circuit	50	600
Campbell Island	Coi-Lyall/Beeman Base	200	1100
	Col Lyall Albatross	50	300
	Mount Honey	50	150
	Northwest Bay Loop	50	150
	Perseverance Shoreline	50	150
	Penguin Bay	50	60

Table 5: Locations for Landing and Visitor Limits within Sub Antarctic Visitor Sites

Each cruise visit provides the number of passengers planned to be landed at each site, on which permit records are based. However, the permitted number of visitors may not reflect the actual numbers who make the trip. Cruise interests suggest that up to 50% of the time adverse weather conditions dramatically affect the number of visitors who may land on an island, such that a permit for 50, may end up with visitors in single numbers on the day. However, this still means that a vessel makes the visit.

Each Island group has one or more designated “refuge islands”, where no-one can land or observe close inshore. The designated refuge islands provide a reserve of critically endangered colonies (often different colonies exist on each refuge island). Vessels do though pass these islands when transiting to landing locations, so they are relevant to the risk assessment. Although the accuracy of S-AIS has some limitations in this respect as it relies on the accuracy of the onboard GPS systems as well as the position of overhead satellites, this has been confirmed from the track database used for the study.

3.4 AUCKLAND, ENDERBURY AND CAMPBELL LANDING SITES

Figure 11: Auckland Island Landing Sites (Stewart et.al, 2013)

According to the most recent DOC Conservation Management Strategy (2016) there are nine visitor locations and/or tracks referenced on Auckland Island, the most among the three visitor-accessible islands. These are shown in **Figure 11**. It is understood that Hardwicke and the Terror Cove visitor area are the most visited sites in the Auckland Islands. These lie on the Northern tip of Auckland Island. Port Ross and even Laurie Harbour are important from the charting perspective. A cruise vessel either drifting or anchored in the Port Ross area can readily land passengers to these areas by RHIB. Both Port Ross and Laurie have relatively recent surveys.

Enderby Island, also to the north of Auckland Island, is reported to be equally popular with visitors (**Figure 12**). Like Auckland and Campbell, DOC has installed a boardwalk across the Island which allows passengers to be dropped off in Sandy Bay and cross by foot to the Northern Cliffs. A track allows the full circuit of Enderby to be completed, but the number of visitors who actually complete this is unclear. The Invercargill office of DOC suggested that with close monitoring the possibility of permitted visitor increase would be accommodated on the basis that actual numbers visiting are generally lower.

Figure 12: Enderby Island Landing Sites (Stewart et.al, 2013)

Campbell Island is almost cut in half by Perseverance Inlet, which forms a natural harbour facilitating landing access. There are a number of boardwalk routes that visitors can take, with the Albatross viewing area attracting the most visitors. The routes are shown in Figure 13. A representative of Heritage Line expressed interest in the possibility of landing on the West Coast of Campbell inside Dent Island, with Northwest bay being a likely candidate. This would increase visitor access to Penguin Bay and the Northwest Bay Circuit.

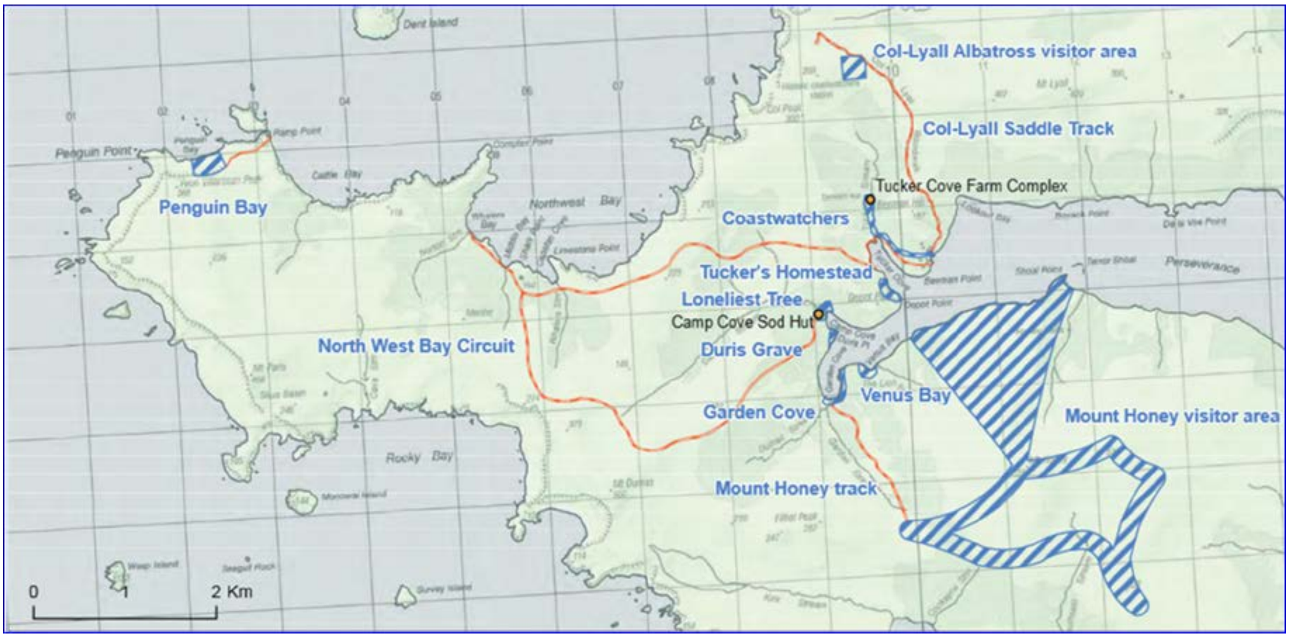


Figure 13: Landing Sites at Campbell Island (Stewart et.al, 2013)

3.4.1.1 SNARES ISLAND CRUISE

The accessibility of Snares Island, being approximately 200 km off the South Island of New Zealand allows cruise vessels to venture beyond New Zealand for just an extra day. This allows for cruise companies to provide a unique addition to their cruise programme and as a result, the Snares Island has the highest concentration of cruise vessels within the Sub-Antarctic Islands.

The Snares present no ability for a large cruise vessel to land passengers, but a planned arrival for an evening observation offshore to the islands is popular. Dawn and dusk are when the residents are most active and thus interesting to visitors. An evening visit also allows a cruise vessel to arrive into the Chatham's the following morning to witness the dawn chorus at another island location.

3.4.2 PASSENGER STATISTICS – GROWTH DEMAND

DOC maintain records of the number of passengers and crews as well as researchers / DOC personnel visiting the islands. Data suggests that expeditions to the Sub-Antarctic Islands have remained fairly consistent since the 1980's. Despite the last 13 years showing a stable trend, the data suggest there is a spike in demand for such cruises every three to four years. This is shown in **Figure 14**.

There is some variation between the various sources of data for passenger volumes that were reviewed during data gathering. Some visitor numbers appear to be based on the capacity of passenger vessels visiting and not necessarily representative of the actual number of passenger visits. IAATO provided a comprehensive data set to the project, which mostly recorded Antarctica locations, but some Sub-Antarctic visits were included. However, DOC was found to provide the best available records on the number of people landing ashore at each authorised location. This may be the key difference between records from IAATO and DOC. The number of people on board a cruise vessel visiting an island and the number of people landing on an island are likely to be different. However, as the DOC record provided a record through the whole passenger season, it was taken by the project as a starting basis for the risk analysis. DOC provides an observer on every passenger vessel visiting the Sub-Antarctic, so such numbers can also be substantiated. The experience of DOC observers is of direct relevance to the project feedback that visitor volumes are set to increase and it is this feedback that has been used when the important question of future growth demand is considered.

Data gathering consultation confirmed that both DOC and the cruise industry agree that there is future growth in passenger numbers visiting on cruise vessels. This is because both interest from the cruise lines is reported to have increased as well as future bookings. **Figure 14** shows the DOC records of passengers **landed** on islands, which can be misleading, as the number of passengers who land does not take account of passenger volume on vessels that visit Islands where landing is not permitted. Nor does it take account of the numbers on cruise vessels visiting the islands.

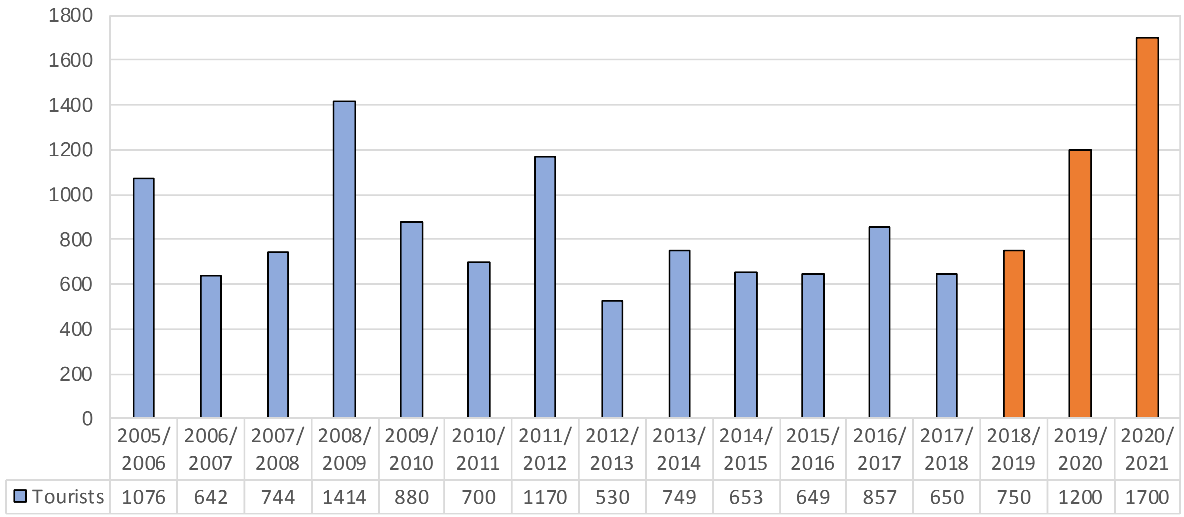


Figure 14: Numbers Landing on Islands as Recorded by DOC Records

As the risk assessment was undertaken, the passenger capacity of the cruise vessels involved was used, with these records providing an upper bound of numbers for safety criteria. The DOC record was thus used to represent vessels visiting the Islands that do not have AIS fitted, as such visits do occur. There was only one vessel where the capacity could not be determined, and the average of 130 people was used for the risk calculations in that case.

There are a very small number of applications to visit from private yachts in the 10-15 metre length range. It can take up to three years to obtain permission from DOC. However, it seems mostly to be the case that yachts cleared to visit ultimately elect to abort their plans, which is thought to be due to weather and sea conditions that prevail in the area. There were no such visits in the 2017 summer period.

3.5 INCIDENT RECORDS

There are some records of vessel incidents in the Sub-Antarctic waters. However, apart from reported wrecks of sailing vessels at Auckland Island (great circle route) these are mostly related to fishing operations. There have been total losses in deep water for large fishing vessels losing stability during fishing operations or by swamping and sinking. There are also some anecdotal DOC reports of degraded oil deposits reaching one of the Islands. None of these are related to hydrography.

There has however been one recent record of a touch-bottom-grounding in the Snares, in an area where charting had been improved - there was a ZOC rating of B in the general location. The location of grounding is shown in **Figure 15**. It emphasises the difficulty of hydrography in areas of rugged seabed topography where isolated pinnacles dangerous to surface navigation may occur in otherwise deep water. It also provides evidence of the need for vessel operators to stick to the letter of the DOC permits to operate, as these focus vessels through waters that have been proven as safe.

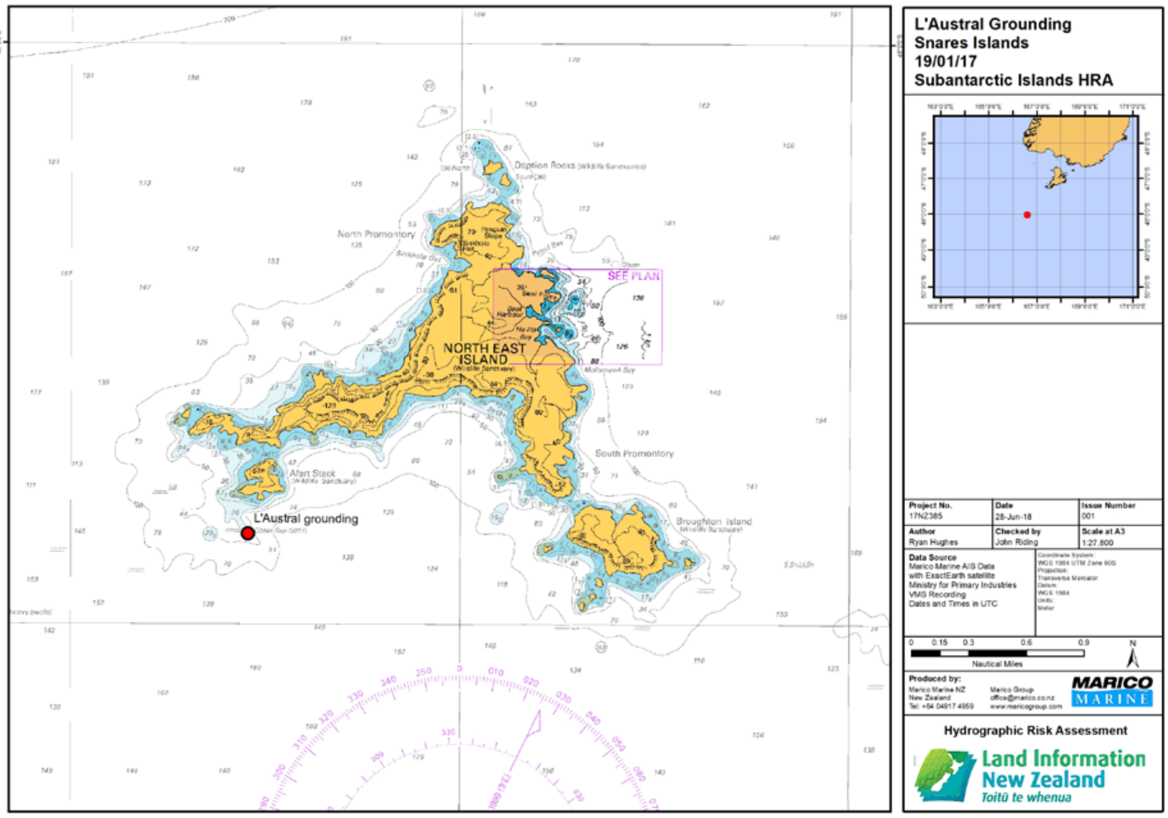


Figure Reference: 17NZ385_RMC_L'Austral_Snares_v2

Figure 15: Reported Touch Bottom Grounding Location - Snares

There have been instances of heavy weather damage to small cruise vessels in the vicinity. The CALEDONIAN SKY, an expedition cruise vessel of just over 100m length, suffered forecastle flooding due to damage from stowed anchors being lifted into their anchor housing boxes, locally piercing the hull integrity. A saloon window was also smashed, but it is uncertain if this was directly due to the sea conditions. This event reportedly took place in the Australian sector.

The incident records do though raise an important question. To date, the westerly sides of Islands have remained un-surveyed because the weather is predominantly from the west (some islands offer very limited shelter anyway and only Campbell and Auckland Islands are of sufficient height to provide meaningful shelter). The Fishing industry has been regularly operating in these waters the longest and are content to shelter always to the east, relying on slow steaming during gales. However, cruise vessels present a greater windage area than a fishing vessel and may have a practical problem of turning if slow steaming in high windspeeds. The direction of storm winds changes rapidly as a depression passes through, so a vessel always sheltering to the east of an island may well be on an exposed shore. If passenger vessel activities are to increase, the commencement of surveys to the west of those Islands providing shelter, i.e. Auckland and Campbell as candidates for charting upgrade, would provide an option for a vessel needing shelter during an easterly to take advantage of a lee side of the island. The weather conditions in the Sub-Antarctic's can be atrocious and there are clearly records of cruise vessels suffering heavy weather damage. Although such vessels would not anchor in the lee side of an island to shelter, they would have the advantage of smoother seas in the lee side as a storm passed through. **Section 4.3** does though provide metocean data analysis, which shows the dominance of the westerly weather flow conditions.

4 TRAFFIC ANALYSIS

4.1 VESSEL TYPES PRESENT

The AIS data record shows the following types of vessel are present in and around the waters of the Sub-Antarctic Islands.

- Passenger Vessels (Cruise)
- Cargo Vessels (including Container)
- Tankers
- Naval Vessels
- Special Purpose Vessels
- Research/Supply Vessels
- Fishing Vessels
- Recreational Vessels
- Bulk Carriers (small in number)
- Other (Class B transmitters) type unknown.

Figure 16 presents an overview of the vessel traffic data in the study area, broken down by vessel type (simplified as Special Purpose and Research Vessels were rolled together). It is the full record, which combines S-AIS and VMS data used for the risk assessment over the period from October 2016 to March 2017.

The plots below provide traffic at the overview. The traffic detail for each Island group is presented with the Hydrographic Risk result for each Island Group.

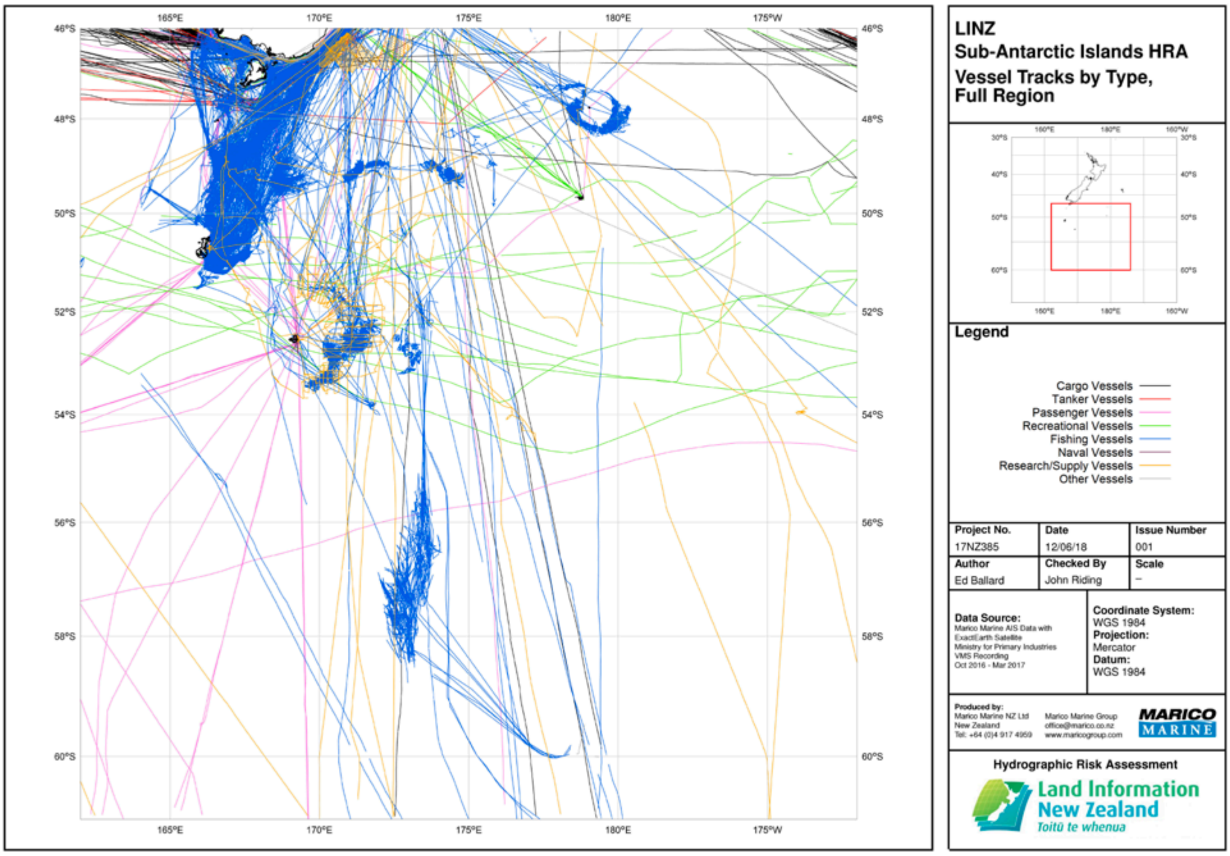


Figure 16: Marine Traffic by Type - Sub-Antarctic Islands

The traffic in the Sub-Antarctic region is, by numbers at least, overwhelmingly dominated by fishing operations. Cargo vessels and tankers are almost exclusively found in the northern parts of the study area, especially immediately north and south of Stewart Island where shipping routes between Australia and New Zealand east coast ports pass. During the time-period covered by the traffic data a round-the-world yacht race passed through the study area, which can be seen as horizontal green tracks. Also of interest are vessels falling into the "Research/Supply" category, which can be seen passing through the study area to continue to Antarctica. This category includes icebreaker vessels (special purpose).

The colouring of the tracks indicates the vessel type groups into which each vessel falls. It can be seen that fishing vessels (blue tracks) are most widespread, especially in the area between the bottom of the South Island and Auckland Island. Additional noteworthy clusters of fishing vessel activity are found to the east of Campbell Island and around the Antipodes Islands.

Figure 17 to **Figure 24** provide plots of the roaming extents of individual vessel types.

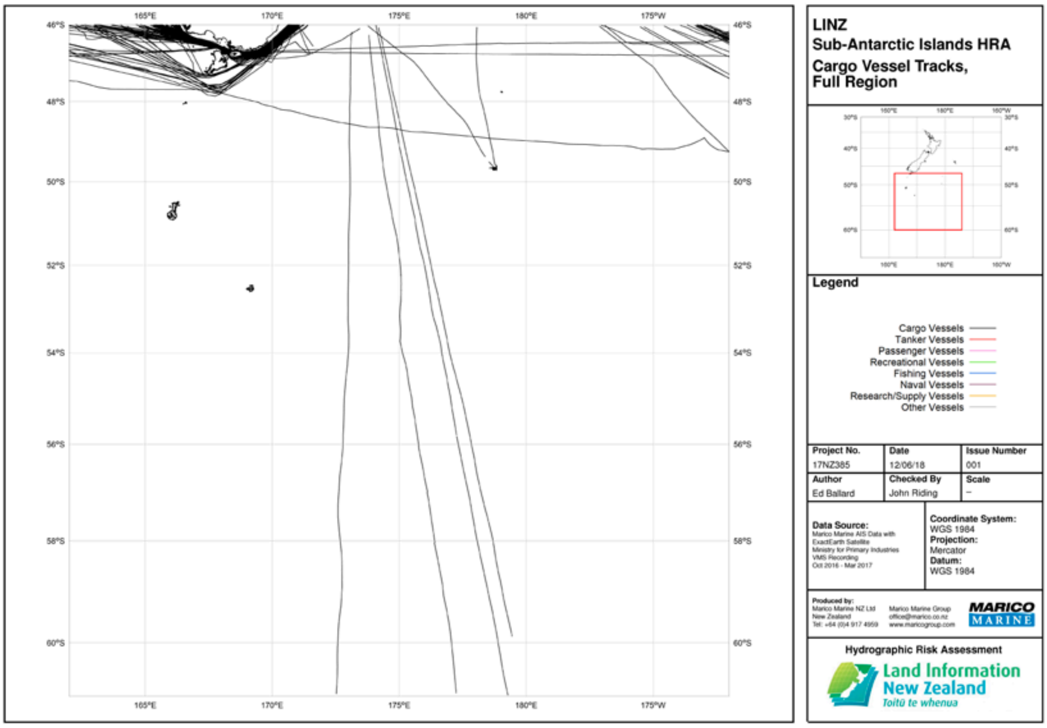


Figure 17: Cargo Vessel Tracks in Study Area

It can be seen that there are vessels classed as cargo that transit the area going south, all of which are providing support to Antarctic activities. Of note though is the fact that the Snares do have a significant number of transits in their general area. The Snares do appear to be on a great circle route option for vessels departing southern Australian ports bound for Panama.

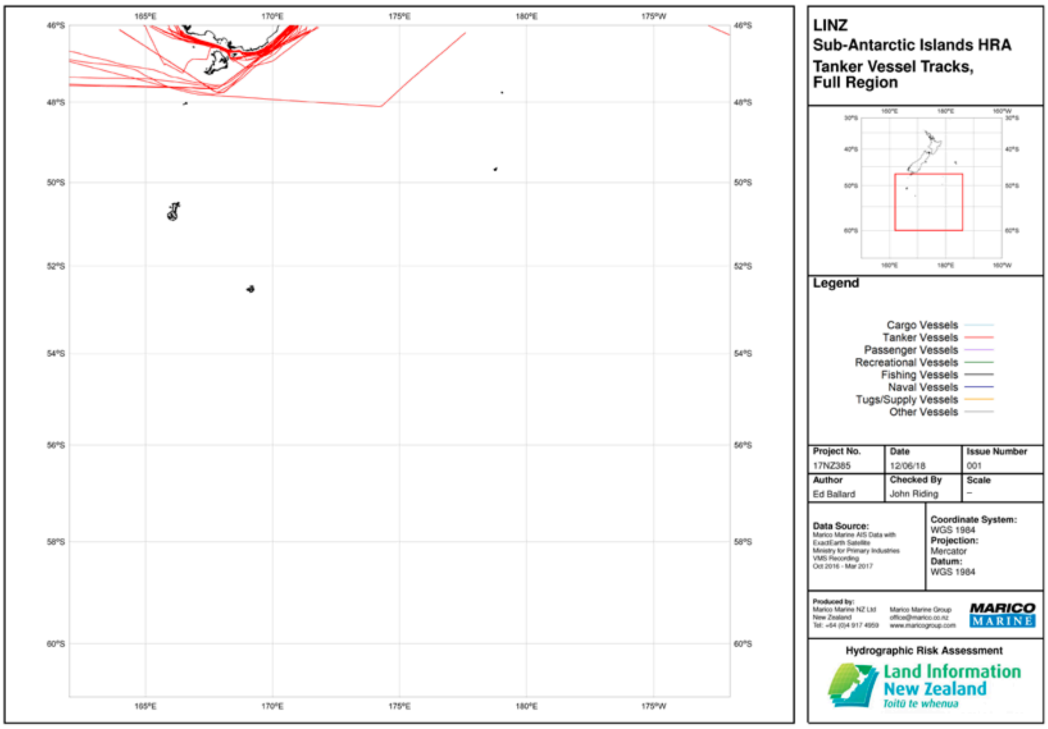


Figure 18: Tanker Vessel Tracks in Study Area

Like the cargo vessel record, tankers do transit past the general location of the Snares. However, those taking a great circle route, of which there is some evidence, will pass through the seas surrounding the Bounty group.

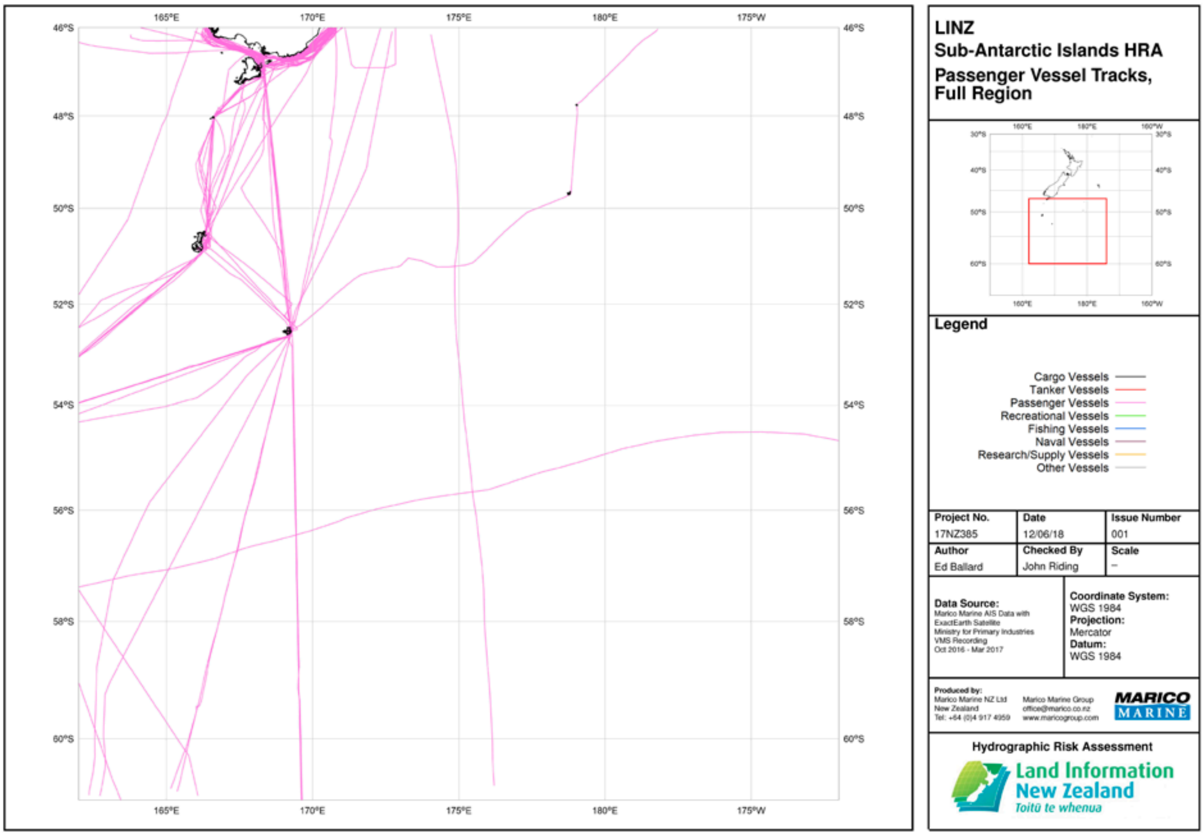


Figure 19: Passenger Vessel Tracks in Study Area

The plot of the passenger vessel routes (**Figure 19**) show the importance of the Snares as a first (and sometimes last) stop-off for cruise visits to the Islands. These Islands provide a vantage stop-off for dusk or dawn visits and this traffic plot alone suggests the importance of the Snares to good charting. As DOC limit landing of people only to Auckland and Campbell in the NZ sector, the routeing of cruise visits reflects this. Auckland, and to a lesser extent Campbell, are also a waypoint for cruise vessels visiting Macquarie Island. A cruise schedule of NZ departure port, then Snares-Auckland-Campbell-NZ destination port is attractive according to this record. Consultation feedback from the NZ Cruise Industry Representation suggested that the option for larger cruise vessels en-route inbound to NZ from Australia (or Vice-Versa) to make a call at the Snares appears logical. There is no record of this occurring in the data set for 2016-17.

It is worthwhile noting that cruise vessels heading South to Antarctica (or North in return) almost always pay a visit to Campbell Island. The landings are universally on the eastern side of these Islands as harbour inlets are to the East. There was only one cruise vessel visiting Bounty and the Antipodes in the year of data.

There appears to have been one cruise vessel in this data set, which passed through the area after visiting Macquarie Island and then proceeded to Cape Horn.

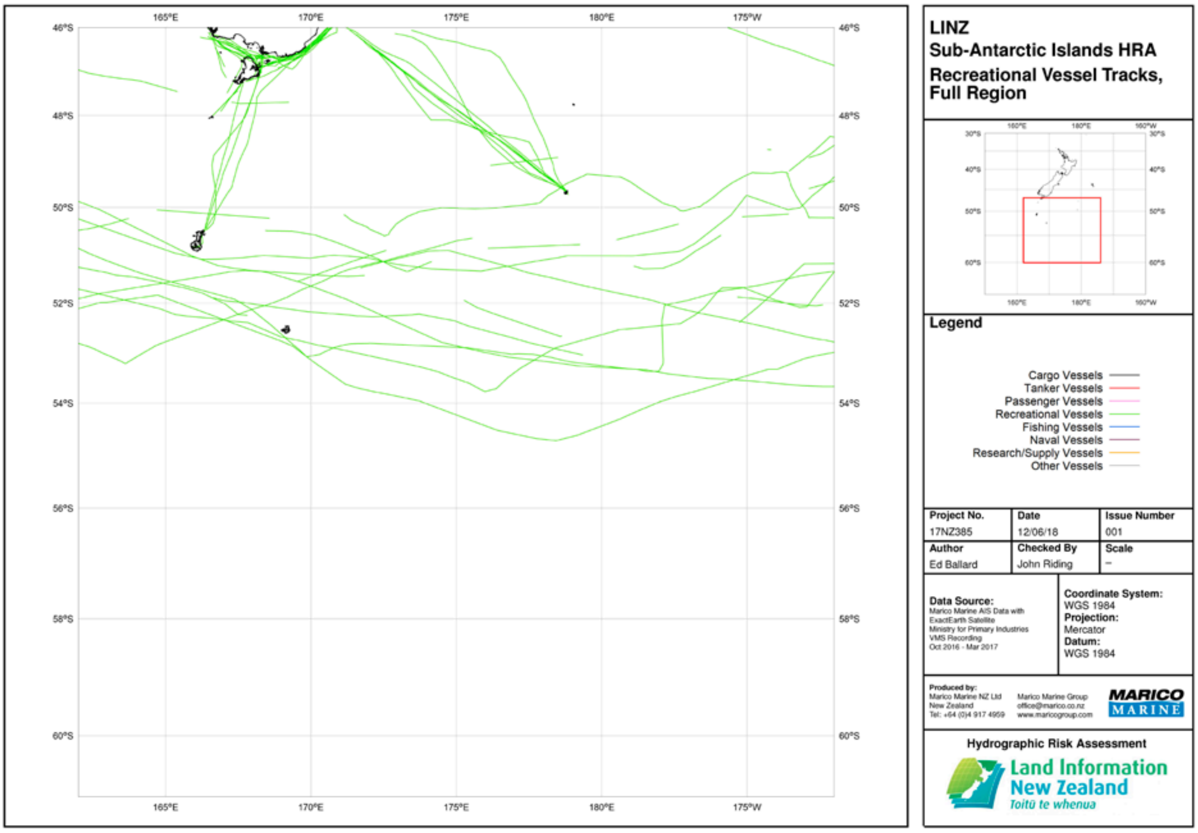


Figure 20: Recreational Vessel Tracks in Study Area

Although recreational craft visiting the Sub-Antarctic are considered to be low in number, they clearly do visit, or at least vessels claiming to be recreational vessels. Visits to Snares, Auckland and the Antipodes are in the record. The tracks running east-west are tracks of a round the world yacht race, which passed through the area that year.

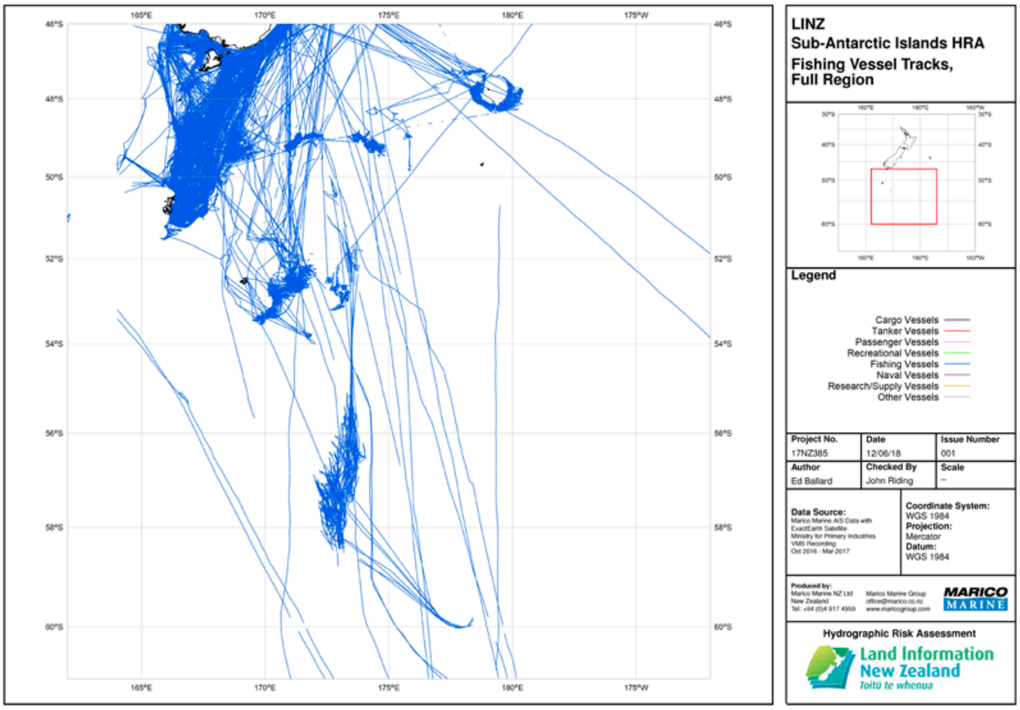


Figure 21: Fishing Vessel Tracks in Study Area

Fishing Operations dominate the track record, which display the extents of fishing in the study area. However, fishing vessels only enter the 12 mile limit around the Sub-Antarctic islands for shelter and this takes place mostly at Auckland and Campbell, due to the height of these islands.

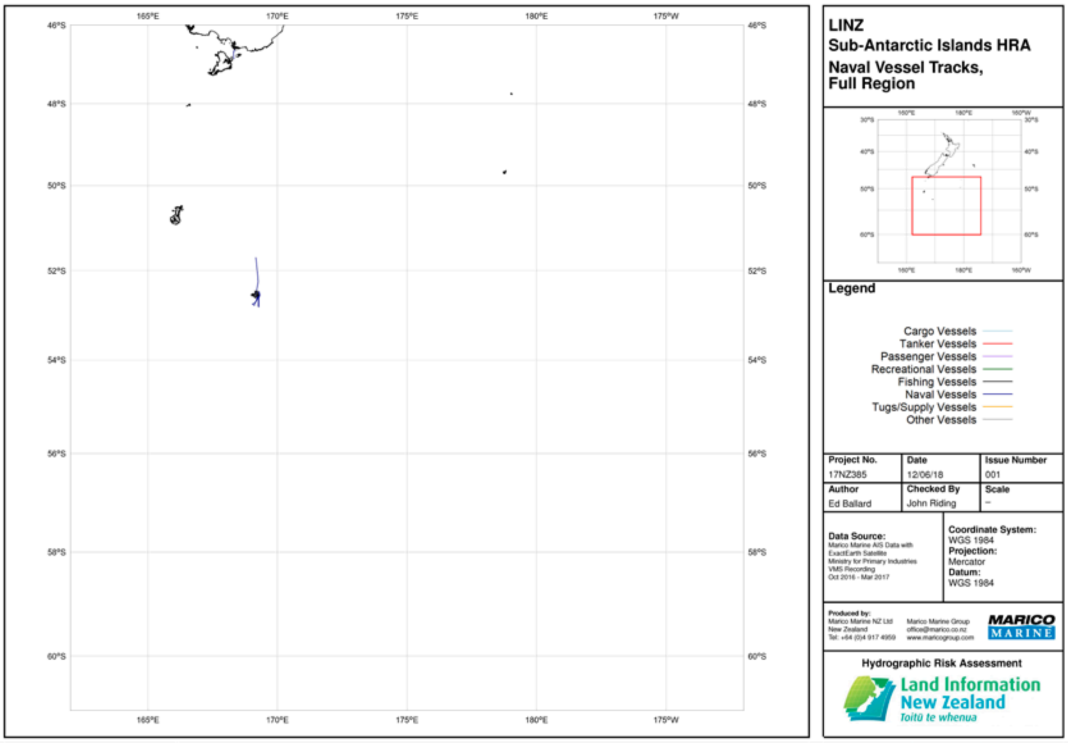


Figure 22: Naval Vessel Tracks in Study Area

Naval vessels have no obligation to transmit AIS records and this is the only record made during the year 2016-2017.

