COCOS (KEELING) ISLANDS LAGOON SHIPPING PASSAGE REALIGNMENT

Graham GREENACRE
Senior Manager, GHD Pty Ltd, Perth WA
ggreenacre@ghd.com.au

Fraser ROBSON
Project Manager, GHD Pty Ltd
frobson@ghd.com.au

Peter SEMAN
Program Manager, GHD Pty Ltd
pseman@ghd.com.au

Abstract

At Cocos (Keeling) Islands in the Indian Ocean, the existing shipping passage into the Lagoon required realignment to reduce the risks to shipping and ultimately the environment. The main user of the channel is the fuel tanker that brings bulk supplies of diesel to the islands to run the electricity generators.

The existing passage is marked with nine lit beacons and ships require a pilot to navigate down the 5.0 kilometre route from the passage entrance. It comprises a series of continuous curves that are difficult to negotiate, and the limiting section of the passage relies on a tidal component to ensure a suitable under keel clearance.

The new shipping passage alignment will be a significant improvement on the current situation by providing a simpler, straighter route which will optimise navigation safety for vessels entering or leaving the Lagoon, and an increased clear depth to 4.5m below Chart Datum.

The main focus of the paper is the environmental impact issues relating to removal of coral outcrops and installation of new navigation aids to meet the current and long-term needs of the Islands.

The scope of work for the project involved the repair, removal or replacement of navigation aids, and removal or permanent marking of coral outcrops considered a danger to shipping vessels.

This project was referred to the Commonwealth of Australia's environmental approval agency, Environment Australia, and approval was obtained following the environmental assessment process. Construction commenced in late April 2001 when periods of calm weather were most likely to be experienced.

INTRODUCTION

At Cocos (Keeling) Islands (CKI) in the Indian Ocean, the existing shipping passage which traverses the lagoon was realigned to reduce the risks to shipping and ultimately the environment. The main focus of this paper is the environmental impact issues relating to the removal of coral outcrops and installation of new navigation aids to meet the current and long-term needs of the Islands. The main user of the passage is the fuel tanker that brings bulk supplies of diesel to the islands to run the electricity generators.

The CKI are an Australian external territory administered in part by its own Shire Council based on a Western Australian model, and in part, by the Non Self-Governing Territories Branch of the Department of Transport and Regional Services (DoTaRS). The government's objective for CK1 is normalisation with the rest of Australia and protection of the national interest.

The islands are located in the Indian Ocean at latitude 12° 05'S and longitude 96° 53'E, 2768km North-West of Perth, Western Australia, and incorporate Australia's only inhabited oceanic atoll (refer Figure 1). The South Keeling Islands form a coral atoll comprising 26 reefs islands, which form a ring around a main central shallow lagoon. The lagoon has an area of 102km², consisting of a shallow southern region (with a mean depth of 3m below sea level) and a deeper (up to 10-20m below sea level) northern section. A single uninhabited island 24km to the north, North Keeling Island, forms the other coral atoll and is a dedicated nature reserve.

The CKI are coral sand islands with the highest elevation being 9m above mean sea level, though generally the land is only 2 to 3m above mean sea level. The islands have a population of about 600 people with 450 Cocos Malays living on Home Island and 150 "expatriate" Australians living on West Island, which is the administrative centre. The region is cyclonic and the islands are subject to storm surge under extreme conditions. Between 1961 and 1992, 23 cyclones passed within 100km of CKI.

The islands are densely vegetated by coconut palms (*Cocos nucifera*), although the traditional industry of copra extraction has been abandoned for many years. The only income generated by the islands is from a very small-scale tourist trade, however there are possibilities for further development of tourism and marine based industries. The lagoon and surrounding waters provide recreation and subsistence fishing to the CK1 community. The total land area of all islands in the group is 14 square kilometres and it has no known resources of any significance. The environment is susceptible to impacts from human habitation and is monitored and protected by Parks Australia North (PAN).

