MARINE POLLUTION RISK ASSESSMENT FOR THE PACIFIC ISLANDS REGION

(PACPOL PROJECT RA1)

VOLUME 1: MAIN REPORT

for
Pacific Ocean Pollution Prevention Programme (PACPOL), South Pacific Regional Environment Programme (SPREP)

By

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July 2003

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1 SUMMARY

This study assesses the risks of shipping incidents that have potential to cause marine pollution in the Pacific Islands Region. The Study classifies the region into zones of high, moderate and low potential for collision and grounding incidents, at three levels: the PICT region as a whole, individual country Exclusive Economic Zones (EEZs) and 31major ports.

The formal definition of "risk" is an equation:

Risk = (Probability of incident) X (Harmful consequences of incident)

This study deals mainly with the comparative probability of maritime incidents with that could have significant pollution consequences. It is a preliminary risk analysis. A full risk assessment would quantitatively evaluate both right-hand terms of the equation.

On the worldwide scale, about 0.75% to 1% of registered vessels are involved in significant casualty incidents each year, and 0.2% to 0.3% become total losses. 283 casualties that occurred in the Pacific Islands region during the period 1976 to 2000 have been classified and geo-referenced. Grounding under power accounted for 65% of incidents, indicating that faulty navigation was the major proximal cause of casualties. Smaller vessels were more likely to become casualties than larger vessels. Fishing vessels had the highest casualty incidence; 66% of fishing vessel incidents led to total loss.

We identified grounding and collision as the commonest casualty types with significant pollution consequences. The model for the assessment of grounding and collision risks at regional and EEZ scales is to calculate for each grid cell in the region:

Risk Potential = (Traffic) X (Presence of hazard)

Risk potential refers to the relative probability of an incident of a specified type. For the calculation of grounding risk potential, the hazard is presence of reef(s) or shoreline in the grid cell. For collision, the hazard is the probability of another vessel in the grid cell. We estimated collision potential as (Total Traffic) X (Number of routes crossing cell). Cell size was one degree square for both analyses. Two-way traffic counted as two routes.

The regional to EEZ maps of risk potential show clusters of high risk in Fiji, French Polynesia and the Solomon Sea shores of Papua New Guinea and the Solomon Islands. There are smaller clusters in Tonga, the Samoa's, Vanuatu, and the corridor from Chuuk northward past Guam and the Northern Mariana Islands. The pattern of predicted casualties corresponds well with the pattern of historical occurrences, except in French Polynesia and New Caledonia, where our database shows fewer historical casualties than the prediction. This apparent difference could be the result of uneven success in data collection, or of chance, or of factors, such as aids to navigation, that reduce risk in these areas.

At the ports scale, we applied a more detailed model to account for physical characteristics of the port in comparison to the requirements of the vessel for safe passage. This model is similar to standard methods practiced in Europe and North America for the evaluation of port and waterway risks. It compares the available channel width (CW) to the Minimum Safe Distance (MSD) required for safe passage of a particular vessel through the most challenging passage to the port, and accounts for environmental variables such as turns, currents, winds and aids to navigation:

Security Measure = (Channel Width) / (Minimum Safe Design)

Security measure equals one indicates a channel just wide enough for safe passage of a particular vessel.

For each port, we calculated the Security Measure for a vessel representative of the larger vessels using that port, under typical challenging environmental conditions at that port . SM is equal to or less than 1.0 at four ports: Port Vila, Avatiu, Malakal and Papeete. This indicates that available channel width is less than that required for secure passage. Saipan, Betio, Pohnpei, Madang and Honiara have low to moderate Security Measure. Most of the less secure ports have low volumes of traffic. In order to assess the potential for a major pollution incident, we compared the security measure to the volume of oil tanker traffic for each port. Lower security with higher traffic indicates greater risk. By inspection, the highest potentials for oil pollution incidents are at Guam, Papeete and Madang. Noumea, Suva and Vuda/Lautoka also have high tanker volume, but risk is moderated by lower security measure.

Fishing vessels, especially the distant water fleets of longline tuna vessels, are prominent among historical casualties. Their risk potential cannot be assessed by the model appropriate to vessels that travel directly from port to port along regular routes. We present a gridded map of longline fishing effort as a proxy for fishing vessel traffic throughout the region, and thus the relative risk potential. Longliners were active in two broad areasin the year 2000: one in the south central pacific from about 160°E to 155°W, and 10°S to 35°S; and one in the western equatorial Pacific from 130°W to 165°W and 0°N to 10°N. Fishing patterns, and ports chosen for transhipment to mother vessels, change from year to year depending on environmental and political factors. Roving tankers refuel some fishing vessels at sea, but this traffic is difficult to assess.

The Pacific Islands region is not heavily industrialised. Therefore hazardous cargoes transit the area in relatively small quantities. Some ultrahazardous wastes transit the area. Spent nuclear fuels are shipped from Japan for reprocessing in Europe, and returned as plutonium/uranium mixed oxides fuel (MOX) and vitrified high level waste (VHLW). Of three routes in use from Europe to Japan, the one via Cape of Good Hope and south of Australia passes through the PICT region. The route westward around Cape Horn crosses the Pacific on a great diagonal that passes east and north of the PICT region, near Hawaii, and onward to Japan.

This study is semiquantitative at the level of a preliminary risk assessment. It is a suitable foundation for a full quantitative risk assessment. We have succeeded in classifying a 1 degree grid of the Pacific Islands region into areas of high, medium and low potential for grounding and collision. We have identified ports of high, medium and low potential for casualties, in particular incidents involving oil tankers. The database and GIS system built for these analyses is open and dynamic. It can accommodate revision, modification or amplification for other uses.

1 INTRODUCTION

Pacific Island States are highly dependent on the maritime sector for the transportation of goods and people. With shipping there is the associated potential of pollution from incidents such as groundings, collisions or accidental discharges during cargo handling. The South Pacific Regional Environment Program (SPREP) in partnership with the International Maritime Organization (IMO), is addressing shipping related marine pollution through the implementation of its Pacific Ocean Pollution Prevention Programme (PACPOL). Figure 2.1 and Table 3.1show the countries and territories participating in PACPOL and are collectively referred to in this document as the Pacific Islands region.

Collectively Pacific Island countries maintain resource access rights and management responsibilities over an ocean area of about 28 million square kilometers. This is equivalent to the combined land areas of Canada, China and the USA. There are at least 11 square kilometers for every coastal Pacific Islander. Jurisdictionally the sea is nearly 200 times more significant to the average Pacific islander than to the average global citizen (Adams et al. 1995). The ocean is clearly the dominant feature of the region. Land area is less than 2% of the total area under the jurisdiction of pacific island countries.

PACPOL has activities in four focal areas: marine spills, ships' waste management, port operations and invasive marine species. In the marine spills focal area, SPREP has developed spill contingency plans at both the regional and national levels. A report on ship groundings within the Pacific islands region has been published (Preston et al. 1997). The present marine spill risk assessment is one of the suite of activities being undertaken within the marine spills focal area.

This report presents an initial marine traffic pollution risk analysis for the Pacific Islands Region. The major output is a series of maps showing ocean areas of high, moderate and low potential, at regional, EEZ and port levels. The risk assessment provides a baseline and framework for identifying issues and areas to be addressed.

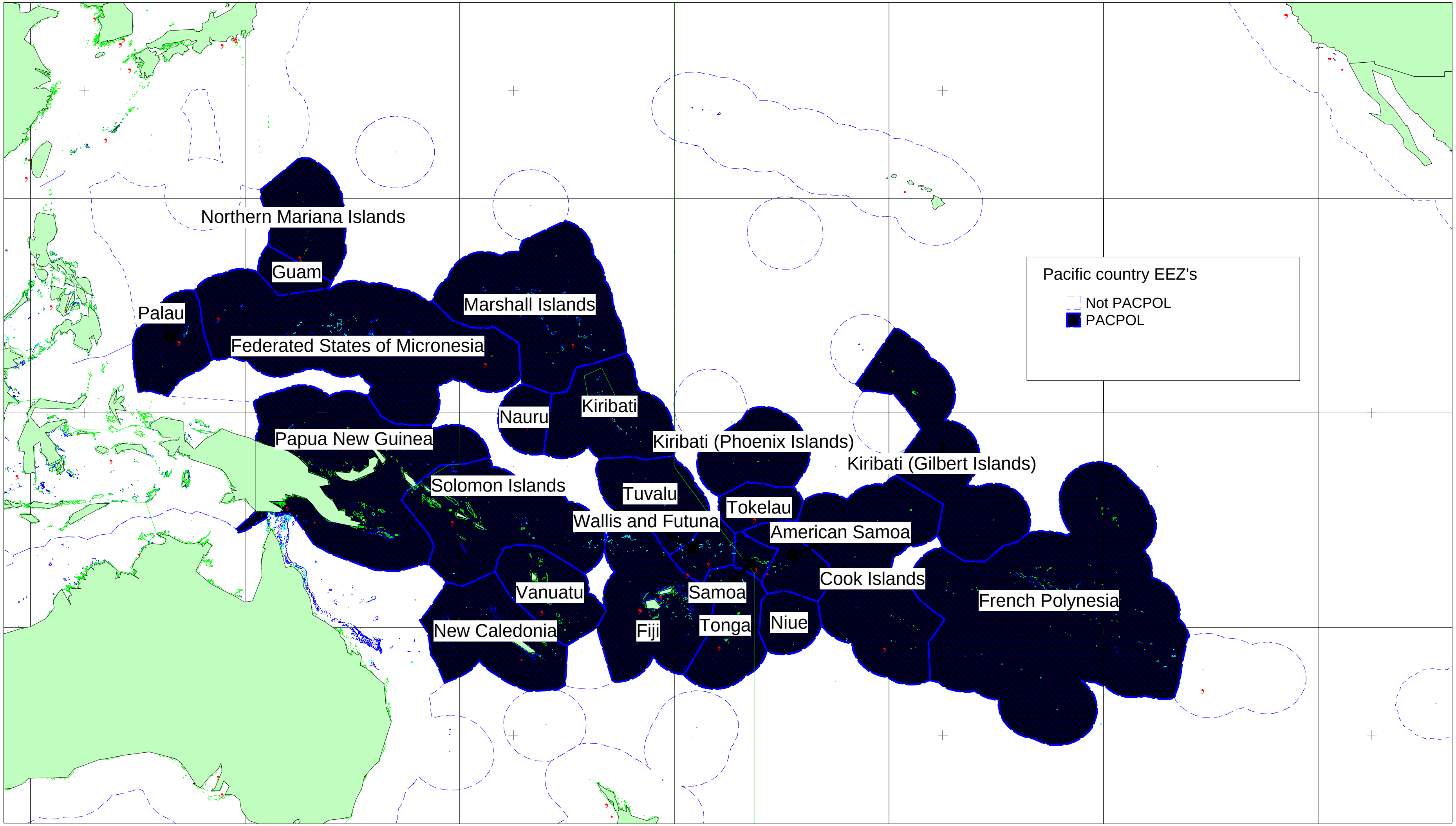


Figure 1.1 PACPOL country and territory EEZ's.

1.1 Perspectives on ship casualties and environmental consequences

1.1.1 World casualty statistics

At present about 0.2% to 0.3% of the world's registered vessels are declared total losses each year. This is a significant improvement over the decades 1960-1980, when total losses were about 0.5% to 0.75% of the world fleet. The recent loss rate for oil tankers is similar to that for other vessels (Filor 1994). However this total loss rate would be found outrageously high for commercial aircraft and unacceptable for road transport. In an analysis of total loss potential for tanker, container and bulk ships, Talley (1997) found that the risk is greater for smaller than for larger ships, and for human-caused and fire/explosion incidents than for other incidents.

Total loss incidents have been used as a convenient indicator as they have the greatest potential for environmental damage. However there are many more cases in which hulls are breached, or cargo lost, but the ship is repaired and returned to service. The *Exxon Valdez* incident in Prince William Sound, Alaska in 1989 was a grounding with loss of 36,000 tonnes of crude oil, less than one fourth of the total cargo (Paine et al. 1996). The ship was refloated and returned to service. Cleanup costs and immediate compensation paid to fishermen were US$2.3 billion. Total costs will probably exceed US$4 billion.

Among 3575 ship accidents reported worldwide in 1994, bulk carriers had 98 grounding and collision incidents per 1000 ships. Container ships had 74 incidents per 1000 ships (Goulielmos et al. 1997). Older vessels, and those of some open-registry (flag-of-convenience) countries, are involved in more groundings and collisions than the world average (Li and Wonham 1999). They found, however, that among 36 principal world fleets over 20 years, the safety record of developing maritime nations as a group is better than that of developed maritime countries.

The Australian Great Barrier Reef Inner Route (GBIR) and Torres Strait present some aspects of navigation similar to those of the Pacific Islands region. About two thousand ships per year transit this route, or pass eastward from Torres Strait through the Great Northeast Channel to the Coral Sea (Quirk 1997; Raaymakers 1997). The traffic is not very dense by world standards, but the passages are restricted for distances of up to 500 nautical miles and contain shallow areas, numerous scattered reefs, nearby areas of inadequate charts and strong tidal currents (Quirk 1997; Small 1997). Aids to navigation are good. Pilotage is compulsory in the GBIR, and most ships accept the International Maritime Organization (IMO) recommendation to engage pilots for the passage through Torres Strait and the Great Northeast Channel.

In 1970, the *Oceanic Grandeur* grounded in Torres Strait , releasing a significant spill of crude oil before it was refloated (see box *Oceanic Grandeur*). The tanker *Mobil Endeavor* also grounded there, in 1986. There have been no major oil spills in the GBIR/Torres region since 1970, but there have been numerous large-ship incidents with serious pollution potential, including 12 ship - ship collisions, 33 groundings and at least 11 significant contacts with port infrastructure in the period 1980-2000 (Raaymakers 1997; GBRSRSS 2001).

One estimate suggests that the rate of groundings in GBIR is 25 times higher, and collisions 17.1 times higher, than in the Strait of Dover, the most densely traveled passage in the world (Evanston and Potts 1990 in Filor 1997).

1.1.2 Navigational hazards of the Pacific Islands region

The region has generally good visibility and benign weather except during occasional intense storms. Most islands and reefs are steep-sided. There are no extended passages in shallow water. Nevertheless, there are substantial hazards throughout the region. Coral reefs surround most land, and many islands are low-lying. There are many off-lying reefs far from identifiable landmarks or aids to navigation. These aids are often unreliable or not well maintained. Few charts are constructed on modern hydrographic surveys, and many include numerous notations on reported shoals, and islands that may lie several miles from their charted positions.

In the event of a grounding or collision incident, effective salvage and pollution control operations will depend on the will and resources of the shipowners, their professional associations and the countries involved. Distance from salvage and pollution control resources and political instability are factors that work against favourable outcomes (See box

Case Study 1: Oceanic Grandeur in Torres Strait.

The tanker Oceanic Grandeur *grounded on an uncharted rock in the Alert Patches, Torres Strait on 3 May 1970. Alert Patches (10°30' S; 142°21' N) is an area of sand waves at the eastern entrance to the strait, and the site of several other incidents.The hull was breached, and between 1400 and 4000 tonnes of crude oil spilled into the waters of Torres Strait and the far northern portion of the Great Barrier Reef. The remaining cargo was transferred to the tanker* Leslie J. Thompson*, and the* Oceanic Grandeur *was refloated and removed. (Watkinson 2000)*

The Oceanic Grandeur *spill did not cause acute large-scale environmental damage because most of the oil dispersed naturally in the open, high current waters of Torres Strait. . Where oil impinged on mangrove shores, it killed patches of trees but spared most of the forest. Little systematic work exists to document either the extent of environmental damage or the recovery process. Twenty-five years later, in 1996, a resurvey of the area by the Australian Institute of Marine Research (AIMS 2001) showed that young* Rhizophora *mangroves had filled in between the larger surviving trees, and oil was not detected in sediments. Recently, there has been a suggestion that dugong left the Torres Strait area after 1970, and are only now returning . Torres Strait is particularly rich in the seagrasses that are the favourite food of dugong.*

This incident occurred just outside our study area. We include it in our discussion because it is an example of a moderately large oilspill that had the potential to affect coral and mangrove habitats, and because it provided an important stimulus to the development of the Australian national plan for response to oil spills (NATPLAN) and a chain of ship safety and spill mitigation initiatives (AUSREP).

In 1981, the United Nations (UN) inscribed the Great Barrier Reef on the World Heritage List. In 1990 the International Maritime Organization declared the Great Barrier Reef and Torres Strait as a Particularly Sensitive Area (PSSA) under MARPOL 73/78, which has permitted Australia to establish special pollution regulations vessel management systems and contingency plans (REEFPLAN, REEFREP). These include compulsory pilotage and position reporting, for all vessels over 70m LOA in the northern portion of the Great Barrier Reef Inner Passage. In most of the Pacific Islands nations, the state of readiness to respond to a large spill is less advanced than that in Australia before the Oceanic Grandeur *incident.*

World Discoverer).

Storms have caused many recent marine pollution incidents, particularly in northern Europe. Although weather in the Pacific Islands Region is generally benign, the occasional rotating tropical storms (cyclones, hurricanes) present localized areas of intense risk. Efficient storm tracking systems based on satellite images and shore-based radar enable large vessels at sea to avoid cyclones, but smaller vessels in regional service or in harbour are at risk (See box Hurricane Val at Pago Pago).

1.2 Commerce and shipping in the Pacific Islands region

1.2.1 General commerce

International trade in manufactured products and small loads of agricultural products and other raw materials were once shipped mainly in small break-bulk freighters. Over the past 20 years, these have been replaced by larger container liners of about 20,000 GT traveling scheduled routes between continental ports with calls at major island distribution centers (Forsyth and Systo 1999; Heathcote 1996; CIA 2001). The movement to standardised containers has brought increased efficiency and dependability of service, but container liners only call at appropriately-equipped larger ports where there is sufficient volume to make a stop economic.

Regional freight or mixed passenger/freight vessels may carry a limited number of containers to remote islands. Distances may be very large, even among the islands of a single nation. Cargo volumes are small, and often of marginal value per tonne (for example copra, once the dominant export for many of the nations). Many of the regional and national shipping services are subsidised or owned by the countries served - for example the Cook Islands National Line and Kiribati Shipping Services Ltd. The Pacific Forum Line, owned by 12 South Pacific island nations, was established in 1977 to assure international services to the region at a time when such services were irregular. Many of the vessels in local and regional service are old and in poor repair, largely because revenues can seldom support new construction. The average age of all ships registered in, and owned by nationals of the Small Island Developing States was 18.3 yr in 1995 (UNEP 1996). The average for container vessels is a few years less than that for tankers, bulk carriers and general cargo vessels. This is representative for Oceania, except Papua New Guinea, where the average age was 10.4 yr.

The major commercial influences in the Pacific Islands are Australia and New Zealand. Shipping services to/from these countries are often integrated with east-west long distance routes to North America, Europe and South Asia. Trade linkages to the USA are strongest in the North Pacific (CNMI, FSM, Guam, Marshall Islands, Palau) and in American Samoa. French influence is strong in the Overseas Territories of French Polynesia, New Caledonia and Wallis and Futuna.

The second major axis of maritime trade is north/south, with connections northward to Hong Kong, Taiwan, Korea and southward through the Pacific Islands Region to New Zealand.

1.2.2 Bulk products

Phosphate fertilisers

Bulk shipments of raw phosphate-rich rock were loaded for many years at Banaba (Ocean Island) and Nauru. The deposits at Banaba have been exhausted, and the island rendered uninhabitable. Phosphate exports from Nauru are nearing exhaustion.

Cane sugar and molasses

Fiji exports annually about 400,000 tonnes of raw cane sugar and 150,000 tonnes of molasses. These commodities are loaded into chartered bulk carriers at dedicated terminals in Lautoka and Labasa. Bulk supplies of fuel oils, caustic soda (NaOH) and calcium phosphate ($CaPO_4$) are imported to supply the sugar industry.

Other agricultural products

A number of traditional exports continue throughout the region. Copra, once the main export of most islands, has declined in importance and is marginally economic. Fruits continue as a trade background, but new export crops such as vanilla and kava are finding more profitable niches. Most of the niche crops are high value/low volume commodities, and are shipped in containers rather than in bulk. Squash are exported in bulk from Tonga to Japan seasonally, in May and again in November-December.

Fish

The only large volume export fishery in the region is that for tuna. The fishery itself has high potential for ship casualties. The Oceanic Fisheries Programme of the Secretariat of the Pacific Community (SPC) estimates that 6025 longline, pole-and-line and purse seine vessels were engaged in the Pacific tuna fishery in 2000 (SPC 2000). The statistical area includes areas outside the Pacific Islands region in the China Sea, and the smaller seas surrounding Indonesia and the Philippines. If only half these vessels fished in the region of interest, they would still be the most numerous vessels in the area. Typical sizes for a distant water longline vessel are in the 300-500 GT range. Purse seiners are usually somewhat larger than long liners; pole-and-line vessels, smaller.

“Mother ships” (auxiliary vessels for delivering supplies and transhipment of catch) attend the distant-water fleets. An elusive number of tankers refuel fishing vessels at sea. No statistics are available for this traffic.

Pago Pago, in American Samoa, is a major tuna canning and shipping port. Noro, in the Solomon Islands also cans and ships tuna, as does Fiji in smaller volume. (Activities in Noro were suspended in 2002 because of political instability.) The highest quality fish are landed at major ports and shipped to market by air.

Logs

Fiji exports timber products in conventional containers and wood chips in bulk from a bulk loading facility at Lautoka. The other Melanesian countries (Vanuatu, Solomon Islands, Papua New Guinea) also export some timber products by container and have significant exports of raw logs loaded directly to vessels from harbours of convenience near the sites of harvest. These operations often bring unpiloted vessels into restricted, unfamiliar and inadequately charted waters without benefit of aids to navigation.

Ores and coal

Papua New Guinea is a major mining nation, with exports of gold and copper ore concentrate. New Caledonia mines and smelts nickel ore. Fiji has two operating gold mines. The larger Melanesian island nations have high potential for new mining activity. Mining activity usually generates bulk cargoes of ore concentrate (but not for gold, which is recovered on site). It also requires substantial imports of chemicals such as flotation agents for concentrating copper ore, dynamite and sodium cyanide for some gold extraction processes.

1.2.3 Oil

Crude oil is produced at only one field in the Pacific islands region: Kutubu, in Papua New Guinea. The Kutubu and associated fields opened in 1991, reached peak production of about 46 X 10^6 bbl/yr in 1992, and are now entering the depletion phase at about 25 x 10^6 bbl/yr. Crude oil from Kutubu is loaded onto tankers at the Kumul marine terminal, 40 km off the southern coast of Papua New Guinea. It is transported in MR tankers westward through Torres Strait to Singapore.

Other crude oil transits Torres Strait eastward, from western Australia via the Great Barrier Reef Inside Route to East Coast refineries. This route is outside our study area.

There are no commercial scale oil refineries in the Pacific Islands region. (A small refinery serves the local requirements of the Kutubu oilfields in Papua New Guinea.) Refined petroleum products are loaded mainly in Australia (Brisbane or Melbourne) for the southern portion of the region, and Singapore for the northern island nations. Medium Range (MRX) Tankers of about 25000 to 60000 dwt transport from the refineries to regional centers. Local Coastal Tankers (LCT) of about 1500 to 5000 dwt perform secondary distribution to one or a few bulk plants in each island country, where products are further subdivided for local delivery by road tankers or in drums.

The major products carried are mid range fuel oils (diesel, jet fuel, kerosene) and light fuels (petrol, avgas). Heavy fuel oils are used to bunker a few ships and fishing vessels, and in some industrial furnaces, for example at the sugar mills and a cement kiln in Suva. The largest importer of petroleum products to Fiji reported that the typical mix is about

Diesel	45%
Aircraft jet fuel	30%
Unleaded petrol	20%
Industrial furnace oil (IFO)	5%

Other importers have a similar mix. The cargoes in secondary distribution by Local Coastal Tankers would have a higher proportion of petrol. Because crude oils are minor components of traffic, oil spills in the Pacific Islands region are likely to have higher acute toxicity, but lower long-term effect, than the most notorious incidents, which are mostly crude oil spills.

1.2.4 Liquefied petroleum gas

Origin Energy supplies Liquefied Petroleum Gas (LPG) with a fleet of two LPG tankers from New Zealand to the South Pacific Islands. The specific products carried are propane/butane mix to Papua New Guinea and the Solomon Islands, and butane to the remainder of the South Pacific. LPG reaches the North Pacific islands by a separate distribution system, by LPG tanker from Singapore or the Philippines to a bulk terminal in Guam.

1.2.5 Nuclear fuels and wastes

Issues involving radioactive materials are particularly sensitive in the Pacific Islands region. The terrible history of open air nuclear weapons testing in the Marshall Islands at Bikini and Enewetok, coupled with fears and protests surrounding recent underground testing in French Polynesia at Muroroa and Fangataufa, have raised broad-based awareness of the dangers of radioactive materials.

The last series of nuclear weapons tests concluded at Mururoa in 1996, but radioactive wastes and nuclear fuels are routinely shipped through the region. No radioactive materials are produced or used in large quantities within any of the Pacific Island Coountries and Territories. Australia, however, is a major producer of raw uranium, which is shipped as uranium hexafluoride concentrate to Japan on routes that must transect the region (UIC, 2001). Military vessels that travel through the region are another source of radioactive materials risk.

The major emerging concern regarding radioactive wastes centers on Plutonium. Plutonium does not occur in nature. It is produced as a by-product in nuclear power reactors by neutron bombardment of Uranium-238, the non-chain-reacting isotope in uranium fuels. Plutonium is probably the most toxic chemical element; it is highly radioactive; and it is a preferred material for making atomic weapons because less than 5 Kg are required and it is easily handled. Uranium-235 is the chain-reacting isotope, which forms several percent of the uranium in conventional nuclear fuel. U-235 is a gamma-emitter. Gamma radiation is very penetrating, requiring massive shielding for safety. Plutonium by contrast is an alpha-emitter. Alpha particles are stopped by very light shielding - they cannot penetrate even human skin - but they are very dangerous if inhaled or ingested because the radiation is at an energy level that damages DNA and thereby causes cancer and abnormal development in addition to the direct toxicity of plutonium. High toxicity and relative ease of conversion to nuclear weapons make plutonium a serious security concern.

Plutonium-239, Plutonium-240 and small quantities of higher mass number isotopes are produced in light water cooled reactors (LWR), the kind used in most power generators. It could be used in another kind of reactor as fuel that would produce more plutonium by neutron bombardment of Uranium-238. The total energy output per gram of uranium in these liquid sodium-cooled fast breeder reactors (FBR) could be 100 times the output from an LWR. During the 1960's and 1970's, industrialised nations concentrated on the development of commercial FBR's. Policies and infrastructure initiated at that time shape the industry today.

Plutonium is recovered from LWR spent fuel in reprocessing plants, which return plutonium and high level radioactive wastes (HLW), while discharging the less radioactive fraction to the sea or storing it on land. There are only two large-scale reprocessing plants in operation in the world: one in Britain, and one in France. The principal clients are French, British, German and Japanese electric power companies. Shipments of Japanese spent fuels to Europe and return of plutonium and HLW to Japan may traverse the Pacific Islands region. (Japan has one small reprocessing plant at Tokai, and another under construction at Rokkasho.)

British Nuclear Fuels Ltd. formed a shipping subsidiary, Pacific Nuclear Transport Ltd. (PNTL) in 1975 to serve the Japan-Europe nuclear fuels trade (BNFL 2001). PNTL has built five special nuclear transport vessels for this trade. Each vessel is about 5000 GT with a variety of safety features including redundancy in power, steering and navigation systems, double hull construction, and advanced fire-fighting and cargo cooling systems. The wastes or fuels are packed in metal canisters, which are in turn inserted into special large transport casks each weighing about 100 tonnes. Two of the vessels, *Pacific Pintail* and *Pacific Teal* were converted to armed merchant ships by the addition of three 30mm cannons and other equipment in 1998-99. These two vessels are used as mutual armed escorts for the transportation of plutonium or MOX. All five vessels appear to be in commission in 2002.

A combination of economics and safety issues has ended most FBR programs. Russia, Japan, India and China maintain demonstration or research FBR programs (Von Hippel 2001). The remaining solutions for disposing of plutonium are to store it as unprocessed spent fuel; to store it as Plutonium oxide; or to return it to LWR's as fuel. Plutonium can be used in LWR's in mixture with enriched uranium as mixed-oxide fuel (MOX). Japan has received three publicly recorded return shipments of reprocessed plutonium, one as plutonium dioxide in 1993 and two of MOX in 1999-2001. Australia has sent at least three shipments of spent fuel to Europe for reprocessing. All materials sent for reprocessing are returned to their countries of origin. Several hundred more shipments have apparently taken place outside the public record (NCL 1996; UIC 2001). Spent fuels may travel on ordinary container ships. The volume of spent fuels awaiting reprocessing, the momentum of existing contracts and the continued existence of a dedicated fleet of five ships indicates that this trade is expected to continue for at least several years at similar or higher volume.

1.2.6 Other hazardous materials

Virtually all small-volume solid cargo enters the region in containers. As the island economies develop, increasing quantities of hazardous materials such as pesticides, explosives, radioactive materials, medical supplies, and industrial chemicals are imported. Any container may contain a hazardous substance. A US Army shipment of field rations (Meals Ready to Eat, or MRE) caused a wharf fire in Guam recently, when the lithium heating agents got wet and overheated - the "Meals Ready to Explode" incident (MRE 2001). Such incidents are alarming because fire among containers aboard ship is difficult to control and may involve a deadly mix of cargoes. For example, a collision between the container ship *Ever Decent*, and the cruise liner *Norwegian Dream* in the English Channel on 24 August 1999 caused a vigorous fire among the containers. There were 400 tonnes of hazardous materials on board, including a large quantity of paint and 32 tonnes of sodium cyanide. The sodium cyanide was near the fire, but fortunately it was not released. The fire burned for six days before attending salvage vessels brought it under control (Stone 2002; Anon 1999).

The International Maritime Organization (IMO) has performed risk assessments for over 2000 chemical substances carried by shipping. Each has been assigned a hazard rating based on aquatic toxicity, bioaccumulation, risks to human health and reduction of environmental amenities. The ratings have been used to assign the potential pollutants to categories under MARPOL 73/78. This provides guidance for the carriage of bulk or packaged goods with respect to choice of ship type, discharges from tank cleaning and deballasting, packaging, labeling and response to accidental releases (Wells et al. 1999). The schedules of hazardous and noxious substances (HNS) are updated annually (IMO 2002). These measures will reduce the risks of releases, and assist in the reduction of harmful consequences.

New Zealand has conducted a risk assessment for HNS incidents from shipping in its' ports (Woodward Clyde, 2000). This study concludes that a shipping incident involving bulk liquid HNS can be expected about once every two years, with HNS release every 13 years. The probabilities are split about equally for petroleum tankers and other bulk liquids. The dynamics of dispersal, environmental effects and control procedures for oil are much easier to predict for petroleum products than for other bulk liquids. Losses of packaged HNS from containerships are similar in recurrence time, but difficult to assess because of sparse statistics on the carriage of HNS in containers. Australia has undertaken a similar study.

1.3 Pollution from shipping

1.3.1 Major incidents

The pollution incidents of greatest concern are oil spills. Tankers loaded with refined petroleum products traverse all parts of the region regularly. In addition, every ship carries fuel for its own use (bunkers). Larger vessels may contain 5000 or more tonnes of bunkers. That is more than the cargo of a typical local coastal tanker. Some ships use heavy oil (like Bunker C). Most burn diesel. Although petroleum products are not extremely toxic substances, concern arises from the large volume shipped. This creates the potential for catastrophic spills from ships and shore facilities, as well as chronic pollution from marine and industrial operations.

The safety of international tanker operations has increased in recent years, largely through the adoption of the UN conventions Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution by Ships (MARPOL 73/78), both administered through the International Marine Organization (IMO 2000). The most significant of these regulations, for our purposes, is the requirement that all tankers of 5000 DWT or more ordered after 6 July 1993 have double hull construction to reduce the probability of cargo loss in collision or grounding. This extends the safety provided by the protective location of segregated ballast tanks, required by MARPOL 78.

The phase out of single hulled tankers has been accelerated by recent amendments to MARPOL 73/78 (IMO 2000). Most single hull tankers over 5000 DWT must be removed from service by age 25 and not later than 2015. Older tankers must also comply with a Condition Assessment Scheme. The significance of this is clear in the cases of the the *Erika* in the Mediterranean Sea off France in 1999 and the *Kirki* off Western Australia in 1991. *Erika*, age 25 years, simply broke apart and sank. *Kirki*, age 22 years, lost her bow and collision bulkhead, breaching the forward tanks, and caught fire. Neither incident occurred in extreme weather. Both were attrtibuted to age, corrosion and poor maintenance.

In general, the lighter (lower boiling point) petroleum products, especially in the diesel range, are most toxic, but they evaporate quickly. Crude oil and heavy residual oils are persistent, difficult to disperse or remove, and contain polycyclic aromatic hydrocarbons (PAH), some of which are carcinogens.

Because of the general lack of heavy industry in the region, there are few other cargoes with potential to cause major pollution incidents. The main industry for which toxic materials are shipped in large quantities is mining. This activity is concentrated in Papua New Guinea, New Caledonia and Fiji. Sodium cyanide (NaCN) and dynamite are two of the dangerous cargoes associated with mining. There was a spill of 270 tonnes of NaCN in the estuary of the Fly River, Papua New Guinea (Kelleher 1991). There is no available record of environmental damage, but the receiving ecosystem must have been affected by this large amount of a very toxic chemical. Caustic soda (NaOH) is also transported in bulk to Fiji for use in cleaning sugar mill equipment.

Every time a ship grounds, especially on a coral reef, there is mechanical damage to the reef and abrasive loss of the ship's antifouling paint. Attempts to free the ship may cause more damage than the initial grounding (see box *Oceanus*). In the past, this has been accepted with little notice, but it has recently become apparent that damage to even a few hundred square meters of reef causes significant economic loss, and there may be subtle effects that extend some distance and time from the visible scar (Negri et al. 2002).

At the lowest end of incident probability, but the highest end of potential harm, nuclear fuels, radioactive wastes, nuclear weapons and decommissioned chemical weapons occasionally transit the region. They may also be stored in neighboring territories.

The potential for marine spills from World War II wrecks has resurfaced as an issue for the region. In November 1944, USS *Mississinewa* sank at Ulithi Atoll, Yap. In August 2001, this wreck began to leak significant quantities of heavy fuel oil (see box USS *MIssissinewa*). Many other wrecks of similar age and construction exist in the region. A separate PACPOL initiative addresses this source of marine spills.

Case Study 2: Oceanus at Satawal.

The bulk carrier Oceanus*, left Newcasatle, Australia on 10 March 1994, fully loaded with approximately 67,000 tonnes of coal for Japan.* Oceanus*, at 225m LOA and 38,891 GT was a well-equipped vessel of Liberian registry, built just one year earlier, travelling on a frequently-used route. On March 18, at about 1415 the vessel ran aground on Weinimong Reef, Satawal Island, Federated States of Micronesia (07° 22'N; 147° 02' E) (Preston et al. 1997). Satawal is a low, isolated island. Sailing directions contain several cautions about offlying hazards and a report that the island lies about 1.75 nmi NNW of its charted position. There is no airstrip is at Satawal. The state administrative center is at Yap, 550 nmi West. The nearest practical salvage base is at Guam, 400 nmi NNW.*

The immediate environmental effect was limited to the direct mechanical damage of vessel impact. The vessel ran partially onto the reef, but sustained damage only in the forepeak area. The stern remained afloat in open water. Tanks for Oceanus*'s fuel, approximately 300 tonnes of heavy oil and 90 tonnes of diesel, were at the stern.*

When the ship reported that it was unable to free itself, the owners, Poseidon Shipping Co. Ltd. of Piraeus, Greece, began salvage preparations. One week after the grounding, a 31m salvage tug was alongside the grounded vessel, and FSM government agents were on scene. On March 23, a larger 93 m salvage tug arrived from Manila, and a day later the FSM Marine Emergency Intervention Team had arrived and begun their environmental assessment. A third tug arrived on April 1. These arrivals can be considered prompt, given the isolation of the site.

When first attempts to refloat Oceanus *failed, the salvors decided to offload part of the cargo. A second bulk carrier was chartered, fitted with special cranes in Singapore, and secured alongside the* Oceanus. *Between 21 April and 2 May,. about one fifth of the cargo was transhipped, with loss overboard of 20 to 50 tonnes of coal. Another attempt to refloat, on 3 May, was successful.* Oceanus *sailed with tug escort to Guam, where the vessel was inspected and permitted to continue the loaded voyage to Kwangyang, Korea.* Oceanus *was repaired and returned to service.*

The proximal cause of the grounding appears to have been human error. The incident occurred in midafternoon, in clear, calm weather. There were no reported malfunctions. The vessel grounded at the north end of the island, near taro gardens where women of the island are reported to work shirtless. The persistent speculation is that the crew strayed from the normal course in order to engage in sightseeing,

During the salvage operation at Satawal, shore access of the crews was limited at the request of island chiefs. Nevertheless, the normal activities of the 750 inhabitants were severely disrupted. The Yap Marine Resources Management Division determined that 30,000m^2 of reef were damaged or destroyed by the original grounding and salvage operations. Poor housekeeping aboard the salvage vessels was a major irritant. Garbage, spilled oil and bilge water caused visible pollution, and sewage was probably discharged near the reef. Under less favourable conditions, the damage could have been much worse.

In April, 1995, Edward King, former Chief Justice of Micronesia, sought damages from the Oceanus*'s owners on behalf of the residents of Satawal. This kind of legal action is unusual in the Pacific Islands Region, but likely to become more common. In February 1998. The court awarded $2 million to the residents of Satawal.*

1.3.2

1.3.3 Routine operations

The most recent estimates for inputs of oil to the sea (NRC 2002) continue to rank small chronic releases from petroleum consumption, including ship consumption and land based sources, as the largest source of oil discharge to the oceans (Table 2.1):

Table 1.1. Petroleum input to the oceans.

Source	**Oil to sea, tonnes**	
	North America	**World**
Natural seeps	**160,000**	**600,000**
Petroletum extraction	**3,000**	**38,000**
Petroleum transportation	**9.1**	**150,000**
Petroleum consumption	**84,000**	**480,000**
Total **(2 significant figures)**	**260,000**	**1,300,000**

Source: NRC 2002 (draft)

Increasing aerial surveillance and prosecution, for example in Australlia and Canada, have reduced discharges from ships in nearshore waters. IMO regulations, in particular the requirement under MARPOL 73/78 to install automatic equipment to measure oil in discharge waters, to prevent any discharge of oil over 15 ppm or within 50 nmi from shore, and to keep an Oil Record Book of all overboard oil discharges, have also been effective. Segregated ballast tanks are required on all new construction tankers above 20000 dwt (30000 dwt for product tankers) delivered since 1983

Smaller vessels are less likely to install and use effective oil separation devices. It is still common practice to pump oily wastewater, including used engine oil, overboard; the evidence is readily visible in many Pacific Island harbours. SPREP is coordinating efforts to facilitate waste oil reception in Pacific Island ports and harbours.

Small spills during transfer operations are not uncommon, and there is a potential for larger discharges. Two of the largest oil terminals in the region, at Vuda Point (Fiji) and Kumul Marine Terminal (Papua New Guinea), are offshore moorages with transfers to shore through submerged pipelines. At some smaller terminals, such as Malau (Fiji) , discharge is through floating pipelines. These pipelines are vulnerable to breakage. Leaks may go unobserved

We should recall that some of the largest marine spills, for example the 1986 *Galeta* spill in Panama, originate in shore facilities. Large volumes in storage and transfer, poor maintenance, lack of vigilance, absence of monitoring equipment and old tanks with inadequate secondary containment structures are factors that, especially in combination, increase the probability of large spills into confined waters.

Petroleum storage tanks are not the only tanks of concern. At Suva, for example, asphalt and LPG are pumped ashore through submerged pipelines to tankage, and other liquid products such as molasses and cooking oil are stored in tanks and transferred in much the same way as petroleum.

Case Study 3. USS Mississinewa at Ulithi Atoll

Early on the morning of 20 November 1944, two Japanese I-Class submarines approached Ulithi Atoll, in the Federated States of Micronesia (09 55', 139 40'E), where a large fleet of US naval vessels was massed in preparation for an an advance toward the Japanese mainland. The submarines released five Kaiten Class manned torpedoes. Each Kaiten was 14.6 m long and carried a single pilot and a 1500 Kg warhead. Four of the Kaiten sank by grounding, ramming or defensive gunfire. One penetrated Urishi Anchorage and exploded against the starboard bow of the USS Mississinewa, AO-59, a 25,425 ton fleet oiler. Mississinewa was carrying a full load of bunker fuel and several tanks partially filled with aviation gas. The tanker burst into flames and sank later that day with the loss of 63 USA lives and the Japanese pilot (AO-59 Web Site 2002;Pacific Wreck Database 2002)).

Fifty-seven years later, on 6 April 2001, a team of divers discovered the the rusting wreck, of USS Mississinewa lying mostly inverted on sand bottom in 37m of water. Several months later, a storm apparently disturbed the wreck, initiating an oil spill that was first reported on 6 August. About 19000 L of heavy oil escaped before the leaks were patched. A second spill was reported on 23 December 2001. This leak was plugged by US Navy divers in February 2002. The US government has accepted responsibility for the wreck and allocated $500,000 for immediate containment and assessment activities. The remaining oil, estimated in excess of $3.4*10^7$ *L, is to be removed, and the wreck left intact on the bottom as a memorial to the lost crew (Honolulu Star-Bulletin 17 Feb 2002).*

The spills from USS Mississinewa have apparently not caused severe environmental damage. Only a small portion of the cargo has escaped, and the leaks have been relatively easy to contain. Nevertheless, the incident is an important reminder that there are many more wrecks of similar vintage and construction throughout the western Pacific. Other leaks have occurred in the past, and more can be expected. Some of these "sleeper" spills may be large, persistent and difficult to control. The effects of this kind of spill can be locally devastating because they may occur within undeveloped harbours and lagoons, remote from containment and recovery equipment, and where the population are dependent on local marine resources. The lagoon at Ulithi Atoll is the world's fourth largest, at about 209 square miles (540 km2), but the land area is only 1.75 square miles (4.5 km2) of coral rubble and sand. The 700 residents of the atoll depend completely on the marine resources of the lagoon and reef. A large spill from the USS Mississinewa could render Ulithi uninhabitable.

1.4 Pacific island environments at risk to marine pollution

1.4.1 Physical geography

On the world scale, the region known as Oceania is a vast archipelago, a continent of islands. The combined sea area (Territorial Sea plus EEZ) of the South Pacific Islands included in PACPOL is 27,816,000 km^2, with only 552,000 km^2 (1.99%) of emergent land. When the largest island nation, Papua New Guinea, is excluded from the calculation, the land/sea ratio is 0.35% (Table 1).

These islands rise abruptly from the sea floor, with narrow to nonexistent continental shelves Coral encrusts every shallow coastal area, except where it is prohibited by unstable substrate, freshwater or active sedimentation. The islands fall into two distinct main types: high islands, with exposed igneous rock rising sometimes in excess of 1000 m above sea level; and low islands, composed of carbonate materials with maximum elevations from a few meters to about 100 m . The largest high islands in the southwest quadrant of the region are continental in geological character, while those to the north and east rise from the ocean floor as volcanic seamounts. Low islands are also of two types: atolls composed of coral caps over submerged seamounts, forming a narrow ring of sandy islets surrounding a shallow lagoon; and elevated carbonate platforms created by raised atolls. The islands of some nations, for example Kiribati and the Marshall Islands, are all atolls. These are especially vulnerable to pollution and also to climate change.

1.4.2 Open ocean ecosystems

The Pacific Islands region lies within the Trade Winds Zone. North of the equator, winds are predominantly from the northeast; south of the Equator, from the southeast. Trade winds seldom exceed 30 kn, and are steadier in the drier season, from May to October in the Southern Hemisphere. Tropical cyclones (hurricanes) may occur at any time during the wet season, more commonly in the western part of the region. The peak season for cyclones is February-March in the Southern Hemisphere and August-September in the Northern Hemisphere. Cyclones are rare near the equator.

Continental influences increase westward. The western Pacific is monsoonal. There is a distinct rainy season occurs during the summer months, when moisture-laden winds blow from the ocean over the land, and a dry season during the winter months, when winds blow from the Asian landmass back to the ocean. Tropical cyclones (typhoons) may strike southeast and east Asia from May to December. Near the Equator, winds are generally light and variable. Showers may occur at any time, but cyclones are rare.

Winds produce two major surface current systems in the Pacific Ocean: a clockwise northern gyre (great circular current) and a counterclockwise southern gyre. The Pacific Islands region sees only the westward portions of these gyres, with currents generally less than 1 kn, intensifying westward. There is an eastward countercurrent at about 5-6° N. In the western Pacific, currents are less predictable, and eastward flows my occur , especially when trade winds relax. Relaxation of trade winds and eastward currents are common during El Nino years, especially in the western tropical Pacific.

Because of solar heating and climatic stability, nutrients for plant growth are depleted in the Pacific Islands region. Therefore in the open ocean, primary production of phytoplankton (microscopic plants) is low. The water is consequently very clear, and animal life is sparse and adapted to a constant environment. This adaptation may make the ecosystems of the open tropical Pacific Ocean more vulnerable than temperate or estuarine ecosystems to the effects of pollutants.

Because oil lies mainly at the surface, and most other pollutants disperse rapidly in the ocean, pelagic ecosystems are not usually considered sensitive to point-source pollutants. The exception is seabirds and mammals, which are dependent on the air-sea interface and thus vulnerable to oiling.

1.4.3 Coral reefs

Corals are essential to economic and cultural survival in all of the Pacific Islands. Coral reef communities form the dominant ecotype of most shores, and provide the entire physical structure of the atoll nations. They are also exceptionally sensitive to pollutants.

Corals form extensive shallow water reef flats, where they are vulnerable to direct contact with floating oil. A low or receding tide can lead to direct stranding of oil or other floating pollutants on the living colonies. Multiple field studies have shown that oiling can produce direct mortality, coral bleaching and reproductive failure as well as prevent larval recruitment (NRC 1985). Shallow and emergent corals suffer the worst effects.

Two recent large crude oil spills in tropical waters have vastly increased knowledge of the effects of oil on corals. Both originated in shore facilities and contaminated large expanses of coral reef. The effects, however, were very different, and in the differences there is much to understand and apply.

On 27 April 1986, a storage tank at the Galeta refinery, Columbia, ruptured. An estimated 14,300 tonnes of mixed Venezuelan and Mexican crude oils spilled into Bahia Las Minas, where onshore winds trapped it for six days near the release site. Then offshore winds and freshwater runoff spread the oil over a widening area. About 82 km of coastline were heavily oiled, including mangrove forests, seagrass beds and intertidal reef flats. Beginning nine days after the spill, 21,000 L of dispersants were applied.

This spill has been particularly well studied because it affected a biological preserve of the Smithsonian Tropical Research Institute. Qualified scientists were available, and there was a 16-year history of sampling to form a baseline against which to measure change. The US government, recognising the opportunity, funded studies of the fate and effect of oil in this tropical ecosystem for an initial five years, and for a reduced schedule of continuation studies.

Where the oil floated over reef flats, there was little direct mortality. At low tides, oil was trapped on emergent corals, and there was extensive mortality. A second wave of mortality occurred when oiled mangroves died back and released contaminated sediments. This killed many subtidal reef corals to a depth of 6 m, and recovery in these affected places had not begun after five years. Guzman et al. (1993) estimate recovery time on the order of 10 to 20 years. A critical factor in recovery was the proximity of source populations for recolonisation.

The contrasting large tropical spill is the release of 1,770,000 tonnes of crude oil into the sea near Kuwait in 1991 as a result of the Persian Gulf War (Price 1998). This spill did produce short-term damage to corals, but at five years post-spill, recovery was virtually complete. The difference appears to be that the reservoir of oil in mangrove sediments at Galeta continually re-oiled and set back recovery of the surrounding ecosystems.

Short-term exposure to low concentrations of oil is not necessarily lethal. The water-soluble fractions of oil (benzene, toluene, ethylbenzene, xylene) are toxic and can reach submerged corals. These fractions are also volatile, and evaporate rapidly in contact with the atmosphere. Mixtures of dispersants and oil are more toxic to corals than oil alone (Peters et al. 1997).

1.4.4 Seagrasses

Seagrasses are true flowering plants with nutritive roots that grow in shallow subtidal areas. They are frequently cited for their role in sediment stabilization on reef flats and in providing food for herbivores. Although they can grow from seed, seagrasses propagate mainly by rhizome extension.

The effects of oil and other pollutants on seagrasses are less well known than those on corals and mangroves. Because of their subtidal habitat, seagrasses often escape initial oiling events. In the case of the Persian Gulf War spills, Kenworthy et al. (1993) detected no difference between oiled and unoiled seagrass meadows one year after the spills. This surprising resiliency may be attributable to the fact that seagrasses relate mainly to the underlying sediments, and do not require the water column for the dispersal of seeds. Nearby shrimp stocks, however, suffered a complete collapse of recruitment. After the Galeta spill, seagrass beds recovered from initial sublethal effects within eight months, except on the shoreward margins. There, seagrasses died back in a narrow band, and remained highly altered for two to three years. As the oiled mangrove forest and seagrass meadows died back, oiled sediments were exposed and eroded, providing a chronic source of oiled sediment for redeposition on adjacent habitats. The reason for the difference in outcomes may lie in the fact that the Kuwait crude formed thick blankets of emulsified oil that stranded and weathered in the intertidal rather than dispersing in subtidal sediments as did the Galeta spill.

1.4.5 Mangrove forests

Mangrove forests are common everywhere along the protected shores of the western Pacific Islands, especially near river mouths on the larger islands and on the inner shores of atoll islands. Mangroves decline in species diversity and coverage eastward, and are rare to absent in French Polynesia. Where they occur, mangrove forests are valuable because of their roles in shoreline stabilization, as refuges and nurseries for fisheries, and as sources of fuel and cultural materials.

Mangroves are generally tough and resilient, and have strong ability to repopulate naturally . They do, however, have several physiological adaptations, related to their special position as marine intertidal trees, that make them vulnerable to oil pollution. Mangroves generate low oxygen environments in the sediments that accumulate around their roots, but the roots must take care of their own oxygen needs for respiration. They do this by having exposed portions (“knees”) that perform gas exchange. When these structures are coated with oil, the roots may be starved of oxygen. Oil can also be assimilated and passed to leaves, where it can block transpiration in all mangroves and prevent salt excretion in black mangroves. The same complex and interlocked root system that allows mangroves to protect and advance shorelines also permits them to trap oil, thus delaying recovery in both the mangrove and adjacent habitats.

The intensity of oil effects on mangroves depends on the oil type, spill volume and details of the initial event. For example, the state of the tide during the initial oiling determines the degree of root oiling and substrate penetration. Younger trees are most vulnerable. Light, refined products can be acutely toxic, for example the jet fuel spill in Puerto Rico that killed 5.5 ha of mangroves (Ballou and Lewis 1989). Heavier products and crude oil may also cause acute effects, together with persistent oiling, chronic effects, and mortality delayed by one to five years (Lewis 1981; Lamparelli et al. 1997; Burns et al. 1994). After the Galeta spill, recovery proceeded on a time scale of decades, and oil washed from mangrove sediments was a persistent source of pollution to other habitats.

Because of the potential for damage and the difficulty of working among mangroves, active cleanup has been confined to very heavily oiled environments, for example at the Galeta spill in Panama. There, aggressive interventions cut channels into the affected 1000 ha. No beneficial effect was demonstrated. Two other possible ways to limit damage and speed recovery are the use of dispersants and bioremediation by supplying nutrients. The Gladstone field trials in Australia have examined both methods in an experimental application of a medium crude oil and bunker C oil to plots of *Rhizophera* mangrove and *Halosarcia* salt marsh (Burns et al. 2000; Duke et al. 2000). The dispersant Corexit 9527 reduced tree mortality, and bioremediation improved the condition of surviving trees.

1.4.6 Lagoons and shoreline ecosystems

Bare rocky shores are relatively rare in the study area. They are also less rich in resources, and easier to clean than either coral reefs or mangrove forests. Sandy shores are often economically significant because of their tourist potential. Fortunately, they are relatively high energy environments, relatively easy to clean and not likely to be disfigured for long by spills of the medium to light grade petroleum products that are the common tanker cargoes and small vessel fuels in the region.

1.4.7 Ports

Most ports in the Pacific Islands, and around the world, suffer chronic pollution from ship and shore activities. Oil can usually be seen on the surface of harbours, and the surrounding industrial activity and concentration of human population contribute a rich mixture of pollutants.

1.4.8 Social and economic issues: commercial and subsistence fisheries, tourism

The effects of oil and other pollutants on fish are likely to be more subtle and longer lasting than on intertidal organisms. Free-swimming fish are not in direct contact with the highest concentrations of pollutants, and because of their motility their exposure is transitory. Effects on adult fish are likely to be chronic, transmitted by biomagnification up the food chain. Larval and juvenile fish, especially those dependent on shallow water environments, are at greater risk to pollution. Unfortunate timing for a spill may cause the loss of an entire year class of fish.

Until recently, subsistence fisheries have been undervalued. New approaches in natural resource economics have brought quantitative support to the observation that interference with a subsistence activity can have severe social and economic consequences. The least equivalent value of a subsistence resource is the cost of replacing that resource from market sources. The loss of a small section of reef may seem insignificant on a regional scale, but that loss can be devastating to the social and economic fabric of the village that depends on it. Inshore marine resources are locally owned throughout the Pacific Islands region. The people who depend on them cannot simply transfer their fishing to another location.

1.5 Focus and objectives

The primary objective of this project is to assess the risks of marine accidents by analysing shipping information together with marine charts, sailing directions and interviews with mariners. We have performed the assessment at three levels (region-wide, country EEZ's and major ports) and now present results in GIS format as areas of low, moderate, and high potential for maritime incidents.

In order to achieve the primary objective, we have gathered extensive contemporary information on the shipping routes, schedules, nature of cargoes and vessels used in trade within, among and through the Exclusive Economic Zones of South Pacific island nations and territories.

In parallel with the predictive assessment, we have collected and geocoded historical data on shipping incidents in the region. International marine statistics further inform the discussion. This information has allowed us to discuss the relative roles of risk factors such as vessel type, traffic density, navigational difficulties and crew qualifications, in contributing to accident probability.

1 GENERAL METHODS

1.1 Application and scope

1.1.1 Vessels and operations

“Vessels” in this study includes all self-propelled vessels of and greater than 200 GT. We set this lower size limit to include distant water fishing vessels, which are very numerous in the study area, and other small vessels such as chemical tankers and fuel barges, which have the potential to cause serious environmental damage because of the special nature of their cargoes.

In both the risk analyses and the database of historical casualties, we have directed our attention to vessel incidents that have significant potential to cause environmental damage, such as grounding, collision or sinking. We also consider routine operations that may have environmental consequences such as deballasting, offshore loading/discharge of tankers and lighter operations.

Tanker operations receive highest priority. We give special attention to cargoes of high public interest such as hazardous wastes and nuclear materials. Naval vessels are excluded. The consequences of war, sabotage and piracy can only be addressed in speculative terms.

We include all marine traffic within the definition of “vessel”, whether transoceanic transit traffic, regional traffic or local shipping.

1.1.2 Geographic scope

The study area is the SPREP region encompassed by the Exclusive Economic Zones (EEZ's) of the Pacific Island Countries and Territories (Figure 2.1).

1.1.3 Levels of assessment

Risk assessments have been carried out at three levels: the Pacific Islands region, country EEZ’s and major ports (Table 3.1, Figure 2.1).

Table 1.1. Major Pacific Island Ports included in risk assessment

Country	Port	Latitude	Longitude
American Samoa - Tutuila	Pago Pago	14°17.00'S	170°40.57'W
Cook Islands - Rarotonga	Avatiu	21°11.59'S	159°46.44'W
Federated States of Micronesia	Pohnpei (Ponape)	06°59.01'N	158°12.21'E
Federated States of Micronesia	Chuuk (Truk)	07°20.00'N	151°50.00'E
Federated States of Micronesia	Yap (Colonia)	09°30.98'N	138°08.04'E
Federated States of Micronesia	Lele (Kosrae)	05°19.70'N	163°01.54'E
Fiji - Vanua Levu	Malau (Labasa)	16°22.00'S	179°21.00'E
Fiji - Viti Levu	Lautoka	17°36.08'S	177°27.51'E
Fiji - Viti Levu	Vuda Point	17°41.00'S	177°23.00'E
Fiji - Viti Levu	Suva	18°07.68'S	178°24.35'E
French Polynesia - Tahiti	Papeete	17°32.37'S	149°35.33'W
Guam	Apra	13°26.90'N	144°38.91'E
Kiribati - Tarawa	Betio	01°22.73'N	172°56.62'E
Marshall Islands	Majuro Atoll	07°07.21'N	171°11.55'E
Nauru	Nauru	00°32.14'S	166°53.71'E

Country	Port	Latitude	Longitude
New Caledonia	Noumea	22°15.86'S	166°24.61'E
Niue	Alofi	19°02.63'S	169°55.51'W
Northern Mariana Islands	Saipan	15°14.00'N	145°44.00'E
Palau	Koror	07°20.02'N	134°30.24'E
Palau	Malakal	07°20.00'N	134°28.00'E
Papua New Guinea	Lae	06°45.00'S	147°01.00'E
Papua New Guinea	Port Moresby	09°28.40'S	147°08.35'E
Papua New Guinea	Madang	05°12.22'S	145°48.36'E
Papua New Guinea	Rabaul*	04°11.00'S	152°09.00'E
Pitcairn Islands	Pitcairn Island	25°04.69'S	130°06.68'W
Samoa	Apia	13°49.00'S	171°46.00'W
Solomon Islands - Guadalcanal	Honiara	09°25.00'S	159°58.00'E
Tokelau	Nukunonu Atoll*	09°07.45'S	171°52.50'W
Tonga – Tongatapu	Nuku'alofa	21°06.91'S	175°11.59'W
Vanuatu – Efate	Port Vila	17°44.59'S	168°18.26'E
Wallis and Futuna – Ile Futuna	Ava Leava	14°17.81'S	178°07.41'W
Wallis and Futuna – Iles Wallis	Mata - Utu (Ile Uvea)	13°16.55'S	176°12.36'W

* no harbour chart available

1.2 Data gathering

1.2.1 Vessels and vessel traffic

The main method of collecting data on vessels and marine traffic was by interview with port authorities and by direct inspection of port entry ledgers. This was supplemented by contacts with shipping line agents and oil companies. Standard data recording forms were used in both interviews and correspondence, usually by email. Success in data gathering was variable. In general, for the larger countries, especially those that could be visited in person, we achieved satisfying records at least for international traffic through the major ports. For about half the countries, data remains fragmentary. We filled in the gaps by extrapolation from known traffic. Appendix 5 shows the forms used to collect port data.
We supplemented the direct contact information with publicly available routes and schedules. This technique was most useful for container lines and regional ferry services. Regional field offices of the major oil companies provided much useful information on vessels, routes and schedules. Lloyd's Register of Ships was used to fill in characteristics of registered vessels.
Data came in two primary forms: port-to-port information from harbour authorities, and shipping route information from shipping lines. In theory, the port-to-port information should give a complete and consistent picture of traffic, because port entry records usually include the last port and next port. Therefore, for each trip from port to port, there should be two records of the trip. Shipping line data comes usually in the form of a port sequence and the frequency of that service. This should match the port information. Unfortunately, the data usually did not match, and some judgement was required not only to avoid double entry of the same information from different sources, but also to interpret the inconsistent reporting periods, nomenclature and interpretations. A shipping line might say, for example, that a service from Yokohama - Betio - Suva - Honiara - Port Moresby - Hong

Kong - Yokohama operated monthly, but the vessels might only call at Betio three times a year when sufficient cargo was available to justify a stop. We dealt with this kind of variability by representing a shipping line by two or three typical port sequences.

The practice of keeping port entry ledgers has evolved to a worldwide standard, which is practiced throughout the Pacific Islands. A few countries maintain electronic databases for this purpose. Almost all produce an annual summary of traffic in a standard form that does not include sufficient details for our purposes. Most do this manually. None appeared to have capacity to query their port entry databases in an interactive manner.

Information on the actual tracks of vessels exists for a subset of vessels and for some ocean areas that are governed by traffic control or position reporting schemes. There exist at least two global sources for vessel tracks:WNI OceanRoutes/OceanWeather, a ship routing service; and the Voluntary Observing Ships programme (VOS) coordinated by the World Meteorological Organization (WMO 2002). VOS is a cooperative international programme of shipboard weather observatories. We selected sequences of position reports from commercial vessels from the VOS database and plotted these as a test of the accuracy of our assumed vessel tracks based on interviews and sailing directions Section 4.5 and Figure 4-17). We also evaluated a test set of data from the US component of VOS (USNMCDC database TD1129), but found these to be less useful.. The WeatheRoutes data may be more representative, but we could not determine that the utility of the data justified its expense.

Australia has become the first country to establish a nation-wide ship position reporting system, known as AUSREP. A more stringent compulsory reporting scheme, REEFREP, applies to the Torres Strait and Great Barrier Reef Inner Route. Traffic on the important bulk coal route from eastern Australian ports to Japan will be captured in this manner.

1.2.2 Shipboard practices

Our data collection on shipboard practices such as disposal of waste oil, solid wastes and deballasting is as yet too sparse to be considered meaningful.

1.2.3 Navigational hazards and environmental sensitivities

Despite the visible evidence of ships on reefs, none of our respondents included concerns about hazards to navigation. This is perhaps because local vessels routinely avoid a known hazard.

1.3 Data storage

We stored all data on vessels, vessel traffic and locations of ports and waypoints in a Microsoft Access database, MarRisk.mdb. MarRisk.mdb contains facilities for statistical analysis and organisation such as linking vessel traffic with the geographic coordinates of the corresponding routes. We used the MapInfo GIS system to display all maps and thematic interpretations of data. Appendix 2 shows the relationships among Access and MapInfo tables.

1.4 Geographical information

1.4.1 Charts

For purposes of data collection and route discussions, we referred to small scale (large area) Admiralty and US Defense Mapping Agency charts such as USDMA 526, Pacific Ocean Central Part. At the larger scales of region and port, we used the best available charts at appropriate scales, usually Admiralty charts.

SOPAC provided all of the GIS maps used in our data presentation. The base map is the USDMA Digital Chart of the World, converted to a Pacific-centered coordinate system. It

includes one layer for the 0m contour and one for the reef edge. At regional to oceanic scales, we substitute a coarse resolution version of WVS. The SOPAC map of the Economic Zones (EEZ) of the PACPOL countries is supplemented by a rough representation of the remainder of the world's EEZs drawn at 200 nmi from land. Geographic coordinates in all maps are transformed to a Pacific-centered system (Longitude 0° to 360°E instead of conventional 0° to 180° E and 0° 180° W). These vector (line drawing) base maps are used for displays at the regional and country EEZ scales.
At the port scale, more detail is required. SOPAC has provided raster (image) maps of the major ports in each study country, produced from best available paper charts and adjusted to WGS84 datum. We have used these port charts for both background illustrations, and as sources of channel characteristics data for the ports risk analysis. Table 3-1 contains a list of the ports that we analysed.

1.4.2 Thematic mapping

We were able to gather from port authorities some information on actual routes used from port to port. More came from shipping lines and mariners. Where such direct information was absent, we used best judgment based on "Ocean Passages for the World" (OPW 1973) and its supplementary charts HO5127 and HO5128. We also referred to the USA Sailing Directions (Enroute) (USDMA 1996, 2000a, 2000b) for local information on ports and port entry.
Routes from port to port are divided intofrom four to about 16 line segment subroutes from waypoint to waypoint in order to give a realistic representation of routes actually traveled. In most cases, the subroutes are not more than a few hundred nmi long. We have represented longer routes as great circle tracks in only a few cases, such as Panama - Japan. Otherwise, they are straight line Mercator tracks.
We have divided vessel traffic into three major categories for thematic display: container vessels, tankers and all others. (Figures 4-1 to 4-12). Nuclear waste vessels are treated separately because there is little public information on this trade. Further categories could be assembled and displayed, for example bulk or ferry. The basic thematic maps display these categories by frequency of transit and cargo capacity (GT or DWT) per year). We were not able to represent actual volume of cargo or fuel carried
Fishing vessel traffic is diffuse. Therefore, it is better characterised as areas of activity than as routes between ports. The Oceanic Fisheries Programme of the Secretariat of the Pacific Community have provided information on fishing effort, as days fished for purse seine tuna vessels and as hooks set for longliners. We present these data thematically as a proxy for vessel-days in each grid area (Figures 6-15 and 6-16). (Forum Fisheries Agency has actual vessel positions in near real time, but cannot release this information).

1.5 Risk analysis

Risk is the product of two variables: the probability of an incident occurring and the severity of harmful consequences of the incident:

Risk = Probability of Incident X Harmful Consequence of Incident

This study estimates the relative probability of collisions and groundings throughout the Pacific Islands region. Because we do not have a thorough and quantitative measure of the harmful consequences of maritime incidents at the spatial resolution of our study, we address the first term of the risk equation directly, and provide a discussion of the consequences of marine incidents in typical environments of the Pacific Islands region.
This study is at the level of a preliminary risk analysis, not a full risk assessment. Different methods are used to rank the probabilities of pollution incidents at the regional scale, and

at the ports scale. Section 6 presents detailed descriptions of the methods used for the risk analyses.