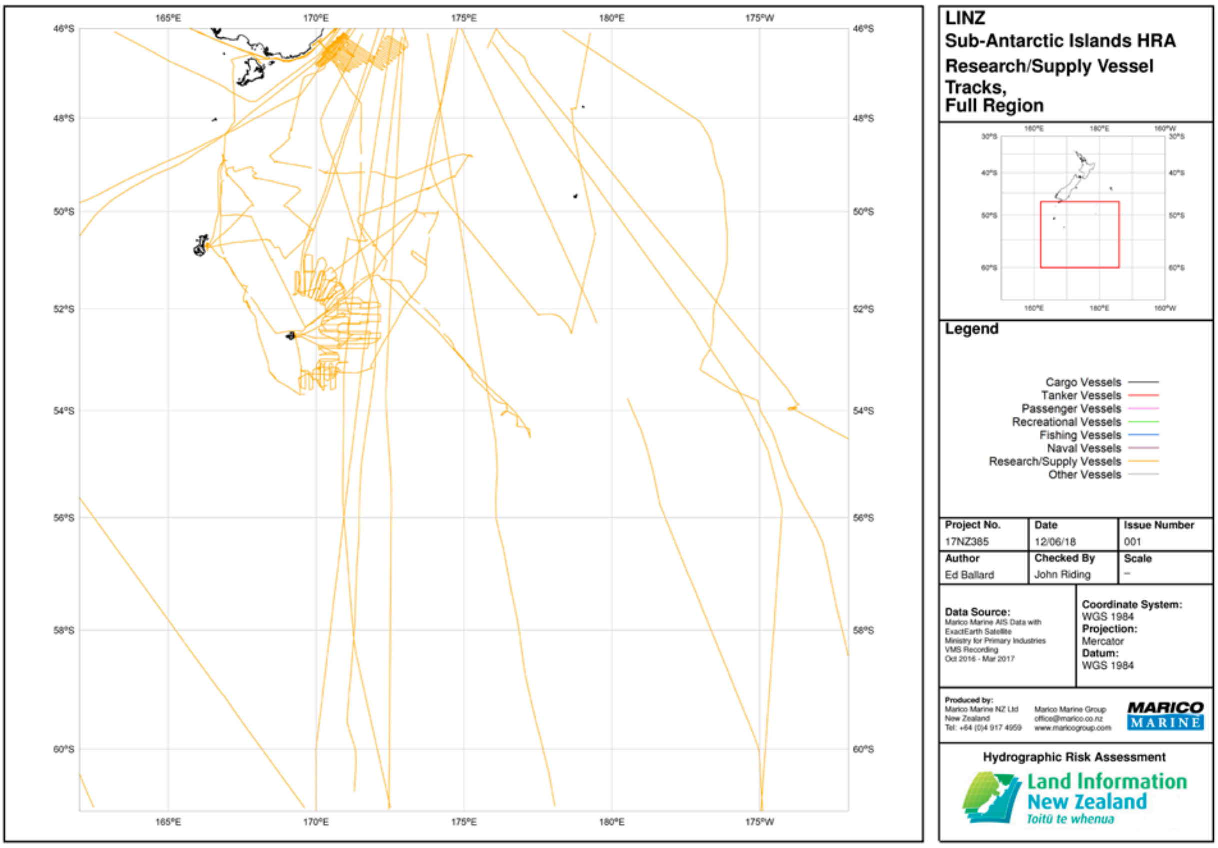


Figure 23: Research/Supply Vessel Tracks in Study Area

Research/Supply vessels regularly pass through these waters. Characteristic tracks of survey runs are apparent. There are also research vessels heading to and from Antarctica for the summer months.

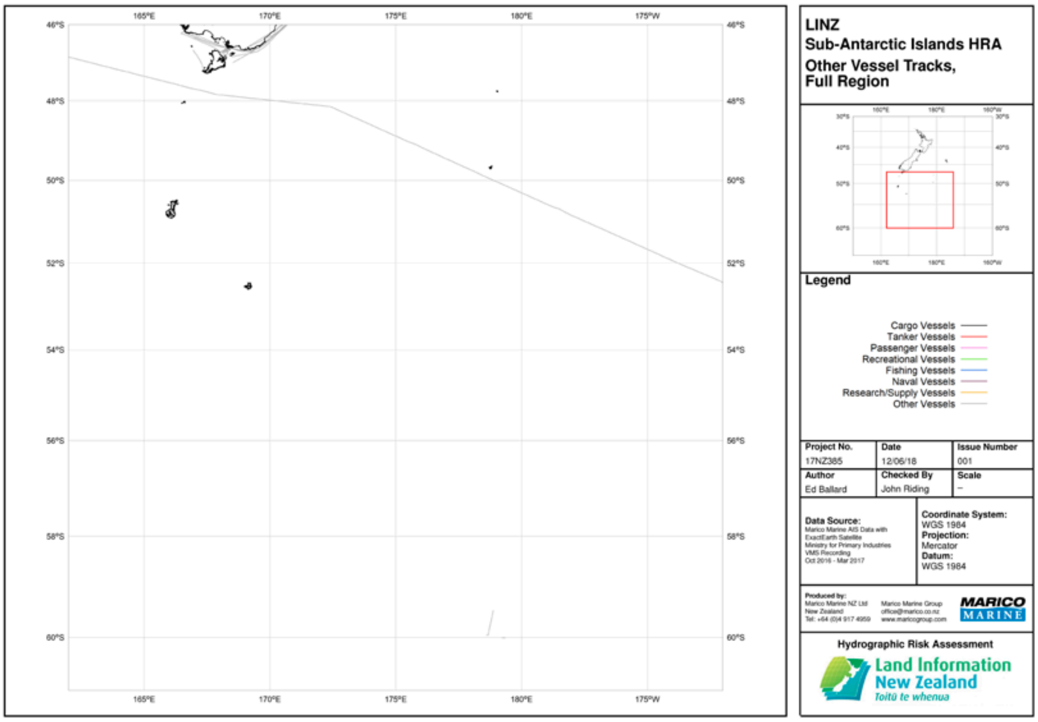


Figure 24: Other Vessel Tracks in Study Area

Figure 24 presents tracks of vessels with unknown type. There is one track displayed passing the Antipodes on what appears to be a Great Circle route to Cape Horn. This is thought to be a large bulk carrier, possibly with a fault in its AIS transmission.

4.2 GREAT CIRCLE ANALYSIS

The traffic profile in the North of the Study area has posed interest. While fishing vessel operations dominate the traffic within the study area, it was found that there was a higher than expected number of large bulk carriers in the traffic data set. These vessels were most commonly found passing through the north-eastern corner of the study area.

It was suspected that these vessels could be following a great circle route. To test this theory, a number of great circle routes were plotted using a Gnomonic projection, whereby great circle routes appear as straight lines. A number of routes from the East Coast ports of Australia to Panama and Cape Horn were plotted and are presented in **Figure 25** at macro scale for context and zoomed in at **Figure 26.** Those routes heading to Cape Horn are all routed so as not to pass further South than 60deg, where the restrictions on the burning of heavy fuel oil effectively bar the majority of large vessels. It can be seen that a number of the routes pass through the study area, some south of Auckland and Campbell Islands.

Comparing the AIS tracks in the north-eastern corner of the study area in **Figure 16** with the hypothetical routes in **Figure 25 and 26,** suggests that the only significantly used great circle route at present is that from Cook Strait to Cape Horn, which would be associated with vessels departing from the northern Queensland ports or parts of Asia. A single large tanker (Seoul Spirit, 159,966dwt) took a route that was close to a Panama-bound route south of New Zealand, but it is unlikely that the Panama Canal was this vessel's destination due to it being too large to use the locks.

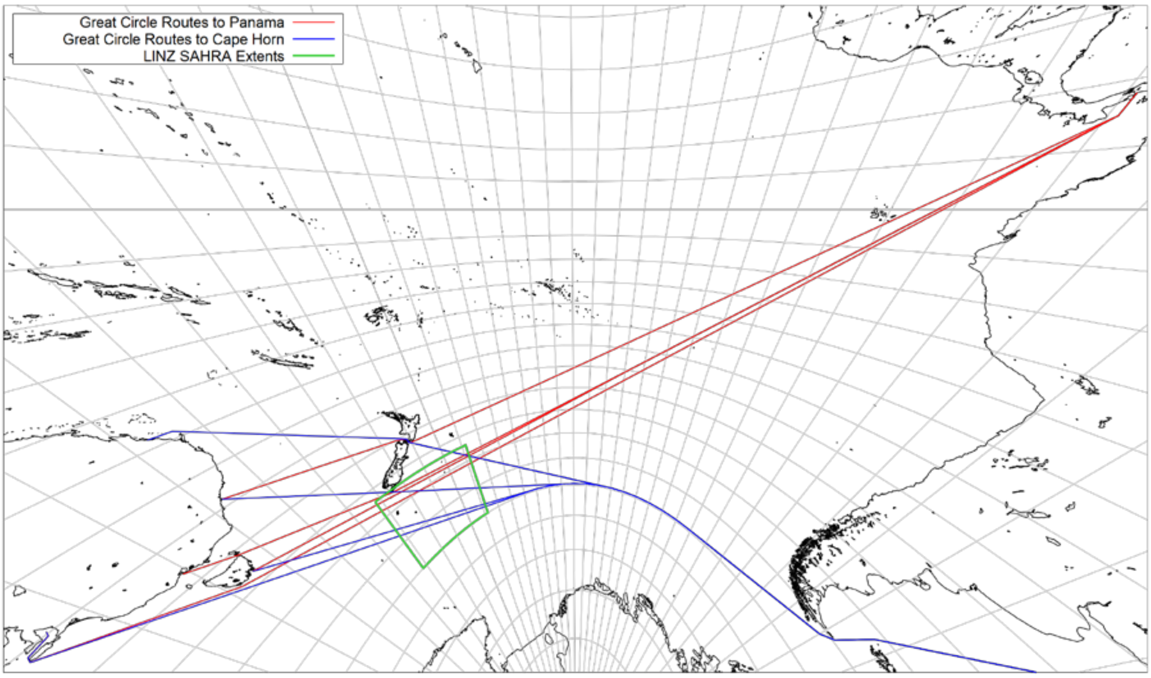


Figure 25: Great Circle Routes from Australia to Panama Canal and Cape Horn

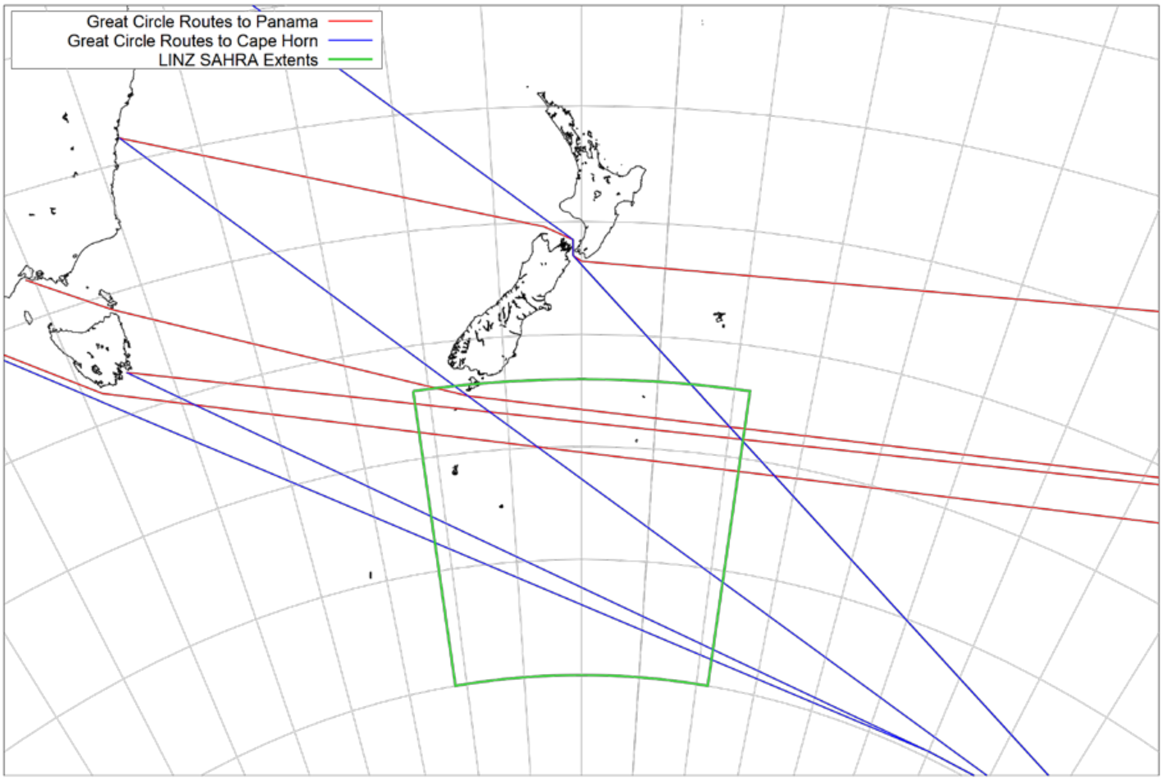


Figure 26: Zoom of Great Circle Routes from Australia to Panama Canal and Cape Horn

4.3 TRAFFIC DENSITY

Figure 27 presents a combination of views of the resultant traffic density across the entire study area as well as for the individual island groups. It can be seen that areas heavily trafficked by fishing vessels produce the areas of highest density, with the areas between the Snares Islands and Auckland Island and to the East and Southeast of Auckland Island of particular note. Local to the individual islands, the greatest vessel traffic densities are found at Port Ross and Carnley Harbour in the Auckland Islands and Perseverance Harbour in Campbell Island. This is consistent with the data gathering analysis associated with available visitor landing points. The record for the Bounty Islands shows the result of one vessel visiting.

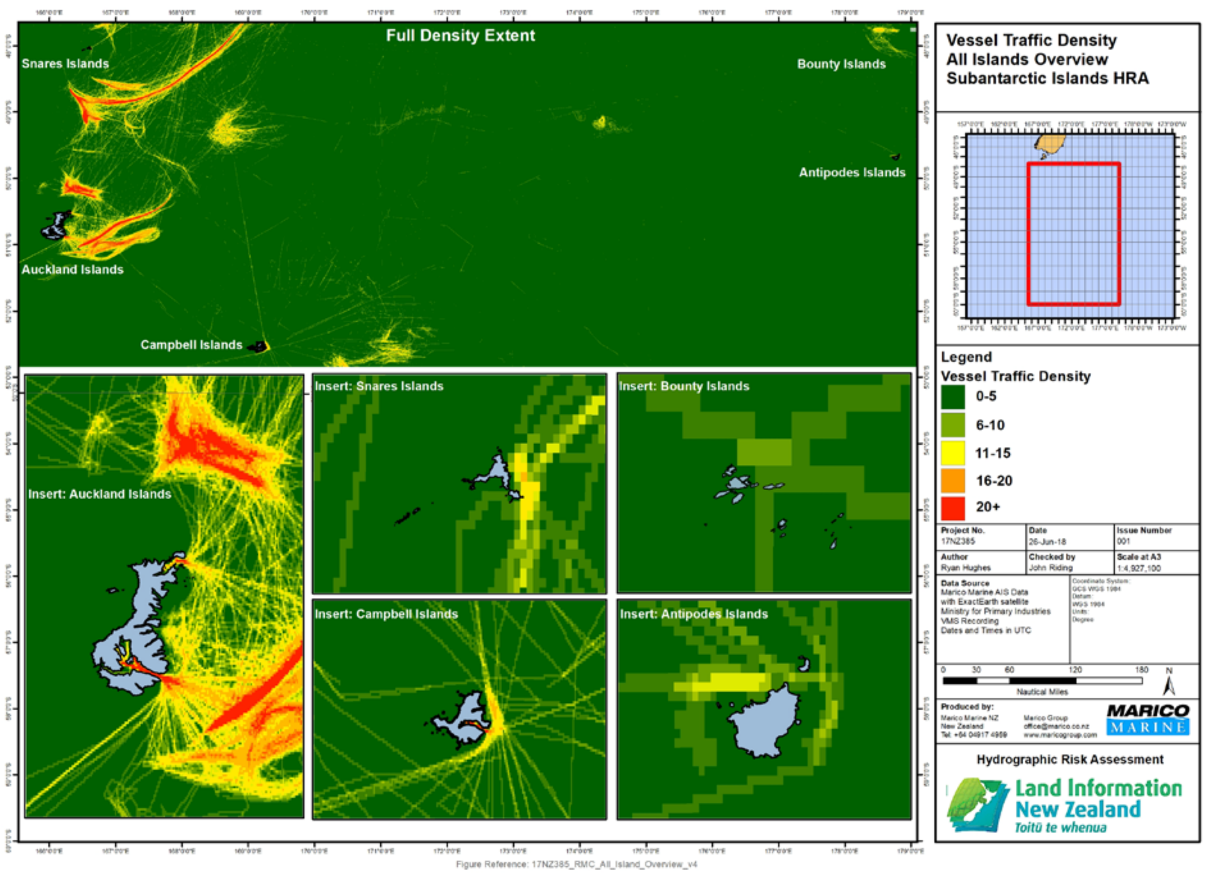


Figure 27: Marine Traffic Density for Sub-Antarctic Islands Study Area

5 RISK MODEL

5.1 DEVELOPMENT OF RISK CRITERIA

This section describes an overview of the individual input layers into the risk model. There is a full methodology report (Marico Marine NZ 17NZ385-1), which lays out how the criteria for the risk assessment were derived and the resulting matrix that sets the calculation parameters. A copy of the resultant risk matrix is attached at **Annex A**.

The risk criteria are split into causation criteria and consequence criteria and individually sectioned into a categorised rating. The individual input layers are presented at **Annex C,** in the form of plots, each of which show the effect of that criteria, georeferenced to each region.

There are a number of factors which, in combination with inadequate charting coverage, could cause an incident to occur. Each category contains factor weightings and category weightings. Of the categories, charting is weighted as the most important category whilst the availability of mitigation and general bathymetry are rated less important than others. **Section 5.3** contains a summarised comparison of all factors, including the category weightings. For a more in depth presentation of these weightings, please refer to the risk matrix in **Annex A.**

5.2 CAUSATION FACTORS

5.2.1 CHARTING

The standard of the existing charting in the area is an important causation factor with significant influence on navigational risk in this study. The influence is explained further in the Risk Criteria report for this study. The Risk Matrix has scores for:-

- Chart Quality – Assessed according to the ZOC ratings in the area;
- Age of the Source Data on which the chart is based;
- Charting Adequacy.

Of the three criteria, Charting Adequacy is the more subjective, as it is in part a combination of the other two, explained in **Figure 28.** The intended purpose of the chart is also taken into consideration when assigning a chart adequacy score, and as such it relates as much to usability as it does to numerical data.

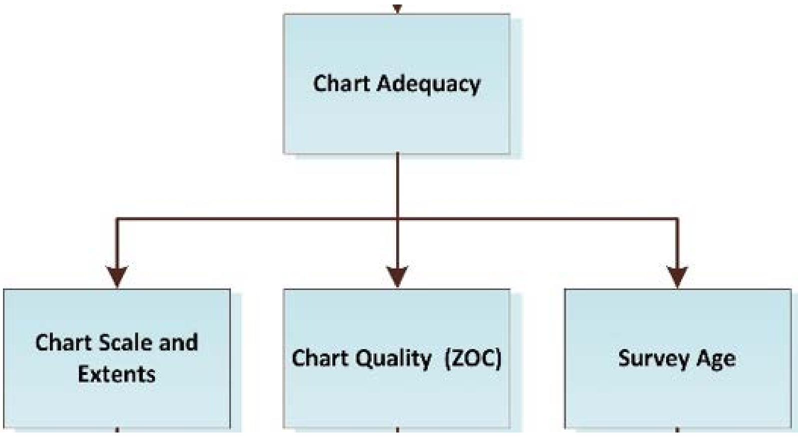


Figure 28: The Components of Charting Adequacy

The IMO recommended chart scales for the differing types of navigation are of assistance for this judgement. However, the skill of an experienced navigator is an essential input, used to determine if the extents as well as scale of a particular chart are of practical use to a bridge team making an approach or negotiating an offshore obstacle. Charting scale and extents have been set in the experience of the Hydrographic office, but charting need can change over time, or as vessel size increases or new vessel types use the waters. Linking a user (navigator) to the assessment is essential and the risk scoring provided valuable.

The concept of Charting Adequacy is used in much greater detail in the charting benefit model, which breaks down ZOC rating into its components to deliver a useful assessment of benefit that would accrue from investment in charting upgrade. In this assessment, where locations are remote and navigational use low, many charts have been derived from only occasional data collection between the islands with an understandable survey focus on the coastal areas around the islands. The charting benefit model takes account of the data coverage as well as the type of technology historically used for the survey, and the bottom coverage recorded. The Charting Benefit model does not form part of the present study scope.

The Chart Zone of Confidence (CATZOC) score has been provided by the Hydrographic Office and is used in this risk assessment directly to provide the risk matrix scoring for that criterion. CATZOC was used across the scale of A to U and applied throughout the area, with CATZOC A providing the lowest risk influence. CATZOC U, has the highest risk influence (level 5), that is, provided there is evidence of navigational use in the time of the AIS data record (See **Annex A** for the Risk Matrix).

The recorded date of the last hydrographic survey provided the score for charting age in each cell. Natural change in the sea bed and human actions over time, as well as improving technology, drive the need to resurvey and undertake a review of charting. A chart data age of 5 years or less provides the lowest risk influence, whereas a survey greater than 30 years ago, using older technology, scores the highest in each cell (level 5). Any unsurveyed area is automatically ranked with the highest score on the risk matrix (Level 5). Charting quality is thus rated in the matrix as excellent to *"unacceptable".*

In more detail, charting influence on causation may be categorised as excellent if the chart has a low survey age (less than 5 years old), a good CATZOC score in approach channels and an IMO compliant range of chart scales relative to the intended usage of the chart. When a chart is rated as "good", the chart may have a survey age 5 to 10 years, have a CATZOC score of B, and have a good range of chart scales relative to the size of the area, for example. Alternatively, a chart may score ''moderate" with a survey age of 10 to 30 years, a CATZOC score of B or C. A charting quality of "poor" can be classified if the survey age is between than 20 to 30 years, a CATZOC score of D is evident or there are some un-surveyed areas.

Chart extents would also suggest that there is some inadequacy affecting coastal navigation (for example, some areas have a scale of 1:100 000 for entire Island groups with only selected areas of island charted at 1:25 000). When charting adequacy is categorised as "unacceptable", the survey age may be greater than 30 years, a CATZOC score of U would be evident or the area would present un-surveyed areas, as well as the charting scale being judged as insufficient for coastal navigation.

Scoring was undertaken using the expert opinion of a suitably qualified master mariner with significant regulatory and navigational experience in NZ waters (note the record of report authors). Given that the purpose of this assessment is as a hydrographic risk assessment, with low traffic levels, charting factors (quality, survey age, adequacy) have a less significant influence in the risk calculation than other hydrographic risk studies.

5.2.2 ROUTE CHARACTERISTICS

Route characteristics describe other external factors which may cause a vessel to have an incident. As the available navigable waters decreases around a vessel it becomes more likely that the failure to hold the required course will result in an incident. Route characteristics are measured in two ways; the navigational complexity and the proximity to shallow waters.

The navigational complexity of a waterway identifies whether navigation is open (at sea) or constrained (in a port). The proximity to the 15 metre contour describes how likely a large commercial vessel may run aground. Navigational complexity is ranked lowest on the risk matrix when a vessel is 10 nm offshore and ranked highest on the risk matrix when navigationally constrained within 1 nm.

5.2.3 METOCEAN

MetOcean conditions such as wave, wind and tide may force a vessel away from safe waters. The prevailing wave and wind conditions was used to describe how exposed a waterway is and therefore the degree of leeway a vessel may experience. If the location is on a lee shore of the Islands resulting in exposure to strong prevailing wind and waves on 'most days' this was rated highest risk on the risk matrix. Exposure on most days was defined whereby the maximum wave height exceeds 7.5 m annually. If the island provides some shelter then this will present a lower risk score out of the risk matrix. Tides and currents were ranked as lowest in the risk matrix if they are shown in the existing charting of lying between 1 kts to 2 kts and ranked highest on the risk matrix if tides and currents exceeded 5 kts.

Similarly tides and currents will be measured and the longwave and surge conditions will be identified.

Seasonal variations in the MetOcean data can be found in **Annex E**.

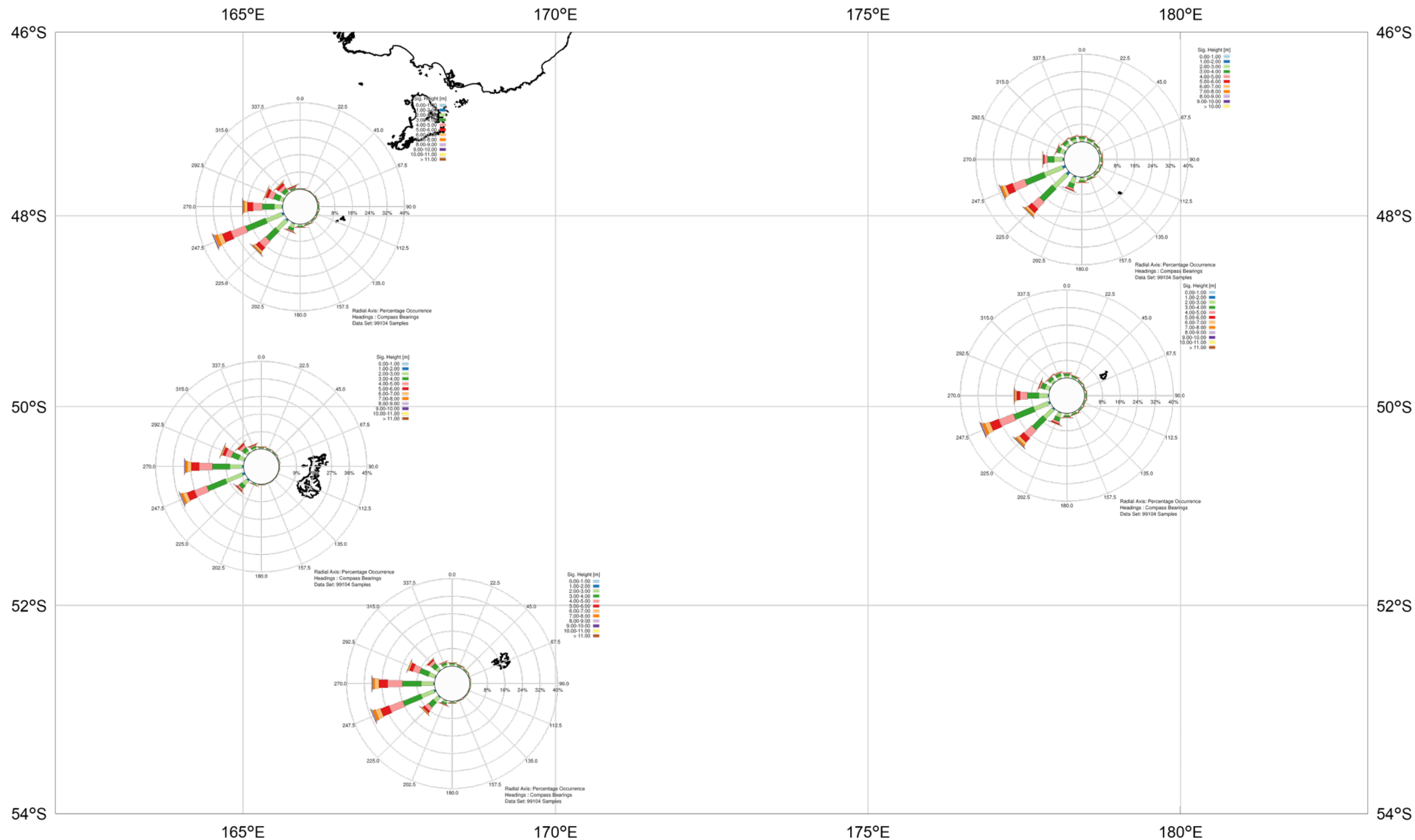


Figure 29: Wave Rose Statistics for All Islands

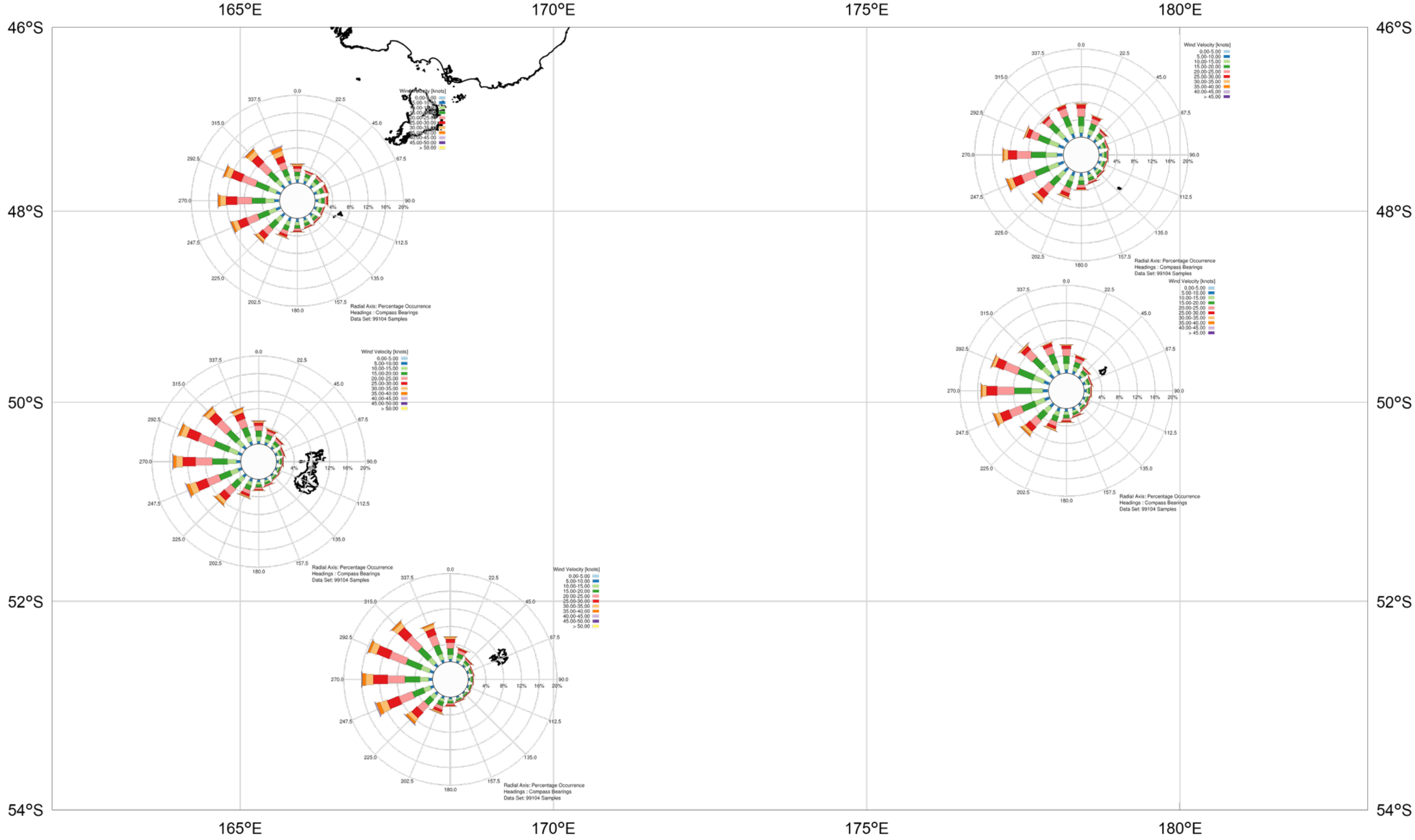


Figure 30: Wind Rose Statistics for All Islands

5.2.4 NAVIGATIONAL HAZARDS

Navigational hazards described on charts, describe localised dangers to vessels and include sea mounts, wrecks, breaking reefs and tidal races or tidal overfalls.

These hazards were mapped and the proximity of vessel traffic to these dangers measured. Vessels which navigate closer to these hazards have a greater risk of an incident than those navigating further away. Charted tidal hazards and isolated dangers provide a heightened risk score when the proximity of vessel traffic is within 500m of either a rock, a wreck or a charted tidal hazard. Charted tidal hazards and isolated dangers are of lower risk in the risk matrix when the proximity of vessel traffic is within a distance greater than 2.5 nm away from either a wreck or charted tidal hazard. Known sea mounts are considered to be of heightened risk in the risk matrix within 1 nm of a seamount and lowest risk when greater than 10 nm away from a known sea mount. Sea mounts are present in the Sub-Antarctic waters, but were not a significant cause of risk increase in this risk assessment.

In terms of weighting, large surface breaking reefs are weighted in the derived risk matrix as the most important hazard, whilst seamounts are weighted less important.

5.2.5 ICEBERG EFFECT ON NAVIGATION

The presence of hazardous ice is also to be considered, not so much as a general risk increment, but where ice can have a specific effect on navigation. When large icebergs calve, as has occurred in 2017, they can affect the existing tried and tested sea routes into and through the Ross Sea and all the way to the ice face. The diversion of transits due to the presence of a very large iceberg, means vessel have to deviate from transits that have been proven and navigate sea areas where the charting standards may be more uncertain and isolated dangers may be uncharted.

Data gathering for the Ross Sea project included an understanding of the locations where ice calving affecting the Ross Sea and its approaches predominantly occurs. Antarctica research expertise were consulted with to establish if there are any identifiable patterns that affect the routes that such icebergs may be more likely to take after floating free from the ice shelves.

For the Sub-Antarctic Islands study, the presence of icebergs were accounted for using the monthly mean maximum iceberg extents presented in the UKHO "Routeing Chart, South

Pacific Ocean" series. Each monthly chart in the series contains mean maximum iceberg limits based on UK Met Office data for the period 1912-1956. These limits are used to develop the regions presented in **Figure 31**, whereby 6 regions (corresponding to 0-5 integer scaling) are defined in terms of the number of months for which the area lies within the mean maximum iceberg limits.

Heightened risk as defined in the risk matrix is ice that is present throughout the year and the lowest risk in the risk matrix is ice that is not present throughout the year.

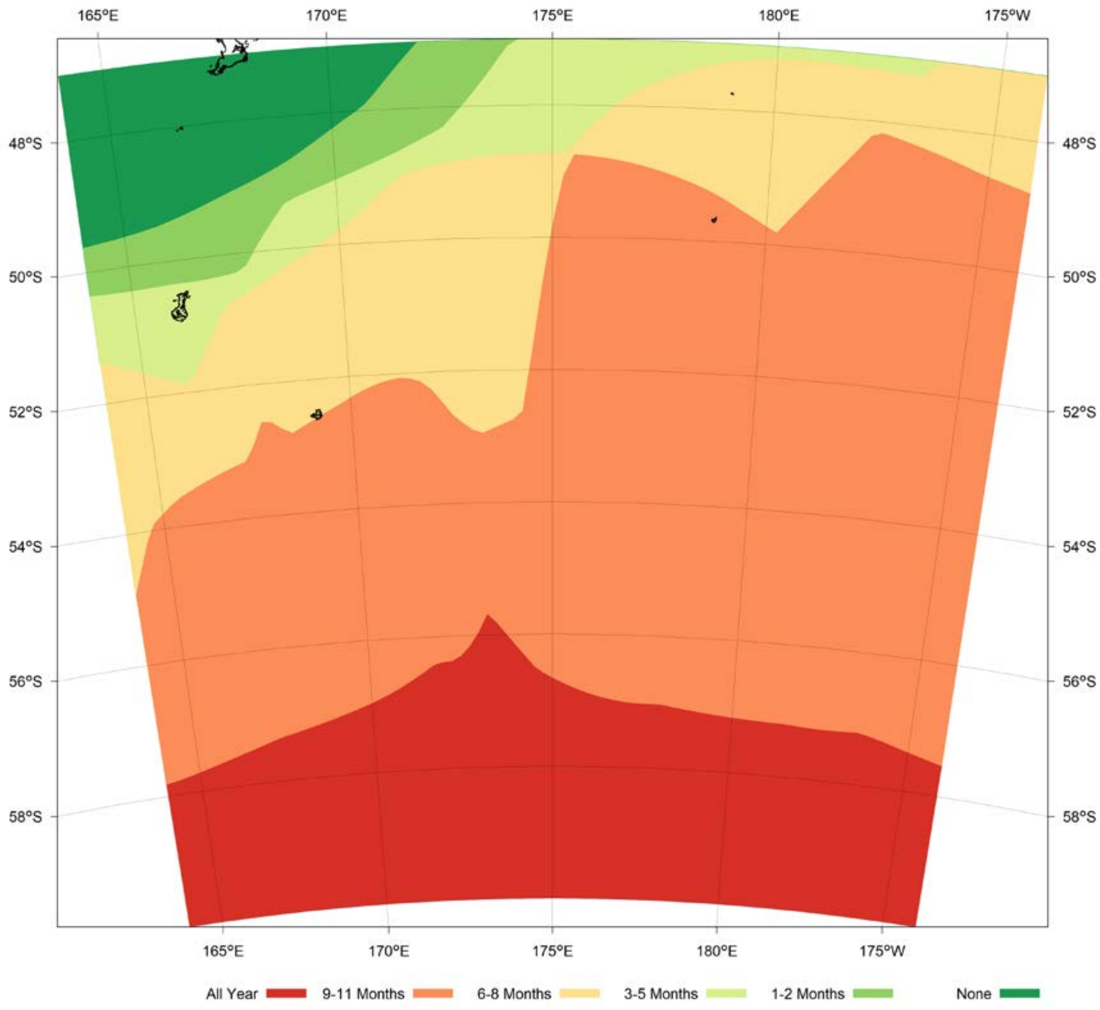


Figure 31: Iceberg Extents

The categorisation of the variability of the iceberg extents provides an estimate of the likelihood of encountering icebergs at any time of the year. This is appropriate for the risk model used which does not account for temporal variation in other parameters.

5.3 CAUSATION FACTORS – CONTRIBUTION TO RESULTS ASSESSMENT

Causation factors have been scored in the derived risk matrix (**Annex A**). A ranked comparison of all causation factors, which shows their relative importance of influence on the risk assessment, is shown in **Table 6**.

.

Chart Quality	**25%**
Chart Adequacy	**17%**
Navigational Complexity	**12%**
Survey Age	**8%**
Depth of Water 15m Contour	**8%**
Hazardous Ice (Large Calvings)	**5.7%**
Isolated Dangers - Rocks/Wrecks/etc.	**5.7%**
Charted Tidal Hazards	**5.7%**
Prevailing Wave/Wind	**5%**
Tides/Current	**5%**
Known Sea Mounts	**2.9%**

Table 6: Ranked Causation Factors

6 CONSEQUENCE FACTORS

Each incident has the potential for a consequence and specific local conditions which may make the impacts much greater, these conditions represent consequence factors.

This project has used existing development work by Marico Marine NZ, which established a relationship between the vessel types in the study area and their likely release of pollutants in a casualty.

6.1 VESSEL IMPACTS – EVENT TREES

Event Trees were developed for the vessel types that operate in the Sub-Antarctic Islands. The most likely and worst credible outcomes of a cruise vessel accident in the Sub-Antarctic islands was determined using these structures. The Event Trees used for the project are presented at **Annex D**. Quantification of these in terms of pollution release has taken a more sophisticated approach, relating vessel type to the expected oil outflow due to grounding.

6.2 ENVIRONMENTAL IMPACT - EXPECTED FUEL OUTFLOW QUANTITIES

The potential oil outflow of an incident depends on the size and type of a vessel. However the environmental and societal impact that oil may cause once released can be considerable. The proximity of an oil spill to key ecological and environmental protection areas needs to be considered.

Expected fuel outflow quantities are determined based on average fuel capacities of vessels within each type and size subtype (where used). For the Most Likely Scenario, it is assumed that 5% of the total fuel capacity is lost to the sea. For the Worst Credible Scenario, the total fuel lost is 50% of capacity.