This paper outlines the process that was followed and the studies undertaken to address the environmental impact issues relating to the removal of coral outcrops and installation of new navigation aids for the new shipping passage. Each of these issues had to be investigated and managed before approval for this project could be achieved. The paper covers all facets of the design, environmental management, construction and verification after completion.

BACKGROUND

GHD was asked by DoTaRS to investigate the limitations of the existing shipping passage, define a scope of work, and develop cost effective, practical and environmentally sensitive options for a realigned shipping passage. The investigations included two hydrographic surveys to identify all coral outcrops along the routes of the options considered, a wave study, a preliminary pile design and a condition survey of existing piled navigation aids.

Historically, freight unloading and handling, which are both crucial to the Territory, have been characterised by many logistic and environmental problems. Currently, container ships visit the Territory on an approximate six-week cycle from Fremantle, Western Australia, and a small fuel tanker visits the Territory once every six to eight months. These supply ships transporting goods to and from CKI use one of two anchorages within the area defined by the port limits. The Blue Holes is a safe anchorage situated in the lee of Direction Island at Port Refuge located at the northern

end of the lagoon. Here the container ship off-loads 10-15 twenty foot containers onto the 150 tonne *Jasa Cocos* dumb barge.

The second anchorage is the Shell Buoys, about 2.0 km East-North-East of the West Island Jetty. The Shell Company of Australia Ltd (Shell) owns, operates and maintains the three mooring buoys at this location. These are used by the small fuel tanker that traverses a marked passage across the lagoon from Port Refuge. The vessel is secured to the three mooring buoys and a submarine fuel line is retrieved from the sea bed by a diver to pump the fuel to tanks at the north end of West Island.

The current draft limitation of 4.1m recognised by Shell is less than the fully laden draft of their chartered tankers, and this limits Shell to supply jet and dieseline fuel on an approximate 8-month cycle. As both types of fuel only have a product shelf life of around 9 months, the current draft is adequate for supply volume requirements, based on the size of vessels servicing the terminal.

In 1995, the safety of the passage to the Shell Buoys was questioned by the Marine Consultant engaged by Shell to pilot the fuel tanker once it is inside the lagoon. The existing passage comprises a series of continuous curves, which are difficult to negotiate, increasing the potential for a fuel tanker or freight vessel to encounter a coral high spot while traversing the lagoon. If a vessel was severely damaged, the resulting spill would lead to unacceptable pollution of the marine and terrestrial environments.

The existing passage is marked with 9 lit beacons and ships require a pilot to navigate down the 5.0 km route from the passage entrance to the Shell Buoys anchorage. The limiting section of the passage relies on a tidal component to ensure a suitable under keel clearance (U.K.C) and this has restricted the ship-handling time frame.

From a safety perspective, it is therefore important that the fuel tanker is able to access the Shell Buoys anchorage as quickly as possible if there are indications that strong winds are imminent. An increased clear depth and straighter route will therefore provide a safer passage and also an increased daytime manoeuvring timeframe.

DESIGN PROCESS

A Marine Consultant was engaged by GHD in 1996 to define the design criteria for a new improved shipping route to the Shell Buoys anchorage (1). The Marine Consultant determined that the existing passage does not realistically delineate a safe track and therefore requires realignment. The Consultant also confirmed that a minimum passage width of 75m is required to satisfy maritime safety standards for beam/channel width ratios laid down under PIANC guidelines. The appropriate ratio depends upon the direction and force of the prevailing wind and current, and also the nature of extremities at the narrow section.

Alternative options for the new passage were considered prior to arriving at the preferred alignment (2). The preferred route was selected based on a number of factors including environmental impacts from dredging and optimisation of navigation safety.

The following is a summary of the works associated with the new shipping passage:

- New gateway of navigation aids to mark the approximately 100m passage width to the south-east of the rear lead Griffith Beacon;
- Removal or lowering of 6 coral outcrop high spots;

- Installation of 8 new tubular steel piled navigation aids with solar powered lighting and an expected lifespan of 25-30 years; and
- Removal of 7 existing piled navigation aids;

Further supplementary items were incorporated to address lagoon navigation requirements including installation of minor beacons along the ferry route and replacement of navigation aids in other areas of the lagoon.