1 MARINE TRAFFIC PATTERNS IN THE PACIFIC ISLANDS REGION

1.1 International container vessel routes, lines and vessels

Overview

During the period 1960-1980, world shipping of manufactured goods was revolutionized by containerization. Almost all trade by sea travels in standardized containers, which are packed at the place of origin, transported by road to the port, carried by ship to the destination port, and complete the journey by road to the destination. The most common container size is 20 feet long by eight feet high by eight feet wide (6.06 by 2.44 by 2.44 m). These are standard in the Pacific. Ship capacity in these containers is measured in container equivalent units (TEU). (FEU refers to capacity in containers 40 feet long by eight feet wide by eight feet high.) The Pacific Islands participated in this transition to containers, which has brought greater efficiency and frequency of service, at least to the larger centres. Container liners visit the larger ports, especially the major regional hubs at Noumea, Suva, Papeete Port Moresby and Guam, either as way stops on intercontinental routes or as the main stops on regional circuits (Forsyth and Systo 1999; Heathcote 1996; CIA 2001).

Vessels and ports

Containerisation has grown into a worldwide transportation network that integrates road transportation, ports and sea carriage. Container ships stow cargo both in holds below deck, and on deck above the hatches. They are fitted to stow and secure cargo on racks with minimal crew, but they usually have no deck equipment for loading and unloading cargo. For this, they depend on shore installations. Ports must have multiple cranes, specialized container carriers, and large storage areas to handle containers efficiently. The trend is to larger and faster container ships.

Figure 4.1 shows the size distribution of container ships visiting Pacific Island ports. The vessels below about 3000GT are in local trades, serving at most a few countries. A typical container vessel in the Pacific international trade would be about 20,000GT, 200m LOA, traveling at 18-20kn and carrying 2500 containers. The mean age of container ships in 2000AD was 14 years.

Major routes and lines

Two major patterns of trans-Pacific traffic cross the Pacific Islands Region: east/west traffic from West Coast North America and Panama Canal to Southeast Asia, Australia and New Zealand; and north/south traffic from the Philippines, North China, Taiwan, Korea and Japan through Eastern PNG waters and southward to East Coast Australia and New Zealand. Figures 4.2 and 4.3 show traffic that crosses at least one PICT EEZ. The highest volume routes in the Pacific, from West Coast North America and Panama Canal to Japan, Korea and North China, pass north of Hawaii on great circle tracks, and do not cross any PICT EEZ. The direct route from Panama to New Zealand passes near the Pitcairn Islands.

The pattern of port calls is partially organized by trading spheres of influence. Australia and New Zealand are the dominant trading partners in most of the South Pacific. French connections are strong in New Caledonia, French Polynesia and Wallis and Futuna. USA interests are paramount in Guam and American Samoa, very strong in the Northern Marianas Islands and the Marshall Islands, and significant elsewhere in the northern islands.

Here are some typical shipping lines and routes (actual voyages will add or omit some ports) :

Tanspacific, East/West

Bank Line : Panama – Papeete – Suva – Port Vila – Santo – Honiara – Lae - Madang - Singapore (Bank line voyages are westward circumnavigations)

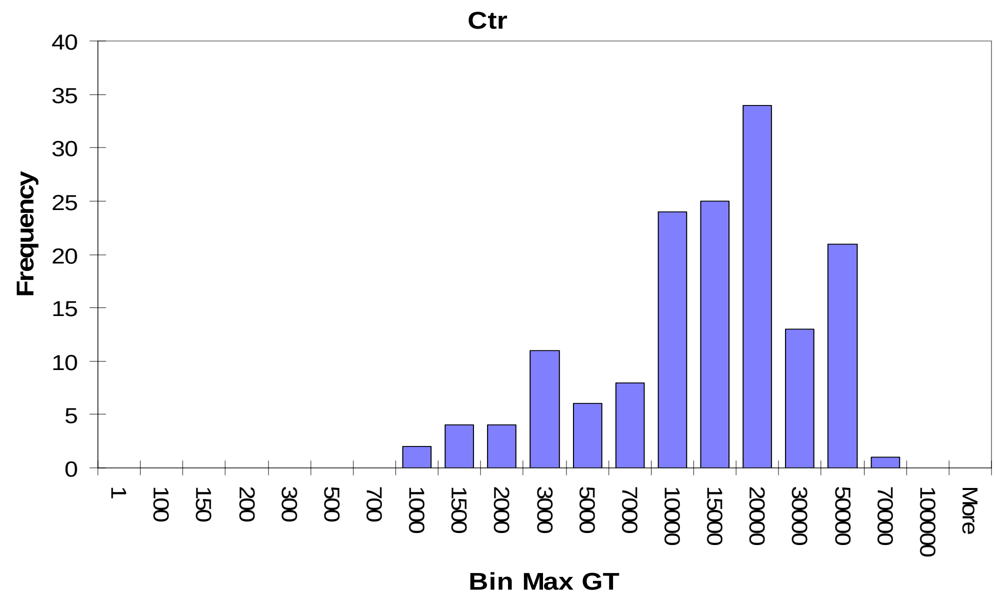


Figure 1.1. Size distribution of container vessels.

Columbus Line, P&O Nedloyd: Australia – New Zealand – Suva – Long Beach – Fiji – New Zealand - Australia

Australia New Zealand Direct Line (ANZDL) : Australia – New Zealand – Suva – North America – New Zealand – Australia

FESCO: Los Angeles- Papeete - Suva– Auckland – Sydney – Melbourne – Auckland – Papeete – Los Angeles

Maersk Sealand: Kaohsiung – Sydney – Melboourne – Brisbane – Tokyo - Kaohsiung

Auckland – Singapore – Auckland

PM&O: Los Angeles – Pago Pago – Apia – Majuro – Ebeye – Lele Harbour – Pohnpei – Manila – Hong Kong – Kaohsiung – Malakal (Palau) – Yap – Saipan – Chuuk – Pohnpei – Majuro – Apia – Pago Pago – Honolulu – Los Angeles

USA Military Transport: Honolulu – Apra –Saipan - Yokohama – Apra – Honolulu

(Seven US Military cargo ships of about 32900 GT or 40600GT served bases in Guam and Saipan several times per month).

Transpacific, North/South

NZ – Orient Line: SE Asia – Noumea – Suva/Lautoka – SE Asia

COSCO: East Asia – Suva – NZ – East Asia, Japan

Tasman Asian Shipping Co.: East Asia – Suva – New Zealand – East Asia

Kyowa: Singapore – Port Moresby – Honiara – Lae – Noumea – Townsville – Singapore

Yokohama – Port Vila – Noumea – Lautoka – Suva – Apia – PagoPago – Papeete – Noumea – Kaohsiung

CSX Sealand: Honolulu - Apra – Saipan –HongKong

Regional Circuits

Sofrana Unilines: Auckland – Noumea – Brisbane - Port Vila – Port Moresby – Lae – Rabaul – Lihir – Honiara – Auckland

Pacific Forum Line: New Zealand – Lautoka/Suva – Apia – Pago Pago – Nuku'alofa – Neiafu – Avatiu – New Zealand

Pacific Direct Line: New Zealand – Suva – New Zealand

Matson: Honolulu – Ebeye – Majuro - Honolulu

Kyowa: Manila –Apra – Saipan – Apra - Manila

Chief Container Service: New Zealand – Australia – Port Vila – Santo – Honiara – Majuro – Tarawa – New Zealand - Australia – Port Moresby – Madang – Lae – Australia

Southern Cross Shipping: Australia – Noumea – Suva – Nuku'alofa – Neiafu – Apia – Pago Pago – Wallis – Lautoka – Australia

Cook Islands National Line: New Zealand – Nuku'alofa – Apia - Avatiu – New Zealand

Kiribati Shipping Services: Betio – Funafuti – Suva – Funafuti – Betio . (The Cook Islands National Line and Kiribati Shipping Ltd. are examples of national lines that extend the web of transoceanic container services to smaller ports).

Far East Micronesia Line (FEML): Keelung – Saipan – Apra – Malakal (Palau) – Keelung

Seabridge (Super Shuttle): Apra – Saipan – Tinian – Saipan – Apra

Saipan Shipping Co.: Apra – Saipan –Tinian – Rota - Apra . (Francisca Class barges of 867 GT carry much of the cargo from Guam to the Commonwealth of the Northern Mariana Islands)

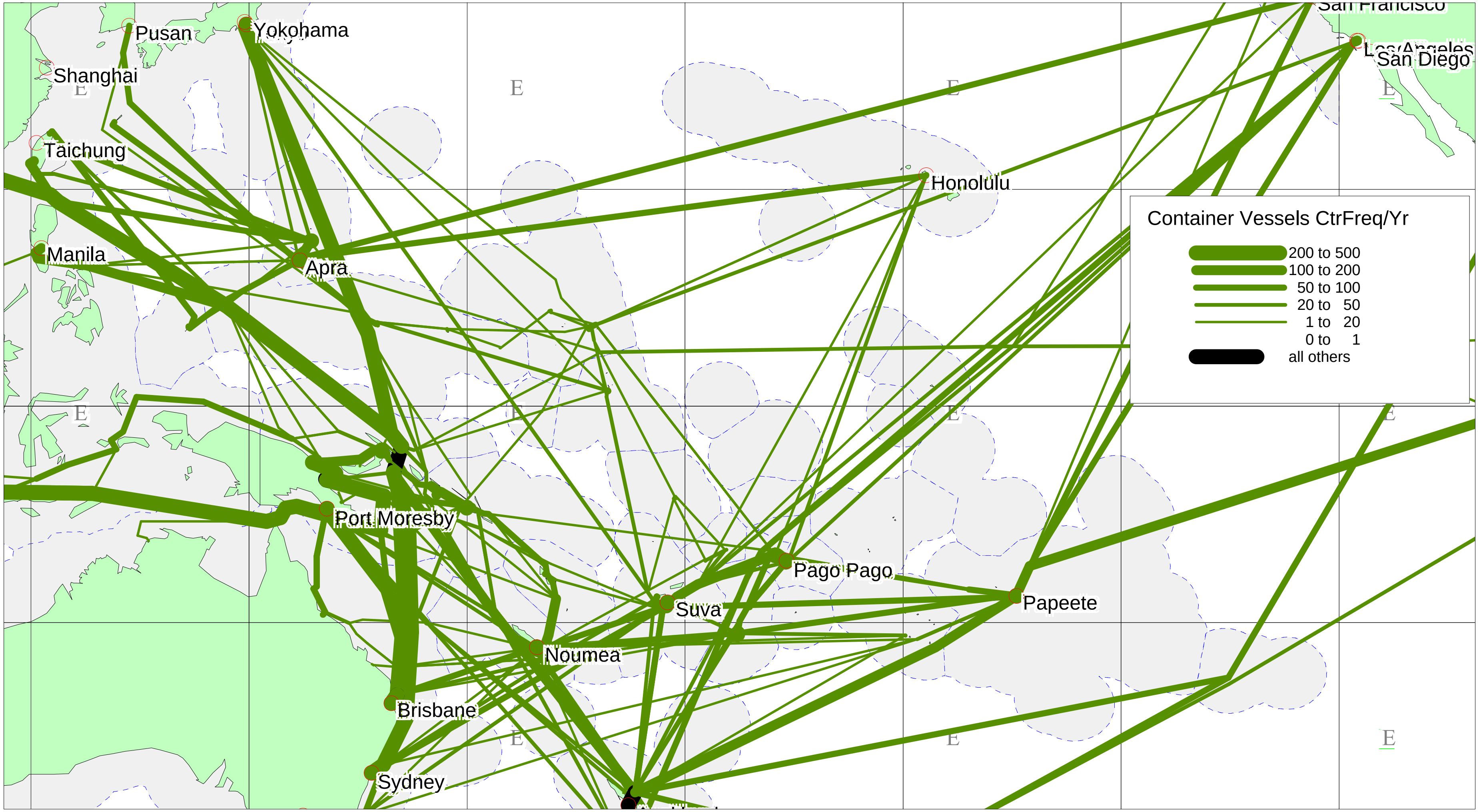


Figure 1.2: Container vessel traffic by frequency.

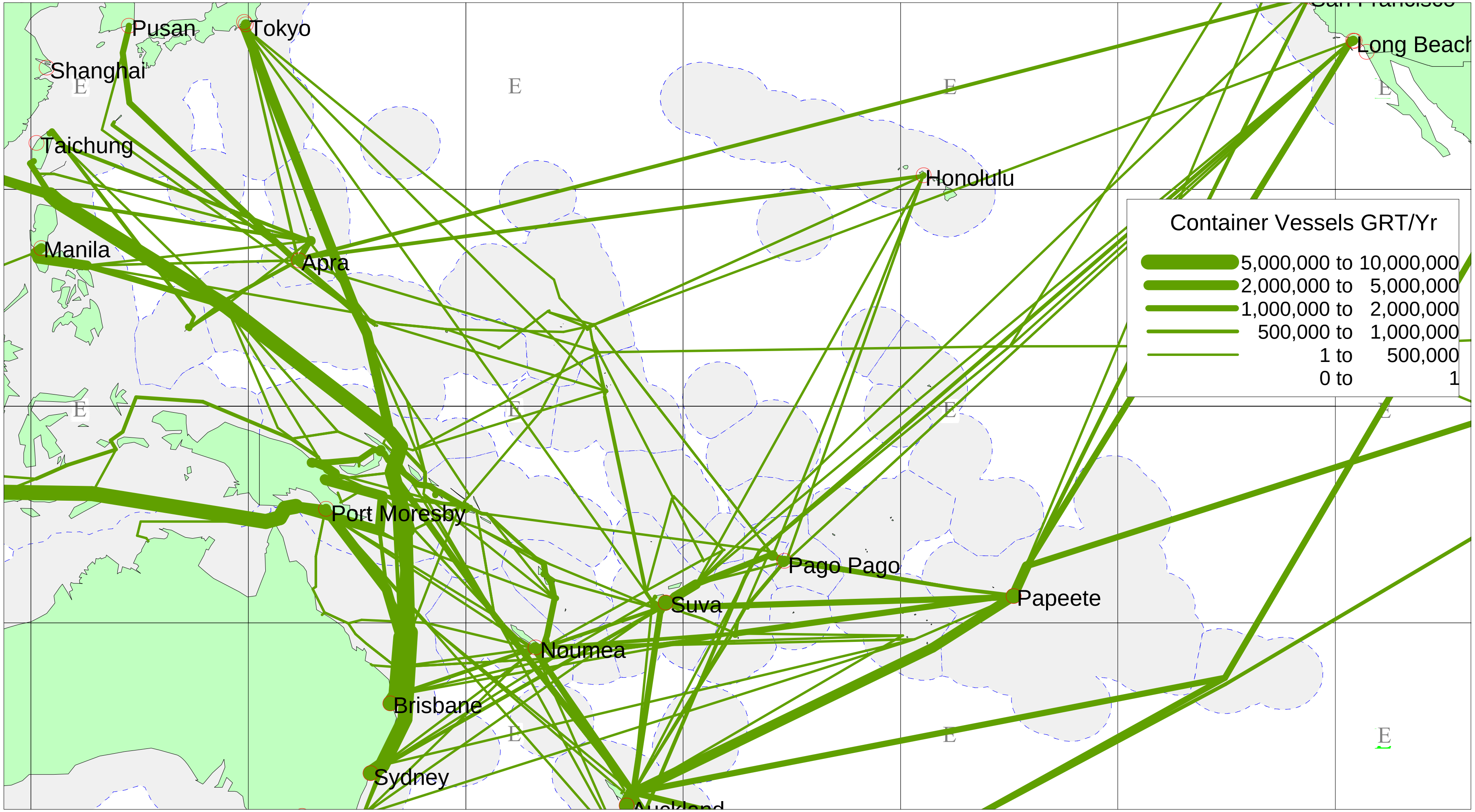


Figure 1.3. Container vessel traffic by GT.

1.2 Petroleum products

Figure 4.4 is a size-frequency analysis of tankers operating in the study area. By size and function, there are three main types of petroleum product tankers: Local Coastal Tankers (LCT) of about 1000 to 5000DWT; mid-sized tankers (mostly in the PNG area or servicing the fishing fleet) of about 10,000 to 20,000DWT; and Medium Range Tankers (MR) of about 30,000 to 60,000 DWT. The average age of vessels, for which we know year built, was 19 years; the range, 13 to 27 years.

Figures 4.5 and 4.6 show the regional petroleum supply routes for the Pacific Islands. Supply routes to the northern region (Guam to Marshall Islands) are separate from those to the remainder. Medium range tankers load products at Singapore for delivery to Guam, with occasional excursions to Palau, Saipan, FSM and Majuro. On rare occasions, supplies may come from West Coast USA or Hawaii.

Refineries in Brisbane and Melbourne supply most of the petroleum requirements for the southern Pacific Islands. Singapore supplements the Australian sources. There are two main petroleum delivery circuits in the south: from Brisbane to PNG, Solomon Islands and Vanuatu; and from Melbourne (occasionally Brisbane or Singapore) to Noumea, Suva/Vuda Point, the Samoas and Papeete. MR tankers accomplish the primary deliveries. Oil is backloaded at Suva or Vuda Point into LCT's for distribution to the other southern islands. Most countries have at least one bulk petroleum terminal. Larger countries (Fiji, PNG, French Polynesia) have several.

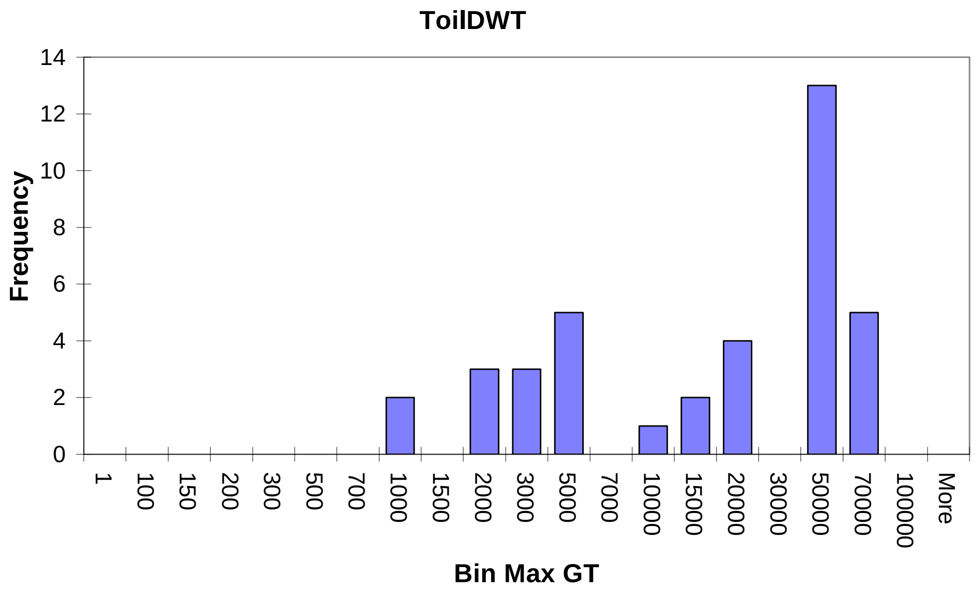


Figure 1.4. Tanker size frequency, DWT.

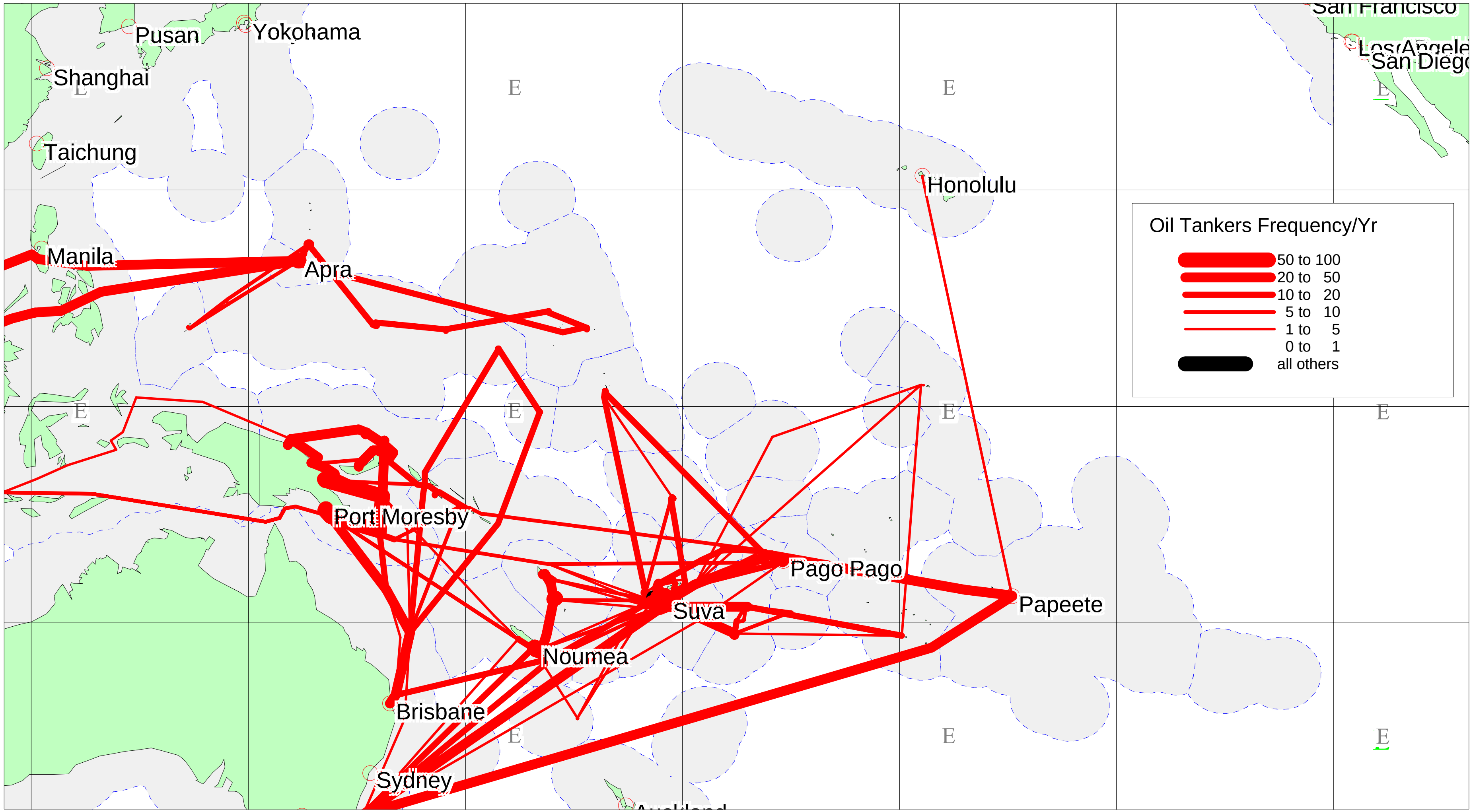


Figure 1.5. Tanker traffic by frequency.

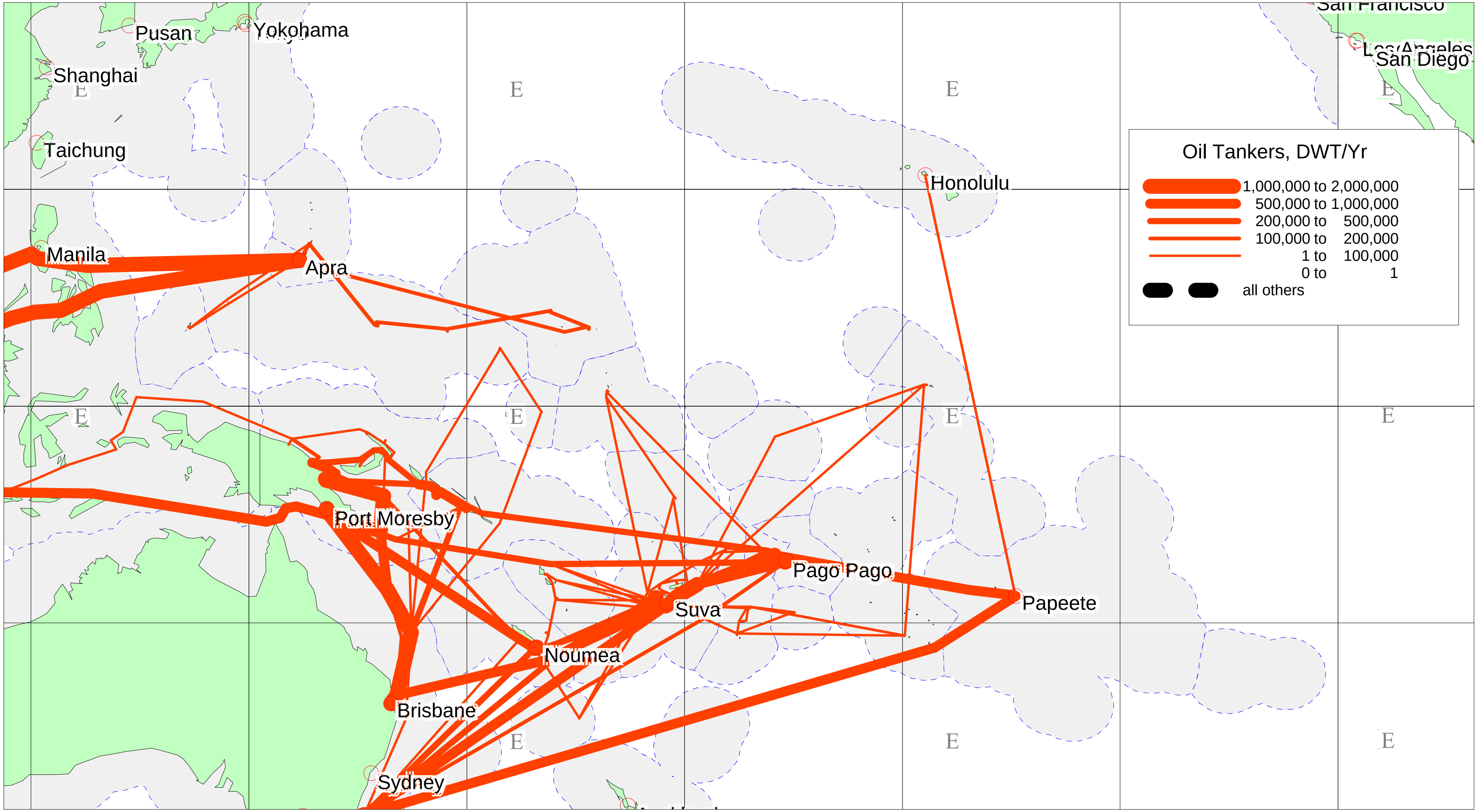


Figure 1.6. Tanker traffic by DWT.

1.3 Nuclear fuels and wastes

Vessels of Pacific Nuclear Transport Ltd. (PNTL) have made seven deliveries of reprocessed nuclear fuel from France or Great Britain to Japan (BNFL 2001; NCI 2001). The shipments comprise either mixed plutonium and uranium oxides (MOX) for use as fuel in conventional light water power reactors to generate electric power, or the remaining radioactive residue as vitrified high level waste (VHLW).

PNTL's five purpose-built ships, each of about 5000 GT, have used three major routes to deliver MOX or VHLW from Europe to Japan:

- South about the Cape of Good Hope and Southern Australia, then north through the Pacific Islands region;
- South about Cape Horn, then northeast across the Pacific Ocean to Japan;
- Or west across the Atlantic Ocean, through the Caribbean to Panama Canal and on to Japan.

Other possible routes through Suez Canal and north about Australia through the Makassar Strait have been rejected for political reasons. The northern route through the Arctic Ocean and Bering Sea is possible (this is the Murmansk Run of World War II), but difficult.

Figures 4.7 and 4.8 show the most likely courses of the three routes, as inferred from press releases, OPW 1973 and the principle of avoiding country EEZ’s. Ships transiting the Panama Canal route would likely track by approximate Great Circle route, which would take them northwestward along the coast of North America and west across the Pacific Ocean, north of Hawaii. The Cape Horn Route would likely join the Panama Route north and East of the Pacific Islands region. On the one occasion for which actual positions are known, the *Pacific Pintail* took a variant of the Cape Horn route that passed south of Hawaii, but outside the PACPOL EEZ’s (Greenpeace 1995). The route via Cape of Good Hope and South Australia must transit the Pacific Islands region. PNTL claims the right of passage through the EEZs outside the Territorial Seas, but in practice is likely to travel as much as possible in International Waters, and avoid as much as possible the EEZ's of objector nations, of which there are many.

Chile, Argentina, Australia, South Africa and New Zealand have requested that the ships not transit their EEZ's. In 1995, a Chilean naval vessel escorted the *Pacific Swan* away from Chile’s EEZ, thus denying it the use of the Straits of Magellan. The most likely balance between economy, safety and protest avoidance is northward between Australia and New Zealand, passing close west of New Caledonia and thence between Solomon Islands and Vanuatu, through the western Pacific "donut hole" of international water, north across the EEZ of the Federated States of Micronesia, East of Guam and the Commonwealth of the Northern Marianas, and on to Japan. Entry to Japanese ports of the Inland Sea is most likely North around the main island of Honshu, well clear of the Korean EEZ. Only spotty details of actual routes, usually at restricted passages, are public knowledge. There is little public information on deliveries of spent fuel from Japan to Europe, or on the nuclear fuels traffic of other nations that might pass through the Pacific Islands region. Australia is a major raw uranium producer, and shipments of ore or uranium hexafluoride to the USA or Europe would likely pass through the Pacific Islands region. One shipment of spent fuel from a research reactor for reprocessing in France is known to have traveled aboard a commercial vessel, the *Bouguenais.* Media exposure intensified when Greenpeace sought an injunction against the import of nuclear waste into France.

Because of the extreme toxicity of plutonium, and its potential for use in nuclear weapons, US regulations have required that shipments of Pu and other fissionable materials be accompanied by armed naval escort. This regulation applies to the PNTL shipments of MOX because the plutonium was generated in power reactor fuel originally supplied by the United States to Japan under a binding agreement (PM Press Guidance January 20, 1999).

The first shipment of recovered plutonium, in 1992, was in the form of plutonium dioxide. This was transported by PNTL *Pacific Crane*, renamed for the voyage *Akatsuki Maru* and accompanied by a Japanese naval vessel. In 1985-6, the *Pacific Pintail* and *Pacific Teal* were converted to armed merchant vessels. Three, 30 mm naval cannon were fitted, and the vessels staffed by a 13 member civilian defense crew with light arms and other protective measures. These two vessels have sailed in pairs, as mutual armed escorts, for all subsequent plutonium shipments. Shipping the plutonium as MOX provides an additional measure of safety. Diversion of the cargo is much more difficult because of the intense gamma radiation of uranium.

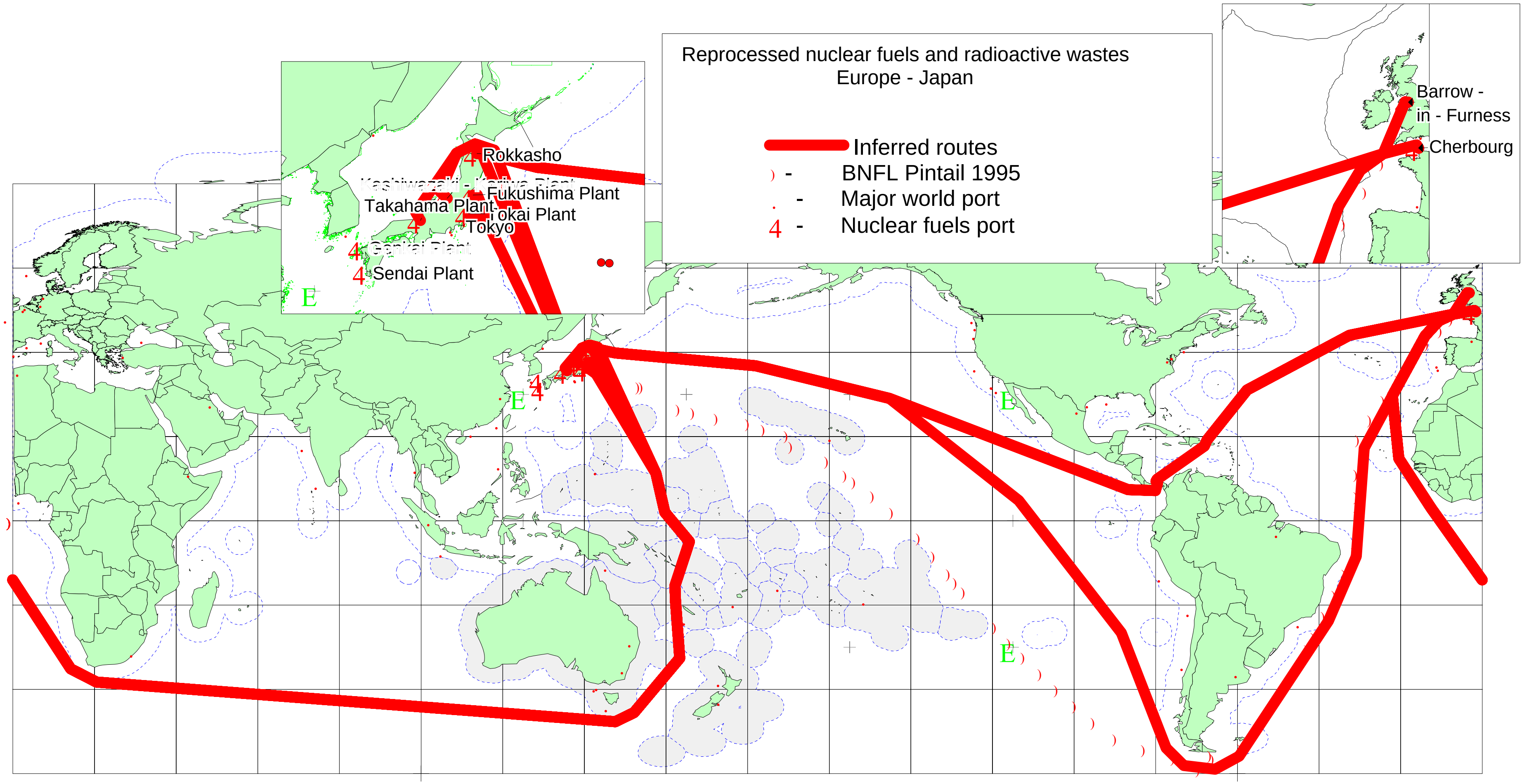


Figure 1.7. Nuclear fuel and waste shipments by specialised vessels, world pattern.

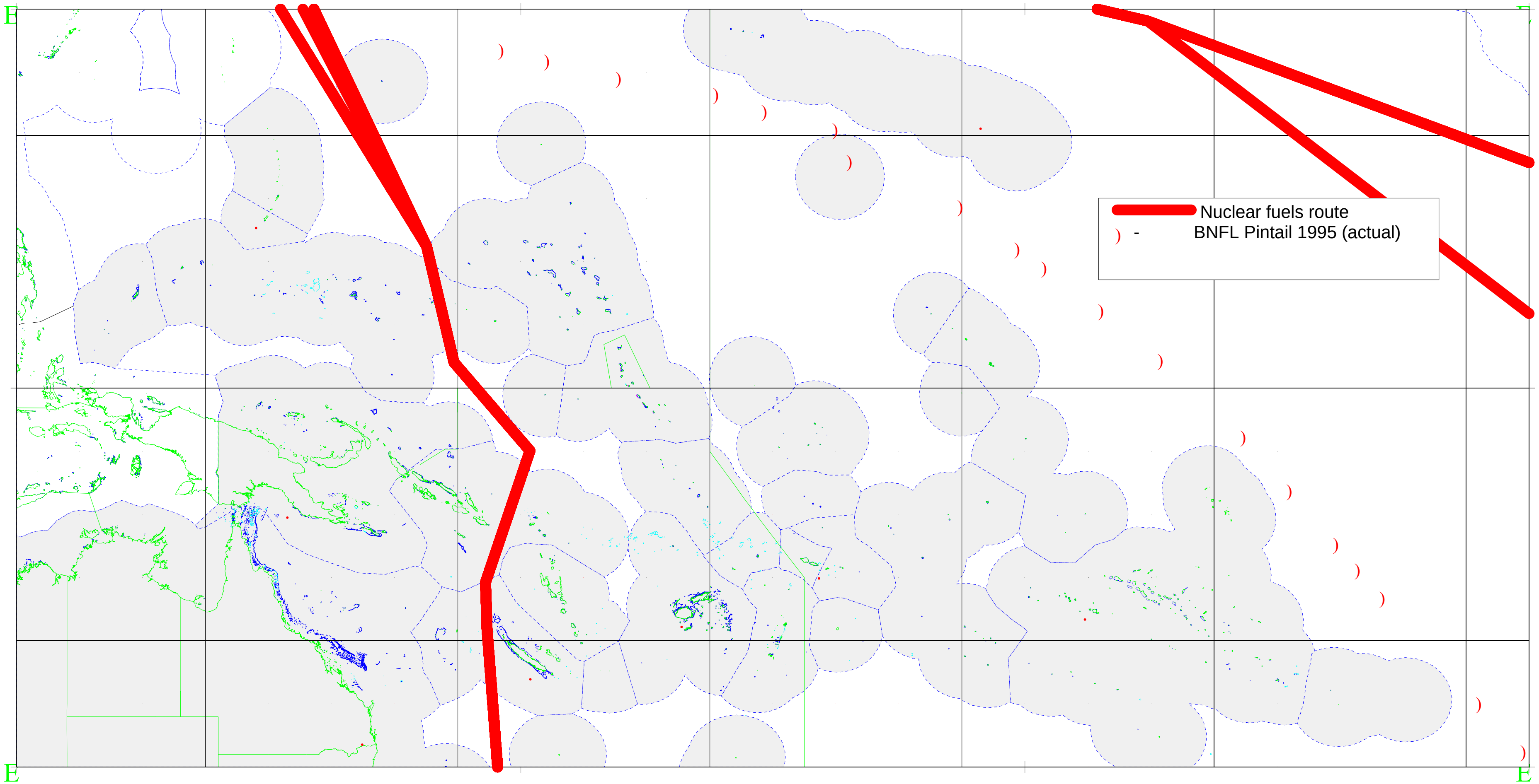


Figure 1.8. Most probable routes for nuclear fuel and waste shipments by specialised vessels, Pacific Islands region.

1.4 Other traffic

Interisland shipping

The international sea transport routes serve only major ports. In most of the island groups, there is a secondary marine transportation network served by smaller vessels under 2000 GT on scheduled routes, reticulated into an informal tertiary network of very small vessels that connects every island and every coastal community. Figure 4.9 shows the size distributions of the mixed cargo/passenger vessels engaged in interisland shipping. Comparison of Total Traffic (Figures 4.11-4.17) with Container Vessel Traffic (Figures 4.1-4.2) demonstrates the secondary network, especially in Papua New Guinea, Fiji, French Polynesia, Kiribati and Gaum/Northern Marianas. We have probably underestimated the secondary web, because internal traffic does not appear in port entry books, and ferry schedules or itineraries were not uniformly available. In a few cases,for example Moorea-Papeete ferries, we have probably included traffic in vessels smaller than 200 GT, because tonnages were not available.

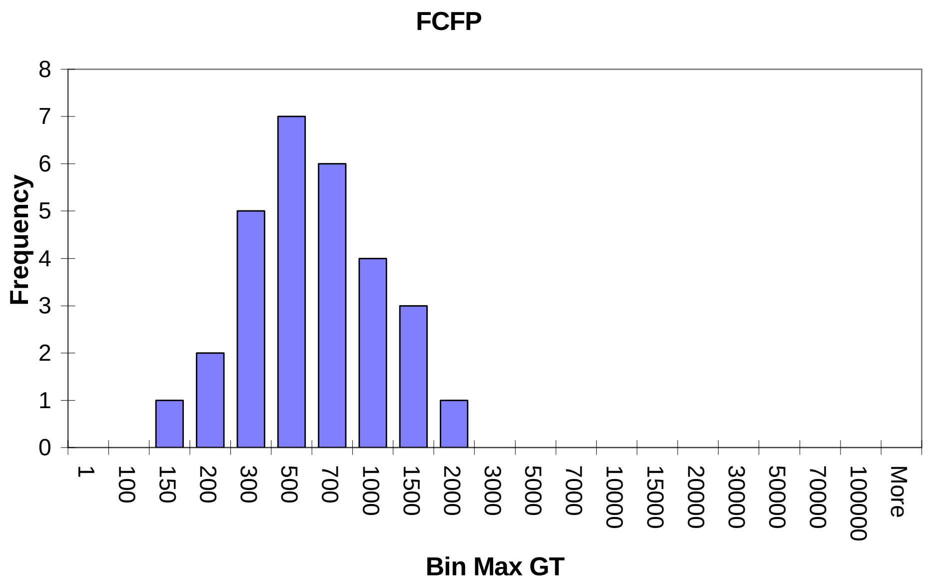


Figure 1.9. Size distribution of interisland passenger/cargo ferries.

Bulk shipping

There are a few established bulk commodity routes in the region. Phosphates from Nauru is a declining trade. Squash from Tonga to Japan is seasonal, and accounts for about five voyages per year. Sugar from Fiji goes mostly to European countries. Through the Indian Ocean and Suez. Copper ore concentrate from Papua New Guinea goes to smelters in Australia, Japan and Asia.. New Caledonia has 20% of the world's known nickel, but this does not generate a large bulk trade because all of the ore is smelted in-country. Figure 4.10 shows the size distribution of bulk vessels

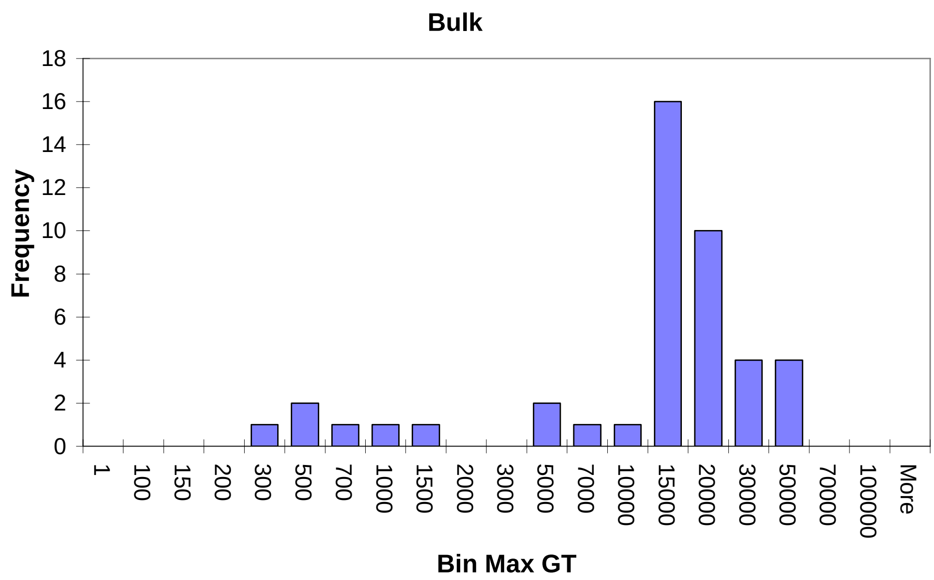


Figure 1.10. Size distribution, bulk freighters

in our database. The bulkers in the coastal PNG trade and log exports are generally smaller than 5,000 GT. Bulkers in the other Pacific trades are mostly in the 10,000 to 20,000 GT range.

Liquefied natural gas

Origin Energy LPG tankers load at New Plymouth, New Zealand and deliver throughout the region from New Caledonia to French Polynesia, including Fiji, Tonga and the Samoas. Two LPG tankers carry supplies to dedicated terminals in the major ports, where gas is bottled and distributed. Secondary ports and smaller nations are supplied by bulk tanks carried as deck cargo. Tuvalu, for example, is supplied in this way from Fiji, and Kiribati is supplied directly from New Zealand by the company Rockgas.

LPG reaches the North Pacific islands by a separate distribution system Several years ago, Guam was the only port to receive bulk tanker shipments, by Shell Oil Co. from the Philippines and by Exxon from Singapore These companies bottled gas for delivery to the remainder of Micronesia. by regular freight services. Supplies for the Marshall Islands came direct from USA west coast ports.

Cruise and other passenger vessels

Cruise liners traverse the Pacific Islands region regularly, on routes that vary from voyage to voyage. Figure 4.10 shows the size frequency distribution of cruise vessels in our database. There are a few cruise vessels below 1000 GT, and more local cruisers that were below the minimum size of inclusion.. Small cruise liners, in the size range 1000 to 10000 GT are mostly engaged in local circuits of one or a few countries, on itineraries that include smaller ports or anchorages. The typical vessel in the Pacific Islands is in the medium size range, from about 15000 to 50000 GT, carrying 200 to 1000 passengers. These vessels usually travel in ocean – wide to global patterns governed by season and demand. Some are in regular regional circuits, such as the “Paul Gauguin” from Papeete to the islands of French Polynesia, the “Pacific Sky” from Sydney to Noumea, PNG and Vanuatu, and the “Asuka” from Japan to the Northern Marianas and others in Micronesia. The largest liners, for example the *Queen Elizabeth II*, 70327 GT and 1500 passengers, travel global routes with a few stops at larger island ports.

1.5 Comparison of vessel traffic routes with some actual tracks.

The World Meteorological association coordinates a worldwide network of marine weather observations gathered from shore stations, automated buoys and voluntary ships of opportunity (WMO 2002). All data include latitude and longitude rounded to the nearest one tenth degree, and radio callsign. The most useful source of consolidated data files was NOAA 2002. The callsign field allowed us to separate the positions of vessels of the Voluntary Observing Ships programme (VOS) from fixed or drifting observatories, and to select only records from commercial vessels. We rejected positions from research ships, fishing vessels and yachts because these would not be representative of the main traffic patterns. Figure 4.14 compares the VOS positions for the year 2000 , with the thematic map of total vessel frequency on routes inferred mainly from interviews and OPW 1973. In several cases, notably around Pioneer Channel, Papua New Guinea, and on the passage from Papeete to Panama, it was evident that common practice is to take a more direct route between hazards than is recommended in the sailing directions. We have adjusted several inferred routes to reflect this fact.

Correspondence between the actual and inferred tracks is generally encouraging, but some actual tracks do not correspond to any of our routes. The VOS ships varied their courses substantially from voyage to voyage, producing a diffuse pattern of positions in some areas, for example on passages between New Zealand and South America/ Cape Horn.

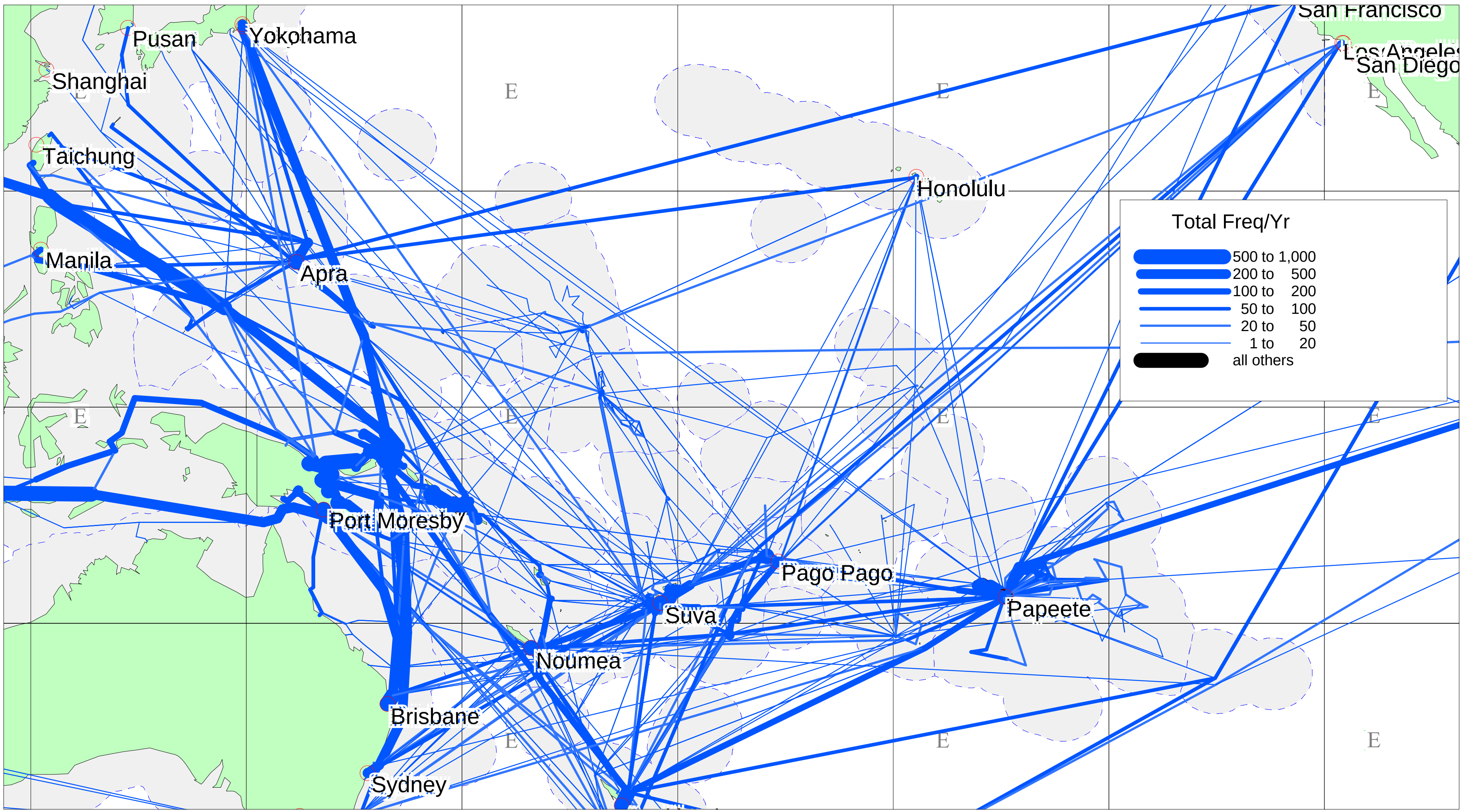


Figure 1.11. Total vessel traffic by frequency.

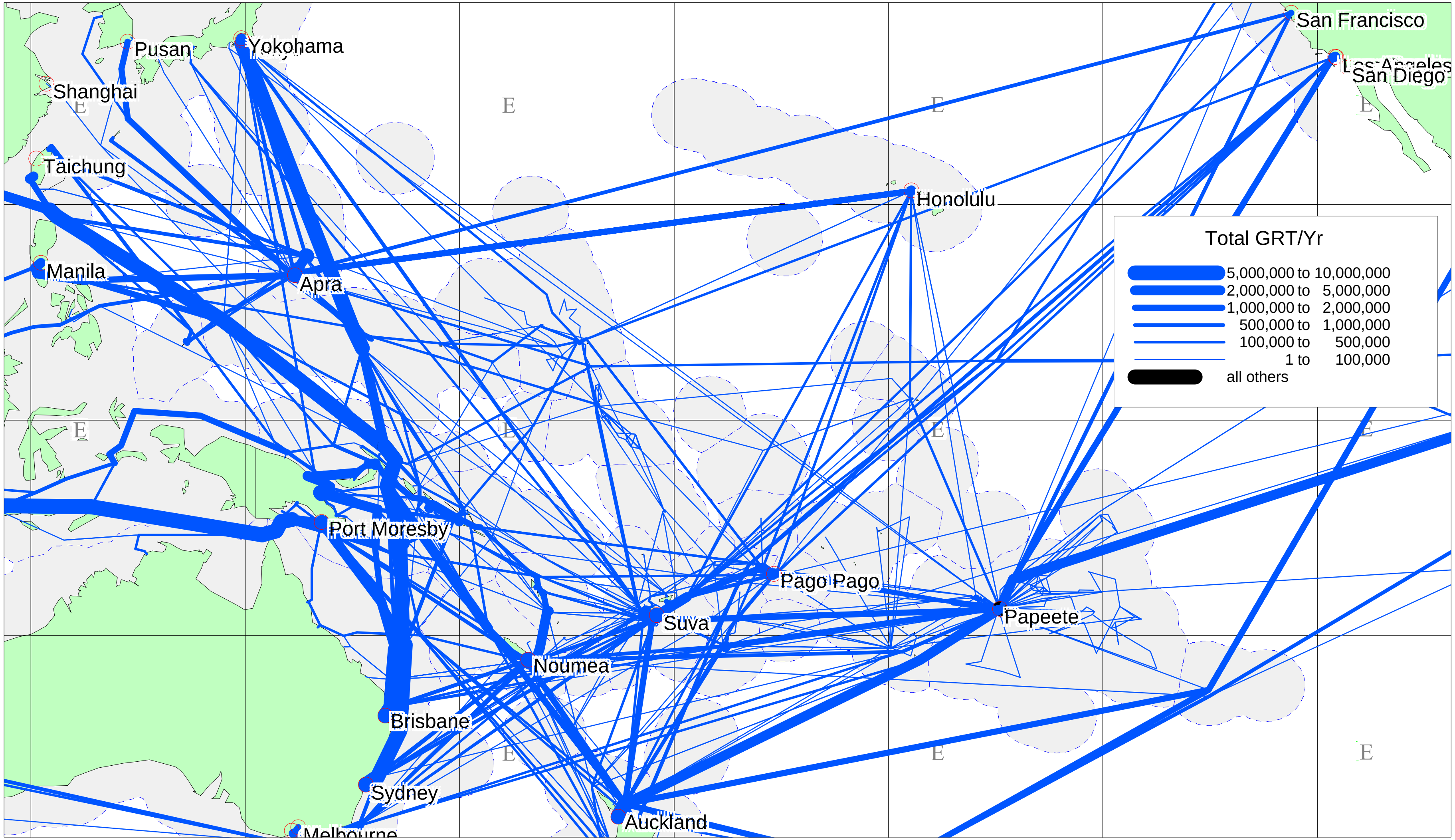


Figure 1.12. Total vessel traffic by GT.

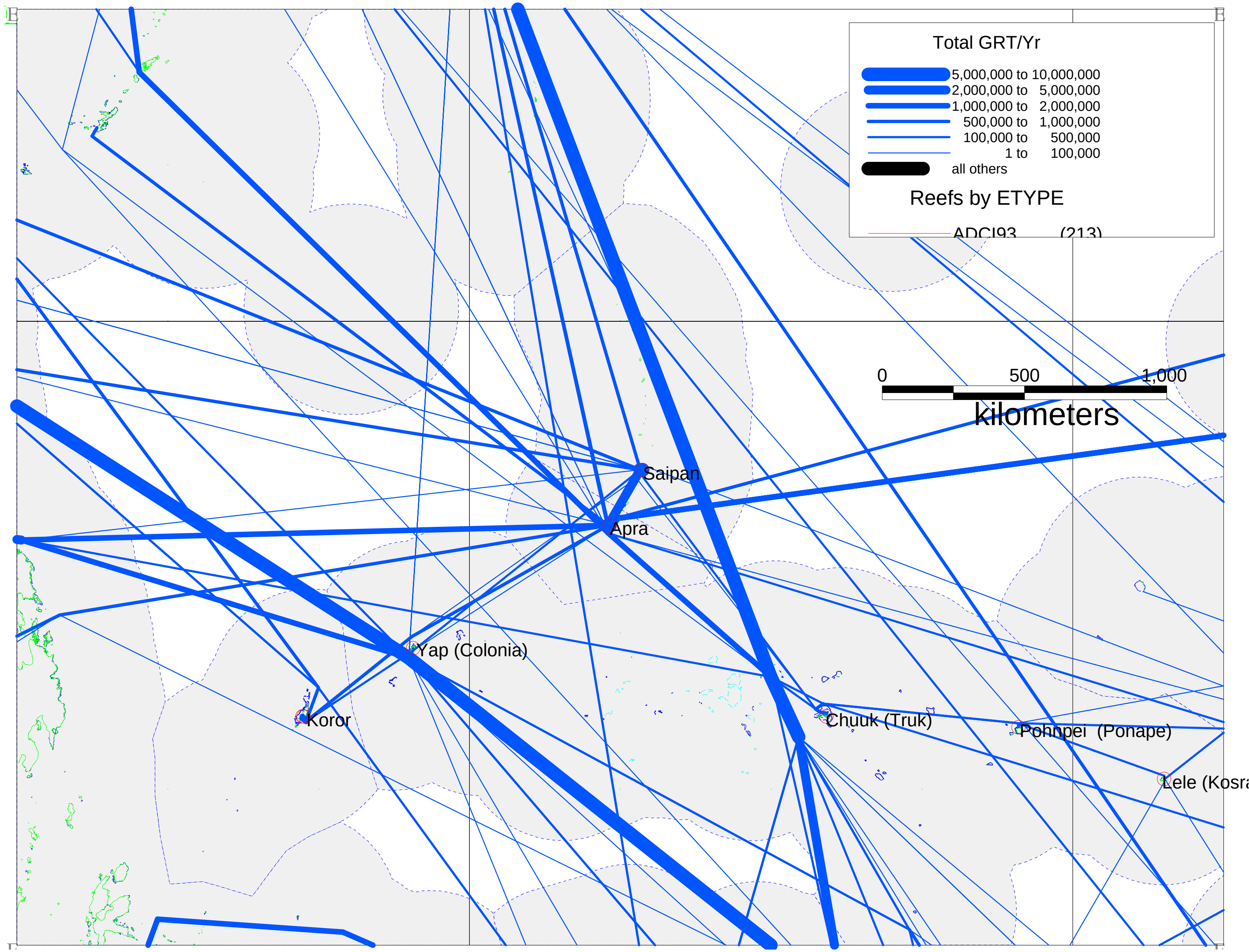


Figure 1.13. Total vessel traffic by GT, northwest subregion.

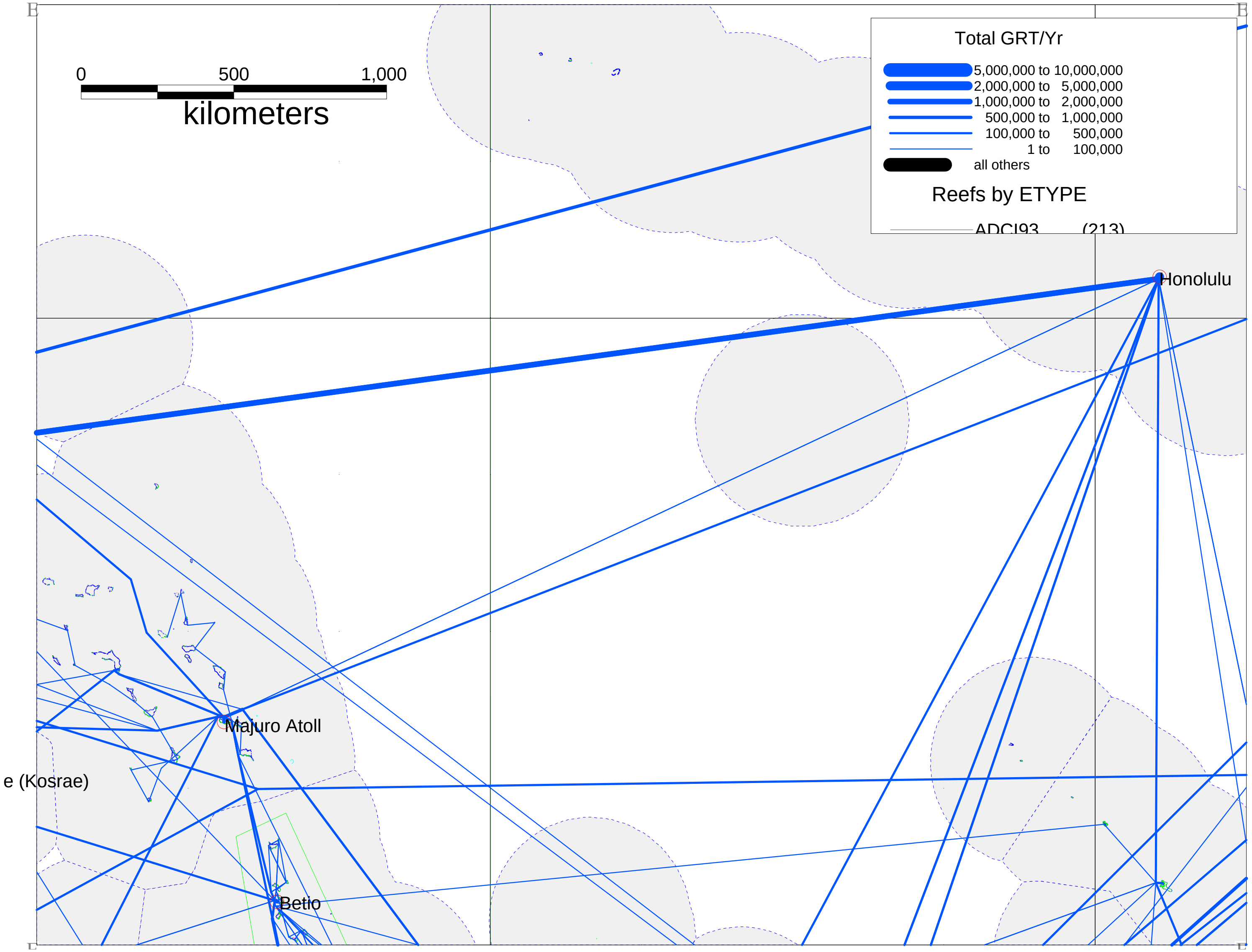


Figure 1.14. Total vessel traffic by GT, north central subregion.

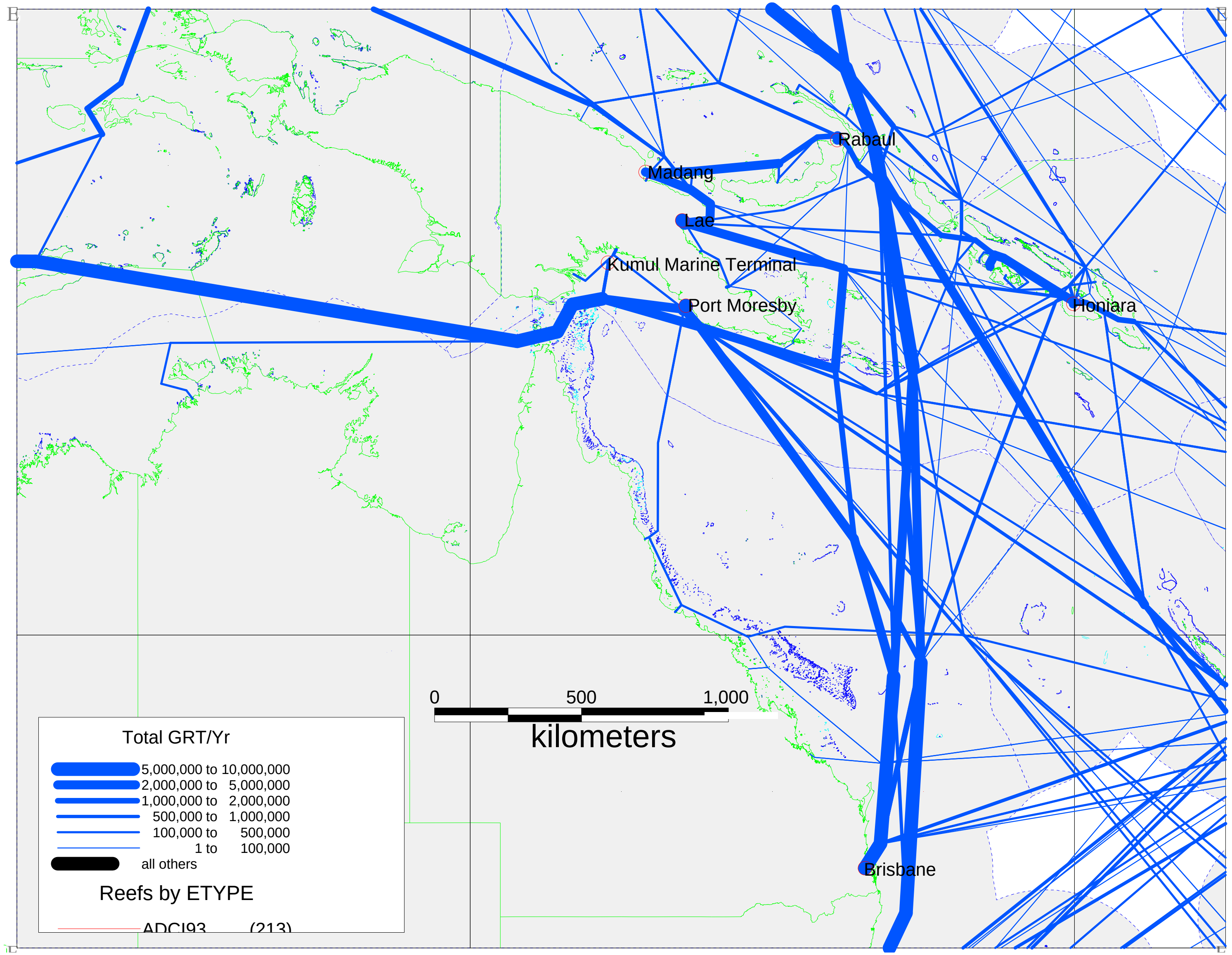


Figure 1.15. Total vessel traffic by GT, southwest subregion.