6.2.1 FUEL LOAD CALCULATION AND EXPECTED FUEL OUTFLOW FROM GROUNDING

6.2.1.1 ESTIMATION OF MAIN ENGINE POWER

The gross tonnage of each vessel in the S-AIS Record is used to determine the expected main engine power using data for the World Fleet 2010:

$$P = A \times GT^B \text{ [kW]}$$

Where: GT = Gross Tonnage

Vessel Type	Coeff A	Power B
Bulk Carrier	35.91	0.53
Container Ship	2.92	0.87
Fishing Vessel	9.76	0.75
General Cargo	5.56	0.74
Icebreaker	5.56	0.74
Other	59.05	0.55
Passenger Vessel	9.55	0.76
Recreational Vessel	59.05	0.55
Reefer	5.56	0.74
Research/Patrol	2.92	0.87
RoRo Cargo	164.58	0.44
Tanker	14.76	0.61
Tug/Supply	54.22	0.64

Table 7: Coefficients for Calculation of Main Engine Power from GT

Gross tonnage data was not available for around half of the fishing vessel fleet present in the study area, so the relationship between GT and vessel Length Overall (LOA) where GT was known was used to develop a standard relationship that could be used to determine GT where it wasn't known. **Figure 32** illustrates the results of this exercise and standard statistical analysis techniques were used to fit the representative line used for the risk model.

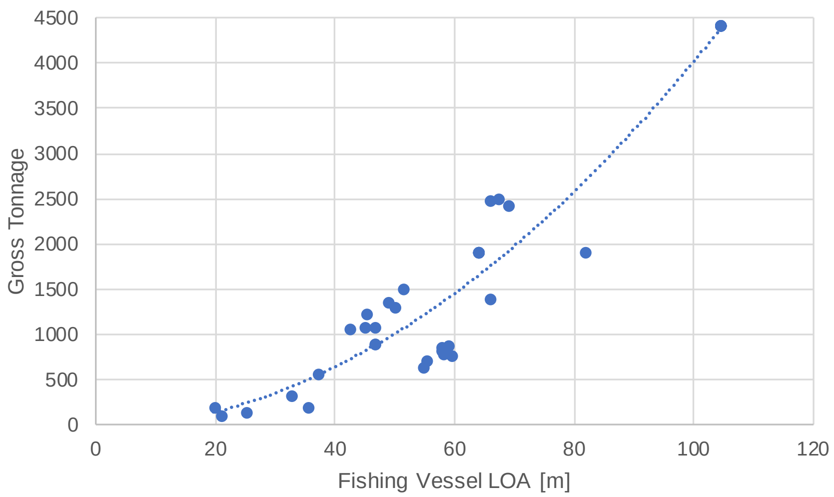


Figure 32: Derived LOA to GT Relationship for Fishing Vessels

Gross tonnage is also not defined for smaller recreational vessels. Consequently, fuel loads were estimated directly, without using the calculation of main engine power via GT as an intermediate step.

6.2.2 Estimation of Fuel Capacity

Estimation of fuel capacity has been carried out using the assumption that the fuel capacity (FC) is equal to:

$$FC\ [te] = \frac{Endurance\ [days] \times Mean\ Power\ [kW] \times SFOC \left[\frac{g}{kWh}\right] \times 24 \left[\frac{h}{day}\right]}{1 \times 10^6 \left[\frac{g}{te}\right]}$$

It is assumed that for all vessels apart from Icebreakers their endurance is 6 weeks. For Icebreakers it is assumed to be 8 weeks. Mean power output is assumed to be 75% of MCR.

The Specific Fuel Oil Consumption (SFOC) depends on engine type. SFOCs for main engines depending on fuel type according to the Third IMO GHG Study (IHO, 2014) are given in **Table 8**.

Engine Type	Fuel	SFOC [g/kWh]
Slow Speed	HFO	195
Medium Speed	MDO	215
High Speed	MDO	227

Table 8: Derived SFOC for Different Engine Types

6.2.3 Bulk Carriers

Figure 33 presents the relationship between vessel length and fuel capacity determined for bulk carriers in the traffic record. On the basis of averages calculated for all vessels falling within each size sub-type, it is proposed that the fuel capacity for bulk carriers of under 200m is assumed to be 1000t and for those over 200m is 1800t.

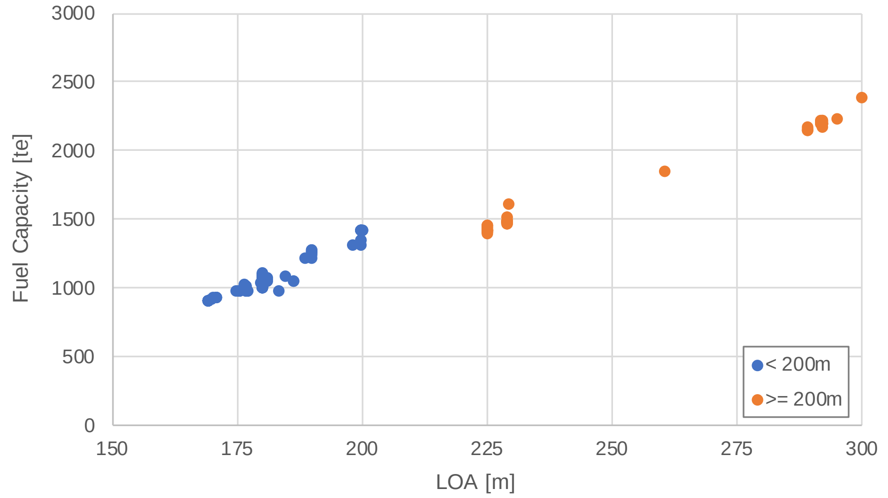


Figure 33: Derived LOA to Fuel Capacity Relationship - Bulk Carriers

6.2.4 CONTAINER VESSELS

Figure 34 presents the derived relationship between vessel length and fuel capacity, determined for any container vessels in the traffic record. On the basis of averages calculated for all vessels falling within each size sub-type, it was proposed that the fuel capacity for container vessels of under 200m is assumed to be 2000t and for those over 200m is 5000t.

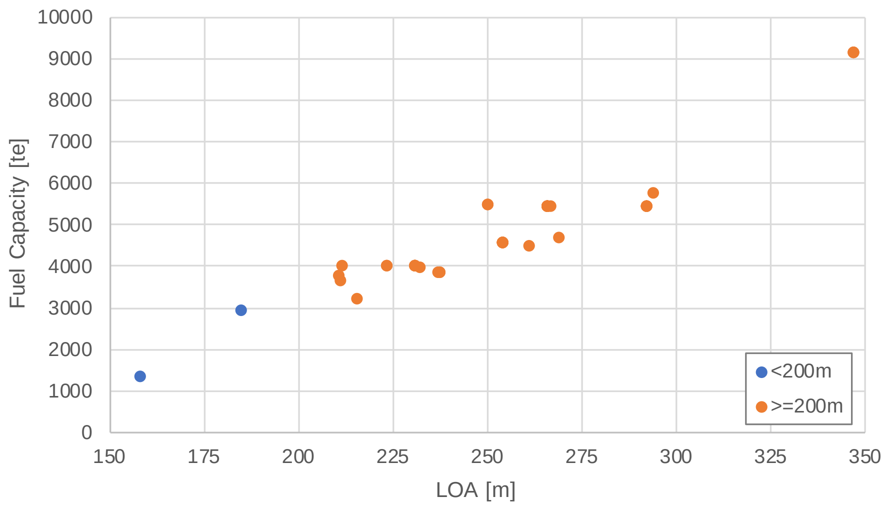


Figure 34: Derived LOA to Fuel Capacity Relationship - Container Vessels

6.2.5 GENERAL CARGO VESSELS

Figure 35 presents the relationship between vessel length and fuel capacity determined for general cargo vessels. On the basis of averages calculated for all vessels, it is proposed that the fuel capacity for general cargo vessels is assumed to be 1200t.

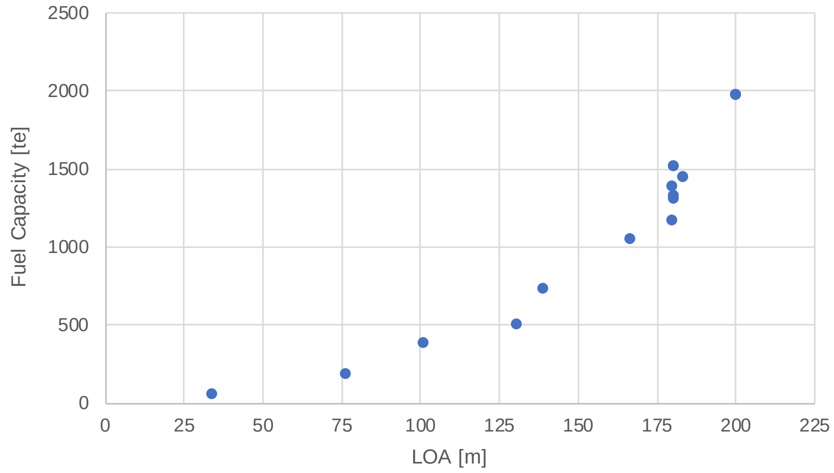


Figure 35: Derived LOA to Fuel Capacity Relationship - General Cargo Vessels

6.2.6 PASSENGER VESSEL

Figure 36 presents the relationship between vessel length and fuel capacity determined for passenger vessels. On the basis of averages calculated for all vessels falling within each size sub-type, it is proposed that the fuel capacity for passenger vessels of under 200m is assumed to be 2500t and for those over 200m is 7500t.

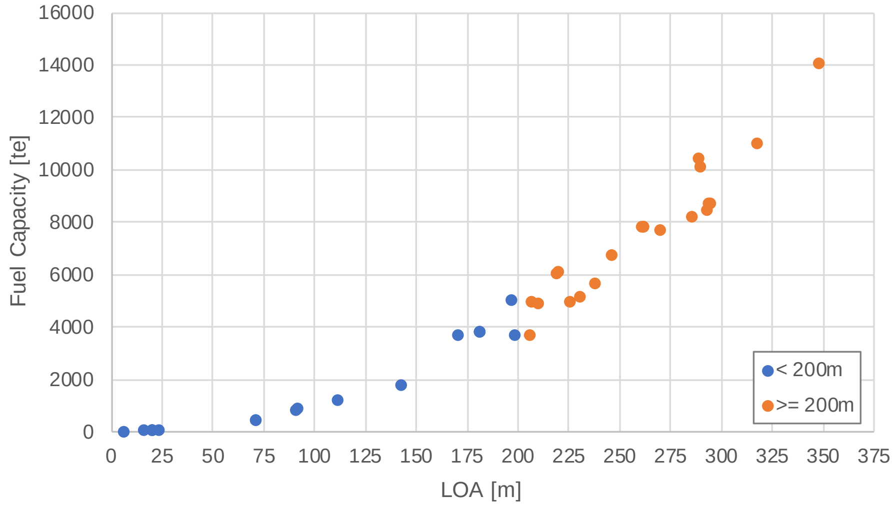


Figure 36: Derived LOA to Fuel Capacity Relationship - Passenger Vessels

6.2.7 RESEARCH/PATROL/ ICEBREAKER

Figure 37 presents the relationship between vessel length and fuel capacity determined for research, patrol and icebreaker vessels. On the basis of averages calculated for all vessels, it is proposed that the fuel capacity for these vessels is assumed to be 2000t.

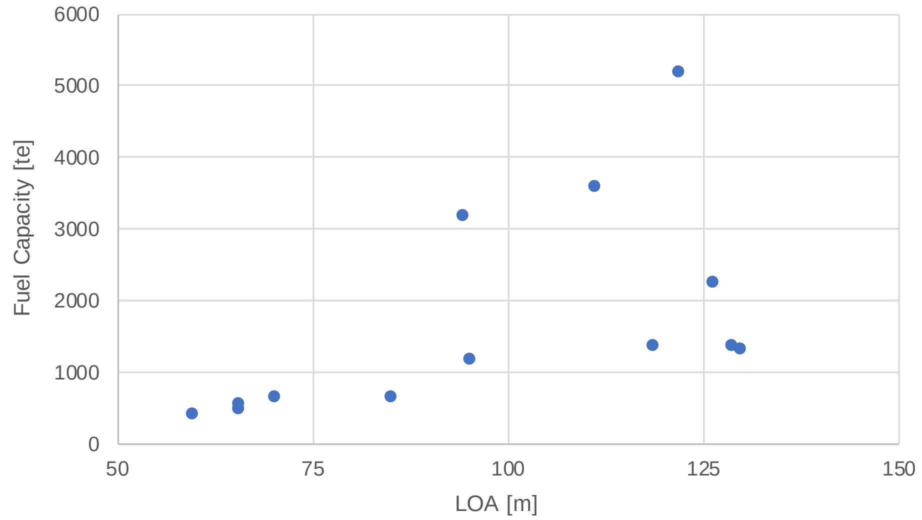


Figure 37: Derived LOA to Fuel Capacity Relationship - Research/Patrol/ Icebreakers

6.2.8 TANKERS

Figure 38 presents the relationship between vessel length and fuel capacity determined for tankers. On the basis of averages calculated for all vessels falling within each size sub-type, it is proposed that the fuel capacity for tankers of under 200m is assumed to be 800t and for those over 200m is 2000t.

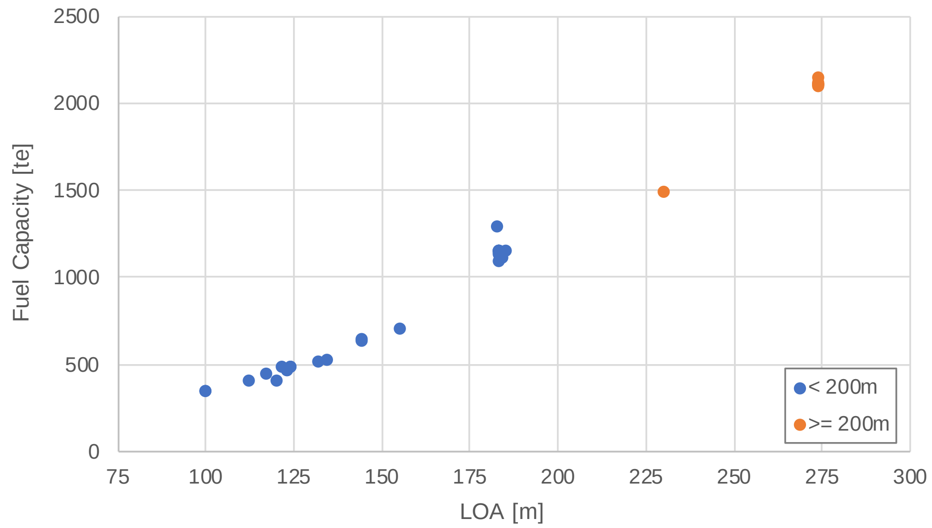


Figure 38: Derived LOA to Fuel Capacity Relationship - Tankers

6.2.9 TUG/SUPPLY VESSELS

Figure 39 presents the relationship between vessel length and fuel capacity determined for tugs and supply vessels. On the basis of averages calculated for all vessels, it is proposed that the fuel capacity for tugs & supply cargo vessels is assumed to be 350t.

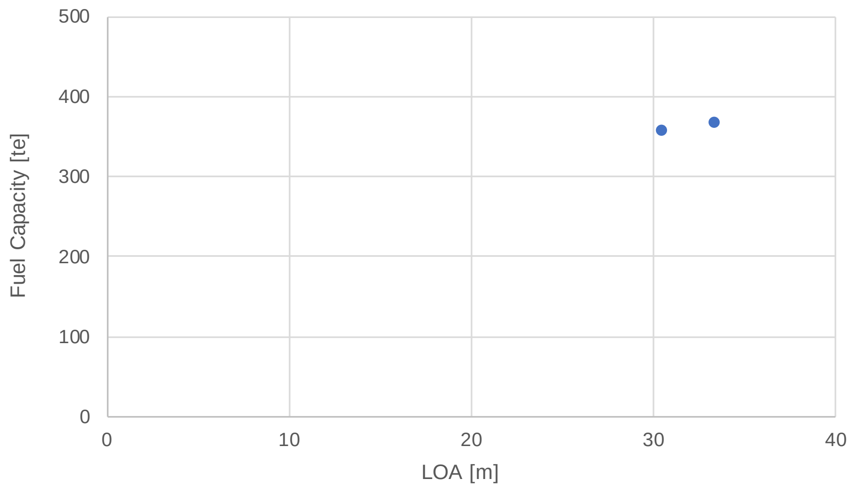


Figure 39: Derived LOA to Fuel Capacity Relationship - Tug/Supply Vessels

6.3 PROXIMITY TO KEY HABITATS

The proximity of an incident to sites of key sensitive habitats, such as underwater reefs and corals has been spatially represented. Data was made available from DOC to determine the locations of unique benthic ecosystems and fishing grounds. The criteria reflect their sensitivity and ecological importance within the Risk Matrix.

6.4 ECOLOGICAL SUBSET VALUE (ESV)

The Ecological Subset Value (ESV) is a means of ranking the ecological sensitivity, uniqueness, and population health of a species of interest in relation to each other within the project area. In order to determine the ESV, a formula was derived from the conservation status (NZTCS[10]), regional endemism, local endemism, and population health of each species. This is shown below.

[10] **Department of Conservation, (2009, 2012, 2013, 2017)**

$$C_{St} = C \times C_S$$
$$S_{UI} = E_I + E_{IG}$$
$$ESV = C_{St} + (S_{UI} + P_d)$$

Each of these factors had a numerical value assigned to them. The definitions for each value found in the formula are defined in **Table 9**. Species were then grouped based on their ESV scores, allowing the risk matrix to assign weighting to each group of species within the model. Higher risk category weightings are associated with higher scoring ESV groups, and these weightings diminish with lower ESV scores. Proximity to high scoring ESV species group habitats were used to scale the level of ecological risk in the event of an incident.

ESV =	**Cst**	**Conservation Status**
		C = NZTCS Category CS = NZTCS Sub-Category
	SUI	**Species Uniqueness Index**
		EI = Species Endemism to Sub Antarctic Islands EIG = Species Endemism to Sub Antarctic Island Group
	Pd	**Population in Decline (Population Health)**

Table 9: Definitions for the ESV Formula

The ESV score is categorised from 1/2, 2/3, 3/4, 4/5, 5/6, 7/8 and 9/10. Species categorised with an ESV score of 9/10 were defined as the most ecological sensitive in relation to all other species within the Sub-Antarctic's. Those rated 9/10 are the most environmentally sensitive to pollution impacts within the project area.

The categorised ESV scores are considered to show the highest risk when multiple species are present with the same cell with the risk model. Lower risk is determined in the risk model when the proximity of a vessel is greater than 20 nautical miles from the species colonies.

6.5 PROXIMITY TO SITES OF ENVIRONMENTAL PROTECTION

The proximity of an incident to environmental protection areas will be considered in the Risk Model. A variety of sites exist, including:

- World Heritage Site

- Proximity to Marine Protected Area

6.6 ECONOMIC IMPACTS

The economic impact will be determined through the comparison of the economic damage following an incident in the proximity of fishing grounds and cruise vessel stops, mapped across the study area.

6.7 RESPONSE (SAR) COMPLEXITY

The potential consequence for loss of life was modified by the distance to search and rescue assets. The reality of the Sub-Antarctic Islands is that an effective SAR response to a serious incident is likely to take days. This means that vessels visiting the islands need to have the ability to deliver self-help and any SAR response would practically be available from another vessel in the vicinity.

6.8 SALVAGE COMPLEXITY

The potential consequences and costs of salvage was modified by the difficulty in undertaking salvage of a wrecked vessel. The difficulty of salvage increases the likelihood of pollution reaching the extremes of the study area.

7 RISK MODEL COMBINATION

7.1 INHERENT RISK

Given the variable cell sizes and the traffic therefore represented as a density; the final result produced is a risk map with each cell showing a hydrographic risk score with each cell directly comparable. The original intent of this study was to use a Risk Model similar to that used for earlier studies Marico Marine has performed for LINZ (including SW Pacific and New Zealand). However, during the data gathering and research phases of study, it became apparent that the characteristics of the Sub-Antarctic Islands were significantly different and warranted a modified approach. The particular points of difference included the relative sparsity of vessel traffic, little or no permanent human habitation and the unique ecological landscape for an array of distinct endemic species. Economic factors are consequently reduced in importance, though it is clear that the remote and unique nature of the Sub-Antarctic Islands makes this location particularly attractive to the tourism industry.

Therefore, the concept of Inherent Risk has been developed. The earlier hydrographic risk assessments used the following approach to build a risk score for each special grid cell:

$$CAUSATION \times CONSEQUENCE = INHERENT\ RISK$$

Inherent risk represents the product of Causation and Consequence, resulting in:

$$TRAFFIC \times INHERENT\ RISK = HYDROGRAPHIC\ RISK$$

7.2 RISK SCORING USING THE RISK MATRIX

The calculations to determine the score of each factor in each cell is based on the values set in the Risk Matrix (**Annex A)**. Ratings and weightings (discussed further in the following sub-sections) were set for the project during the methodology development stage, recognising that a review of results does drive minor modifications to the relationships. It should be noted that rating values are not needed for the ESV factors, which have been introduced for this project. This is because the ESV factors by design, have a relative importance built-in.

At the overview, the overall weightings which make up the raw risk contributions have been applied in accordance with the original methodology - Traffic 25%; Causation Criteria 25%; Consequence Criteria 50%. This section explains the further breakdown of these criteria for risk calculations.

Once the inherent risk was calculated, an additional calculation was performed with unit traffic scoring in each cell to develop an overall risk/quality description of the region. Such information was useful for assessing relative risk for vessels that may start going to locations that are currently not or are infrequently visited. Plots illustrating the distribution of inputs to the risk matrix are found in **Annex C.**

7.3 RISK FACTOR SCORING

Each risk criteria factor was scored on a scale of 0 (absence) to 5 (maximum) given the risk matrix presented in this report. All grid cells used in the analysis therefore have a score for each of the risk factors.

7.4 WEIGHTING

Weightings between the risk factors are also recorded in the risk matrix. The weightings provide a relative significance to each factor with respect to the factors as a whole -in effect ranking them in importance, within the groupings of likelihood and consequence.

7.5 CATEGORY RELATIONSHIP VALUES

The traffic, causation and consequence impact criteria will produce nine scores between 0 and 5.

- Traffic:
    - The highest consequence score (in terms of monetary equivalent) is identified and used as the maximum score of 5. All potential scores are then transformed to a 0 to 5 continuous scale; and
    - Four potential consequences scores for life/pollution/salvage/economic between 0 and 5.
- Causation:
    - The cell scoring for each factor are multiplied by the factor weighted and the sum calculated to give a single cell causation score between 0 and 5.
- Consequence:
    - Response complexity and wreck removal complexity are single cell scores of between 1 and 5;
    - Environmental significance and economic impact are calculated by multiplying the factor scores by the factor weights and summed;
    - This produces four impact scores between 0 and 5.

7.6 CUMULATIVE MODEL

The final model is the total of the four consequences multiplied by the causation factor. In each of the four consequences, the potential from traffic is 25% of the model, the causation factor is 25% of the model and the consequence factor is 50% of the model.

The total score is the summation of:

- Potential loss of life * response complexity * causation factor * 0.42;
- Potential pollution * environmental sensitivity * causation factor * 0.38;
- Potential economic impact * economic significance * causation factor * 0.15;
- Potential salvage costs * salvage complexity * causation factor * 0.05.

Both inherent risk and total risk are presented in the results, along with descriptions of sites of notable risks and what inputs drive risk in these areas.

8 HYDROGRAPHIC RISK RESULTS

8.1 SUB-ANTARCTIC ISLANDS INHERENT RISK RESULTS

The inherent risk result across the study extents is presented at **Figure 40.** Inherent risk is a calculation of contribution made across all the factors, but without the application of traffic. Although leading this section with a plot showing Inherent Risk can cause some confusion, it does show the differing importance of each island group in terms of the ecology they support. At the overview, the plot shows that each Sub-Antarctic Island group supports a range of different endangered species. The application of traffic completes the risk calculation as it includes the consequence effects of an incident affecting the vessel types present.

Figure 40 shows the areas of heightened inherent risk around each of the Island groups, while highlighting some areas of low risk offshore. These offshore regions of low risk primarily represent offshore fishing grounds and great circle routes, rather than typical abiotic/biotic risk factors, which are clustered around the Island groups. This provides a more complete picture of risk in the study extent without requiring the presence of vessel traffic.

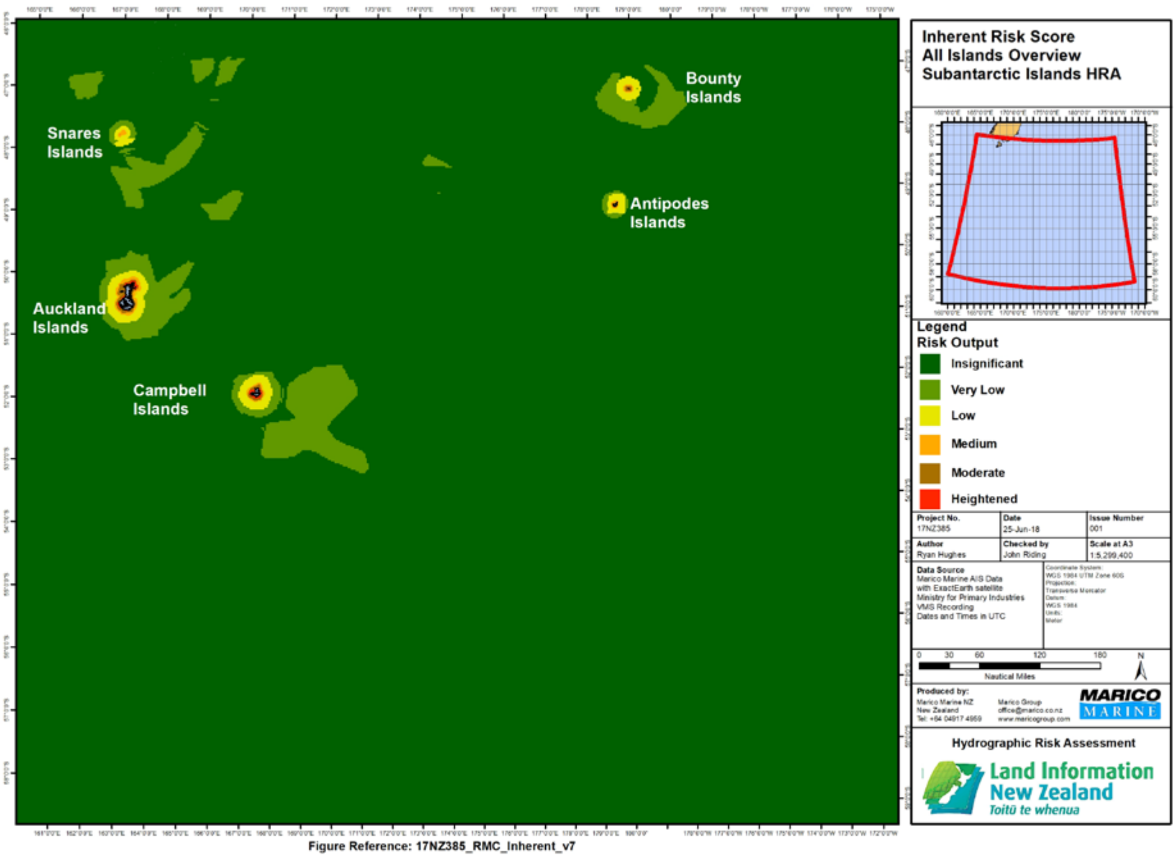


Figure 40: Inherent Risk Result – Sub-Antarctic Islands

8.2 SUB-ANTARCTIC ISLANDS HYDROGRAPHIC RISK RESULT - OVERVIEW

An overview plot of the hydrographic risk result for the Sub-Antarctic Islands is presented at **Figure 41**. The total hydrographic risk is inclusive of traffic data. Heightened risk is evident around each of the Island groups, in particular around Campbell, Auckland and Snares Islands. Areas of moderate risk also feature prominently around the Auckland and Campbell Islands. Regions of low risk are situated around offshore regions and represent fishing grounds and great circle routes, rather than typical abiotic/biotic risk factors, which are clustered around the Island groups.

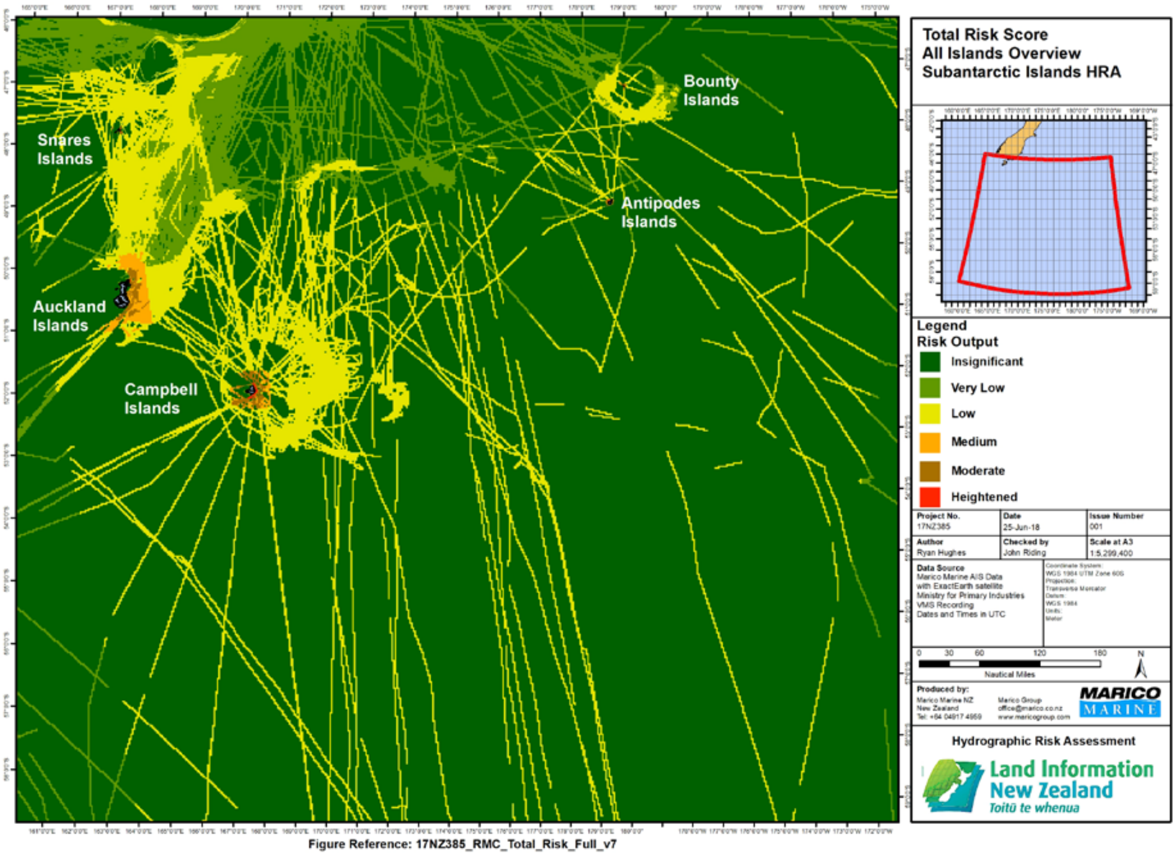


Figure 41: Hydrographic Risk Result - Sub-Antarctic Islands

A comparison of the inherent risk distribution from **Figure 40,** with the Hydrographic Risk Result, above illustrates that the addition of traffic into the risk equation. For example, the distribution of risk to the south of Bounty Islands is evident in both figures and demonstrates where heavy fishing activity takes place, via proximity to fishing grounds in the inherent risk calculation and the fishing vessel tracks themselves in the hydrographic risk calculation.

Differences between the inherent risk and total risk are also apparent when comparing **Figure 40** and **Figure 41**. The inherent risk for the Auckland Islands forms a multi-layered ring of risk around the entire Island group, whereas the total risk for Auckland is low for the majority of the western side – indicating that while risk to the west is high, the absence of vessel traffic does not result in a high total risk score. Comparing the inherent risk and hydrographic risk of the Island groups reveals more detailed similarities and differences and can be found in their relative results sections.

9 RESULTS – AUCKLAND ISLANDS

9.1 INTRODUCTION

This section presents results of the complete risk results including all risk inputs for the Auckland Islands. The components that contribute to the overall hydrographic risk, namely chart quality, marine traffic and the inherent risk, are presented followed by the hydrographic risk results.

9.2 CHARTING – AUCKLAND ISLANDS

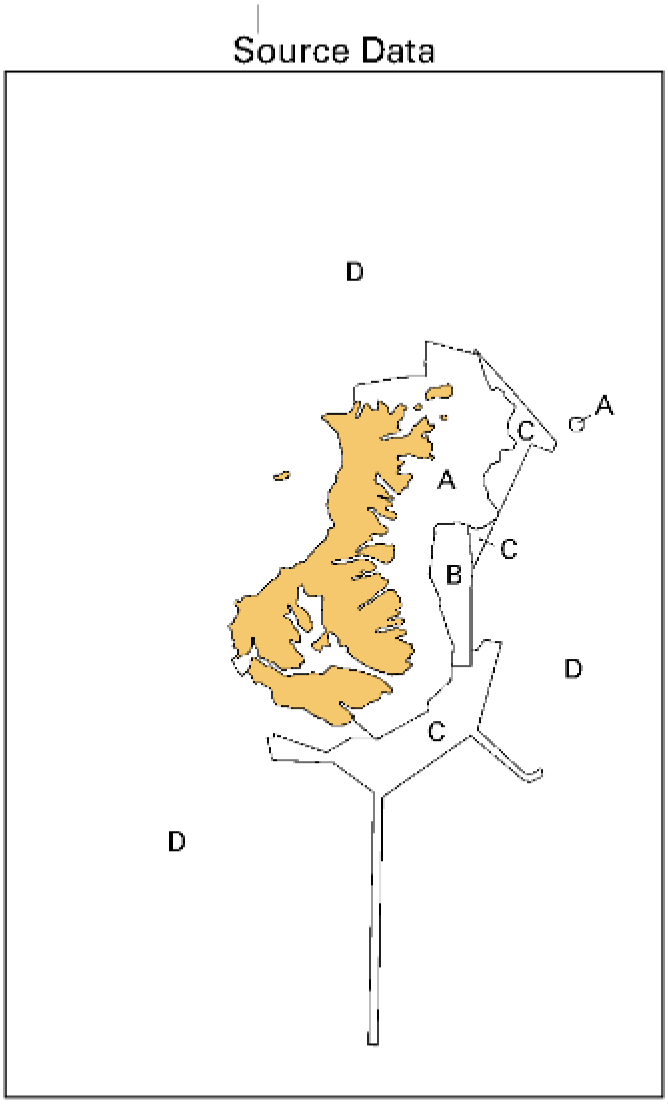
The results for charting quality assessment for Auckland Islands are shown in **Table 10**. **Figures 42** and **43** show the chart source data record of Auckland Islands. **Table 11** and **Figure 45** illustrate the criteria and input for the chart adequacy of the Auckland Islands.

NZ286 - Auckland Islands	
Scale 1:150,000	Published July 1997
Source Data	2015 - Land Information New Zealand. Scale , 1:25,000 1991 – HMNZS Monowai- Scale 1:50,000 and larger 1981-1991 – HMNZS Monowai. Scale 1:100,000, Sketch Surveys Un-surveyed Soundings from various sources.
Coastal Navigation	Mariners should exercise caution when navigating in the vicinity of these Islands due to lack of survey data
ZOC	2015 multibeam survey covers the entire eastern side of the island, from Black Head along the northern coast to Cape Thomson, south of Carnley Hbr, and out through Victoria Passage. This area is ZOC A1. From North East Cape northwards, western side of the island, southwards through to Norman Inlet there is paucity of sounding data with much of the coast not being subject to survey **ZOC 'U'.** Remainder of chart area classed as **ZOC 'D'**
NZ2862 - Plans in the Auckland Islands	
Enderby Island to Smith Harbour, Scale 1:50,000	
Source Data	2015 - Land Information New Zealand. Scale , 1:25,000 1991 – HMNZS Monowai- Scale 1:50,000 and larger 1980-1991 – HMNZS Monowai. Scale 1:100,000 and larger, Sketch Survey. 1840-1945 Sketch surveys from various sources Un-surveyed Soundings from various sources.

Coastal Navigation	Mariners should exercise caution when navigating in the vicinity of these Islands due to lack of survey data
ZOC	Haskell Bay, Chambres Inlet, Granger Inlet and Griffiths Inlet in the east and the area from Black Head to North East Cape in the west and north are extensively covered by the recent LINZ 2015 survey and are classed as ZOC A1.

Smith Harbour to South Cape, Scale 1:50,000	
Source Data	2015 - Land Information New Zealand. Scale , 1:25,000 1991 – HMNZS Monowai- Scale 1:50,000 and larger 1980-1991 – HMNZS Monowai. Scale 1:100,000 and larger, Sketch Survey. 1840-1945 Sketch surveys from various sources Un-surveyed Soundings from various sources.
Coastal Navigation	Mariners should exercise caution when navigating in the vicinity of these Islands due to lack of survey data
ZOC	From Deep Inlet south to and including McLennan Inlet, Gilroy Head to Cape Thomson is classed as **ZOC 'A1'.** From Cape Thomason westwards to South West Cape and the remainder of the western side of the Island **ZOC 'U'** Carnley Harbour – Cape Farr to Grafton Point and the remainder of eastern seaward area **ZOC 'A1'**

Table 10: Chart Quality Information for NZ286 andNZ2862



A. Land Information New Zealand 2015 1:25 000
B. HMNZS MONOWAI 1991 1:50 000 and larger
C. HMNZS MONOWAI Sketch Surveys 1980-1991 1:100 000 and larger
D. Unsurveyed, random soundings from various sources

Figure 42: Chart NZ286 – Auckland Islands, Source Data

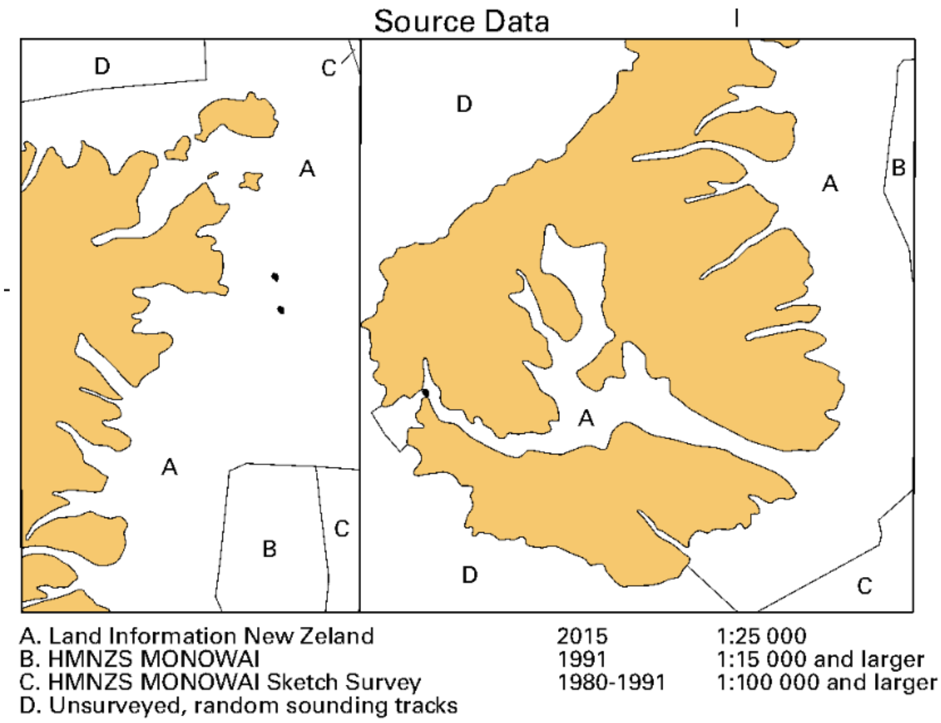


Figure 43: Chart NZ2862 – The Auckland Islands, Source Data

Chart quality within the Auckland Islands is variable, **Figure 44**. Already improved charting quality coincides with the harbour entrances on the eastern region of Auckland Island. The eastern region of the Auckland Islands is comparatively more sheltered than the western region, resulting in a focus of completed hydrographic surveys on the eastern side. This focused survey approach has resulted in sections of unsurveyed areas on the western side of the Island, but excellent charting adequacy through harbour approaches. Outwards of Auckland Islands charting quality has a CATZOC score of D, classified as poor.