The new shipping passage alignment provides a simpler route with less turning manoeuvres and increased clear depth, which will optimise navigation safety for vessels entering or leaving the lagoon. It will provide a passage with clear depth to 4.5m below Chart Datum (CD) with a draft limit of 4.1m. This will benefit all lagoon users and provide location points for lost and disabled boats.

Not improving the existing infrastructure (the 'do nothing' option) was not considered an acceptable strategy because although it had provided a workable navigation system, the markers were rapidly approaching the end of their useable life with a limited expected lifespan of 0-5 years if no improvements were carried out.

Equally, retaining the existing alignment and upgrading the existing infrastructure was rejected on the grounds that it would not change the overall risk to the environment and Cocos Community posed by the potential for a vessel to be grounded on a coral outcrop.

CONSULTATION PROCESS

Throughout the planning and development stages of the project, key stakeholders on CKI and the mainland were consulted extensively. The consultation process provided stakeholders with the opportunity to review and comment on the recommendations made. Considerable liaison has been carried out to ensure that all issues and alternative options have been adequately investigated and that satisfactory design and management processes have been developed to minimise environmental risks.

The CKI Harbour Master is the governing authority to give final approval for the suitability of the new shipping passage under the Shipping and Pilotage Act. He advised that the new shipping passage design is acceptable and met with his requirements. PAN and the Indian Ocean Territories Environment Officer (IOTEO) were consulted on the possible effects that the project may have on the environment. The views of the Cocos Administration, Shire Council, the Cocos Marine Officer, Australian Federal Police, and Shell were also sought to involve them in the consultation process. Their recommendations and comments on navigation aid requirements were assessed and incorporated into the scope of work.

ENVIRONMENTAL MANAGEMENT

There is a general paucity of algal, seagrass and coral species along the new shipping passage route and the sediments are a mixture of coral rubble, sand and silt. Most fauna species identified during the field surveys in the lagoon are considered to be residents, having either defined territories or confined mainly to seagrasses and algal beds. Schools of small fish including damsels were observed, and non-resident transitional species such as *Carchahinus melanopterus* and *Carangoides ferday*, were also identified. However, significant and diverse fish life was limited to large coral outcrops with abundant soft and hard corals including coverage of staghorn and porites.

Extensive investigations of the local marine environment and research into proposed construction methodologies indicated that significant environmental impacts were

unlikely. The region is a relatively stable, low energy environment. From the light data collected, it was determined that a significant long term decrease in water clarity would be required to cause significant mortality of benthic species due to light starvation. Since the construction program was to take place over a short duration, there would not be a significant impact on benthic species from reduced light levels resulting from construction activities.

Areas of environmentally significant "*thassyedendron*" seagrass meadows did not have to be removed from the seabed along the new passage by dredging but this would have been required on flat sandy sections along proposed alternative routes.

Investigations

During a two-week field survey (3) undertaken in April 1998 over the 4km length of the proposed new route, a number of coral outcrop high spots identified by a DOT hydrographic survey in February 1998 were located using GPS. The field survey provided a detailed description of the coral outcrop high spots and documented information including approximate size, shape and type of coral material. The relative density and abundance of flora and fauna around individual coral outcrops was documented as well as the environmental significance of the formations. The surrounding seabed was also documented at each location to determine the preferred site for pile driving for navigation aids or the site for lowering pieces of coral, thus minimising the environmental impact on local flora and fauna. Video footage, photographs and visual observations were taken for future reference, and each individual outcrop was marked with an identification tag.

Several representative coral samples, approximately 400mm in diameter, were selected from outcrops to ensure that an adequate core sample could be obtained for laboratory testing. Tests were performed in a saturated moisture condition and determined the uniaxial compressive strength, indirect tensile strength (Brazil Method), and indirect shear test. Overall, the test results indicated that the coral formations in the Cocos lagoon are generally composed of a relatively high strength material with a compressive strength of at least 21.5 MPa, which is comparable to that of medium strength concrete. The testing laboratory confirmed that the process of cutting samples with a diamond saw was achieved with relative ease. The test results provided information for contractors submitting tenders for the coral removal work to determine the cost and methodologies required.