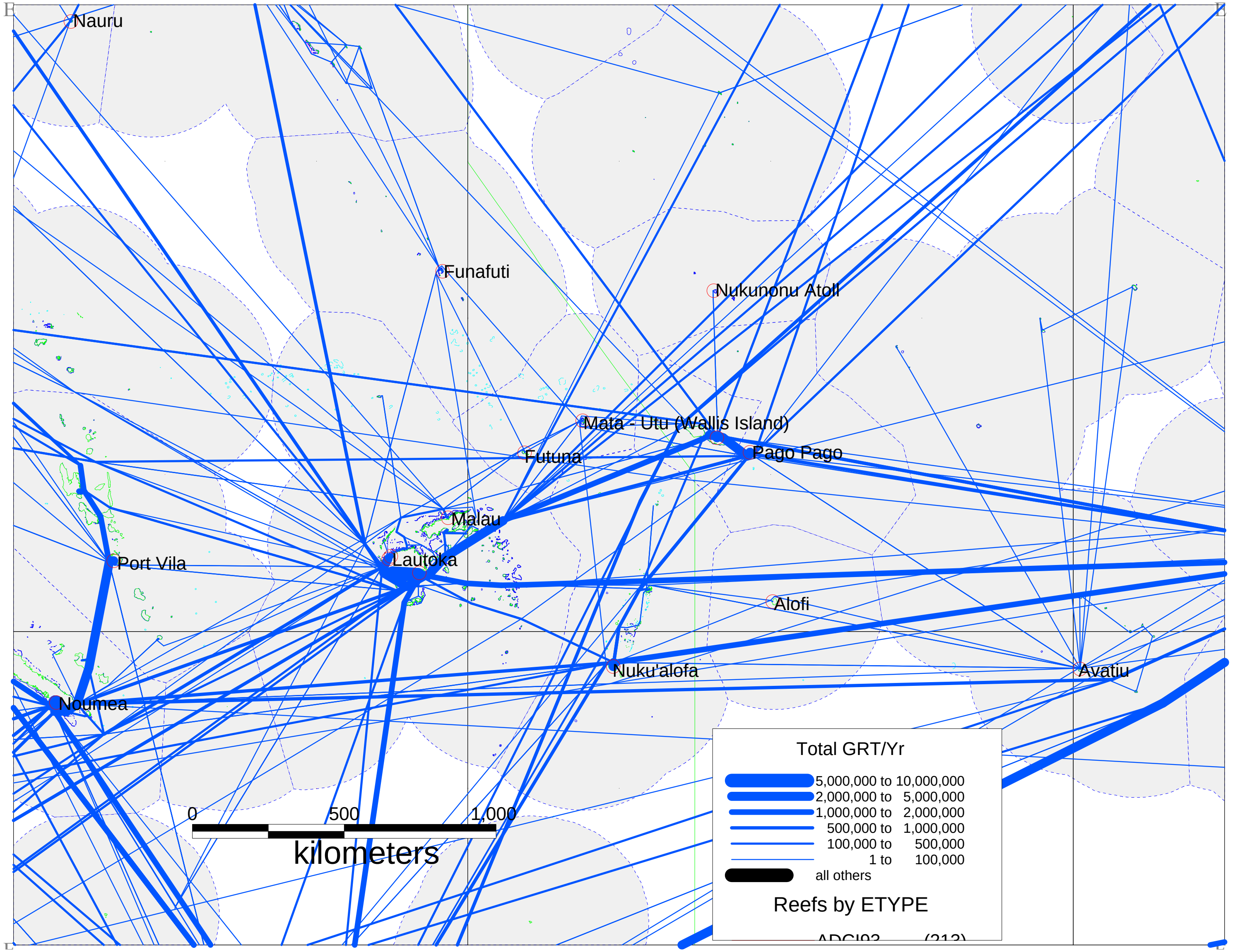
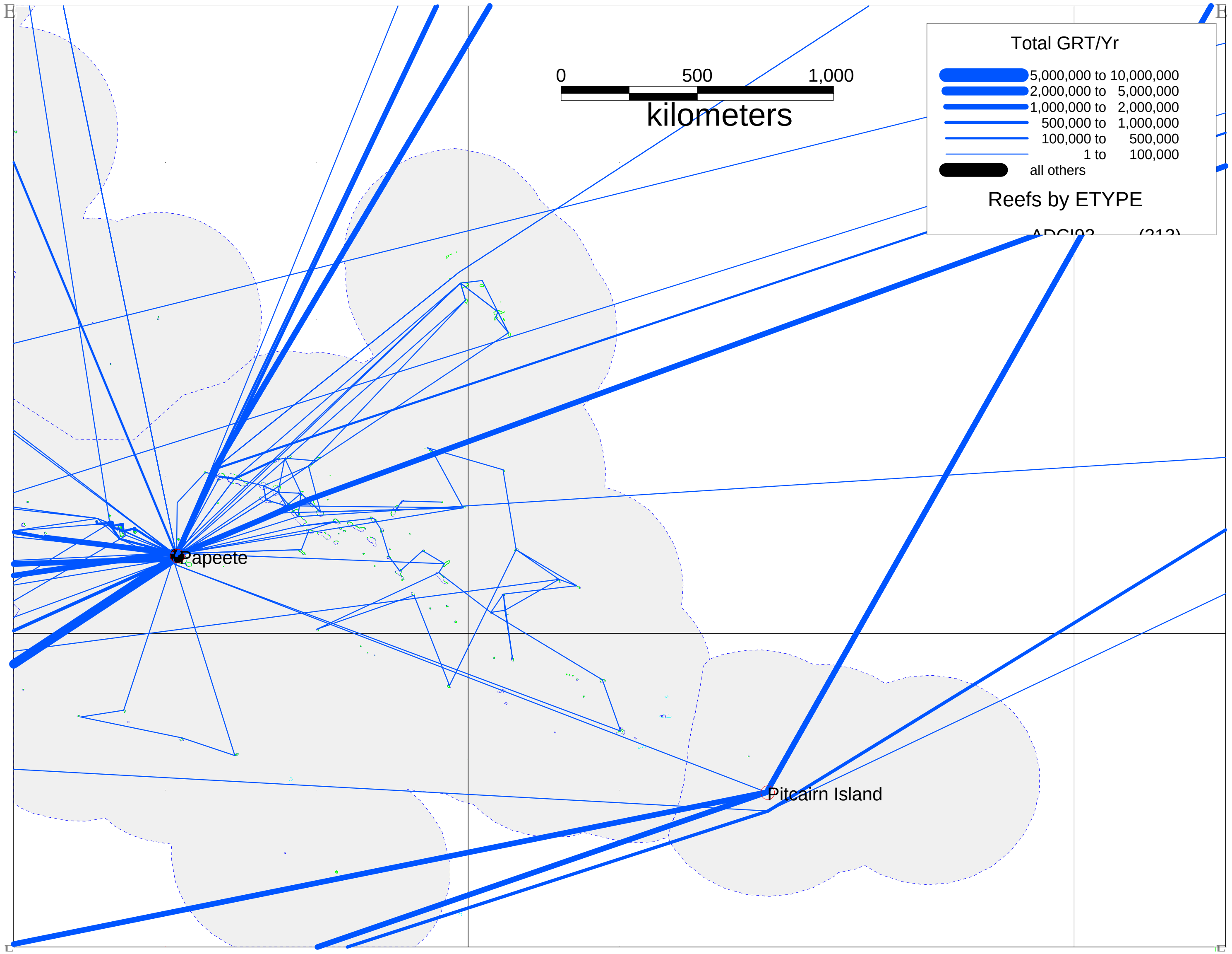


Figure 1.16. Total vessel traffic by GT, south central subregion.

Figure 1.17. Total vessel traffic by GT, southeast subregion.



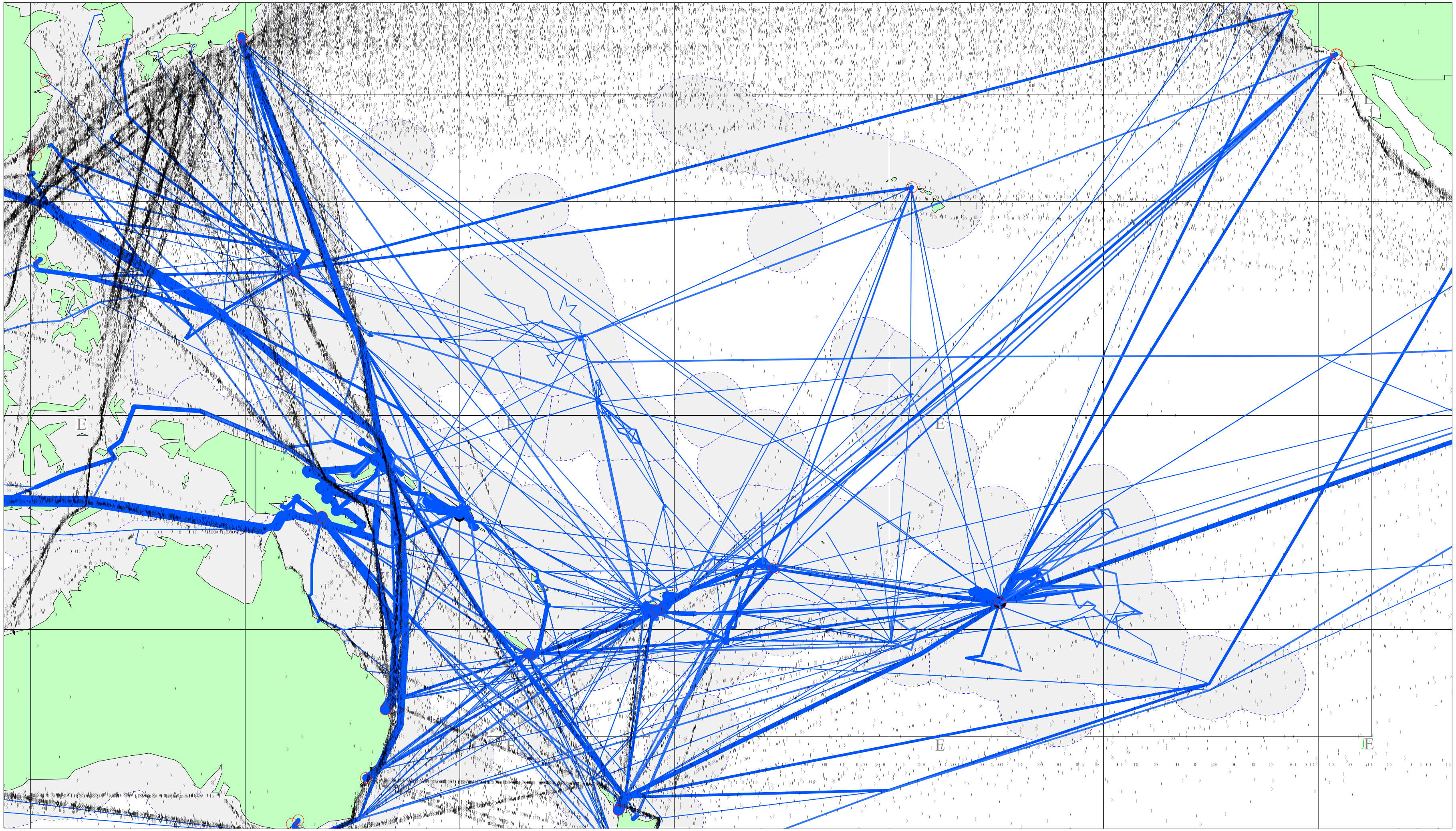


Figure 1.18. Comparison of total vessel frequency routes with actual tracks of VOS ships (black circles).1999.

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1 HISTORICAL PATTERNS OF SHIP CASUALTIES IN THE PACIFIC ISLANDS REGION

Data on ship causalities was collected from published and original sources to form a baseline for risk assessment, and as validation on the results of our predictive risk assessment. "Ship casualty" in this case means any incident involving a vessel, either resulting in damage or loss of the vessel, or having a clear potential for significant damage to the vessel or the environment. Thus we included all groundings, sinkings, collisions, and events such as fire or vessel adrift at sea that are likely to result in damage or loss. We excluded reports of events related to vessel management or maintenance that had little potential for environmental damage, such as a generator failure or financial dispute. We extended our coverage to include some other incidents with environmental implications, such as spills of fuel, improper discharge of wastes or overboard loss of cargo from vessels.

1.1 Provisional database of shipping incidents

1.1.1 Data sources

The initial source for this database was Preston et al. 1997. Preston's report collected data on grounding events that occurred from 1 January 1976 through 1995 involving vessels over 100GT. It is based on information from Lloyd's Casualty Archive, a database maintained by Lloyd's Maritime Information Service. We have extended the coverage through November 2002, mainly by reference to national maritime safety authorities, web sources and news

Case Study 1. **Charngh Yi No. 12** ***at Mabulici Reef.***

On 27 July 2000, the Charngh Yi No.12*, a 230 GT Taiwanese longline fishing vessel built in 1984, crossed the Koro Sea, returning to fishing after a port stop at Suva. The vessel ran aground in reported bad weather and heavy seas on Mabulici Reef (18°04.56'S; 179°12.48'E), about 7 nmi south of Gau Island, Fiji. Gau is a high island, about 11 nmi long with a maximum elevation of 715 m. It is surrounded by fringing and barrier reefs extending up to 3 nmi offshore. Charts show a navigation light on the south end of the island. Mabulici Reef is low, unmarked and separated from Gau by a deep channel about 5 nmi wide.*

At the time of grounding, the Charng Y*i drove entirely onto the reef. A Fiji naval vessel rescued the crew with some difficulty caused by the position of the vessel. The owners soon declared the vessel a loss. (Fiji Receiver of Wrecks?) sold the wreck to a trading company based in Fiji. Fuel and cargo were salvaged, but the company lacked the financial ability to complete the salvage of the hull, which sustained further damage and was stripped of remaining equipment.*

The Captain of the Charngh Yi No.12 *reported that the vessel's autopilot had malfunctioned, and the problem was noticed only as the vessel grounded. Mabulici is a particularly hazardous reef because it is isolated from nearby visual or radar target references. The local trading and passenger carrier Kaunitoni grounded on the reef on 08 August 1986.*

The loss of the Charngh Yi No.12 *passed almost unnoticed. International casualty lists contain no reference to it. There has been no environmental damage assessment. The easy abandonment is typical of fishing vessel casualties among the distant waters longline fleet, many of which are ageing and in poor repair. This particular vessel was 26 years old at the time of the incident, and had very little residual value. Reefs throughout the region are decorated with wrecks of this type. The vessels are small, and their loss, particularly at sites remote from official oversight, does not draw significant attention. Despite their small size, they can cause significant direct damage to reefs and release locally damaging oil spills. On a national scale, these events may appear insignificant, but to the nearby inhabitants whose resources are damaged, the effects can be devastating.*

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reports.

1.1.2 Data treatments and presentation

In order to archive the shipping incident information into a useful database, we have reduced all information for each incident to one record in the database Casualties.mdb. Less than half the source reports included geographic coordinates. Wherever possible we have converted placenames to latitude/longitude, so that the reports could be georeferenced. Positions must be considered approximate. Figures 5.1 and 5.2 summarises the distribution of all casualties and casualties over 1000 GT among categories severity from minor damage to total loss. Appendix 4 contains the complete casualties database.

Case Study 2. **World Discoverer** ***at Sandfly Passage***

The World Discoverer *was a cruise ship of 3724 GT built in 1974. Society Expeditions of Seattle, USA purchased the vessel, and after a substantial refit operated her under Liberian registry. The vessel cruised to less-visited locations, including the Antarctic, Alaska and smaller Pacific Island ports.* World Discoverer *was ice-strengthened, double hull construction, and equipped to operate independently in remote areas. On 30 April 2000 the vessel was in Sandfly Passage (09° 01' S;160° 07'E), which separates the islands of Mbokinimbeta and Nggela Sule, north of Guadalcanal, Solomon Islands. Around 3:30 PM, the* World Discoverer *struck an uncharted coral reef and sustained such damage that the captain ran the vessel ashore on, Nggela Sule, to avoid sinking. The Australian Marine Safety Agency (AMSA) received the initial distress message, which was sent by the relatively new radio system Digital Selective Calling (DSC). AMSA alerted the Solomon Islands Police who relayed the message to Solomon Islands Rescue Coordination Centre (SIRCC). SIRCC and AMSA coordinated rescue operations.*

The 112 passengers and 80 crew evacuated safely to Nggele Sule in ship's boats, and transferred to Honiara in the Solomon Islands vessel Isabella*. Seawater progressively flooded the vessel throughout, and it settled onto the bottom near the mangrove-lined shore, starboard deck awash, with a list of about 40 degrees. There were no reports of spills or other pollution, and some later photographs show the vessel in calm water surrounded by an oil containment boom.*

Representatives of the vessel's owners and insurers were on scene within a few days. The decision was made to refloat the vessel, which at this point was a good prospect for an early return to service. Proximity to the port of Honiara, and Australian salvage equipment improved the prognosis. The salvage company "K" Salvage of Australia patched the vessel, pumped it out, righted it, and were preparing to tow on 21 June, when civil unrest ashore spilled into the area. The salvage crew withdrew, and as of 1 September 2001 the vessel's managers reported that they did not know the current situation of the vessel. The vessel has probably been stripped of equipment, provisions and fuel. It has been declared a total constructive loss. Society Expeditions has bought another vessel to replace the World Discoverer *and resumed the vessel's service.*

This incident illustrates some common features of ship accidents in the Pacific Islands region and elsewhere. Modern equipment, qualified crew, and well-maintained vessels are not a guarantee of safety. Adventure cruises, a form of travel most nations encourage, entail visits to remote places, unfamiliar waters and passages less traveled. This exposes them to many of the risks that routinely claim distant waters fishing vessels and bulk carriers. When incidents do occur, time is often lost because of poor communications. There is usually no prompt and quantitative environmental assessment. Proximity to a major seaport with salvage and pollution control equipment favors successful containment, clean-up and salvage.

1.1.3 Is the database complete? Is it representative?

The initial database was incomplete because national systems for recording incidents are not equally developed across the region (Preston et al. 1997 p7, p11). The data in Lloyd's Casualty Archive can be expected to reflect the interests of that agency. Coverage will be best in proximity to a Lloyd's agent, or involving a major vessel. Incidents involving distant-waters fishing vessels often go unreported. We have, for example, newspaper and anecdotal reports of several distant-water longline fishing vessels that grounded without loss of life on Fiji reefs, were subsequently abandoned, but left no record in international casualty archives. (See box *Charngh Yih No. 12*).

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Incident Type	Minor	Partial	Total Loss	Unknown	Totals
Collision	3	6	1		10
Fire		4	9	1	14
Grounding	1	1			2
Grounding adrift	2	8	16	1	27
Grounding under power	50	66	56	12	184
Hull	3	2	7	1	13
Mechanical	12	3	1	3	19
Storm	5	1	9		15
Other	2	1	9		12
Unknown		1	13	5	19
Totals	78	93	121	23	315

One test of the completeness of the database is to compare it with independent sources, and note whether additional incidents are discovered. The Fiji Islands Marine Safety Authority (FIMSA) has reviewed our initial database and chart of casualties for Fiji waters, and responded with their corresponding information for 1998 through 2000. The databases are different. This report presents five Fiji incidents during 1998 through 2000; only one of which appears in the FIMSA database. Of two incidents in the FIMSA database that clearly qualify for inclusion in our record, we found one. Further inquiries will determine how much of the discrepancy is attributable to different standards for inclusion in the databases (for example different minimum tonnage or severity criteria) and how much to incomplete data

capture.

We present this database of maritime casualties in the Pacific Islands region as a work in progress. It is the most comprehensive compilation to date, and the only available georeferenced resource on ship casualties in the region, but it is not complete. We hope that this effort will serve as a stimulus to regional efforts to record, maintain and share information.

1.2 Distributions of ship casualties

1.2.1 Casualties by incident type and severity

Table 5.1 is a summary of casualties by type of incident, graded as total loss, partial loss and minimal damage. Of 315 incidents, 121 (38%) resulted in total loss, a category that includes total constructive loss for insurance purposes and abandonment after grounding. (See boxes *World Discoverer* and *Charngh Yi No.12*.) This proportion is unexpectedly high, probably caused by underreporting of less dramatic incidents. Collisions were rare relative to groundings, and most groundings occurred under power, indicating navigational error as the predominant cause of all grades of losses.

Table 1.1. Casualties by incident type

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1.2.2 Casualties by vessel type and severity

Table 5.2 summarises the casualty data by vessel type and degree of loss. The results indicate that casualties among smaller vessels and bulk freighters are more likely to result in total losses than are casualties among larger vessels in scheduled services, such as container liners, tankers and cruise liners. Casualties among fishing vessels were mostly total losses. It is not clear whether this high proportion of total losses (62% versus 28% for other vessel types combined) represents a tendency of owners to abandon vessels, or whether it results from underreporting of less serious incidents among small vessels.

Table 1.2. Casualties by vessel type.

Vessel Type	Minor	Partial	Total Los	Unknown		Totals
Barge			1	1		2
Bulk cargo	4	9	5	2		20
Cargo general	20	19	20	7		66
Cruise Liner			1			1
Container vessel	6	2	1			9
Ferry (primarily cargo)	2	1	5	1		9
Ferry (passenger)	3	4	7			14
Fishing Vessel	12	20	60	5		97
Landing Craft	4	6	2			12
Other	3	4	3	1		11
Reefer	1	2				3
Roll-on roll-off cargo	3	3	2			8
Research Vessel	1	1				2
Specialised				1		1
Tanker (chemicals)		1				1
Tanker (LPG)	2	2				4
Tanker (petroleum oil)	10	5	2	1		18
Tug		4	1	1		6
Unknown	7	10	11	3		31

Totals	78	93	121	23		315

Fortunately, oil tankers and container vessels, the commonest large vessels in the region, are less frequently involved in incidents. Only one container vessel has been a total loss, and this vessel capsized at the wharf in Suva with minimal environmental damage (*Polynesian Link*, 15 October 1991). All 13 incidents involving oil tankers must be considered serious because of their potential for environmental damage. Neither of the two total losses (*Yujin Busan* 1550 tonnes in 1994, 400 nmi South of Truk (Chuuk) Island; *Seefalk* 639 tonnes 1999 at anchor Noumea) is reported to have caused significant environmental damage. The two incidents of partial damage to LPG tankers, which carry liquid petroleum gas in refrigerated or pressurised tanks, are highly significant as potential dangers to human safety. In some ports, for example in Papeete, LPG terminals are located close to centers of population. An LPG incident culminating in total loss of cargo and a fireball or explosion is an unlikely event, mainly because of the extensive safety precautions surrounding the operation of these vessels. Nevertheless, such an incident could destroy buildings and kill people within a radius of several miles (Lovins and Lovins 2001). An LPG incident in Apra Harbour, Guam, *Esso Tees in* 1992, did cause an explosion and fire, which were contained without serious damage.

Case Study 3.Hurricane Val at Pago Pago Harbor.

Pago Pago is one of the best harbours in the Pacific Islands. It is the largest center for the Pacific tuna canning industry. On December 10, 1991, Hurricane Val struck a direct hit on Pango Pango. Nine of the fleet on longliner fishing vessels sheltering there were torn from their moorings and wrecked on the reefs of the northeastern portion of the harbour. Several of the 170-foot, 300 ton vessels began leaking diesel fuel and oil. The immediate threats of oil pollution were contained by the US Coast Guard and contractors, but the vessels were severely damaged. All were abandoned by their owners and lay rusting while authorities considered their options.

Oil remained aboard the vessels, together with other potential pollutants such as ammonia in the refrigeration systems. In February of 1997, one of the rusting hulks, the Koram No.3 began leaking oil. By May 1998, a report stated that the vessels were "..falling apart, moving around and spreading debris all over the reef." Something had to be done.

Most of the wrecked longliners were too far up the reef, too damaged and too rusted to refloat. It was decided to remove all pollutants from the nine vessels, cut them into pieces, remove them by barge, and dump the remains into deep water offshore. The project was ambitious. Causeways were required to reach the vessels, and the work was difficult, expensive and dangerous even with the specialized heavy equipment that was brought in from Hawaii.

During August 1999 - June 2000 seven vessels were cut up and removed. The other two were refloated and scuttled offshore in March 2000. The last debris was cleared by January 2001. By the end of the operation, several thousand gallons of diesel oil had spilled, but 1900 tons of metal, 36,000 gallons of diesel oil, 600 lb of anhydrous ammonia and ten pounds of Freon were removed from the nine wrecks, at a cost of over US$12 million. Physical scars and contaminants such as bottom paints remained, but a major pollution event had been averted.

This favorable outcome was the result of luck (no intervening storm to shatter the wrecks) and resources (Pago Pago is USA territory, with support from the US Coast Guard and EPA). Storms of this magnitude can be expected in other Pacific harbours, most of which have much less capacity toassess damage, combat pollution or conduct large salvage operations.

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Figure 5.1 shows the locations of all casualties in our database. Casualties are distributed throughout the region, but there are some obvious concentrations. The figure shows several clusters of incidents, notably among the Fiji Islands, along the Guam - Saipan corridor and around the rim of the Solomon Sea in Papua New Guinea and Solomon Islands. These areas are hubs of regional and international shipping. They are also likely to be well-reported. There are lesser aggregations about regional centers, for example in the Cook Islands near Rarotonga.

Figure 5.2 shows incidents involving partial to total loss of vessels over 1000GT. There are four distinct clusters of incidents involving large vessels: one around Pago Pago, one about the Fiji group, one along the Guam – Saipan axis and again around the shores of the Solomon Sea, in Papua New Guinea and Solomon Islands. Several of the most notable casualties have occurred in the Commonwealth of the Northern Marianas and Palau..

Moderate to severe incidents involving larger vessels should be better reported than those involving smaller vessels or minimal damage. The overall pattern of large-vessel incidents is not obviously different from the pattern of small vessel incidents. This does not support the idea that the clusters are caused by uneven reporting.

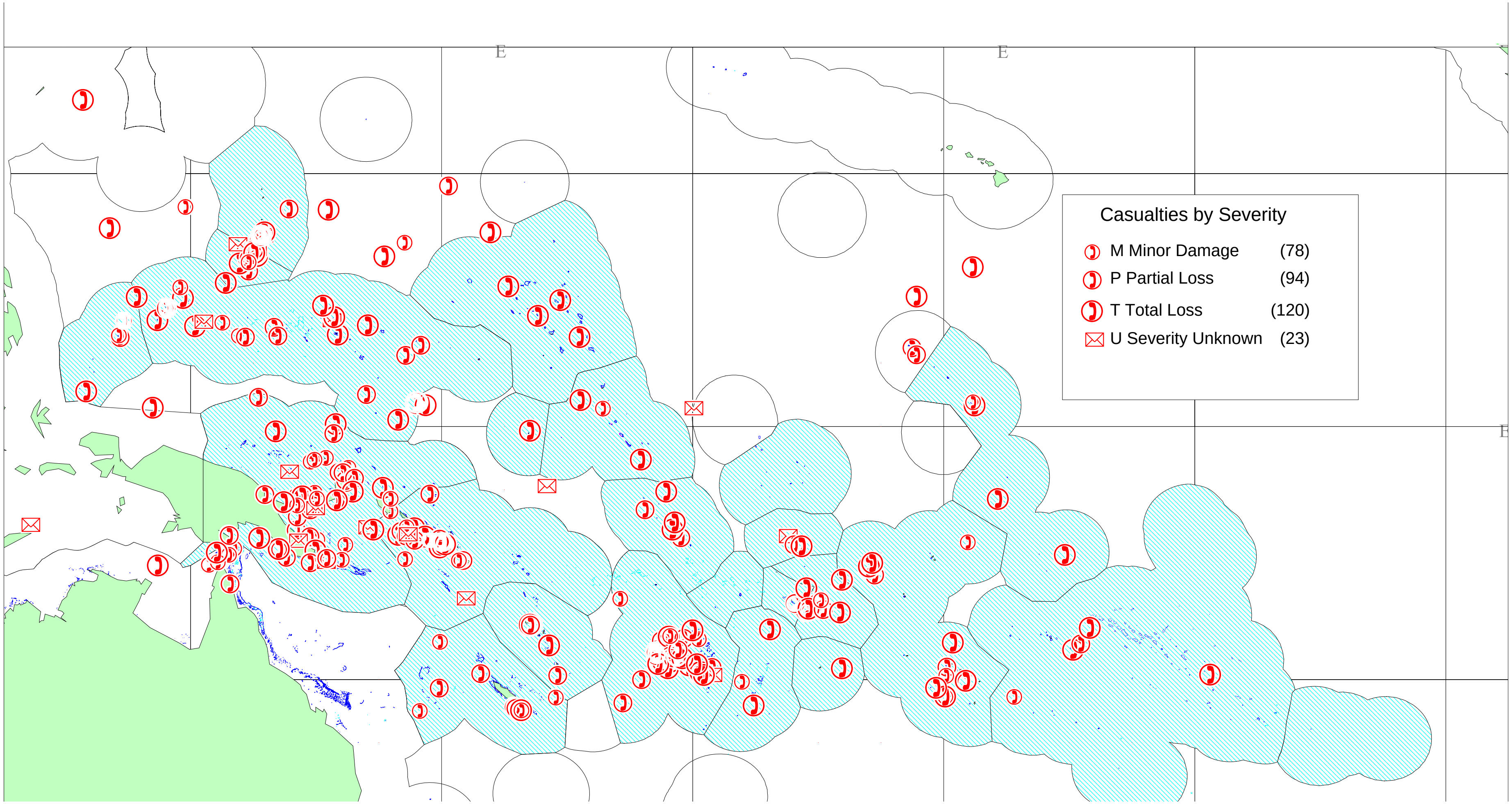

Figure 1.1. Geographic distribution of all casualties, 1976 – 2002

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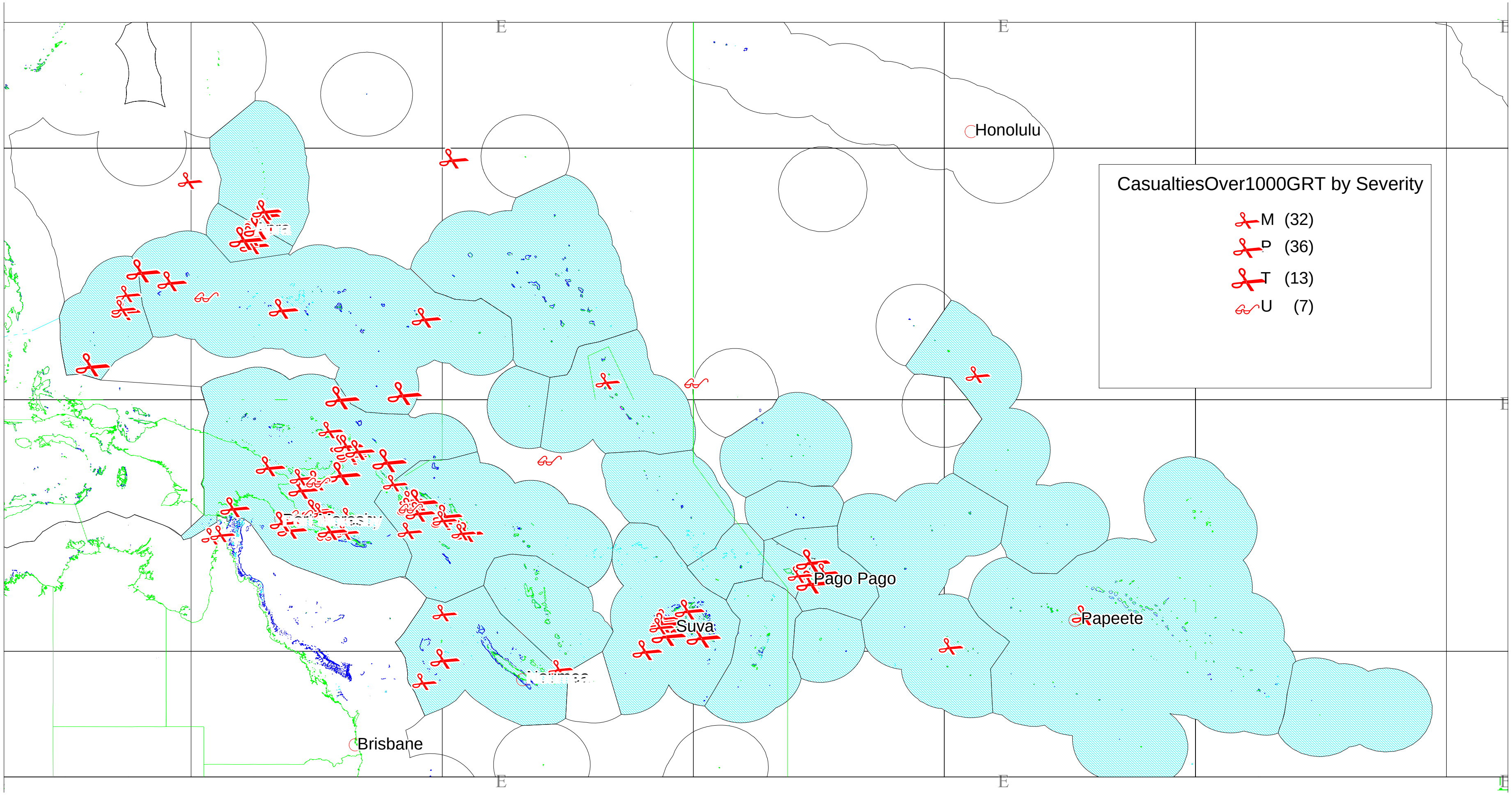

Figure 1.2. Geographic distribution of casualties over 1000 GT, 1976 - 2002.

1 RISK ANALYSES

Regional and EEZ levels

The basic model for the analysis of grounding potential is built on the simple observation that a grounding event occurs when a vessel moves into a space that is already occupied by solid earth. Thus the probability of grounding in a particular place is the frequency of vessels straying into that place, times the presence (1) or absence (0) of an obstacle at that place:

$$P(G) = P(V) \times P(O)$$

Where P(G) is the probability of grounding

P(V) is the probability of finding a vessel in a particular place

P(O) is the probability that that the place is also occupied by an obstacle

If we could map this function over the whole region at a fine grid scale, we would have the desired map of grounding probability for the region.. We have estimated the function by dividing the region into 1 degree grid squares, finding the frequency of vessel traffic through each grid square, and multiplying by the presence/absence of reef edge or shore within the square. The choice of 1 degree squares (60 miles on a side at the equator) is arbitrary, based partly on computational capacity to perform the required calculations . (The study area is about 55 degrees of latitude by 110 degrees of longitude, or 6050 grid squares.) The ideal grid size would be on the order of the distance that vessels can be expected to stray from their intended courses.

Collision potential is based on a similar model. A collision occurs when two vessels attempt to occupy the same space. Therefore the probability of collision is the probability of one vessel in a space, times the probability of a second vessel in the same space:

$$P(C) = P(V_1) \times P(V_2)$$

where P(G) is the probability of collision
$P(V_1)$ is the probability of finding a vessel in a particular space
$P(V_2)$ is the probability of finding a second vessel in or partially in the same space

We have estimated this function by multiplying vessel traffic frequency within each grid square, times the number of routes (including reverse routes) that intersect the grid cell. This calculation includes the ideas that vessels on the same course are much less likely to collide than vessels on crossing or opposed courses, and that multiple courses in the same vicinity create more difficult avoidance problems. The ideal grid size for this calculation would be on the order of the encounter radius, that is the distance at which vessel crews notice one another and prepare to take avoidance actions. The probability of collision is strongly reduced by these avoidance actions.

Both the grounding and the collision methods allow one to calculate a risk index for each grid cell, and to classify each cell as an area of relatively high, moderate or low risk. In this study, we have performed the risk analysis entirely in the Geographic Information System (GIS) MapInfo, which is also used to present the results in thematic maps that indicate areas of high, medium and low risk potential by shading or colour. Section 6.2. presents details of the grounding and collision risk analyses at the regional and EEZ levels.

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Ports level

The risk analysis at the ports level has a different structure because at this scale we can assimilate details of the individual passages. The goal of the ports risk analysis is to calculate an index of the potential for maritime incidents that might cause marine pollution. For this purpose, we have adapted a method in common use for European and Canadian ports to calculate the relative safety of the entry to major Pacific Island ports. The basic calculation is :

SM = CW / MSD,

Where SM is Security Measure
CW is Channel Width in the critical passage
MSD is Minimum Safe Design channel width

The variables in the MSD calculation are measures of the difficulty of passage (channel width, depth, turn radius, current, wind, two-way or one-way traffic), risk control measures (aids to navigation, pilotage) and the physical characteristics of a typical large vessel using this passage. When Security Measure = 1, the channel is just adequate for safe passage. SM less than one indicates increased risk potential. Section 6.3 presents details of the MSD method and results.

1.1 Some Language of Risk Assessment

The challenge for communication in risk assessment is that different authors and readers may apply different terms to basic risk analysis concepts. Many of the terms used in risk assessment are common words or phrases, that have specific meaning in risk assessment.

Because of this underlying ambiguity, there is often a discrepancy between what risk component a study intends to measure, and what is actually measured. The problem begins with the definition of risk. In ordinary speech, “risk” is often used to refer to the probability or frequency of occurrence of a hazardous event. In Risk Assessment, “risk” includes not only the probability of a hazardous event, but also the harmful consequences of that event. “Risk”, and by extension “risk analysis” and “risk assessment” are often used incorrectly.

What is risk, and what is the scope of the port risk analysis? We presented the basic definition of risk in Introduction:

Risk = Probability of Incident X Harmful Consequences of Incident

Table 6.1 presents some additional risk definitions. Figures 6.1 and 6.2 show the steps in the risk assessment process, with emphasis on the very important component of risk communication. This study is at the level of preliminary risk analysis, with the output of qualitative accident probability. A preliminary analysis involves both hazard identification and the use of risk scenarios.

Table 1.1. Risk management concepts.

Term	Comment
Risk—the chance of injury or loss, defined as a measure of the probability and severity of an adverse effect to health, property, the environment, or other things of value. (Example: The probability of an oil spill **times** the magnitude of the financial consequence to the environment.)	This study discusses consequences for various components of the environment, but it does not evaluate consequences at the same resolution as the potential for incidents. Therefore, risk is not measured quantitatively.
Hazard—a source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these.	Example: narrow passage through a coral reef is a hazard to shipping. A narrow passage is a source of potential harm in terms of damage to property, the environment and human injury.
Preliminary Analysis—includes the steps of scope definition, hazard identification using risk scenarios, stakeholder analysis and information gathering for a risk information library.	**Preliminary Analysis is the focus of this study. Hazard identification and the use of risk scenarios broadly defines the scope of the port risk analysis. The Region and EEZ analyses have the same components, in more general form, with exceptionally large geographic coverage.**
Risk estimation—the activity of estimating the frequency or probability and consequence of risk scenarios, including a consideration of the uncertainty of the estimates.	Risk estimation follows the preliminary analysis. It is where the frequency and consequence of risk scenarios are measured. This study provides an index of relative probability of incidents. It does not estimate the quantitative probability and consequence of any risk scenario. Therefore, this study does not go beyond a preliminary analysis stage of risk management.
Risk analysis—the systematic use of information to identify hazards and to estimate the chance for and severity of, injury or loss to individuals or populations, property, the environment, or other things of value. This is the overall process of preliminary analysis and risk estimation.	Because the regional and port risk analyses do not conduct a risk estimation, they are not full risk analyses.
Risk evaluation—the process by which risks are examined in terms of costs and benefits, and evaluated in terms of acceptability of risk considering the needs, issues and concerns of stakeholders.	No evaluation of consequences or acceptability of risk was conducted.
Risk assessment—the overall process of risk analysis and risk evaluation.	The risk analysis work was confined to a preliminary analysis. No risk evaluation work was required. Therefore, the study is better defined as a preliminary risk analysis rather than as a risk assessment.

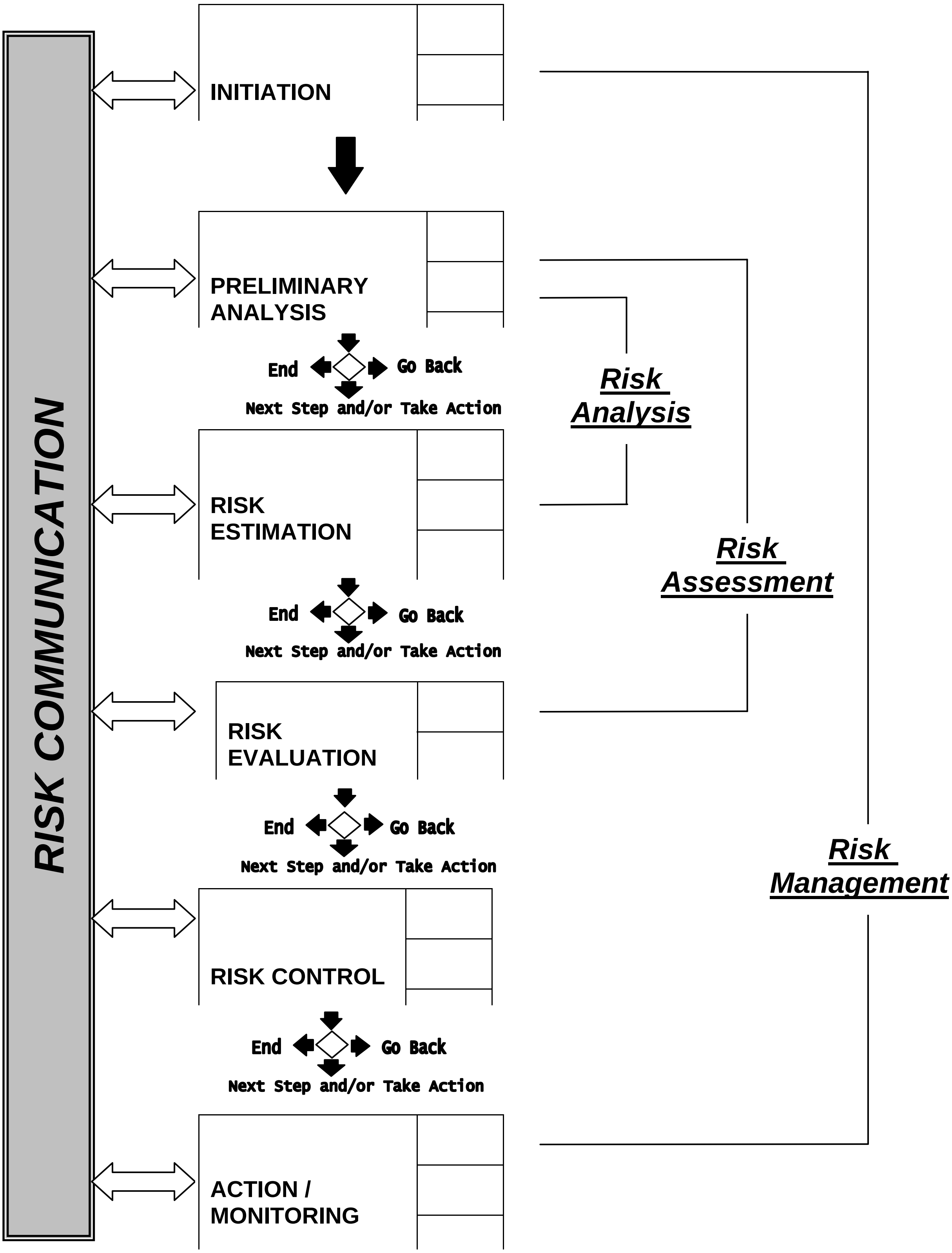

Figure 1.1. Steps in a risk management decision-making process and hierarchy of risk management concepts.

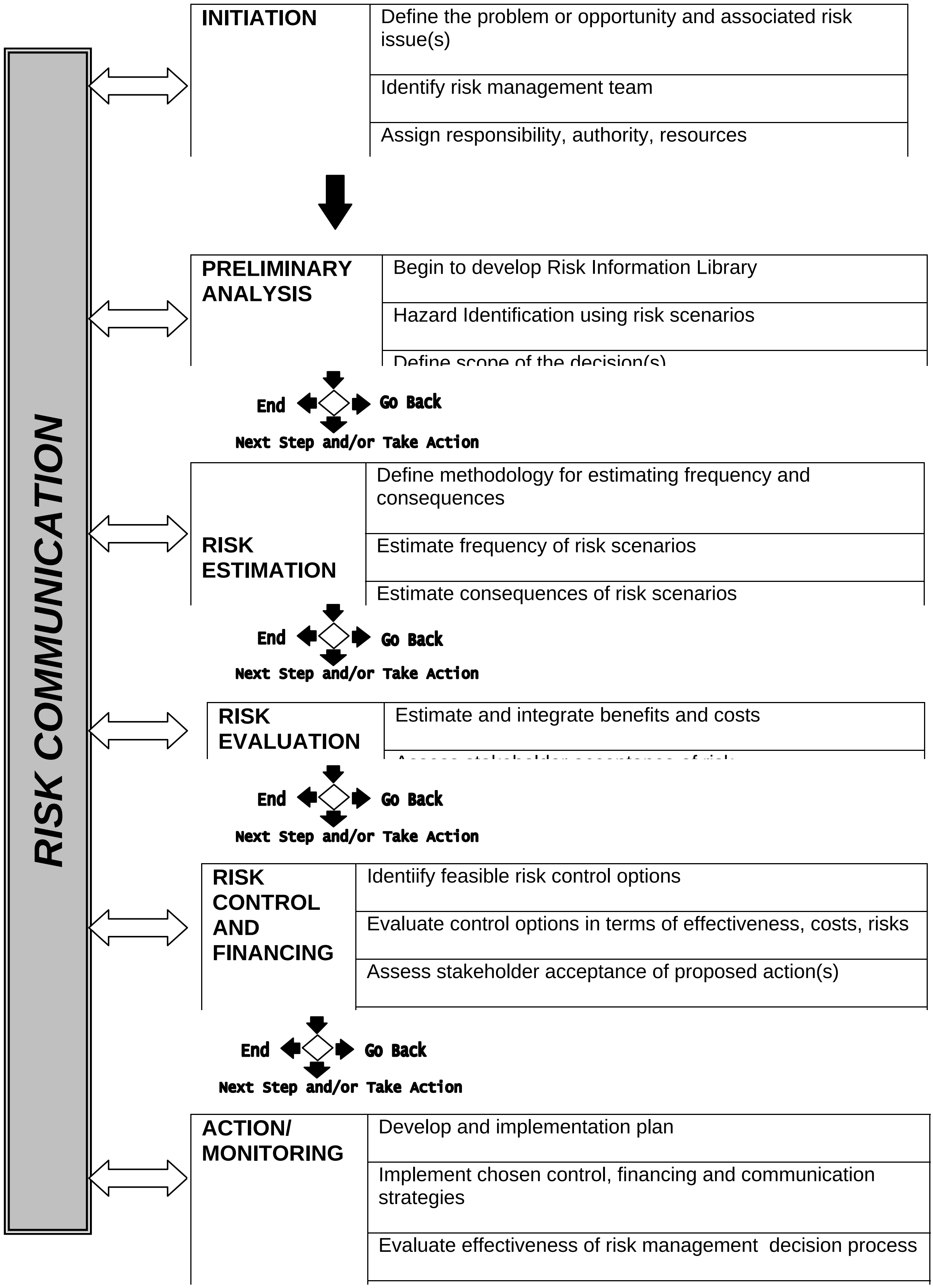

Figure 1.2. Steps in a risk management decision-making process with details of tasks for each step.

1.2 Risk Analyses at the Regional and EEZ Levels

1.2.1 Regional and EEZ Risk Methods

Several map layers were required to create the grounding and collision potential maps. The summary of data from our vessel traffic survey is presented in a map of vessel traffic routes and volumes. The contextual map layers (reefs and shorelines) form a second map. The grounding and collision potential maps are derived from these two basic maps. In order to make the required calculations, we divided the study area into one degree grid cells, that is squares of about 60 nautical miles per side. The derived maps perform calculations for each grid cell and present the results as thematically shaded map layers. For example in the grounding potential map (Figure 6.3), areas of high grounding potential are shaded dark red, grading with decreasing potential to light blue.

We calculated grounding potential as the product of the existence (or not) of a reef or shoal within each one degree grid cell times the traffic volume. We calculated collision potential as the product of the count of traffic routes within each one degree grid cell and the traffic volume. This function is intended to associate a higher collision potential with multiple routes in close proximity. The term “potential” is preferred to “risk” because consequences were not measured and Risk = Probability x Consequences. These grounding and collision maps are suitable for comparing the marine casualty potential in one EEZ to another because the map images maintain a consistent geographic scale. Appendix 6 presents details of the methods.

1.2.2 Regional and EEZ Risk Results

1.2.2.1 Grounding Risk

Figure 6.3 presents the grounding potential results for the Pacific Islands region as a whole. The most intense clusters of grounding potential are around Papua New Guinea, Fiji, New Caledonia, Solomon Islands, the Samoa's and Tonga. Other nations which rank highest for grounding potential included: Northern Marianas, Guam, Federated States of Micronesia, Marshall Islands, Kiribati, Vanuatu, New Caledonia, Tonga, and French Polynesia. Grounding potential around New Guinea is probably underestimated because the data collection did not capture bulk coal traffic from Australia to Japan or crude oil tankers from the Kumul terminal to Torres Strait.

In order to display the results at EEZ scale, we divide the study area into six subregions: Northwest, North Central, Northeast, Southwest, South Central and Southeast. Grounding and collision potential maps were created for each region. The Northeast subregion did not present a grounding or collision risk. Therefore we include no detail maps of this area. Figures 6.4 through 6.8 show the grounding potential results for the subregions.

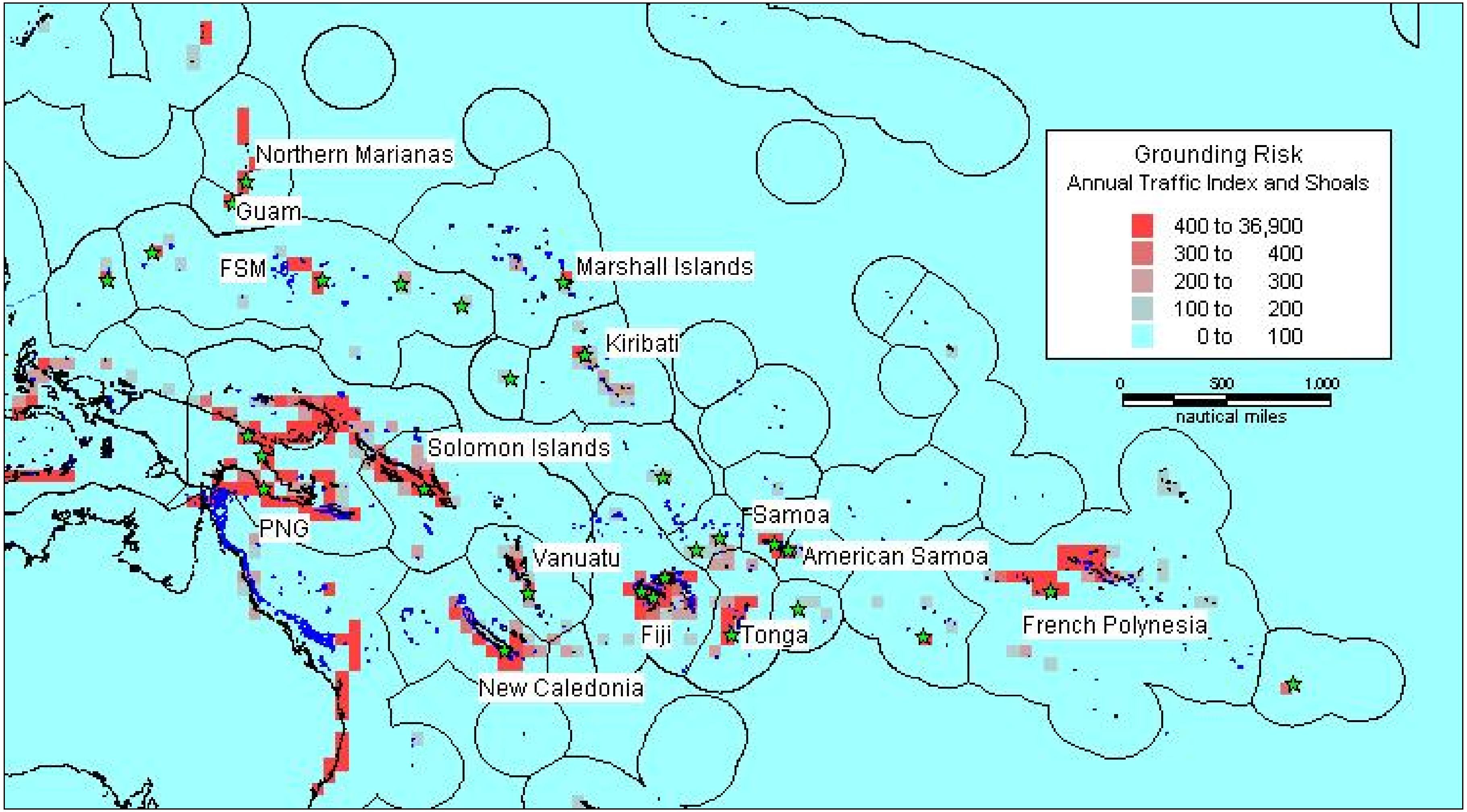

Figure 1.3. Grounding potential, Pacific Islands region.

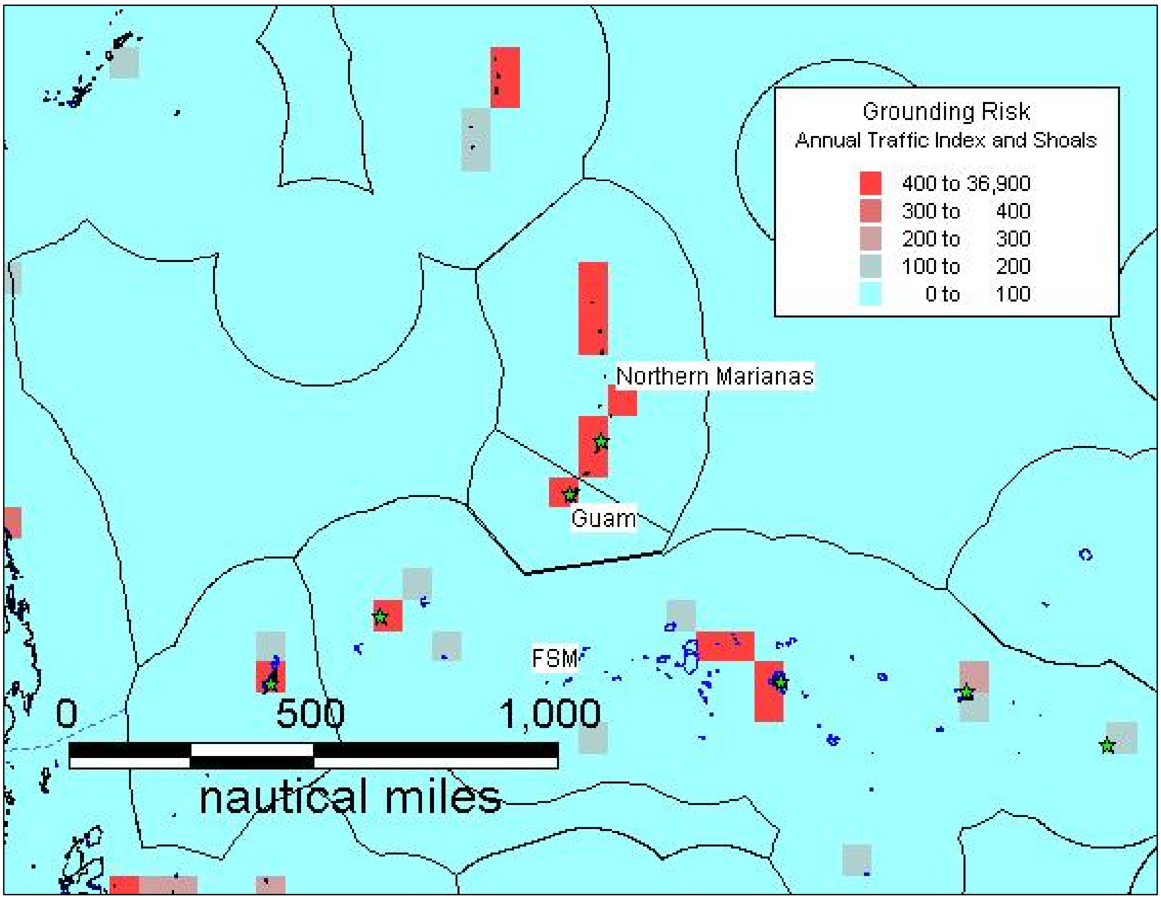

Figure 1.4. Grounding potential, northwest subregion.

The north west subregion shows several clusters of high grounding potential. One of these, in the Guam – Saipan corridor, represents high frequency of international traffic to Apra, including a substantial US military supply route Honolulu – Apra – Yokohama, and the busy secondary supply route from Apra to to Saipan and the Northern Marianas. The others, near Palau, Yap and Chuuk, relate to trans-Pacific through routes. The common routes from east coast Australia and New Zealand to Japan, Korea and northern China converge on a wide channel west of Chuuk. The extension to Japan travels up the eastern side of the Northern Marianas. Yap is similarly a waypoint on routes from eastern Australia to Manila, Hong Kong and Shanghai. Palau is an alternate waypoint on this route, and near the Central Pacific Route from Panama to Manila and Singapore. The remainder of the subregion shows relatively low grounding potential because of sparse traffic.

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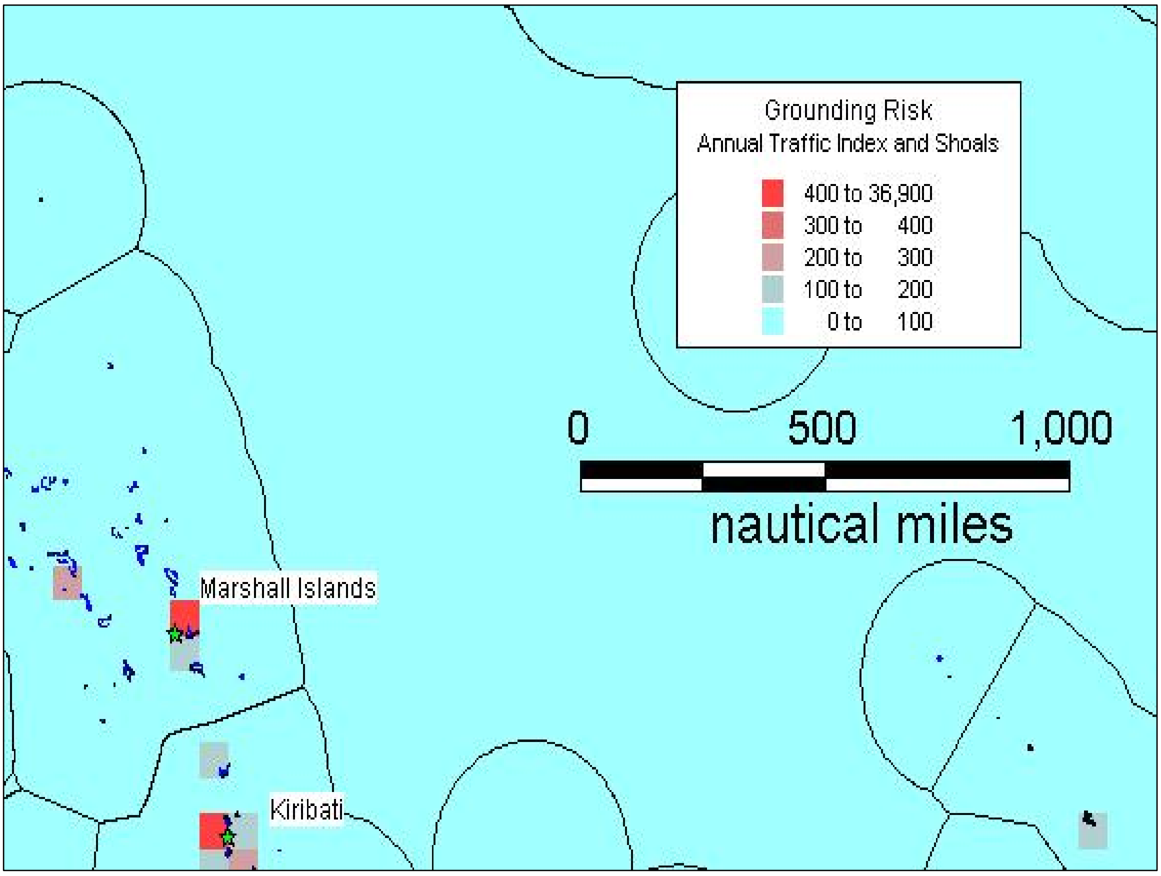

Figure 1.5. Grounding potential, north central subregion.

In the north central subregion, there are just two small regions of high grounding potential, near Majuro and Betio (Tarawa). Both of these ports are hubs for the reception and redistribution of international container traffic and petroleum products.

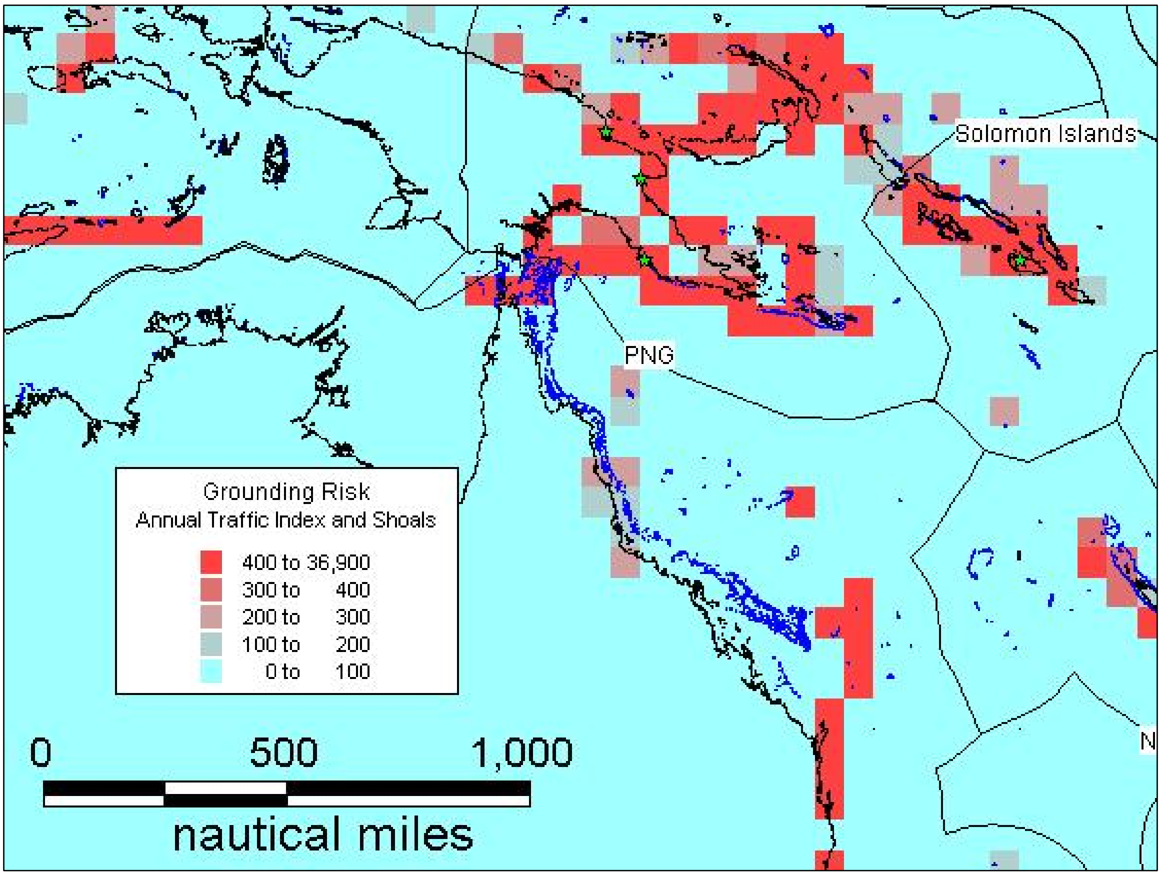

Figure 1.6. Grounding potential, southwest subregion

The south west subregion contains the largest and most intense clusters of high grounding potential in the Pacific Islands region. Papua New Guinea has by far the largest population of all the PACPOL nations, and the largest mining and petroleum industries with their attendant demands for transportation of supplies, personnel and products. PNG has four major ports, Port Moresby, Lae, Madang and Rabaul (although traffic at Rabaul was reduced by major damage from a volcanic eruption in 1994). The country has at least six other significant ports. PNG has an intense coastal traffic, with some unique elements such as tug – and - barge services to supply mining interests on the Fly and Sepic Rivers.

PNG also occupies a critical position on routes from Australia to northern Asian ports. Traffic from east coast Australia must pass first between the reefs and islands of Jomard Entrance, just east of the New Guinea mainland, or east of the easternmost of the D'Entrecasteaux islands that extend from the eastern cape of New Guinea. Once in the Solomon Sea, these vessels can choose either Bougainville Strait, between Bougainville (PNG) and Choiseuil (Solomon Islands), or Pioneer Channel between Bougainville and New Ireland. The political situation at Bougainville has discouraged the use of Bougainville Strait.

The only regular crude oil traffic in the Pacific Islands region is loaded at the Kumul offshore terminal, south PNG, and passes mostly westward through Torres Strait to West Australia and Singapore. Torres Strait is just outside the study area, but it is notable because of the high volume of traffic, coupled with significant navigational difficulties at the northern edge of the Great Barrier Reef World Heritage Area. A catastrophic oil spill in Torres Strait could also affect Papua New Guinea.

The Solomon Islands and New Caledonia also show high grounding potential. The international port at Honiara and fish processing at Noro, Solomon Islands are hubs for marine traffic. (Activity at Noro is temporarily suspended because of political instability.) New Caledonia, a department of France, enjoys a relatively advanced economic development and a vigorous nickel mining and smelting industry. Coastal traffic from Noumea northward is confined to a narrow band outside the fringing reef, corresponding to the band of high grounding potential. In the South of New Caledonia, inside the reef, there is a constricted east – west natural channel, the Canal de la Havannah. This channel provides the preferred route from Noumea eastward, and from east coast Australia to Fiji and eastward to North America. The Canal de la Havannah and the reef passages to Noumea are areas of special interest in risk assessment.