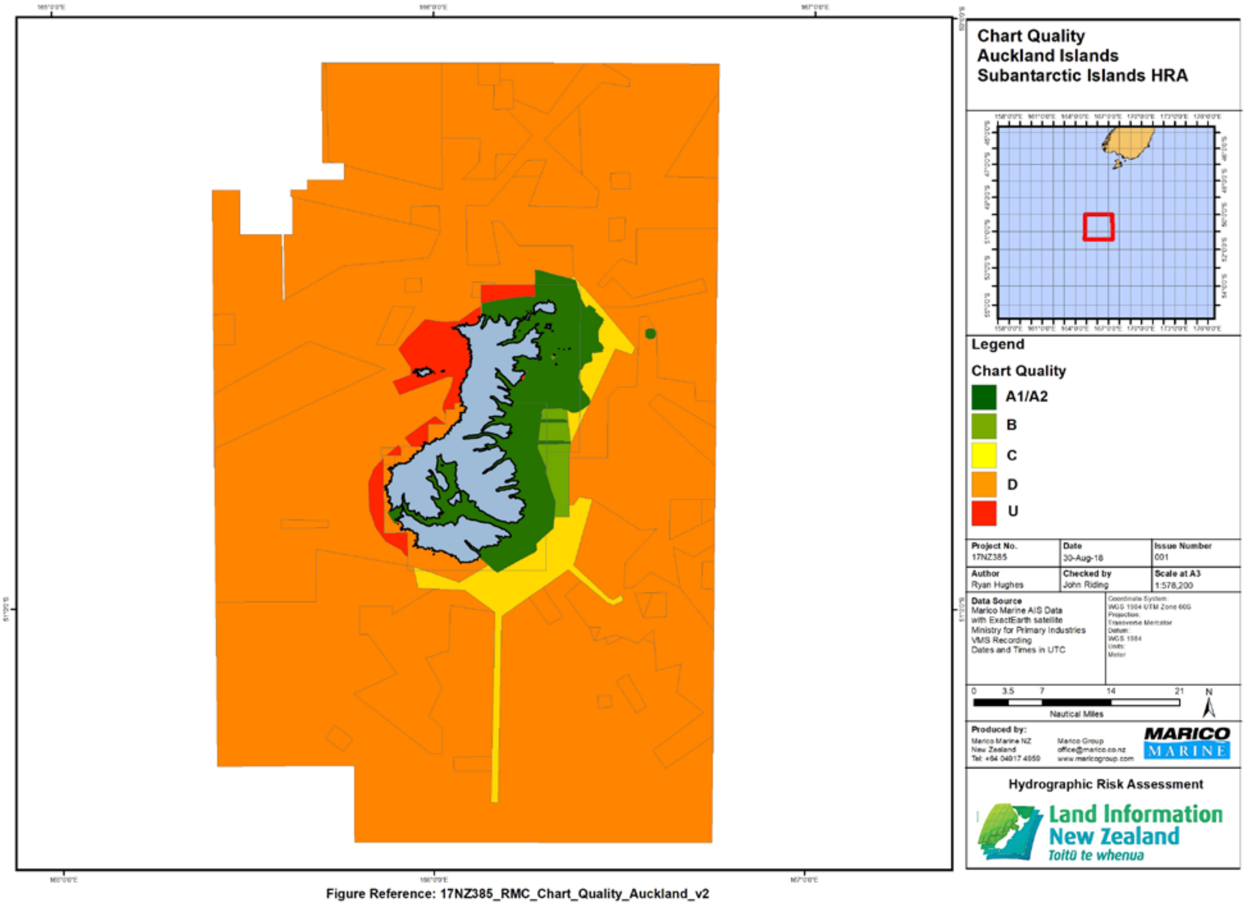


Figure 44: Chart Quality, Auckland Islands

Scales	Chart	CATZOC and Criteria Score	Survey Age and Criteria Score	Overall Charting Adequacy Score
1 : 25 000	NZ2862 Plan	A (1), B (2), C (3), D(4), U (5)	1980 (5), 1991 (4), 2015 (1), Unsurveyed (5)	Moderate (3)
1 : 50 000	NZ2862 Plan			
1 : 50 000	NZ2862 Plan			
1: 150 000	NZ286			

Table 11: Charting Adequacy Criteria and Input, Auckland Islands

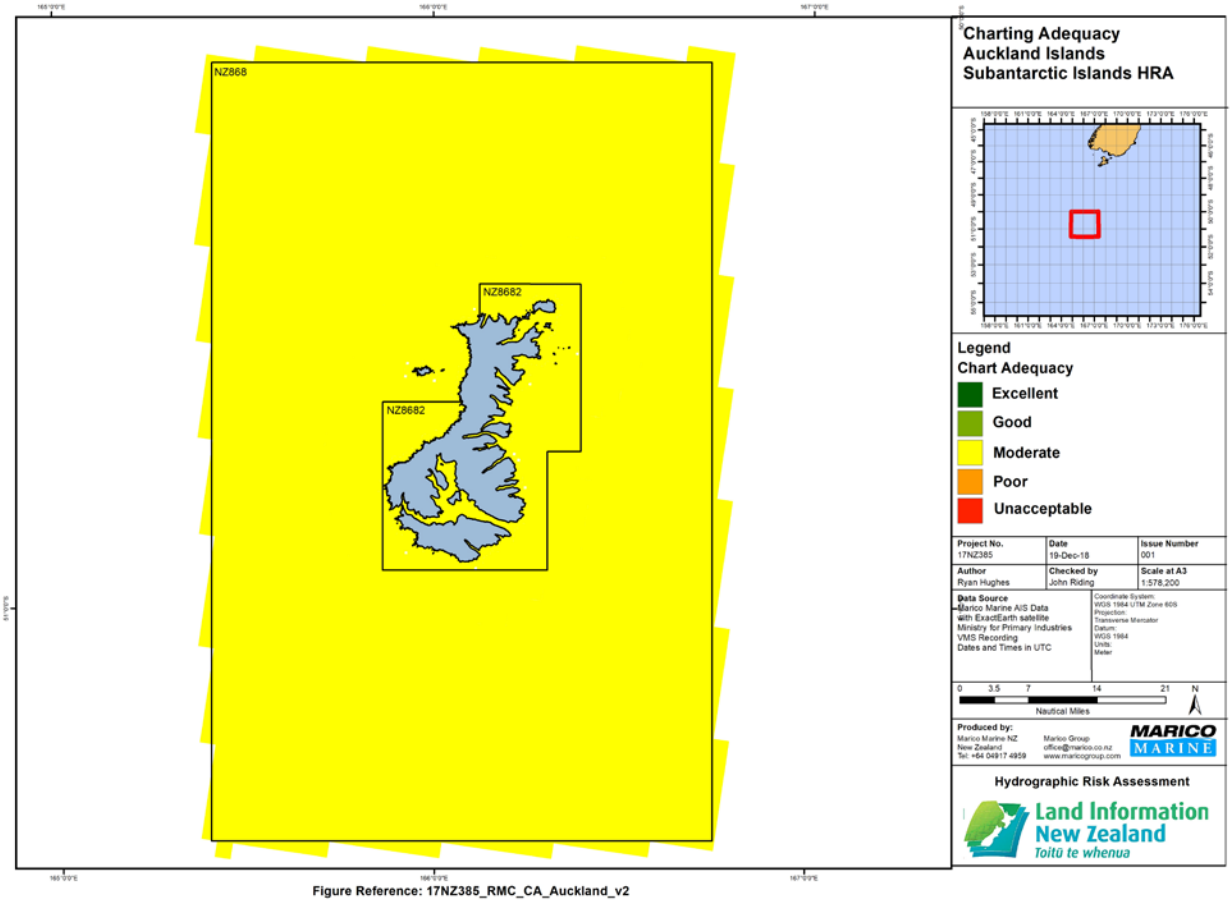


Figure 45: Chart Adequacy, Auckland Islands

As seen in **Figure 45**, the overall chart adequacy score for the Auckland Islands is Moderate. The Auckland Islands contain a variation of scales (**Table 11**), and CATZOC scores ranging from A – U. Survey age scores well on the eastern side of the islands and within the harbour, although the western side remains unsurveyed.

9.3 INHERENT RISK RESULT – AUCKLAND ISLANDS

The inherent risk at the Auckland Islands is presented in **Figure 46,** illustrating the variation and distribution of species across the island group. For example, the northern area of the island group, containing northern Auckland Island and Enderby Island, holds a high number of species colonies and breeding sites with a range of ESV scores. This results in an area of high inherent risk. The southern area of the island group, containing southern Auckland Island and Adams Island, also contain a wide distribution of species, with breeding sites having a range of ESV scores along the coast and within Carnley Harbour. By comparison to both of the areas to the north and south, the centre of Auckland Island contains relatively fewer species, resulting in a moderate risk score.

A zone of low risk surrounds the Island group, and diverges into two channels to the East, mirroring the fishing grounds that are located there.

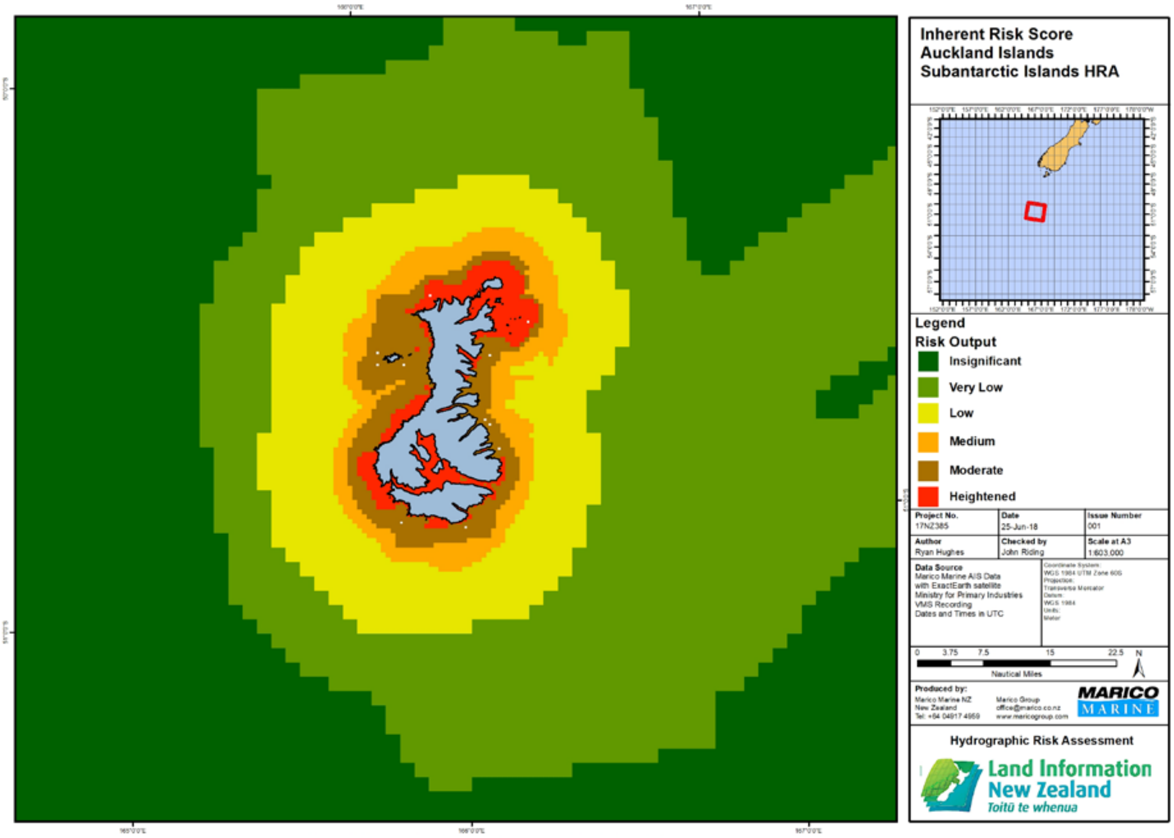


Figure 46: Inherent Risk, Auckland Islands, Standard Scale

9.4 SITES OF NOTABLE INHERENT RISK – AUCKLAND ISLANDS

Areas of heightened inherent risk within Auckland Islands are detailed in **Figure 47.** Twelve locations have been identified; North Harbour, Enderby Island, Port Ross, Ewing Island, Dundas Island, Chambres Inlet, Carnley Harbour—North Arm, Carnley Harbour—Western Arm, Carnley Harbour—Entrance, Adams Island, Victoria Passage, Auckland Island – West. The contributing factors to heightened inherent risk are detailed in **Table 12**. There are a number of contributing factors associated with heightened inherent risk within the Auckland Islands, most notably, the high number of species colonies that are in close proximity to each other, proximity to charted tidal hazards, proximity to charted isolated dangers. Three areas showed chart quality contributed to heightened inherent risk, these areas are the southern coast of Adams Island, Victoria passage and Auckland Island-West.

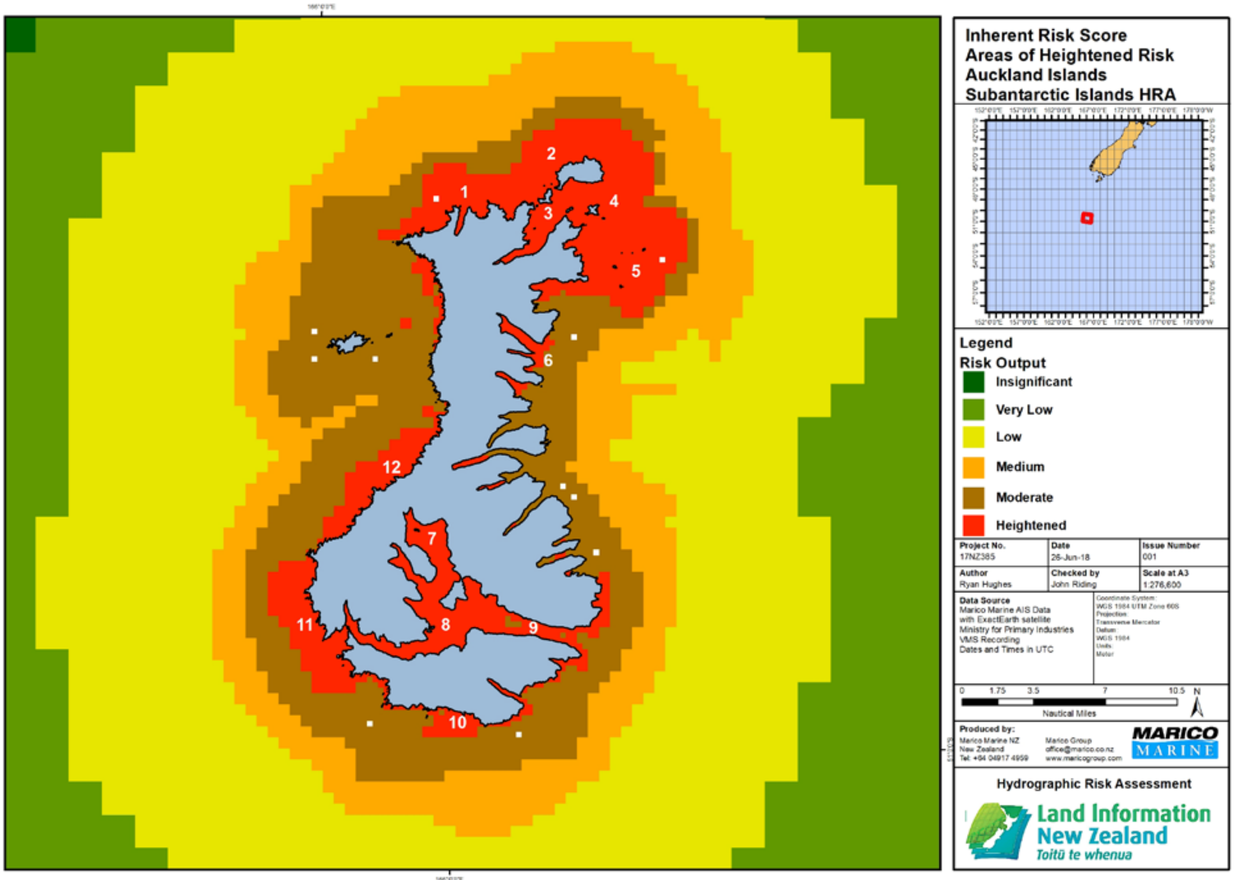


Figure 47: Sites of Notable Inherent Risk, Auckland Islands

Site #	Location	Risk Level	Risk Source
1	North Harbour	Heightened	• High number of species colonies and breeding sites in close proximity • Proximity to Charted Isolated Dangers • Proximity to Tourist Sites
2	Enderby Island	Heightened	• High number of species colonies and breeding sites in close proximity • Proximity to Charted Tidal Hazards • Proximity to Isolated Dangers • Proximity to Tourist Sites
3	Port Ross	Heightened	• High number of species colonies and breeding sites in close proximity • Proximity to Isolated Dangers • Proximity to Tourist Sites • Shallow Depth
4	Ewing Island	Heightened	• High number of species colonies and breeding sites in close proximity. • Proximity to Charted Tidal Hazards • Proximity to Isolated Dangers • Proximity to Tourist Sites
5	Dundas Island	Heightened	• High number of species colonies and breeding sites in close proximity.

Site #	Location	Risk Level	Risk Source
			• Proximity to Charted Tidal Hazards • Proximity to Isolated Dangers • Shallow/Uncharted Depth
6	Chambres Inlet	Heightened	• Proximity to Tourist Sites
7	Carnley Harbour—North Arm	Heightened	• High number of species colonies and breeding sites in close proximity • Proximity to Isolated Dangers • Proximity to Tourist Sites
8	Carnley Harbour—Western Arm	Heightened	• High number of species colonies and breeding sites in close proximity • Proximity to Isolated Dangers • Proximity to Tourist Sites
9	Carnley Harbour—Entrance	Heightened	• High number of species colonies and breeding sites in close proximity • Proximity to Isolated Dangers • Proximity to Tourist Sites
10	Adams Island (Southern Coast)	Heightened	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Shallow/Uncharted Depth
11	Victoria Passage	Heightened	• High number of species colonies and breeding sites in close proximity • Proximity to Charted Tidal Hazards • Proximity to Isolated Dangers • Low CATZOC Score • Proximity to Tourist Sites • Shallow Depth
12	Auckland Island—West	Heightened	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Shallow/Uncharted Depth

Table 12: Sites of Notable Inherent Risk in the Auckland Islands

9.5 TRAFFIC ANALYSIS – AUCKLAND ISLANDS

This section provides plots of all traffic in the area surrounding the Auckland Islands. A plot of all vessel types recorded in the area for the study period is shown in **Figure 48.** The corresponding total vessel traffic density for the area is shown in **Figure 49**. The vessel track density illustrates that the inshore regions with highest traffic are the entrances to Port Ross at the north of Auckland Island and Carnley Harbour in the south. Offshore of the Auckland Islands, high vessel traffic densities are found to the North and Southeast. These areas correspond to water depths between 200m and 500m where valuable commercial fish species such as Ling are found.

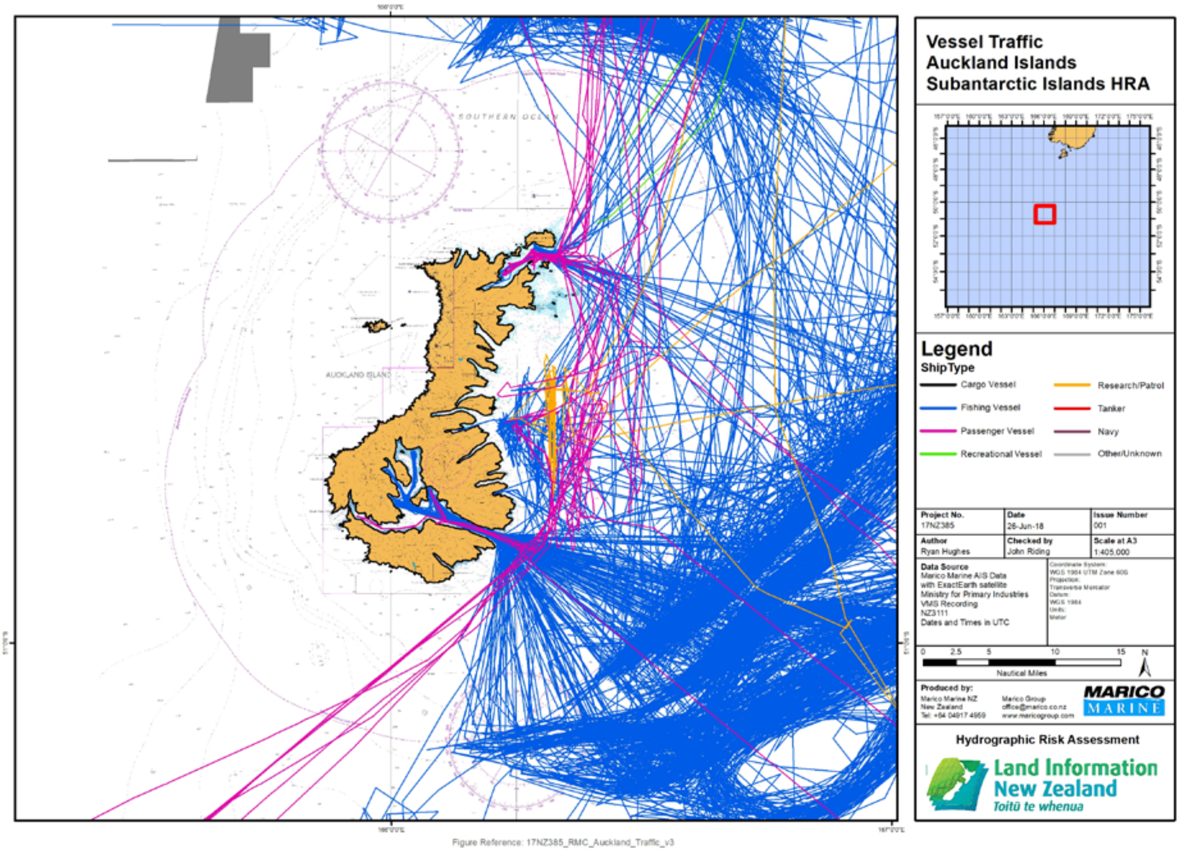


Figure 48: Vessel Tracks, Auckland Islands

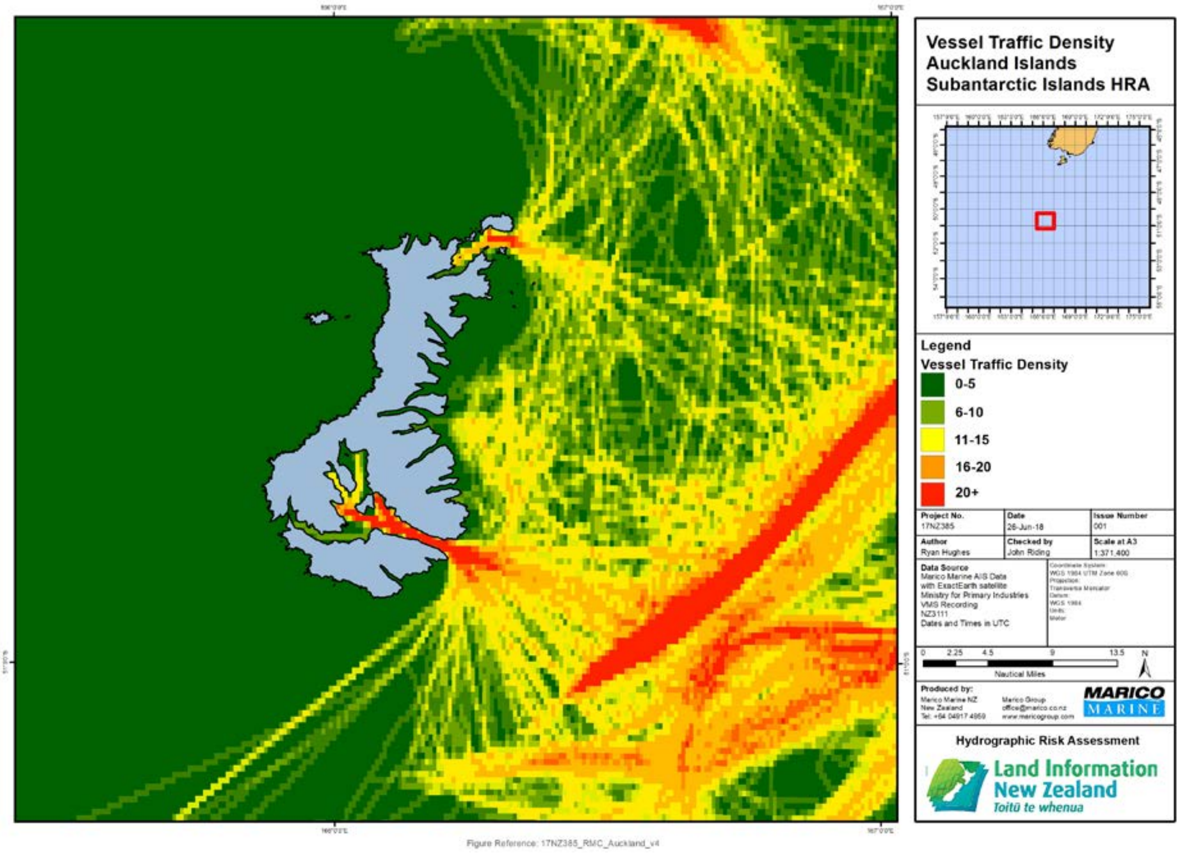


Figure 49: Vessel Track Density, Auckland Islands, Standard Scale

9.6 HYDROGRAPHIC RISK RESULT – AUCKLAND ISLANDS

The summation of risk components inclusive of vessel traffic accounts for the hydrographic risk for the Auckland Islands (**Figure 50**). With the majority of the vessel traffic concentrated at the harbour entrances (Port Ross and Carnley Harbour) areas of heightened risk are evident. Heightened risk appears in areas where vessel traffic interacts with locations of colonies and breeding sites that are highly sensitive. Many of these species occur in close proximity to one another, resulting in high ESV group scores. Offshore of the Auckland Islands, regions of medium and moderate risk are concentrated around commercial fishing grounds where high vessel traffic densities are present. As vessel traffic does not at present travel to the western regions of the Island, minimal hydrographic risk is exhibited.

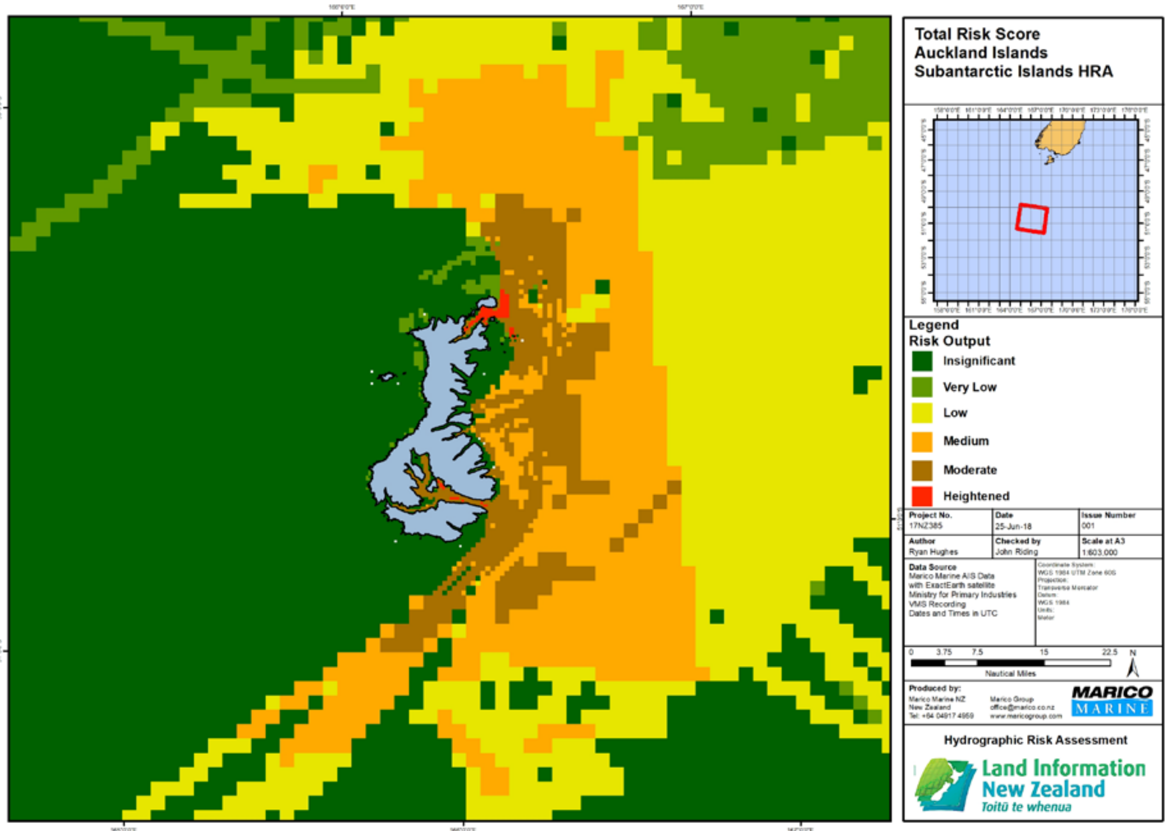


Figure Reference: 17NZ385_RMC_Total_Risk_Auckland_v2

Figure 50: Hydrographic Risk Result - Auckland Islands - Standard Scale

9.7 SITES OF NOTABLE HYDROGRAPHIC RISK – AUCKLAND ISLANDS

The hydrographic risk was moderate at five locations and heightened at six locations within the Auckland Islands. This is visually depicted in **Figure 51**. Areas of heightened risk are evident where there is heavy traffic, such as within the harbour entrances of Auckland Island, in particular, Port Ross, Enderby Islands, Ewing Island, Dundas Islands, Carnley Harbour – entrance and Auckland Island – East. Traffic type contributing to heightened risk within

Auckland Island has both fishing and passenger vessel traffic. Moderate traffic risk within Auckland Islands is focused around the fishing traffic (**Table 12**).

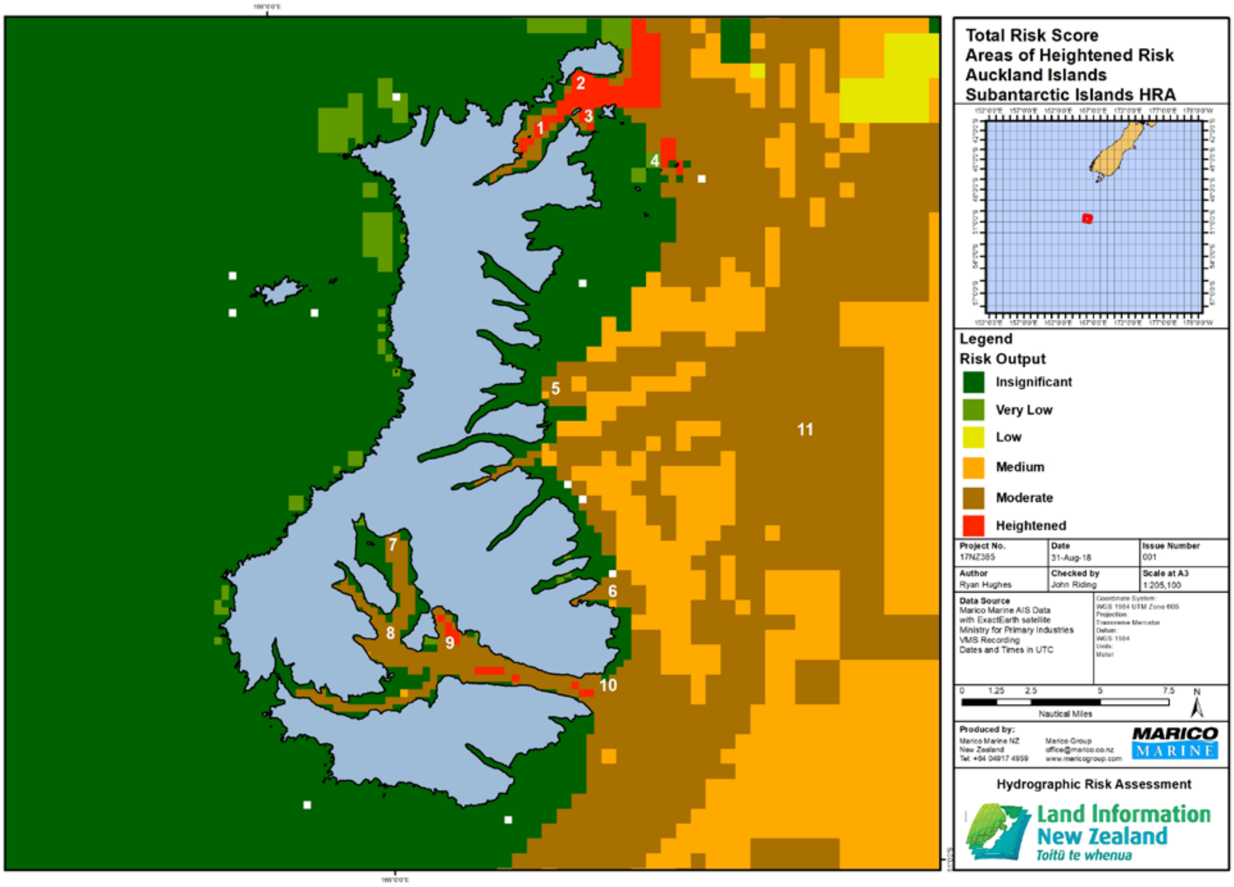


Figure Reference: 17NZ385_ES_Total_Risk_Auckland_v2

Figure 51: Sites of Notable Hydrographic Risk - Auckland Islands

Site #	Location	Risk Level	Traffic of Notable Risk Contribution
1	Port Ross	Heightened	Fishing + Passenger
2	Enderby Island	Heightened	Fishing + Passenger
3	Ewing Island	Heightened	Fishing + Passenger
4	Dundas Island	Heightened	Fishing + Passenger
5	Falla Peninsula	Moderate	Fishing + Passenger
6	Cape Bennett	Moderate	Fishing
7	Carnley Harbour—North Arm	Moderate	Fishing
8	Carnley Harbour—Western Arm	Moderate	Fishing
9	Carnley Harbour—Tagua Bay	Moderate	Fishing
10	Carnley Harbour—Entrance	Heightened	Fishing (Heavy) + Passenger
11	Auckland Island—East	Heightened	Fishing + Passenger + Research/Patrol

Table 13Sites of Notable Hydrographic Risk - Auckland Islands

10 RESULTS – CAMPBELL ISLANDS

10.1 INTRODUCTION

This section presents results of the complete risk results for the Campbell Islands. The components that contribute to the overall hydrographic risk, namely chart quality, marine traffic and the inherent risk, are presented followed by the hydrographic risk results.

10.2 CHARTING – CAMPBELL ISLANDS

The results for the charting quality for Campbell Islands are shown below in **Table 14. Figure 51** represents the charting source data at Campbell Islands. **Table 15** and **Figure 54** illustrate the criteria and input for the chart adequacy of the Campbell Islands.

NZ 3111 – Campbell Island/Motu Ihupuku	
Campbell Island/Motu Ihupuku, Scale 1:150,000	
Source Data	1985 - HMNZS Monowai 1:100,000
Coastal Navigation	Coastal Navigation. Mariners should exercise caution when navigating in the vicinity of these Islands due to lack of survey data and differing variations between plans
ZOC	Northeast Harbour is classed as **ZOC 'B'**. Eastern side of Island from Bull Rock to South Point up to 7nm off shore is classed as **ZOC 'C'**. The remainder of adjacent sea, including the western side of the island is classed as **ZOC 'D'**.

Campbell Island Plans - Perseverance Harbour, Scale 1:50,000	
Source Data	1985 - HMNZS Monowai, scale 1:31,860
Coastal Navigation	Coastal Navigation. Mariners should exercise caution when navigating in the vicinity of these Islands due to lack of survey data and differing variations between plans
ZOC	Inlet classed as **ZOC 'B'**

Table 14: Chart Quality Information for NZ 3111 Relating to the Campbell Islands

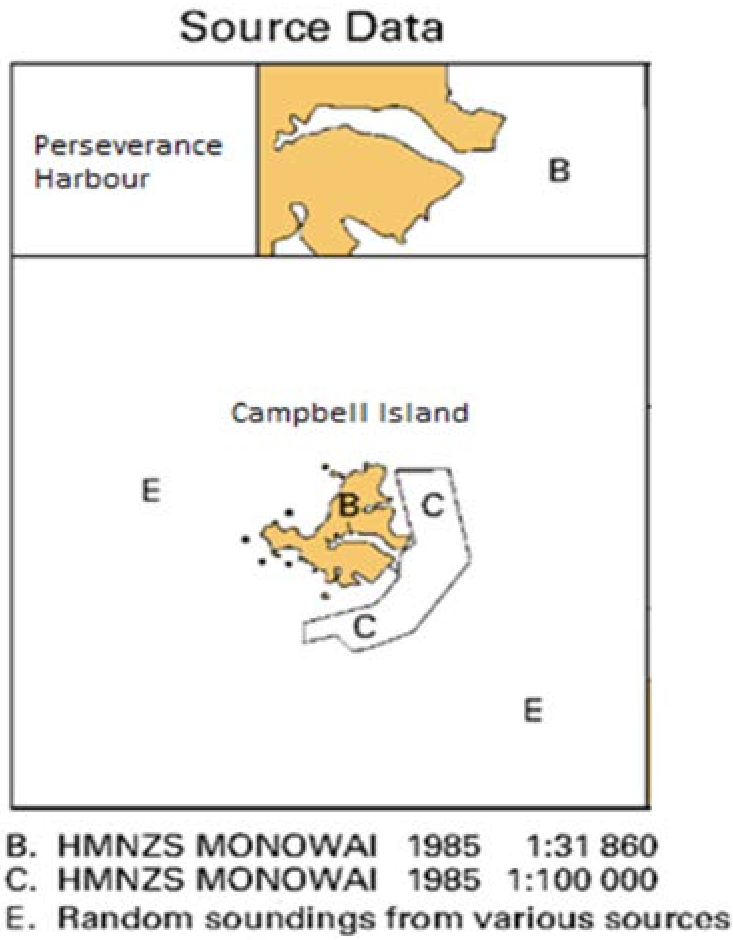


Figure 52: Chart NZ3111 – Campbell Island/Motu Ihupuku, Source Data

The overall chart quality for Campbell Island is illustrated in **Figure 53**. The chart quality shows similar trends to Auckland Islands where the quality coincides with the harbour entrances on the eastern region of the Island. The eastern region of Campbell Islands is comparatively more sheltered than the western region resulting in a focus of hydrographic surveying on the eastern side. The chart quality around the island has a CATZOC rating of C and D and therefore is classified as moderate to poor. The area within Perseverance Harbour is classed as CATZOC B and is considered good.