CONSTRUCTION METHODOLOGY

To carry out pile driving, coral removal work and hydrographic verification surveying the optimal conditions are low wind speed and wave height. Construction was therefore planned to commence in early 2001 to take advantage of favourable weather conditions when longer periods of calm weather were most likely to be experienced. All works were required to be carried out prior to the removal of the existing navigation aids.

Coral Removal

Initially 24 coral outcrop high spots were to be removed to achieve a total clear depth of 5.0m. However, this was subsequently reduced to only 6 coral high spots to achieve a total clear depth of 4.5m below CD, after Shell confirmed that the current draft limit of 4.1m was acceptable for the foreseeable future. This had the advantage of reducing the potential impact of construction work on the surrounding marine environment and also reduced the cost of the project.

Impact on the lagoon environment was also minimised by utilising coral removal methods which were least damaging to the environment. PAN and the IOTEO both confirmed that the use of explosives for lowering or removal of coral outcrops was not acceptable, and mechanical removal techniques were therefore used. Various methods were initially considered including the use of chemical expanding grout, high-pressure water, barge mounted drilling rig, and hydraulic excavator. However, these methods were assessed to be overly expensive or slow.

The following acceptable coral removal techniques were developed in conjunction with industry experts:

- **Chisel** – powered by compressed air, an underwater chisel is most effective for situations where a coral high spot only needs to be lowered nominally. The chisel is used to remove small amounts of coral from the top of a high spot and is an environmentally friendly method with low impact on the surrounding marine environment if used in the appropriate situation.
- **Under-water chainsaw** –a tungsten tip underwater chainsaw has the advantage that the seawater acts as a lubricant and coolant to reduce wear on the equipment. This method also has the significant advantage that selected lumps of coral can be removed directly from the main coral formation with minimal impact on surrounding flora and fauna. The lumps can then be lowered to the seabed by hand or by mechanical means and transplanted under controlled conditions. Any coral placed on the seabed can then become a site for new coral growth and rehabitation by flora and fauna.
- **Cutting wire** – this removal method is suitable for removing larger amounts of coral. A cutting wire is placed around the stem of the coral formation at the required level and anchor blocks positioned in front of the outcrop. The wire is taken to the surface and passed through an A-frame structure with a winch on one side and a pulley located on the deck of a vessel or floating platform. The equipment is powered by compressed air and the wire is alternately pulled from either side in a seesaw action to produce a cutting effect. This is an effective method to cut through larger cross-sectional areas of relatively soft coral formations and has minimal impact on the local marine environment.
- **Lift and Move** – depending on the size of the coral outcrop to be removed a floating platform can be used to lift the complete coral high spot and move it to a suitable clear area on the sea bed outside the extent of the new shipping passage.

The Contractor was experienced in a number of non-explosive coral removal techniques, including those above, and used the most appropriate method to suit the size and height of each coral formation identified.

Data collected during the 1998 field survey confirmed that 6 coral outcrops only had to be lowered by an average of approximately 350mm to achieve a minimum clear depth of 4.5m below CD along the entire route of the new passage. This was generally achieved by removing small individual coral lumps extending from the main coral formation. It was not necessary to completely remove any of the coral formations. However, removal and relocation of a complete formation was carried out if it would minimise environmental impact.

The heights of the 6 high spots identified for lowering were reduced by an additional 200mm to allow for the expected annual coral growth rate of up to 10mm per year. This would provide up to 20 years before maintenance work would be required.

The Contractor was required to minimise damage to adjacent coral outcrops and other surrounding marine flora and fauna at all times including when anchoring any floating work platform, and during coral removal operations. The Contractor provided before and after photographs of the coral high spots identified for removal for record purposes.