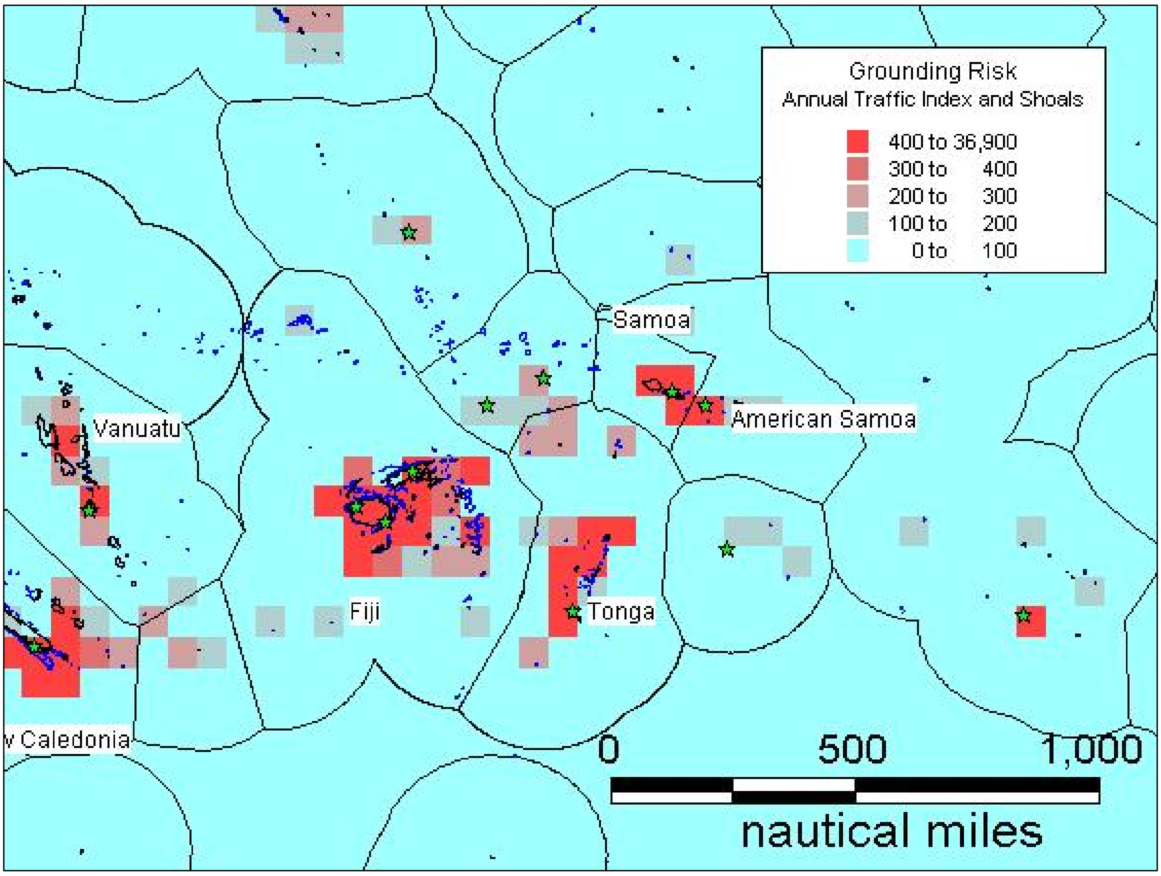

Figure 1.7. Grounding potential, south central subregion.

The south central region contains the second most significant concentration of high grounding potential. Fiji is notable because bulk terminals at Vuda Point and Suva are the major ports for reception, storage and transhipment of petroleum products for the southern Pacific Islands Region. The approaches to Vuda Point and Suva are wide and aids to navigation are adequate. These passages are relatively safe. The passages northward from Vuda Point are narrow, complex, and less well-marked. Vessels with local knowledge, including Local Coastal Tankers, regularly use these passages.

Suva is a major port. Many transpacific vessels call there. Fiji islands are also on preferred routes from Australia to Panama and North America. Even more vessels transit Fiji waters through the Koro Sea and Nanuku Passage along this major northeast/southwest sealane.

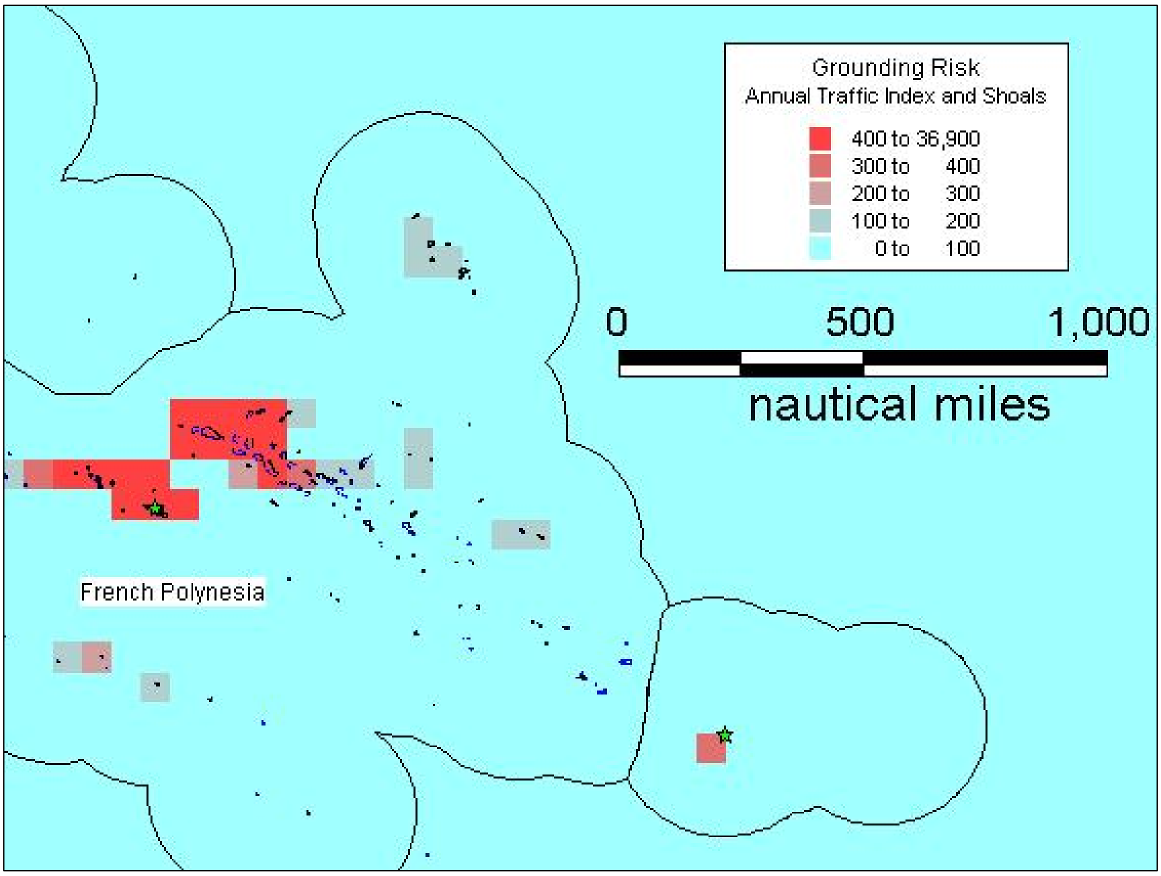

Figure 1.8. Grounding potential, southeast subregion.

The southeast subregion includes French Polynesia,Pitcairn and s few outlier islands of Kiribati. Papeete is a major international port, and the hub of an intense interisland web of small vessel transportation. It is also a significant centre for cruise liners. There is a cluster of high grounding potential around Papeete (Tahiti) and westward to the large islands of Raiatea and Bora Bora. The direct courses from Papeete eastward to Panama and North America would pass through the Tumotus Archipelago. These low-lying atolls were once called the Dangerous Archipelago. OPW 1973 recommends a course that begins northeastward, to pass northwest of the Tuamotus, and thence direct to the destination. (The Marquesas Archipelago, further northeast, are high islands that present less navigational hazard.) The shorter route to Panama goes passes between Tuamotu atolls. Local information and examination of VOS positions indicates that vessels take the shorter route in favourable weather, as shown in Figure 4.17.

Several outlier islands of Kiribati also lie in the southeast subregion. (Kiritimati, the administrative center and port for eastern Kiribati, lies in the north central subregion), This part of the Kiribati EEZ attracts little traffic. The direct routes from Auckland to Los Angeles and from Papeete to Honolulu pass through this portion of the Kiribati EEZ.

Pitcairn Islands form the western extension of the study area. Great circle routes from Panama to New Zealand pass near Pitcairn, and some of these vessels stop near Pitcairn long enough to trade or land cargo by longboat. There is a small patch of moderate grounding potential associated with Pitcairn.

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1.2.2.2 Collision Potential

We calculated collision potential in each grid cell as the product of traffic volume and the number of multiple routes intersecting the cell. The results are displayed for the entire study area in Figure 6.8, and for the subregions in Figures 6.9 through 6.14. By world standards, collisions are infrequent and collision potential is relatively low in the region because of generally low traffic density. Areas of relatively high collision potential are concentrated close to major ports, and in a few places where several ocean routes converge or intersect. Those nations which ranked highest for collision potential included: Guam, Papua New Guinea, Solomon Islands, New Caledonia, Fiji and French Polynesia.

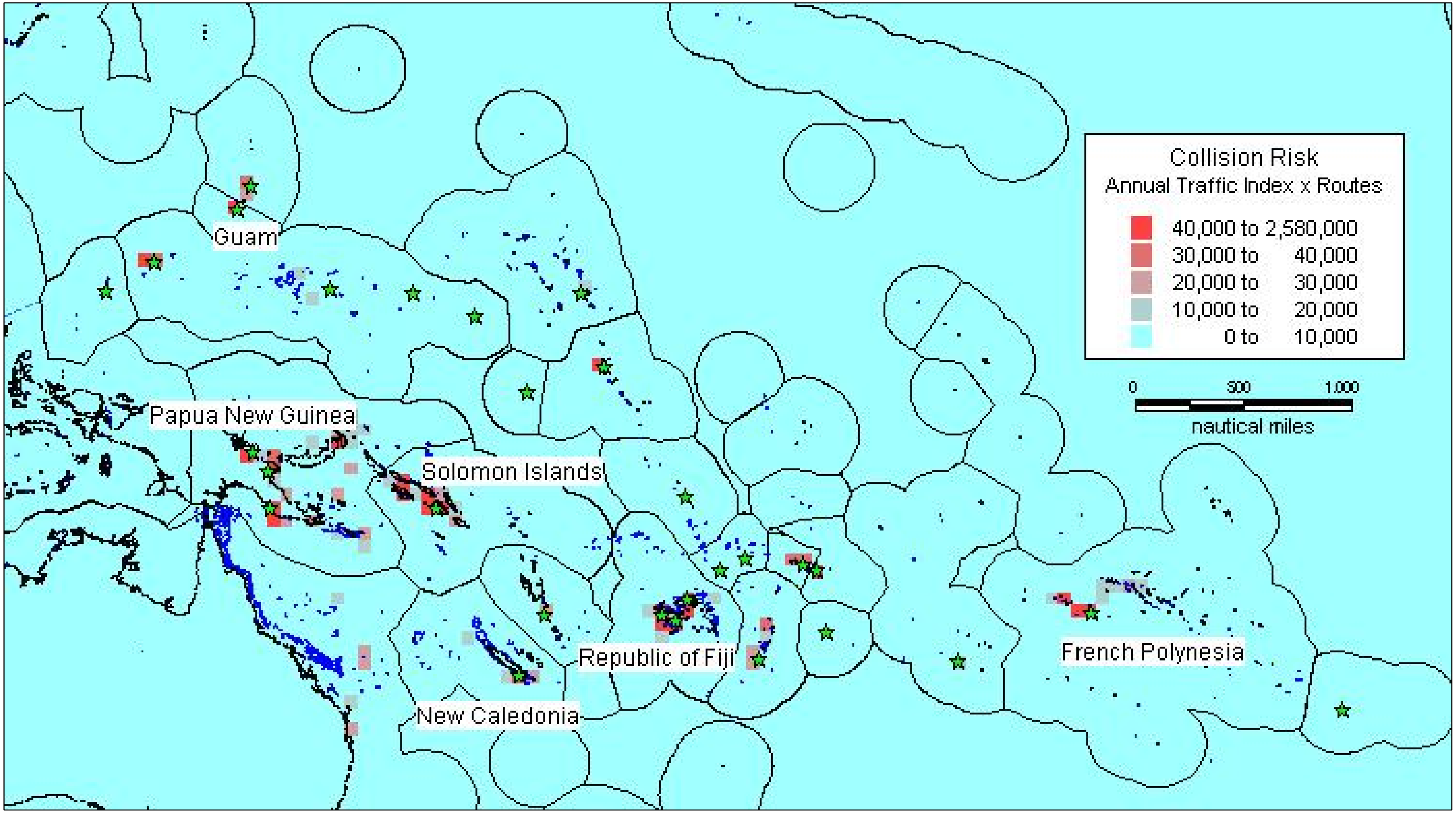

Figure 1.9. Collision potential for the Pacific Islands region.

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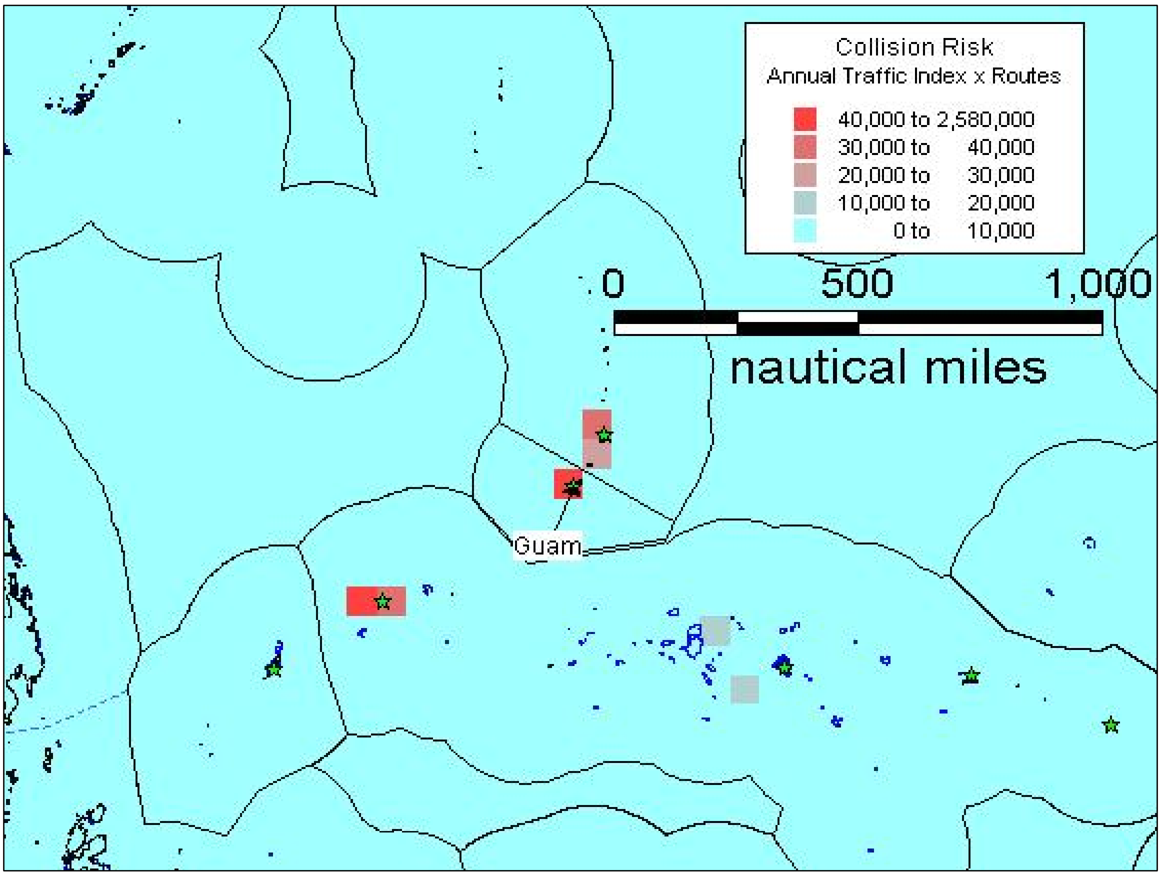

Figure 1.10. Collision potential, northwest subregion.

In the north west subregion, there are two concentrations of high collision potential: one near Apra and along the transportation corridor to Saipan, and the other where several ocean routes converge near Yap. There are moderate indications of risk near Chuuk, again in a region where ocean routes converge.

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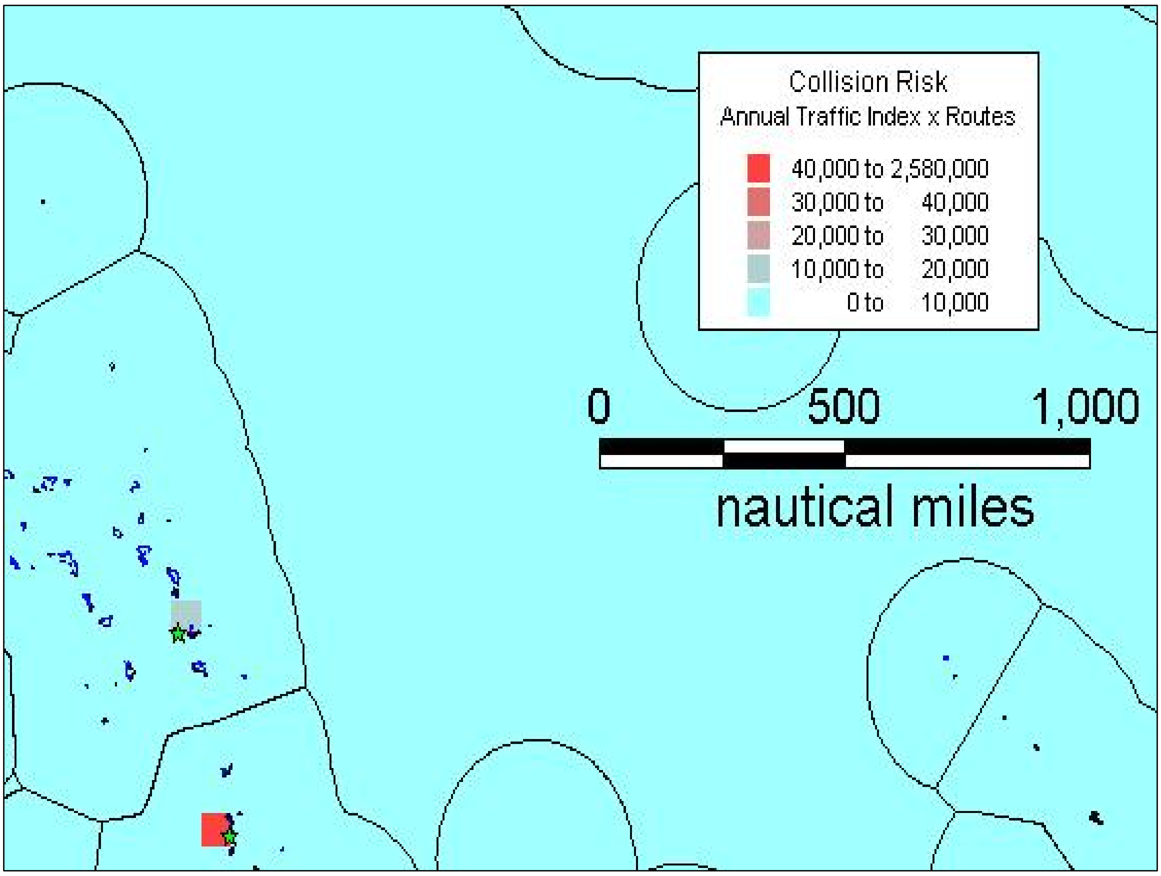

Figure 1.11. Collision potential, north central subregion.

The north central subregion presents significant collision potential potential only near the maritime traffic hub at Majuro.

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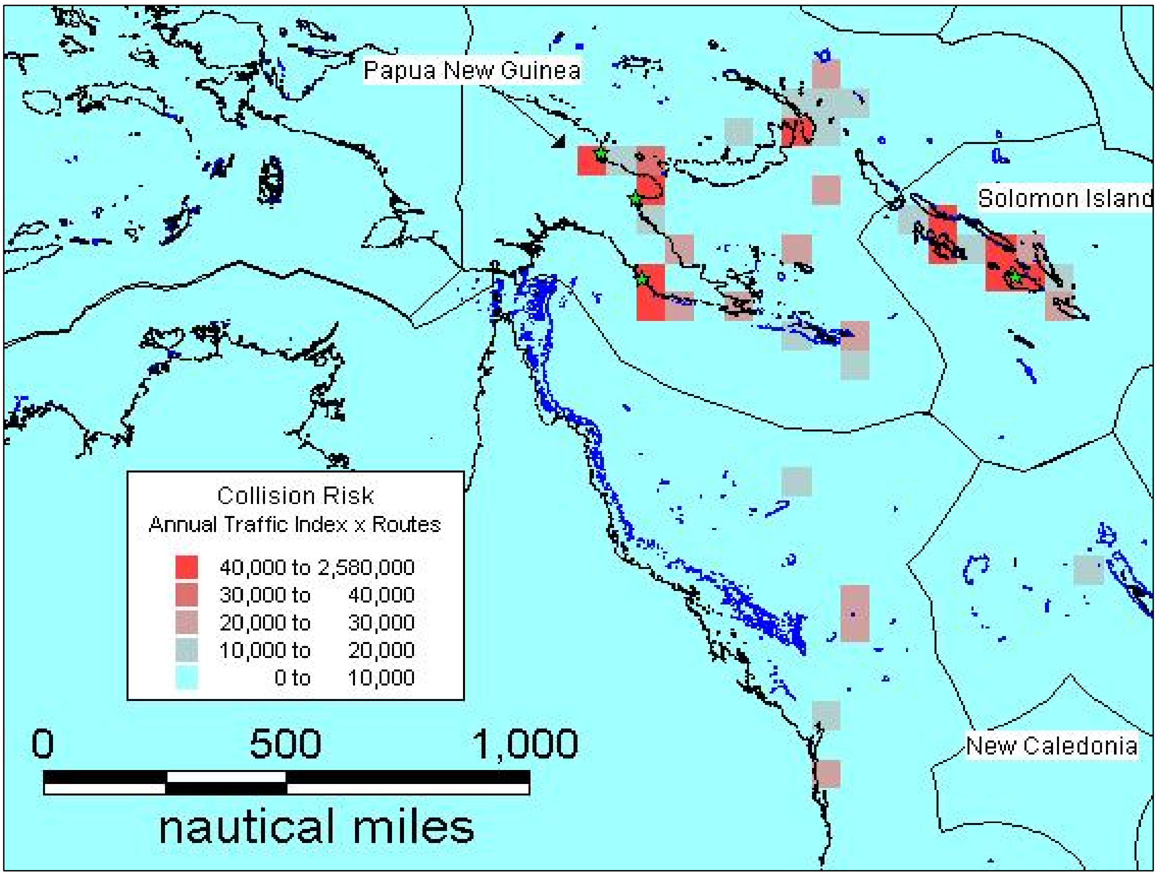

Figure 1.12. Collision potential, southwest subregion.

In the south west subregion, the highest concentration of collision potential is near Honiara and Guadalcanal. This region outranks PNG in collision potential because of the complex web of multiple routes to and from Honiara and other Solomon Islands ports. PNG has smaller clusters of high collision potential near the ports of Port Moresby, Madang and Lae, with another cluster near Rabaul in the constricted passage between New Britain and New Ireland.

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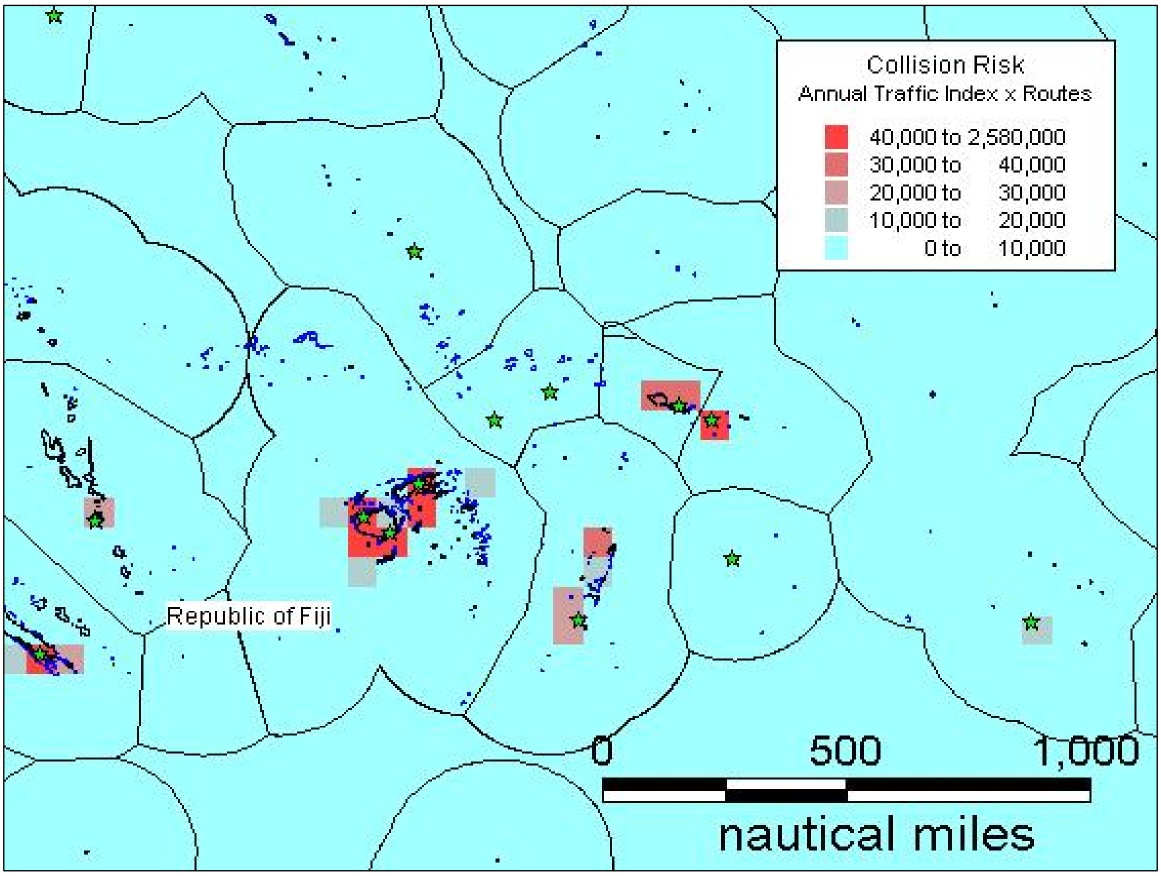

Figure 1.13. Collision potential, south central subregion.

The concentrations of high collision potential in the south central subregion lie near Noumea and the Canal de la Havannah in New Caledonia and in the approaches to Suva and Vuda Point / Lautoka in Fiji. Fiji also has relatively high potential in the convergence of transpacific routes trending northeast/southwest, from Kadavu Passage through the Koro Sea to Nanuku Passage. The ports of Pago Pago and Apia also show concentrations of collision potential in their approaches. Nuku'alofa and Port Vila show only moderate collision potential, probably because of lower traffic density. There is a small patch of moderate collision potential along the west side of the Vava'u Group in Tonga, related to the combination of local interisland traffic and international routes that converge to pass around the northwest side of the Vava'u Group.

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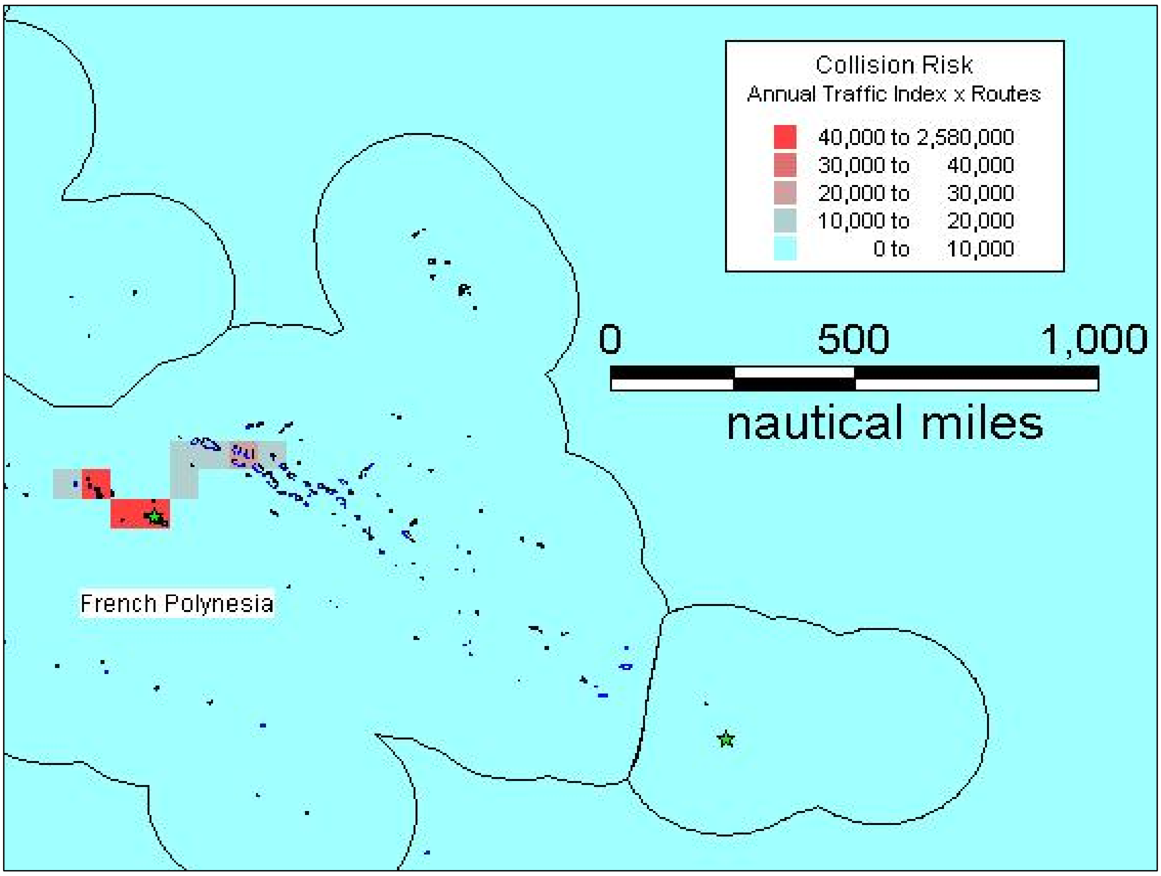

Figure 1.14. Collision potential, southeast subregion.

In the Southeast subregion, collision potential is high only near Papeete and the interisland corridors to Moorea, Bora Bora and Raiatea. There is a diffuse area of moderate risk representing traffic en route to or from North America. These vessels must divert around the Tuamotu Archipelago or choose one passage or another between the Tuamotus.

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1.2.2.3 Fishing vessel distribution

Because of the complex and irregular pattern of fishing vessel passages, port entry records do not capture fishing vessel traffic very well. For the same reason, they are at high potential of grounding incidents because they travel outside normal shipping routes, without the benefit of local knowledge. The best comprehensive information we have on fishing vessel distribution comes from the fishing effort records systematically collected by the Oceanic Fisheries Programme at the Secretariat of the Pacific Community, Noumea (SPC). Effort is recorded as fishing days for purse seine tuna vessels, and hooks set for longliners, within each five degree grid square. In both cases, the data is truncated east of 150°E. Figure 6.15 shows the fishing effort in hooks set by longline vessels during 1999. Figure 6.16 shows fishing days for purse seiners in 1999. Fishing patterns vary from season to season and from year to year.

Longliners, the most numerous of the tuna vessels, concentrated their fishing effort in two large regions in the study area: one in the northwest, corresponding approximately to the EEZ's of FSM and Palau; and one in the south central region, from the Samoas to Vanuatu and New Caledonia.

Purse seiners had a different distribution: a single broad band, near the equator, from about 5°N to 10°S, and from 140°E to 175°E. There is a gap in this distribution, along the northwest shores of the Solomon Islands and New Ireland.

Fishing vessels contribute a significant, widely-distributed elevation of environmental risk throughout the region. This factor is not included in the maps showing risk potential for commercial vessels in transit between ports.

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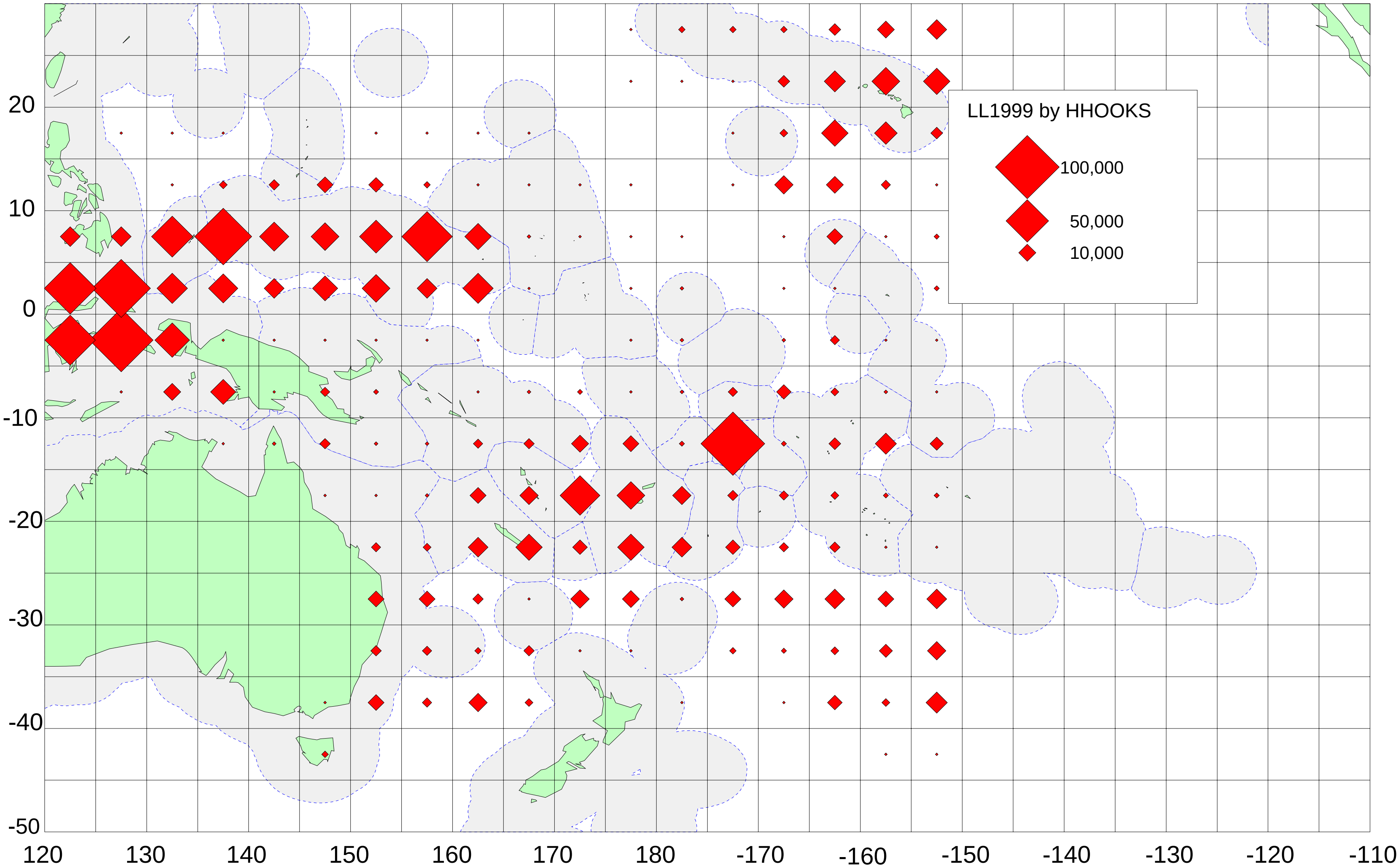

Figure 1.15. Fishing effort by longline tuna vessels,1999/

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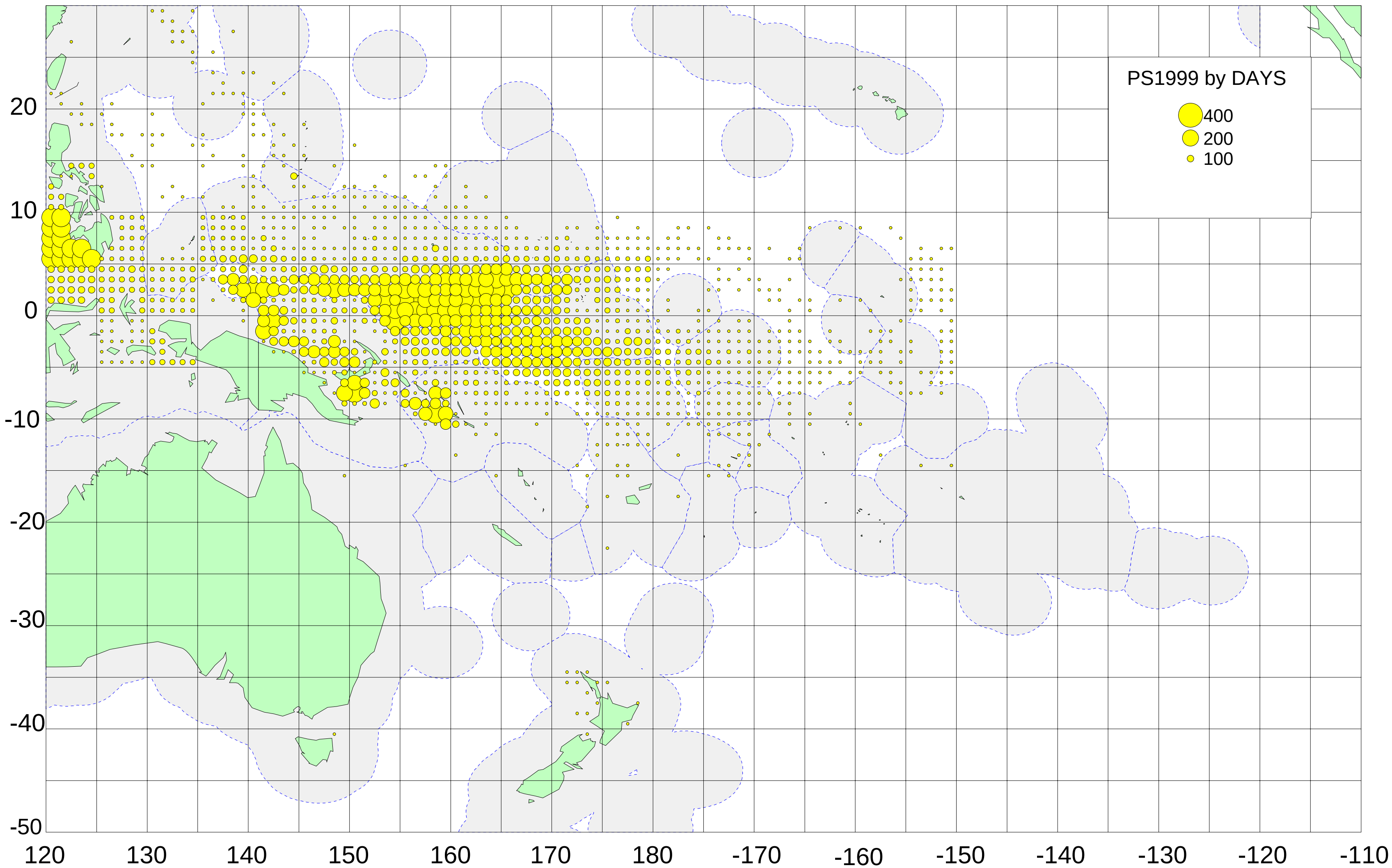

Figure 1.16. Fishing effort by purse seine tuna vessels,1999.

1.3 Risk Analysis at the Ports Scale

1.3.1 Minimum Safe Design Method

The goal of the port risk analysis is to identify and classify hazards to shipping in Pacific Island ports or approaches approaches. This information will support future risk estimation work in follow-on studies. Because the areas under consideration in the approaches to each port are relatively small, we are able to include more of the details of vessels and their operational requirements in the ports risk analysis, than was possible for the regional risk analysis

Marine navigation hazard identification presents several key problems:

- Difficulty in modeling the hazardous situation or risk factors such as wind, currents and passage width.

- Difficulty in keeping the analysis methodology transparent. Exposing the methodology to critical review is often in conflict with corporate goals to protect proprietary technology.

- Difficulty in accounting for risk control options, such as aids to navigation or GPS, that mitigate navigation hazard)

We considered the goals of the study and the available data on ports and vessels in the context of these key problems, and evaluated various commonly applied methods for risk analysis. The most appropriate port risk analysis method is the calculation of Security Measure as the ratio between available Channel Width (CW) and the minimum channel width required for safe passage. Because the method was developed to aid in the evaluation and design of improvements to restricted waterways, the minimum channel width is named Minimum Safe Design (MSD) (See general discussion at the head of Section 6). The MSD method is similar to methods applied in Europe and North America for risk analysis in restricted waterways.

The concept of calculating MSD is similar to that of determining a safe place to anchor. A vessel swings about an anchor depending upon the wind and current. Therefore, the vessel must be able to swing in a complete circle at a defined distance about its anchor position without grounding. The distance from the extremity of the 'swinging circle' to the nearest shoal is its safety margin and the position of the vessel is estimated and plotted at intervals to ensure that the vessel is not drifting.

Similarly, a vessel underway will require horizontal room to maneuver to account for variations in the course-keeping ability of the vessel and the helmsman, to account for the geometry of executing a turn (advance and transfer through the water), to counteract drift caused by wind and current, and to allow for the physical dimensions of the vessel. Vertical clearance (water depth) is required to accommodate vessel draft plus an additional allowance for "squat", which is the additional draft caused by vessel speed (PIANC 1997). Added to this measurement of physical dimensions and maneuvering room is the uncertainty of position depending upon the quality of aids to navigation in the waterway, navigation aids on the bridge and the experience of the pilot or master. The MSD application measures the residual navigation hazard, which accounts for both the natural hazards in a waterway and the reduction in hazard, provided by risk control measures such as aids to navigation.

The application that we used to calculate MSD is transparent, user friendly and available on request. The application Minimum Safe Design (MSD) was developed for the Canadian Coast Guard to assist with risk management in approach waterways or pilotage waters. It is a Microsoft Excel ™ workbook designed to record and evaluate a plausible worst case scenario for navigation in the approaches to a port or on a constrained track within a port. The required inputs can be extracted from harbour charts, tide tables, sailing directions, and published characteristics of typical large vessels that use each port.

The MSD calculation incorporates risk factors such as physical constraints, environment, manoeuvrability and positioning quality. It can be used to compare the relative potential for maritime incidents in different ports, or in the same port under different circumstances.

In this study, MSD and Security Measure were calculated for the most constrained and exposed navigation track either within a port or in its approaches. This most hazardous track is used as the measure of the navigation hazard presented by the port for comparison purposes.

It is not possible nor helpful to present the details of the calculations in the MSD method here, but to maintain transparency and invoke discussion, the reader is referred to the digital files of the Microsoft Excel workbooks to examine the values input for each scenario and the calculated results. These workbooks document the scenarios and define the measurement of each factor in popup ‘info windows’ called ‘comments’ in Excel 97 and 2000. The high level measurements are presented in Section 6.2 for each port.

$$SecurityMeasure = \frac{ChannelWidth}{MSD}$$

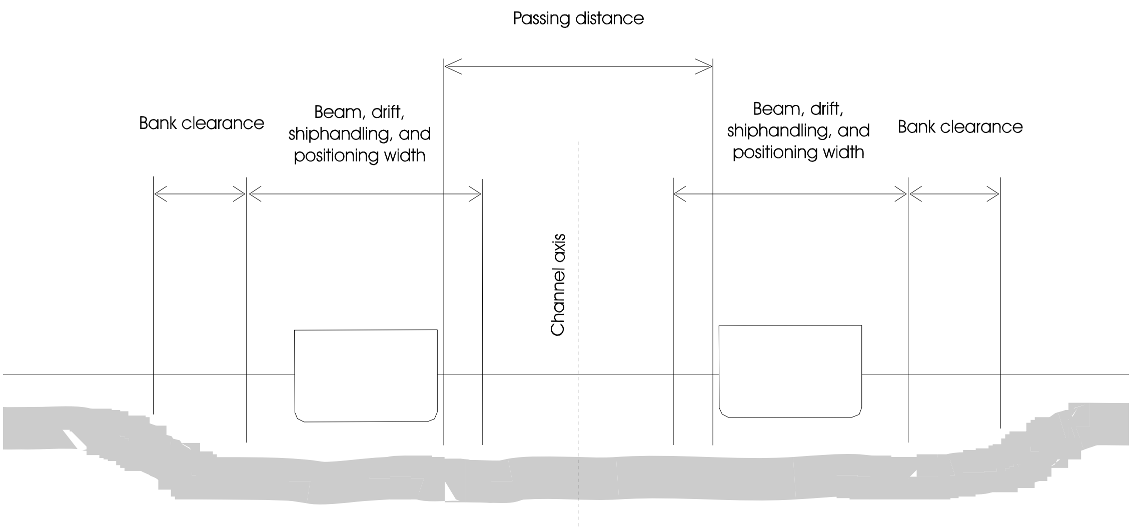

Figure 1.17. Input values for calculating Security Measure.

1.3.2 Regional distribution of port risks

In this section we compare the navigation safety margins among ports. Table 6.2 summarises the port-by-port analyses. The ports are sorted by the security measure calculated for each approach waterway.

For each port, we used an appropriate large vessel plus commonly occurring challenging winds and currents to assess the minimum safe design width required for a single vessel to transit the waterway, given the navigation aids configuration shown in charts and sailing directions.

Only Port Vila, Republic of Vanuatu, and Avatiu, Rarotonga, Cook Islands showed a Channel Width to Minimum Safe Distance (CW/MSD) ratio of less than one. This means that the existing channel width at these ports is less than that required for the conditions and vessel size. The reference vessel chosen for the calculating MSD at Avatiu was a small coastal freighter of only 100 DWT. In fact, vessels of up to 3000 DWT, including MR tankers and container liners routinely enter Avatiu in favourable conditions.

Both Malakal Harbour, Koror, Republic of Palau and Papeete, French Polynesia showed a channel width and aids configuration that was equal to the width required by the large vessels transiting into those ports.

The approach to Bounty Bay anchorage, Pitcairn Islands was an unusual application for the MSD tool. The distance to the nearest shoals was used as a substitute for the channel width, as was done for Nauru. This resulted in a large security measure.

Figure 6.47 displays security measure alongside the total annual petroleum tonnage for each port. Security measure and traffic volume jointly measure the potential for casualties.

Ports with large volumes of petroleum or oil products and lower security measures present greater potential for large spills. These ports include: Papeete, French Polynesia, Madang Harbour, Papua New Guinea, Honiara, Solomon Islands, and Apia Harbour, Samoa.

While the MSD tool estimates navigation quality with the assumption that a pilot is conning the vessel, it does not consider consequence mitigation measures that might be present to reduce the overall risk. These measures might include spill response equipment and tugs. Ports with lower security measures and lower traffic may still be at greater risk if they are not equipped with an effective response capability or if potential consequences are greater.

Table 1.2. Summary of port-by-port oil tanker casualty potential.

COUNTRY	PORT	HIGH RISK WATERW	MINIMUM SAFE DESIG	CHANNEL WIDTH	CW / MSD	CONTAINER FREQ	CONTAINE GT	PETROLEUM FREQ	PETROLEUM DWT	TOTAL FREQ	TOTAL GT
Vanuatu	Port Vila, Mele Bay	Entrance to Paray Bay to fuel jetty	194ft	110ft	0.6	56	613384	54	47675	133	**1523450**
Cook Islands	Avatiu (Rarotonga)	Entrance to Avatiu	165ft	110ft	0.7	20	29280	19	50380	78	**83736**
Palau	Malakal Harbour, Koror	Malakal Pass	266ft	280ft	1	70	1010464	9	63792	79	**1050145**
French Polynesia	Papeete	Passe de Papeete	334ft	340ft	1	429	6961403	21	876000	6284	**14490620**
Northern Marianas	Saipan	Reef transit, entrance to Saipan	356ft	400ft	1.1	241	2453388	-	-	435	**5150383**
Kiribati	Betio, Tarawa Atoll	Betio Entrance	458ft	600ft	1.3	54	622944	14	39730	161	**697943**
Federated States of Micronesia	Pohnpei	Jokaj Passage	223ft	300ft	1.3	36	325728	18	127584	54	**405090**
Papua New Guinea	Madang Harbour	Dallman Passage-Turn to jetty approach	579ft	800ft	1.3	263	2096648	39	569715	690	**2670479**
Solomon Islands	Honiara	Approach to tanker moorings	313ft	450ft	1.4	191	2161561	19	698000	425	**3455250**
Samoa	Apia Harbour	Reef passage to mooring buoys	420ft	700ft	1.7	275	2822025	33	1293600	482	**4262194**
Papua New Guinea	Port Moresby	Basilisk Passage-Lark Patch Turn	709ft	1300ft	1.8	342	2703740	39	248475	762	**3236947**
Tonga	Nuku'alofa	Ava Lahi Pass-turn to 215°	1077ft	1980ft	1.8	223	1854552	28	58425	348	**2430058**
Wallis and Futuna	Ile Futuna	Ava Leava Anchorage	310ft	600ft	1.9	18	33891	0	0	18	**33891**
Marshall Island	Majuro	Calalin Channel	399ft	800ft	2	78	769077	18	127584	108	**944795**
Federated States of Micronesia	Tamil Harbour, Yap	Entrance to Tamil Harbour	197ft	400ft	2	18	162864	9	63792	27	**202545**

.

Federated States of Micronesia	Lele Harbour, Kosrae	Lele Approach	283ft	600ft	2.1	18	162864	12	19200	30	**175620**
Wallis and Futuna	Mata Utu Harbour, Ile Uvea,	Passe Honikulu	244ft	500ft	2.1	29	65276	14	40580	51	**127128**
Guam	Apra Harbour	Outer Harbour entrance	389ft	900ft	2.3	253	3053578	69	1808376	510	**8162854**
Nauru	Phosphate Moorings	Approach to cantilever & moorings	421ft	1000ft	2.4	12	195600	12	19200	24	**208356**
Niue	Alofi Bay	Alofi Bay Anchorage	185ft	500ft	2.7	0	0	6	14400	8	**56744**
Papua New Guinea	Lae	Lae Approaches	353ft	1000ft	2.8	596	4191808	61	1438869	1162	**5553772**
Federated States of Micronesia	Moen Harbour, Chuuk	Northeast Passage	306ft	900ft	2.9	42	428856	18	127584	60	**508218**
American Samoa	Pago Pago Harbor,	Harbour entrance	283ft	900ft	3.2	264	2678234	23	1089232	380	**3384681**
Republic of Fiji	Vuda Point/ Lautoka	Navula Passage	1133ft	4100ft	3.6	85	668217	6	204000	128	**1457667**
Republic of Fiji	Suva	Levu Pass	332ft	1300ft	3.9	439	5604607	37	657600	892	**7056251**
New Caledonia	Noumea	Passe de Dumbea	543ft	2200ft	4	352	3828463	65	906550	542	**7515329**
Republic of Fiji	Malau (Labasa)	Mali Pass	686ft	2900ft	4.2	0	0	19	48249	45	**294756**
Tuvalu	Funafuti	Te Ava Te Lape Pass	356ft	1600ft	4.5	20	97512	10	17250	42	**124494**
Pitcairn Islands	Bounty Bay	Approach to anchorage	277ft	2100ft	7.6	0	0	0	0	3	**96124**
Papua New Guinea	**Rabaul**	**(No chart available)**	**-**	**-**	**0**	**197**	**1610258**	**43**	**467600**	**692**	**2746515**

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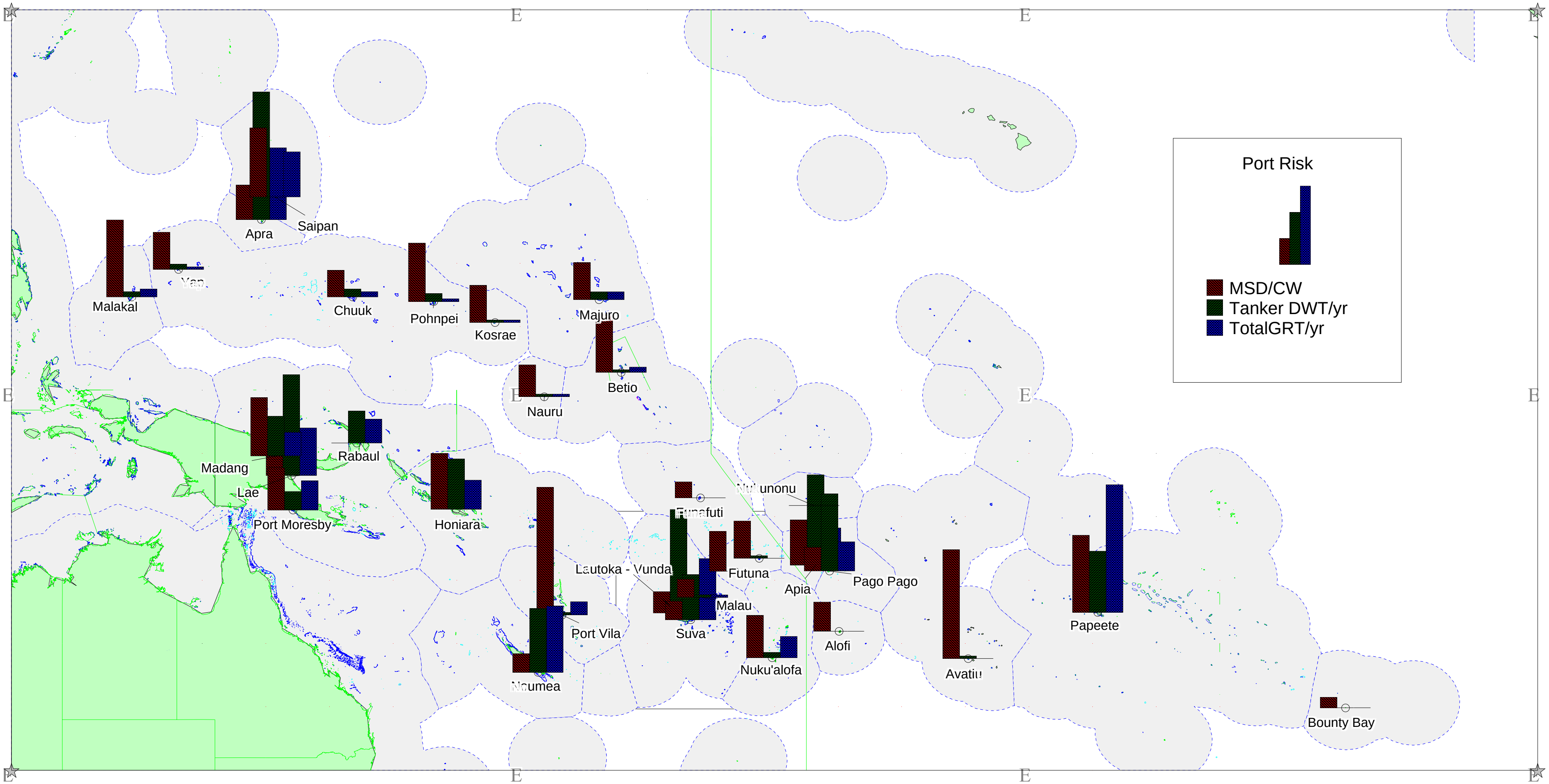


Figure 1.18. Regional distribution of port risk

1.1.1 Port Risk Results A: Saipan, Apra, Majuro, Moen Harbour, Lele Harbour.

1.1.1.1 Saipan, CNM

COUNTRY	Commonwealth of the Northern Marianas
PORT	Saipan
HIGH RISK	Reef transit, entrance to Saipan

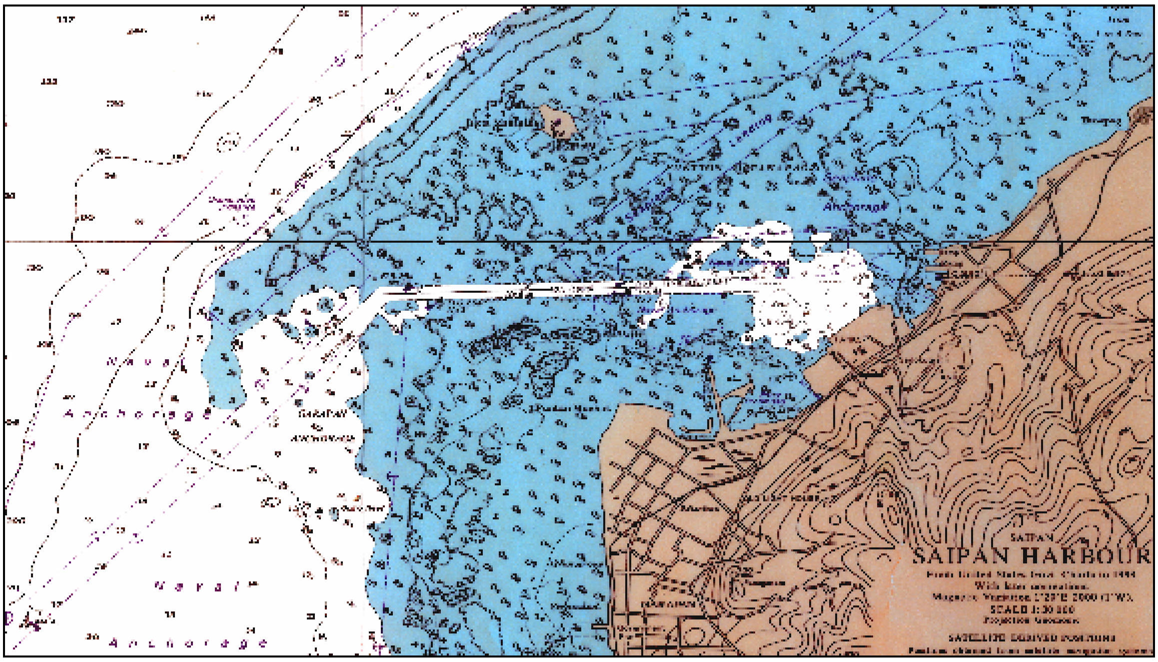
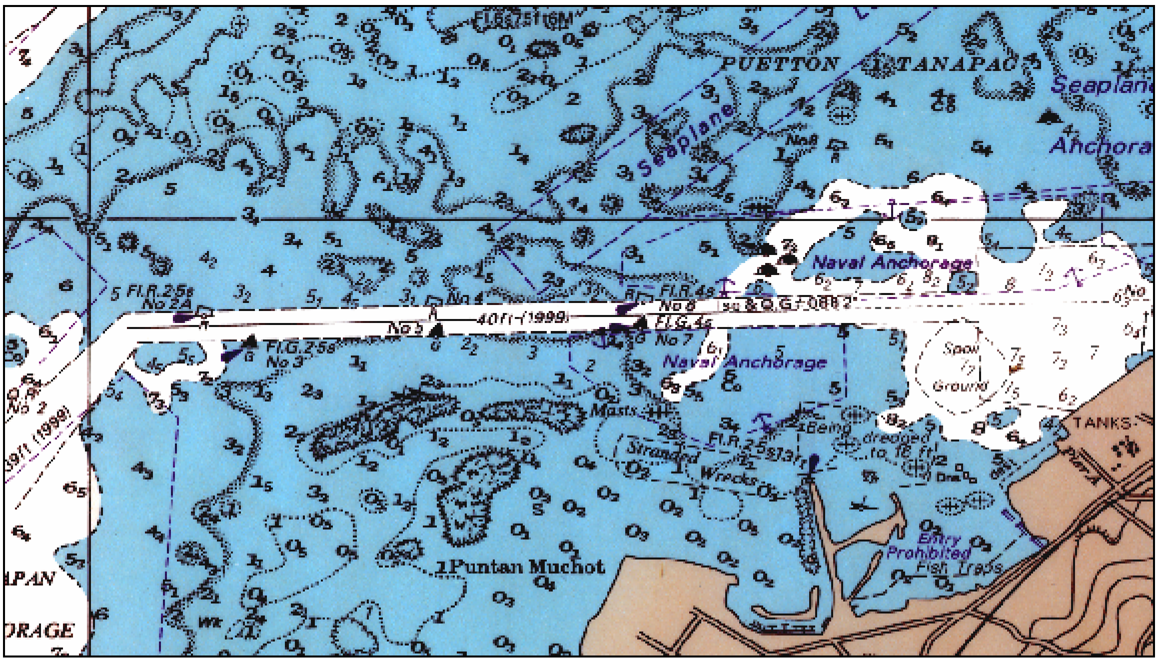


Figure 1. Saipan Harbour



High risk waterway: Reef passage

COUNTRY	Commonwealth of the Northern Marianas
PORT	Saipan
HIGH RISK WATERWAY	Reef transit, entrance to Saipan

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
164ft	142ft	50ft	356ft	400ft	1.1

Environment for simulation

Height of tide	0.5m	Wind direction	135°
Current direction	312°	Wind speed	25kts
Current speed	2kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Conus* of 31950 DWT was the reference vessel for the MSD analysis. A range, a fixed aid, seven buoys and multiple natural radar targets, supports positioning in the entrance to Saipan. With good visibility, the approach provides a security measure of 1.1.

1.1.1.2 Apra, Guam

COUNTRY	Guam
PORT	Apra Harbour
HIGH RISK WATERWAY	Outer Harbour entrance

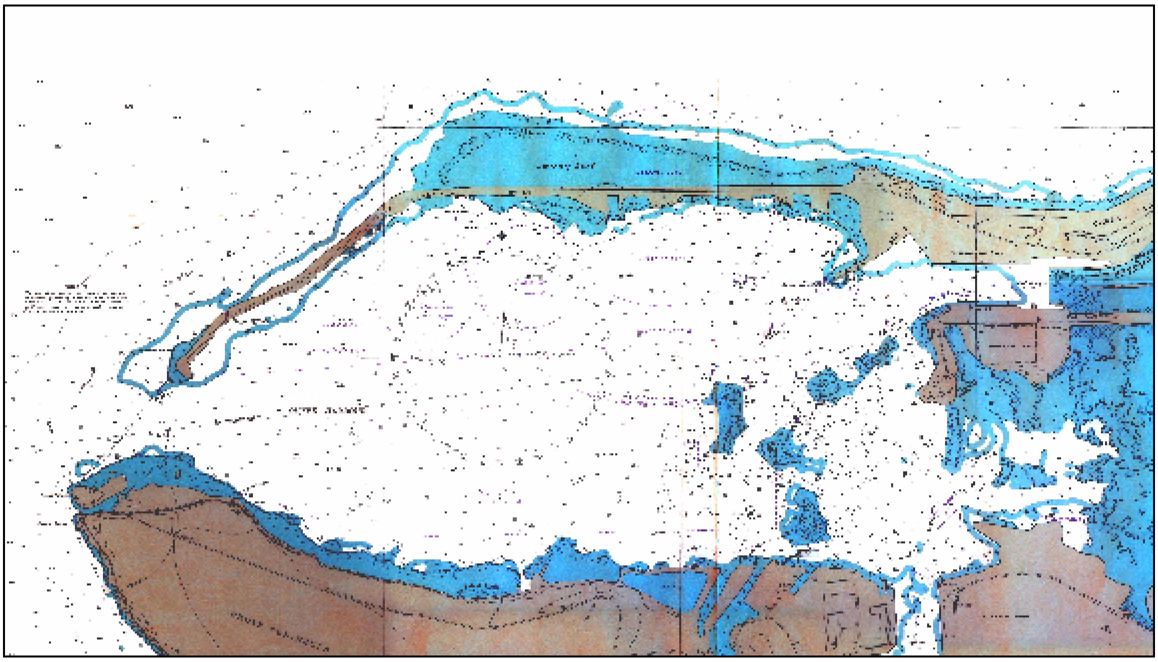
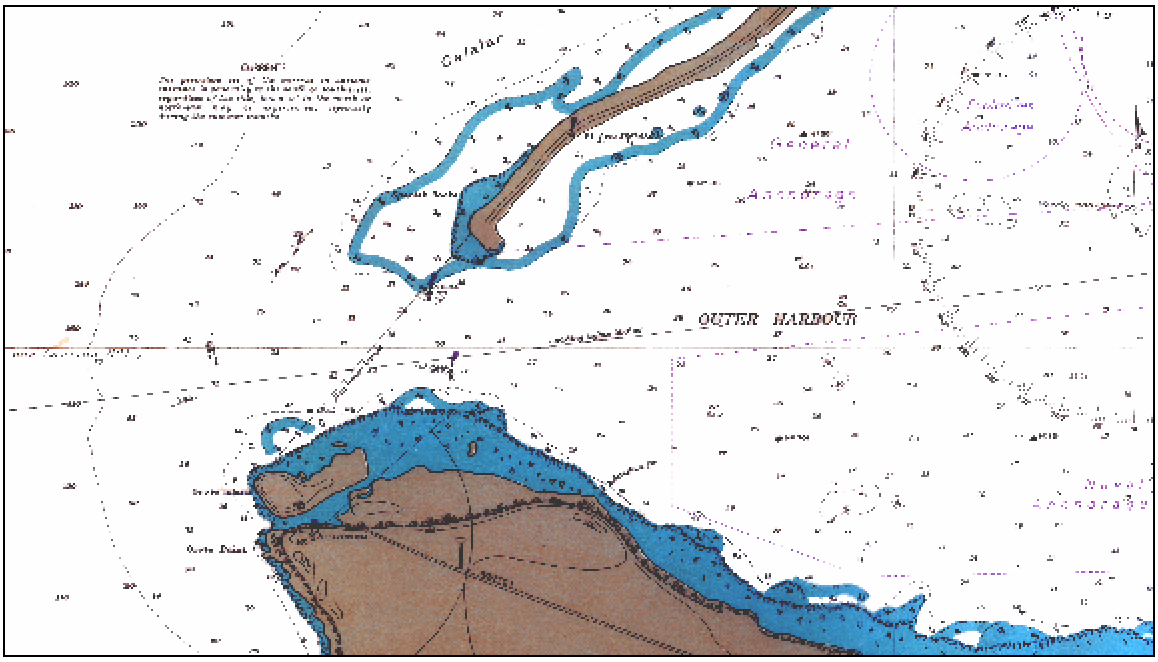


Figure 2. Apra Harbour



High risk waterway: Outer Harbour Entrance

COUNTRY	Guam
PORT	Apra Harbour
HIGH RISK WATERWAY	Outer Harbour entrance

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
160ft	179ft	50ft	389ft	900ft	2.3

Environment for simulation

Height of tide	1m	Wind direction	135°
Current direction	215°	Wind speed	25kts
Current speed	1.25kt	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *High Spirit* of 46475 DWT was the reference vessel for the MSD analysis. A range, two buoys and multiple natural radar targets, supports positioning in the entrance. With good visibility, the approach provides a security measure of 2.3.