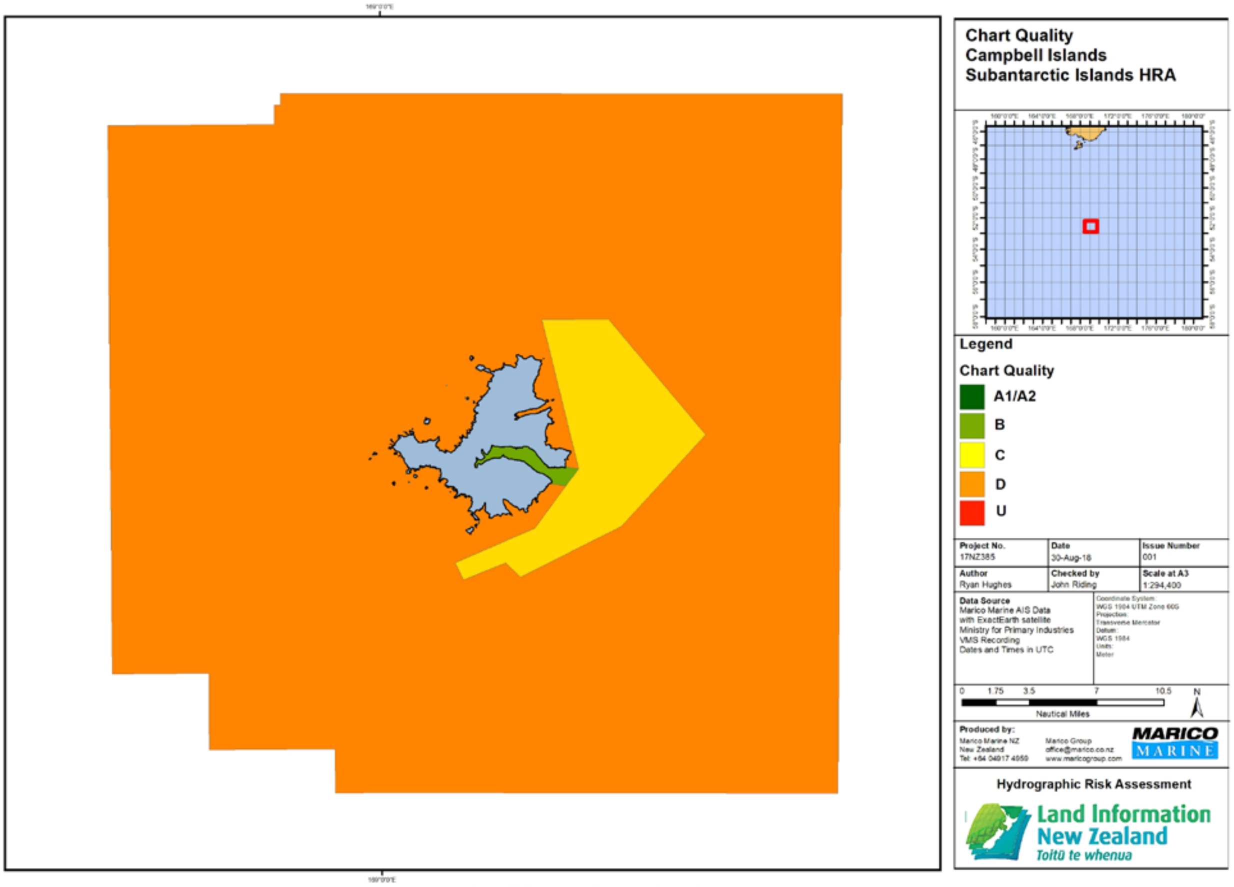


Figure Reference: 17NZ385_RMC_Chart_Quality_Campbell_v2

Figure 53: Chart Quality Plot - Campbell Islands

Scales	Chart	CATZOC and Criteria Score	Survey Age and Criteria Score	Overall Charting Adequacy Score
1 : 50 000	NZ3111 Plan	B (2), C (3), D (4)	1985 (5)	Poor (4)
1 : 150 000	NZ3111			

Table 15: Charting Adequacy Criteria Assessment Data - Campbell Islands

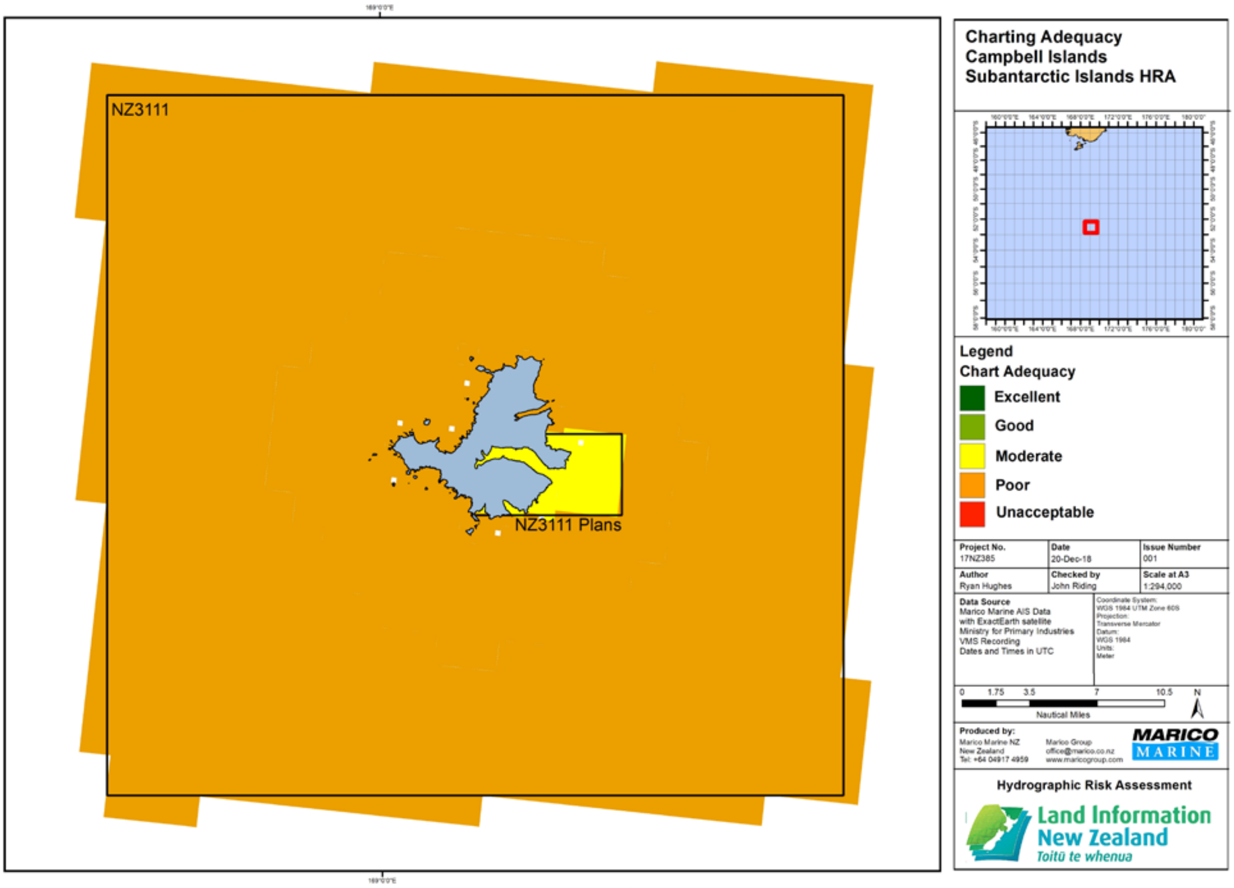


Figure 54: Chart Adequacy, Campbell Islands

As seen in **Figure 54**, the overall chart adequacy score for the Campbell Islands is Poor, with the area within the NZ3111 plans scoring moderate. The Campbell Islands have two scales and the CATZOC scores varying from B – D. The survey age at Campbell Islands (**Table 15**) originates from 1985, with random soundings comprising much of the charting information.

10.3 INHERENT RISK – CAMPBELL ISLANDS

The inherent risk result of the Campbell Islands is presented in **Figure 55** and shows a ring of heightened risk that extends around the entire island group. This is likely a result of the bathymetrical soundings at the Campbell Islands originating from "Random soundings from various sources". This has led to a default maximum risk score for the depth of water route characteristic extending from the islands out to the first recorded depth sounding – which was sometimes notably offshore and often began at depths of over 100m.

The presence of heightened risk surrounding the island group is further exacerbated by the distribution of numerous species across the coastline, many of which occur in close proximity to one another, resulting in high ESV group scores.

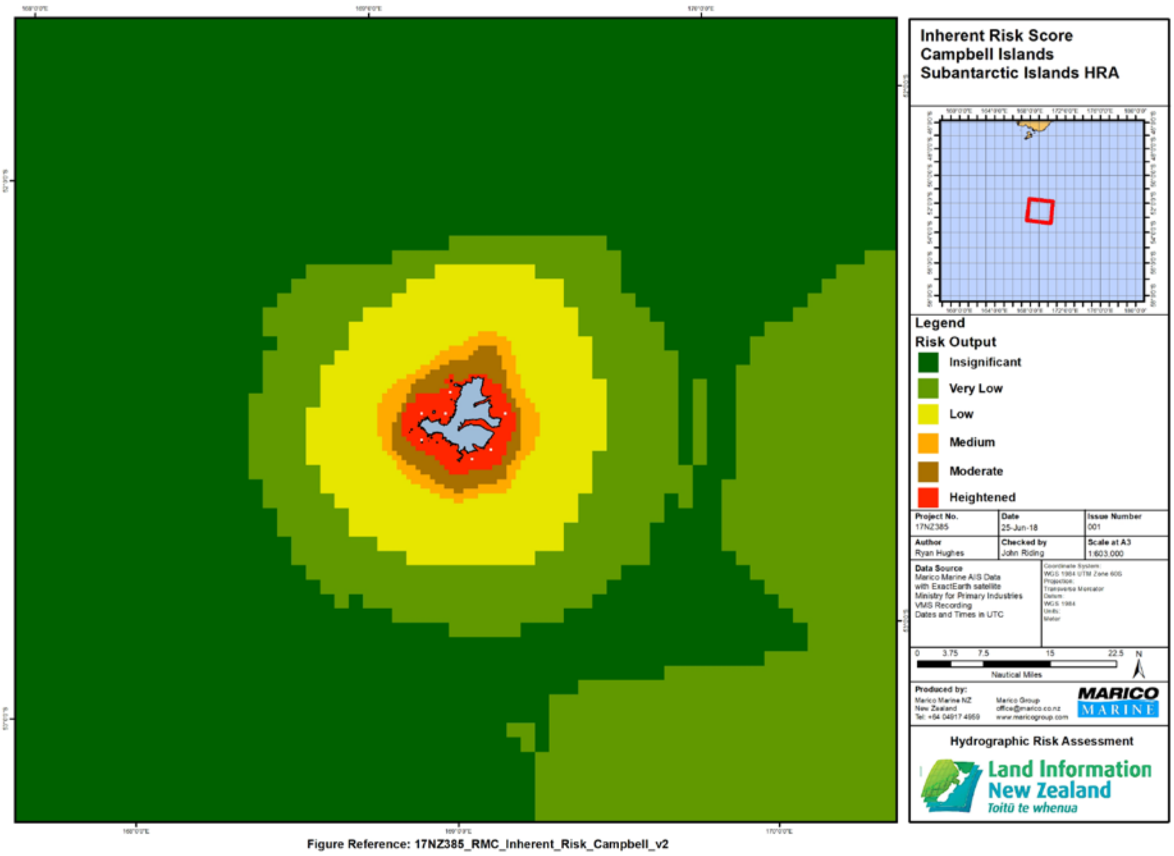


Figure 55: Inherent Risk, Campbell Islands, Standard Scale

10.4 SITES OF NOTABLE INHERENT RISK – CAMPBELL ISLANDS

Areas of heightened inherent risk within Campbell Islands are detailed below in **Figure 54.** Ten locations have been identified; Isle de Jeanette Marie, North Cape, North East Harbour, East Cape, Perseverance Harbour, South East Harbour, Jacquemart Island, Survey Island, Penguin Point and Northwest Bay. The contributing factors to heightened inherent risk are detailed in **Table 14**. There are a number of contributing factors associated with heightened inherent risk within Campbell Islands, most notably, the high number of species colonies that are in close proximity, charting quality (low CATZOC score) and shallow/uncharted depths.

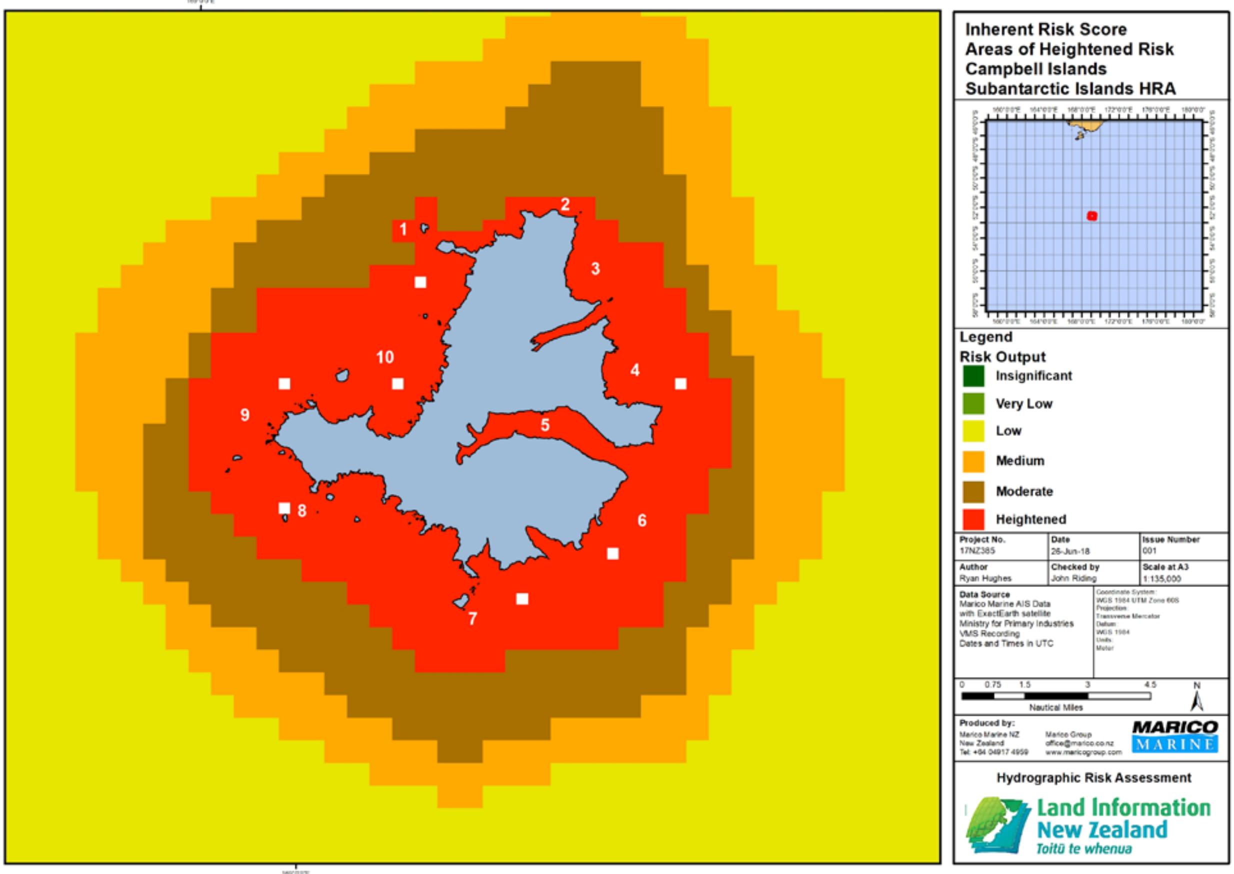


Figure Reference: 17NZ385_ES_Inherent_Campbell_v2

Figure 56: Sites of Notable Inherent Risk - Campbell Islands

Site #	Location	Risk Level	Risk Source
1	Isle de Jeanette Marie	Heightened	• High number of species colonies and breeding sites in close proximity • Proximity to Charted Tidal Hazards • Low CATZOC Score • Shallow/Uncharted Depth
2	North Cape	Heightened	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Proximity to Isolated Dangers • Shallow/Uncharted Depth
3	North East Harbour	Heightened	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Shallow/Uncharted Depth
4	East Cape	Heightened	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Proximity to Isolated Dangers • Shallow/Uncharted Depth

Site #	Location	Risk Level	Risk Source
5	Perseverance Harbour	Heightened	• High number of species colonies and breeding sites in close proximity • Proximity to Isolated Dangers • Proximity to Seamounts
6	South East Harbour	Heightened	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Shallow/Uncharted Depth
7	Jacquemart Island	Heightened	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Proximity to Isolated Dangers • Shallow/Uncharted Depth
8	Survey Island	Heightened	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Shallow/Uncharted Depth
9	Penguin Point	Heightened	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Shallow/Uncharted Depth
10	Northwest Bay	Heightened	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Shallow/Uncharted Depth

Table 16: Sites of Notable Inherent Risk in the Campbell Islands

10.5 TRAFFIC ANALYSIS - CAMPBELL ISLANDS

This section provides plots of all traffic in the area surrounding Campbell Island. A plot of all vessel types recorded in the area for the study period is shown in **Figure 57**. The corresponding total vessel traffic density for the area is shown in **Figure 58**. The vessel track density illustrates that the inshore region with highest traffic is the entrance to Perseverance Harbour. The highest vessel traffic densities offshore are found to the immediate East of the island, where a significant proportion are fishing vessels finding shelter from the prevailing westerly winds.

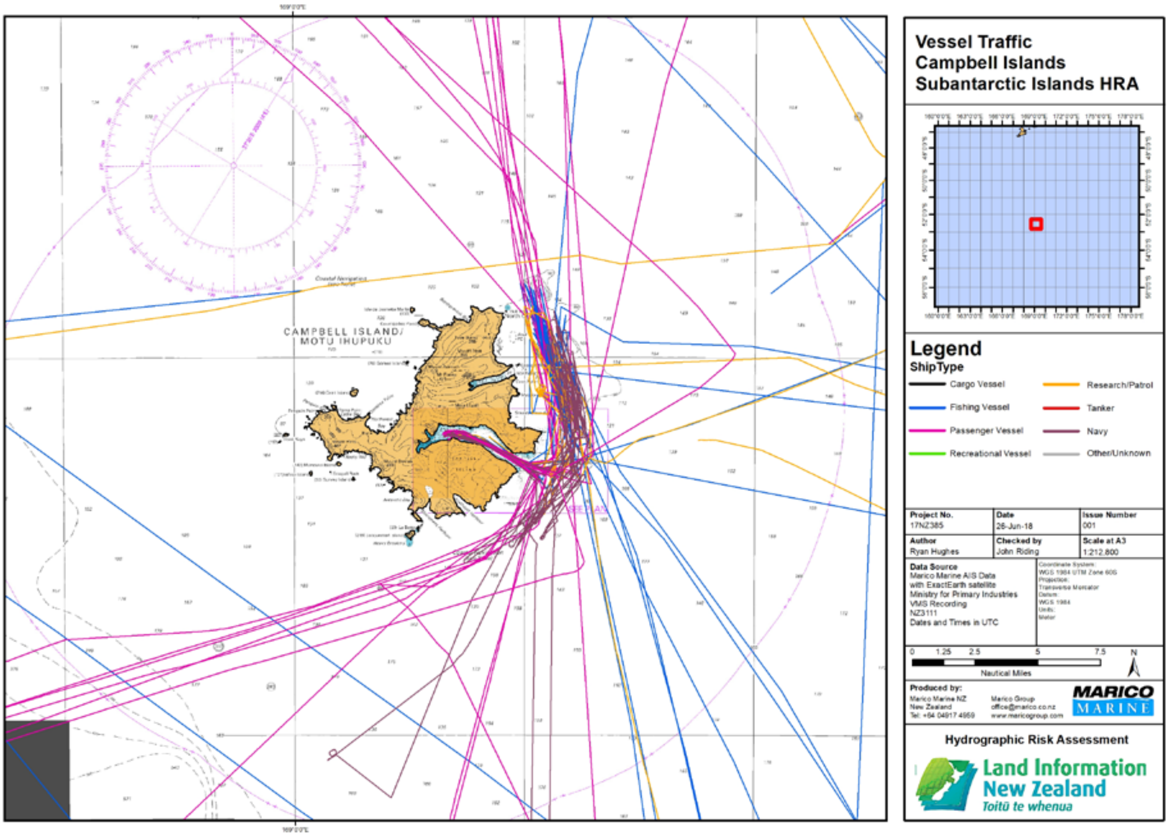


Figure 57: Vessel Tracks, Campbell Islands

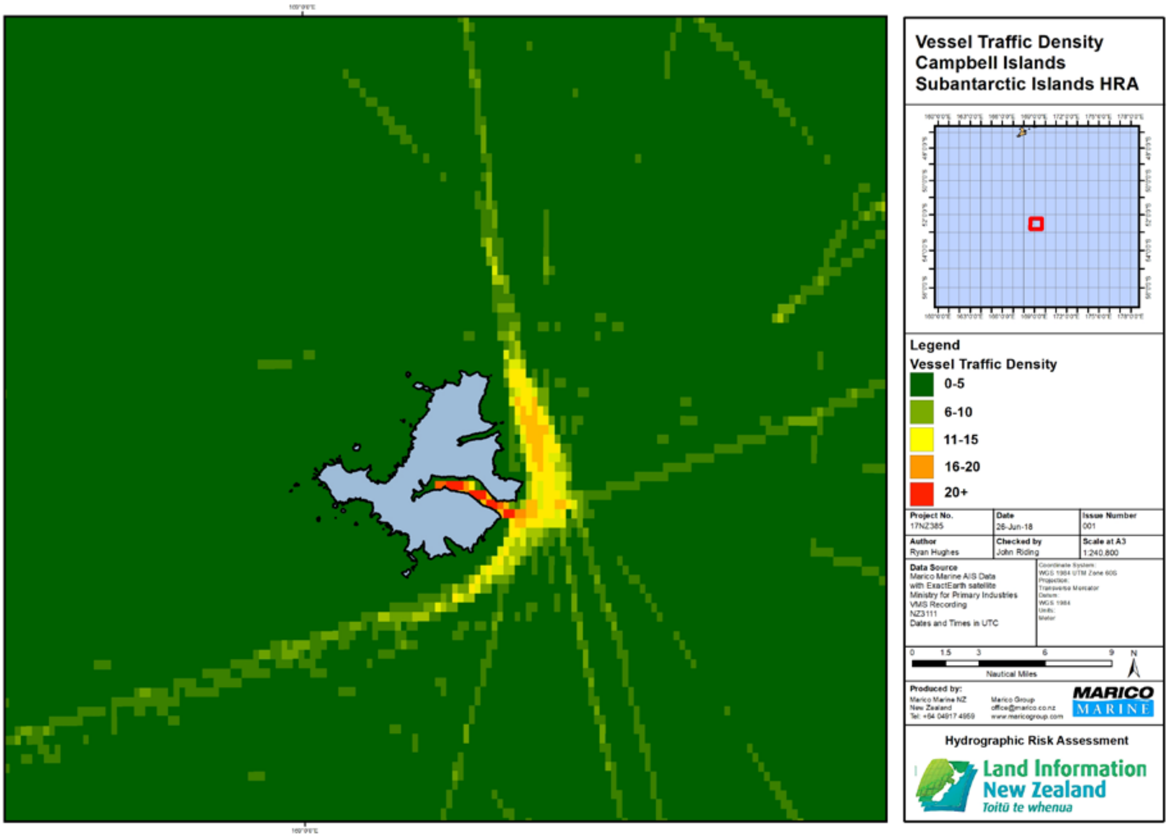


Figure 58: Vessel Track Density, Campbell Islands, Standard Scale

10.6 HYDROGRAPHIC RISK RESULT – CAMPBELL ISLANDS

The summation of risk components accounts for the hydrographic risk for Campbell Island (**Figure 59**). The hydrographic risk result for Campbell Island is heightened around areas where vessel traffic coincides with higher inherent risk locations. With large numbers of vessels sheltering on the eastern side of the Island, in addition to the entrance to Perseverance Harbour, heightened risk is evident within these areas. Heightened risk is concentrated around the eastern coast and is likely influenced by the underlying chart quality. The result provides a higher risk score for deeper waters, where vessels transit, due to unreliable bathymetrical soundings. These are referenced in the chart as "Random soundings from various sources." Additionally, the distribution of highly sensitive species across the coastline, many of which occur in close proximity to one another, results in high ESV group scores.

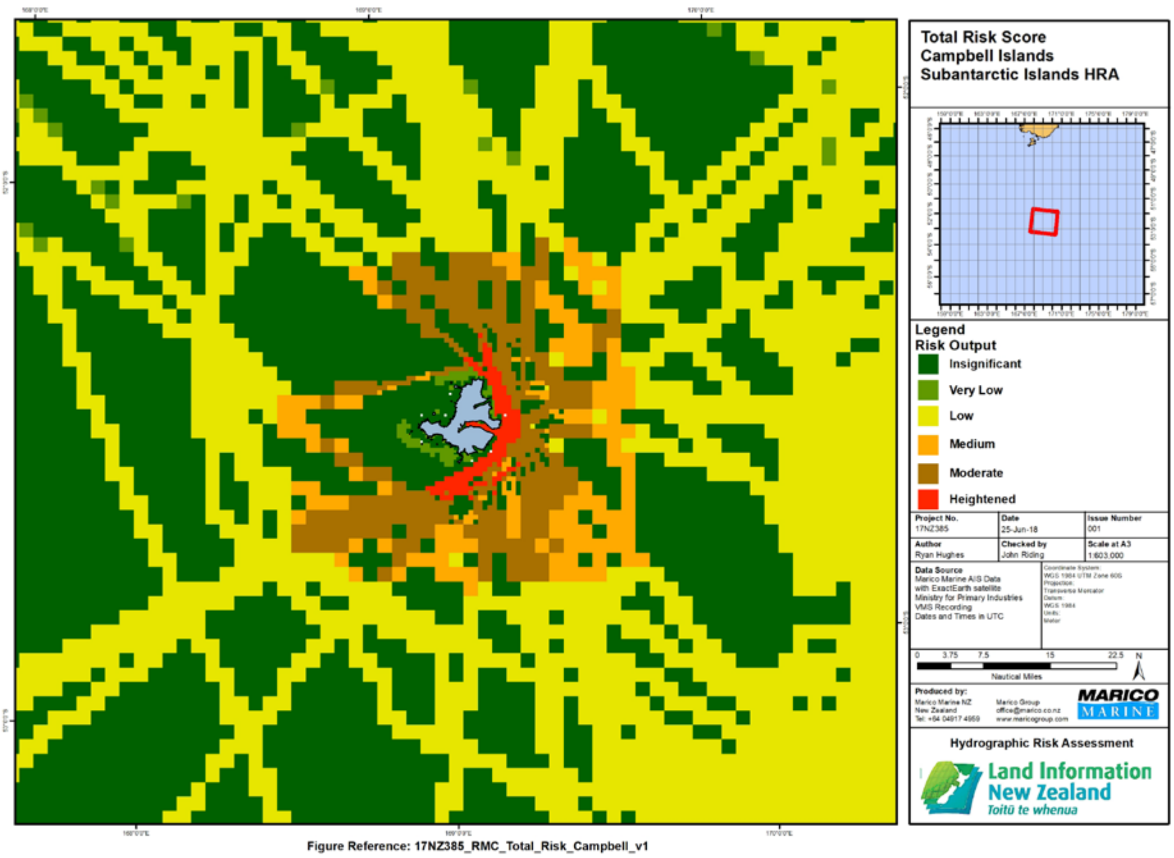


Figure 59: Hydrographic Risk Result - Campbell Islands - Standard Scale

10.7 SITES OF NOTABLE HYDROGRAPHIC RISK – CAMPBELL ISLANDS

The hydrographic risk was heightened at four locations with Campbell Islands. This is visually depicted in **Figure 58**. Areas of heightened risk are evident within the Eastern coast and the entrance to the harbour of Campbell Islands. These areas are the North Cape, East Cape, Perseverance Harbour and Campbell Island - South. Perseverance, in particular, has an inset plan of scale 1:50,000 and given the DOC licencing requirements, this could be increased to 1:22,000 or even 1:12,000. Traffic type contributing to heightened risk within Campbell Islands were fishing traffic, passenger traffic, and traffic associated with research/patrol from the Navy (HMNZ Otago) (**Table 15**).

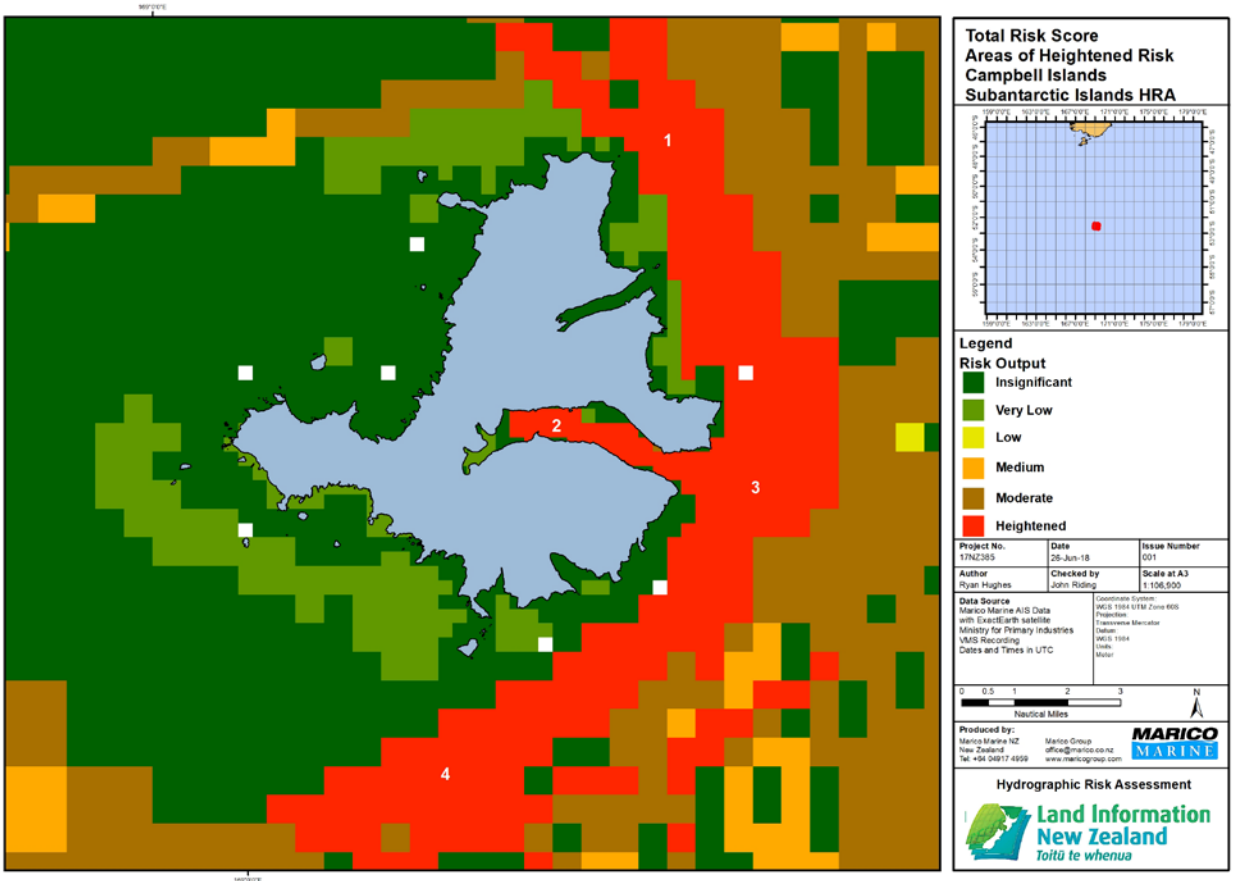


Figure Reference: 17NZ385_ES_Total_Risk_Campbell_v2

Figure 60: Sites of Notable Hydrographic Risk, Campbell Islands

Site #	Location	Risk Level	Traffic of Notable Risk Contribution
1	North Cape	Heightened	Fishing + Passenger + Research/Patrol + Navy (Otago)
2	Perseverance Harbour	Heightened	Fishing + Passenger + Research/Patrol + Navy (Otago)
3	East Cape	Heightened	Fishing + Passenger + Research/Patrol + Navy (Otago)
4	Campbell Island—South	Heightened	Passenger

Table 17: Sites of Notable Hydrographic Risk in the Campbell Islands

11 RESULTS – BOUNTY ISLANDS

11.1 INTRODUCTION

This section presents the hydrographic risk results for the Bounty Islands. The components that contribute to hydrographic risk, namely chart quality, marine traffic and inherent risk, are presented first, followed by hydrographic risk.

11.2 CHARTING – BOUNTY ISLANDS

The results for charting quality for the Bounty Islands are shown below in **Table 18**. **Figure 61** represents the charting source data record at Bounty Islands.

Table 19 and **Figure 63,** in combination, represent the criteria used for a mariner to make an of assessment of determine a chart adequacy rating for the Bounty Islands risk output.

NZ 3111 – Bounty Islands	
Scale 1:25,000 and 1:100,000	
Source Data	2005 LINZ, 1:50,000 and larger.
ZOC	Area immediately surrounding landmass ZOC 'U', channels between the islands and remaining sea area shows regularly spaced sounding data **ZOC 'A1'**

Table 18: Chart Quality Information for NZ3111 Relating to the Bounty Islands

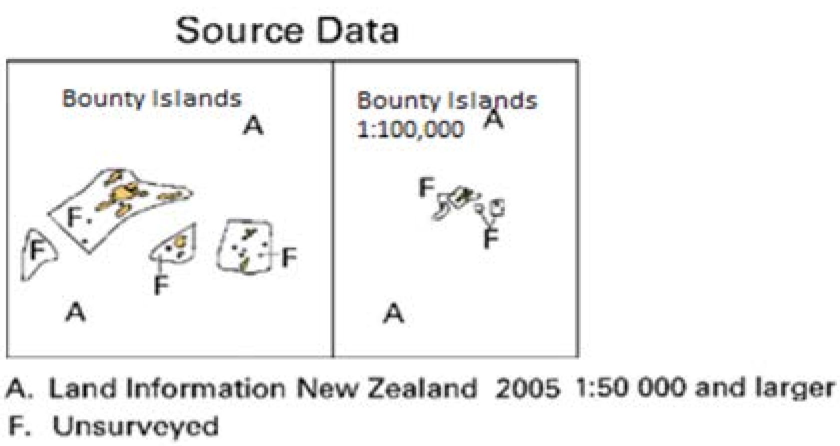


Figure 61: Chart NZ3111 – Bounty Islands, Source Data

The overall chart quality for Bounty Islands is illustrated in **Figure 62**. Most of the area has a CATZOC rating of A1/A2, while there are unsurveyed areas surrounding each of the islands. The unsurveyed areas thus provide a CATZOC rating of U.

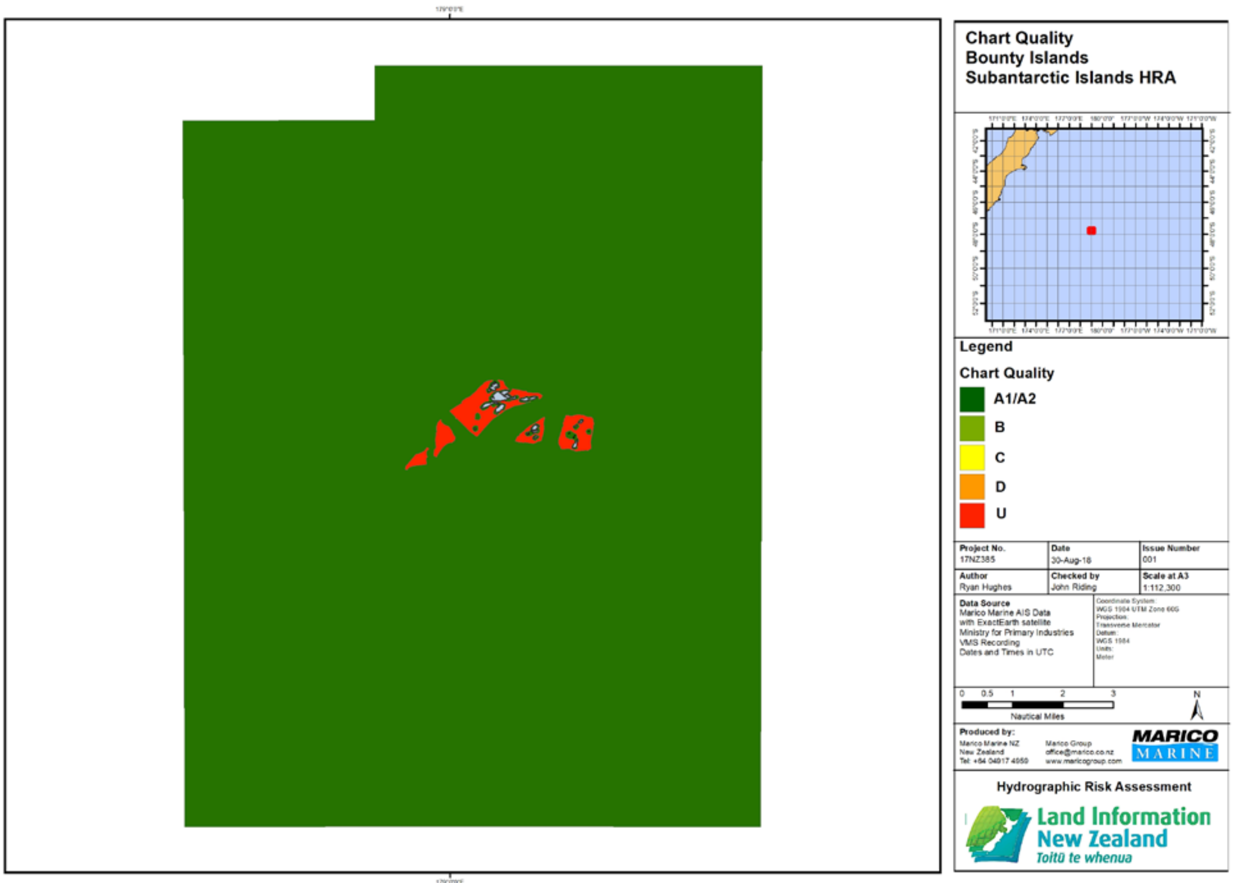


Figure Reference: 17NZ385_RMC_Chart_Quality_Bounty_v2

Figure 62: Chart Quality - Bounty Islands

Scales	Chart	CATZOC and Criteria Score	Survey Age and Criteria Score	Overall Charting Adequacy Score
1 : 25 000	NZ3111 Plan	A (1), U (5)	2005 (3), Unsurveyed (5)	Moderate (3)
1 : 100 000	NZ3111			

Table 19: Charting Adequacy Criteria and Input, Bounty Islands

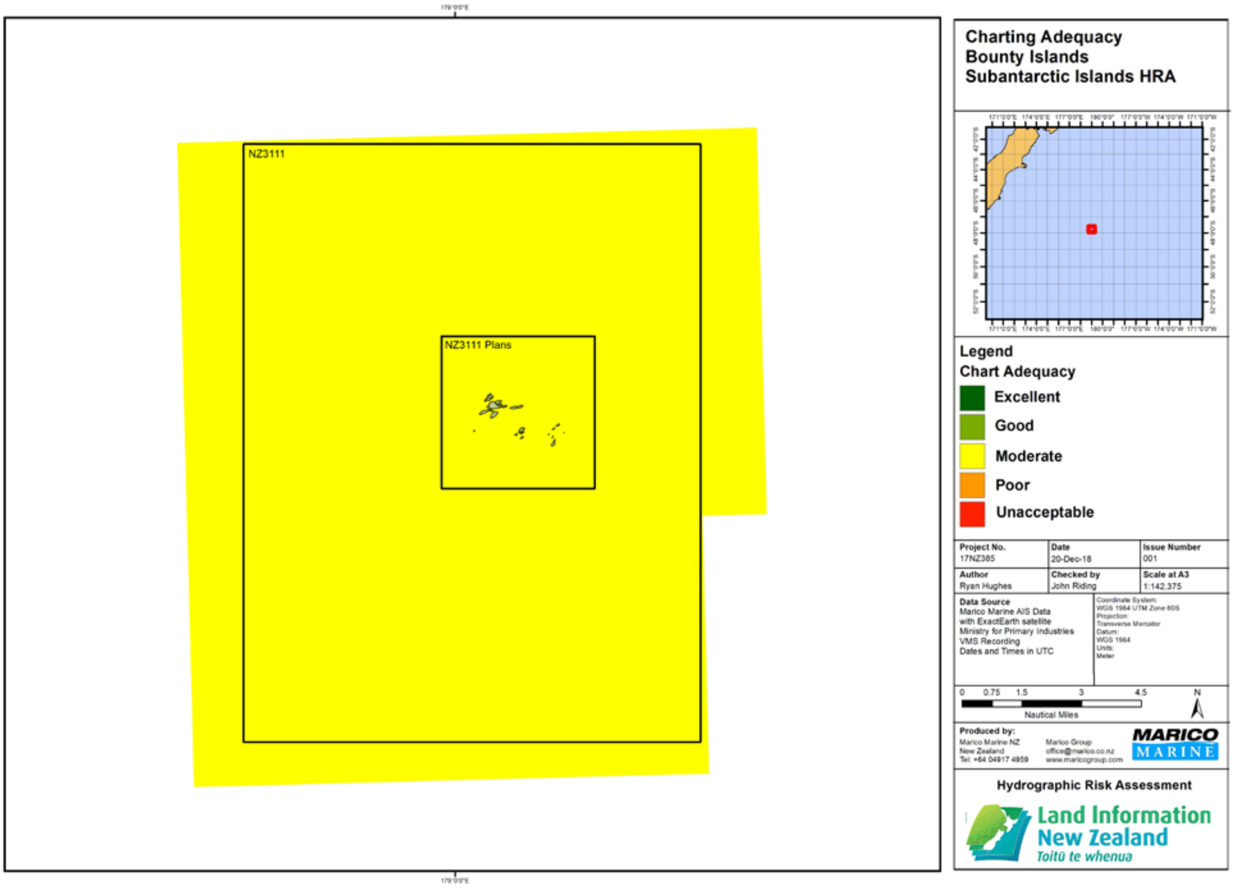


Figure Reference: 17NZ385_RMC_CA_Bounty_v2

Figure 63: Chart Adequacy - Bounty Islands

As illustrated by **Figure 63,** the overall Chart Adequacy score for the Bounty Islands is moderate. Two scales are present at the Bounty Islands (**Table 19**), and the CATZOC score ranks highly at an A, although the area immediately surrounding the islands is unsurveyed. The Bounty Islands were most recently surveyed in 2005.