Installation of Navigation Aids

Two options were considered for the replacement of existing piled navigation aids along the main shipping passage and ferry route; piled markers and floating spar buoys. After consideration of issues such as dynamic loads, maintenance requirements, anchoring of buoys in calcareous seabed material and the impact of cyclones and heavy swells, it was determined that piled beacons were the most appropriate solution for CKI marine and weather conditions (4). Preliminary investigations confirmed that coral rubble/ silt detritus/ substrates for full pile penetration depth would be available at each of the nominated coral outcrop locations.

To minimise the impact on environmentally significant formations with extensive and diverse fish colonies and abundant soft coral coverage, navigation aids were installed to permanently mark the limits of these outcrops so that vessels maintain a safe distance from the hazard. The Contractor was required to verify that piles were not pitched on top of massive surface corals before commencing driving.

Verification Survey

An independent hydrographic verification survey will be undertaken over the full extent of the new passage to confirm the final reduced heights of coral outcrop high spots and verify that the Contractor has completed coral removal to the required performance specifications. The survey will confirm the position of newly installed navigation aids and also confirm that all coral formations have been identified. The most suitable system to undertake the final sweep sounding with a 100% coverage of the new passage is considered to be a single beam echo sounder option, coupled with sidescan sonar. A final chart will be produced to complete the commissioning of the new passage.

APPROVALS

This project was referred to the Commonwealth of Australia's environmental approval agency, the Environment Protection Group (EPG) of Environment Australia (EA), and approval was obtained following the assessment process. A detailed Notice of Intent (NOI) (5) was prepared to provide sufficient information to satisfy the requirements of the Environment Protection (Impact of Proposals) Act (6). The NOI addressed the environmental impact issues associated with the project as well as standards to be applied to provide the maximum possible protection to the environment.

An Environmental Management Plan (EMP) was developed, approved by the IOTEO and incorporated in the tender documents for the new shipping passage. This set out the potential environmental risks and environmental management measures and safeguards the Contractor had to submit for approval and implement during construction to ensure that the works did not impose significant lasting impacts on the environment.

The Contractor prepared an Emergency Response Plan that identified the risks of a fuel spill to the marine environment, spill clean up techniques and procedures to follow in the event of a spill or other emergency scenario.

Compliance with the requirements of the EMP and regulations governing issues such as noise, air, and water quality under the Environmental Protection Act, 1986 (WA) (CKI) (7) were monitored by the relevant statutory authorities.

CONCLUSION

The proposal to construct a new shipping passage across the Cocos (Keeling) Islands lagoon provided some interesting challenges for the Project Management and design team. To achieve the necessary approvals a series of technical studies and investigations were undertaken to identify and quantify the project risks, develop the scope, and determine environmentally acceptable construction methods.

The construction of a new shipping passage will overcome the inadequacies and environmental risks associated with the existing shipping passage and navigation infrastructure. If the existing alignment and infrastructure were retained, then the risks associated with navigation safety would not be adequately addressed. Not to proceed could also conflict with the Australian Government policy for CKI to achieve equivalent mainland standards and normalisation with the rest of Australia.

The benefits and advantages of this project have to be considered and assessed in the context of the overall freight management system appropriate to CKI. The need to supply the islands with fuel is most economically achieved in bulk and for this reason, the hazardous nature of the cargo and its potential impact on the fragile environment had to be taken into consideration.

The works associated with the project involved the application of standard, well-proven technologies that posed a very low level of risk to the environment. The new shipping passage alignment is located in an area of the lagoon that is suitable for the facilities and they are not expected to have any major adverse impact on the natural or social environment. The overall change to the ecosystem is assessed to be positive.

Key Words

Environmental Management; Environmental Impact; Environmental Risks; Environmental approval; Consultation; Shipping Passage; Maritime Safety; Navigation Safety; Navigation Aids; Coral Removal; Marine Environment; Piles.