1.1.1.3 Majuro, Marshall Islands

COUNTRY	Republic of Marshall Island
PORT	Majuro
HIGH RISK	Calalin Channel

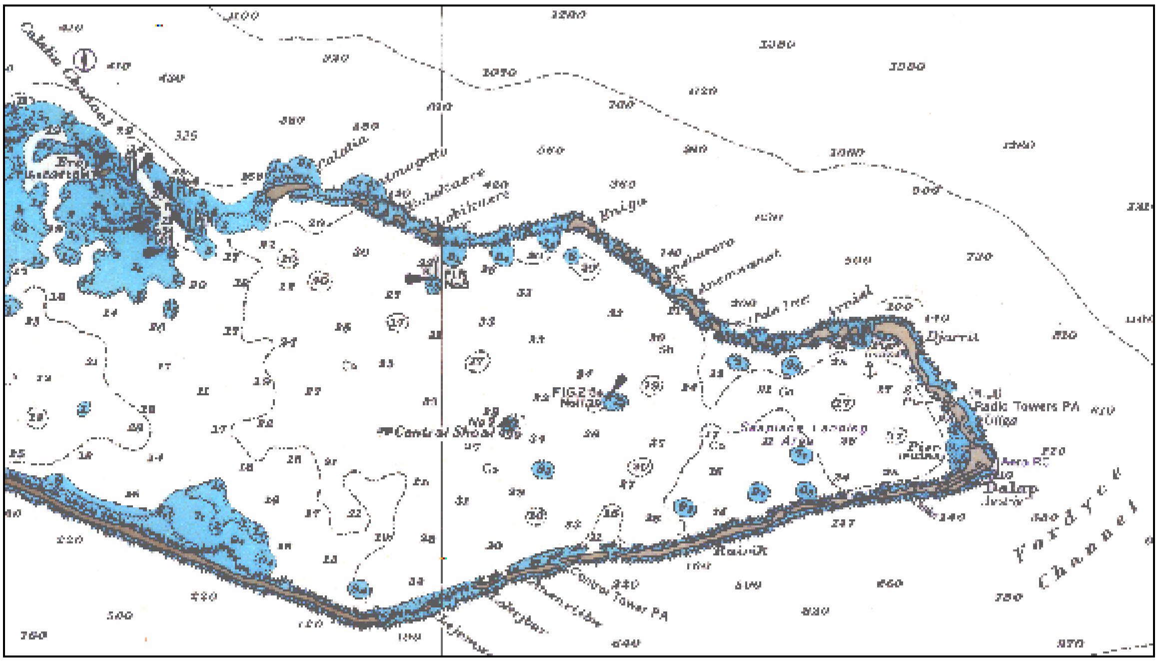
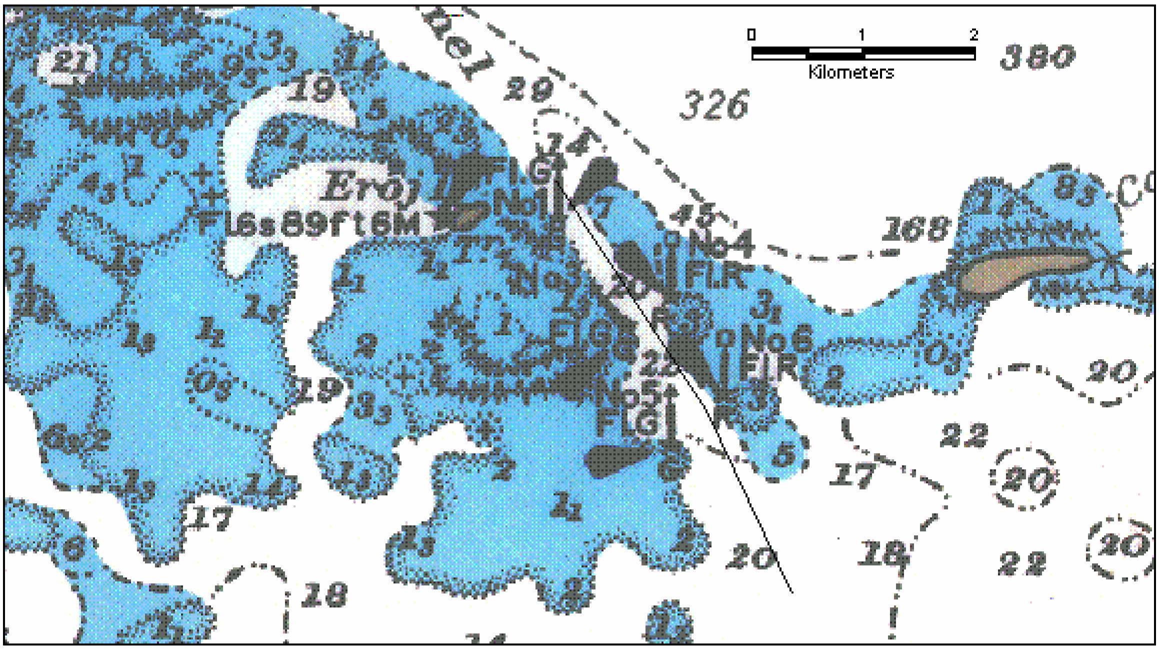


Figure 3. Majuro Atoll.



High risk waterway: Calalin Channel

COUNTRY	Republic of the Marshall Islands
PORT	Majuro
HIGH RISK WATERWAY	Calalin Channel

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
136ft	163ft	100ft	399ft	800ft	2.0

Environment for simulation

Height of tide	1m	Wind direction	147°
Current direction	180°	Wind speed	15kts
Current speed	1kt	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *High Spirit* of 46475 DWT was the reference vessel for the MSD analysis. While Calalin channel does not have a leadmark, it is well marked by buoys and a fixed aid, which provides a security measure of 2.

1.1.1.4 Moen Harbour, Chuuk, CNM

COUNTRY	Federated States of Micronesia
PORT	Moen Harbour, Truk Islands
HIGH RISK WATERWAY	Northeast Passage

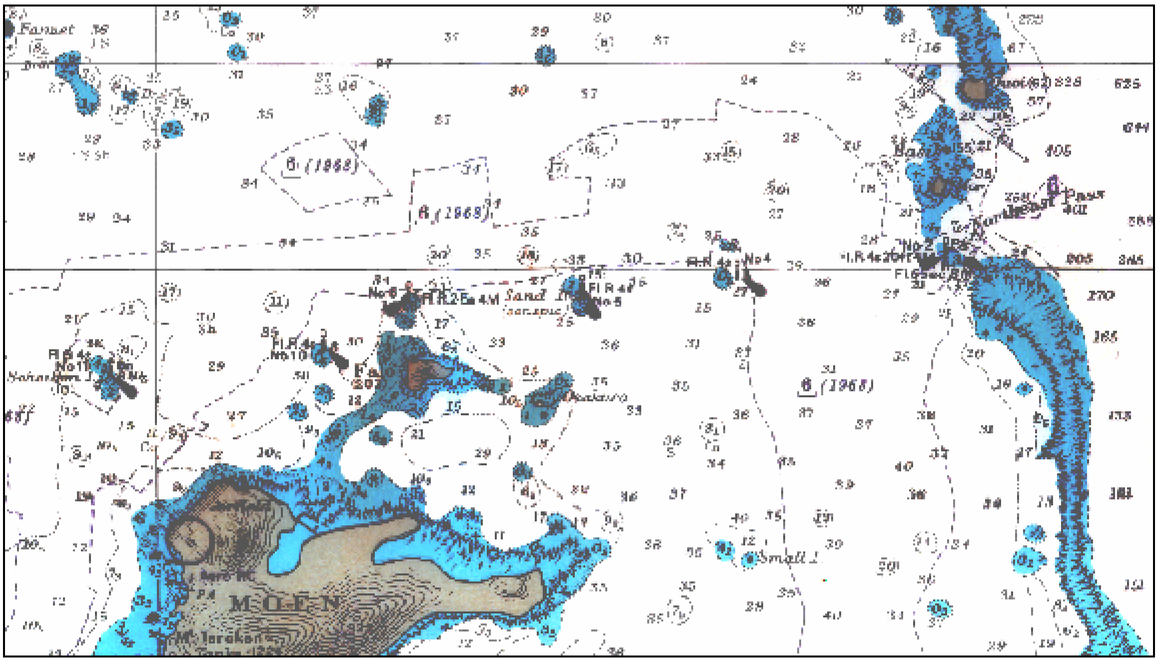
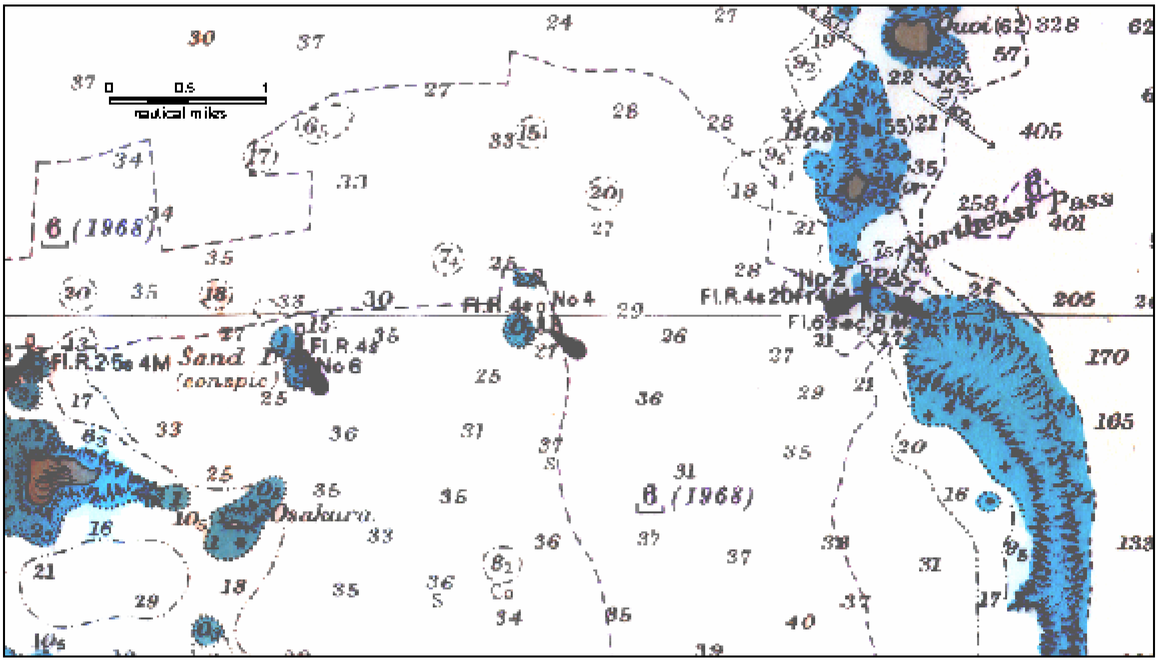


Figure 4. Moen Harbour, Chuuk



High risk waterway: Northeast Pass

COUNTRY	Federated States of Micronesia
PORT	Moen Harbour, Truk Islands
HIGH RISK	Northeast Passage

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
80ft	76ft	150ft	306ft	900ft	2.9

Environment for simulation

Height of tide	0.5m	Wind direction	135°
Current direction	330°	Wind speed	25kts
Current speed	1kt	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Petro Discoverer* of 3283 DWT was the reference vessel for the MSD analysis. Fixed aids and natural leadmarks support positioning in Northeast Pass. Buoys mark dangers enroute to Moen Harbour. The channel provides a security measure of 2.9.

1.1.1.5 Lele Harbour, Kosrae, CNM

COUNTRY	Federated States of Micronesia
PORT	Lele Harbour, Kosrae Island
HIGH RISK WATERWAY	Lele Approach

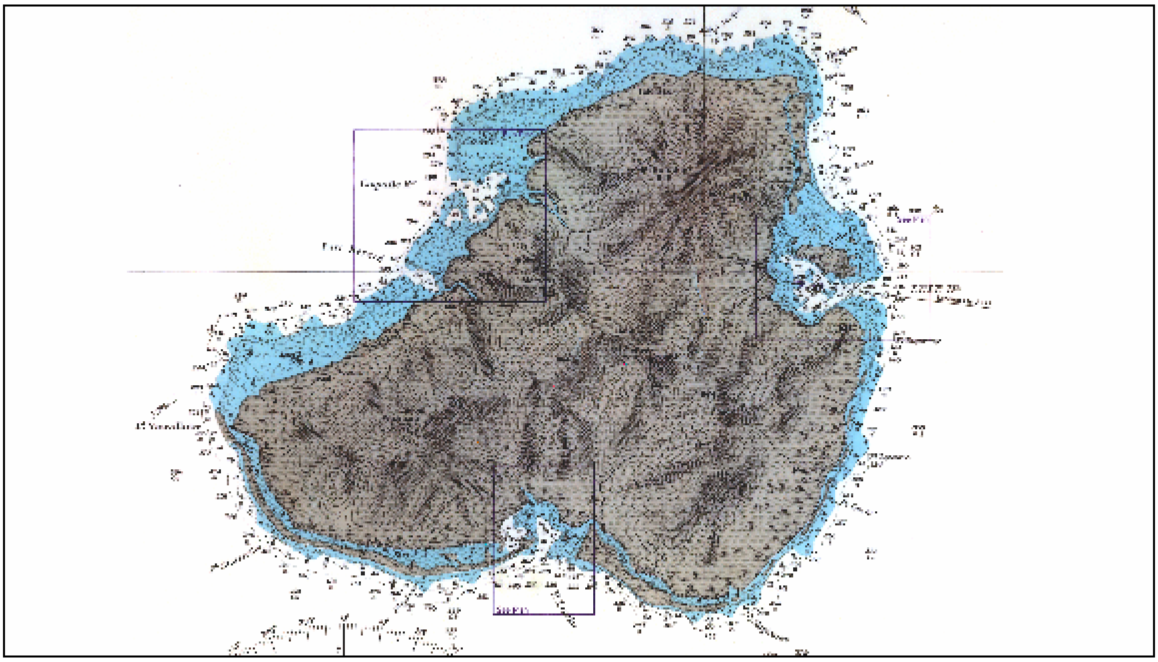
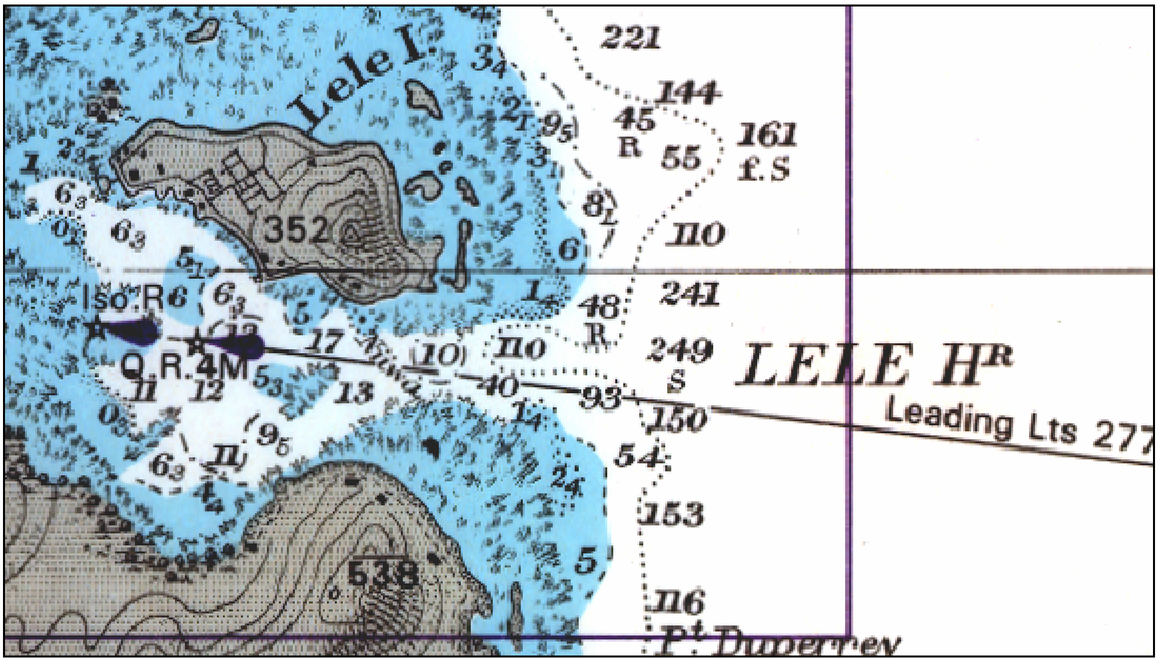


Figure 5. Lele Harbour, Kosrae Island



High risk waterway: Lele Harbour Approach

COUNTRY	Federated States of Micronesia
PORT	Lele Harbour, Kosrae Island
HIGH RISK WATERWAY	Lele Approach

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
108ft	75ft	100ft	283ft	600ft	2.1

Environment for simulation

Height of tide	0.5m	Wind direction	045°
Current direction	225°	Wind speed	30kts
Current speed	3kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Petro Discoverer* of 3283 DWT was the reference vessel for the MSD analysis. Positioning in the approach channel is supported by a range and good natural radar targets. The channel provides a security measure of 2.1

1.1.1 Port Risk Results B: Tamil Harbour, Pohnpei, Malakal Harbour, Betio

1.1.1.1 Tamil Harbour, Yap, CNM

COUNTRY	Federated States of Micronesia
PORT	Tamil Harbour, Yap Island
HIGH RISK WATERWAY	Entrance to Tamil Harbour

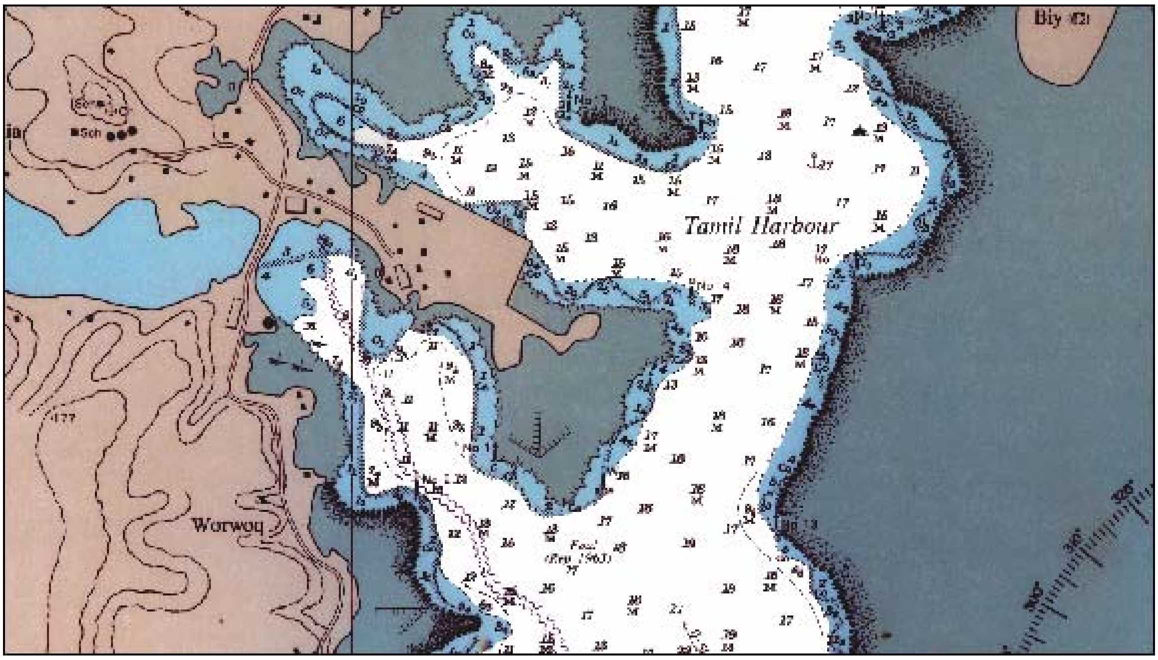
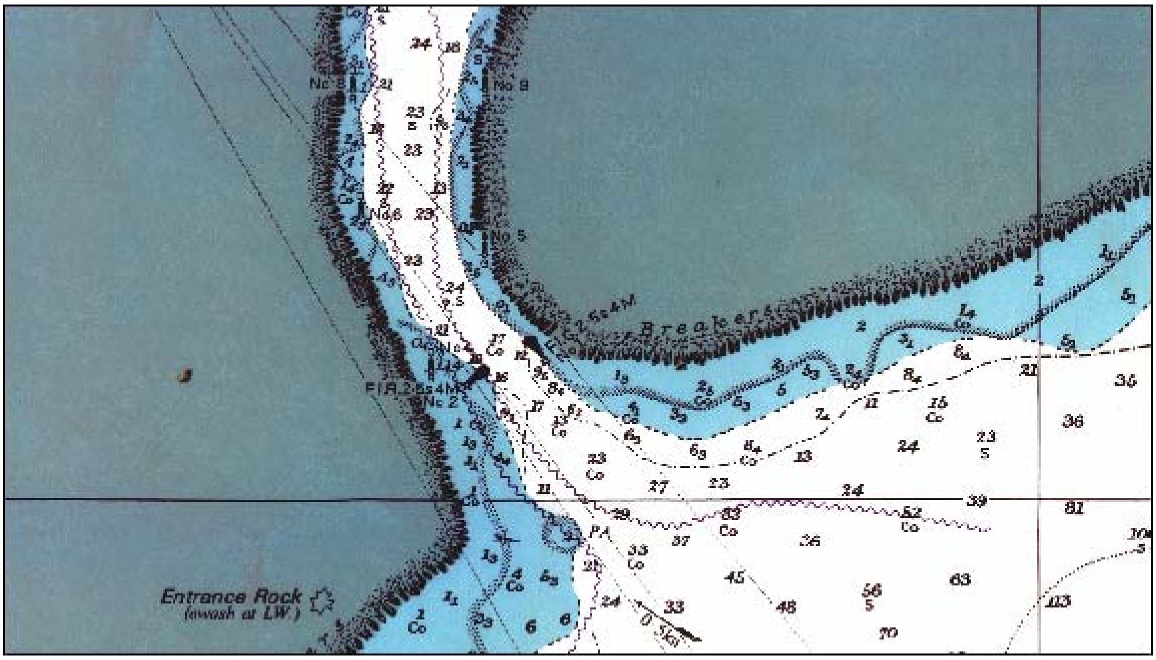


Figure 6. Tamil Harbour, Yap



High risk waterway: Entrance to Tamil Harbour.

COUNTRY	Federated States of Micronesia
PORT	Tamil Harbour, Yap Island
HIGH RISK WATERWAY	Entrance to Tamil Harbour

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
72ft	75ft	50ft	197ft	400ft	2.0

Environment for simulation

Height of tide	0.5m	Wind direction	090°
Current direction	270°	Wind speed	25kts
Current speed	1kt	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Petro Discoverer* of 3283 DWT was the reference vessel for the MSD analysis. A range, fixed aids and buoys supports positioning in the entrance channel. The channel provides a security measure of 2.

1.1.1.2 Pohnpei Harbour, Pohnpei, CNM

COUNTRY	Federated States of Micronesia
PORT	Pohnpei
HIGH RISK WATERWAY	Jokal Passage

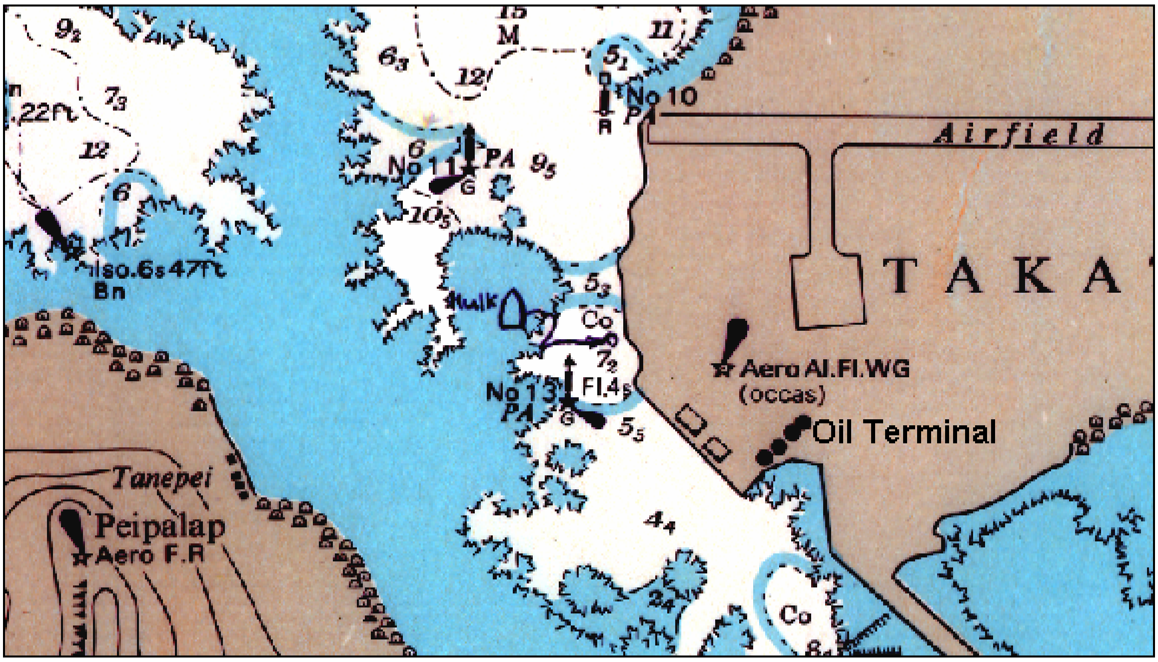
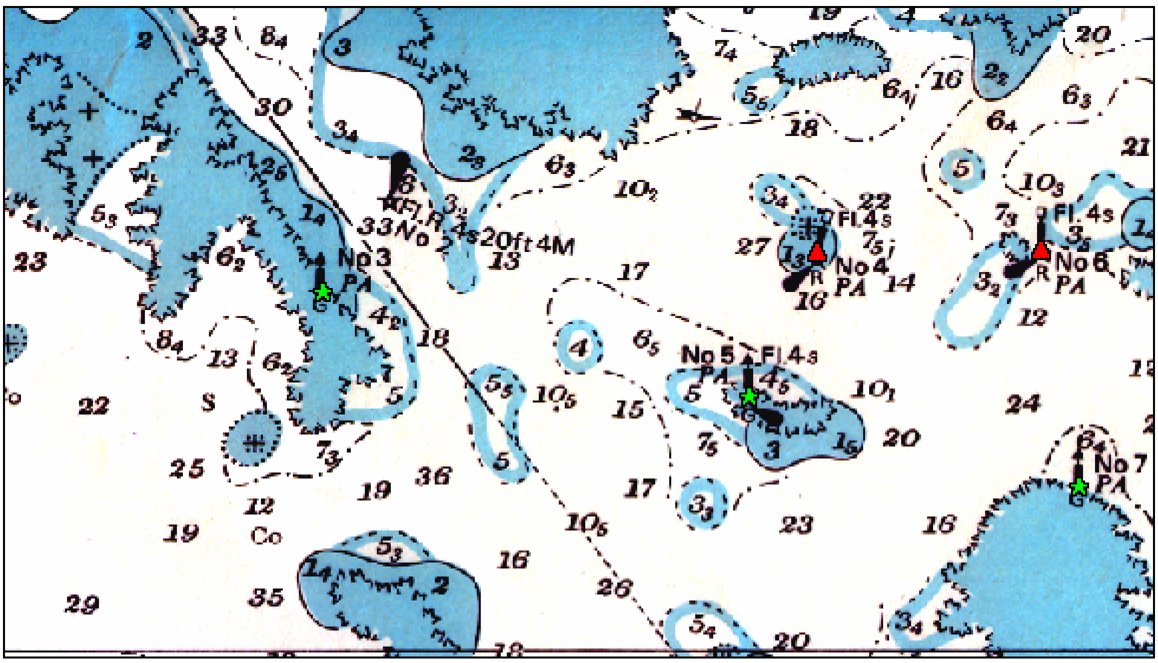


Figure 7. Pohnpei.



High risk waterway: Jokaj Passage.

COUNTRY	Federated States of Micronesia
PORT	Pohnpei
HIGH RISK WATERWAY	Jokaj Passage

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
56ft	117ft	50ft	223ft	300ft	1.3

Environment for simulation

Height of tide	0.5m	Wind direction	045°
Current direction	325°	Wind speed	30kts
Current speed	1kt	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Petro Discoverer* of 3283 DWT was the reference vessel for the MSD analysis. A range, a fixed aid and a buoy support positioning in Jokaj Passage. The channel provides a security measure of 1.3.

1.1.1.3 Malakal Harbour, Palau

COUNTRY	Republic of Palau
PORT	Malakal Harbour, Capital Island, Koror
HIGH RISK WATERWAY	Malakal Pass

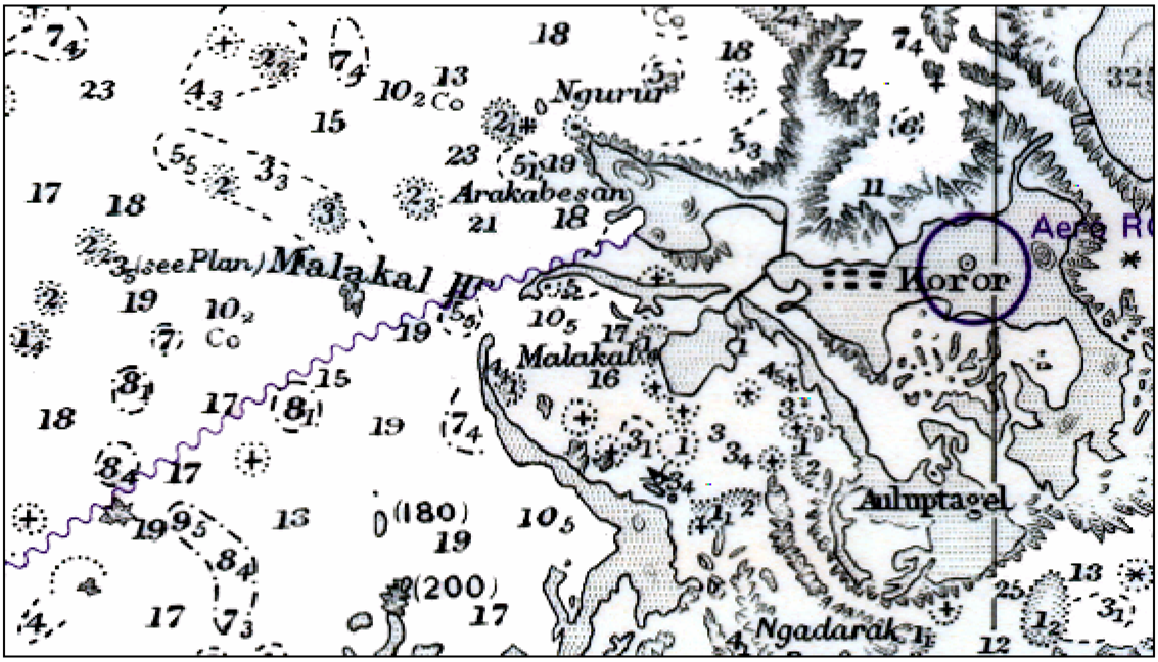
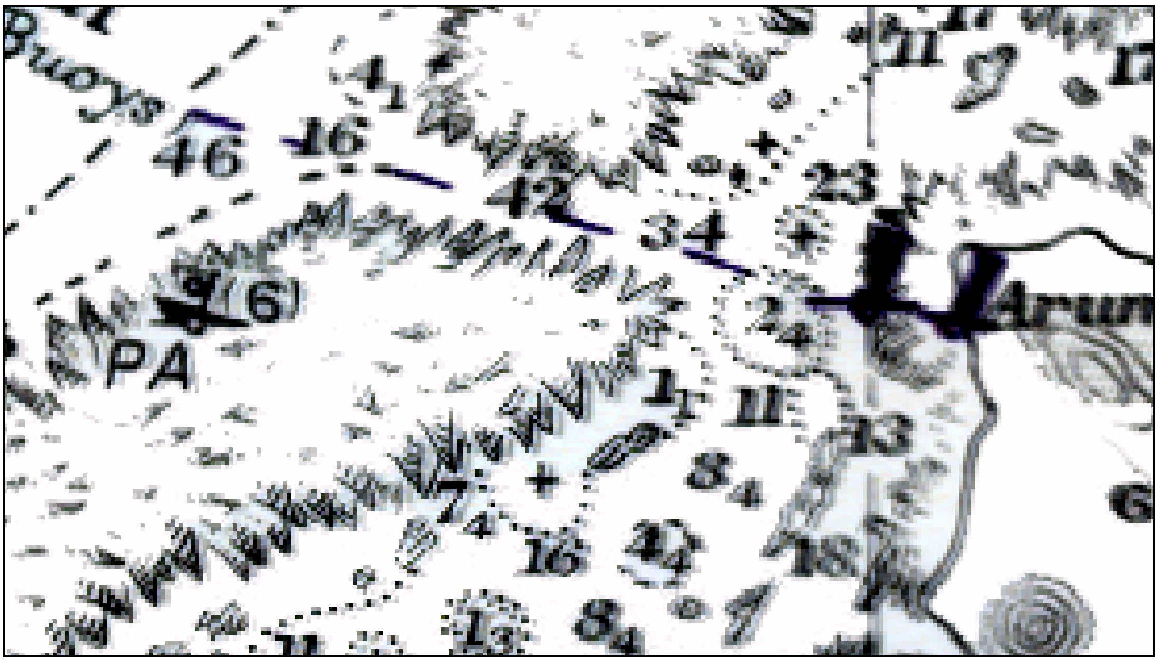


Figure 8. Malakal Harbour, Koror.



High risk waterway: Malakal Pass.

COUNTRY	Republic of Palau
PORT	Malakal Harbour, Capital Island, Koror
HIGH RISK WATERWAY	Malakal Pass

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
97ft	119ft	50ft	266ft	280ft	1.0

Environment for simulation

Height of tide	0.5m	Wind direction	070°
Current direction	180°	Wind speed	12kts
Current speed	2kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Petro Discoverer* of 3283 DWT was the reference vessel for the MSD analysis. A range, fixed aids and buoys supports positioning in this narrow passage. The entrance channel provides a security measure of 1.

1.1.1.4 Betio, Tarawa, Kiribati

COUNTRY	Republic of Kiribati
PORT	Betio Island, Tarawa Atoll
HIGH RISK WATERWAY	Betio Entrance

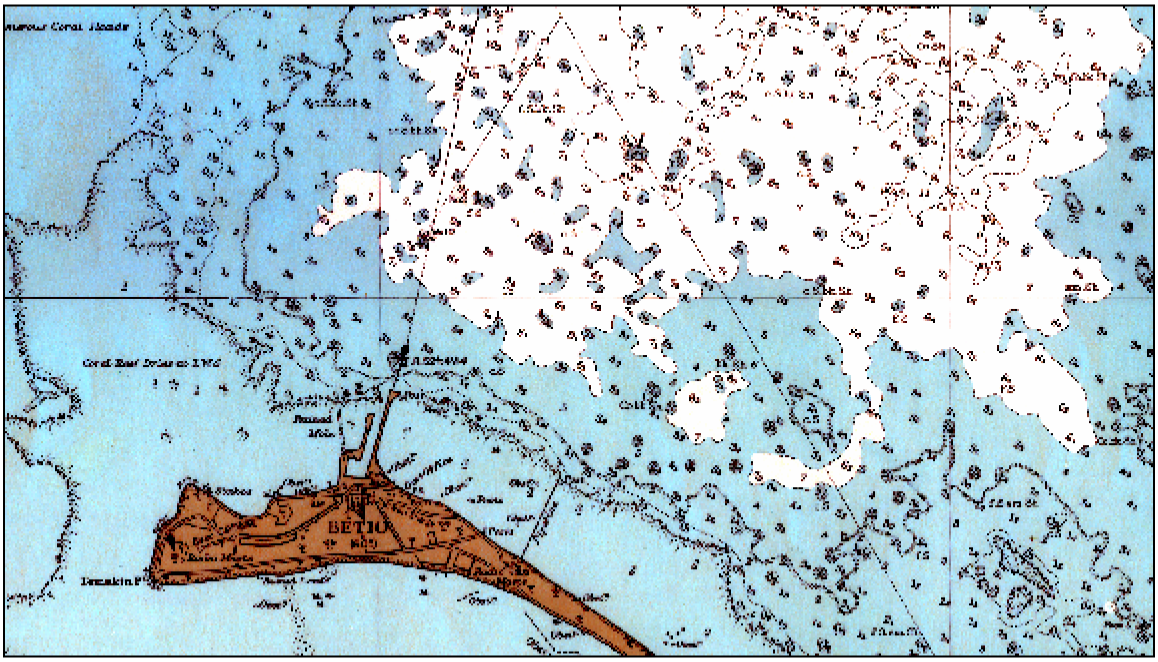
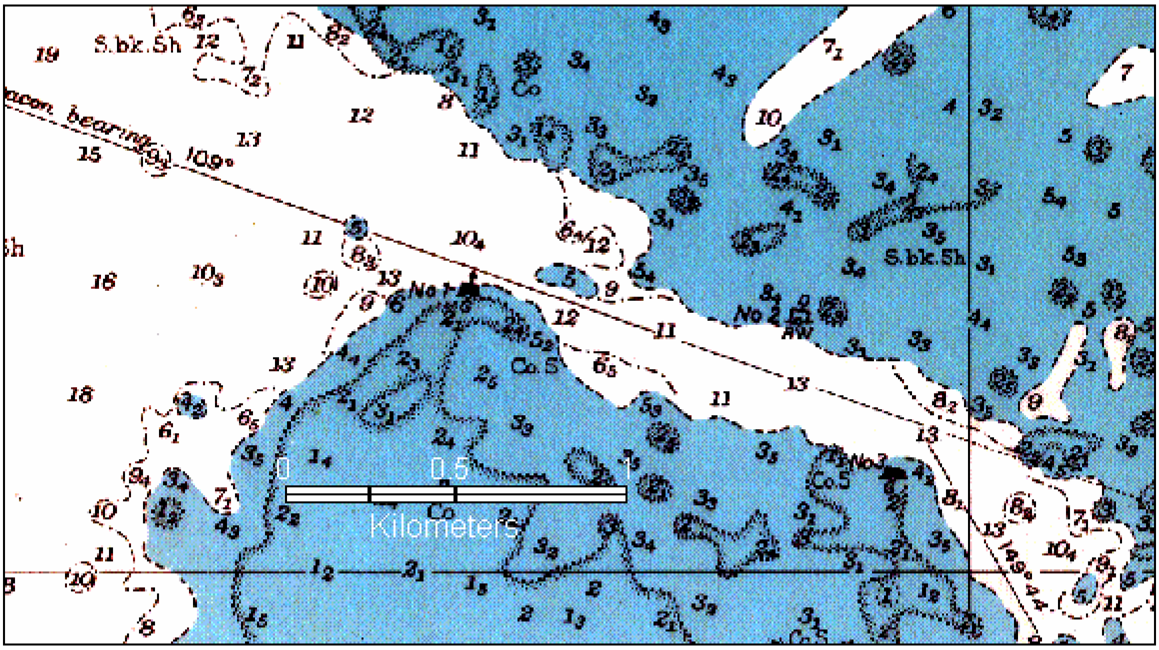


Figure 9. . Betio Anchorage.



High risk waterway: Betio Entrance

COUNTRY	Republic of Kiribati
PORT	Betio Island, Tarawa Atoll
HIGH RISK WATERWAY	Betio Entrance

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
79ft	329ft	50ft	458ft	600ft	1.3

Environment for simulation

Height of tide	0.5m	Wind direction	120°
Current direction	120°	Wind speed	30kts
Current speed	0.8kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The container vessel *Coral Chief* of 10553 DWT was the reference vessel for the MSD analysis. Aids to navigation for the turn in Betio Entrance include a leadmark transit, fixed aids and buoys. The turn requires additional shiphandling room because the channel is narrow and the turn must be executed under continuous helm—a large ship has insufficient room to alter course in 10° steps. With good visibility, the channel provides a security measure of 1.3.

1.1.1 Port Risk Results C: Port Moresby, Madang, Lae, Port Vila.

1.1.1.1 Port Moresby, Papua New Guinea

COUNTRY	Papua New Guinea
PORT	Port Moresby
HIGH RISK WATERWAY	Basilisk Passage—Lark Patch Turn

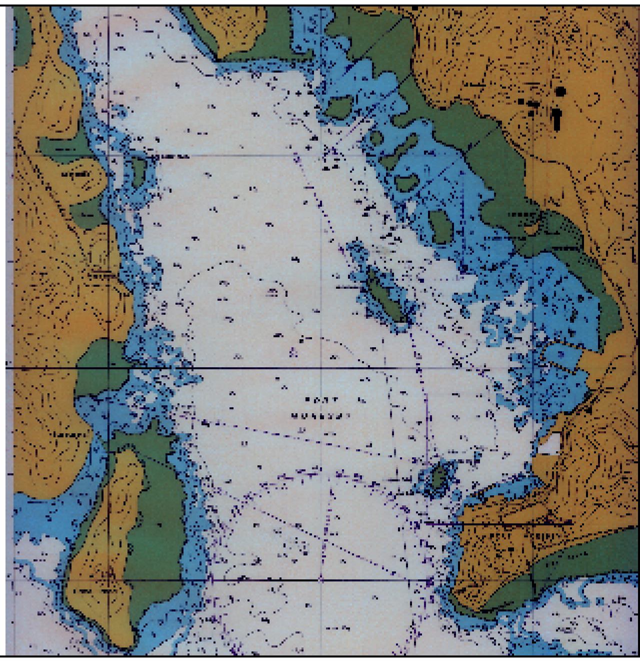
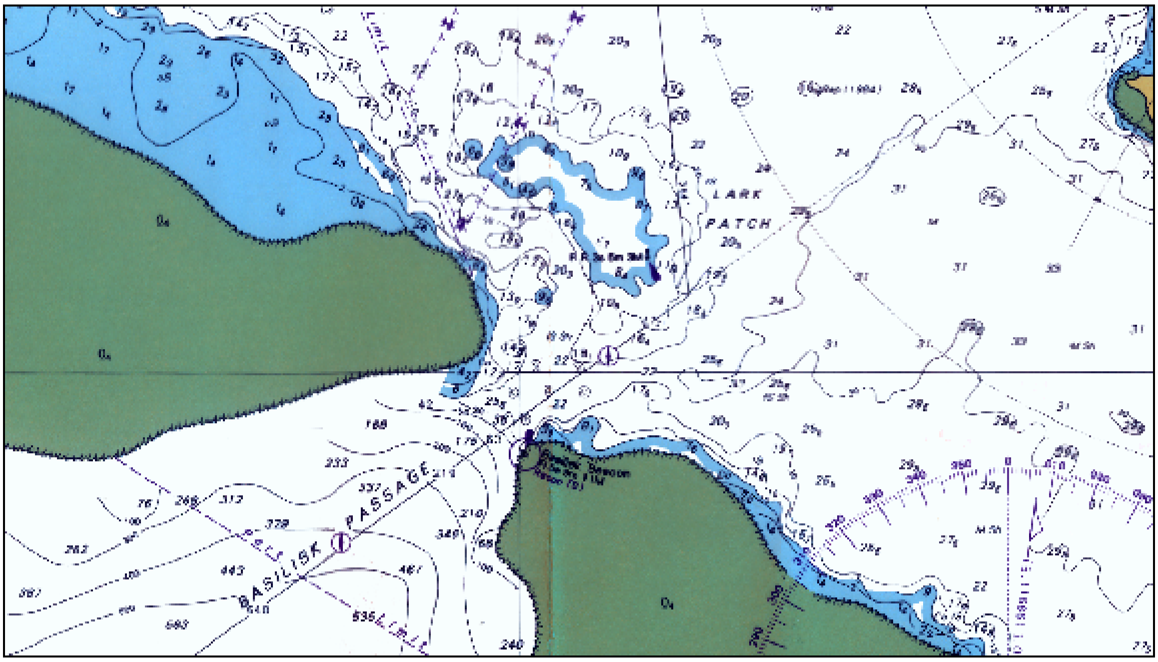


Figure 10. Port Moresby.



High risk waterway: Basilisk Passage, Lark Patch.

COUNTRY	Papua New Guinea
PORT	Port Moresby
HIGH RISK WATERWAY	Basilisk Passage—Lark Patch Turn

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
155ft	504ft	50ft	709ft	1300ft	1.8

Environment for simulation

Height of tide	0m	Wind direction	315°
Current direction	360°	Wind speed	15kts
Current speed	1.5kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Conus* of 31950 DWT was the reference vessel for the MSD analysis. Aids to navigation for the turn in Basilisk Passage include a range, fixed aids, a racon and buoys. The turn requires additional shiphandling room because the Lark Patch shoals force a turn under continuous helm—a large ship has insufficient room to alter course in 10° steps. With good visibility, the channel provides a security measure of 1.8.

1.1.1.2 Madang, Papua New Guinea

COUNTRY	Papua New Guinea
PORT	Madang Harbour
HIGH RISK WATERWAY	Dallman Passage—Turn to jetty approach

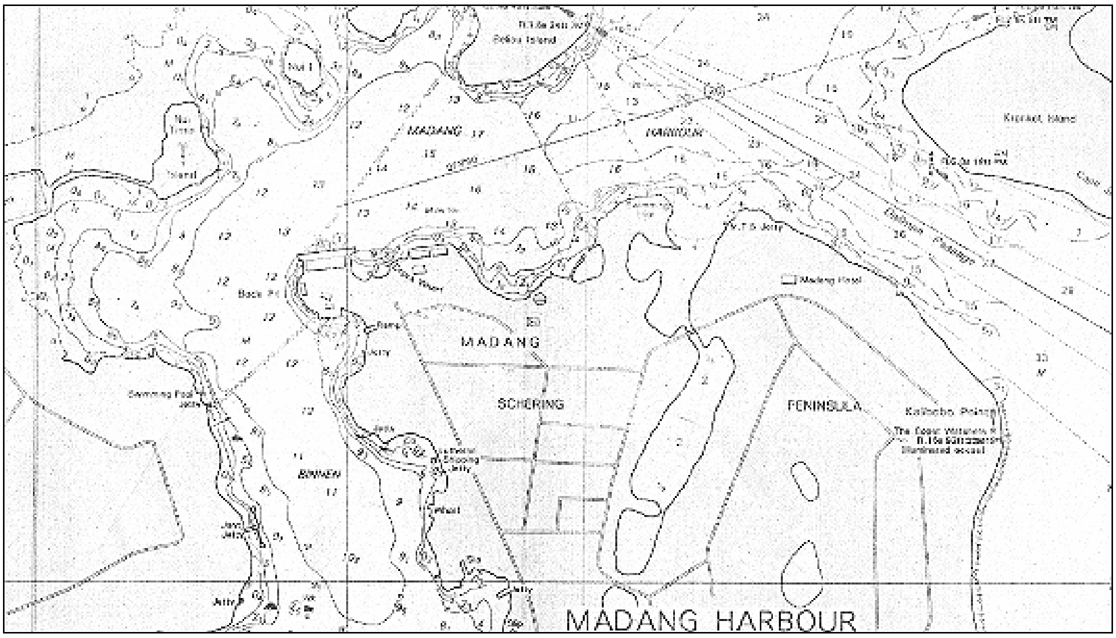
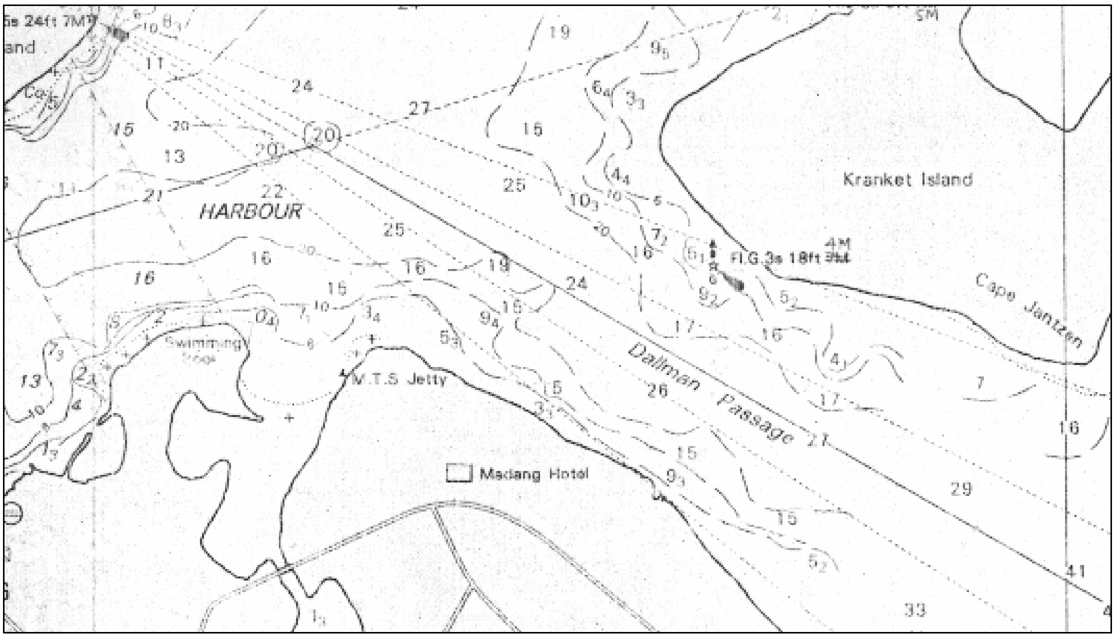


Figure 11. Madang.



Dallman Passage—Turn to jetty approach.

COUNTRY	Papua New Guinea
PORT	Madang Harbour
HIGH RISK WATERWAY	Dallman Passage—Turn to jetty approach

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
105ft	374ft	100ft	579ft	800ft	1.3

Environment for simulation

Height of tide	0.5m	Wind direction	315°
Current direction	250°	Wind speed	2kts
Current speed	0.2kts	Vessel speed	5kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Conus* of 31950 DWT was the reference vessel for the MSD analysis. A range supports positioning in the approach turn and good natural radar targets, but requires additional maneuvering room under continuous helm. With good visibility, the approach provides a security measure of 1.3.

1.1.1.3 Lae, Papua New Guinea

COUNTRY	Papua New Guinea
PORT	Lae
HIGH RISK WATERWAY	Lae Approaches

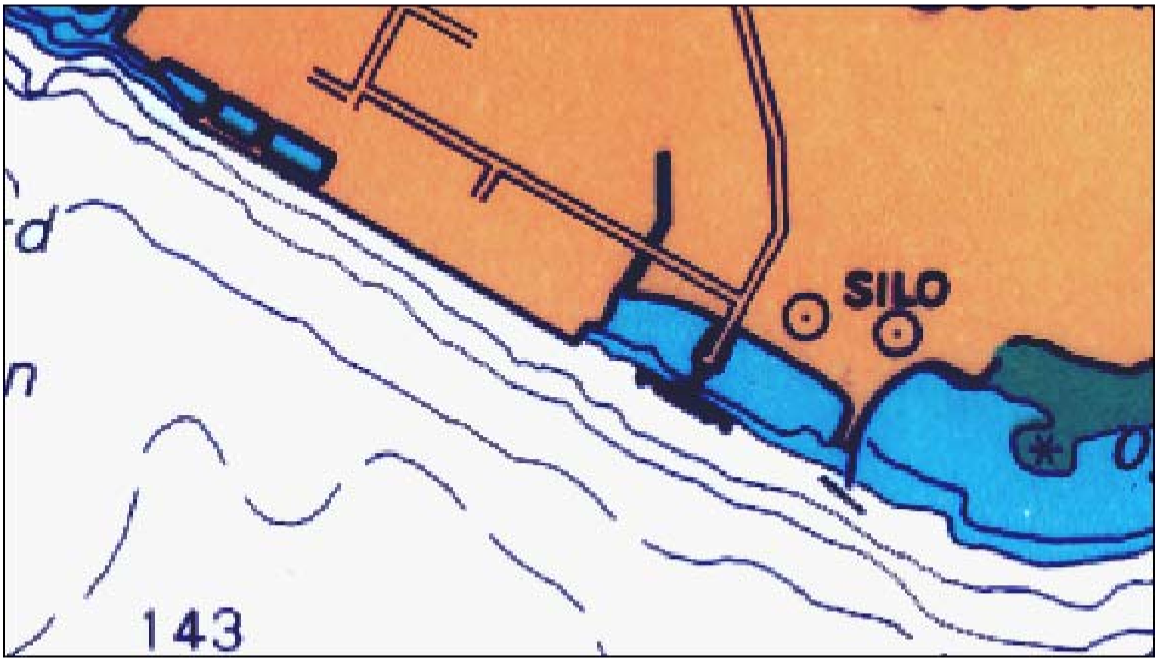
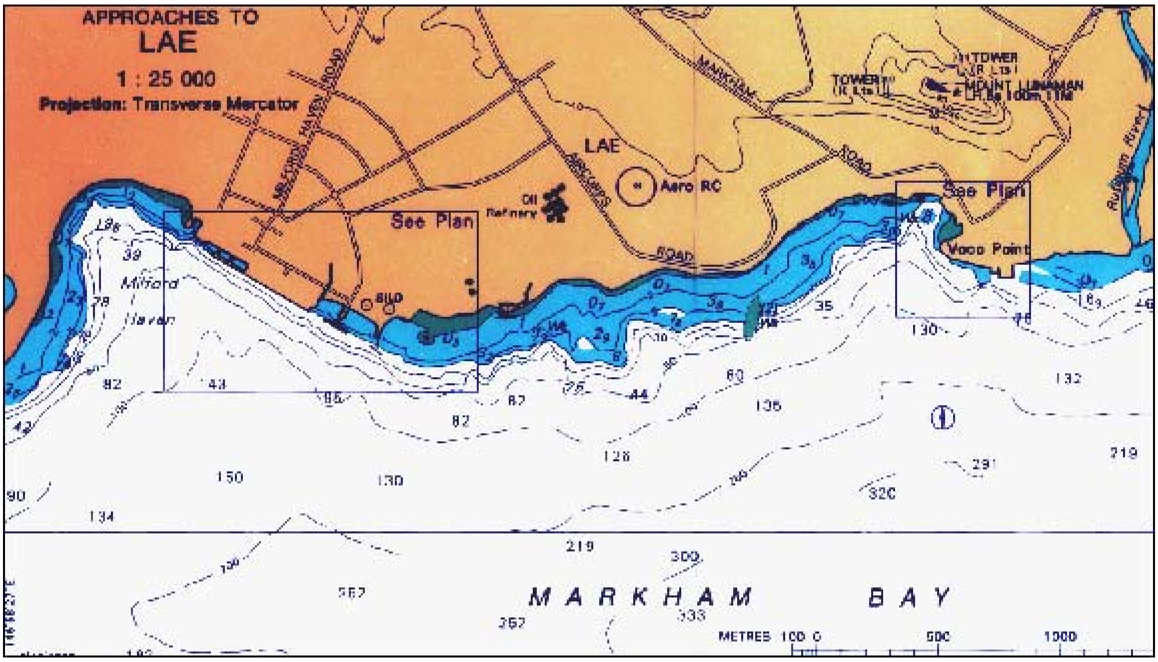


Figure 12. Lae.



High risk waterway: Approaches to Lae.

COUNTRY	Papua New Guinea
PORT	Lae
HIGH RISK WATERWAY	Lae Approaches

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
89ft	64ft	200ft	353ft	1000ft	2.8

Environment for simulation

Height of tide	0.5m	Wind direction	315°
Current direction	315°	Wind speed	15kts
Current speed	1.5kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Conus* of 31950 DWT was the reference vessel for the MSD analysis. Positioning in the approach is supported by good natural radar targets and visual leadmarks. With good visibility, the approach provides a security measure of 2.8.

1.1.1.4 Port Vila, Vanuatu

COUNTRY	Rebublic of Vanuatu
PORT	Port Vila, Mele Bay
HIGH RISK WATERWAY	Entrance to Paray Bay to fuel jetty

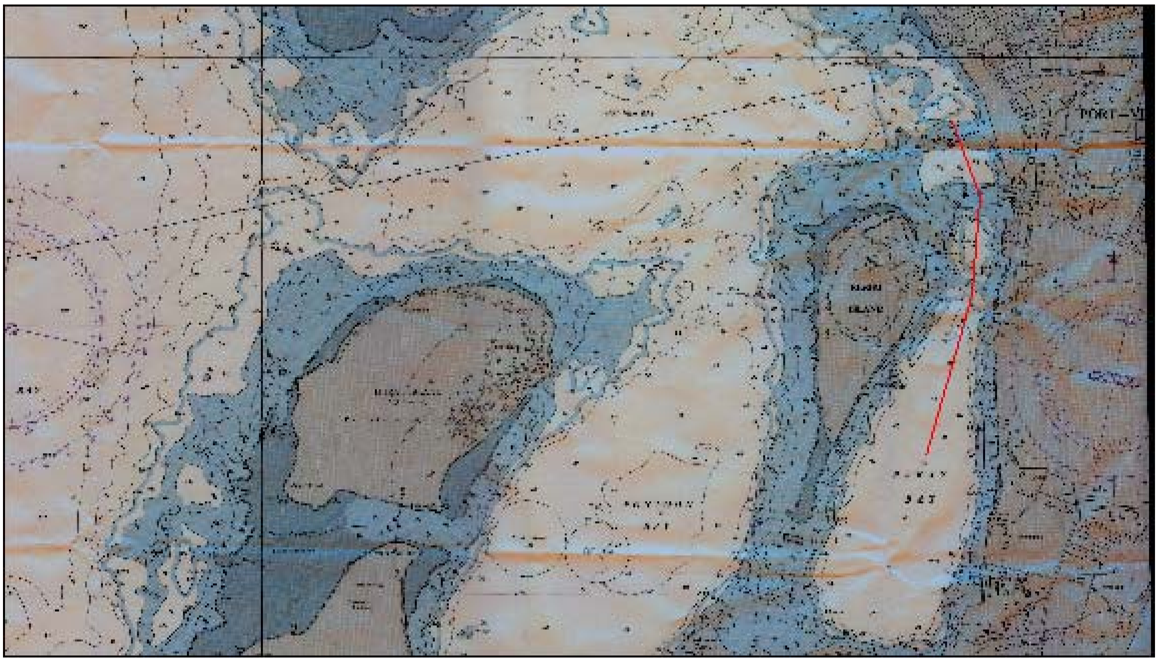


Figure 13. Port Vila Harbour.

High risk waterway: Entrance to Paray Bay to fuel jetty.

COUNTRY	Rebublic of Vanuatu
PORT	Port Vila, Mele Bay
HIGH RISK WATERWAY	Entrance to Paray Bay to fuel jetty

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
38ft	81ft	75ft	194ft	110ft	0.6

Environment for simulation

Height of tide	1m	Wind direction	135°
Current direction	340°	Wind speed	5kts
Current speed	0.2kts	Vessel speed	5kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Pacific Explorer* of 1725 DWT was the reference vessel for the MSD analysis. Three buoys support positioning in the narrow entrance to Paray Bay. The narrowness of the channel results in a relatively low security measure of 0.6.

1.1.1.5 Honiara, Solomon Islands

COUNTRY	Solomon Islands
PORT	Honiara
HIGH RISK WATERWAY	Approach to tanker moorings

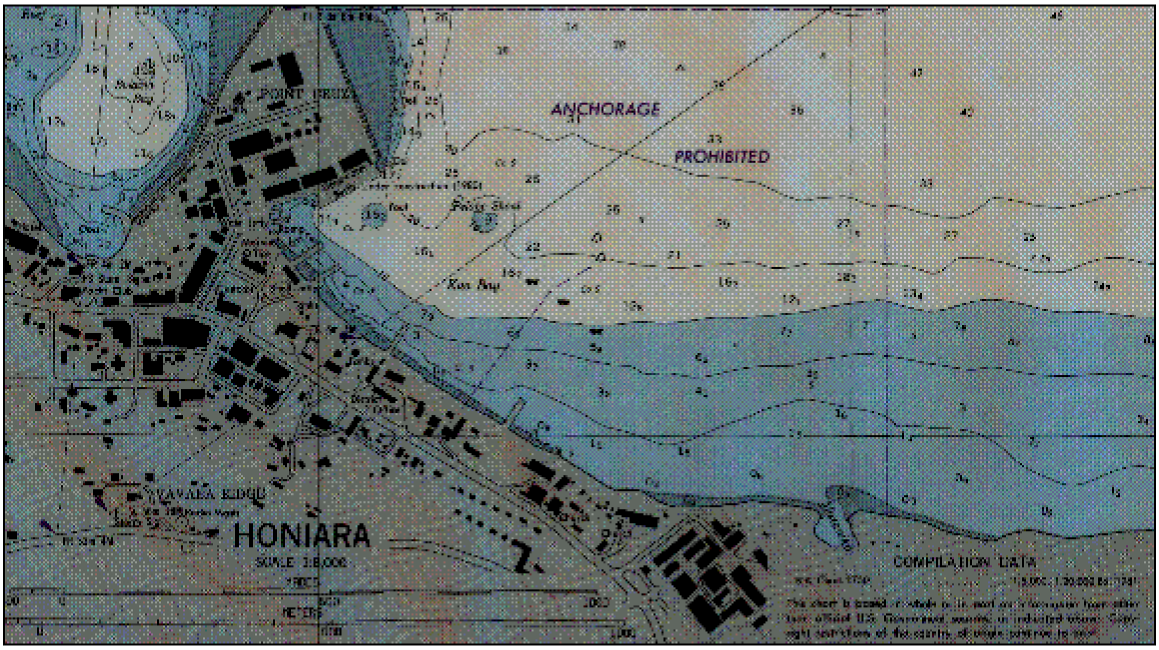
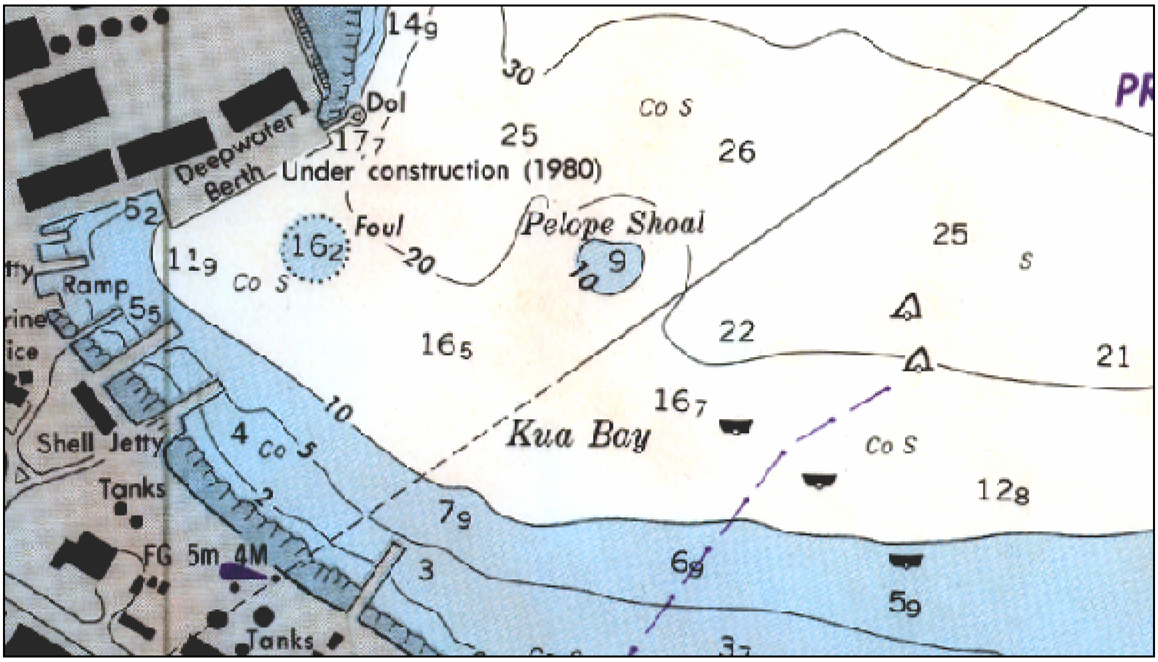


Figure 14. Honiara.



High risk waterway: Approach to tanker moorings.

COUNTRY	Solomon Islands
PORT	Honiara
HIGH RISK WATERWAY	Approach to tanker moorings

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
198ft	65ft	50ft	313ft	450ft	1.4

Environment for simulation

Height of tide	0m	Wind direction	315°
Current direction	135°	Wind speed	15kts
Current speed	2kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Conus* of 31950 DWT was the reference vessel for the MSD analysis. A range, natural radar targets and buoys support positioning in the approach to the tanker mooring buoys. With good visibility, the approach provides a security measure of 1.4.