11.3 INHERENT RISK – BOUNTY ISLANDS

The inherent risk present at the Bounty Islands, shown in **Figure 64** and zoomed at **Figure 65,** results in a layer of moderate and medium risk around the island group, with heightened risk at Lion Island, and at both the Centre and East island groups. The distribution of risk surrounding the Bounty Islands is the result of the unsurveyed area around the islands, with patches of heightened risk (see **Figure 65**) in areas where multiple species of varying ESV scores are present, within close proximity to one another.

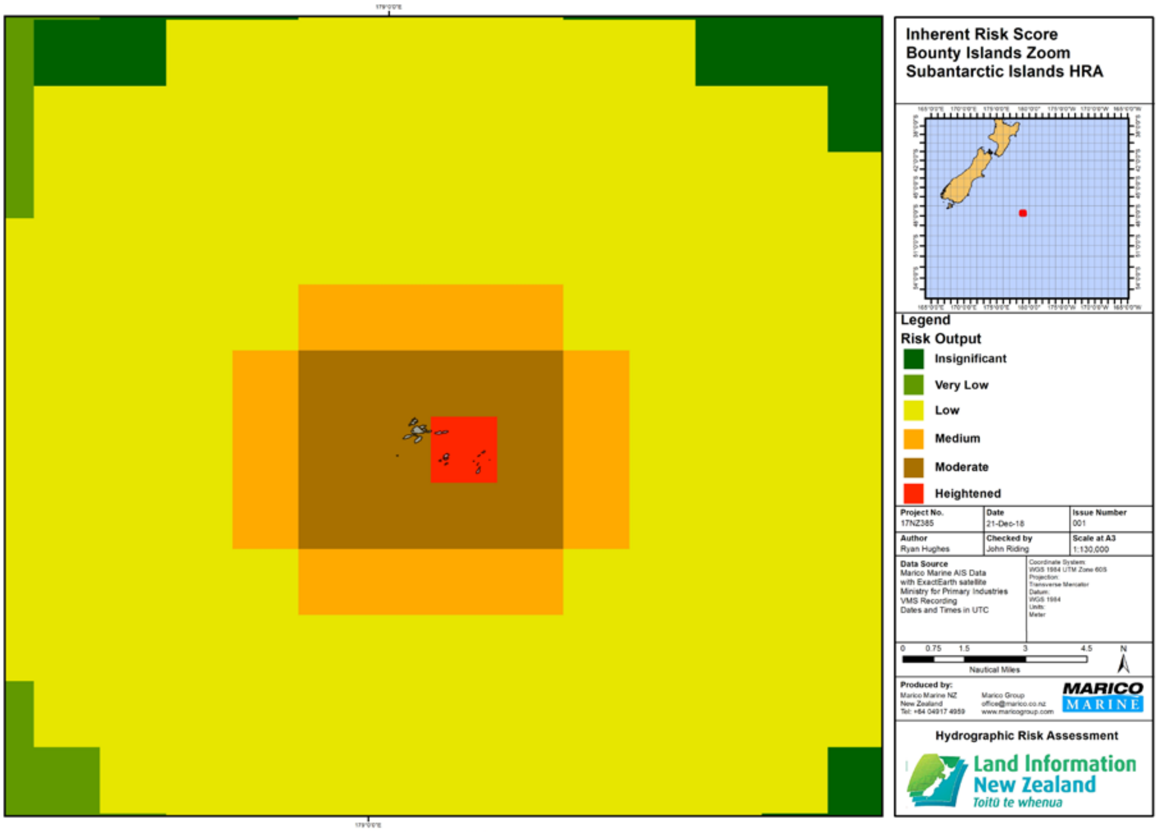


Figure Reference: 17NZ385_RMC_Inherent_Bounty_Zoom_v2

Figure 64: Inherent Risk - Bounty Islands - Zoomed Scale

11.4 SITES OF NOTABLE INHERENT RISK – BOUNTY ISLANDS

Areas of heightened inherent risk within the Bounty Islands are detailed below in **Figure 65.** Three locations have provided a localised heightened risk result; Lion Island, Centre Group Island and East Group Island. **Table 20** records areas where the inherent risk result is heightened, together with a record of contributing factors. Of these, most notable is the number of colonies of different endangered species that exist on separate islands in close proximity to each other. Others are chart quality (Low CATZOC Score when close to islands), proximity to isolated dangers and shallows in combination with uncharted areas.

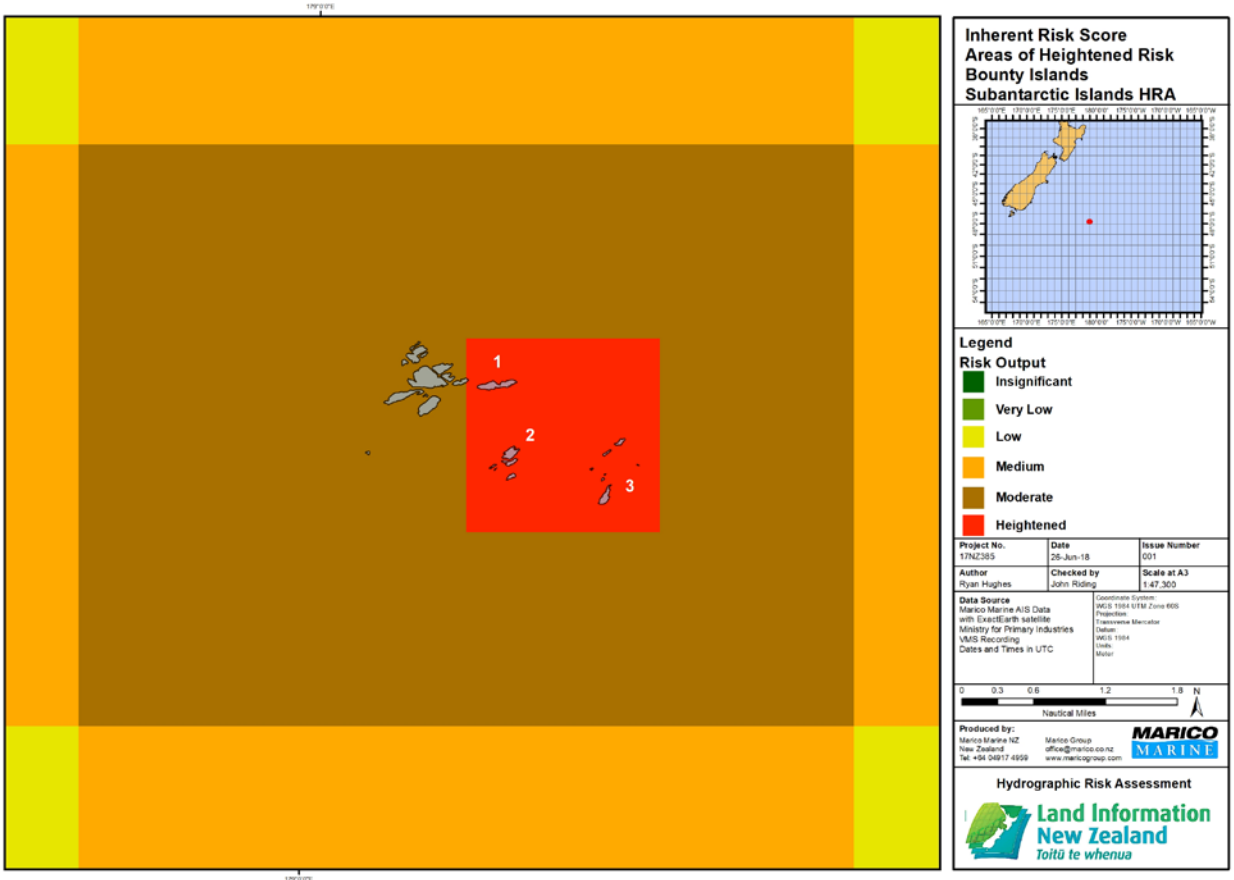


Figure Reference: 17NZ385_ES_Inherent_Bounty_v2

Figure 65: Sites of Notable Inherent Risk - Bounty Islands

Site #	Location	Risk Level	Risk Source
1	Lion Island	Heightened	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Proximity to Isolated Dangers/ Shallow/Uncharted Depth
2	Centre Group	Heightened	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Proximity to Isolated Dangers • Shallow/Uncharted Depth
3	East Group	Heightened	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Proximity to Charted Tidal Hazards • Shallow/Uncharted Depth

Table 20: Sites of Notable Inherent Hydrographic Risk - Bounty Islands

11.5 TRAFFIC ANALYSIS – BOUNTY ISLANDS

A plot of all vessel types recorded in the Bounty Islands for the study period is shown in **Figure 66**. The corresponding vessel traffic density for the area is shown in **Figure 67**. The vessel track density illustrates that there is very little traffic close to the islands. Rather, the highest vessel traffic densities are found offshore to the west of the island, where significant amounts of fishing is undertaken.

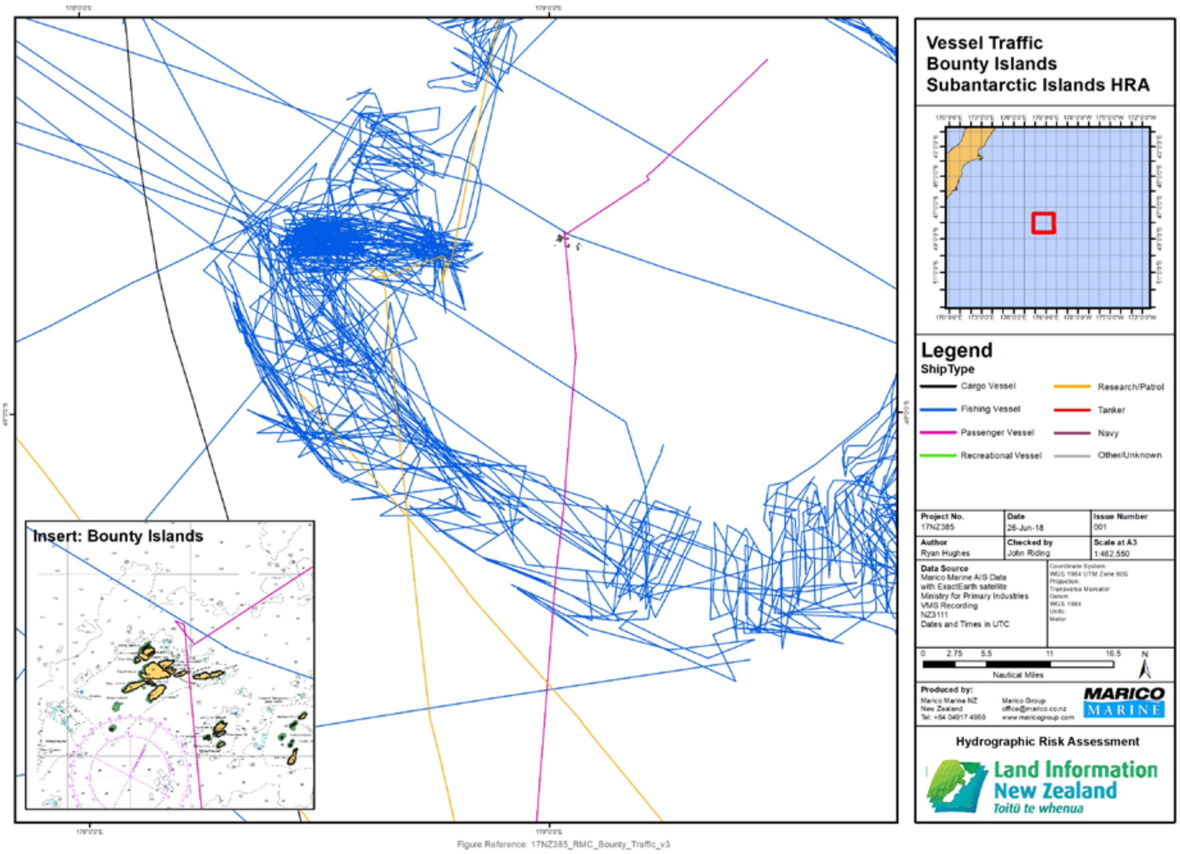


Figure 66: Vessel Tracks - Bounty Islands

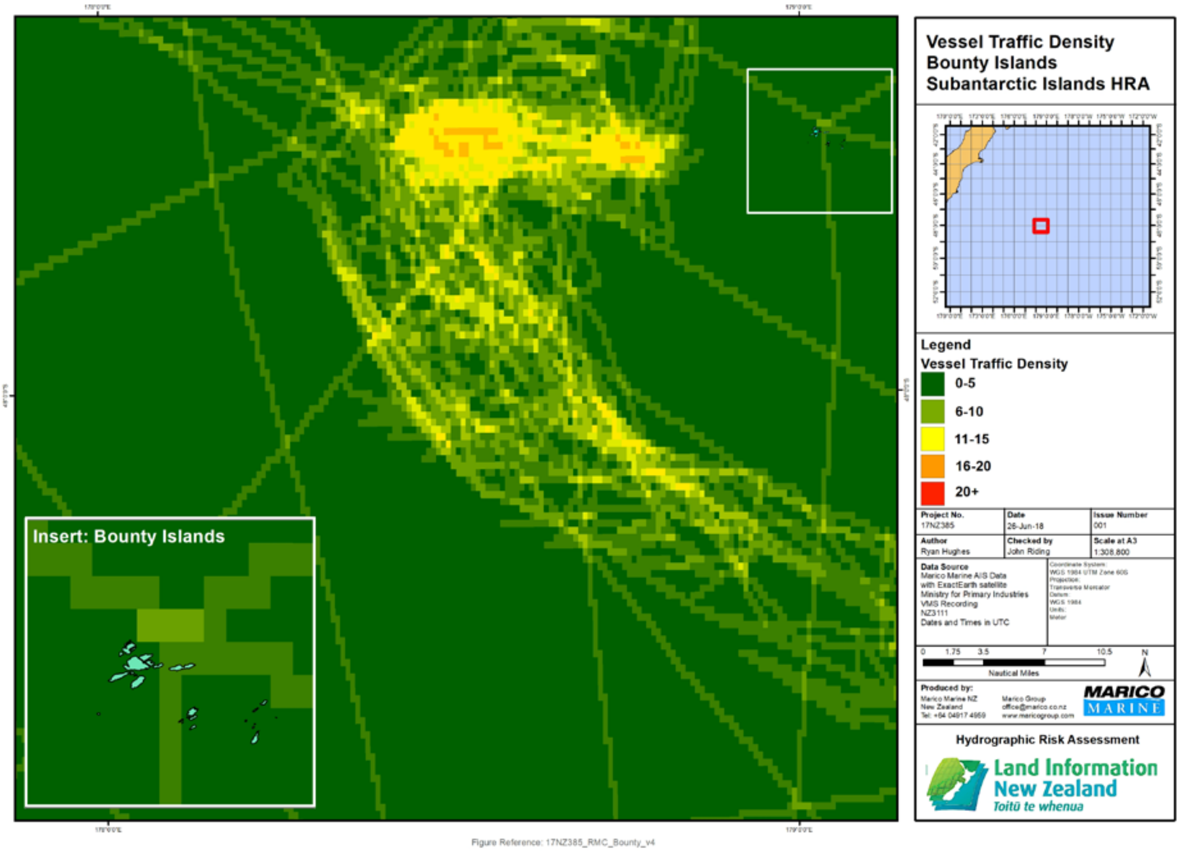


Figure 67: Vessel Track Density - Bounty Islands

11.6 HYDROGRAPHIC RISK RESULT – BOUNTY ISLANDS

The hydrographic risk result for the Bounty Islands is presented at **Figure 68** (with an accompanying zoom at **Figure 69)**. The results for Bounty Islands show risk that is an order of magnitude lower than that in Campbell, Auckland and the Snares Islands. At an overview, this lower level of hydrographic risk suggests that no action is necessary.

However, a feature of the Bounty Islands is that they comprise groups of smaller islands that lie in close proximity to one another. The Islands as a whole represent a large number of extremely vulnerable colonies, each of which are isolated on one or more islands, even though colonies on different islands are relatively close to one another. The net result is that the biodiversity of the Bounty Islands is the most extensive of any of the Sub-Antarctic Islands. Collectively, they provide a high inherent risk score, and for good reason[11].

Figure 66 (previous page) presents the traffic analysis, which shows just one track of a cruise vessel visiting the Bounty Islands in the data year. There is no doubt this occurred, even if the track had to be completed where SAIS received data was lacking. The fact that just one such

[11] **The Bounty Island result alone shows the value of the Inherent Risk solution developed for this hydrographic risk assessment**

transit is delivering the risk number achieved means that this result should be treated with caution. In a Charting Benefit assessment, sensitivity analysis would highlight which criteria are the predominant drivers of the result, allowing the need for charting improvements to be better understood. Some review work has been undertaken within this study, showing that that any further increase in traffic record would deliver a large change in result. The level of inherent risk means that the result is sensitive to any (passenger) traffic in the record. In short, even three cruise transits in a year through the Bounty Islands would deliver a dramatic increase in hydrographic risk[12] result. This is localised in relation to the other areas of the Sub-Antarctic islands, but it is important.

The total risk score is, of course, greatest around areas of traffic that coincide with the inherent risk components.

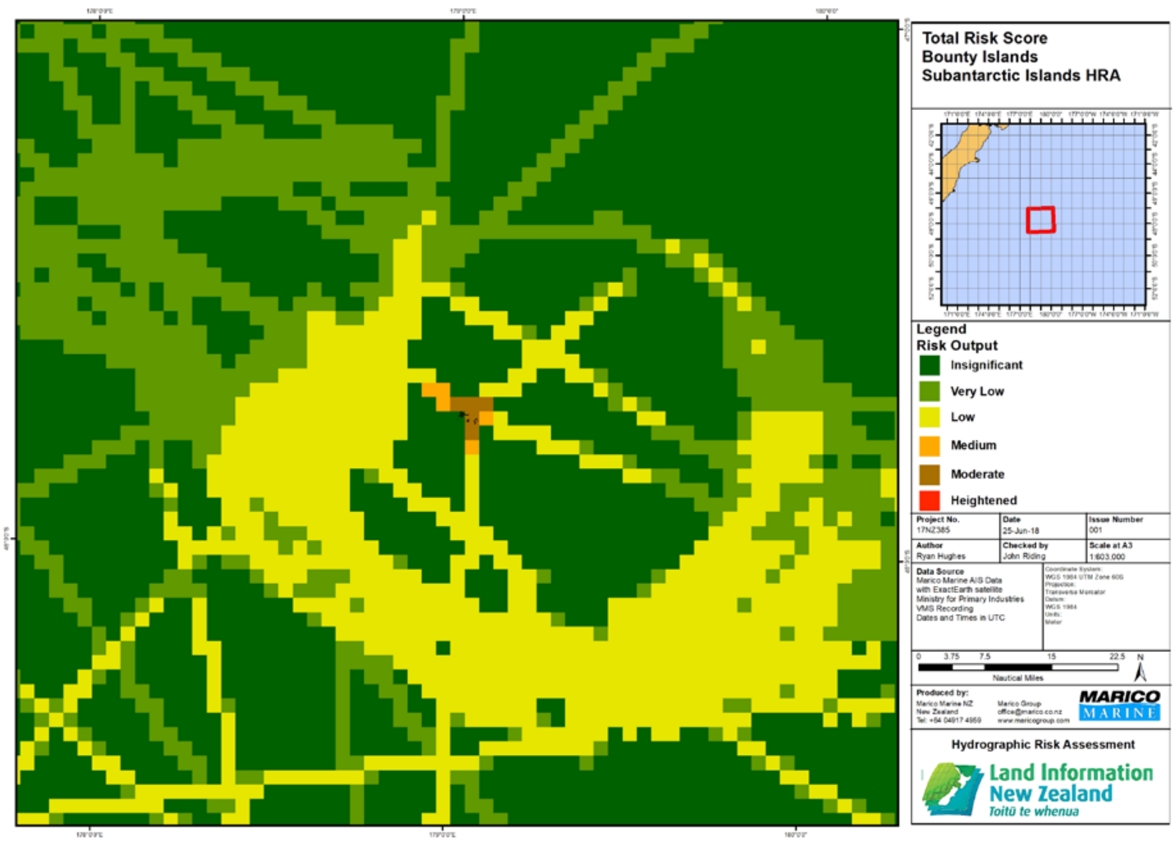


Figure 68: Hydrographic Risk Result - Bounty Islands - Standard Scale

12

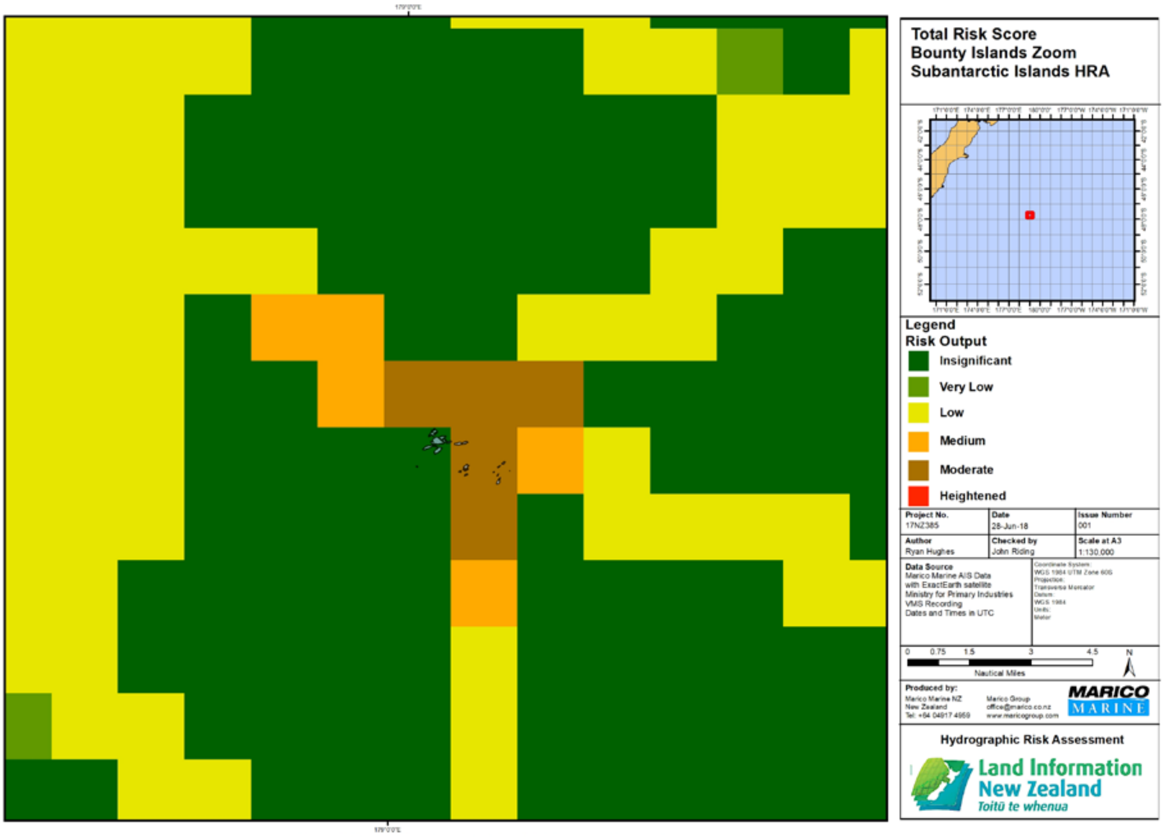


Figure Reference: 17NZ385_RMC_Total_Risk_Bounty_Zoom_v2

Figure 69: Hydrographic Risk Result - Bounty Islands – Overview Scale

11.7 SITES OF NOTABLE HYDROGRAPHIC RISK – BOUNTY ISLANDS

The hydrographic risk result recorded moderate risk at three locations in the Bounty Islands region. This is shown in **Figure 69,** with **Figure 70** presenting a localised zoom. **Table 20** summarises these locations.

Areas providing a moderate risk result lie at Lion Island and the centre and east coast groups. Vessel types contributing to moderate risk within the Bounty Islands were almost all fishing traffic. However a single passenger vessel transit passing through the islands represents an immediate increased risk result[13],

The distribution of risk surrounding the Bounty Islands is the result of unsurveyed areas immediately surrounding the island groups. Multiple species with high ESV scores in close proximity to each other show how vulnerable the Bounty Islands are to a marine incident and most of the surrounding areas are unsurveyed.

[13] **This was a Heritage Cruises vessel and is verified to have made the visit to Bounty and the recorded transit through the islands.**

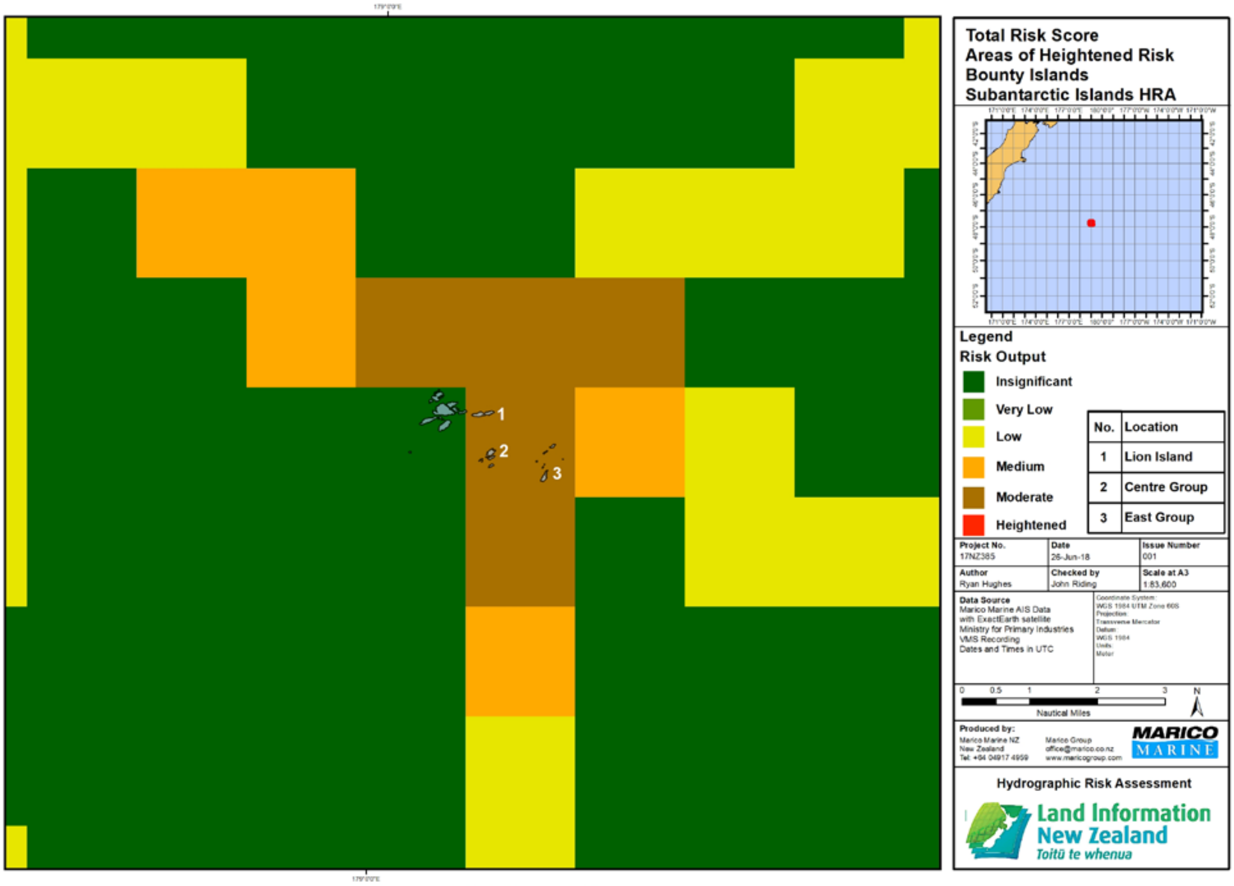


Figure Reference: 17NZ385_ES_Total_Risk_Bounty_v2

Figure 70: Sites of Notable Hydrographic Risk - Bounty Islands (Zoom)

Site #	Location	Risk Level	Traffic of Notable Risk Contribution
1	Lion Island	Moderate	Fishing + Passenger
2	Centre Group	Moderate	Fishing + Passenger
3	East Group	Moderate	Passenger (Professor Khromov)

Table 21: Sites of Notable Hydrographic Risk - Bounty Islands

12 RESULTS – ANTIPODES ISLANDS

12.1 INTRODUCTION

This section presents hydrographic risk results for the Antipodes Islands,. The components that combine to produce hydrographic risk result, namely chart quality, marine traffic and inherent risk, are presented followed by the resultant hydrographic risk results (**Figure 87**).

12.2 CHARTING – ANTIPODES ISLANDS

The results for the charting quality for Antipodes Islands are shown below in **Table 22.** The charting source data at Antipodes Islands is shown in **Figure 71**.

NZ 3111 – Antipodes Islands	Scale 1:25,000 and 1:100,000
Source Data	2005 LINZ, 1:50,000 and larger, 1985 HMNZS Monowai, 1:15,000 sketch survey,
ZOC	The area between Bollons Island and Antipodes Island, perpendicular Head to Reef Point – Anchorage Bay - **ZOC 'B'**. The area 0.5 nautical miles seaward of Antipodes Island **ZOC 'U'**. Remaining seaward area shows regularly spaced sounding data **ZOC 'A'**

Table 22: Chart Quality Information for NZ3111 - Antipodes Islands

Table 23 and **Figure 73** illustrate the criteria and input for the chart adequacy of the Antipodes Islands.

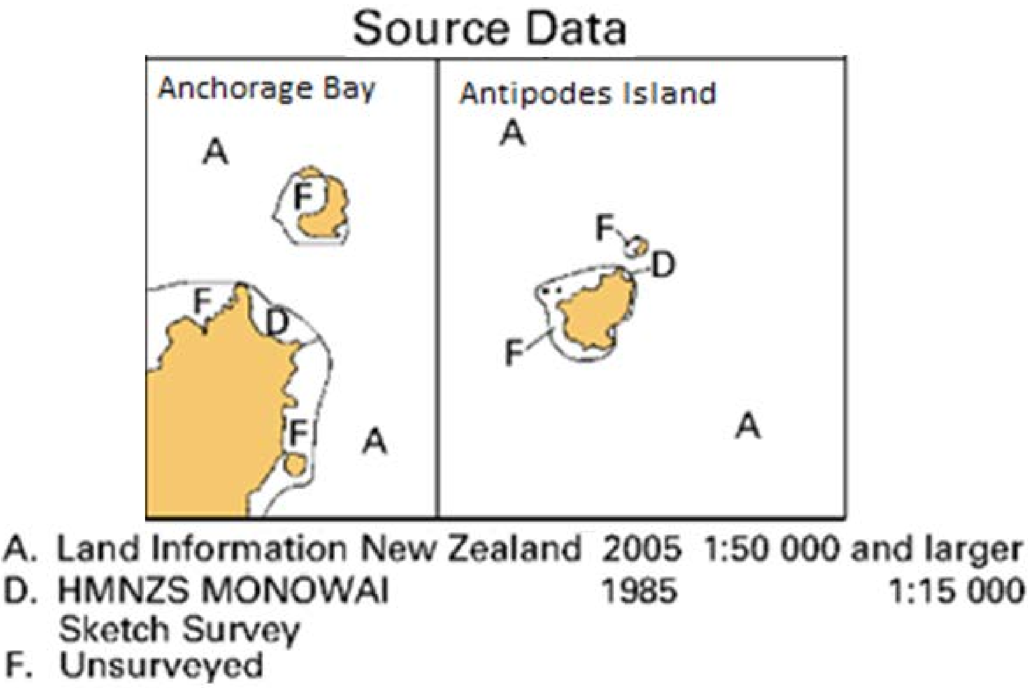


Figure 71: Chart NZ3111 – Antipodes Islands, Source Data

The overall chart quality for Antipodes Islands is presented at **Figure 72**. The chart quality result references an unsurveyed area encompassing most of the Antipodes and Bollons Islands. There is a distinct region of moderate chart quality (CATZOC score B) between the main Island and Ballons Island and to the East of Antipodes Island. The surrounding area is mostly comprised of CATZOC A chart quality.

Table 23 and **Figure 73** illustrate the criteria and input for the chart adequacy assessment of the Antipodes Islands.

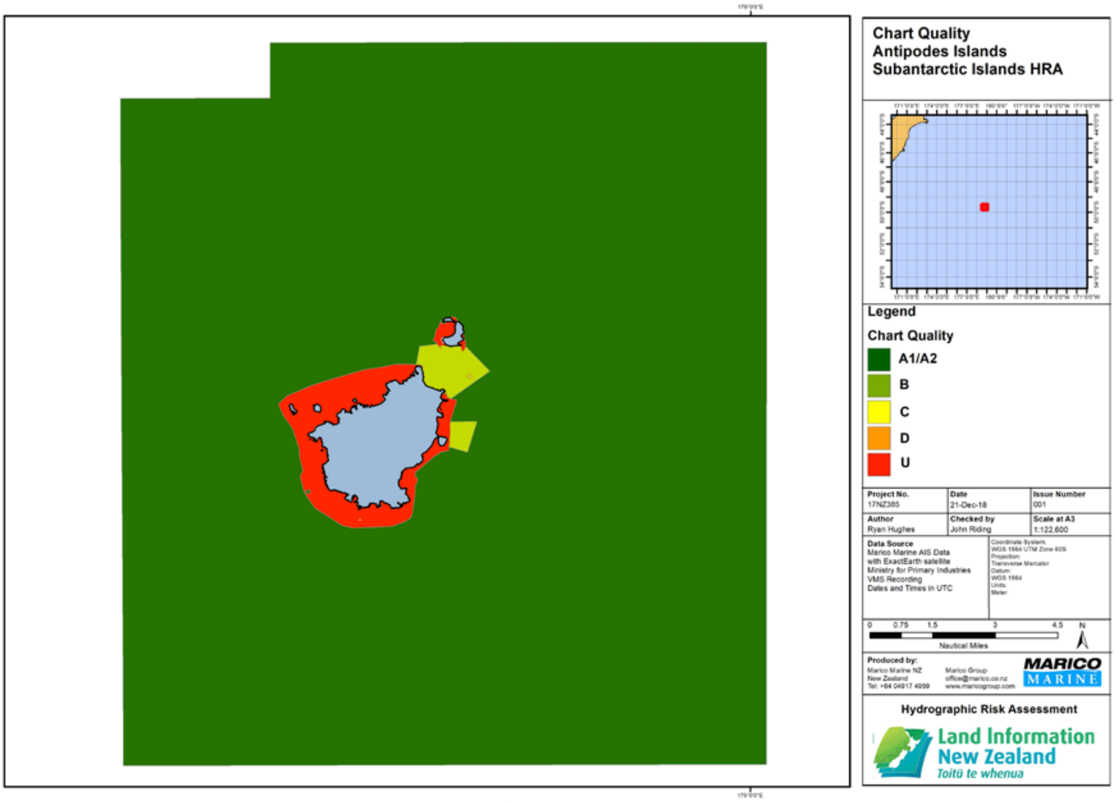


Figure Reference: 17NZ385_RMC_Chart_Quality_Antipodes_v2

Figure 72: Chart Quality - Antipodes Islands

Scales	Chart	CATZOC and Criteria Score	Survey Age Score	Overall Chart Adequacy Score
1 : 25 000	NZ3111 Plan	A (1), B (2), U (5)	2005 (3), Unsurveyed (5)	Poor (4)
1 : 100 000	NZ3111			

Table 23: Charting Adequacy Criteria and Input - Antipodes Islands

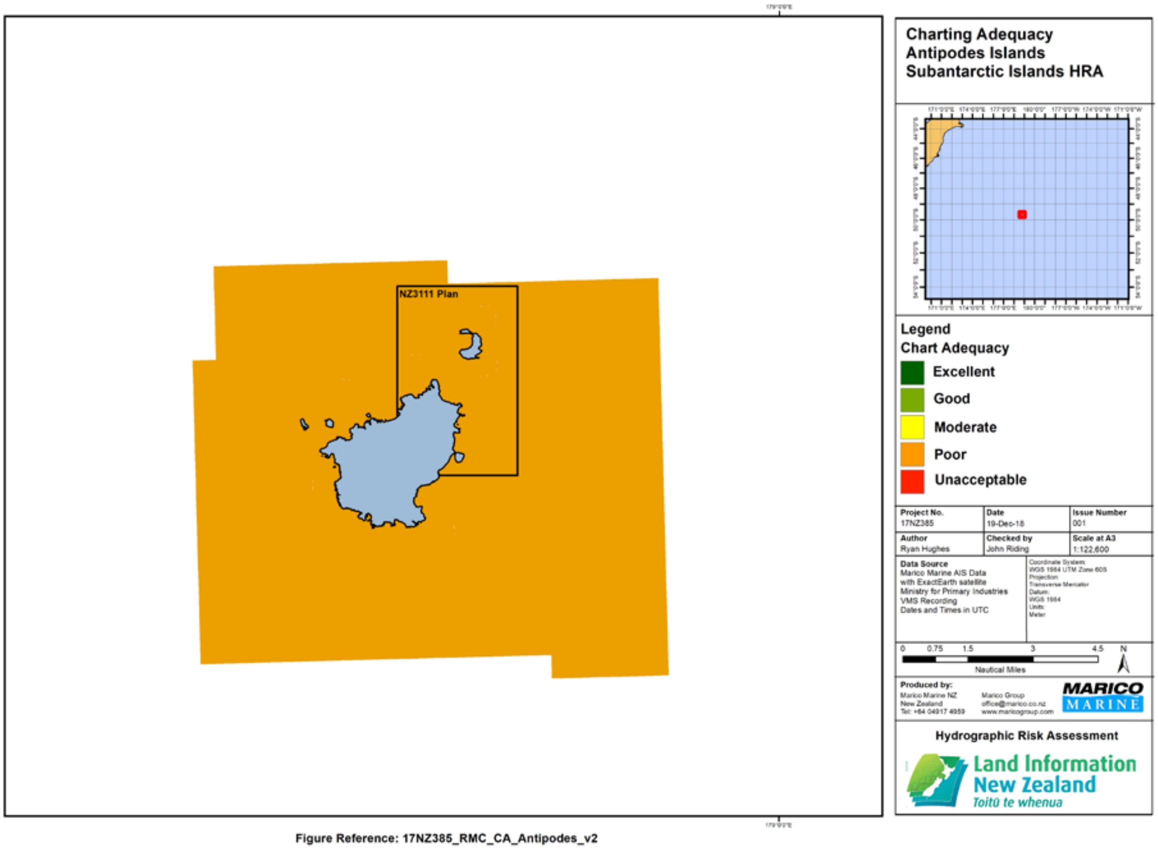


Figure 73: Chart Adequacy - Antipodes Islands

Figure 73 presents a Chart Adequacy plot for the Antipodes Islands. There are two charting scales present at the Antipodes Islands (**Table 23**). CATZOC scores offshore are A, with the area in between Antipodes Island and Bollons Island scoring B. The area immediately surrounding Antipodes Island and Bollons island is mostly unsurveyed. The most recent survey of the Antipodes Islands was in 2005.