References

1. Placer Marine Consultants "Cocos (Keeling) Islands Main Shipping Passage Design Criteria Report", October 1996.
2. Gutteridge Haskins & Davey Pty Ltd, "Cocos (Keeling) Islands – Recommended Option for Proposed Shipping Passage", December 1997.
3. Gutteridge Haskins & Davey Pty Ltd, "Cocos (Keeling) Islands – Survey and Assessment of Coral Outcrop High Spots", 1998.
4. P&O Asset Services, "Report on Pile Driving in the Cocos (Keeling) Islands", June 1998.
5. Gutteridge Haskins & Davey Pty Ltd, "Cocos (Keeling) Islands Lagoon Navigation Project Shipping Passage Realignment Notice of Intent", March 2000.
6. Environment Protection (Impact of Proposals) Act, 1974.
7. Department of Environmental Protection, Perth, "Environmental Protection Act, 1986 (WA) (CKI).

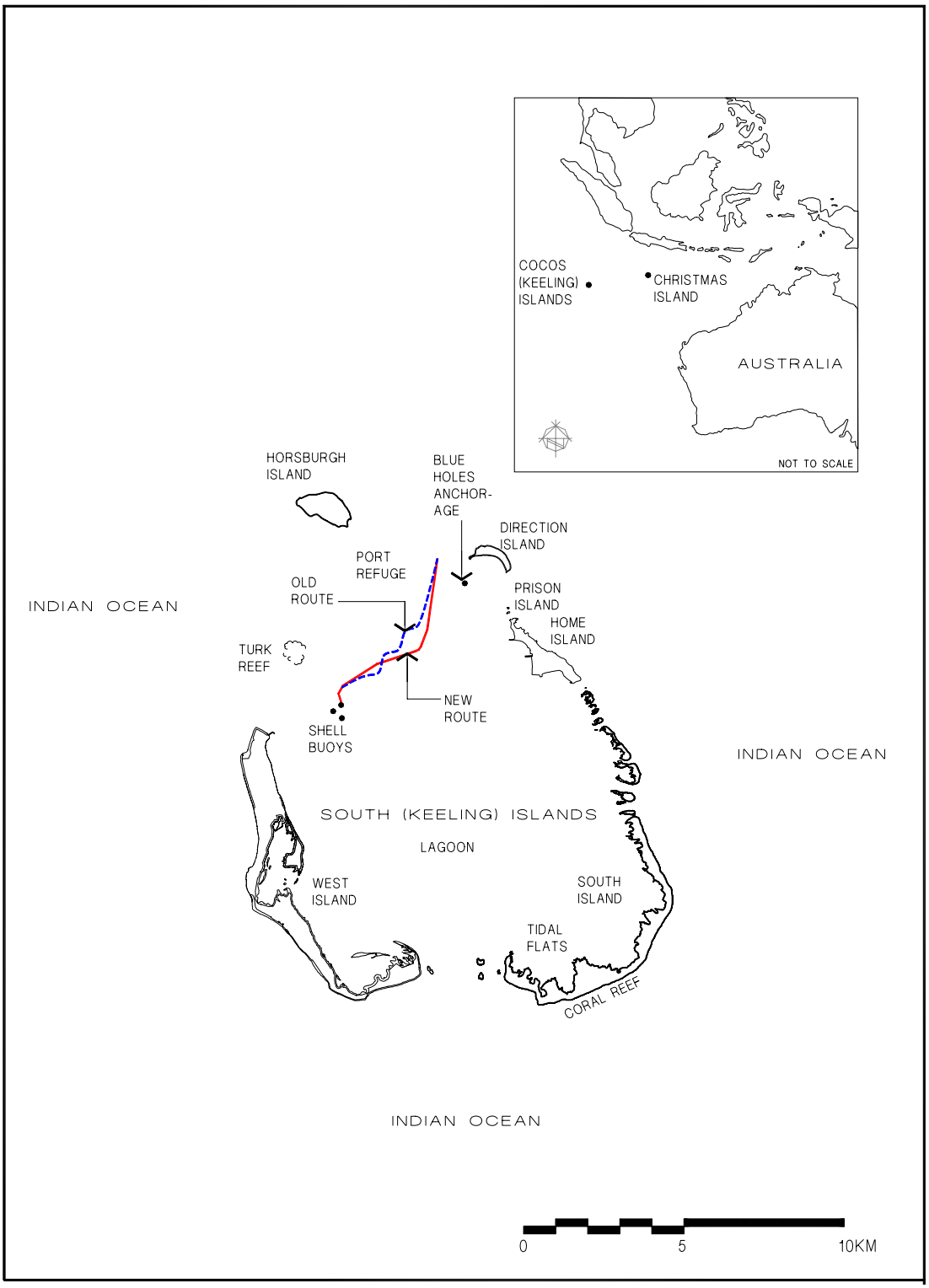

Figure 1. Cocos (Keeling) Islands, Indian Ocean
Location Plan

Figure 2. Old Shipping Passage Navigation Aid

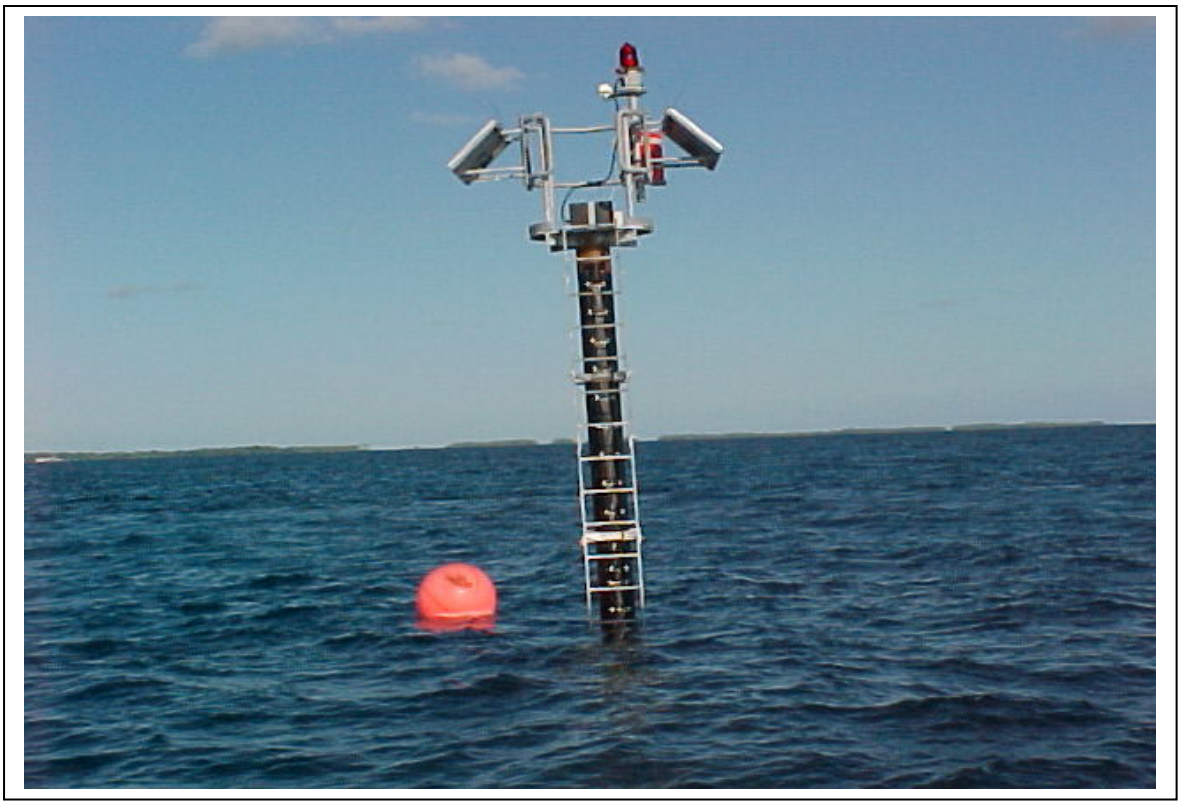

Figure 3. New Shipping Passage Solar Powered Navigation Aid

Figure 4: Coral Outcrop High Spot No. 6 – To be marked with New Beacon

Figure 5: Coral Outcrop High Spot No. 19 - Identified for Lowering