1.1.1 Port Risk Results D: Suva, Vuda Point/Lautoka, Malau, Noumea.

1.1.1.1 Suva, Fiji

COUNTRY	Republic of Fiji
PORT	Suva
HIGH RISK WATERWAY	Levu Pass

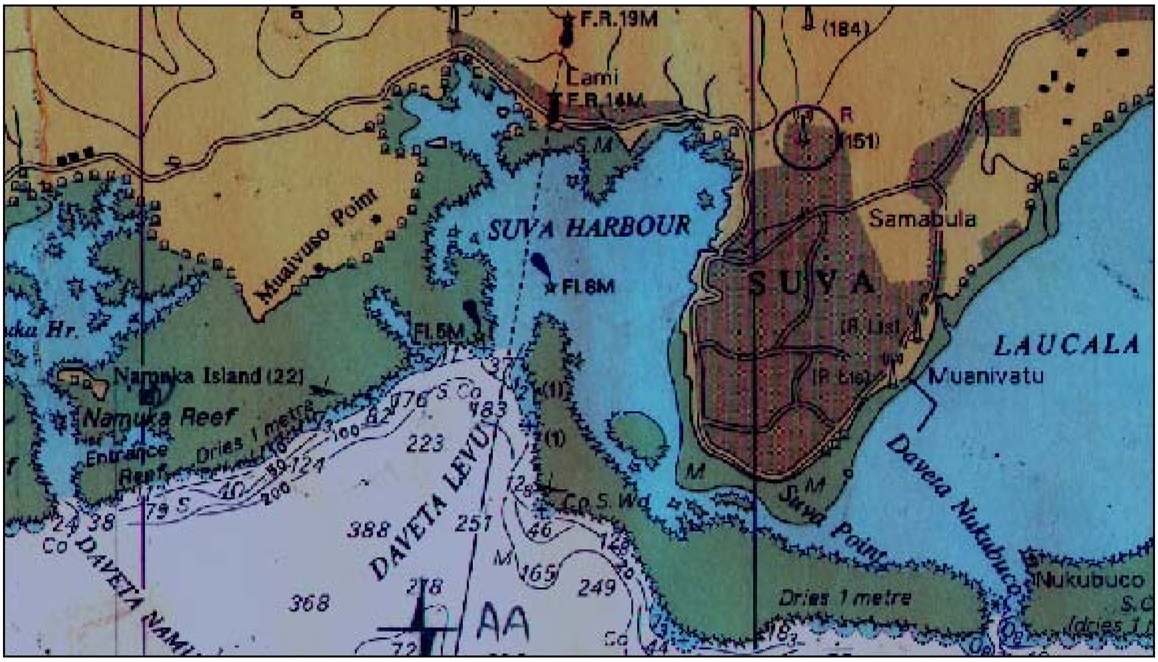
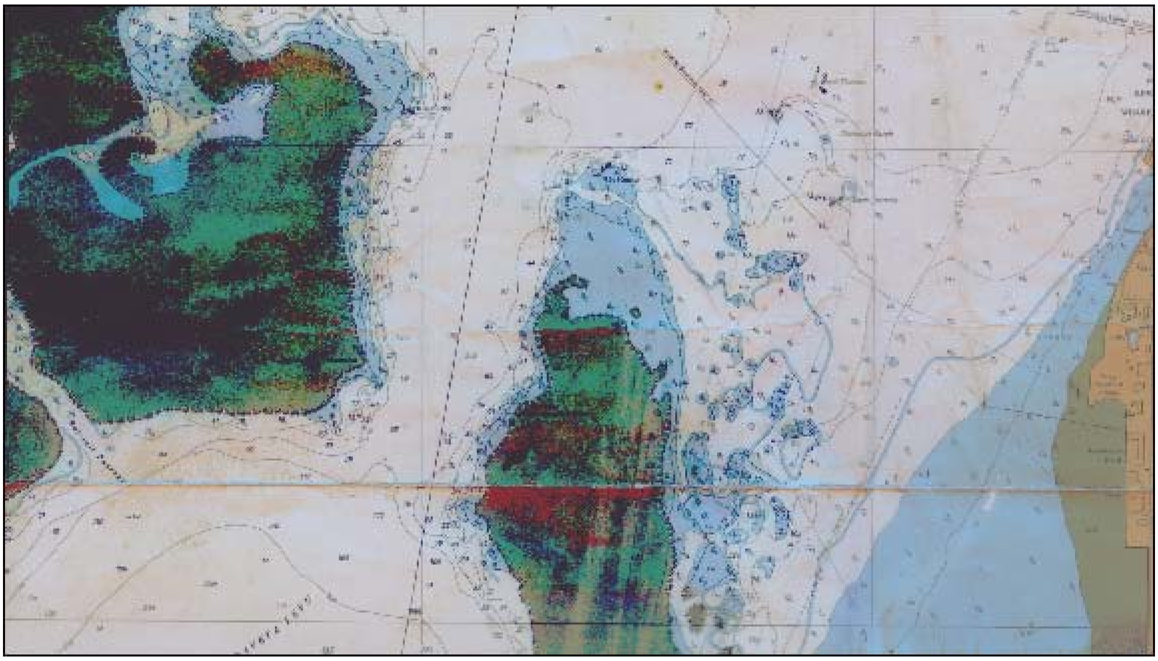


Figure 15. Suva.



High risk waterway: Levu Pass.

COUNTRY	Republic of Fiji
PORT	Suva
HIGH RISK WATERWAY	Levu Pass

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
128ft	154ft	50ft	332ft	1300ft	3.9

Environment for simulation

Height of tide	1m	Wind direction	090°
Current direction	350°	Wind speed	20kts
Current speed	1kt	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *High Spirit* of 46,475 DWT was the reference vessel for the MSD analysis. A wide channel width of 1300 feet, marked by a range, fixed aids and a buoy, result in the relatively high navigation security measure of 3.9 for the Port of Suva.

1.1.1.2 Vuda Point and Lautoka, Fiji

COUNTRY	Republic of Fiji
PORT	Lautoka, Vuda Point
HIGH RISK WATERWAY	Navula Passage

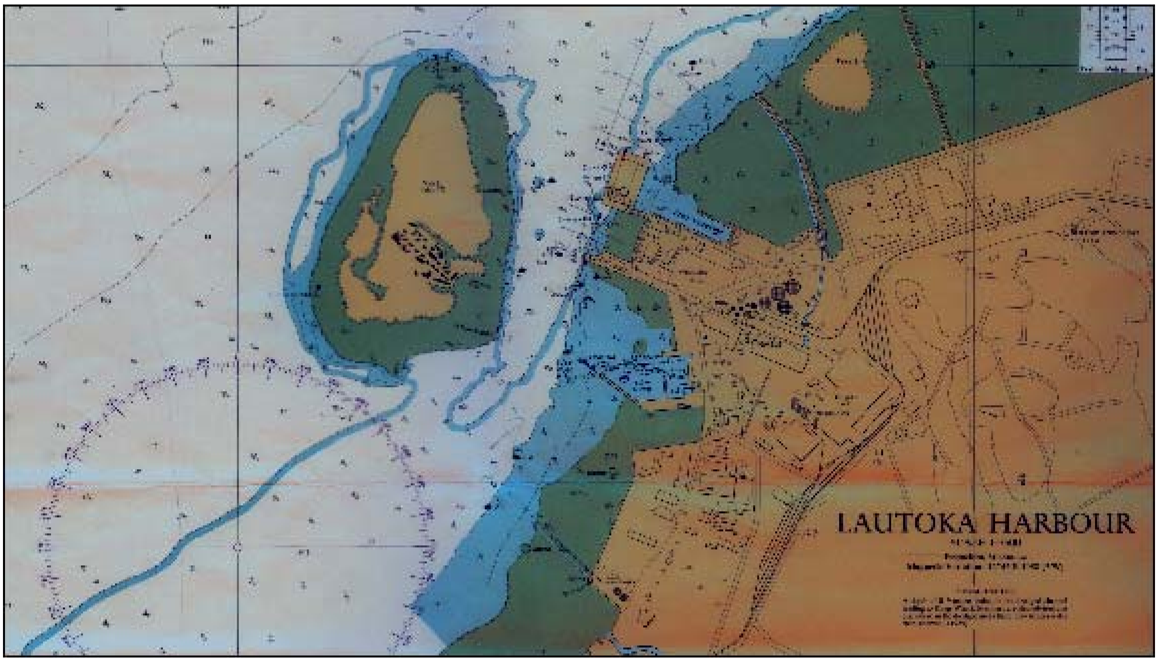
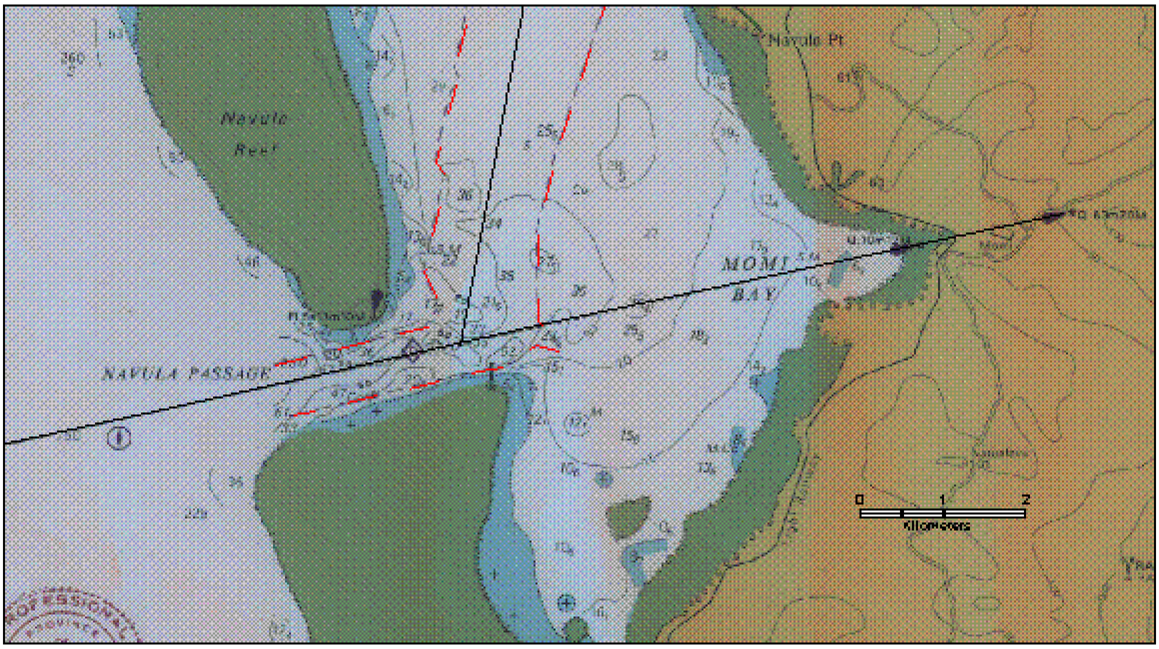


Figure 16. Lautoka Harbour.



High risk waterway: Navula Passage.

COUNTRY	Republic of Fiji
PORT	Lautoka, Vuda Point
HIGH RISK WATERWAY	Navula Passage

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
294ft	589ft	250ft	1133ft	4100ft	3.6

Environment for simulation

Height of tide	0m	Wind direction	180°
Current direction	315°	Wind speed	20kts
Current speed	6kts	Vessel speed	12kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *High Spirit* of 46,475 DWT was the reference vessel for the MSD analysis. When inbound in Navula Passage, an alteration of course to the NNE opens into an inner waterway of 4100 feet in width. Two fixed aids assist with positioning in the turn. The increase in maneuvering room results in a navigation security measure of 3.6 for Lautoka/Vuda Point.

1.1.1.3 Malau (Labasa), Fiji

COUNTRY	Republic of Fiji
PORT	Malau Harbour, Labasa
HIGH RISK WATERWAY	Mali Pass

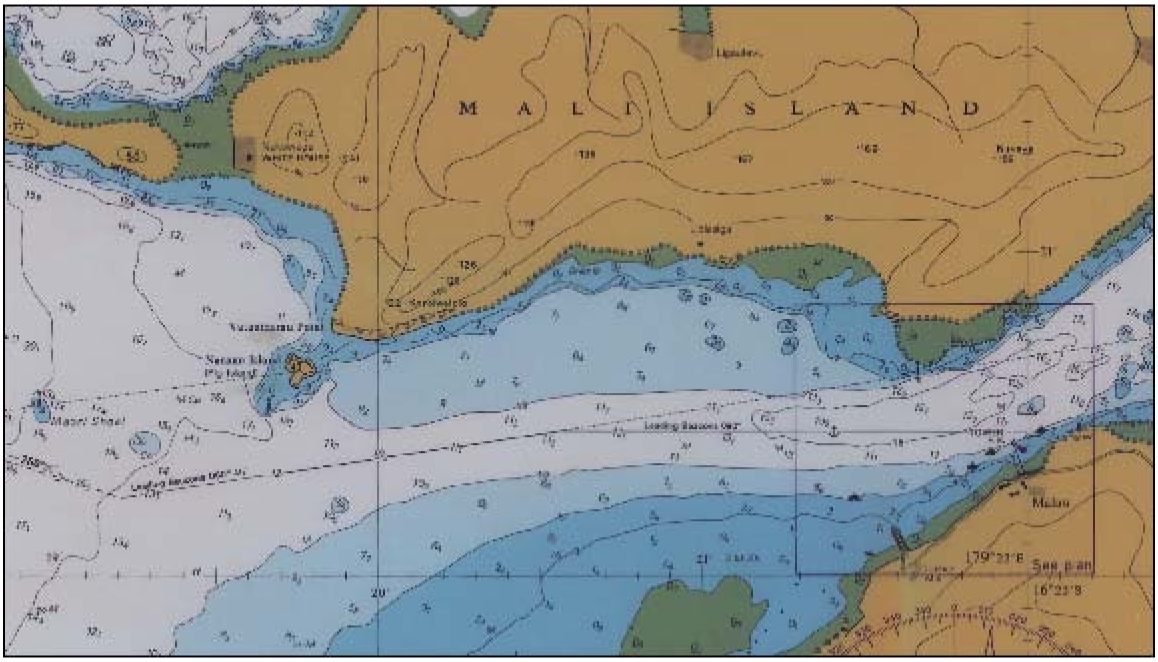
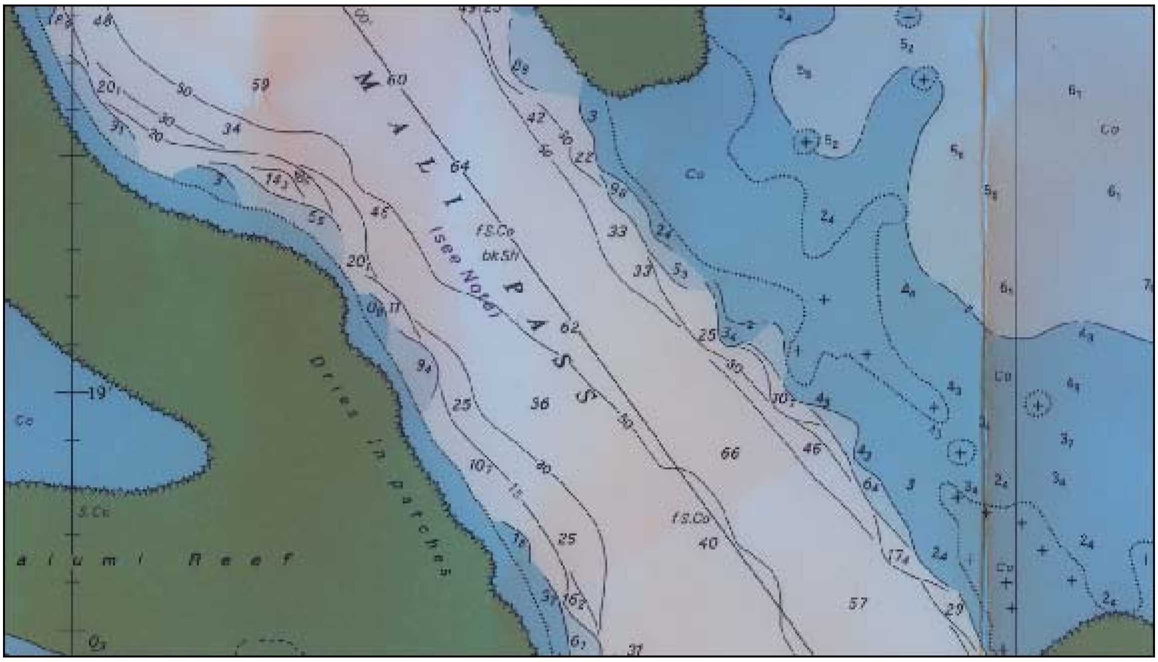


Figure17. Malau (Labasa).



High risk waterway: Mali Pass.

COUNTRY	Republic of Fiji
PORT	Malau Harbour, Labasa
HIGH RISK WATERWAY	Mali Pass

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
111ft	28ft	547ft	686ft	2900ft	4.2

Environment for simulation

Height of tide	1m	Wind direction	090°
Current direction	270°	Wind speed	30kts
Current speed	3kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Petro Discoverer* of 3283 DWT was the reference vessel for the MSD analysis. Mali Pass is transited without aids to navigation. A good visual leadmark and a natural radar target provide a minimum position quality for a 6 nautical mile range scale. The minimum passage width of 2900 feet provides sufficient sea room to provide a security measure of 4.2.

1.1.1.4 Noumea, New Caledonia

COUNTRY	New Caledonia
PORT	Noumea
HIGH RISK WATERWAY	Passe de Dumbea

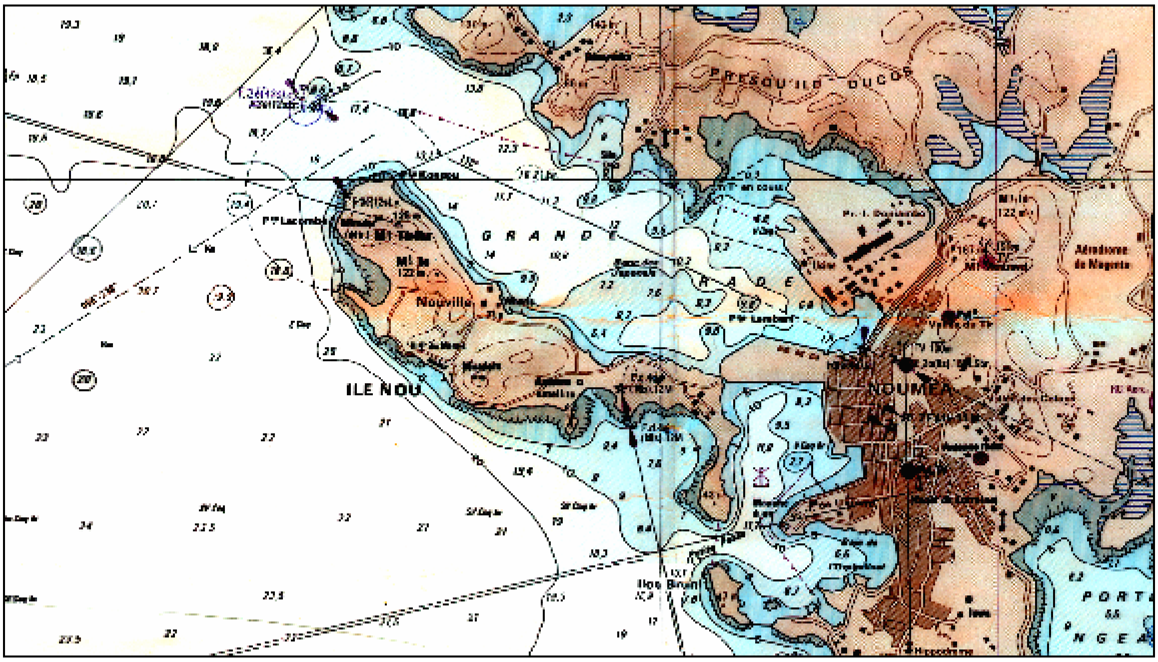
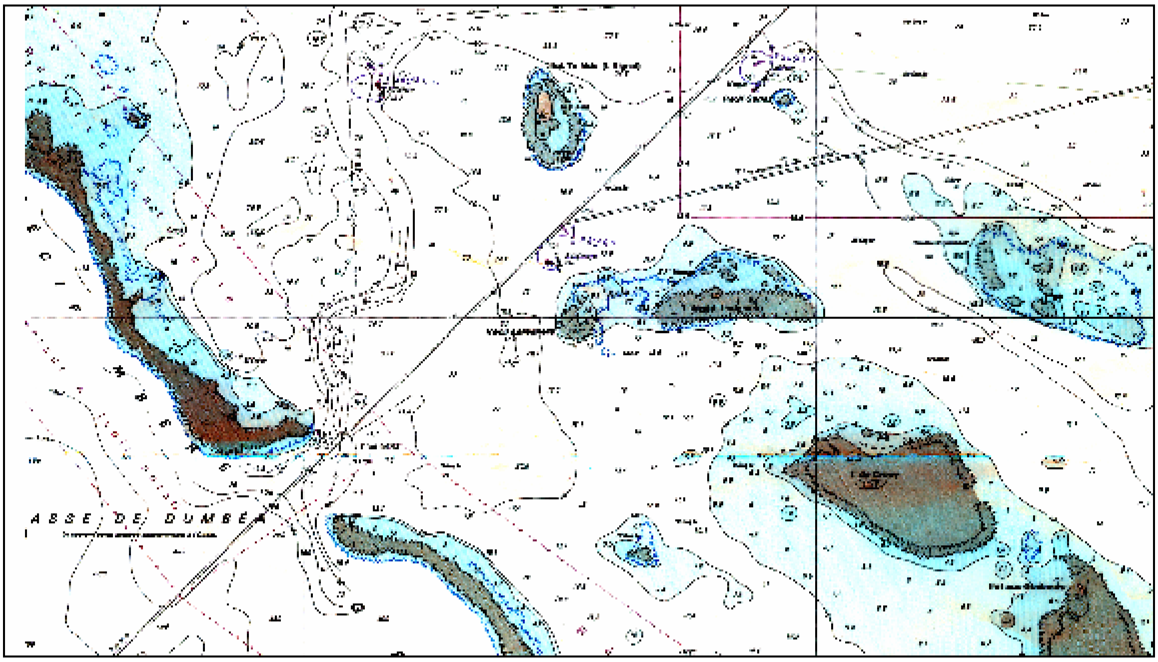


Figure 18. Noumea Harbour.



High risk waterway: Passe de Dumbea

COUNTRY	New Caledonia
PORT	Noumea
HIGH RISK WATERWAY	Passe de Dumbea

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
177ft	166ft	200ft	543ft	2200ft	4.0

Environment for simulation

Height of tide	1m	Wind direction	090°
Current direction	050°	Wind speed	30kts
Current speed	1kt	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

A super tanker of 147,443 DWT was the reference vessel for the MSD analysis. Positioning in the entrance is supported by two fixed aid, two buoys and two natural radar targets. With good visibility, this wide reef pass provides a security measure of 4.

1.1.1 Port Risk Results E: Avatiu, Alofi Bay, Apia, Nuku'alofa, Funafuti.

1.1.1.1 Avatiu, Rarotonga, Cook Islands

COUNTRY	Cook Islands
PORT	Rarotonga (Avatiu)
HIGH RISK WATERWAY	Entrance to Avatiu

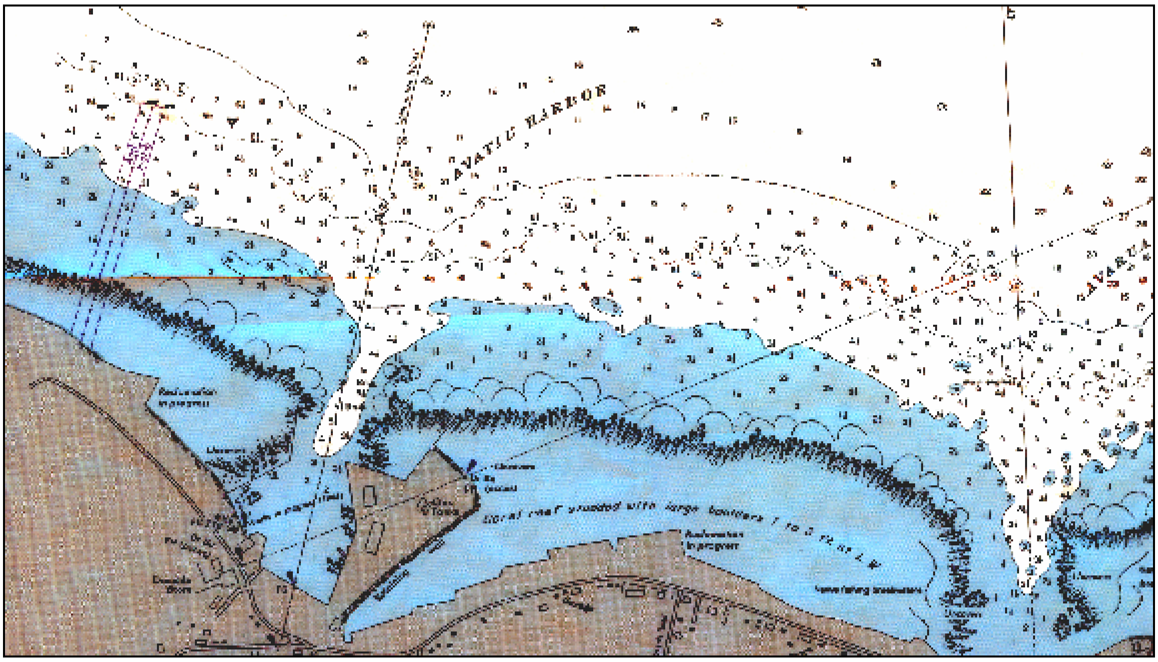
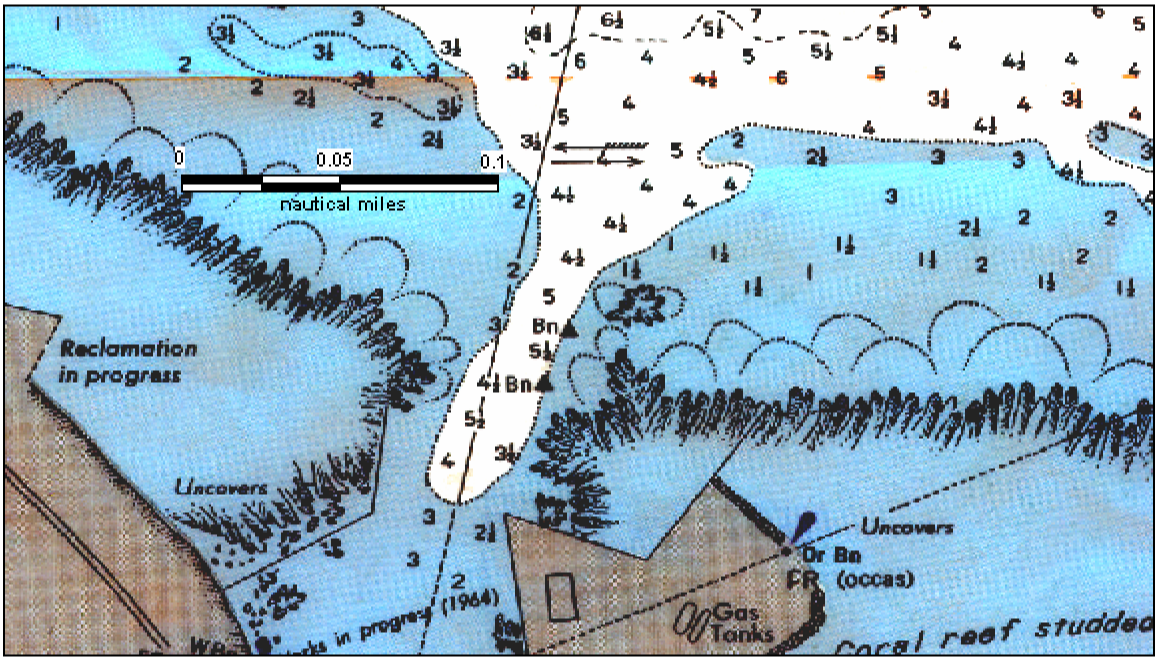


Figure 19. Avatiu, Rarotonga.



High risk waterway: Avatiu Entrance.

COUNTRY	Cook Islands
PORT	Rarotonga (Avatiu)
HIGH RISK WATERWAY	Entrance to Avatiu

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
44ft	46ft	75ft	165ft	110ft	0.7

Environment for simulation

Height of tide	0m	Wind direction	315°
Current direction	270°	Wind speed	5kts
Current speed	0.5kts	Vessel speed	5kts
Daylight	Yes	Existing aids	Yes

Discussion

A coastal tender of 100 DWT was the reference vessel for the MSD analysis. The reef pass is very narrow and exposed. Given a channel width of only 110 feet, there is little margin for error. Positioning aids include a range, fixed aids, visual marks and natural radar targets. However, because the approach is constrained, the security measure is a low 0.7.

The reference vessel is smaller than many that use Avatiu, and the environment for simulation less challenging. Container liners to 3000GT (example: Southern Express, 2800GT, 86m LOA) and local coastal tankers to 3300dwt (example: *Petro Discoverer*, 3283dwt, 88m LOA) routinely use the port. Cross-channel current speeds of 1kn and winds of 20kn are common. Pilots occasionally decline to bring vessels in, and even under the best conditions the entry is hazardous.

1.1.1.2 Alofi Bay, Niue

COUNTRY	Niue
PORT	Alofi Bay
HIGH RISK WATERWAY	Alofi Bay Anchorage

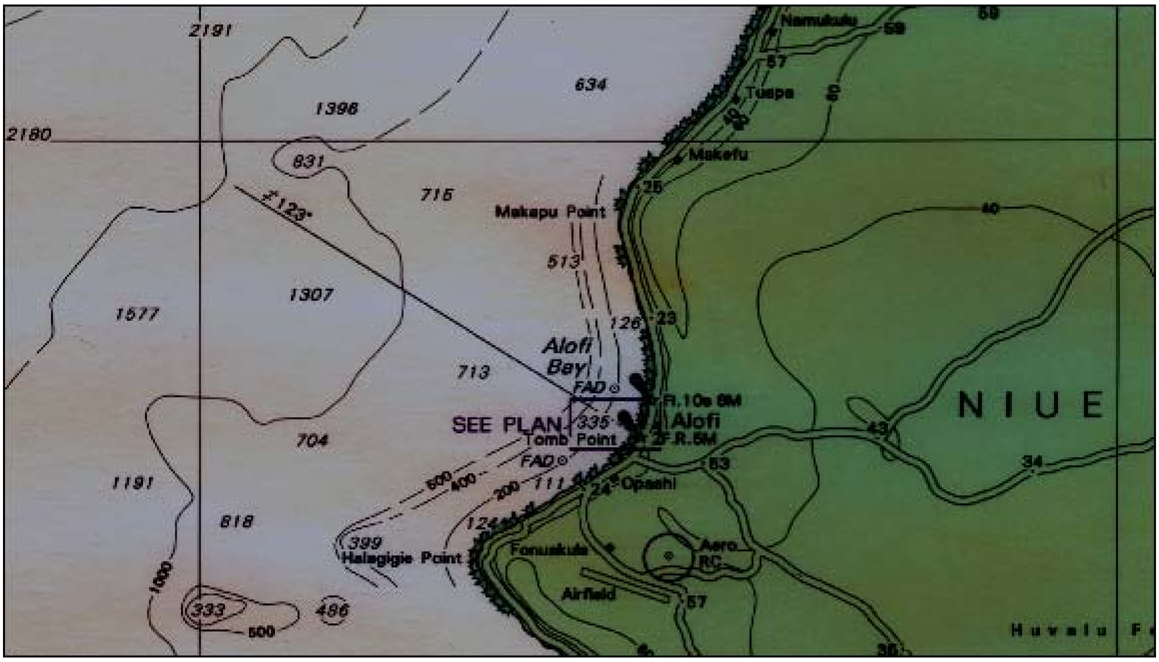
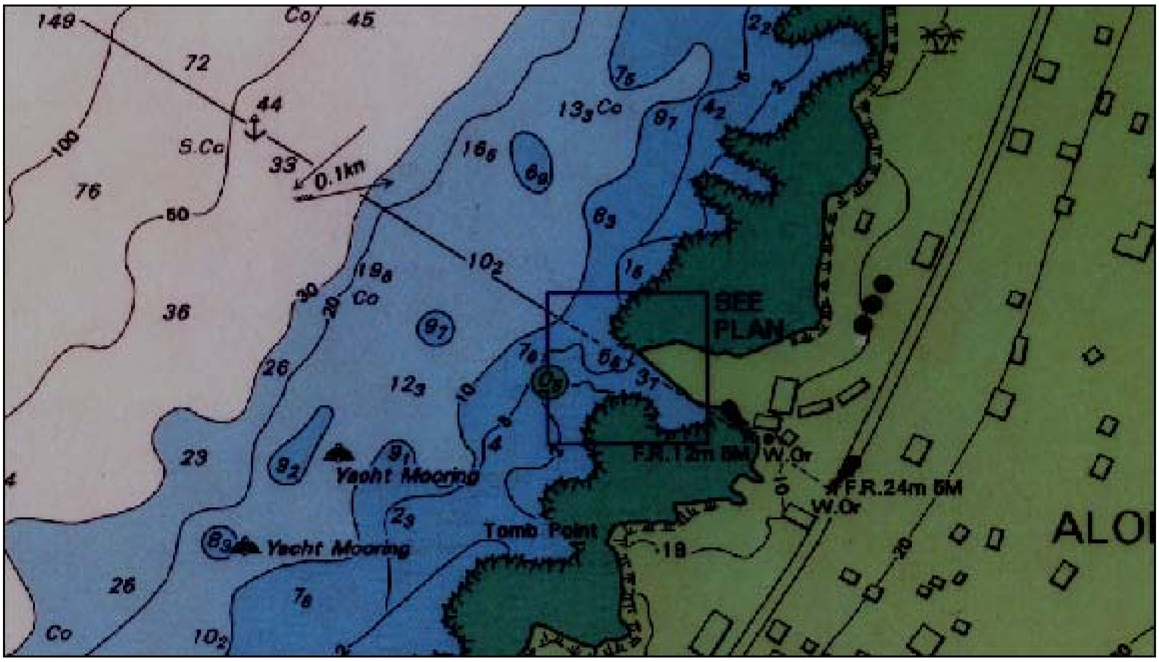


Figure 20. Alofi Bay, Niue.



High risk waterway: Anchorage.

COUNTRY	Niue
PORT	Alofi Bay
HIGH RISK WATERWAY	Alofi Bay Anchorage

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
61ft	24ft	100ft	185ft	500ft	2.7

Environment for simulation

Height of tide	0m	Wind direction	135°
Current direction	045°	Wind speed	25kts
Current speed	1kt	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Pacific Explorer* of 1725 DWT was the reference vessel for the MSD analysis. Positioning in anchorage is supported by a range and natural radar targets. The anchorage provides a security measure of 2.7.

1.1.1.3 Apia, Samoa

COUNTRY	Samoa
PORT	Apia Harbour
HIGH RISK WATERWAY	Reef passage to mooring buoys

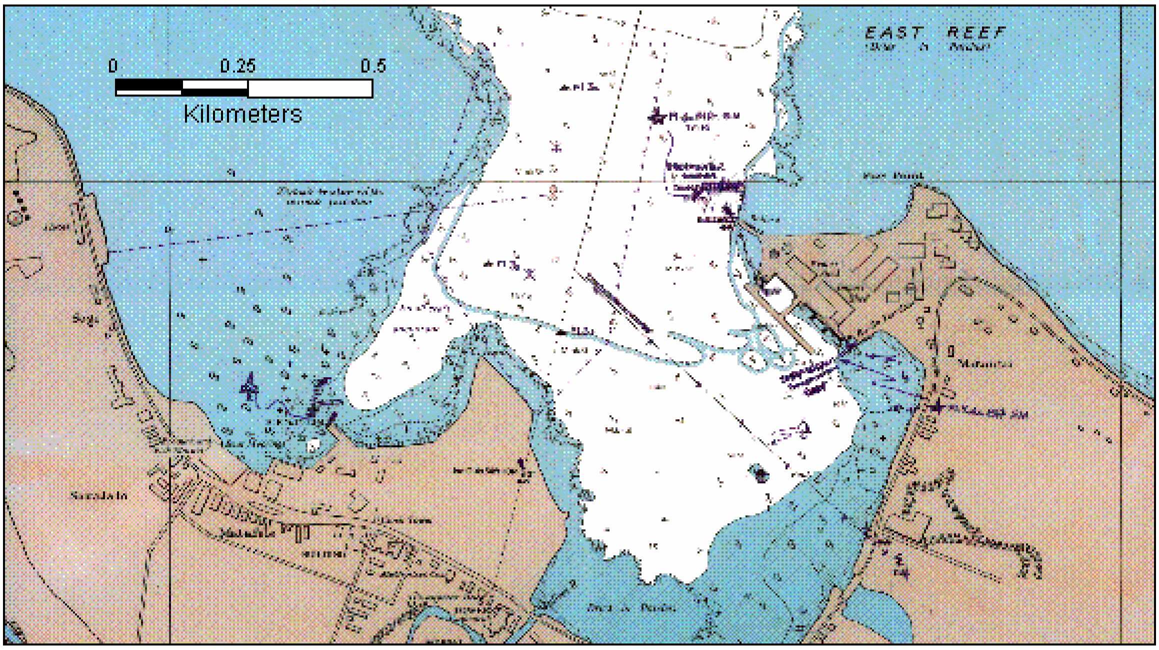
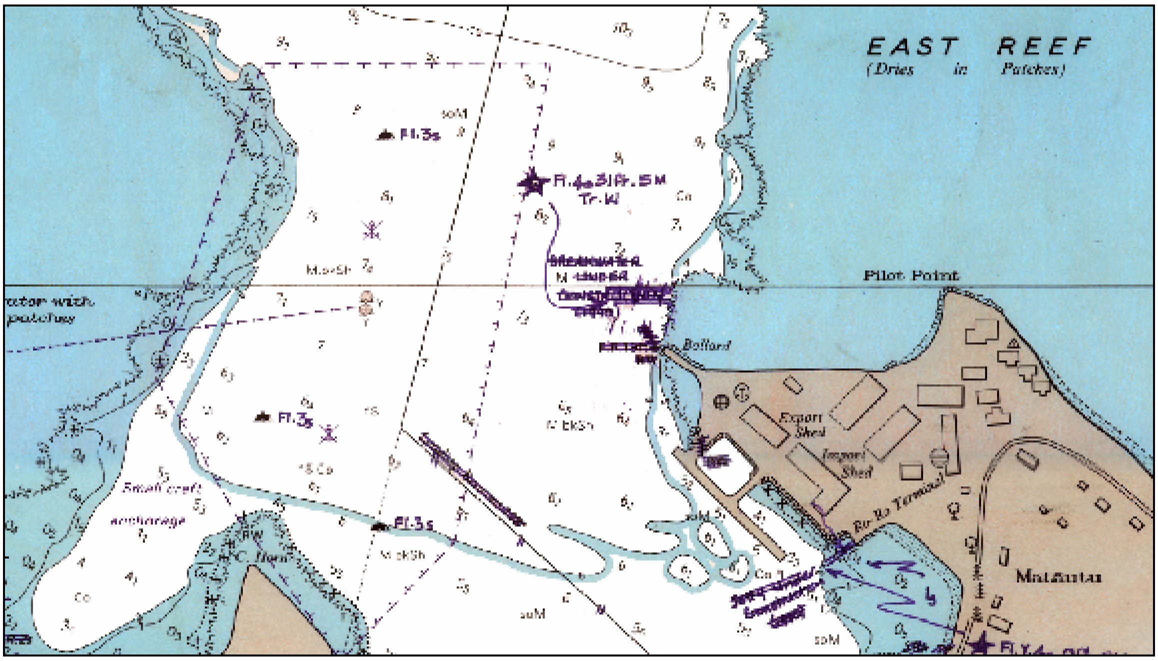


Figure 21. Apia Harbour.



High risk waterway: Reef Passage.

COUNTRY	Samoa
PORT	Apia Harbour
HIGH RISK WATERWAY	Reef passage to mooring buoys

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
200ft	145ft	75ft	420ft	700ft	1.7

Environment for simulation

Height of tide	1m	Wind direction	090°
Current direction	270°	Wind speed	20kts
Current speed	2kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Conus* of 31950 DWT (like Captain Martin) was the reference vessel for the MSD analysis. A range, fixed aids and buoys supports positioning in the approach to the tanker mooring buoys. With good visibility, the approach provides a security measure of 1.7.

1.1.1.4 Nuku'alofa, Tonga

COUNTRY	Kingdom of Tonga
PORT	Nuku’alofa
HIGH RISK WATERWAY	Ava Lahi Passage—turn to 215°

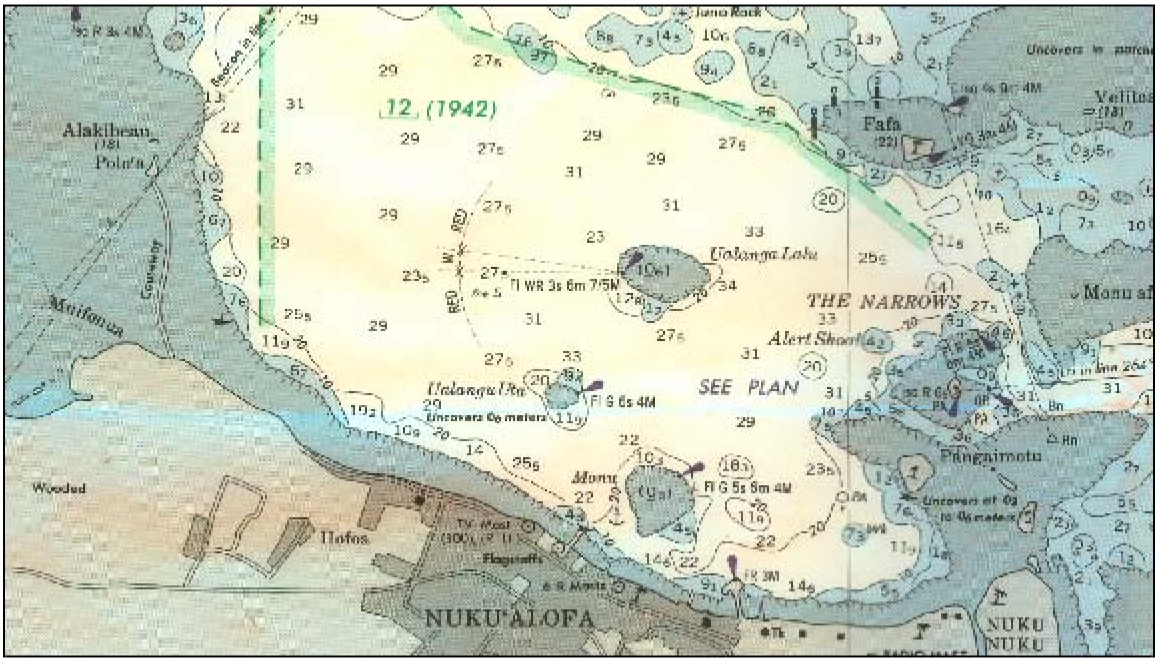
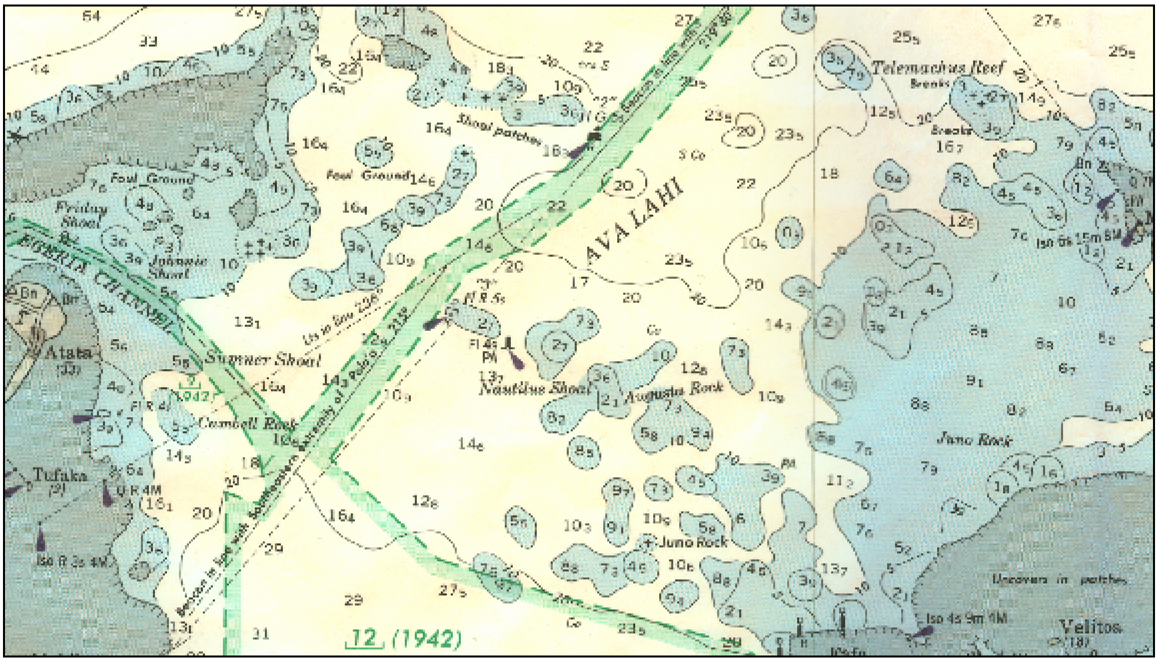


Figure 22. Nuku’alofa Harbour.



High risk waterway: Ava Lahi Passage—turn to 215°.

COUNTRY	Kingdom of Tonga
PORT	Nuku’alofa
HIGH RISK WATERWAY	Ava Lahi Passage—turn to 215°

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
161ft	369ft	547ft	1077ft	1980ft	1.8

Environment for simulation

Height of tide	0.5m	Wind direction	135°
Current direction	315°	Wind speed	15kts
Current speed	1.5kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The container vessel Coral Islander of 13320 DWT was the reference vessel for the MSD analysis. Positioning in the turn to 215° in Ava Lahi Pass is supported by a fixed aid in transit with a natural leadmark and a buoy. The positioning quality is underestimated by MSD in this case. With good visibility, the approach provides a security measure of at least 1.8.

1.1.1.5 Funafuti, Tuvalu

COUNTRY	Tuvalu
PORT	Funafuti Island, Funafuti Atoll
HIGH RISK WATERWAY	Te Ava Te Lape Pass

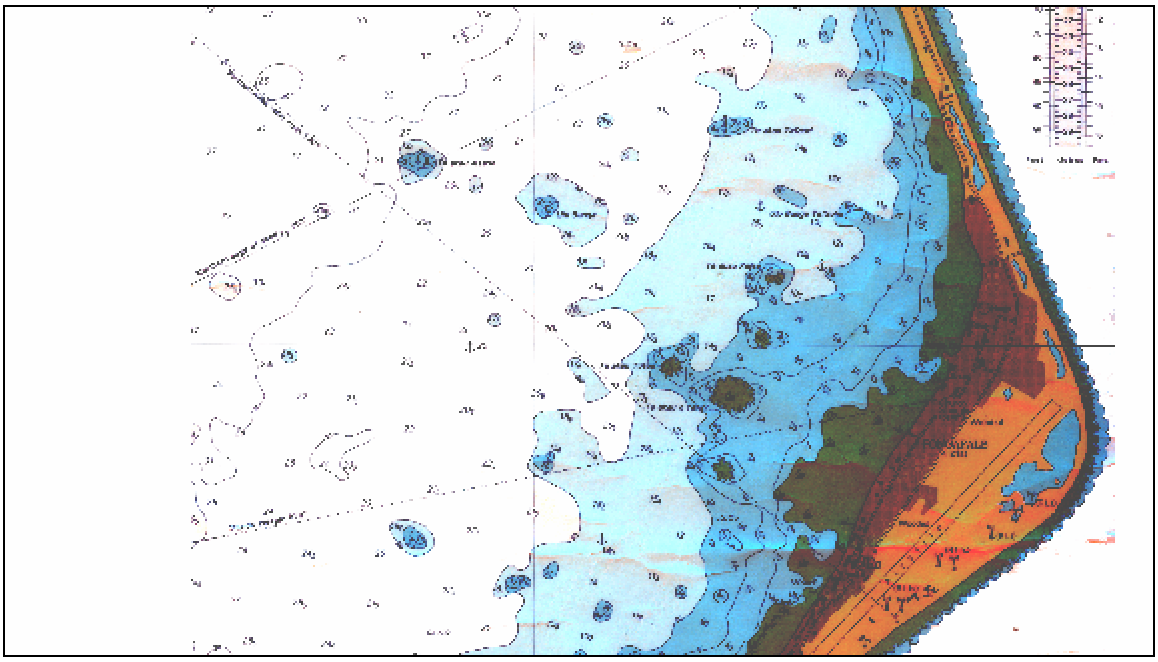
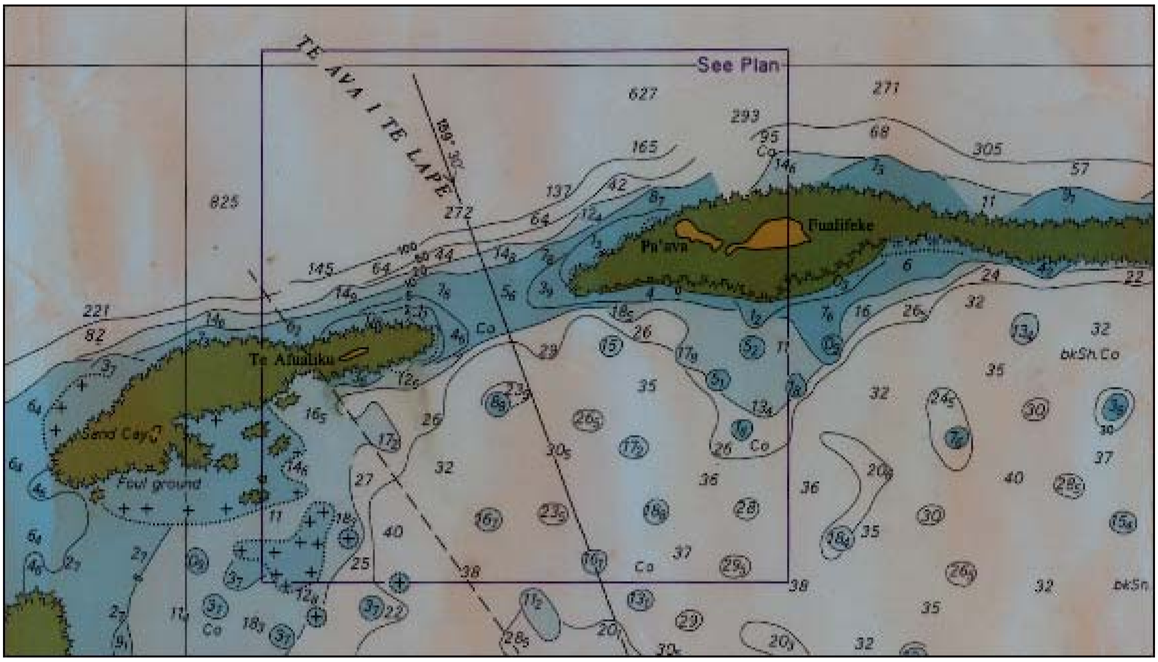


Figure 23. Funafuti, Tuvalu.



High risk waterway: Te Ava I Te Lape Pass.

COUNTRY	Tuvalu
PORT	Funafuti Island, Funafuti Atoll
HIGH RISK WATERWAY	Te Ava Te Lape Pass

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
86ft	70ft	200ft	356ft	1600ft	4.5

Environment for simulation

Height of tide	0.5m	Wind direction	045°
Current direction	200°	Wind speed	17kts
Current speed	4kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Pacific Explorer* of 1725 DWT was the reference vessel for the MSD analysis. Positioning in Te Ava Te Lape Pass is supported by two natural radar targets. Primarily due to the wide channel, a security measure of 4.5 is provided.

1.1.1 Port Risk Results F: Pago Pago, Papeete, Bounty Bay, Ile Futuna, Mata-Utu, Nauru.

1.1.1.1 Pago Pago, American Samoa

COUNTRY	American Samoa
PORT	Pago Pago Harbour, Tutuila Island
HIGH RISK WATERWAY	Harbour entrance

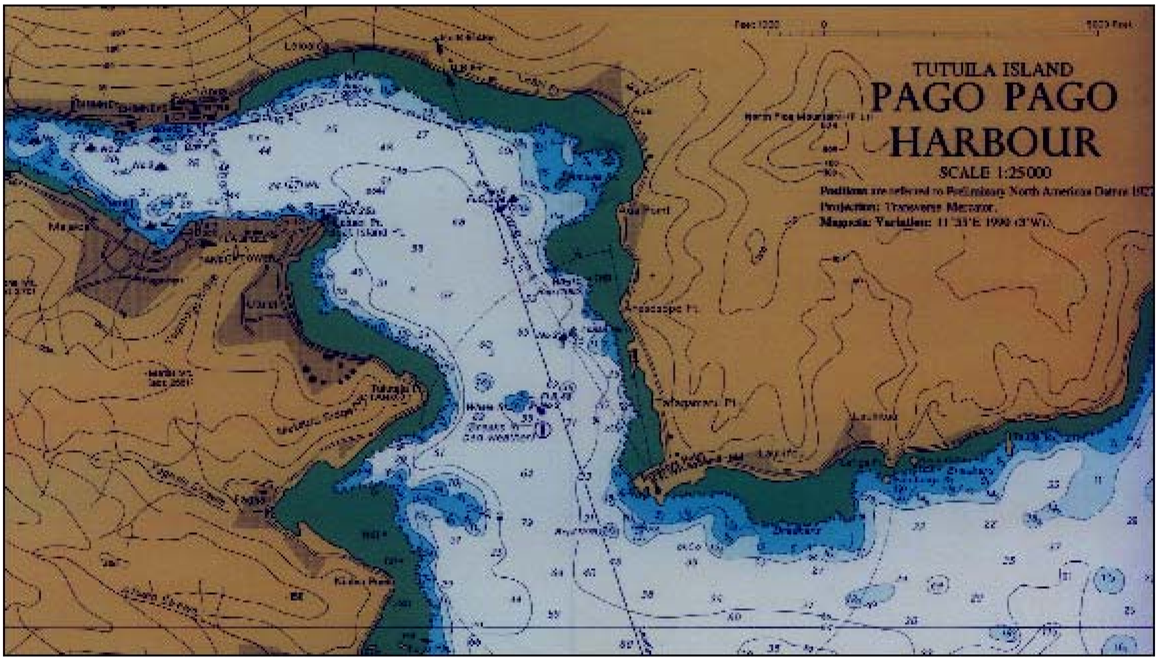
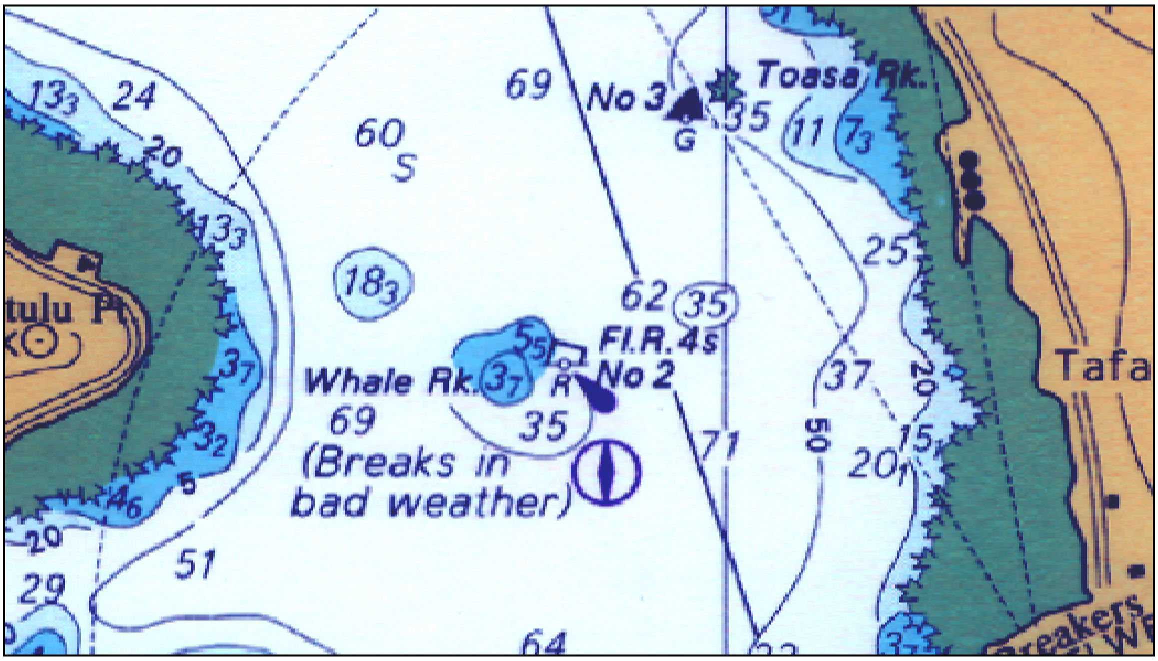


Figure 24. Pago Pago Harbour.



High risk waterway: Entrance to Pago Pago.

COUNTRY	American Samoa
PORT	Pago Pago Harbour, Tutuila Island
HIGH RISK WATERWAY	Harbour entrance

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
91ft	142ft	50ft	283ft	900ft	3.2

Environment for simulation

Height of tide	0.5m	Wind direction	135°
Current direction	160°	Wind speed	30kts
Current speed	1kt	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Conus* of 31950 DWT was the reference vessel for the MSD analysis. A range, a fixed aid, three buoys and multiple natural radar targets, supports positioning in the entrance to Pago Pago. With good visibility, the approach provides a security measure of 3.2.

1.1.1.2 Papeete, Tahiti, French Polynesia

COUNTRY	French Polynesia
PORT	Papeete
HIGH RISK WATERWAY	Passe de Papeete

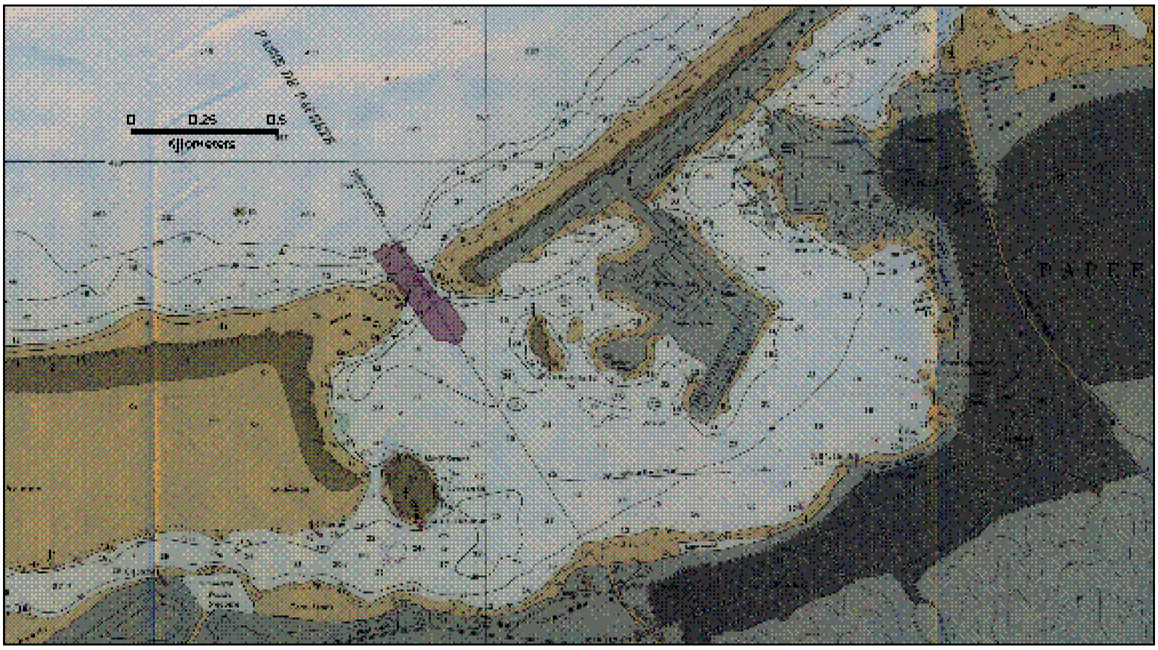
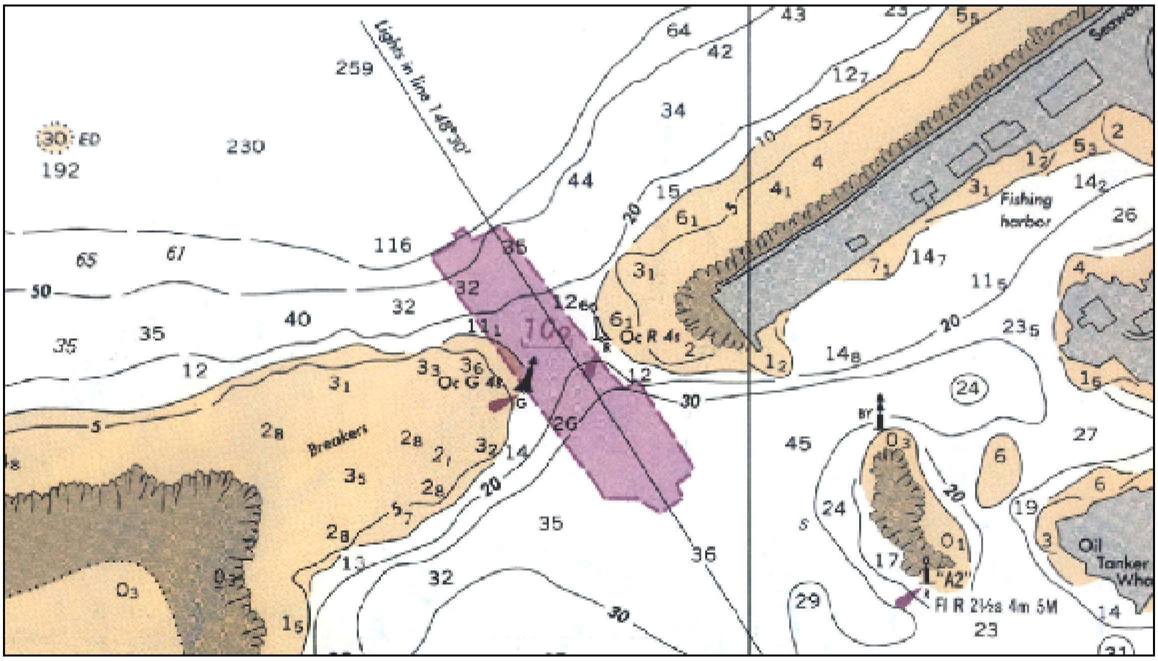


Figure 15. Papeete Harbour.



High risk waterway: Passe de Papeete.

COUNTRY	French Polynesia
PORT	Papeete
HIGH RISK WATERWAY	Passe de Papeete

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
138ft	146ft	50ft	334ft	340ft	1.0

Environment for simulation

Height of tide	0.3m	Wind direction	060°
Current direction	270°	Wind speed	15kts
Current speed	1kt	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Conus* of 31950 DWT was the reference vessel for the MSD analysis. A range, three fixed aids, two buoys and multiple natural radar targets, supports positioning in the Passe De Papeete. With good visibility, the approach provides a security measure of 1.