12.3 INHERENT RISK – ANTIPODES ISLANDS

The inherent risk result from the Antipodes Island group is presented at **Figure 74**. Levels of medium risk are present around both Antipodes and Bollons Islands, see **Figure 46** and **Figure 55**. The distribution of risk around the entirety of the island group is a result of multiple species colonies around the coast, coupled with the area immediately around the islands being unsurveyed. The ESV scores of these species are typically low-moderate, with those few that have high ESV scores rarely occurring within the same cells. This results in a moderate score of 3 or 4 rather than a heightened score of 5. To achieve heightened score, multiple high ESV species would lie in close proximity.

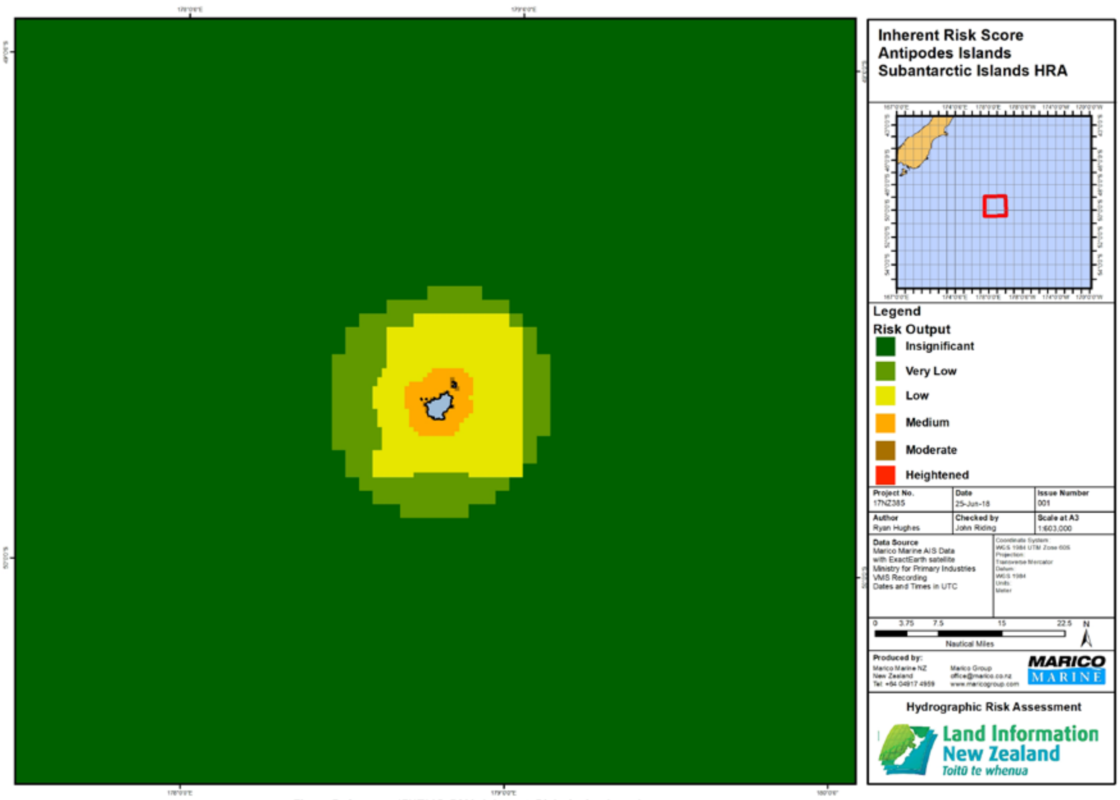


Figure 74: Inherent Risk, Antipodes Islands - Standard Scale

12.4 NOTABLE INHERENT RISK – ANTIPODES ISLANDS

Areas of moderate inherent risk within Antipodes Islands are presented at **Figure 74 and 75**. Three locations are referenced, Bollons Island, Antipodes – North and Antipodes – South. The contributing factors to moderate inherent risk are detailed in **Table 24**.

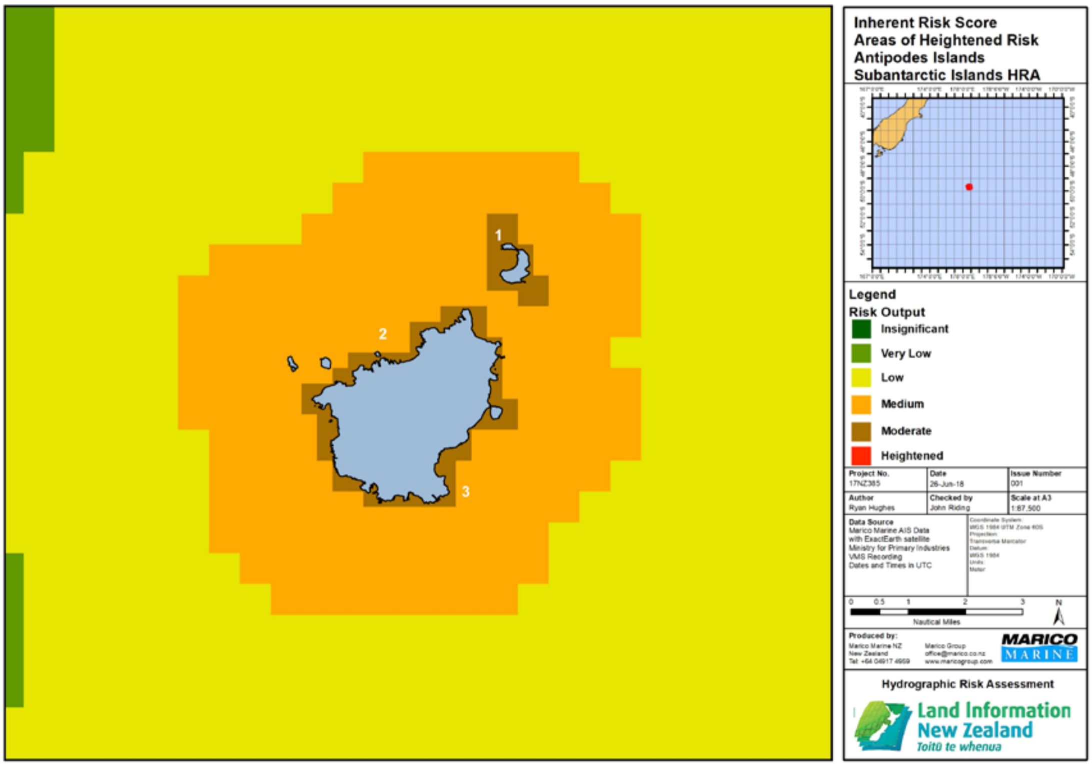


Figure Reference: 17NZ385_ES_Inherent_Antipodes_v2

Figure 75: Notable Inherent Risk - Antipodes Islands

Site	Location	Risk Level	Risk Source
1	Bollons Island	Moderate	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Shallow/Uncharted Depth
2	Antipodes—North	Moderate	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Proximity to Isolated Dangers • Shallow/Uncharted Depth
3	Antipodes—South	Moderate	• High number of species colonies and breeding sites in close proximity • Low CATZOC Score • Proximity to Isolated Dangers • Shallow/Uncharted Depth

Table 24: Sites of Notable Inherent Hydrographic Risk - Antipodes Islands

12.5 TRAFFIC ANALYSIS – ANTIPODES ISLANDS

A plot of all vessel types recorded in the area for the study period is shown in **Figure 76**. The corresponding total vessel traffic density for the area is shown in **Figure 77.**

The vessel track density is largely due to one cargo vessel - *Norfolk Guardian*, which was stationed around the islands in support of the Department of Conservation's "Million Dollar Mouse" eradication project. A single passenger vessel also visited. There are no significant fishing areas near the Antipodes Islands.

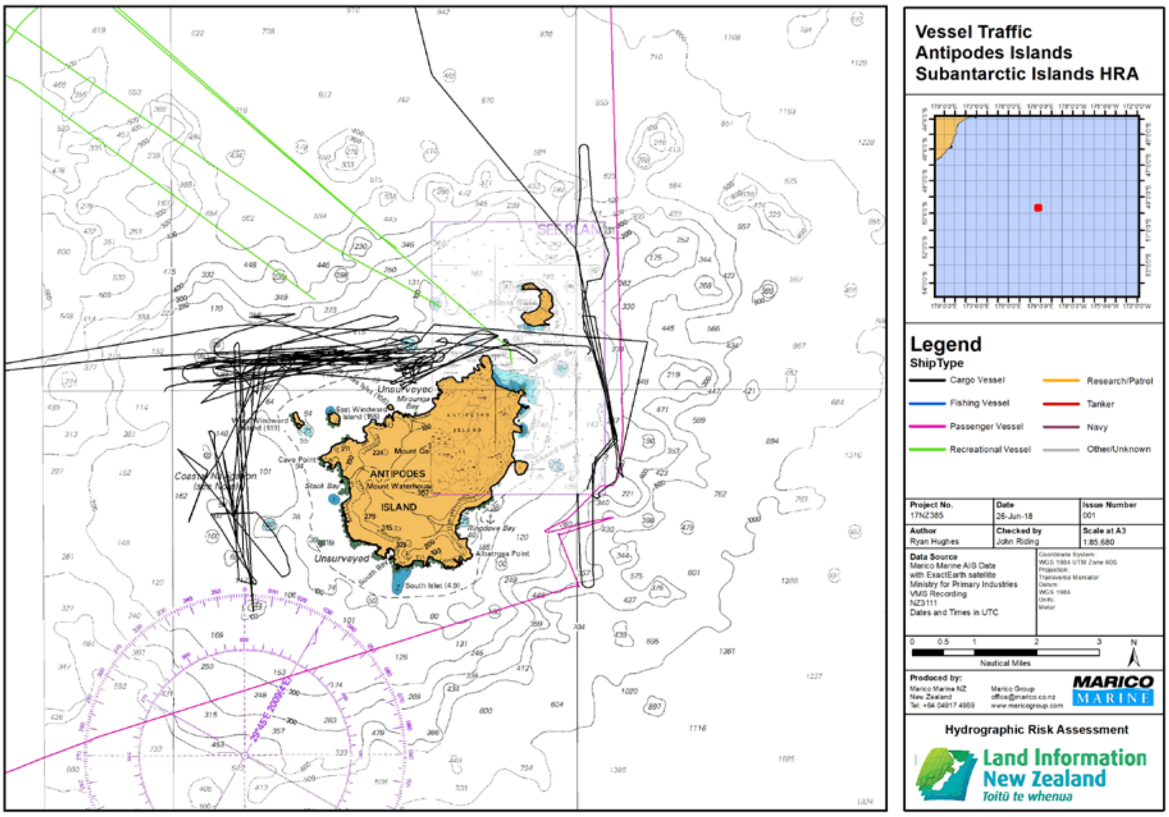


Figure 76: Vessel Tracks - Antipodes Islands

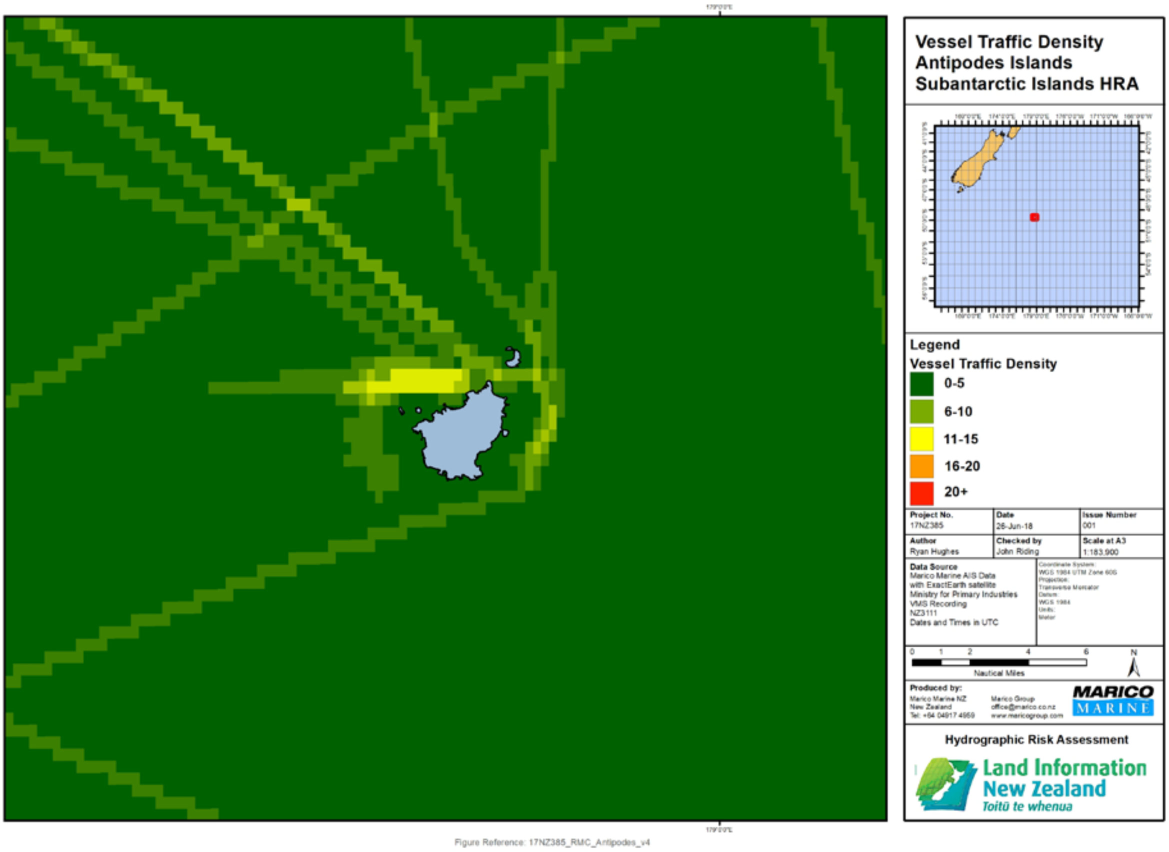


Figure 77: Vessel Tracks Density - Antipodes Islands (Standard Scale)

12.6 HYDROGRAPHIC RISK RESULT – ANTIPODES ISLANDS

Figure 78 presents hydrographic risk result for the Antipodes Islands. This shows a ring of moderate risk, vessel traffic coincides with higher scoring criteria. Risk becomes heightened to the north of Antipodes Island, which is the result of one-off deployment of a single vessel. With no significant fishing grounds in proximity to Antipodes Islands, the vessel density was largely a result of the rodent eradication project. During the eradication, regular visits were made to the area by NZ Navy, together with a support vessel charted by DOC. There was a single cruise vessel visit, which affects this particular risk result. Heightened risk appears to the North West of the Island in accordance with this traffic profile.

Bollons Island remains predator free and the recovery of endemic colonies is likely to provide a future attraction for visiting cruise vessels.

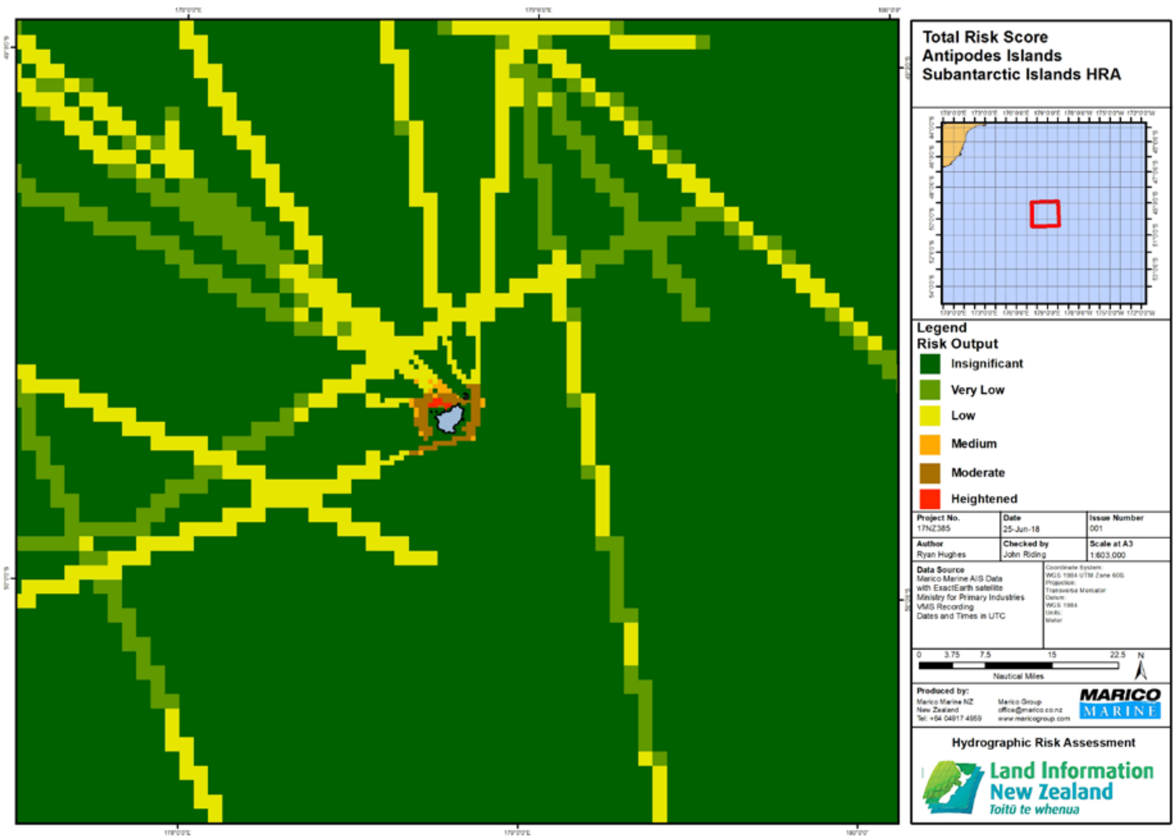


Figure Reference: 17NZ385_RMC_Total_Risk_Antipodes_v2

Figure 78: Hydrographic Risk Result - Antipodes Islands (Standard Scale)

12.7 SITES OF NOTABLE HYDROGRAPHIC RISK – ANTIPODES ISLANDS

The hydrographic risk was heightened at two locations within the Antipodes Islands. This is shown in **Figure 78**. Areas of heightened risk are evident within the North West of Antipodes Islands and Mirouga bay. The traffic type contributing to heightened risk within Antipodes Islands is cargo traffic (**Table 21**), although this was associated with a DOC project in the area and may not by typical of normal traffic. It is expected tough that monitoring would continue to ensure the islands remain predator free.

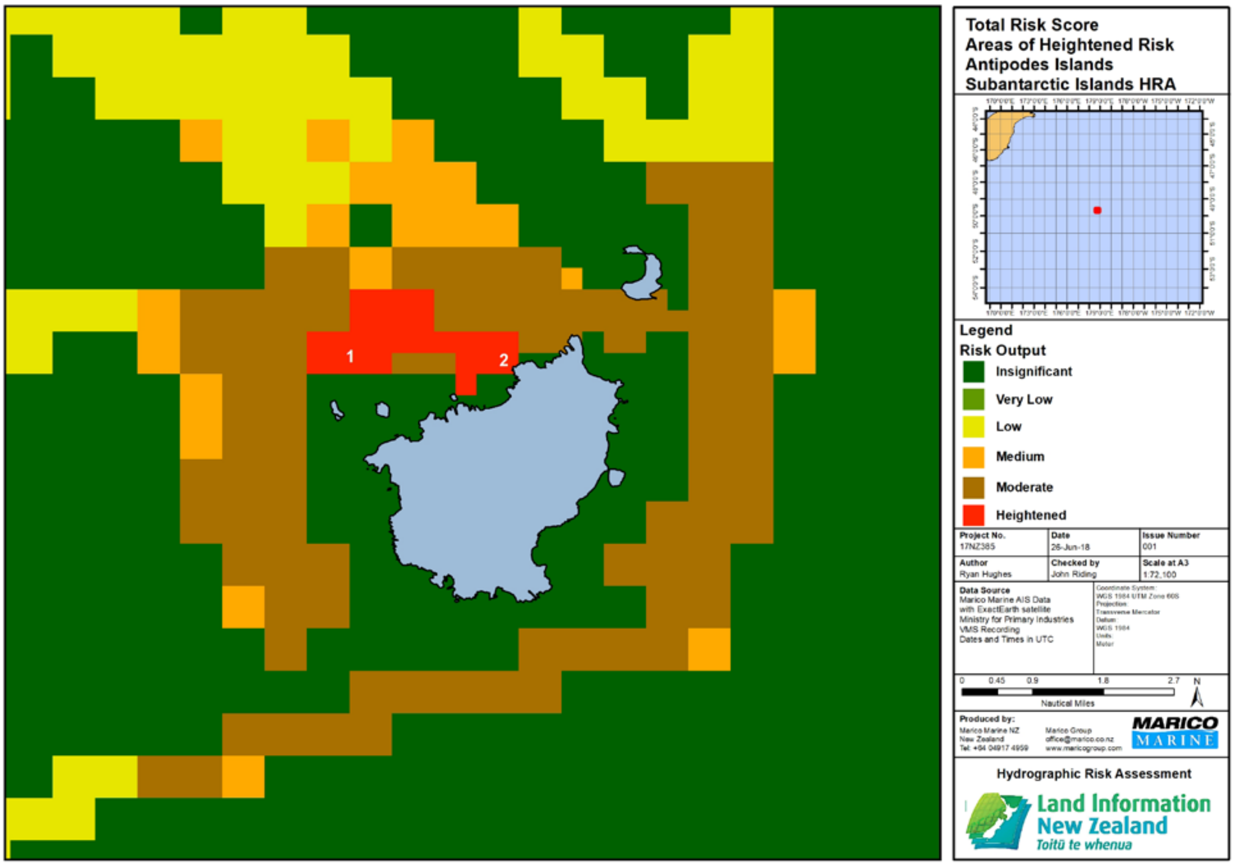


Figure Reference: 17NZ385_ES_Total_Risk_Antipodes_v2

Figure 79: Hydrographic Risk Result - Antipodes Islands (Zoomed Scale)

Site #	Location	Risk Level	Traffic of Notable Risk Contribution
1	Antipodes—Northwest	Heightened	Cargo (Norfolk Guardian)
2	Mirouga Bay	Heightened	Cargo (Norfolk Guardian)

Table 25: Hydrographic Risk Result - Antipodes Islands

13 RESULTS – SNARES ISLANDS

13.1 INTRODUCTION

This section presents the hydrographic risk results for the Snares Islands. The components contributing to the hydrographic risk result - chart quality, marine traffic and inherent risk, are presented first. This is followed by plots of the hydrographic risk result.

13.2 CHARTING – SNARES ISLANDS

The charting quality summary for the Snares is shown below in **Table 26. Figure 80** provides a plot of chart source data at the Snares. The ZOC B rating overall(moderate) is taking account of survey age and bottom coverage achieved, see **Figure 80**.

Table 27 and **Figure 82** illustrate the criteria and input for the chart adequacy of the Snares Islands.

NZ 2411 – Snares Island/Tini Heke	
Scale 1:30,000	
Source Data	1999 - LINZ scale 1:10,000 1999 – LINZ scale 1:5,000
ZOC	**ZOC 'B'**
NZ 2411 – Ho Ho Bay	
Scale 1:5,000	
Source Data	1999 – LINZ scale 1:7,500
ZOC	**ZOC 'B'**

Table 26: Chart Quality Information for NZ2411 - NZ2411 Plan - Snares

Figure 80: Chart NZ2411 – Snares Islands - Source Data

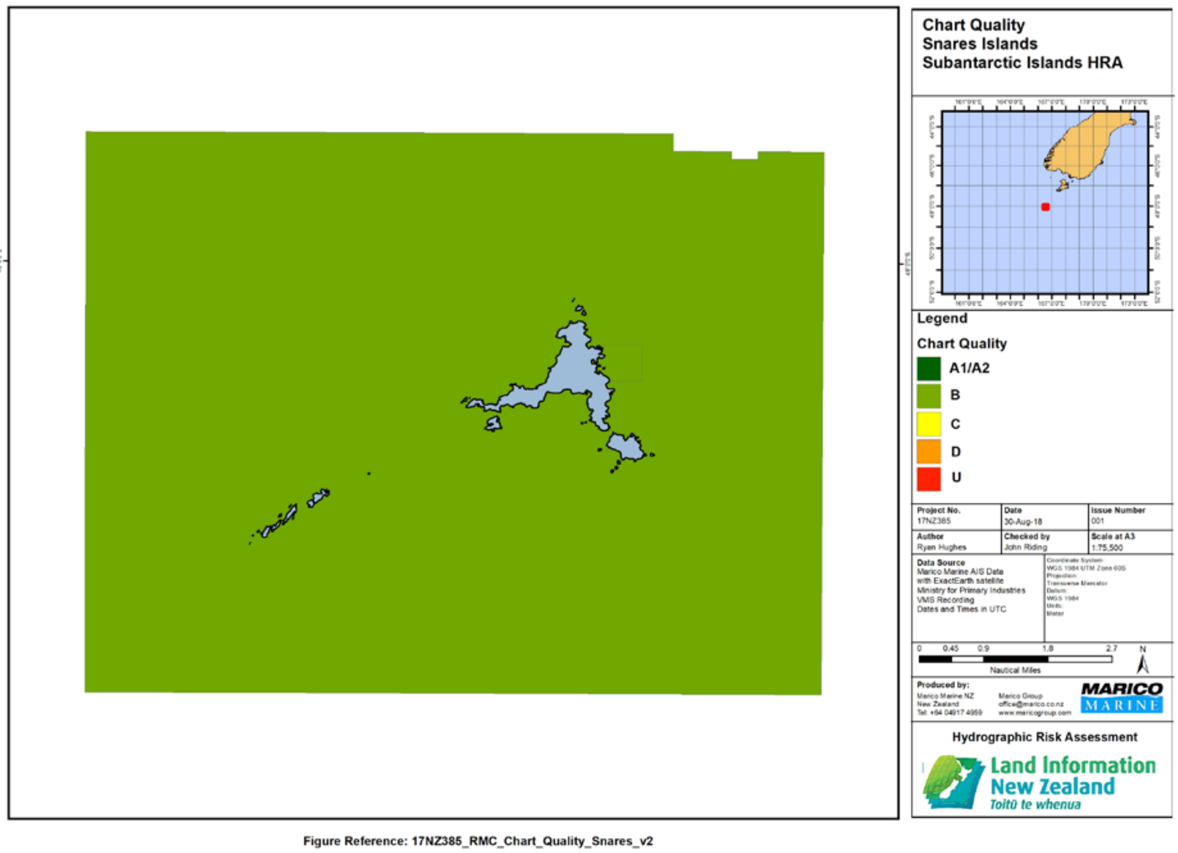


Figure 81: Chart CATZOC Plot - Snares Islands (Moderate)

The Snares are a small Island set, but they are very significant in that their location is within a day's steaming from the NZ South Island coast. The 1:30,000 scale for coastal approach and 1:7,500 for the insert is appropriate to the way DOC licence cruise vessels to visit. Landing is not allowed, so vessels approach to view the colonies from offshore. A CATZOC chart quality plot for the Snares Islands is presented above in **Figure 81,** which is supported by **Table 27** in which charting adequacy data is stated. There is an overall CATZOC score of B, moderate, but overall the score is assessed as poor using the risk assessment criteria.

Scales	Chart	CATZOC and Criteria Score	Survey Age and Criteria Score	Overall Charting Adequacy Score
1 : 7500	NZ2411 Plan	B (2)	1999 (3)	Poor (4)
1 : 30 000	NZ2411			

Table 27: Charting Adequacy Criteria and Input - Snares Islands

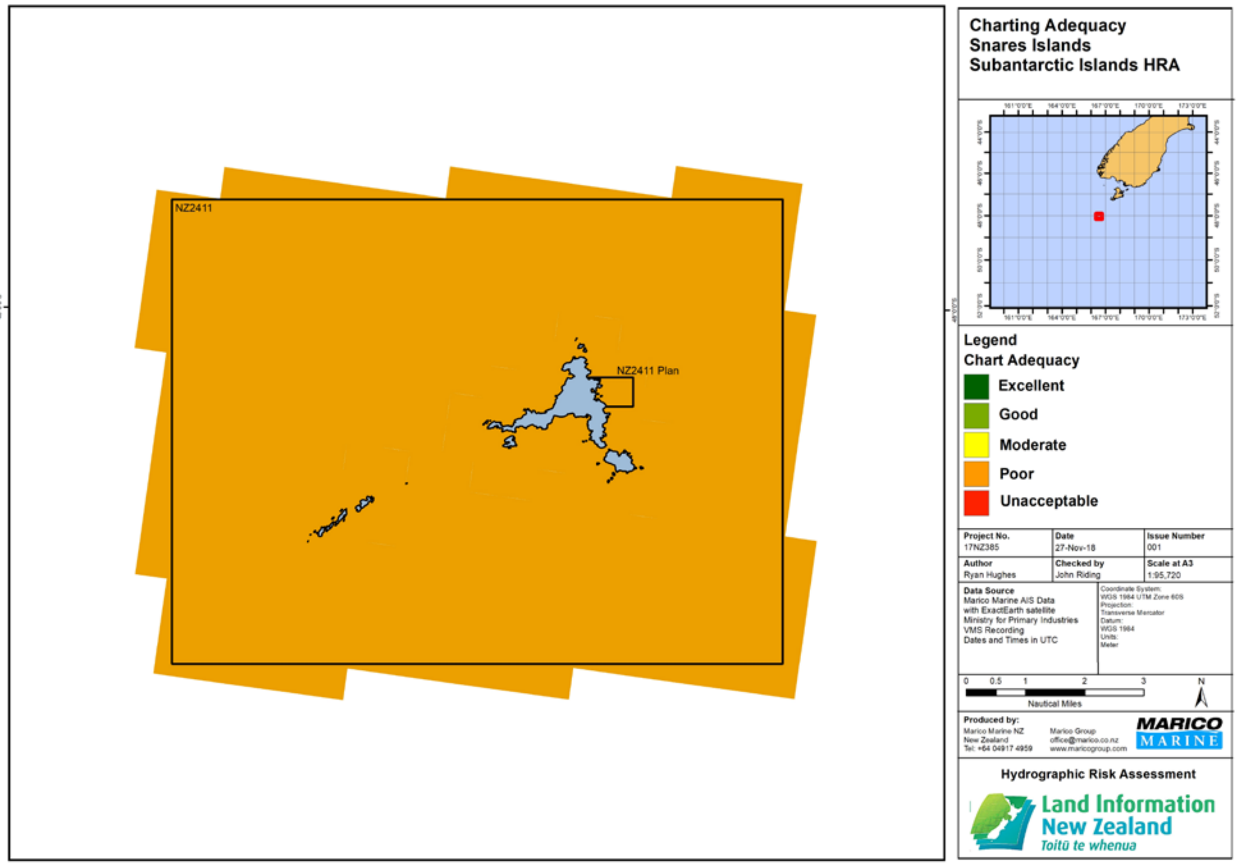


Figure Reference: 17NZ385_RMC_CA_Snares_v2

Figure 82: Chart Adequacy - Snares Islands

As illustrated in **Figure 82**, the overall Chart Adequacy score for the Snares Islands has been assessed as poor. The input criteria from **Table 27** shows that there are two charting scales in use the Snares Islands, one of the coastal approach standard and the other an insert where vessel are expected to drift whilst people observe the colonies. The CATZOC score for the entire area is B. The most recent survey at the Snares Islands was in 1999, which is in part a reason for the adequacy score used in the risk assessment.

13.3 INHERENT RISK – SNARES ISLANDS

Figure 83 provides a plot of the inherent risk result at the Snares Islands. A zoom of this result is at **Figure 84.** This shows a medium score across most of the island group, due to the distribution of multiple species all across the islands. There is a small area of moderate risk around the Western Chain. The Western Chain contains sites where multiple species exist in close proximity, the combination providing a notable ESV score. As the Snares Islands themselves are well surveyed, they show a reasonable chart quality. The main driver of inherent risk at this island group is thus the importance of the colonies themselves.

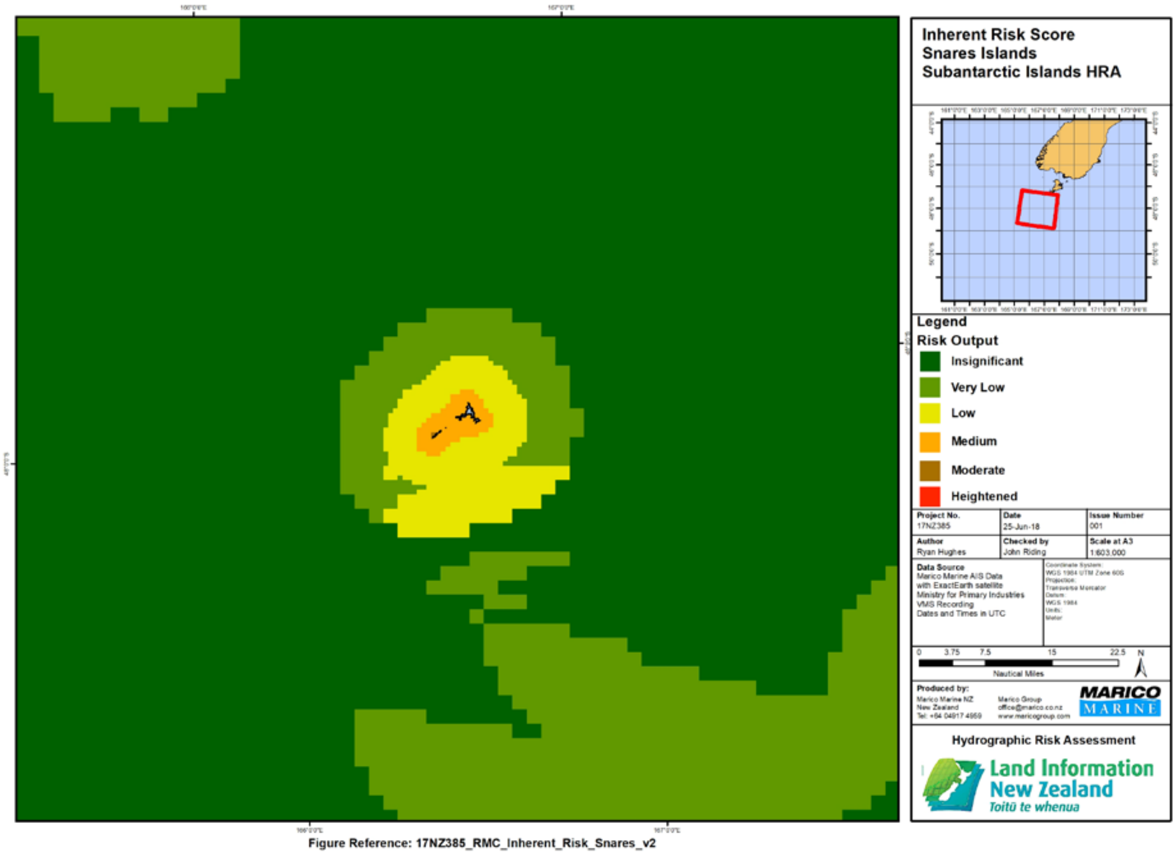


Figure 83: Inherent Risk - The Snares Islands - Standard Scale

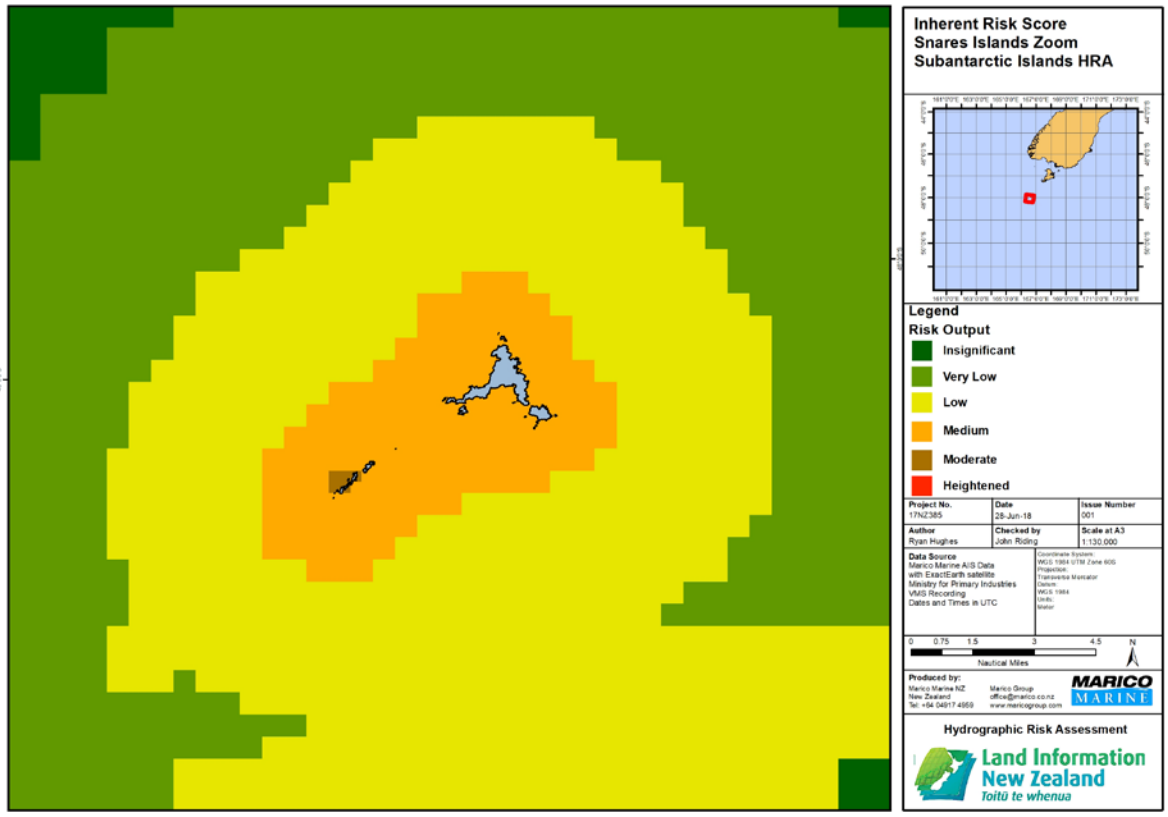


Figure Reference: 17NZ385_RMC_Inherent_Risk_Snares_Zoom_v2

Figure 84: Inherent Risk - The Snares Islands - Zoomed Scale

13.4 SITES OF NOTABLE INHERENT RISK – SNARES ISLANDS

The inherent risk result of the Snares Islands is presented at **Figure 84.** One location within the Western Chain has provided a moderate risk result. The contributing factors to moderate inherent risk are detailed in **Table 28**. These factors included the high number of species colonies and breeding sites in close proximity to each other, the proximity to a recognised great circle route, the proximity to isolated dangers and the shallow/uncharted depth.

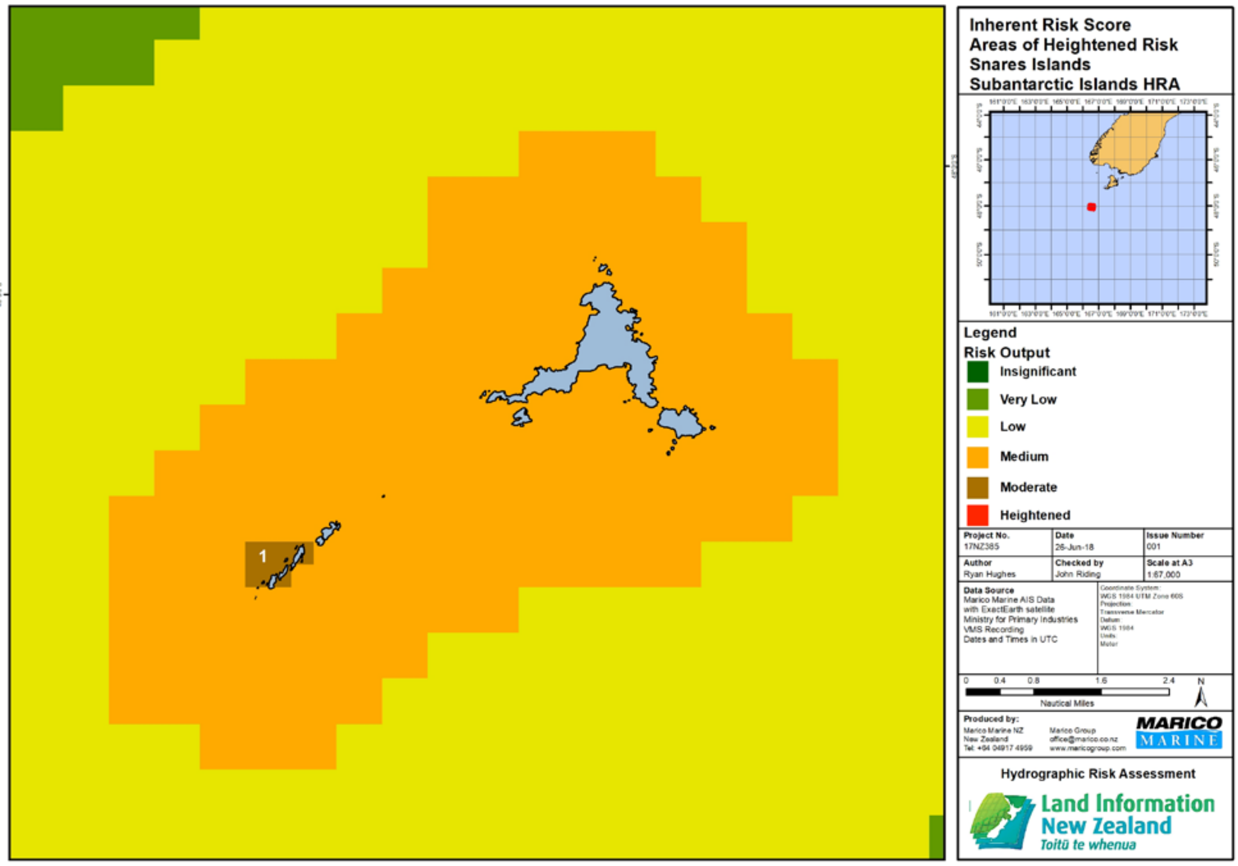


Figure Reference: 17NZ385_ES_Inherent_Snares_v2

Figure 85: Sites of Notable Inherent Risk - Snares Islands

Site #	Location	Risk Level	Risk Source
1	Western Chain	Moderate	• High number of species colonies and breeding sites in close proximity • Proximity to vessels on Great Circle Route • Proximity to Isolated Dangers • Shallow/Uncharted Depth

Table 28: Sites of Notable Inherent Risk - Snares Islands

13.5 TRAFFIC ANALYSIS – SNARES ISLANDS

A plot of all vessel types recorded in the area for the study period is shown in **Figure 86**. The corresponding total vessel traffic density for the area is shown in **Figure 87**.

Nearshore, the main vessel type is passenger vessels. The relative closeness of the Snares to the South Island means that it is a relatively small detour for vessels to visit. Further offshore, there is significant fishing vessel activity to the north and south of the Snares.

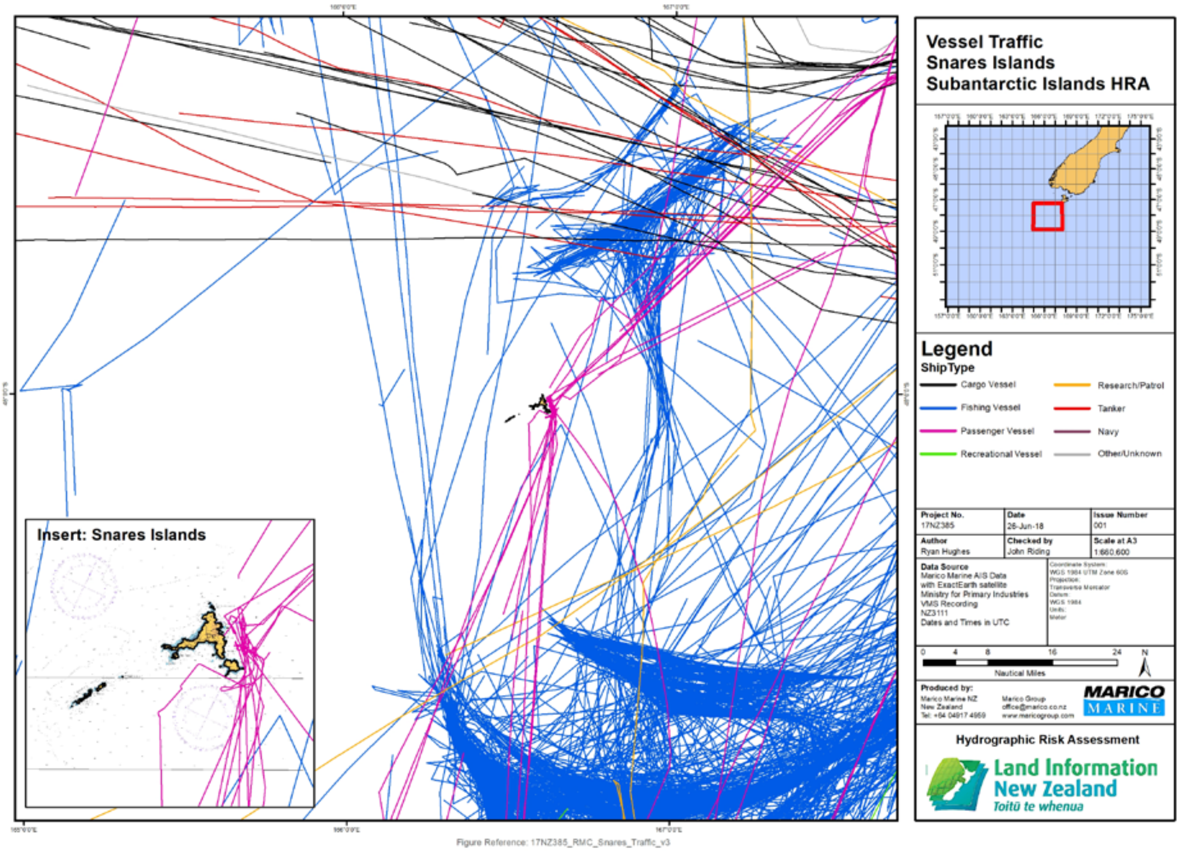


Figure 86: Vessel Tracks - Snares Islands

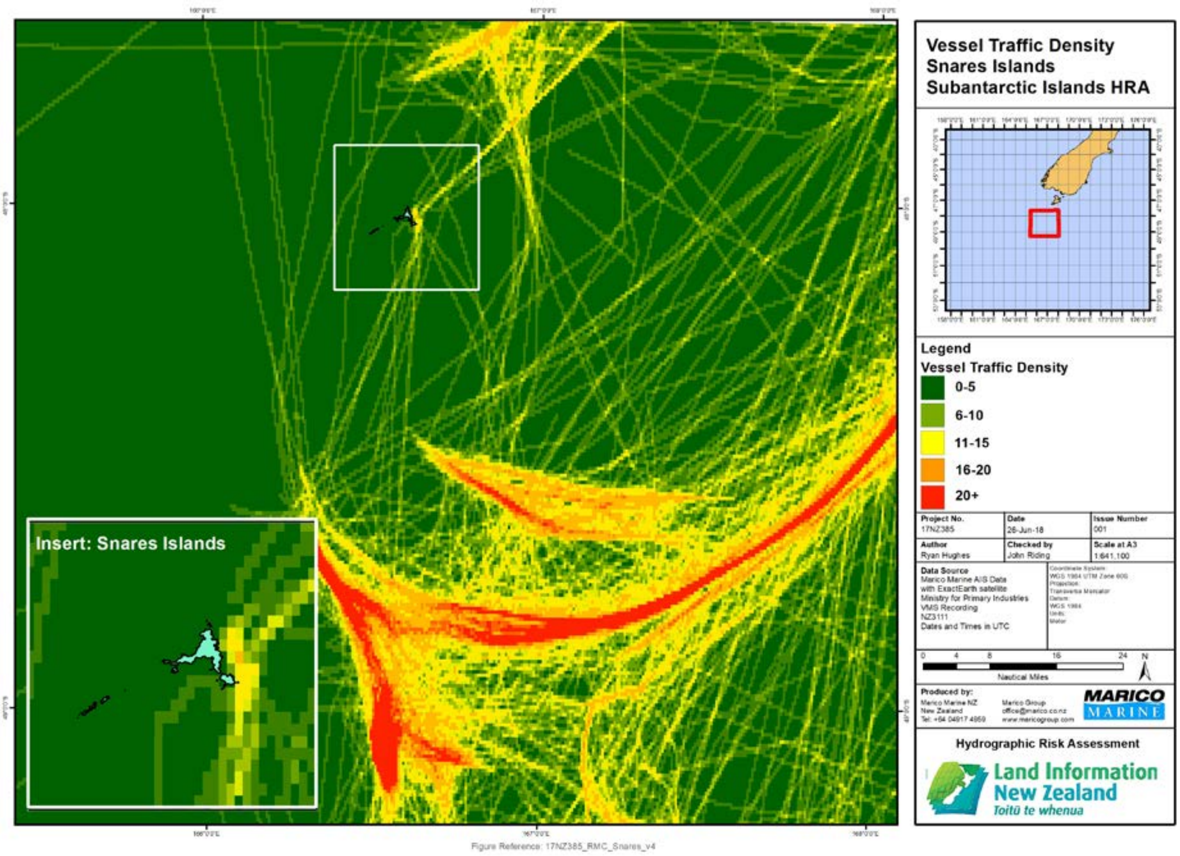


Figure 87: Vessel Track Density - Snares Islands

13.6 HYDROGRAPHIC RISK RESULT – SNARES ISLANDS

The hydrographic risk result for the Snares Islands is presented at **Figure 84**. The hydrographic risk result is in part due to the location of the Island, relatively close to the South Island of New Zealand. The short steaming time allows cruise vessels to transit to the Snares within an overnight passage, such that it is normally the first island call for cruises to the study area. It means that almost all cruise vessels visiting the Sub-Antarctic islands pass through these waters. It is also a convenient call for cruise vessels departing some eastern and southern Australian Ports and taking a (summer) great circle route into New Zealand waters. The Snares have a 2 hour visiting licence for viewing colonies offshore (by application), which presents the opportunity for larger cruise vessels to visit, which may then transit the NZ coastal ports.

There is an area of heightened risk result, east of the Snares. This is equally arising out of traffic as it is arising out of the presence of multiple species of threatened colonies all across the islands. The Snares appear to be a good candidate for charting review (scales and extents for stooging close offshore), especially as they present opportunity for larger cruise vessel calls (offshore) than at present.

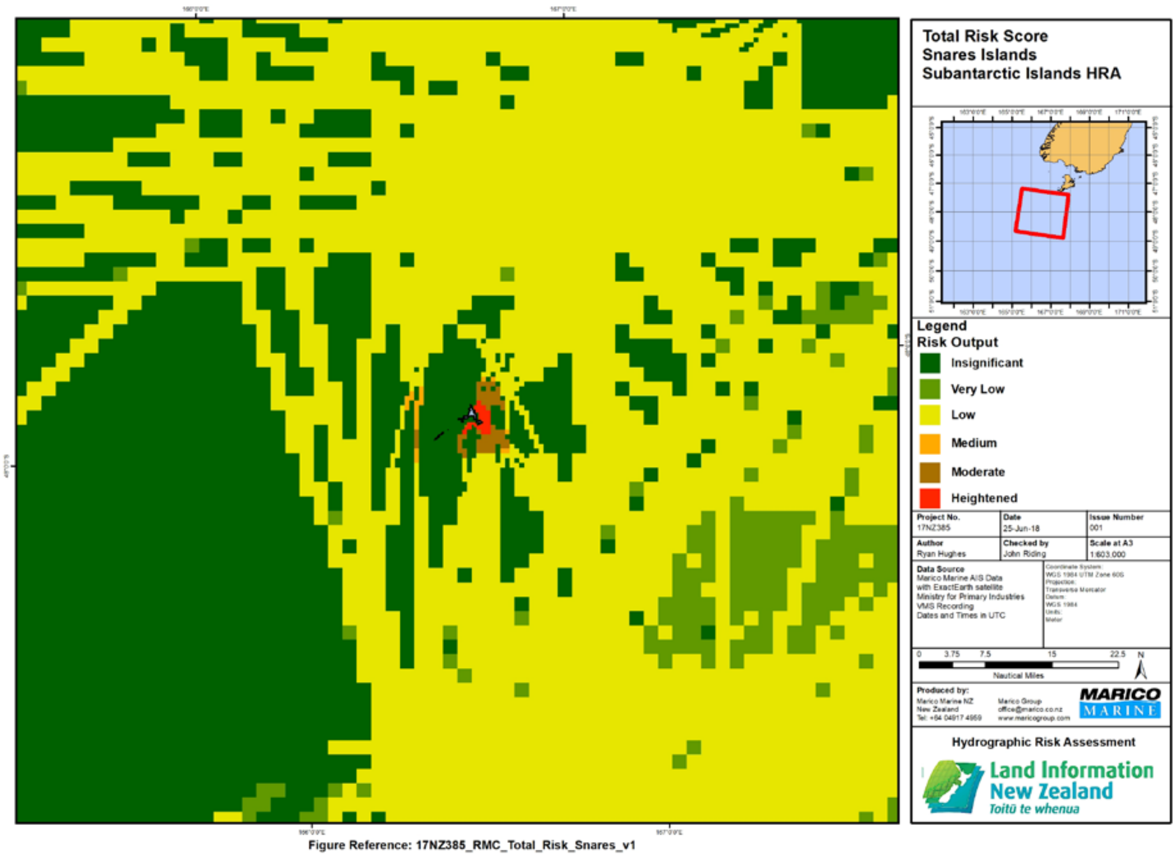


Figure 88: Hydrographic Risk Result - The Snares Islands (Standard Scale)

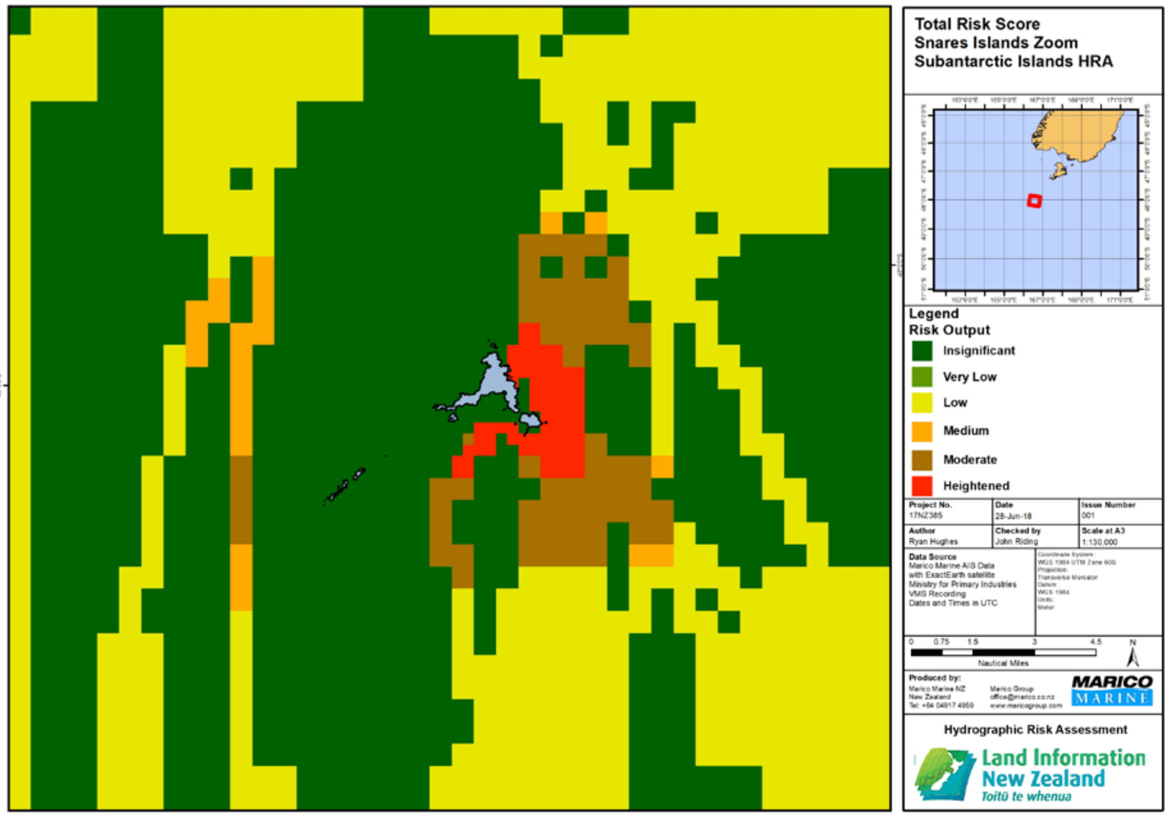


Figure Reference: 17NZ385_RMC_Total_Risk_Snares_Zoom_v1

Figure 89: Hydrographic Risk Result - The Snares Islands (Zoomed Scale)

13.7 SITES OF NOTABLE HYDROGRAPHIC RISK – SNARES ISLANDS

Figure 90 presents the hydrographic risk result for the Snares, with a heightened result at four locations. Areas of heightened risk are evident within the Eastern and Southern coast of Snares Islands. These areas included the northeast, Punui Bay, Broughton Island, Snares Island – south. Traffic type contributing to heightened risk within Snares Island was dominantly passenger traffic, **Table 29**.

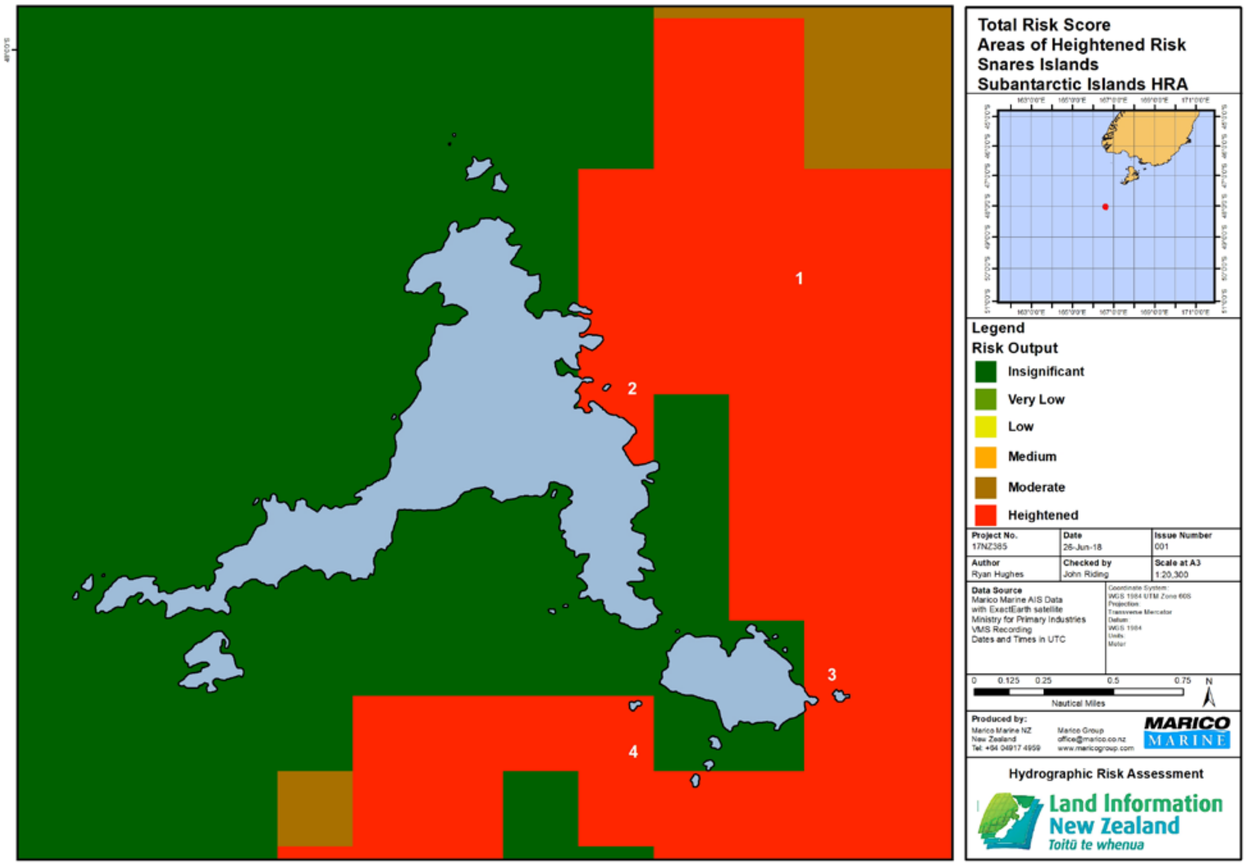


Figure Reference: 17NZ385_ES_Total_Risk_Snares_v2

Figure 90: Sites of Notable Hydrographic Risk - Snares Islands

Site #	Location	Risk Level	Traffic of Notable Risk Contribution
1	Snares Islands—Northeast	Heightened	Passenger
2	Punui Bay	Heightened	Passenger
3	Broughton Island	Heightened	Passenger
4	Snares Islands—South	Heightened	Passenger

Table 29: Sites of Notable Hydrographic Risk in the Snares Islands

14 DISCUSSION

The New Zealand Sub-Antarctic Islands consist of five Island groups; the Auckland Islands, Campbell Islands, Bounty Islands, the Antipodes Islands and Snares Islands. The islands are recognised as a unique ecological landscape for an array of distinct endemic species. Recognised as a UNESCO World Heritage Site in 1998, the islands are home to 40 species of seabird as their principal breeding grounds. The islands are the breeding site of approximately 11% of all seabird species in the world and 30% of the world's petrels, as well as 14 species of endemic land birds. The Islands also feature many species of marine mammals throughout the year, acting as important seasonal breeding grounds for migratory cetaceans, in particular Southern Right Whales.

The remote nature of the islands makes these areas particularly attractive to the specialist expedition cruise tourism industry and there is evidence of growth in the number of visitors who plan to visit the islands. Traffic to the islands is low by any relative measure and this risk result is driven in no small part by the importance of the endangered colonies that exist in these southern islands.

At present, vessel size visiting the Sub Antarctic Islands is limited by DOC to 125 metres length. This DOC limit will not fit this market in the longer term as the average vessel size for the expedition cruise vessel is moving towards 150 metres. These are modest size increases that the DOC licencing system can accommodate and DOC ultimately limits the number of people to any one site. The advice of the New Zealand Cruise Association was that cruise industry development in the Sub Antarctic Islands is inevitable and plans are already in place. Larger vessels in the expedition cruise sector are also being built; for example there is one vessel under construction of 165 metres in length. There is room for passenger number increases within the existing DOC licencing limits. Although this growth may be limited in terms of vessel size, both by the DOC vessel size limits and the specialism of the type of cruise operators who frequent such areas, the risk assessment provides a result that suggests a need for both charting review and survey plans.

14.1 HYDROGRAPHIC RISK

A hydrographic risk assessment has been successfully resolved. Risk has been derived relatively, allowing direct comparison to be made between areas which might have quite different characteristics. This hydrographic risk assessment identified areas of heightened risk within the Sub-Antarctic Islands, suggesting potential areas for survey consideration. This result is not comparable with previous risk assessments from other locations as the risk criteria have been designed for Sub-Antarctic and Antarctic use.

14.2 AUCKLAND ISLANDS

The hydrographic risk was moderate at five locations and heightened at six locations within the Auckland Islands. Areas of heightened risk were evident at the harbour entrances to Auckland Island, in particular, Port Ross, Enderby Islands, Ewing Island, Dundas Islands, Carnley Harbour – entrance and the east of Auckland Island. The contributing factors towards heightened risk involved a combination of a high number of species colonies and breeding sites, charted tidal hazards and the proximity to isolated dangers. The eastern region of the Auckland Islands is comparatively more sheltered than the western region resulting in a focus of hydrographic surveying in the eastern side. This focused survey approach has resulted in sections of unsurveyed areas on the western side of the Island with excellent charting through harbour approaches on the eastern side. Offshore to the Auckland Islands, charting quality has a CATZOC score of D which is classified as poor. Moderate risk in the offshore areas of Auckland Islands can be attributed to the density of both fishing and passenger vessel traffic in proximity to species and causation factors along the eastern coastline and to the north. The prevalence of these factors in combination with *high* levels of traffic (for this region) result in a moderate risk result, despite this part of the area being recently surveyed.

14.3 CAMPBELL ISLAND

The Campbell Islands presented a heightened risk result at four locations; North Cape, East Cape, Perseverance Harbour and the south of Campbell Island. Traffic type contributing to heightened risk within the Campbell Islands was fishing traffic, passenger traffic, and traffic associated with research/patrol from the Navy (HMNZ *Otago*). The contributing factors to heightened inherent risk are; the high number of endangered colonies; the charting quality (low CATZOC score) and shallow / uncharted depths. The eastern region of the Campbell Islands is comparatively more sheltered than the western region, resulting in a focus of hydrographic survey on the eastern side. Generally, the chart quality has a CATZOC rating of C and D and is classified as moderate to poor around the island. Despite a CATZOC score of B within the Perseverance Harbour entrance, heightened risk is evident here as a result of the high number of endangered colonies and breeding sites and the proximity to both isolated dangers and seamounts (a seamount exists around Terror Reef).

14.4 BOUNTY ISLANDS

Bounty Islands provided a moderate hydrographic risk result at three locations, Lion Island, centre group and the east coast group. The vessel traffic type comprised lower volumes of fishing vessels than other islands in the study area, with a single transit of a passenger vessel providing what is an important hydrographic risk result.

In relation to the already low levels of traffic than other Islands of the Sub Antarctics, traffic at Bounty is even lower. The heightened inherent risk result at these three locations is due to a high number of endangered colonies and breeding sites of numerous species of importance. The proximity to isolated dangers and the CATZOC rating of Unassessed (this is in the area immediately surrounding the landmass) in combination with shallow and unsurveyed areas are also drivers. As traffic around Bounty Islands is low, this resulted in a reduction in the overall 'risk' score as accounting for traffic in the risk model drives 25 % of the overall risk score.

Note should be taken of this result by decision-makers as the stakeholder advice is an expected increase in traffic. The Bounty Islands have specialist attractions, even though it is not possible to land. However, any decision for additional survey work in the Bounty Islands will in 2018-9 be based around the levels of inherent risk and thus the highly important concentration of truly endangered species, all existing in close proximity to each other.

14.5 ANTIPODES ISLANDS

The Antipodes Islands showed heightened hydrographic risk at two locations; the North West of Antipodes Islands and Mirouga Bay. The most notable contributing factors to moderate inherent risk within these areas are the high number of species colonies that are in close proximity to each other, charting quality (Low CATZOC Score) and the shallow/uncharted depths. The chart quality illustrates an unsurveyed area encompassing most of the Antipodes and Bollons Islands. There is a distinct region of moderate chart quality (CATZOC score of B) between the main Island and Ballons Island and to the East of Antipodes Island. The surrounding area is mostly comprised of CATZOC B chart quality. Traffic type contributing to heightened risk within Antipodes Islands was cargo traffic. The cargo vessel identified is the Norfolk Guardian, this vessel was used for pest eradication within Antipodes, most notably, the 'million-dollar mouse' project aimed at eradicating mice from Antipodes Islands. Pest control has been paramount in preserving the unique flora and fauna that persist within the Antipodes Islands. The first published reference to the presence of rats or mice on Antipodes was in 1899 and was thought to have resulted from a ship wreck. This successful project began in 2016 when New Zealand public donations raised $250,000 and the WWF[14] gave $100,000, The Morgan Foundation matched their donations with the rest of the final cost funded by DOC was spent on successfully eradicating the mouse population in 2018. Other projects within the Sub-Antarctic's have also resulted in the successful eradication of rabbits and mice in the Auckland Island group from both Enderby and Rose Islands in 1993, the eradication of goats from the main Auckland Island by 1992 and the eradication of rats from Campbell Island in 2001. The cost spent on these Islands presents a significant area of heightened risk, whereby, vessel accidents within these areas could result in a significant degree of loss and additional cost to assist with potential wipe-out of sensitive populations currently recovering on these islands. The expenditure on pest eradication within the Sub-Antarctic's is particularly significant and charting improvements may help to prevent re-infestation.

14.6 THE SNARES

The Snares Islands showed heightened hydrographic risk at four locations; the Eastern and Southern coast of Snares Islands. Traffic density was high around the Snares and the traffic type contributing to heightened risk within Snares Islands was dominantly passenger vessel traffic. The moderate inherent risk result was due to the high number of species colonies and breeding sites, the proximity to the great circle route, the proximity to isolated dangers and the shallow/uncharted depth. The relatively high traffic density in association with the great circle route provides in the heightened hydrographic risk result. Following discussion with representatives from the cruise industry, it was evident the Snares are a convenient stop, lying just one steaming day from the mainland of NZ. Most cruises to the Sub-Antarctic as well as some vessels passing South of New Zealand visit the Snares Islands for either dawn or dusk, when wildlife activity is most active.

14.7 VISITS TO WESTERN SIDES OF ISLANDS

Additionally, an interest to have a choice to visit either the eastern or the western sides of some of the Sub Antarctic Islands was indicated during discussions with the NZ body representing interests of the cruise industry. Referenced were Auckland and Campbell Islands, despite the prevailing weather conditions being unfavourable for significant periods

[14] WWF World Wildlife Fund.

of the year. The lack of access though is already regulated by DOC and there is no evidence of the consent system increasing the flexibility of visit location. This may be of more relevance to Campbell Island where a landing on the West may increase visitor numbers to some of the boardwalk tracks.

Summer months present calmer conditions that may merit visitation to these areas, even offshore for remote wildlife observation. Macquarie Island (Australian Waters), was referenced and presenting similar exposure to weather and sheltering capabilities, though cruise ships are able to visit areas all round these islands, subject to shelter. These waters are surveyed.

While many of the Sub-Antarctic Islands have reasonable charting accuracy, the western sides of most islands are less well surveyed. This reflects the predominant weather conditions in the region, with strong westerly winds and associated long period swell making conditions difficult for surveying, as well as being an unlikely place for small fishing vessels to seek shelter. Fishing vessels can shelter in close to the shore by taking advantage of calmer waters provided. Cruise vessels on the other hand have large hull areas when compared with other ship types and thus high windage loads – meaning it can be impossible for a cruise vessel to swing at slow speed under its own power in high wind speed. As the cruise market develops there is a need to consider providing improved charting on the western side for occasions when the island is directly providing shelter, enabling a cruise vessel to shelter on the lee shore of the Islands, wind direction dependent. However, whilst the probability is lower, strong winds from other directions do occur throughout the region. With the potential for large, high windage cruise vessels to start visiting the islands, the possibility of them trying to seek shelter on either side of the islands will increase. Thus, a future review the uncharted western sides of the islands is recommended, specifically Auckland and Campbell.

Overall, the results of the risk assessment have shown that a number of the Sub-Antarctic Islands have localised regions of heightened hydrographic risk, based on the criteria in the matrix. Areas of particular note for heightened risk include:

- Auckland Islands: Port Ross and Carnley Harbour;
- Campbell Islands: Entire eastern coast of the island;
- Antipodes Islands: Northwest coast of the island;
- Snares Islands: Eastern and Southern coasts of the island.

The Bounty Islands provide an interesting result, because they have a high ecological value overall, thus providing a score of heightened when Inherent Risk is considered. The Bounty Islands are low lying and are comprised of Lion Island, the Centre Group and the East Coast Group.

Given the nature and prominence of medium risk in the nearshore waters of some of the islands, in areas where charting is considered poor it does seem worthwhile to consider a Charting Benefit Assessment.

15 CONCLUSIONS

1) A hydrographic risk assessment has successfully been performed for the New Zealand Sub-Antarctic Islands using a set of risk criteria designed specifically for this region and Antarctica. Risk has been used relatively in the study, allowing direct comparison to be made between areas which might have quite different characteristics.

2) The concept of 'inherent risk' has been developed to solve a critical aspect of this hydrographic risk assessment. Inherent risk is the risk associated with consequence and causation criteria in the absence of vessel traffic. In this risk assessment the ecological importance of the resident endangered colonies is a core driver. The importance and disposition of these colonies throughout the Sub-Antarctic islands has allowed the design of a risk system that differentiates locations on the basis of ecological importance. This approach can be applied, with care, to other truly remote areas, such as Antarctica. A Hydrographic Risk result appears once the traffic component is added.

3) The Sub-Antarctic traffic makeup is presently dominated by fishing vessels, but cruise operations are increasingly present. However, this traffic did not have a large impact on the hydrographic risk result. This is due to fishing activity being largely offshore, as well as the relative level of transit risk accrued by fishing vessels within the risk model.

4) Traffic levels overall in the Sub-Antarctic Islands are at least an order of magnitude lower than other remote areas of the New Zealand EEZ. DOC licencing limits are in place on vessel size (125m length limit) and the number of people that can be landed in any one site. Thus, further expansion is likely to be measured. However both DOC and cruise New Zealand advise of significant interest from cruise operators, with future bookings being made representing increases over the past. The DOC licencing system design has capacity for expansion and this study concludes the expected increases are real. Even a small increase in cruise visits is a significant increase by percentage.

5) The results of the risk assessment have shown that a number of the Sub-Antarctic Islands have localised regions of heightened hydrographic risk. This level of risk is unrelated to the risk results of any other Hydrographic risk study. Areas of particular note for heightened risk include:

- Auckland Islands: Port Ross and Carnley Harbour;
- Campbell Islands: Entire eastern coast of the island;
- Antipodes Islands: Northwest coast of the island;
- Snares Islands: Eastern and Southern coasts of the island.

6) The hydrographic risk result for Bounty Islands shows moderate risk. However, these islands possess significant endangered ecological diversity, in colonies that are grouped in close proximity to each other, but each on a different island. The inherent risk is heightened and the risk assessment is sensitive to any increase in traffic volume. Only one small cruise vessel transit that year provided this result (a verified transit). This in an interesting result, with the inshore waters of each island remaining uncharted as traffic us not expected. This result should be specifically reviewed by hydrographic planners and a decision to make charting improvements may be justified by the ecological importance of the Bounty Islands.

7) It is also noted that whilst many of the Sub-Antarctic Islands have reasonable charting accuracy in the eastern coastal waters, the western sides of most islands are in many cases unsurveyed (CATZOC U). This is a reflection of the predominant weather and sea conditions in the region, combined with natural harbour inlets lying to the east. Shelter is available practically on Campbell and Auckland and whilst the occurrence is low, strong winds from other directions do occur. With the potential for medium sized cruise vessels to start visiting the islands, the possibility of them trying to seek shelter on either side of these islands will increase (hull windage). Thus, it is recommended that surveys be considered to the west of Campbell and to a lesser extent Auckland Island. There are also stakeholder reasoning for this to facilitate landings closer to DOC licenced visitor sites.

8) The traffic profile in the North of the study area was typical of vessel traffic transiting the Great Circle Route north to Panama. The risk criteria of the matrix were modified to cause such transits further offshore to trigger a risk response, on the basis that these are large vessels. The majority of vessels taking the Great Circle Route were far enough from most of the Island groups to not affect their levels of hydrographic risk. The Snares Islands were an exception to this and bulk carriers in proximity to the Snares Islands provide a risk contribution in comparison to elsewhere in the Sub-Antarctic Islands.

9) The Snares Islands are a useful cruise destination due to their proximity to New Zealand (1 day by sea). This, accompanied with anticipated increases in cruise vessel activity poses a significant contribution to the risk result amongst these islands. Like Bounty Group, the Snares present a hydrographic decision-making need as it is possible for larger cruise vessels to visit for offshore viewing as part of a New Zealand itinerary, especially when proceeding to or from southern Australian waters.

10) The results are based on the data that could be gathered. This risk assessment is different to all others undertaken to date in that it was not possible to obtain direct feedback from stakeholders with local knowledge, simply because there are no human residents. Data has thus been taken at face value, which may suggest a vulnerability in the results. Wind and wave data for the area relies on macro gathering and mariners particularly cite, for example, inaccuracy in wave data.

11) It is clear that all stakeholders consulted, including DOC (as regulator and custodian of the Islands), are expecting an increase in both vessel numbers and visitors to these Islands. The present licensing system can accommodate an increase in numbers and in most cases there is variance between consented numbers planning to visit (per vessel) and actual passengers landed. Current trends for the cruise industry equally indicate an increase in passenger numbers, vessel size, and trips to the islands

12) A single incident in 2017 where a cruise vessel touched bottom, demonstrated the potential vulnerability of passenger operations in these remote areas of the globe. This was, in the event, a minor incident, but if the vessel had needed assistance or harbour support interface, this would have been difficult.

13) The cruise industry consultation included the potential for future visits to Western regions of the Sub-Antarctic Islands. While acknowledging high frequency of unfavourable weather conditions from the west, the views expressed were based on some experience of cruise operations able to land or shelter on the west of Macquarie Island – which has similar conditions. Auckland and Campbell Island, in particular, feature suitable topography to provide shelter to high-windage cruise vessels. Additionally, visitation to the upper west coast of Campbell Islands could increase visitor access to Penguin Bay and the Northwest Bay Circuit.

16 RECOMMENDATIONS

1) Given the low levels of traffic (Conclusion 4, above), and the fact that this risk assessment prioritised the importance of the unique ecology in order to deliver a hydrographic risk assessment that differentiated amongst island groups, LINZ is recommended to undertake a Charting Benefit Assessment to assist in decision making.

2) Hydrographic Risk methodology was further developed for this study in that the concept of Inherent Hydrographic risk was derived. It is a solution that should be used where traffic is truly sparse. The Hydrographic Methodology document should be revised to take account of the developments made in the New Zealand EEZ study and now this Sub-Antarctic study.

3) DOC presently have a 125m length limit for cruise vessels visiting the Sub-Antarctic Islands. However, expedition cruise vessels are increasing in size, in common with other vessel types. There was one expedition vessel under construction in 2018 at 180m in length. The increase in length is not significant as passenger demand expansion for expedition cruising is likely to be measured. An increase the DOC length limit to 150-160 metres should be considered as this an increase in allowed length facilitates vessels with better seakeeping capabilities to visit. The passenger capacity of these vessels is unlikely to increase significantly and the daily landing limits set for individual locations can still apply.

4) With the potential for larger, high-windage cruise vessels to start visiting the islands, the possibility of one needing to seek shelter on either side of the islands will increase. This though is only relevant to islands such as Campbell and Auckland, where land height is available to provide some lee shelter in an easterly. Thus, it is recommended that the western side of these Islands, in particular, are given some priority for charting upgrade.

5) This Hydrographic Risk Assessment was necessarily undertaken during the summer period for the Southern Hemisphere. This created some difficulties with data gathering as personnel most able to contribute (including key DOC personnel) were deployed either in Antarctica or the Sub-Antarctic Islands. Project delays occurred in the ability to meet and obtain necessary inputs. It is thus recommended that further work in the Southern Ocean is programmed to take place during the winter period in the southern hemisphere.

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