1.1.1.3 Bounty Bay, Pitcairn

COUNTRY	Pitcairn Islands
PORT	Bounty Bay
HIGH RISK WATERWAY	Approach to anchorage

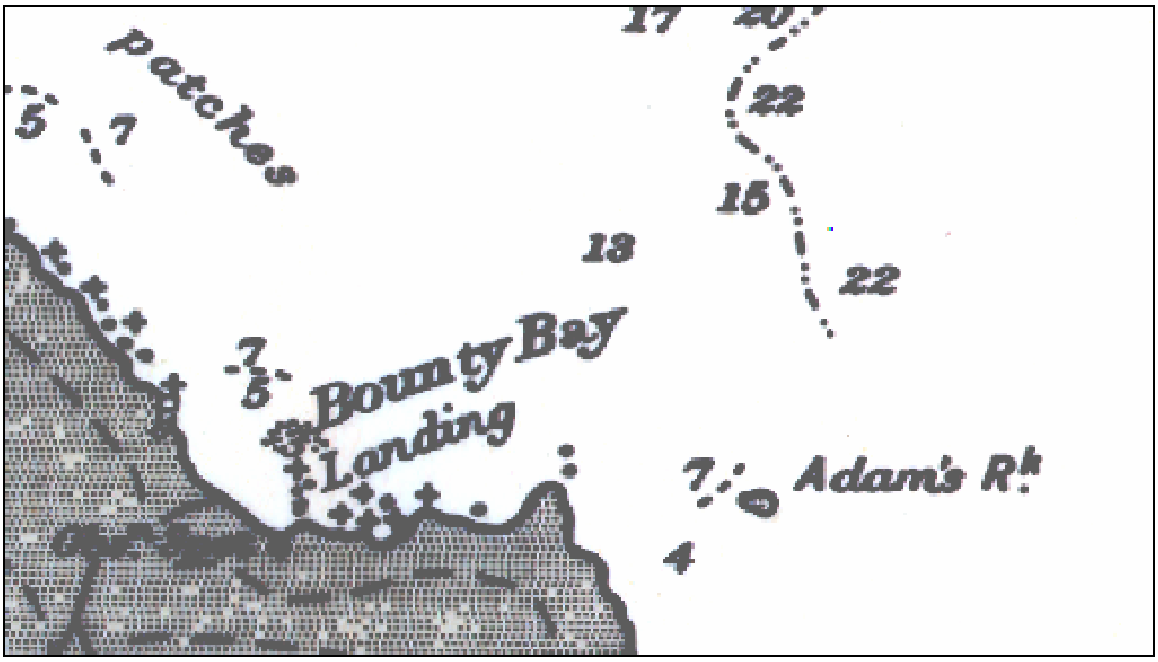
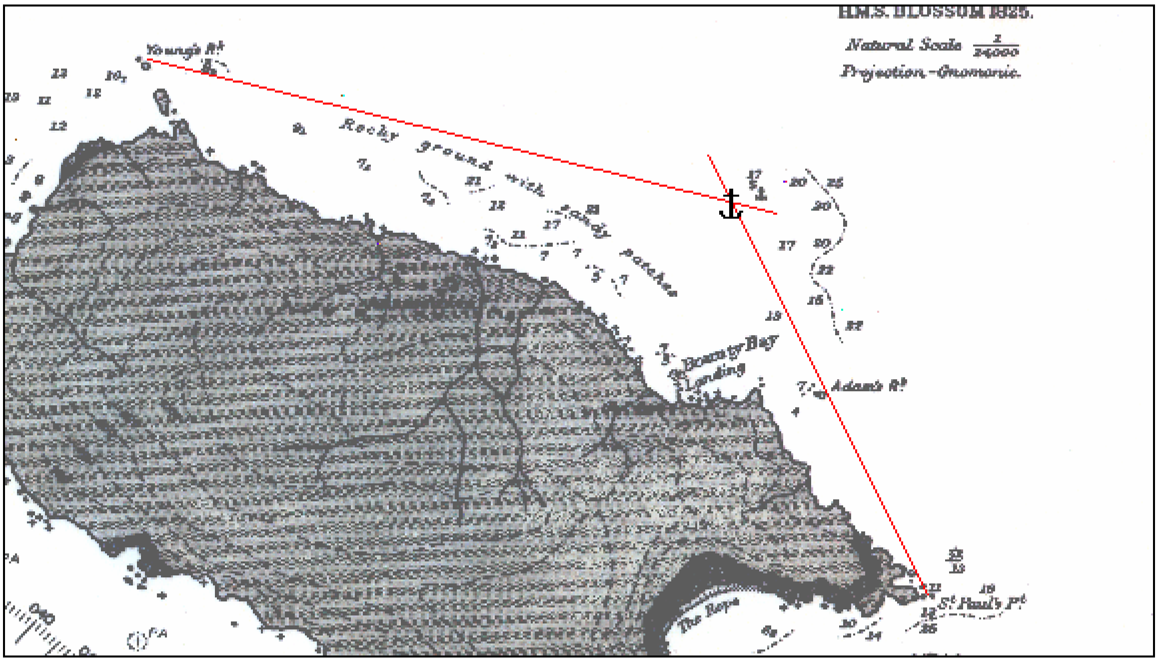


Figure 26. Bounty Bay, Pitcairn.



High risk waterway: Approach to anchorage.

COUNTRY	Pitcairn Islands
PORT	Bounty Bay
HIGH RISK WATERWAY	Approach to anchorage

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
49ft	28ft	200ft	277ft	2100ft	7.6

Environment for simulation

Height of tide	0m	Wind direction	315°
Current direction	270°	Wind speed	16kts
Current speed	0.5kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Petro Discoverer* of 3283 DWT was the reference vessel for the MSD analysis. Multiple natural radar targets support positioning on the anchorage approach. With good visibility and light west winds, this anchorage provides a security measure of 7.6.

1.1.1.4 Ile Futuna, Wallis and Futuna

COUNTRY	Wallis and Futuna
PORT	Ile Futuna
HIGH RISK	Ava Leava Anchorage

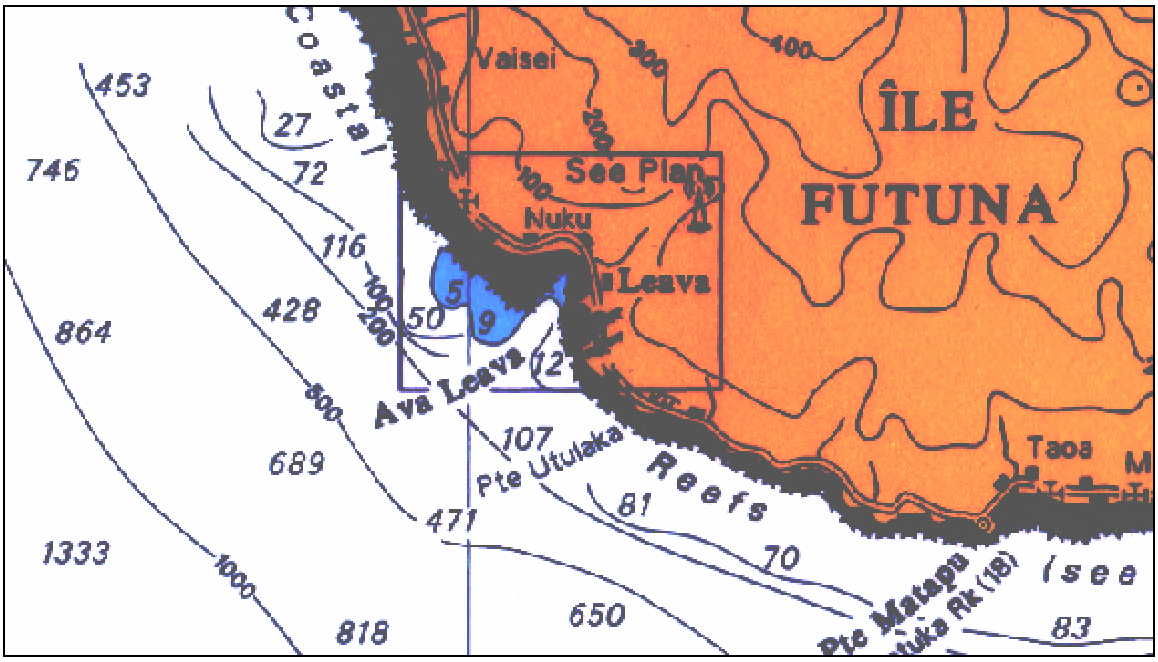
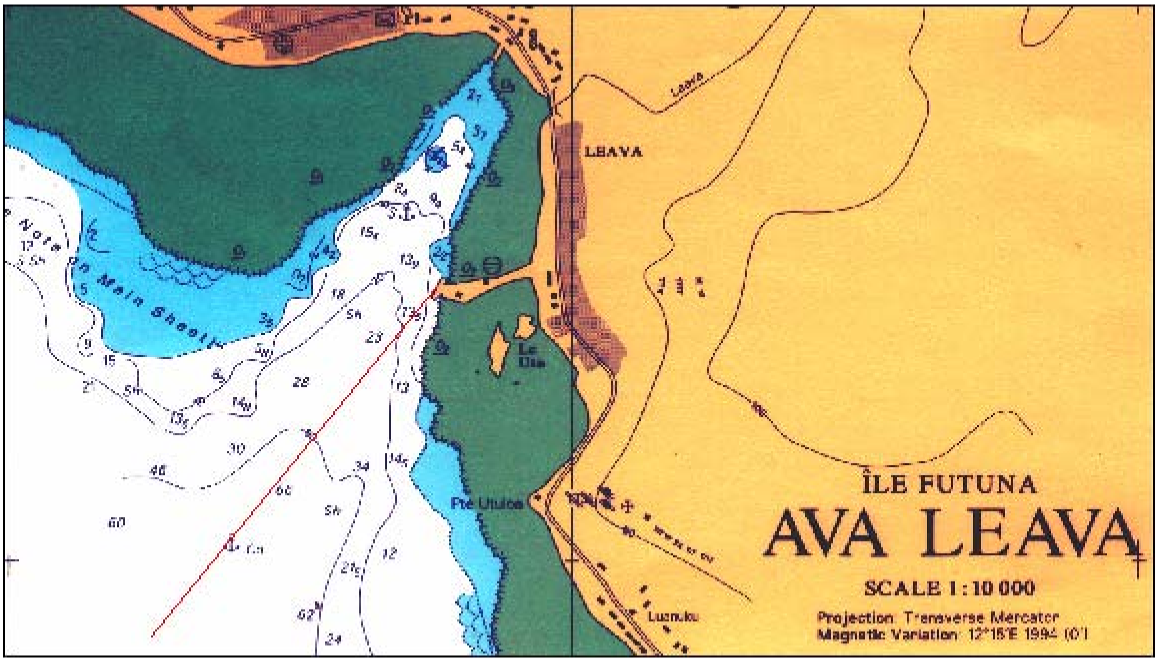


Figure 27. Ava Leava, (Ile Futuna).



High risk waterway: Approach to anchorage.

COUNTRY	Wallis and Futuna
PORT	Ile Futuna
HIGH RISK WATERWAY	Ava Leava Anchorage

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
66ft	44ft	200ft	310ft	600ft	1.9

Environment for simulation

Height of tide	0m	Wind direction	135°
Current direction	315°	Wind speed	25kts
Current speed	1kt	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Pacific Explorer* of 1725 DWT was the reference vessel for the MSD analysis. Positioning on the anchorage approach is supported by three natural radar targets and the jetty as a natural leadmark. With good visibility and light west winds, this anchorage provides a security measure of 1.9.

1.1.1.5 Mata Utu, Ile Uvea, Wallis and Futuna

COUNTRY	Wallis and Futuna
PORT	Mata Utu Harbour, Ile Uvea, Iles Wallis
HIGH RISK WATERWAY	Passe Honikulu

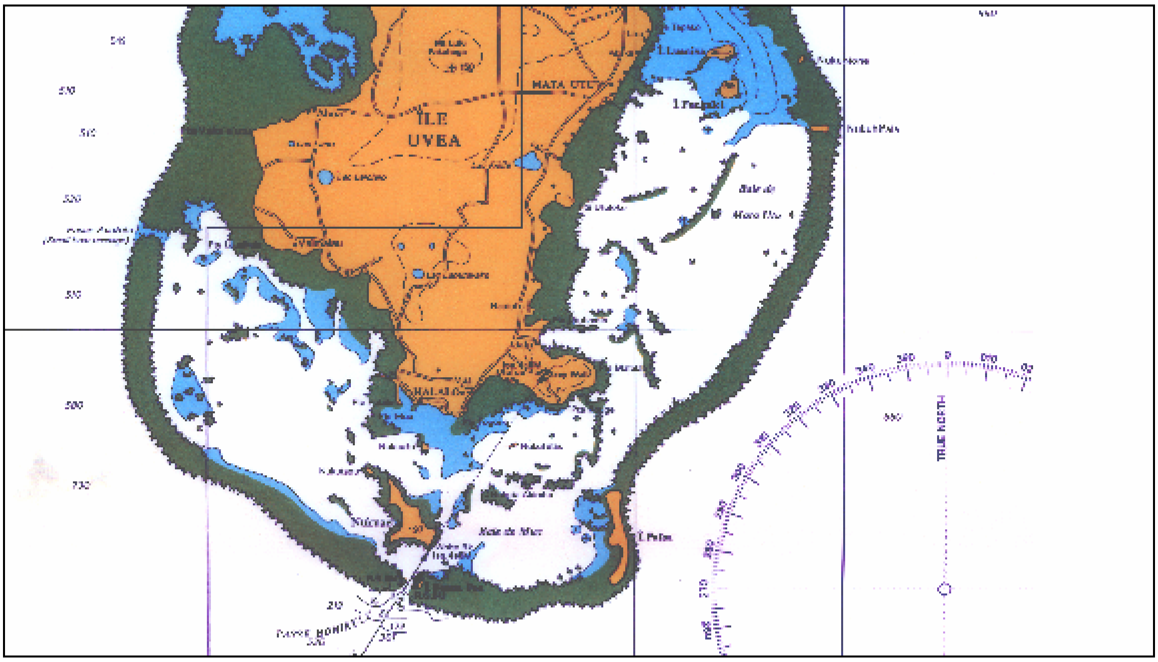


Figure 28. Mata Utu Harbour.

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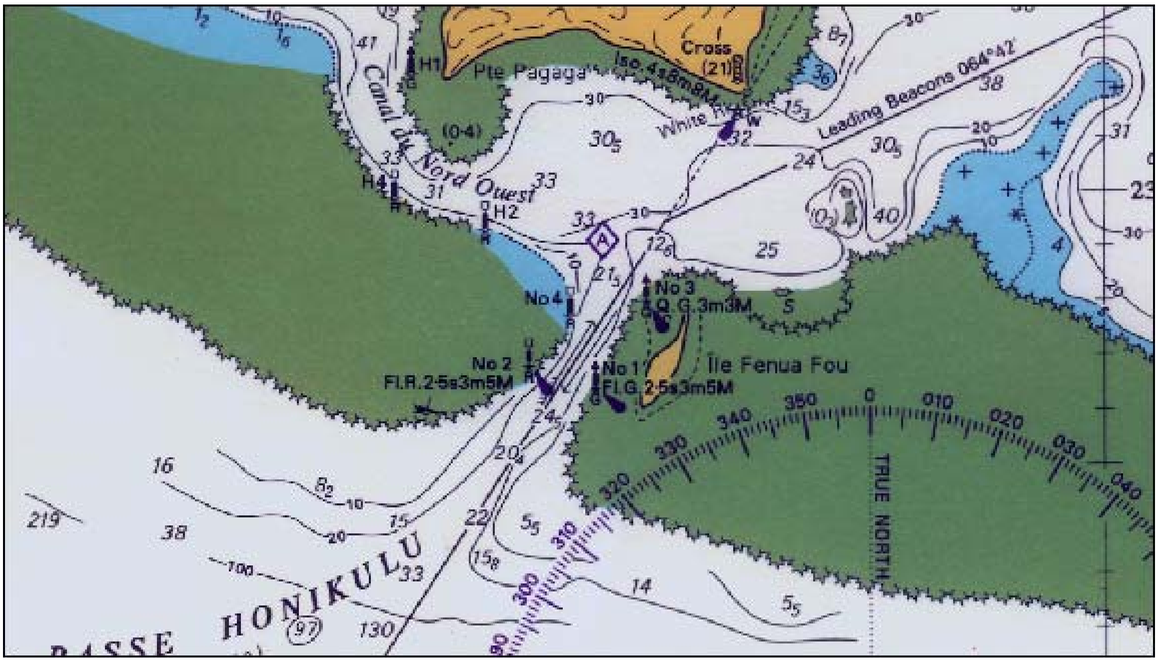


High risk waterway: Passe Honikulu.

COUNTRY	Wallis and Futuna
PORT	Mata Utu Harbour, Ile Uvea, Iles Wallis
HIGH RISK	Passe Honikulu

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
78ft	116ft	50ft	244ft	500ft	2.1

Environment for simulation

Height of tide	0m	Wind direction	135°
Current direction	360°	Wind speed	25kts
Current speed	2kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The tanker *Petro Discoverer* of 3283 DWT was the reference vessel for the MSD analysis. A range, a fixed aid, three buoys and three natural radar targets, supports positioning in Passe Honikulu. With good visibility, this channel provides a security measure of 2.1.

1.1.1.6 Nauru

COUNTRY	Nauru
PORT	Phosphate Moorings
HIGH RISK WATERWAY	Approach to cantilever & moorings

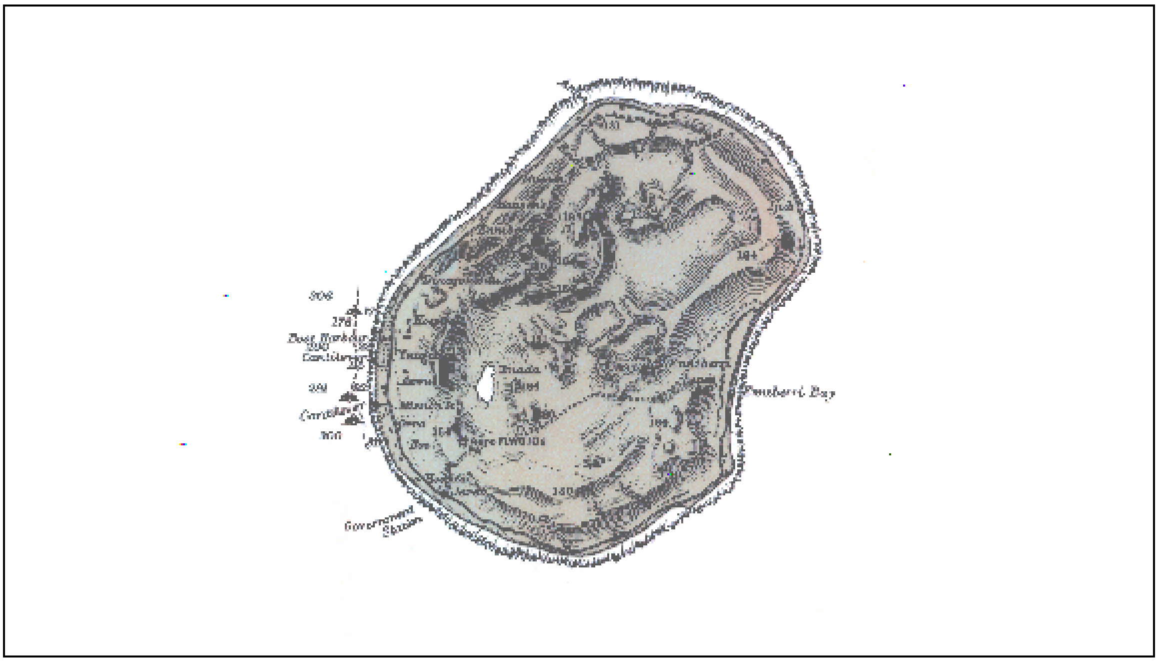
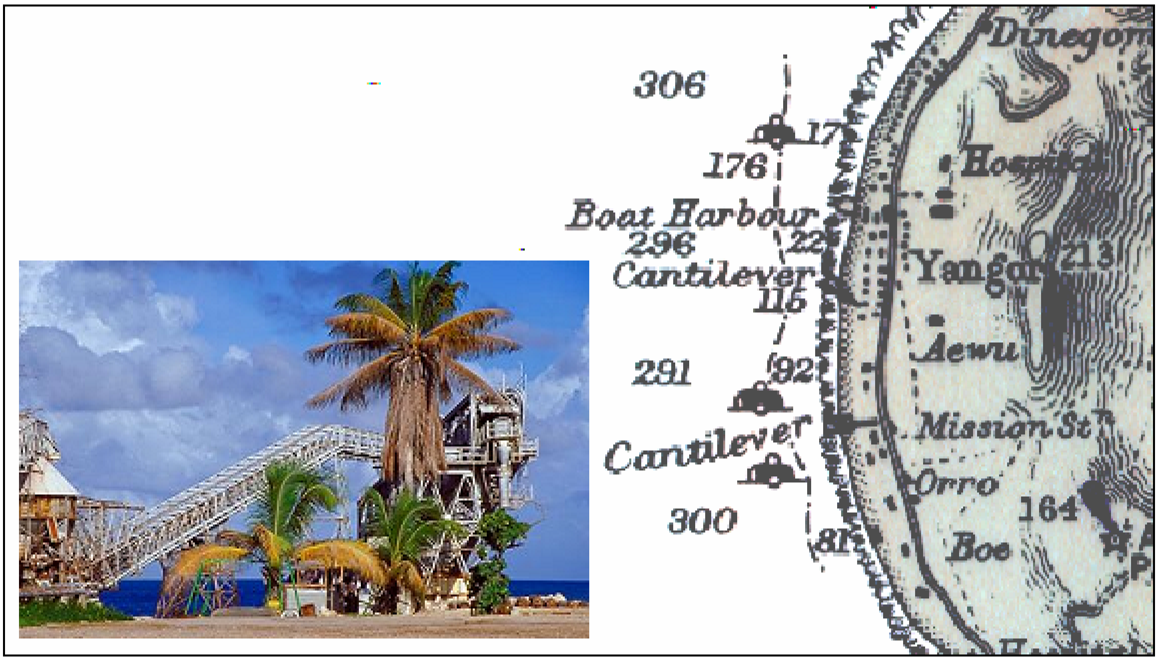


Figure 29. Nauru.



High risk waterway: approaches to phosphate moorings.

COUNTRY	Nauru
PORT	Phosphate Moorings
HIGH RISK WATERWAY	Approach to cantilever & moorings

Navigation Security Measure

Physical	Shiphandling	Positioning	Minimum Safe Design (MSD)	Channel Width (CW)	Security Measure (CW/MSD)
281ft	65ft	75ft	421ft	1000ft	2.4

Environment for simulation

Height of tide	0m	Wind direction	045°
Current direction	270°	Wind speed	25kts
Current speed	4kts	Vessel speed	10kts
Daylight	Yes	Existing aids	Yes

Discussion

The bulk carrier *Galea II* of 41010 DWT was the reference vessel for the MSD analysis. Vessels must be ready to get underway at all times. If wind is from the west and greater than a light breeze the vessel must leave the mooring. Positioning on approach to the head and stern mooring buoys is supported by the natural marks of the cantilever structures, as well as the mooring buoys. With good visibility, the approach provides a security measure of 2.4.

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1 DISCUSSION

Worldwide, there is a consistent and disturbing pattern of maritime casualties. About 0.2 to 0.3% of registered vessels become total losses each year, and nearly 1% are involved in serious incidents. Human error is the proximal cause for most of these casualties, but the sequence of events that set up an incident may stretch far away, perhaps to some combination of vessel construction, maintenance, management decision and government policy. It is not uncommon for vessels to simply break up at sea in heavy weather. Every serious maritime incident has the potential to cause marine pollution. The record of casualties and consequent pollution has improved in recent decades. Part of this improvement is attributable to the UN conventions SOLAS and MARPOL 73/78.

We based our analysis of casualty potential on the fact that a grounding or collision occurs when a ship attempts to occupy a space that already contains an obstruction or another vessel. The probability of such an event at each place in the area of interest is given by the product of two factors: the probability of a vessel at that place, and the presence of an obstruction or another vessel at the same place. In order to estimate the relative magnitude of this function we set a grid size at 1° (one degree) of latitude and longitude. A finer grid size, on the scale of navigational accuracy and vessel straying, would produce a better map of risk. Such refinement would be justified if we had equally accurate information on vessel courses.

Grounding is the most likely class of casualty in the Pacific Islands region. Our map of grounding potential shows large clusters of high risk in French Polynesia, Fiji, and around the Solomon Sea coasts of Papua New Guinea and Solomon Islands. The north/south passages east of Papua New Guinea (Jomard Entrance, Pioneer Channel) also form a high risk corridor. Direct bulk traffic from Australia to Japan along this corridor may be underestimated in our data. There are smaller clusters of high risk in Tonga, the Samoas, and Vanuatu, on the north/south corridor past Chuuk, Guam and the Northern Mariana Islands, and isolated patches of moderate grounding potential elsewhere, for example at Majuro and Tarawa.

Do the areas of high grounding potential correspond to the historical record of actual casualties? Comparison of Figure 5.2,. “Geographic distribution of casualties over 1000 GT, 1976 – 2002”. with Figure 6.3, “Grounding potential, Pacific Islands region." shows similar patterns. There are four clusters of casualties. Clusters in Fiji and the Solomon Sea are similar to the prediction. Those in the Samoas, mostly near Pago Pago, and in the Guam-Saipan corridor, seem to contain more incidents than the prediction. French Polynesia and New Caledonia show the reverse pattern; casualties there are sparse relative to the prediction. This may be the result of underreporting, good management, or just plain good luck. The correspondence between the maps of potential and historical casualties verifies the utility of our approach.

At the ports level, we used a different measure of the potential for casualties, one derived from a standard practice applied in Europe and North America. In this method, we calculated the ratio of available channel width in the most difficult part of the port entrance (CW), to minimum safe distance required for a given vessel type (MSD). This gives CW/MSD, a measure of the security of the passage. Of 28 ports assessed, four (Port Vila, Avatiu, Malakal (Koror) and Papeete have CW/MSD of 1.0 or less, meaning that they have less than the minimum channel width required for

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safe passage. The nine least secure passages include these four plus Saipan, Betio, Pohnpei, Madang and Honiara.

The combination of low security with high traffic volume is a measure of the potential for a marine pollution incident. We have compared all 29 ports in a map showing security measure, annual petroleum tanker traffic and total annual traffic for each port. Because the probability of an incident is greater with lower security measure, we have plotted the reciprocal (MSD/CW) to make longer bars represent greater risk for both security measure and traffic volume. We focus on tanker tonnage because tankers represent the greatest individual potential for harm. (Total tonnage is probably overestimated at some ports because default tonnages have been assigned to local ferry services where actual sizes are not available.) By inspection, the ports with the greatest risk of pollution from maritime incidents are Guam, Papeete, and Madang. Noumea, Suva and Vuda Point/Lautoka have high tanker volumes, but also moderate to high security measure. The security measure is improved at these ports by the presence of good aids to navigation and compulsory pilotage.

We note the occasional presence in the region of nuclear fuels and wastes, as well as other hazardous cargoes. This traffic has a relatively low probability of incident, but high consequence. These special cargoes are certainly significant in terms of pollution potential, but their risk cannot be adequately analysed in this broad and qualitative study.

We have no consistent area-wide information on areas of high environmental sensitivity. It is clear, however, that the entire region is one of special environmental concern because coral reefs are among the most sensitive of marine ecosystem types to oil and other forms of pollution. Thorhaug (1992) gives the order of sensitivity to marine pollution as: 1,corals >2, fish >3, seagrasses > 4, mangrove forests. Unfortunately coral reefs form not only the most sensitive ecotype, but also the most dangerous navigational hazards in the region. Coral surrounds almost every island, and offlying coral reefs can be difficult to see directly, on radar or on echosounders. If a vessel grounds, it is almost certain to ground on coral.

An analysis is only as good as the information on which it is based. Our information came from a variety of sources. We had some difficulty in reconciling the different types of information, and we cannot be sure that we have collected all of the desired information or eliminated all duplications. Some information has escaped because we did not find an appropriate source. Port authorities in every nation record last port/next port for international traffic, but few have comprehensive records of all traffic by major vessels, and even fewer have electronic databases with flexible ability to query them. We hope that the concrete example of this report will encourage Pacific Island nations to make the transition from manual port entry ledgers to comprehensive and regionally standardized computer databases of vessel traffic. Data stored is data useless unless it can be accessed and shared.

Another observation that arises from our data gathering is that different people see differently, depending on their occupations and worldviews. Some think in patterns of global connectivity, while others concentrate on practical detail. Port authorities, for example, are most familiar with arrivals and departures at their individual locations, while shipping agents may see connections to overseas ports, and mariners think of crews, vessels, routes and transit times. The challenge is to find ways to construct standardised information from a very diverse set of respondents.

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Even before any data collection, one must have a clear understanding of the questions to be asked and the methods that will be applied to answer them. This requires the establishment and consistent application of defined terms for the key concepts of the study. This technical vocabulary should be consistent with good scientific, industrial and regional practice. This sounds simple and obvious, but problems of language regularly arise when terms such as “risk”, “assess”, “hazard” and “casualty” have both broad common meanings and precise technical definitions that may be different from the common meanings. We have tried to apply terms precisely and consistently, while avoiding unnecessary technical language.

We have analysed the potential for groundings and collisions at the regional, country EEZ and port scales for the Pacific Islands region. The results allowed us to classify ocean areas and ports into locations of high, medium and low potential for marine casualties that have significant potential to cause marine pollution.

This study reduces a great volume of information to simple tables and thematic maps. All of it must be considered semiquantitative and subject to revision because it is stitched together from diverse sources. The general patterns are, however, informative, and include much more detail than can be brought out in a few summary maps and tables. The same data could answer many different questions. We hope these presentations will be useful, perhaps in ways yet to be discovered.

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DRAFT

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End References

MARINE POLLUTION RISK ASSESSMENT FOR THE PACIFIC ISLANDS REGION

(PACPOL PROJECT RA1)

VOLUME 2: APPENDICES

for
Pacific Ocean Pollution Prevention Programme (PACPOL),
South Pacific Regional Environment Programme (SPREP)

by
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VOLUME 2: APPENDICES

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Latu, Hua		*ph*	(676) 23 334
JFM Shipping Agency		*fx*	(676) 24 070
Nuku'alofa			
Faka'osifolau, Ma'ake		*ph*	(676) 22 699
Mark Shipping Ltd.		*fx*	(676) 24 099
Nuku'alofa			
Fuapau, L.	Assistant Marine Officer	*ph*	(676) 70 639
Ministry of Marine and Ports		*fx*	
GPO Neiafu			
Neiafu			
Vikilani, S.	Acting Secretary for Marine and Ports	*ph*	(676) 22 555
Ministry of Marine and Ports		*fx*	(676) 26 234
PO Box 144			marine@kalianet.to
Nuku'alofa			
Tu'inukuafe, Ms. Amelia		*ph*	(676) 23 311
Pacific Shipping Agencies		*fx*	(676) 23 195
Nuku'alofa			
Tufui, A.		*ph*	(676) 21 699
SCP Agency		*fx*	(676) 22 617
Nuku'alofa			

Tuvalu

Sinapati, Uale	Acting Director	*ph*	(688) 20 052
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Private Mail Bag			marine@tuvalu.tv
Funafuti			
Luaseve, Seve	Secretary	*ph*	(688) 20 052
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Private Mail Bag			
Funafuti			

Vanuatu

Roosen, John T.	Chief Executive Officer	*ph*	(678) 23 768
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PO Box 320, Maritime Resource Center, Marine quay			vma@vanuatu.com.vu
Port Vila			
Yvon, Firiam		*ph*	(678) 23 128
Vanuatu Maritime Authority		*fx*	(678) 22 949
PO Box 320			vma@vanuatu.com.vu

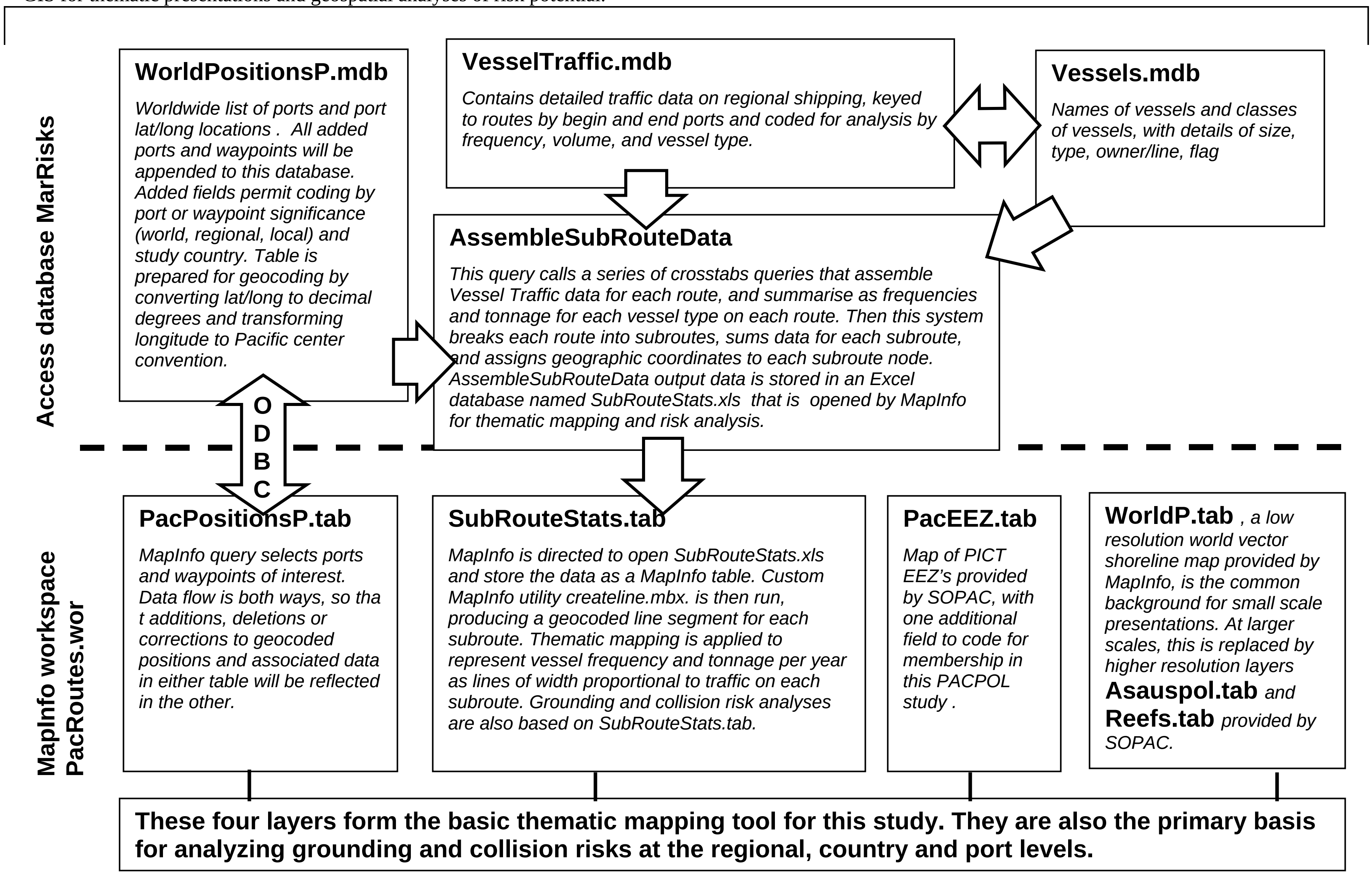
Port Vila

Wallis and Futuna

Lauvray, Joel			ph	(687) 27 5966
Port Autonome de la Nouvelle Caledonia			fx	(687) 27 5490
BP 14, 34 av. James Cook				noumeaportnc@canl.nc
Noumea	98845			
,			ph	(681) 72 2571
Service des Duanes et Affairs Maritimes			fx	(681) 72 2986
Aka'aka - District de Hahake BP 06				
Mata-Utu	98600			
Vanai, Paino		Chef du Service del'environnement	ph	(681) 720 351
Service Territorial de l'environnemen			fx	(670)
BP 294				senv@wallis.co.nc
Mata-Utu	98600			

1 APPENDIX 2: Database structure: Access databases and MapInfo GIS

The organizing principle for analysis was that Microsoft Access would be used as far as practical for primary data storage and statistical analysis, with MapInfo GIS for thematic presentations and geospatial analyses of risk potential.



Access database MarRisks

Casualties.mdb

Database of PICT region marine incidents, prepared for MapInfo geocoding in Pacific-centered convention. Casualties contains information from previous "Ship Groundings …" SPREP report, updated by reference to Lloyd's Casualty Archive and country reports

NQ2000.txt

Data on the actual positions of ships reporting to the International Meteorological Office Voluntary Observing Ships program. This information is opened into MapInfo table NQ2000ByVesselType and plotted for comparison with the routes in our main database on vessel traffic.

FishActiv.mdb

Database of fishing activities, including transshipment, derived from FFA annual reports. Because the information will relate mainly to areas rather than lines (courses) or points (ports, waypoints), it must be handled separately.

MapInfo workspaces

Casualties.tab

MapInfo thematic map showing casualty locations, by type and severity. Info Tool permits interactive reference to Casualties database text details.

NQ2000ByVesselType. Tab

Allows us to compare the actual position sequences of large commercial vessels with the routes inferred from interviews and sailing directions.

FishActiv.tab

MapInfo thematic map showing longline and purse seine tuna fishing activity..

EnvSensP.tab

Placenames and locations associated with discussions of environmental sensitivity, ballast/deballast operations, etc.Locations digitised directly in Mapinfo and data added in browser or info tool.

Auxiliary databases and map layers

1 APPENDIX 3: Vessels, Positions and Traffic

The Microsoft Access database MarRisk2.mdb contains all of the raw data on vessels, vessel traffic, positions and routes. The primary tables are quite large – about 1911 vessel traffic records for 656 vessels over 5017 route segments between 918 positions. Here we present the database table structures as an introduction to the electronic databases, which are provided on compact disk. Printed records can be obtained by running the report utilities PrintVessels, PrintVesselTraffic PrintPacPositionsP and PrintRoutesSubRoutes provided in MarRisk2.mdb:.

The “2” in MarRisk2.mdb refers to the fact that it is an Access 2002 database.MarRisk.mdb is the same data and functionality in an Access 97 database.

Structure of Microsoft Access database MarRisk2.mdb

Table: ISO3166CountryCodes

Properties

ISO 3166 is the list of official country names, two-character country codes and 3-character codes.

Columns

Name	Type	Size
ID	Long Integer	4
Country	Text	50
ISO2	Text	5
ISO3	Text	5
ISONumber	Text	5

Table: PositionTypes

Properties

Codes to distinguish position types, for example P1 for major world ports, W1 for ocean waypoints.

Columns

Name	Type	Size
ID	Long Integer	4
Position_Type	Text	2
Comment	Memo	

Table: MAPINFO_MAPCATALOG

Properties

MapInfo internal bookkeeping

Columns

Name	Type	Size
SPATIALTYPE	Double	8
TABLENAME	Text	32
OWNERNAME	Text	32
SPATIALCOLUMN	Text	32
DB_X_LL	Double	8
DB_Y_LL	Double	8
DB_X_UR	Double	8
DB_Y_UR	Double	8
COORDINATESYSTEM	Text	254
SYMBOL	Text	254
XCOLUMNNAME	Text	32
YCOLUMNNAME	Text	32

Table: PositionTypes

Properties

List of standard codes to distinguish positions by type, for example P1 for major world port, W for waypoint.

Name	Type	Size
ID	Long Integer	4
Position_Type	Text	2
Comment	Memo	-

Table: RoutesSubRoutes

Properties

Table of the subroutes that form the line segments of each route from port to port. All Routes and Subroutes are named by their begin and end position codes from WorldPositionsP.

Columns

Name	Type	Size
MAPINFO_ID	Long Integer	4
RouteName	Text	11
PACPOLArea	Text	1
SubRouteBegin	Text	5

SubRouteEnd	Text	5
OrderInRoute	Integer	2
SubRouteName	Text	10

Table: Vessels

Properties

Vessel names, tonnages, flags and other characteristics.

Columns

Name	Type	Size
VesselID	Long Integer	4
Line	Text	30
VesselOrClass	Text	30
VesselType	Text	5
Flag	Text	5
GRT	Long Integer	4
LOA	Integer	2
TEU	Integer	2
DWT	Long Integer	4
YearBuilt	Integer	2
SpeedKn	Single	4
Passengers	Integer	2
Crew	Integer	2
VesselComment	Memo	-

Table: VesselTraffic

Properties

The main table of detailed data on traffic from port to port by vessel and voyages/year.

Columns

Name	Type	Size
VeTrID	Long Integer	4
VesselOrClass	Text	30
RouteBegin	Text	5
RouteEnd	Text	5
Variant	Text	1
RouteName	Text	11
Frequency	Single	4
Comment	Memo	-
DataYear	Text	5
DataCollBy	Text	3
DataEntryBy	Text	3
LastEditBy	Text	3
LastEditDate	Date/Time	8

Table: VesselTypes

Properties

Columns

Name	Type	Size
VeTyID	Long Integer	4
ListOrder	Integer	2
VesselType	Text	5
VesselTypeDef	Text	50
DefaultGRT	Long Integer	4
DefaultDWT	Long Integer	4
DefaultTEU	Integer	2
DefaultPopulation	Integer	2
Comment	Memo	-

Table: WorldPositionsP

Properties

A large list of world ports, plus ports and waypoints added for this study, coded for position type, and including coordinates in Lat/Long by decimal minutes (traditional) and decimal degrees (for MapInfo)XCOORDP contains decimal degree longi in Pacific-centered format (0-360 degrees eastward)

Columns

Name	Type	Size
MAPINFO_ID	Long Integer	4
Position	Text	50
P_Code	Text	5
Country	Text	50
C_Code	Text	5
Position_Type	Text	5
PacIsland	Text	5
Latitude	Text	10
Longitude	Text	11
XCOORD	Single	4
YCOORD	Single	4
XCOORDP	Single	4

1 APPENDIX 4: Casualties

Provisional database of ship casualties with significant potential to cause marine pollution. January 1976 – October 2000, in 22 Pacific Island countries and territories

Key to abbreviations

Vessel Type

Toil	Tanker (crude oil and petroleum products)
Tchem	Tanker (chemicals)
Tlpg	Tanker (LPG)
Ctr	Container vessel
RoRo	Roll-on roll-off cargo vessel
CG	Mixed cargo (break bulk)
Bulk	Bulk cargo
OBO	Oil-bulk-ore
R	Reefer
FC	Ferry (Cargo and passenger)
FP	Ferry (primarily passenger)
SP	Specialized function
FV	Fishing Vessel
LC	Landing Craft
Other	Other
CL	Cruise Liner
U	Unknown

Incident type

G	Grounding (details unknown)
GP	Grounding under power
GD	Grounding adrift
C	Collision
F	Fire
M	Mechanical
H	Hull
S	Storm
O	Other
U	Unknown

Severity of incident

T	Total loss
P	Partial loss
M	Minor Damage
U	Unknown

Structure of database CasualtyReports2.mdb

Table: Casualties

Properties

The table of casualties with significant pollution potential in the Pacific Islands Region, 1976-2002 – coded by type and severity, and georeferenced.

Columns

Name	Type	Size
ID	Long Integer	4
VesselName	Text	50
Flag	Text	20
Type	Text	20
GRT	Long Integer	4
YearBuilt	Integer	2
DateIncident	Date/Time	8
CountryOfIncident	Text	50
LocationName	Text	50
Latitude	Text	10
Longitude	Text	11
TypeIncident	Text	5
Severity	Text	5
Comments	Text	255
YCOORD	Single	4
XCOORD	Single	4
XCOORDP	Single	4
CoordChangeFlag	Yes/No	1

Table: IncidentTypeCodes

Properties

Columns

Name	Type	Size
ID	Long Integer	4
IncidentTypeCode	Text	50
IncidentType	Text	50

Table: ISO3166CountryCodes

Properties

Columns

Name	Type	Size
ID	Long Integer	4
Country	Text	50
ISO2	Text	5
ISO3	Text	5
ISONumber	Text	5

Table: MAPINFO_MAPCATALOG

Properties

MapInfo internal bookkeeping

Columns

Name	Type	Size
SPATIALTYPE	Double	8
TABLENAME	Text	32
OWNERNAME	Text	32
SPATIALCOLUMN	Text	32
DB_X_LL	Double	8
DB_Y_LL	Double	8
DB_X_UR	Double	8
DB_Y_UR	Double	8
COORDINATESYSTEM	Text	254
SYMBOL	Text	254
XCOLUMNNAME	Text	32
YCOLUMNNAME	Text	32

Table: VesselTypes

Properties

Standard vessel type categories, with default tonnage values.

Columns

Name	Type	Size
VeTyID	Long Integer	4
ListOrder	Integer	2
VesselType	Text	5
VesselTypeDef	Text	50
DefaultGRT	Long Integer	4
DefaultDWT	Long Integer	4
DefaultTEU	Integer	2
DefaultPopulation	Integer	2
Comment	Memo	-

Detailed contents of table Casualties

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity / Longitude	Year Built	Comments
Hoto Maru	JP	U	60	1978	Sank. All crew rescued.
-		U	T		
-					
Celtic Kiwi	NZ	U	0	0	Sank after leaving NZ. 13 crew members rescued by 'Rock Steady' and brought to NZ. Was carrying 850 tonnes of cement.
-	27-Oct-1991	O	T		
-					
Michelangelo	-	FV	1066	1970	Stranded, refloated & proceeded to Whangarei for repairs. Vessel sank whilst proceeding to Whangarei.
American Samoa	22-Dec-1978	GP	T		
Reef Outside Tafuna Airport, Tutuila		14°21.00'S	170°49.00'W		
Hsiung Hsing	-	FV	187	1977	Wrecked. During salvage operations ship capsized
American Samoa	09-Jun-1980	GP	T		
Off Tutuila Island		14°17.00'S	170°39.00'W		
Jui Man No.3	-	FV	216	1969	Wrecked in heavy weather. Cargo fish. Extensive damage to double bottom allowed small quantity of fuel to leak out. Failry extensive damage. Fire after grounding.
American Samoa	08-Apr-1981	GP	P		
Off Pago Pago		14°16.70'S	170°35.20'W		
Kwang Myung No. 65	-	FV	352	1968	Stranded, refloated, taken to inner port where sank, remaining partly submerged. Oil and fuel removed from vessel. 12 tonnes of oil collected from beach and disposed of.
American Samoa	31-Oct-1982	GP	T		
Pago Pago, Samor Island		14°18.00'S	170°38.00'W		

Vessel Name Flag Type GRT Year Built Comments
Country of Incident Date of Incident Type Incident Severity
Location Name Latitude Longitude

Young Kwang No.1	-	FV	233	1963	Wrecked in heavy weather. Vessel holed and engine room
American Samoa	22-Jun-1985	GP	T		flooded
Aunun (Aunuu?) Island		14°17.00'S		170°33.00'W	
Fotu o Samoa	-	LC	271	1979	Stranded, refloated, taken to Pago Pago for survey and
American Samoa	22-Mar-1991	GP	P		repair. Bottom buckled and distorted. Damage to a tank
Reef at Fa'asouga Point, Tau Island		14°17.00'S		169°31.00'W	and rudder.
Koram No.3	-	FV	304	1973	Wrecked on reef during Cyclone Val (6-10 Dec 1991).
American Samoa	08-Dec-1991	GD	T		Removed from reef and sunk in deep water on 16 Mar
Pagopago Harbour		14°17.00'S		170°40.00'W	2000.
Koram No.1	-	FV	304	1973	Wrecked on reef during Cyclone Val (6-10 Dec 1991).
American Samoa	08-Dec-1991	GD	T		Later cut down to water line and scrap metal dumped at
Pagopago Harbour		14°17.00'S		170°40.00'W	sea.
Kwang Myung No.63	-	FV	352	1968	Wrecked on reef during Cyclone Val (6-10 Dec 1991).
American Samoa	08-Dec-1991	GD	T		Later cut down to water line and scrap metal dumped at
Pago Pago Harbour		14°17.00'S		170°40.00'W	sea.

Vessel Name	**Flag**	**Type**	**GRT**	**Year Built**	**Comments**
Country of Incident	**Date of Incident**	**Type Incident**	**Severity**		
Location Name		**Latitude**		**Longitude**	
Kwang Myung No.51	-	FV	347	1967	Wrecked on reef during Cyclone Val (6-10 Dec 1991).
American Samoa	08-Dec-1991	GD	T		Later cut down to water line and scrap metal dumped at
Pago Pago Harbour		14°17.00'S		170°40.00'W	sea.
Miga No.5	-	FV	0	0	Wrecked on reef during Cyclone Val (6-10 Dec 1991).
American Samoa	08-Dec-1991	GD	T		Later cut down to water line and scrap metal dumped at
Pagopago Harbour		14°17.00'S		170°40.00'W	sea.
Yute No.1	-	FV	0	0	Wrecked on reef during Cyclone Val (6-10 Dec 1991).

American Samoa	08-Dec-1991	GD	T			Removed from reef and sunk in deep water 19 Mar2000.
Pagopago Harbour		14°17.00'S		170°40.00'W		
<u>**Korbee No.7**</u>	-	FV	304		1974	Wrecked on reef during Cyclone Val (6-10 Dec 1991).
American Samoa	08-Dec-1991	GD	T			Later cut down to water line and scrap metal dumped at
Pago Pago Harbour		14°17.00'S		170°40.00'W		sea.
<u>**Kwang Myung No.72**</u>	-	FV	346		1969	Wrecked on reef during Cyclone Val (6-10 Dec 1991).
American Samoa	08-Dec-1991	GD	T			Later cut down to water line and scrap metal dumped at
Pagopago Harbour		14°17.00'S		170°40.00'W		sea.
<u>**Kwang Myung No.58**</u>	-	FV	347		1968	Wrecked on reef during Cyclone Val (6-10 Dec 1991).
American Samoa	08-Dec-1991	GD	T			Later cut down to water line and scrap metal dumped at
Pagopago Harbour		14°17.00'S		170°40.00'W		sea.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Amiga No.5	-	FV	284	1970	Stranded during Cyclone Val
American Samoa	10-Dec-1991	GP	T		
Pago Pago		14°17.00'S		170°40.00'W	
Kao Ya No.137	TA	FV	560	1990	Collided with BHP fuel dock causing a spill of 600 gallons of oil into harbour.
American Samoa	13-Nov-1996	C	P		
Pagopago Harbour		14°21.00'S		170°40.00'W	
Adriatic Sea	US	FV	1559	1970	Sank in rough seas. Crew safely rescued.
American Samoa	23-Jan-1998	S	T		
90 miles north of Tutuila		12°40.00'S		170°50.00'W	
Capt. Cristiano da Rosa	US	FV	1348	1986	Reported taking on water. Safely towed to Pagopago
American Samoa	04-Oct-1998	M	M		
One mile off American Samoa		13°35.00'S		169°42.00'W	
Laura	FR	CG	0	0	Sunk. Developed engine problems in rough seas and developed a heavy list. Crew abandoned vessel and were later rescued. Vessel was being towed when it sank.
Australia	26-Feb-1998	M	T		
Near Wessel Island		10°50.00'S		137°30.00'E	
Teknik Putra	PA	Other	1009	1980	Vessel grounded lightly. Refloated with tug assistance. Minor damage to propellor, none to hull.
Australia	24-Jan-2000	GP	M		
Thursday Island		10°34.28'S		142°14.90'E	
Pratidina 05	ID	FV	0	0	Vessel grounded. Ten crew removed and returned to Indonesia. Vessel not found by subsequent aircraft patrols, presumed sunk.
Australia	13-Nov-2000	U	T		
Numar Reef, Torres Strait					
Doric Chariot	GR	Bulk	0	0	Vessel ran aground northbound after failing to execute a planned turn. Cargo coal. Extreme damage to Breat Barrier Reef feared, but vessel was refloated with tug
Australia	29-Jul-2002	GP	P		
Piper's Reef, 330 nmi N Cairns		12°15.00'S		143°14.00'E	

					assistance on 08 Aug 02. No oil or cargo lost. TBT antifoulant and mechanical damage to reef.
Aremiti	PF	FC	608	1994	Enroute Singapore to Fiji. Entered Stephens Islet due to taking water. Proceeded to Cairns for repairs.
Australia?	17-Aug-1996	H	M		
Stephens Islet		09°30.00'S		143°33.00'E	
Shotoku Maru No.65	-	FV	339	1962	Stranded, refloated and towed to Suva. Condemned.
Cook Islands	24-Aug-1978	GP	P		
Nassau Island		11°33.00'S		165°25.00'W	
Lien Ho No.1	-	FV	162	0	Wrecked in heavy weather. Crew rescued from Pukapuka Island.
Cook Islands	02-Mar-1981	GP	T		
Reef off Pukapuka Island		10°55.00'S		165°51.00'W	
Manuvai	-	CG	284	1960	Stranded. Holed during refloating attempts.
Cook Islands	28-Dec-1988	GP	T		
Reef at Nassau Island		12°00.00'S		168°00.00'W	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Edna	-	CG	132	1918	Stranded after dragging anchors in heavy weather
Cook Islands	28-Nov-1990	GD	P		
Atui (Atiu) Island		20°02.00'S		158°07.00'W	
Fiammetta	GB	U	9	1957	Dragged anchor, drifted onto rocks and sank.
Cook Islands	13-Aug-1991	GD	T		
Avarua Harbour		21°12.00'S		159°47.00'W	
Marthalina	NZ	U	0	0	Ran aground. Later floated off with no damage.
Cook Islands	21-Feb-1992	GP	M		
Penrhyn Island		09°00.00'S		158°00.00'W	
Acadea B	US	FV		1977	Damaged while berthed at Rarotonga during Cyclone 'Gene'. Vessel had disabled engine.
Cook Islands	16-Mar-1992	S	M		
Rarotonga		21°12.00'S		159°47.00'W	
Acadea B	CK	CG	69	0	Sank enroute to Northern Islands. Overloading of cargo possible cause
Cook Islands	02-Sep-1995	O	T		
-		16°56.00'S		159°10.00'W	
Kaunitoni	FJ	FP	384	1975	Disabled (engine breakdown) and adrift at sea on way from Rarotonga to Mururoa Atoll to take part in protest against resumption of nuclear testing. Towed to Rarotonga for repairs.
Cook Islands	02-Sep-1995	M	M		
350 nautical miles east of Rarotonga		21°13.54'S		154°18.34'W	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Orongo	-	Tug	0	0	Tug and lighter went aground in heavy rain and poor
Cook Islands	04-Jan-1996	C	P		visibility. Subsequently salvaged.
Reef at Aitutaki, north of passage		18°50.00'S		159°40.00'W	
Kura Ora	PF	U	299	1967	Foundered after ingress of water in hold through crack in
Cook Islands	30-Sep-1996	H	T		shell plating.
Two miles off Pukapuka		10°40.00'S		165°35.00'W	
Avatapu	NZ	FC	0	0	Abandoned by passengers/crew. Vessel since not sighted
Cook Islands	21-Feb-1997	O	T		and presumed to have sunk
-		20°30.00'S		160°30.00'W	
Aroa Nui	CK	CG	117	1968	Stranded. Engine room holed and flooded. Expected to be
Cook Islands	15-Jun-1998	GP	T		constructive total loss.
Reef at Atiu		19°59.00'S		158°08.00'W	
Thor Lisbeth		Ctr	1395	0	Ran aground on a reef. Able to free herself. Proceeded to
Cook Islands ?	06-Nov-1995	GP	M		Rarotonga
-		19°31.40'S		159°43.72'W	
Ika Vuka	-	CG	180	1944	Stranded, refloated and taken to Savusavu Bay.
Fiji	27-Feb-1977	GP	T		Condemned. Cargo copra.
Reef off Toberua Island		17°58.00'S		178°45.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Ji Nam No.22	-	FV	194	1965	Grounded, refloated and towed to Suva for repairs.
Fiji	16-Feb-1978	GP	P		
Southern Reef		18°30.00'S		177°55.00'E	
Nam Hai No.231	-	FV	159	1965	Grounded in heavy rain on dark night. Subsequently capsized in heavy seas during 2nd salvage attempt. Crew taken off and vessel abandoned. Cause unknown currents. Attempts to salvage remaining cargo (bulk fertiliser)
Fiji	14-Mar-1978	GP	T		
Off Suva Harbour on reef		18°10.00'S		178°25.00'E	
Mobil Producer	-	Toil	18258	1974	Stranded on soft mud patch. Refloated without any assistance, examined and proceeded. Minimal damage.Sailed for Singapore.
Fiji	09-Jun-1978	GP	M		
North of Viti Levu		17°12.90'S		177°33.40'E	
Akhilles	-	FV	2654	1970	Grounded, refloated with assistance of sister ships and continued on voyage.
Fiji	15-Nov-1978	GP	M		
On Reef Suva Harbour		18°10.00'S		178°24.00'E	
Cenpac Rounder	-	FP	3179	1961	Stranded in heavy weather (winds from passing cyclone). Refloated, towed to Suva and thence taken to Busan and broken up.
Fiji	28-Mar-1979	GP	T		
Votualailai Reef, Off Suva		18°30.00'S		177°40.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Colville	-	CG	123	1943	Stranded and sank. Raised, repaired and refitted.
Fiji	18-Apr-1979	GP	T		
Reef off Tavua		17°20.00'S		177°53.00'E	
Tui Cakau II	-	RoRo	1965	1961	Stranded, refloated without assistance and continued on voyage. Some bottom damage.
Fiji	26-Jul-1979	GP	M		
Off Lautoka		17°31.00'S		177°24.00'E	
Kwang Myung No.9	-	FV	236	1966	Stranded, refloated and taken to Suva for repairs. Prior to refloating fish and bait were removed by helicopter. Moderate damages to 80% of bottom extending to P&S bilge keels. No damage to stern gear and skeg.
Fiji	22-Mar-1980	GP	P		
Cakaulekaleka Reef, SW of Vatulele		18°28.00'S		177°37.00'E	
Pacific Gas	-	Tlng	903	1967	Stranded, refloated without assistance and proceeded to Suva for discharge. Shell plating set up in isolated places.
Fiji	08-Nov-1980	GP	P		
1 mile north of Navula Light		17°53.00'S		177°12.00'E	
Nam Pyung No.5	-	FV	218	1962	Stranded, refloated with tug assistance and proceeded for inspection. No repair was necessary, returned to service.
Fiji	24-Nov-1980	GP	M		
Reef In Suva Harbour		18°10.00'S		178°24.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Tokerau	-	CG	349	1937	Stranded, refloated with assistance and towed to Suva where brokem up. Entire bottom hull corrugated, keel strake set up and buckled, 3 propeller blades bent, main engine and auxiliary engine water damaged.
Fiji	24-Dec-1980	GP	T		
Reef 37 km NNW of Yandua Island		16°28.00'S		178°12.00'E	
Stardust II	-	FP	159	1945	Stranded after 73-knot winds. Returned to service. Needed port propellor shaft and minor repairs to the timber hull.
Fiji	15-Jan-1981	GP	P		
Suva Harbour (also reported as "off Nadi")		18°10.00'S		178°24.00'E	
Taoniu	-	CG	514	1958	Stranded during Cyclone Arthur. Refloated with no serious damage.
Fiji	15-Jan-1981	GD	M		
In Suva Harbour		18°10.00'S		178°25.00'E	
Dae Yang No.10	-	FV	192	1964	Stranded during Cylcone Eric. Refloated and taken to Suva. Scuttled. At least one double bottom fuel tank breached and oil leaked to sea.
Fiji	30-Dec-1981	GP	T		
Off Suva Harbour		18°10.00'S		178°25.00'E	
Viti	-	FP	114	1941	Struck reef and sank approx. 5 miles off Lautoka. All crew members and passengers rescued.
Fiji	27-Aug-1982	GP	T		
Tivoa Reef		17°37.10'S		177°21.50'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Kekanui / **Fiji** / Suva Harbour	- / 02-Mar-1983	CG / GD / 18°08.00'S	400 / M	1954 / 178°25.00'E	Stranded after dragged anchor during Cyclone Oscar (1-2 Mar 1983). Refloated by own means and towed back to anchorage by Ports Authority tug where re-anchored.
Fiji Gas / **Fiji** / Reef north of Lautoka	- / 22-Oct-1983	Tlng / GP / 17°29.00'S	1587 / M	1972 / 177°26.00'E	Stranded, refloated without assistance. No major bottom damage, continued on voyage to Labasa.
Pacific Shell / **Fiji** / Labasa River	- / 15-Jan-1984	Toil / GP / 16°24.00'S	493 / M	1975 / 179°20.00'E	Touched bottom in river, continued on voyage, surveyed at Suva, where repairs effected. Minor repairs.
Ika No.5 / **Fiji** / Cakaulevu Reef, Lau	- / 27-Apr-1984	FV / GP / 18°52.00'S	105 / P	1980 / 178°22.00'W	Ran aground on reef. All passengers and crew rescued, no injuries. Vessel's hull extensively damaged, oil tanks leaking. Refloated, towed to Suva, repaired and returned to service.
Independence / **Fiji** / Vatu Vula Reef, near Makogai Island	- / 07-May-1984	FV / GP / 17°28.00'S	125 / P	1983 / 178°55.00'E	Stranded, refloated with assistance and towed to Suva. Later repaired and returned to service. Crew rescued. Hull holed.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Na Mataisau **Fiji** Reef off Moala Island	- 17-Jan-1985	FC GD 18°44.00'S	274 T	1978 179°50.00'E	Sustained main engine breakdown 6 miles SW of Moala Island, struck reef and sank off Moala after draggging anchor during Cylone Eric. 2 died. Mast and other gear removed and recovered and vesseal left as lies in 15-18 meters of water.
Kekanui **Fiji** Northern Anchorage, Suva Harbour	- 18-Jan-1985	CG GD 18°07.00'S	400 T	1954 178°25.00'E	Stranded whilst anchored in Suva during Cyclone Nigel. Sank in Northern Anchorage in heavy weather. Vessel was looted by local fishermen.
Matthew Flinders **Fiji** Reef in Saweni Bay	- 05-Mar-1985	FP GP 17°37.00'S	1002 P	1954 177°25.00'E	Dragged anchor and stranded on reef during Cyclone Gavin. Refloated and proceeded to Lautoka. Refloating hampered by heavy winds and rough seas, tug assisted. Some bottom and propeller damage.
Young Kwang No.1 **Fiji** Suva Harbour	- 13-Apr-1985	FV GP 18°10.00'S	233 P	1963 178°24.00'E	Stranded whilst departing Suva in heavy weather, refloated without assistance and anchored. Returned to service. Port bilge keel buckled.
Pacific Shell **Fiji** Coral reef between Labasa and Lautoka	- 04-May-1985	Toil GP 16°25.00'S	493 M	1975 178°17.00'E	Stranded whilst on voyage from Labasa to Lautoka. Refloated without assistance and proceeded on voyage. Minor damage.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Ika No.1	-	FV	114	1972	Stranded whilst manoueuvering through channel. Refloated and returned to Lautoka. Subsequently flooded, towed and beached. Part of vessel badly damaged.
Fiji	11-Feb-1986	GP	P		
Mana Island channel		17°40.00'S		177°07.00'E	
Talofa	-	LC	141	1984	Capsized and stranded after sustaining steering trouble. Refloated and towed to Suva for repairs. 8 crew members missing.
Fiji	15-Apr-1986	GD	P		
Reef at Yasawa Island		16°42.00'S		177°35.00'E	
Kaunitoni	-	FP	384	1975	Stranded in good weather, refloated and taken to Suva for repairs. All passengers and crew safely rescued. Hull bottom holed.
Fiji	08-Aug-1986	GP	P		
Mabulithi Reef, south of Gau Island		18°13.00'S		179°18.00'E	
Boral Gas	-	Tlng	1897	1970	Stranded, refloated without aid. Slightly damaged.
Fiji	19-Apr-1987	GP	M		
Entrance to Navula Passage, Momi Bay, Nadi		17°55.06'S		177°13.00'E	
Shin Chyun No.7	-	FV	163	1974	Stranded, refloated and towed to Suva for repairs. Sold, renamed 'Tasu No.2'. Engine room flooded.
Fiji	22-Jun-1988	GP	P		
300 miles SW of Fiji		21°40.00'S		174°32.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Matthew Flinders	-	FP	1002	1954	Wrecked. Passengers and crew rescued. Hold and engine room flooded.
Fiji	11-Jul-1989	GP	T		
Navatu Reef, SE of Moala Island		18°39.00'S		179°33.00'W	
Mollie Dean	FJ	U	110	0	Sank. Passengers rescued by Fiji Navy vessel. Salvage not possible.
Fiji	13-Aug-1991	H	T		
8 miles SE of Beqa		18°32.00'S		178°17.00'E	
Polynesian Link	-	Ctr	0	0	Sank in Suva Harbour alongside the Kings Wharf obstructing part of wharf. Floating containers of meat were looted. Vessel a constructive total loss. Subsequently wreck was removed and scuttled in deep water outside Suva Harbour.
Fiji	15-Oct-1991	O	T		
Port of Suva		18°08.00'S		178°25.00'E	
Wairua	-	FP	618	1961	Wrecked, 13 miles NE of Cape Washington, off Naikorokoro
Fiji	08-Aug-1993	GP	T		
Near Namalata Reefs		18°58.00'S		178°08.00'E	
Arauco	-	Bulk	15080	1979	Stranded, refloated with tug assistance and taken to Savusavu for temporary repairs. Taken to Singapore for repairs. Sustained damage to forepeak double bottom tank and water in one hold.
Fiji	15-Feb-1994	GP	P		
Reef off Labasa		16°34.00'S		179°23.00'E	

Vessel Name	Country of Incident	Location Name	Flag	Date of Incident	Type	Type Incident	Latitude	GRT	Severity	Year Built	Longitude	Comments
Congresso del Partido	**Fiji**	-	CU	09-Jun-1994	Bulk	M	19°47.71'S	9626	P	1975	176°00.44'E	Broke down and drifted without power en route for Noumea. Vessel located and towed to Fiji. Some damages. Cargo bagged fishmeal.
Kin Sin II	**Fiji**	90 km south of Nadi	-	10-Jul-1994	FV	F	18°37.00'S	0	T	0	177°22.00'E	Taiwanese trawler reported burning as a result of an internal explosion. Crewmen rescued by NZ Air Force.
Rybnovsk	**Fiji**	Suva	MA	06-Oct-1994	Ctr	O	18°08.00'S	0	M	0	178°25.00'E	Listed 45 degrees during unloading. Two dock workers injured. Water pumped from engine room to stablize vessel.
Garden Sun	**Fiji**	Nanuku Reef	-	13-Jan-1995	FV	GP	16°40.00'S	100	M	0	179°26.00'W	Grounded due to poor navigation. Refloated without assistance on high tide.
Archer	**Fiji**	Waters within Suva Harbour	-	03-Feb-1996	FV	F	18°08.00'S	0	T	0	178°25.00'E	Caught fire at wharf. Towed into harbour by vessel 'Playing Hookey' and navy vessel 'Maika Tora'. After fire out, towed r back to Kings Wharf. Vessel later the centre of dispute, unlawfully removed and stripped of equipment.

Vessel Name Country of Incident Location Name	Flag Date of Incident	Type Type Incident Latitude	GRT Severity	Year Built Longitude	Comments
Christine **Fiji** -	US 27-Dec-1996	Other GP	0 P	0 000°00.00'E	Yacht. Crew rescued by Fiji Navy. Lower portion flooded. Salvage operation by Marine Pacific Ltd.
Dong Huai **Fiji** Near naval base, Walu Bay	- 30-Jan-1997	FV O 18°07.00'S	0 T	0 178°25.00'E	Oil spill from sinking vessel. Firefighters used spill dispersant to lessen pollution risk. Vessel abandoned about a year before the incident.
Bulou Ni Ceva **Fiji** -	FJ 07-May-1997	FP M 18°15.00'S	0 M	0 178°26.00'E	Towed to Suva Harbour. Sustained minor damage. Back to regular schedule.
Arctic P. **Fiji** -	BA 25-May-1997	Other GP	0 P	1970	Serious bottom damage sustained after went aground. Yacht.
Jubilee **Fiji** Reef off Nabuwalu	JP 18-Jul-1998	RoRo GP	0 T	0	Grounded, flooded and sank.
Sofe **Fiji** Near Naselai Passage	FJ 22-Jul-1998	RoRo S 18°12.00'S	997 M	1968 178°35.00'E	Developed heavy list in rough seas. Damaged vehicles on board.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Ulu 1	FJ	FV	0	0	Sank.
Fiji	27-Aug-1998	U	T		
Udu Point, Northern Coast of Vanua Levu		16°00.00'S		179°54.00'W	
Fortuna No.8	-	U	0	0	Ran aground. Initial efforts to refloat vessel failed. Authorities working to refloat the vessel. No casualties reported.
Fiji	21-Sep-1999	GP	P		
Near Mavutulevu Village, Viti Levu					
Kamoea	TO	U	0	0	Capsized. Navy sent a search for the vessel and five missing seamen the following day.
Fiji	21-Dec-1999	U	T		
Lau Waters		19°16.00'S		179°17.00'W	
Pacific Mariner	FJ	Toil	1384	1977	Tanker grounded near Shell Oil terminal, Taveuni. Area to be resurveyed indicates possible uncharted obstacle.
Fiji	27-Feb-2000	G	M		
Waiyevo, Taveuni		16°52.50'S		159°57.00'E	
Charng Yih No.12	TA	FV	230	1974	Ran aground in bad weather and rough seas. Engine room subsequently flooded causing power shut down. Crew rescued by Fiji naval vessel. No salvage operation intended due to severe structural damage.
Fiji	27-Jul-2000	GP	T		
Mabulithi Reef		18°14.00'S		179°18.00'E	

Vessel Name Country of Incident Location Name	Flag Date of Incident	Type Type Incident Latitude	GRT Severity	Year Built Longitude	Comments
`SK **Fiji** King's Wharf, Suva Harbour	FV 09-Nov-2000	542 C 18°09.00'S	1986 M	 178°26.00'E	Bow of Sung Kyung No. 507 contacted stern of Direct Kiwi(16281 GT, built 1997). One crewman of Sung Kyung No.507 killed. Master Direct Kiwi states his vessel moored and discharging at time.
Chelsea **Fiji** Southern Lau	FJ 12-May-2001	FV GP 19°30.00'S	0 U	0 178°30.00'W	Grounded on reef near uninhabited island in southern Lau. Crew rescued by naval vessel "Kiro". Owner Steve Ayers considering salvage.
Grete Theresa **Fiji** Navula Passage	VU 01-Jul-2002	Toil GP 17°54.82'S	821 M	1996 177°13.00'E	Grounded under power on sandy bottom en route Vuda Point to Port Vila. Freed by tug "Maika Tora 4 Jul 02, inspected Vuda Point and proceeded.
Massachusetts **Fiji** Southern Lau	US 16-Jul-2002	FV GP 19°30.00'S	0 T	0 179°00.00'W	Attempts to refloat by South Seas Towage , United Salvage unsuccessful. Insurer liable for $525,000 loss and possible costs of removal. Report variously refloated by Seamech Fiji Ltd on 21 Sep 02, and still aground on 23 Oct 02.
Niuselelevata **Fiji** Northern Anchorage	FJ 08-Nov-2002	U U 18°07.44'S	0 U	0 178°25.23'E	Cause of sinking unknown. Investigation under way.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Tai Nui	-	FV	120	1973	Stranded and sank
French Polynesia	21-Dec-1983	GP	T		
Off Papeete		17°30.00'S		149°35.00'W	
Taporo II	-	CG	343	1963	Sprang leak in engine room and beached on reef to save cargo and lives of passengers and crew.
French Polynesia	25-Nov-1984	Gp	T		
Reef off Nukutavake, Tuamotu Archipelago		19°30.00'S		138°40.00'W	
Byron No.16	-	Rfr	1872	1970	Stranded, refloated after cargo offloaded and towed to Japan where repairs effected. Later in service. Hull bottom and steering gear damaged, rudder bent and prop blade twisted. Vessel later trading under name 'Sky Frost'.
French Polynesia	08-Sep-1988	GP	P		
Tetiaroa Island		17°00.00'S		149°00.00'W	
Dory 2	FR	FC	348	1973	Caught fire, sank one day later. Passengers and crew rescued with slight injuries.
French Polynesia	13-Aug-2002	F	T		
Off Makatea Island		15°50.00'S		148°15.00'W	
Meiho Maru No.7	-	FV	349	1962	Stranded, subsequently refloated & taken to Ishinomaki. Repaired & returned to service.
FSM	22-Apr-1979	GP	P		
-		08°03.00'N		146°44.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Etna	-	CG	3654	1972	Stranded, refloated with tug assistance and berthed at Yap.
FSM	25-May-1979	GP	M		
Yap Harbour		09°31.00'N		138°08.00'E	
Micro Spirit	-	CG	790	1978	Aground, refloated and reported back in service.
FSM	14-May-1980	GP	M		
Sandbar near Woleai		07°22.00'N		143°55.00'E	
Curacao	-	FV	367	1960	Wrecked in heavy weather. Crew rescued. Engine room flooded and tidal. Rudder carrier bolts sheared and rudder stock lifted 15cm, skeg set up.
FSM	16-Jan-1982	GP	T		
Ngulu Atoll		08°33.00'N		137°28.00'E	
Hinode Maru No.56	-	FV	344	1972	Stranded and sank.
FSM	12-Sep-1982	GP	T		
Off Truk Island		07°25.00'N		151°50.00'E	
Kitcho Maru No.28	-	FV	404	1968	Wrecked. Extensively damaged.Owners state vessel not to be removed due to extent of damages. Possible cause is captain not making sufficient adjustment for fast moving east tide over reef. MFV 'Fukuwa Maru No.1' approached to give assistance but also got
FSM	27-Nov-1982	GP	T		
Mint Reef		08°05.00'N		154°14.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Fukuwa Maru No.1	-	FV	306	1969	Wrecked. Declared a total loss and not removed. Vessel
FSM	28-Nov-1982	GP	T		abandoned.
Mint Reef		08°05.00'N		154°14.00'E	
Conic No.1	-	FV	908	1983	Stranded and presumed to have sank.
FSM	30-May-1984	GP	T		
Sorol Island		08°04.00'N		140°28.00'E	
Tong Wha No.71	-	FV	221	1963	Stranded, refloated and taken in tow to Guam.
FSM	17-Mar-1985	GP	P		Subsequently sold. Towed to Manila.
Near Ifalik Atoll		07°15.00'N		144°27.00'E	
Meiho Maru No.17	-	FV	432	1972	Stranded, refloated with assistance after several attempts
FSM	29-Apr-1985	GP	P		and towed to Ponape. Towed to Hachinohe thence
-		05°48.88'N		157°13.35'E	Ishinomaki where repaired and SD. Bottom plate damaged.
Micronesian Commerce	-	Ctr	5730	1982	Stranded, refloated and berthed at Yap Pier. Sailed to
FSM	02-Nov-1988	GP	P		Palau Islands and thence to Manila. Sustained heavy
Yap,W.C.I.		09°32.00'N		138°10.00'E	bottom damage to fuel oil tanks and hull.
Crest 1	PH	Bulk	0	0	'Dead in water' following collision with Tenfu (Reefer). No
FSM	29-Mar-1991	C	P		casualties.
-		02°43.00'N		154°06.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Golden Camia **FSM** NE of Yap Island	PH 15-Mar-1992	Bulk O 10°16.00'N	0 T	0 139°30.00'E	Sank. Crew abandoned ship due to shifting of cargo (logs) in heavy fog and rain. Crew safely rescued. Oil slick produced.
Nanshin Maru No.78 **FSM** -	JP 19-Aug-1992	FV U 02°00.00'N	19 T	0 158°07.00'E	Sank. Crew rescued safely.
Yujin Busan **FSM** 420 miles south of Truk	PA 27-Feb-1994	Toil F 00°20.00'N	1550 T	1974 151°40.00'E	Sank. Attempts to fight a fire in the engine room resulted in the flooding of the vessel. Crew rescued safely.
Oceanus **FSM** Wenimong Reef at Satawal Island	GR 18-Mar-1994	Bulk GP 07°22.00'N	38891 P	1993 147°02.00'E	Ran aground with 70,000 tons of coal. Refloated after part cargo transferred to barges. Proceeded Guam inspection, Ulsan repairs. Satawal residents sued for damages for pollution by coal, spilled oil and garbage dumped during salvage.
Jin Fwu Yi 366 **FSM** -	TA 06-May-1994	U U 08°47.00'N	0 T	0 151°33.00'E	Vessel missing. Aircraft reported debris.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Dang Delima	PA	CG	5903	1985	Stranded, refloated and achored at Ponape. Sailed in tow to Busan after repairs. Fuel tanks holed. Oil pollution.
FSM	16-Jun-1994	GP	P		
Reef at entrance to Ponape Harbour		06°40.00'N		158°25.00'E	
Ocean Harmony	PA	CG	3769	1973	Disabled and adrift with engine problems.
FSM	23-Jun-1994	M	U		
-		08°26.00'N		140°57.00'E	
Deborah	PA	Bulk	4010	1984	Sank. Departed Yap with cargo of logs. Sank but due to cargo drifted 5ft below surface. Crew rescued safely
FSM	20-Sep-1994	O	T		
-		10°23.60'N		135°49.20'E	
Valerie	ME	FV	1127	1983	Sank due to crack or holing of hull. All crew rescued.
FSM	29-Nov-1995	H	T		
-		00°39.00'N		156°38.83'E	
Mister Bill	-	Other	196	1971	Supply vessel. Took water and sank during typhoon 'Fern'. Crew rescued safely.
FSM	24-Dec-1996	S	T		
85 miles NE of Yap Island		11°13.00'N		165°25.00'E	
Mina Maru	JP	FV	0	0	Ran aground. Crew rescued.
FSM	06-Apr-1998	GP	U		
West of Fayu Island		08°33.00'N		151°10.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Hung Sun Tai	TW	FV	0	0	Vessel reported adrift and sinking 25 Apr. Six crew
FSM	25-Apr-2001	U	T		rescued by Taiwan longline fv Hung Sun Tsai, length 66 ft.
-		09°40.00'N		150°40.00'E	No further sightings 1 may, assumed sunk.
Cecilia 1	-	LC	365	1990	Flooding in Engine Room through hole (leak?) Patched by
FSM	20-Jun-2002	H	M		Coast Guard Guam. Cargo petrol in barrels.
-		08°23.00'N		142°36.00'E	
Micronesia Sunrise	-	Toil	3535	1971	Reported stranded, refloated and proceeded to Guam for
Guam	19-Oct-1980	GP	P		temporary repairs. Sustained a small hole in one tank , fuel
Ibay, off Guam		13°32.65'N		144°41.78'E	transferred to another tank with slight loss of cargo. Oil
					Pollution.
Bright Peak	-	Bulk	9735	1978	Stranded, refloated and diverted to Guam for temporary
Guam	07-Apr-1981	GP	P		repairs. Subsequently towed to Onishi for repairs.
South of Guam		12°32.00'N		144°42.00'E	Returned to service. Cargo wheat.
American Legion	-	Ctr	19157	1968	Stranded, refloated with tug aid and entered port where
Guam	13-Dec-1985	GP	P		temporary repairs effected. Sailed to Kaohsiung for
Entrance to Apra Harbour		13°27.00'N		144°37.00'E	permanent repairs. 80000 gallons of bunker fuel spilled
					after an oil tank and cargo hold were ruptured. Oil
					pollution.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Toros Bay	-	CG	8931	1973	Stranded, refloated and taken to Apra, subsequently taken
Guam	22-Dec-1986	GP	P		to Kaohsiung, sold, and broken up. Some extensive
On reef		13°15.00'N		144°38.00'E	damage as vessel stern contacted reef during refloating.

Kotobuki Maru No.1	-	FV	253	1966	Stranded during typhoon 'Roy'
Guam	12-Jan-1988	GP	U		
Guam		13°28.00'N		144°32.00'E	
Kaiyo Maru No.5	JP	FV	0	0	Ran aground. Refloated same day.
Guam	28-Jan-1991	GP	M		
Apra Harbour		13°27.00'N		144°37.00'E	
Glacier Bay	US	Other	0	0	Tank barge. Damaged due to heavy contact with tug.
Guam	07-Jan-1992	C	P		
Vicinity of Guam		13°52.00'N		145°22.00'E	
Jean Charcot	PA	RV	0	0	Research vessel ran aground while conducting survey of ocean floor.
Guam	18-Mar-1992	GP	M		
Tumon Bay		13°30.00'N		144°47.00'E	
Esso Tees	SI	Tlng	0	0	Explosion occurred while vessel discharging pressurised liquefied gas followed by a fire. Immediate action halted the fire. No injuries.
Guam	17-Aug-1992	F	P		
Apra Harbour		13°27.00'N		144°37.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Seaspan	CA	Brg	0	0	Barge adrift.
Guam	31-Aug-1992	U	U		
90 miles NW of Guam		14°34.00'N		143°40.00'E	
Francisca	US	Brg	1075	0	Deck barge. Broke from tow of tug during typhoon "Hunt" and was lost at sea.
Guam	18-Nov-1992	S	T		
15 miles NE of Guam		13°50.00'N		145°11.00'E	
Yasiu Maru	-	U	0	0	Sank after crack developed in hull.
Guam	09-Feb-1994	H	T		
Off Guam		11°30.00'N		142°55.00'E	
Miya Maru No.88	JP	U	349	1982	Took in water resulting in vessel disabled and drifting. Later towed to Guam.
Guam	17-Nov-1995	M	M		
-		14°07.00'N		144°23.00'E	
Anangel Might		U	0	0	Adrift due to engine failure. Later towed by US Navy vessel and then tug Chamorro to Guam
Guam	04-Nov-1998	M	M		
South west of Guam		11°09.20'N		139°15.40'E	
Carolines	PA	Bulk	0	0	Sank due to bad weather and rough seas. Cargo 6,000 tons of silica sand. Crew rescued safely.
Guam	17-Jan-1999	S	T		
Near Guam		13°38.00'N		145°24.00'E	

Vessel Name Country of Incident Location Name	Flag Date of Incident	Type Type Incident Latitude	GRT Severity	Year Built Longitude	Comments
Fokutoku Maru No.5 **Guam** 7 nmi S Guam	JP 30-May-2000	FV M 13°08.00'N	119 M	1984 144°42.00'E	Broke down, adrift 2 days. Tug "Chamorro" towed to Apra for repairs.
1st Lt. Baldomero Lopez **Guam** 520 nmi NW Guam	US 05-Aug-2002	RoRo F 15°12.00'N	32908 P	1985 145°42.00'E	Fire in engine room. Two crew injured. Vessel disabled. Tug Bei Hai 102 dispatched from Busan
Hangil No.12 **High Seas** -	SK	FV U 12°45.00'N	0 T	0 157°35.00'W	Sank.
Flag Mars **High Seas**	MA 08-Apr-1992	CG M 14°41.00'N	0 M	0 157°08.00'E	Damaged rudder. Towed to Guam.
Midas Ocean **High Seas** -	HD 02-Jan-1995	Bulk H 01°50.00'N	0 T	0 158°50.00'E	Sank. On passage from Nauru to Inchon with phosphate when ingress of water caused vessel to sink. All crew safely recued.
Sybarite **High Seas** -	US 12-May-1995	U H 10°23.00'N	0 T	0 162°03.00'W	Vessel taking in water. Water pumped out and vessel continued on voyage Samoa for Honolulu. Crew later picked up when vessel in sinking condition 300 miles from Honolulu. Assumed vessel sank.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Ming Fong Sheing	TA	FV	0	0	Caught fire and sank. Nine crew rescued, three missing.
High Seas	11-Apr-1997	F	T		
-		15°50.00'N		133°40.00'E	
Sapir	PA	Toil	54980	1990	Leak in cargo tank discovered at sea by crew. Cargo redistributed and vessel continued to Honolulu for inspection.
High Seas	06-Mar-2000	H	M		
400 nmi N Guam		17°31.00'N		139°40.00'E	
Ji Moon Chun	TW	FV	0	0	Fire at sea. Vessel burned and sank. Crew rescued by helicopters from USN amphibious assault vessel "Boxer", 40,000 gt, returning from Arabian Gulf.
High Seas	21-Aug-2001	F	T		
648 nmi E Guam		13°32.00'N		155°33.00'E	
Chiyo Maru No. 3	JP	FV	77	1978	Fire. Nine crew rescued by another FV. No further sightings, assumed sunk.
High Seas	13-May-2002	F	T		
-		17°17.00'N		151°05.99'E	
Katsuura Maru No. 28	JP	FV	164	1985	Sank in open water. Pumps unable to control leak, believed caaused by grounding in Micronesia.
High Seas	19-Jul-2002	H	T		
At Sea		15°30.00'N		164°00.00'E	
Sea Hawk No.3	SK	FV	0	0	Sank after colliding with Reefer Jia Year No.66. All crew rescued.
indonesia - West Papua	16-May-1991	C	T		
		-		01°36.00'N 137°06.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Lara K.	BA	Bulk	0	0	Lost power.
Indonesia?	24-Jul-1991	M	U		
north of Wetar Island		07°38.00'S		127°10.00'E	
Kwang Myung No.62	-	FV	352	1968	Wrecked. Crew rescued.
Kiribati	25-Mar-1980	GP	T		
Tamana island		02°30.00'S		175°59.00'E	
Nam Chang	-	FV	227	1971	Wrecked. Crew rescued
Kiribati	23-Feb-1982	GP	T		
Off Starbuck Island		05°35.00'S		155°35.00'W	
Young Kwang No.5	-	FV	243	1964	Struck reef, refloated but sank off Christmas Island at 01 41 05N, 156 40 05 W on 22 Nov 82.. All crew rescued. Sank due to severe leakage of seawater through fractured holes of bottom and one oil tank area.
Kiribati	17-Nov-1982	GP	T		
Reef		01°47.00'N		157°26.00'W	
Fentress	-	CG	3805	1945	Stranded while on loaded voyage from Honolulu to Fanning Island. Refloated and resumed voyage.
Kiribati	03-Nov-1983	GP	M		
Off Christmas Island		02°05.00'N		157°35.00'W	
Evelyn da Rosa	-	FV	966	1974	Struck submerged object and subsequently foundered. 18 persons rescued.
Kiribati	03-May-1993	GP	T		
-		02°14.00'N		171°10.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Aito / **Kiribati** / Caroline Atoll	PF / 20-Nov-1994	Tug / GP / 10°00.00'S	0 / T	1962 / 150°15.00'W	Tug grounded on reef while attempting to tow yacht Oracle. Considered a total loss.
Vostochnyy Bereg / **Kiribati** / Tarawa Atoll	RU / 31-Dec-1994	Rfr / GP / 01°34.00'N	7856 / M	1981 / 172°56.00'E	Grounded. No damage occurred.
Maasmond / **Kiribati** / Approx 415 nautical (500 miles) east of Tarawa	- / 07-Jan-1997	FC / F / 01°35.00'N	1055 / U	1971 / 179°59.00'E	Drifting without power after fire in engine-room. En route Tarawa to Christmas Island.
Marshall Islands / **Marshall Islands** / Off Jemo Island	- / 16-Dec-1979	CG / GP / 10°05.00'N	798 / T	1976 / 169°34.00'E	Wrecked. Salvage attenpts unsuccessful. Constructive total loss.
Tong Wha No.101 / **Marshall Islands** / Off Kwajalein Atoll	- / 13-Jun-1983	FV / GP / 08°48.00'N	215 / T	1965 / 167°48.00'E	Wrecked.
Seifuku Maru No.1 / **Marshall Islands** / -	- / 16-Jan-1994	FV / GP / 07°06.00'N	119 / T	1985 / 171°07.00'E	Struck a rock and sank.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Victor Eoaeo	-	FV	948	1977	Struck reef and sank after moorings parted in heavy weather. 9 crew members rescued.
Nauru	29-Jan-1986	GD	T		
Reef off Nauru		00°20.00'S		167°10.00'E	
Purau	-	Tug	247	1986	Stranded. Refloated by own power and taken to Poume. Towed to Noumea for temporary repairs and thence Tonagasaki for permanent repairs. Vessel was on delivery voyage.
New Caledonia	07-Aug-1986	GP	P		
On coral reef		19°21.00'S		163°12.00'E	
Konemu	NC	Toil	755	1990	Grounded. Refloated with tug assistance. Leakage of light petrol into lagoon.
New Caledonia	24-Jan-1997	GP	P		
Reef of Porc Epic, an island 10 miles from Noumea		22°01.00'S		165°52.00'E	
Contship France	-	Ctr	16236	1993	Minor damage and partial loss of contents of two containers overboard during bad weather. Vessel en route from Noumea to New York.
New Caledonia	14-Feb-1997	S	M		
-		21°15.91'S		169°10.57'E	
Mary D. Princess	NC	FP	0	0	Grounded. Damaged, repaired, and resumed normal service.
New Caledonia	02-Aug-1997	GP	P		
Off Noumea		22°04.00'S		166°00.00'E	

Vessel Name	Country of Incident	Location Name	Flag	Date of Incident	Type	Type Incident	Latitude	GRT	Severity	Year Built	Longitude	Comments
Nisshin Maru	New Caledonia	400 nautical miles off east coast of Australia	JP	20-Nov-1998	RV	F	20°29.00'S	7569	P	1987	159°54.00'E	Research vessel/fish factory caught fire and drifting without power. No injuries. Later towed to New Caledonia for repairs.
Padang Hawk	New Caledonia	-	SI	10-Jul-1999	Bulk	S	22°20.00'S	27011	M	1995	158°20.00'E	Encountered rough seas en route New Caledoni to Townsville and developed a 15 degree list, attributed to liquefaction of nickel ore cargo.essel arrived safely in Townsville.
Seefalk	New Caledonia	Anchored at Noumea	-	16-Nov-1999	Toil	U	22°17.00'S	639	T	1962	166°26.00'E	Sank at anchor.
Komenu	New Caledonia	Noumea Harbour	NC	14-Jan-2000	Toil	C	22°17.00'S	0	M	0	166°26.00'E	Collided with bulk carrier Arctic Trader (14,922 gt, built 1985) in Noumea Harbour. Damage minor. Reportedly the master of Komenu was drunk.
Lucifero	Niue	200 km east of Niue	-	25-May-1999	Other	U	19°00.00'S	0	T	0	168°00.00'W	Two crew rescued from sinking yacht.

Vessel Name Country of Incident Location Name	Flag Date of Incident	Type Type Incident Latitude	GRT Severity	Year Built Longitude	Comments
Fentress	-	CG	3805	1945	Stranded during typhoon 'Hazen'. Refloated with
Northern	15-Nov-1981	GP	P		assistance after lightening, arrived in Osaka for repairs and
Saipan Island		15°18.00'N		145°42.00'E	then resumed trading.
Nam Sung No.62	-	FV	287	1962	Wrecked due to failure of gyrocompass and radar in heavy
Northern	20-Jul-1982	GP	T		weather. Vessel left as lies due to heavy damage sustained
Rota Island		14°10.00'N		145°09.00'E	
Sun Long No.8	-	Rfr	3662	1968	Stranded while entering harbour. A hold and engine room
Northern	23-Aug-1986	GP	P		flooded.
Entrance to Tinian Harbour		14°57.00'N		145°34.00'E	
Petro Service	-	Sp	573	1968	Stranded during typhoon 'Kim'. Vessel a supply ship
Northern	03-Dec-1986	GP	U		(O.R.S.V)
On reef off Saipan Island		15°15.00'N		145°44.00'E	
Isla Grande	-	Toil	2915	1979	Touched bottom whilst manouvering at Saipan Island.
Northern	17-Mar-1990	GP	M		Sailed for China. Sustained propeller damage,
Saipan Island		15°14.00'N		145°42.00'E	
Belait Kingfisher	-	LC	253	1974	Stranded, refloated with tug assistance, towed to Guam
Northern	15-Sep-1990	GP	P		after temporary repair. Towed to Cebu for repairs to hull
Rota Island		14°06.00'N		145°12.00'E	bottom, tailshaft, propellor, and both rudders.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Tumon 2 **Northern** 14 miles NE of Saipan	MH 06-Oct-1991	CG GP 15°30.00'N	194 T	1970 146°00.00'E	Grounded. Subsequently broke in two and sank during typhoon 'Seth'.
Manila Harmony **Northern** Between Saipan and Tinian Islands	- 04-Nov-1991	U S 15°06.00'N	0 P	0 145°42.00'E	Shifted at sea while sheltering from typhoon 'Seth' resulting in flooding of hold.
Maria **Northern** Off Rota Island	- 20-Feb-1996	CG U 14°11.00'N	80 U	0 145°13.00'E	na
Guernsey Express **Northern** -	PH 09-Nov-1996	Other S 13°02.00'N	4255 T	1967 144°01.00'E	Livestock carrier (cattle) sank due to bad weather. Crew rescued safely.
Fidel Jr. **Northern** Saipan Dock	BE 25-Apr-1997	U O 15°16.00'N	192 P	1961 145°44.00'E	Sunk due to leaks in starboard tanks while loading containerised cargo. Containers were recovered but severley damaged. Fuel to be removed.
Shogun **Northern** Rota Island	PA 05-Nov-1997	Tchem GP 14°09.00'N	717 P	1977 145°08.00'E	Grounded in bad weather. Minor diesel spillage. Efforts to refloat hampered by typhoon 'Keith'. Cargo offloaded before refloated. Proceeded to Rota and thence to Phillipines for repairs.

Vessel Name	Country of Incident	Location Name	Flag	Date of Incident	Type	Type Incident	GRT	Severity	Year Built	Latitude	Longitude	Comments
China Progress	Northern	North of Northern Marianas Islands		18-Feb-2000	PA	H	Bulk0	P	0	17°23.00'N	147°56.00'E	Vessel with cargo of copper concentrate, Chile for Japan, sustained hull damage in heavy weather. Flooding in No. 1 hold and ballast tank. Vessel proceeded Guam under tug escort for temporary repairs, thence departed for Qindao 25 Feb.
China Progress	Northern	-	PA	18-Feb-2000	Bulk	S	0	M	0	17°23.00'N	147°56.00'E	Vessel took in water due to hull damage sustained in heavy storms. Proceeded to Guam under escort from Japanese salvage tug. Cargo copper concentrate.
Greenville III	Northern	Entrance Saipan Harbour	US	27-Aug-2001	Other	GP	0	M	0	15°12.00'N	145°42.00'E	Submarine brushed bottom in rough seas on approach to Saipan Harbour. Minor repairs effected Apra Harbour. Greenville was the sub in collision with Japanese training vessel "Ehime Maru" off Diamond Head 9 Feb 01
Bovenhusen	NZ?	-	CY	02-Jul-2001	U	M	3186	M	1990	33°30.60'S	171°02.50'E	Engine breakdown, adrift. Tug dispatched with engineer and parts 4 July .
Bowoon No.7	Palau	-	-	22-Apr-1980	Toil	GP	3084	P	1969	07°14.85'N	134°28.65'E	Stranded. Refloated after jettisoning part cargo and anchored in Koror, Palau. Oil pollution.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Bluefin Endeavour	-	FV	1010	1977	Struck reef (north of PNG) and sank.
Palau	05-Jun-1992	GP	T		
Helen Reef		02°55.00'N		131°48.00'E	
Blue Diamond	-	U	0	0	Sank.
Palau	28-Aug-1992	O	T		
Vicinity of Helen Reef		02°55.00'N		131°48.00'E	
Golden Eagle	LI	Toil	36865	1982	Grounded. Proceeded to Balboa for repairs
Palau	05-Apr-1998	GP	M		
Off Palau		08°30.00'N		134°45.00'E	
Pacific Falcon	PA	Ctr	8132	1998	Grounded while on passage from Australia to Japan, carrying 7142 tonnes of containers and copper. Refloated by partial unloading and assist from tug Koyo Maru. Anchored and inspected Palau. No immediate repairs required.amage.
Palau	21-May-2000	GP	M		
-		07°22.12'N		134°22.46'E	
Partner	CY	U	0	0	Grounded. Refloated and proceeded to Rabaul.
PNG		GP	M		
-					

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Maluka	-	CG	584	1950	Vessel stranded on reef in hazy conditions. Iin two rescue attempts 'Sepik Energy' and 'Hebe' both stranded on same reef and considered total losses. Maluka refloated, anchored at Salamaua Bay, sold and broken up.
PNG	01-Jun-1977	GP	T		
Ragave Point, Cape Vogel		09°41.00'S		150°03.40'E	
Hebe	-	CG	296	1946	Stranded while attempting to refloat stranded 'Maluka'. Subsequently refloated, towed to Samarai and scuttled off Salamaua.
PNG	06-Jun-1977	GP	T		
Ragave Point, Cape Vogel		09°41.08'S		150°03.40'E	
Carla Manus	-	LC	174	1970	Stranded. Refloated and resumed service. Damage presumed minor
PNG	09-Mar-1979	GP	M		
Reef near Willaumez Penninsular, New Britain		05°05.00'S		149°58.00'E	
Rudolph Wahlen	-	CG	115	1964	Wrecked. Weather good at time of casualty. Abandoned after attempts to refloat failed. Some cargo saved
PNG	27-Jun-1979	GP	U		
Circular Reef		03°26.00'S		147°47.00'E	
Idun	-	CG	300	1971	Grounded. Refloated under own power.
PNG	02-Aug-1979	GP	M		
Dove Island		09°59.00'S		143°08.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Ambusa **PNG** Cape Gloucester, New Britain	- 02-Aug-1979	LC GP 05°24.00'S	180 M	1972 148°25.00'E	Stranded. Refloated& continued on voyage.
Chiang Wei **PNG** Kalili Harbour, New Ireland	- 01-Jan-1980	CG GP 03°26.72'S	3981 P	1979 151°55.00'E	Stranded. Refloated with assistance after cargo jettisoned & continued service. Probable cause strong current.
Dai Wang No. 105 **PNG** Coral Island	- 15-Jan-1980	FV GP 02°28.00'S	299 M	1964 149°57.00'E	Stranded in poor visibility. Refloated by tug and towed to Rabaul.
Waigani Express **PNG** Off Hood Point	- 04-Jul-1981	CG GP 10°09.00'S	5084 P	1971 147°43.00'E	Stranded. Refloated and towed to Port Moresby thence Singapore where sold, renamed 'Papua' and returned to service. Damage to port forward and starboard.
Seiha Maru **PNG** Reef off Rabaul, New Britain	- 08-Nov-1982	Tug GD 04°12.80'S	1033 P	1969 152°30.00'E	Tug. Stranded after tow wire fouled propellor whilst towing 'Hinode Maru No.8'. Refloated,towed to Sakoshi, sold, broken up.
Manhattan Duke **PNG** Basilisk Reef	- 16-Jul-1983	Toil GP 09°33.00'S	39349 P	1976 147°08.00'E	Stranded in heavy weather, whilst awaiting pilot. Refloated with tug assistance. Towed to Singapore for repairs. Extensively damaged. Oil pollution.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Cosmaris	-	RoRo	340	1978	Stranded during heavy weather. Refloated with tug assistance and redelivered to owners at Rabaul. Minor damage.
PNG	27-Nov-1983	GP	M		
Coral Reef off Tingwon Group		02°37.00'S		149°39.00'E	
Longan	-	CG	4660	1977	Stranded . Refloated with own power but assisted by tug. Minor damage
PNG	27-Mar-1984	GP	M		
30 miles south of Kieta, Bouganville Island		06°33.00'S		156°00.00'E	
Tangir	-	LC	170	1971	Stranded. Capsized and sank after cargo shifted and attempts to refloat. .
PNG	17-Jan-1985	GD	T		
Reef off Port Moresby		09°32.00'S		147°07.00'E	
Moale Chief	-	LC	262	1981	Stranded. Taken to slipway at Port Moresby, repaired and returned to service. Mechanical damage
PNG	28-Feb-1985	GP	P		
Reef at Gadaisu Point, Orangerie Bay		10°35.00'S		149°37.00'E	
Bow's Brother	-	CG	4719	1977	Stranded after dragging anchor in heavy weather, refloated with tug aid, towed to Rabaul thence Kobe where repairs effected, returned to service. Mechanical damage.
PNG	23-Jun-1985	GD	P		
Between Rabaul and New Ireland		04°04.00'S		152°26.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Ok Tarim	-	Tug	126	1982	Stranded when main towing line became entangled in port propeller. Taken to port where surveyed and repaired and returned to service. Slight damage.
PNG	19-Aug-1985	GP	P		
Off Port Moresby		09°32.00'S		147°07.00'E	
Bright Ace	-	RoRo	7666	1978	Stranded. Refloated and taken to Port Moresby, then to Ulsan and Japan. Repaired and returned to service. Sustained mechanical damage.
PNG	11-Oct-1986	GP	P		
33 miles NE of Cape Nelson		08°35.00'S		149°40.00'E	
Smilax	-	CG	3810	1982	Stranded. Refloated and proceeded to Tufi Anchorage for inspection. Returned to service. Minor damage.
PNG	03-Jan-1987	GP	M		
-		08°47.00'S		150°11.00'E	
Witbridge	-	LC	718	1977	Stranded. Refloated and towed to Cairns for repairs then returned to New Britain. Mechanical damage.
PNG	02-Mar-1987	GP	P		
20 miles east of Cape Ward Hunt		08°00.00'S		148°30.00'E	
Huris	-	LC	354	1977	Stranded whilst unloading in heavy swell. Refloated with tug assistance and towed to Rabaul. Minor damage.
PNG	05-Oct-1987	GP	M		
Lihir Island		03°06.00'S		152°39.00'E	
Sun Island	-	CG	3931	1974	Stranded. Refloated without assistance and towed to Port Moresby for temporary repairs. Minor damage
PNG	09-Mar-1989	GP	M		
Off Woodland Island		09°09.78'S		152°24.25'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Kim Lien	-	CG	6020	1977	Stranded after sustaining engine failure. Refloated with tug assistance and towed to Port Moresby.
PNG	18-Jul-1990	GD	P		
Reef 2 miles off Port Moresby Harbour entrance		09°32.00'S		147°07.00'E	
Glomaris	-	LC	371	1981	Stranded. Capsized and sank. Subsequently raised and repaired. Vessel holed.
PNG	26-Jul-1990	GP	P		
Off Jacquinot Bar, New Britain		05°40.00'S		151°36.00'E	
Steel Rover	PG	Other	0	0	Logging barge. Reported drifting without anyone on board.
PNG	15-Mar-1991	U	U		
south west of Bouganville Island		07°50.00'S		154°00.00'E	
Simbang	PG	FC	0	0	Sank after being hit by a freak wave which drove it onto a reef before capsizing. 9 people died and 24 missing.
PNG	04-Sep-1991	GP	T		
Vitiaz Strait, near Port Sialum, northern PNG		05°50.00'S		147°32.00'E	
AdhigunaNugraha 1	IN	CG	4928	1980	Stranded in heavy weather. Refloated with tug assistance and towed to Rabaul then Singapore for repairs. Minor damage. Log carrier
PNG	06-Sep-1991	GP	M		
Reef near Cape Sena, New Ireland		02°19.32'S		150°51.10'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Costa de Marfil	SK	U	807	0	Collided with Atlantis (1,427 tons).
PNG	09-Oct-1991	C	M		
-		05°34.00'S		156°01.00'E	
Shilla Pioneer	SK	FV	0	0	Collided with Fung Kuo No.736. Hull sustained damages.
PNG	21-Nov-1991	C	P		
-		02°30.00'N		145°30.00'E	
Paradise Ocean	PA	Bulk	0	0	Grounded. Refloated under own power.
PNG	20-Feb-1992	GP	M		
-		10°21.33'S		151°01.58'E	
Chemlong	KO	FV	0	0	Sank
PNG	24-Mar-1992	O	T		
100 miles north of Manus Island		00°14.00'S		146°54.00'E	
Sheng Fu No.16	-	FV	311	1972	Wrecked after sustaining steering failure.
PNG	06-May-1992	GD	T		
-		09°49.00'S		142°12.00'E	
Hand Cheong	PA	CG	5030	1978	Stranded in strong wind and current. Refloated and towed to Rabaul for repairs. Cargo logs.
PNG	07-May-1992	GP	P		
Reef on approach to Karu Bay, New Ireland		03°27.60'S		152°13.70'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Ayu Permata **PNG** Reef at Karu, New Ireland	IN 07-May-1992	U GP 03°52.65'S	5030 P	1978 153°08.10'E	Grounded. Holed. Subsequently towed to Rabaul for temporary repairs
Madang Coast **PNG** -	PG 07-Nov-1992	U F	0 P	0	Engine room fire while on voyage from Lae to Oro Bay. Fire extinguished and vessel returned to Lae. Extensive damage. NO injuries.
Carlina **PNG** Natera Reef, on approach to Basilisk Passage	PA 30-Nov-1992	CG GP 09°33.00'S	0 M	0 147°07.70'E	Stranded. Refloated by tug. Minor damage.
Arktis Ocean **PNG** River Fly	- 04-Mar-1993	CG GD 08°25.00'S	1598 P	1987 143°10.00'E	Touched bottom after log caught in propeller. Cargo copper concentrate.
Pixy May **PNG**	PA 22-Mar-1993	CG GP 06°19.00'S	2820 M	1986 149°52.00'E	Stranded. Refloated and towed to Rabaul for repairs. Vessel sailed for Japan.
Olympus Kim **PNG** -	SK 06-Apr-1993	U C 00°22.00'S	0 P	0 151°30.00'E	Collided with Reina No.101. Structural damage.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Armstrong	PA	CG	6719	1970	Ran aground while entering port. Arrived Rabaul with salvor assistance.Subsequently sailed to Aland and broken up. Hull bottom holed. Cargo logs.
PNG	13-Aug-1993	GP	P		
Port Aumo, West New Britain		06°58.00'S		148°36.00'E	
Kris	PG	RoRo	420	1972	Capsized and sunk. Two passengers and a crewman died.
PNG	19-Aug-1993	U	T		
near Samuda Island, West New Britain		05°24.00'S		149°01.00'E	
Tenyu Maru	JP	U	3703	0	Ran aground while entering port.
PNG	17-Oct-1993	GP	U		
Entrance of Port Wasum, SE coast New Britain Is.		06°19.06'S		149°51.14'E	
Tropic Wind	-	CG	0	0	Sank in heavy weather and rough seas caused by Cyclone "Jeana"
PNG	11-Nov-1993	S	T		
-		25°58.00'N		131°32.00'E	
Kwang Il No.3	SK	FV	286	1963	Sank. Crew abandoned sinking vessel and were safely rescued.
PNG	01-Mar-1994	U	T		
Gulf of Papua, 185 km NW of Port Moresby		08°40.00'S		145°35.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Samsun Brave	-	FV	1247	1983	Grounded.Subsequently slipped off reef, capsized, and sank. Crew rescued. 10 islanders that boarded the vessel to remove goods died when vessel capsized and sank.
PNG	06-Mar-1994	GP	T		
Reef off Carteret Island, North Solomon Islands		04°42.00'S		155°26.00'E	
Papuan Chief	HK	Ctr	7914	1991	Grounded. Refloated with assistance and proceeded to Alotau for inspection. Sailed to Singapore for repairs.
PNG	25-Jun-1994	GP	M		
East Island, Bonvouloir Islands		10°23.00'S		152°07.00'E	
Dasa Sebelas	PA	U	0	0	Ran aground. Towed by tug to Port Moresby.
PNG	13-Oct-1994	GP	P		
Star reef area		08°29.00'S		149°35.00'E	
Ocean Yuri	PA	CG	0	0	Grounded. Refloated and towed to Madang for repairs. Cargo logs.
PNG	07-Jan-1995	GP	P		
Off south coast of New Britain		06°24.00'S		149°38.00'E	
Shoei No.2	PA	CG	3007	1982	Grounded. Refloated.
PNG	24-May-1995	GP	M		
Off New Britain		06°05.00'S		148°34.00'E	
Grand Fortune	PA	CG	7913	1976	Ran aground. Refloated with assistance and proceeded to Lae for repairs. Forepeak holed.
PNG	25-Sep-1995	GP	P		
On reef		06°18.00'S		149°50.90'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Armada Kasturi	ML	CG	6784	1975	Grounded. Cargo logs.
PNG	16-Oct-1995	GP	U		
Reef off Sauren, off West New Britain		04°34.10'S		168°17.39'E	
Pera	-	LC	310	1969	Sank in bad weather due to Cyclone 'Justin". 6 of 8 crew rescued.
PNG	09-Mar-1997	S	T		
S tip of New Ireland Prov., SE of Cape St George		05°00.00'S		153°02.00'E	
Orange Wave	SI	Other	7551	1983	Engine breakdown. Towed to Madang Harbour by ferry. Vehicle carrier.
PNG	14-Aug-1997	M	P		
-		05°10.00'S		146°00.00'E	
Elfreide	PG	FV	0	0	Grounded. Crew rescued safely. Attempts to refloat abandoned.
PNG	07-Oct-1998	GP	T		
Reef near Basilisk Passage		09°32.27'S		147°08.07'E	
Star Sun	-	CG	6399	1975	Sank. Initially ran aground on reef at Wasum Bay, West New Britain. Pulled off and towed to Rabaul when sank. Crew rescued.
PNG	09-Dec-1998	GP	T		
Jacquinot Bay, East New Britain		05°42.80'S		151°46.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Bao Ji Shan **PNG** Reef outside entrance to Port Moresby	PA 21-May-2000	CG GP 09°32.00'S	0 M	0 147°06.00'E	Grounded. Cargo logs
Gazelle Coast **PNG** Isulailai Point	HK 14-Jun-2000	U GP 10°33.60'S	4292 U	1984 150°42.40'E	Aground.
Ligaya **PNG** -	HN 08-Aug-2000	CG M 10°46.00'S	4339 M	1982 141°32.00'E	Mechanical breakdown forced vessel to anchor after leaving Port Moresby for Kaohsiung. Towed to Port Moresby, repaired and continued voyage.
Anax **PNG** At Sea	MT 14-Aug-2000	Bulk M 10°20.00'S	18392 M	1979 157°10.00'E	Dissabled by engine problem. Carrying (ore?) concentrate and fish meal for Thailand. Towed to Port Moresby
Coral Trader **PNG** -	BS 25-Jan-2002	RoRo GP 10°14.33'S	4887 P	1978 150°56.27'E	Grounded, with punctured forward double bottom. Ballast tanks. Freed with tug assistance, repaired and resumed service.
Irina 2 **PNG** Oro Bay	MT 29-Jul-2002	Toil GP 08°53.00'S	15063 U	1983 148°29.00'E	Tug from Smit Salvage dispatched to aid crude oil tanker aground. Outcome unknown.

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Kimbe Queen	PG	FP	156	1989	Vessel grounded on leaving Kimbe on regular route to Rabaul. 180 passengers transferred to Rabaul Queen. Vessel refloated 4 days later, returned directly to service. Grounding attributed to lack of navaids.
PNG	01-Oct-2002	GP	M		
Kimbe		05°33.00'S		150°09.00'E	
Polynesia	-	Ctr	10774	1979	Stranded, refloated without assistance, returned to Apia, sailed for Long Beach, CA for temporary repairs. Resumed service. Damage confined to an area aprrox. 2.5 m in length in way of bulbous bow.
Samoa	09-Sep-1988	GP	M		
East Reef, Off Apia, Upolu Island		13°48.70'S		171°45.20'W	
Queen Salamasina	-	FC	714	1977	Stranded during Cyclone Ofa. Refloated and towed to Nelson. Repaired and vessel returned to Samoa.
Samoa	03-Feb-1990	GP	P		
Apia		13°48.00'S		171°45.00'W	
Jin Shiang Fa	TA	FV	363	1985	Struck reef near island which is a bird sanctuary. Created diesel spill. Removed and sunk in deep water.
Samoa	14-Oct-1993	GP	T		
Reef at Rose Island		14°33.00'S		168°09.00'W	
Agnui 1	SB	FV	0	0	Mechanical breakdown, drifted 10 days before being located by Orion aircraft from (??). Six crew well, rendezvous and presumed towed by sister vessel Agnui II.
Samoa	07-Oct-2001	M	M		
160km (86 nmi) west of Savai'i		13°27.00'S		174°18.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Greenville III	SI	Tug	0	0	Tug with barge in tow disabled and adrift.
Seychelles?	05-Nov-1993	M	U		
-		02°06.00'N		073°05.00'E	
Pacific Trader	-	Toil	970	1972	Stranded. Refloated without assistance and proceeded to Honiara for survey. Tanker?
Solomon Islands	23-Mar-1979	GP	M		
Viru Harbour		08°32.00'S		157°44.00'E	
Pacific Voyager	-	Toil	674	1970	Stranded. Refloated with tug assistance and repaired at Rabaul. Mechanical damage.
Solomon Islands	20-Jun-1979	GP	P		
Gizo Harbour		08°06.00'S		156°51.00'E	
Yu Hsing	-	FV	0	0	Stranded. Refloated and taken to Honiara for repairs. Mechanical damage.
Solomon Islands	02-Jul-1979	GP	P		
-		05°08.00'S		159°09.00'E	
Solomon Fisher	-	FV	121	1979	Stranded. Refloated and repaired.
Solomon Islands	16-Sep-1979	GP	P		
Reef at Tulagi		09°06.00'S		160°09.00'E	
Tenryu Maru No.22	-	FV	194	1969	Stranded. Declared a constructive total loss.
Solomon Islands	11-Mar-1980	GP	T		
Soloman Sea		08°00.00'S		154°40.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Soltai No.6	-	FV	103	0	Stranded. Refloated with assistance and towed to Tulagi. Minor mechanical damage.
Solomon Islands	08-Aug-1980	GP	M		
Off Munda lighthouse, New Georgia Island		08°20.00'S		157°13.00'E	
Iu-Mi-Nao	-	FC	518	1965	Stranded on reef. Refloated, repaired and returned to service. Slight damage.
Solomon Islands	13-Aug-1980	GP	M		
Reef		08°55.00'S		159°10.00'E	
Mikolaj Rej	-	CG	9397	1969	Listed after stranding. Discharged cargo and refloated. Pilot error was cause.
Solomon Islands	16-Aug-1983	GP	P		
Honiara Harbour		09°26.00'S		159°58.00'E	
Hanlim Master	-	Bulk	9808	1969	Stranded whilst manoeuvring close to shore to load logs. Oil tank ruptured causing oil pollution . Refloated
Solomon Islands	15-Feb-1984	GP	P		
Beach 3 miles west of Taware Point, San Cristobal		10°22.60'S		161°46.50'E	
Ann	-	CG	262	1958	Stranded in heavy weather. Refloated with no damage. 1 crew missing.
Solomon Islands	03-Mar-1985	GP	M		
1 mile E. of Point Cruz, Honiara		09°25.00'S		159°56.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Soloman Princess	-	FP	121	1969	Wrecked in heavy weather
Solomon Islands	03-Mar-1985	GP	T		
On rocks approx. 1 mile E. of Point Cruz, Honiara		09º25.00'S		159º56.00'E	
Regina M	-	CG	500	1956	Stranded after dragging acnhors during cylcone Namu. Broken up in situ.
Solomon Islands	19-May-1986	GD	U		
Honiara		09°25.00'S		159°57.00'E	
Island Trader	-	CG	199	1969	Stranded. Refloated and taken to shipyard for repairs.
Solomon Islands	20-Jan-1988	GP	P		
Rua Ndika Reef		08°43.00'S		159°56.00'E	
Camphor	LI	U	0	0	Grounded. Refloated.
Solomon Islands	19-Aug-1990	GP	M		
River Enoghae		08°10.00'S		157°18.00'E	
Larix	PA	CG	3810	1981	Touched bottom whilst entering Bay. Towed to Honiara. Minor mechanical damage.
Solomon Islands	17-Apr-1991	GP	M		
Aruraha Bay, Makira Island, San Cristobal		10°26.00'S		161°27.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Soltai No. 25	SI	FV	64	1969	Sank due to rough seas and strong winds whilst on journey from fishing ground to Gizo. 6 crew still missing.
Solomon Islands	04-Jul-1991	S	T		
-		08°27.00'S		156°39.00'E	
Island Trader	SI	CG	199	1969	Stranded during cyclone Daman. Refloated and berthed at Honiara. Scuttled.
Solomon Islands	17-Feb-1992	GP	T		
Ranadi Beach		09°25.00'S		159°57.00'E	
Liapari	SI	U	55	1984	Grounded during sudden squall. Severly damaged.
Solomon Islands	17-Feb-1992	GP	P		
Ranadi Beach, Honiara		09°25.00'S		159°57.00'E	
Harmonica	-	Other	0	0	Yacht. Grounded. Later refloated.
Solomon Islands	17-Feb-1992	GP	M		
Point Cruz					
Princess II	SI	FP	133	1963	Sustained engine trouble and stranded. Subsequently sank. All passengers and crew rescued.
Solomon Islands	27-Jul-1992	GD	T		
Florida Islands		09°09.00'S		160°23.00'E	
Tropical Damsel	PA	CG	5451	1985	Touched bottom. Towed to Noro for temporary repairs. Rudder damaged.
Solomon Islands	13-Oct-1992	GP	M		
Wilson Harbour		07°49.00'S		157°18.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
New Asia	TA	CG	0	0	Ran aground in bad weather caused by cyclone "Nina".
Solomon Islands	01-Jan-1993	GP	U		
Kalena Bay entrance, New Georgia		08°21.40'S		157°38.80'E	
Solomon Catcher	-	Bulk	27	1984	Sank after taking in water. Crew rescued.
Solomon Islands	14-Feb-1993	U	T		
-		08°33.00'S		158°47.00'E	
Pelawan	-	CG	4815	1975	Struck reef whilst manoeuvring and sustained damage to rudder and propeller. Towed to Noro.
Solomon Islands	21-Apr-1993	GP	P		
Sumberged reef at Keneko		08°28.00'S		157°16.00'E	
Qena	EG	Bulk	0	0	Taking in water
Solomon Islands	23-Dec-1993	H	U		
Near Solomon Islands		13°27.00'S		161°51.00'E	
Kinabalu Limabelas	ML	CG	4685	1977	Grounded. Efforts to remove vessel have failed.
Solomon Islands	15-Mar-1994	GP	T		
Entering Kenelo, western Solomon Islands		07°53.73'S		157°56.12'E	
World Discoverer	LI	CL	3724	1974	Beached after hit unchartered reef. No injuries reported.
Solomon Islands	30-Apr-2000	GP	T		
Sandfly Passage		09°01.00'S		160°07.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Sea Star **Solomon Islands** Reef outside Munda, Western Solomons	GE 16-Dec-2000	CG GP 08°22.89'S	6601 U	1977 157°13.81'E	Log vessel grounded on reef, still aground 22 dec 02.
Anyamanii **Solomon Islands** Honiara	- 04-Mar-2002	CG O 09°25.00'S	4581 M	1973 159°57.00'E	Piracy. Vessel boarded and crew robbed by 10 armed men, four with guns. Proceeded to Malaita for cargo of logs.
Hua Di **Solomon Islands** -	MT 03-Oct-2002	CG G 08°47.30'S	10932 P	1977 157°55.70'E	Developed steering gear problems, grounded. Cargo approximately 7000 cubic meters logs. Vessel refloated without assistance, anchored. Tug Hua Ji dispatched from China to tow Hua Di to Shanghai for repairs.
Tai Yang No.103 **Tokelau** Reef on S.W. side of Atafu Island	. 19-Feb-1978	FV U 08°34.00'S	133 U	1967 172°28.30'W	na
Nam Hae No.217 **Tokelau** Off Atafu Island	- 09-Apr-1978	FV GP 08°31.00'S	159 U	1965 172°30.00'W	Stranded in poor visibility

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Sunlight No.22	-	FV	291	1963	Stranded. Refloated and towed to Suva. Repaired and returned to service. Moderate damages
Tokelau	20-Jun-1979	GP	P		
Nukunono		09°10.00'S		171°50.00'W	
Ai Sokula	-	CG	400	1961	Wrecked. Salvage attempts abandoned due to low value of vessel and damage to hull. Cargo plundered by islanders.
Tokelau	26-Feb-1981	GP	T		
Reef off Fakaofo Atoll		09°19.55'S		171°12.90'W	
Young Kwang No.3	-	FV	184	1965	Wrecked
Tonga	23-Feb-1987	GP	T		
Coral Reef		15°57.00'S		173°43.00'W	
Golden Glow	US	U	959	1967	Fire started on board forcing crew to abandon ship. Crew later rescued. Position reports conflict; 175o00.00'E probably in error, corrected to W.
Tonga	03-Feb-1998	F	T		
200 miles south of Tonga		21°59.56'S		175°00.85'W	
Paragon 3259	NZ	FV	0	0	Trawler adrift due to engine problems. Located by RNZAF Orion aircraft on routine patrol. Towed to Tonga by fishing vessel Southwind.
Tonga	27-May-2002	M	M		
At Sea		20°02.00'S		176°00.00'W	
Nam Hae No.203	-	FV	159	1965	Grouned. Refloated and repaired at Suva. Mechanical damage.
Tuvalu	10-Nov-1978	GP	P		
Nanumanga		06°20.00'S		176°17.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Aoi Maru	-	CG	223	1972	Stranded. Refloated without assistance and sold. Casualty occurred in heavy weather. Taken to Suva.
Tuvalu	18-Jan-1979	GP	P		
Funafuti Island		08°31.00'S		179°08.00'E	
Sieh Tsin Jung	-	FV	187	0	Stranded. Left-as-Lies. Major mechanical damage. Charged for illegal fishing by Tuvalu government.
Tuvalu	08-Feb-1981	GP	T		
Nukufetau		08°00.00'S		178°30.00'E	
Sisco	-	CG	481	1949	Wrecked. Bottom extensively damaged. Attempt to refloat unsuccessful. Casualty occurred.
Tuvalu	20-Apr-1981	GP	T		
Vaitup Island		07°28.00'S		178°41.00'E	
Jeanette Diana	US	FV	0	0	Main engine blew starting a fire. Crew abandoned vessel and were later rescued. Vessel sank 50 miles east of Tuvalu.
Tuvalu	21-Apr-1993	F	T		
800 miles NNE of Pagopago		05°00.00'S		178°00.00'E	
Ryoyu Maru No.8	-	FV	134	1973	Stranded after an electrical fault. Owners abandoned vessel to salvors who refloated and effected repairs. Renamed Jucy and used as an auxillary salvage vessel by salvors.
USA - Palmyra	22-Nov-1979	GD	P		
On Kingman reef 40 miles NW of Palymyra Island		06°25.00'N		162°26.00'W	
Hui Feng No.1	-	FV	280	1969	Stranded. Crew rescued. Diesel fuel leakage.Oil pollution
USA - Palmyra	14-Jun-1991	GP	P		
Palmyra Island		05°53.00'N		162°05.00'W	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Shanta Shibani	-	Bulk	15387	1971	Stranded on rocks after moorings broke in heavy weather. Refloated and taken to Guam and thence to Ulsan where temporary reparis effected.
USA - Wake Island	25-Jan-1984	GD	P		
Wake Island		19°17.00'N		160°37.00'E	
Kalili	-	FC	227	1961	Stranded. Subsequently sank following cylcones Eric and Nigel.
Vanuatu	16-Jan-1985	GP	T		
Palikulo Bay, Espiritu Santo Island		15°29.00'S		167°14.00'E	
Federesen Nalkutan	-	CG	341	1958	Wrecked during cyclone Nigel.
Vanuatu	18-Jan-1985	GP	T		
Segond Channel, off Espiritu Santo		15°33.00'S		167°08.00'E	
Fetukai	-	CG	115	1971	Took water and beached. Refloated after temporary repairs and taken to Port Vila.
Vanuatu	16-Jun-1987	H	P		
Tanna Island		19°30.00'S		169°20.00'E	
Lublin II	PO	U	0	0	Vessel leaked oil into port causing pollution
Vanuatu	18-Nov-1992	U	P		
Santos Port		15°31.00'S		167°10.00'E	
Matissimo	VU	U	0	0	Vessel leaked oil into port causing pollution
Vanuatu	18-Nov-1992	M	P		
Santos Port		15°31.00'S		167°10.00'E	

Vessel Name / Country of Incident / Location Name	Flag / Date of Incident	Type / Type Incident / Latitude	GRT / Severity	Year Built / Longitude	Comments
Latua	-	FP	0	0	Vessel went missing during heavy storms. 25 passengers and crew on board.
Vanuatu	08-May-1999	S	T		
Between Port Vila and Shepherd Islands		17°10.00'S		168°40.00'E	
Fetukai	-	CG	115	1971	Took water and beached. Refloated after temporary repairs and taken to Port Vila.
Vanuatu	16-Jun-1987	H	P		
Tanna Island		19°30.00'S		169°20.00'E	
Lublin II	PO	U	0	0	Vessel leaked oil into port causing pollution
Vanuatu	18-Nov-1992	U	P		
Santos Port		15°31.00'S		167°10.00'E	
Matissimo	VU	U	0	0	Vessel leaked oil into port causing pollution
Vanuatu	18-Nov-1992	M	P		
Santos Port		15°31.00'S		167°10.00'E	
Latua	-	FP	0	0	Vessel went missing during heavy storms. 25 passengers and crew on board.
Vanuatu	08-May-1999	S	T		
Between Port Vila and Shepherd Islands		17°10.00'S		168°40.00'E	

1 <u>APPENDIX 5: Risk analysis methods at the regional and EEZ scales</u>

Several map layers were required to create the grounding and collision potential maps. These included the vessel traffic route and volume map, as well as the contextual map layers: reefs and shorelines. The method described here involves two distinct processes: one for the grounding hazard map and one for the collision hazard map. Both maps use a separate ‘thematically-shaded grid’ layer to store information processed from the traffic and context layers. For example: the product of the number of routes in a grid area and the volume of traffic in the area is stored for each grid cell. This information is then coloured for each grid cell as a low, moderate or high collision hazard.

1.1 Grid Creation

First, a grid was created covering the study area. Each grid square has a data field named Zero_depth. If this field is set to ‘1’ then a grounding hazard exists in the form of a reef or a shoreline contour. This grid need only be created once. It is re-used each time a new thematic grid map is required for either collisions or groundings.

Step 1. Create a grid of regions in MapInfo—one degree x one degree in size.

Use the MapInfo Grid Maker add-in tool.

Step 2. Count the reefs and shorelines that intersect with the grid cells

Use the MapInfo Update Column function. The OneDegreeSquares table is pre-processed using the geographic join where intersects and where within from the reefs and auspol tables to the grid table. The Zero_depth field in the grid table is then set to 1 or 0 if there is a grounding danger or not, respectively. Steps 1 and 2 need never be repeated unless the reefs or auspol maps are updated.

1.2 Grounding potential thematic map

In order to cover the entire south pacific study area, the resolution of this map is one degree or 60 nautical miles square. Grounding potential is thematically mapped as the product of the existence or not of a reef or shoal within a one degree grid cell and the traffic volume.

Step 1. Update the Grounding_risk field in the grid cells with the product of the Zero_depth and the traffic count.

1.

Use the MapInfo Update Column function.

Step 2. Create the thematic map using the Grounding_risk field

Use the MapInfo Create Thematic Map function.

1.3 Collision potential thematic map

Collision potential is thematically mapped as the product of the count of traffic routes within a one degree grid cell and the traffic volume. This function is intended to associate a higher collision potential with multiple routes in close proximity.

Step 1. Count the vessel routes that intersect with the grid cells

Use the MapInfo Update Column function. The grid map is processed using the geographic join where intersects with the table Sroutes. The field Count_routes is set to the count of the number of vessel routes that intersect with each grid cell.

Step 2. Update the Collision_risk field in the grid cells with the sum of total traffic frequency data for all routes in Sroutes that intersect with the grid cells

Use the MapInfo Update Column function. The grid map is processed using the geographic join where intersects with the table Sroutes. The field Collision_risk is set to the Sum(TotalFreq) of of SRoutes that intersect with each grid cell.

Step 3. Update the Collision_risk field in the grid cells with the product of the count of routes and the total traffic count

Use the MapInfo Update Column function. The grid map is processed by setting Collision_risk = Count_routes x Collision_risk.

Step 4. Create the thematic map using the Collision_risk field

Use the MapInfo Create Thematic Map function

1 APPENDIX 6: SampleForms

COUNTRY DATA SHEET

PACPOL RA1: Marine Risks Assessment **Reward for return, if lost to:**

Edward Anderson Marine Sciences PO Box 2125 Sidney, BC anderson_e@coastnet.com
or (Feb – Mar 2001) c/o Institute of Applied Sciences, USP, PO Box 1168, Suva, Fiji (679) 313 900
or Sione Tu'itupou Fotu POBox 2461, Nuku'alofa, Tonga (676)22479 stfotu@kalianet.to
or GeoInfoSolutions, 10352 Arbay Close, Sidney, British Columbia, Canada V8L 4S2 (250) 656-7170, bjudson@geoinfosolu tions.com

COUNTRY:	

MAJOR GOVERNMENT AGENCIES: PORTS, FISHERIES, ENVIRONMENT

Agency, Department, Ministry	Contact	Address, Phone, fax, email	Contacted? (When, who)
(one row omitted)			

MAJOR PORTS SERVING INTERNATIONAL OR INTERISLAND SHIPPING

Port	General description	OPTIONAL: Cargoes handled, approx annual volume	Info source, year to which it applies?
(one row omitted_			

COUNTRY DATA SHEET p2

COUNTRY: ____________________

Page ___ of ____

ACTIVE SHIPPING LINES SERVING COUNTRY, VESSELS over 200 GRT, and VESSEL CHARACTERISTICS

Shipping lines active in country (international lines and any in country with vessels over 200 GRT; distant-water fishing vessels may be grouped- e.g. longline FV, 200-400 GRT)			**Vessels** (Vessels that have called in one recent year, especially those that repeat calls on schedule)			
Line name, flag	Agent or contact	Address	Vessel name(s)	Type (container, bulk cargo, oil tanker, LNG tanker, passenger/cargo ferry, etc.)	Tonnage GRT? DWT?	Speed, kn (if known)

(use additional sheets as necessary)

PORT DATA

PACPOL RA1: Marine Risks Assessment

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phone (679) 313 900
fax (679) 300 373

Country	**Port** (separate sheet for each port in country)	**Page __ of ____**

Contact(s) for this port

Data source person, position (or "see country") Department, agency or company	Mail	Phone Fax Email
Data source person, position Department, agency or company	Mail	Phone Fax Email

Traffic Patterns

Vessel (or Line of similar vessels from Country Sheet) (distant waters fishing vessels may be grouped, as in examples)	Inbound from			Outbound to	Frequency (per year)
Examples	examples			examples	examples
(three rows deleted)					

(use additional sheets as necessary)

Port: ________________________________ Page ___ of ___
(continued)

General practices (this section is optional, but any observations will be useful)

Ballast/deballast (Do vessels deballast to enter port? Which types of vessels, and where?)
Solid waste disposal (Do visiting vessels unload solid waste at this port? Dump at sea nearby?)

Sewage (Do vessels discharge sewage to harbour or lagoon?)
Further impressions (Bilge pumping, lube oil disposal, etc.)

Hazards to navigation (optional section - any places of special danger to ships?)

Near port
Within country EEZ on frequently traveled routes

Environmentally sensitive areas at risk to pollution from ships (optional section)

Near port
Within country EEZ

Hazard/sensitive location notes and sketches - use additional pages as necessary (charts, sketches, or rough drawings will help us understand your notes)

Data recording notes (please leave this last section blank)

Comments/verifications	**Data recorded by**
	Date

SHIPPING LINE DATA

PACPOL RA1: Marine Risks Assessment **Reward for return, if lost to:**

Edward Anderson Marine Sciences
anderson_e@coastnet.com
PO Box 2125 Sidney, BC , Canada V8L 3S6
tel (250) 380-8599; fax(250) 389-2247

SHIPPING LINE: **Page _1_ of __**

Contact(s) for this line

	Mail	Phone Fax Email

Vessels over 200 GRT

Vessel Name	Type*	Tonnage (GRT? DWT?)	TEU (container ships)	Year Built	Crew	Passengers	Speed, kn
Example: MV "Island Navigator"	Passenger ferry	1250 GRT	-	1976	15	320	15
(three rows omitted)							

Toil - Tanker, oil and petroleum products; TLNG - Tanker, compressed/liquid gas; OBO - Oil-Bulk-Ore; Bulk - Bulk products carrier; Ctr - Container; RoRo - Rollo-on-Roll-off; Pass - Passenger vessel, including passenger/freight ferry; GenC - General Cargo (may have some passengers); Othr - Other type (explain)

Traffic Patterns

Vessel or Class of similar vessels	Route	Frequency (per year)
Example: "Island Navigator"	1. Suva-SavuSavu-Levuka-Taveuni-Suva 2. Suva - Kadavu - Suva	12 26
(ten rows of blank cells omitted)		

Page 2, All questions optional - but any responses welcome!

Sketches of routes, etc. Use extra pages as necessary.

(extra space omitted here)

Comments, sketches on hazards to navigation (bear port, EEZ). Use extra pages as necessary.

(extra space omitted here)

General practices

Fuel type, total capacity, where taken on
Solid waste disposal (incinerate onboard? Dump at sea? Unload at continental port? unload at island port?)
Sewage (holding? macerate/chlorinate? Discharge to harbour?)
Further impressions (Bilge pumping, lube oil disposal, etc.)

Comments/verifications	Data recorded by	**Date**