Environmental assessment of islets and cays of Tregrosse and Lihou Reefs Coral Sea Marine Park July 2021

Report to Parks Australia Division, Department of Agriculture, Water and the Environment

Chapman F., Brushe J. and McDougall A. (*Editors*)

Australian Marine Parks

Queensland Government

Prepared by: Queensland Parks and Wildlife Service and Partnerships, Department of Environment and Science

The Department of Environment and Science acknowledges Aboriginal peoples and Torres Strait Islander peoples as the Traditional Owners and custodians of the land. We recognise their connection to land, sea and community, and pay our respects to Elders past, present and emerging.

The department is committed to respecting, protecting and promoting human rights, and our obligations under the Human Rights Act 2019.

Citation

Report:

Chapman F., Brushe J. and McDougall A. (Eds.) (2022) Environmental assessment of islets and cays of Tregrosse and Lihou Reefs, Coral Sea Marine Park, July 2021. Report to Parks Australia Division, Department of Agriculture, Water and the Environment. Queensland Parks and Wildlife Service and Partnerships, Department of Environment and Science

Individual chapters (example):

McDougall A. (2022) Birds. In Environmental assessment of islets and cays of Tregrosse and Lihou Reefs, Coral Sea Marine Park, July 2021, Eds. Chapman F., Brushe J. and McDougall A. (pp. 22-24). Report to Parks Australia Division, Department of Agriculture, Water and the Environment. Queensland Parks and Wildlife Service and Partnerships. Department of Environment and Science

Front cover: Masked booby *Sula dactylatra* gently tends to her featherless, new chick using her body to protect it from the sun. For five months the parents will fish from the sea until their chick is a two month old fledgling. The isolated cays of the Coral Sea Marine Park are free from mainland predators providing a safe breeding place for migratory seabirds important for species like masked boobies that nest on the ground with a simple scrape in the sand or coral rubble. Photo. Andrew McDougall

Back cover: From a featherless chick, a young masked booby *Sula dactylatra* with developing pin feathers will soon launch its wings to become a bird of the ocean only returning to cays to breed. The Coral Sea Marine Park supports globally important habitats for seabird species that depend entirely on breeding habitats free of predators and nearby foraging areas to raise their young. Photo. Felicity Chapman

Acknowledgement

Thanks to Martin Russell, Coral Sea Marine Park Manager, and John Prichard, Coral Sea Marine Park Senior Marine Park Officer, Parks Australia Division for the dedicated work in managing this project and voyage; Teresa Scurrah Assistant Director, Parks Australia Division for her ready assistance with all field tasks; the skipper and crew of M.V. Argo who safely transported us to and from the cays, including over 65 hours of tender vessel operations for the deep reef ROV surveys and for Bobby's superb food; Dr Chris Burwell (Senior Curator, Entomology), Dr Robert Raven (Head, Terrestrial Biodiversity & Principal Curator, Chelicerata) and Dr Owen Seeman (Arachnology Collection Manager) at the Queensland Museum for invertebrate identification; Colleen Foelz (edenink – scientific editing) for information on hippoboscid flies; Dr David Appleton (Senior Scientific Officer, School of Agriculture and Food Sciences) at the University of Queensland for analysis of soil samples; and the Queensland Herbarium for plant identification.

January 2022

Contents

Figures

Tables

Executive summary

An Island Health assessment was undertaken by Parks Australia Division and Queensland Parks and Wildlife Service in July 2021 on 25 islets and cays in the Diamond Islets and Lihou Reef in the Coral Sea Marine Park (CSMP): West Diamond Islet, Central Diamond Islet, East Diamond Islet and South Diamond Islet (all in the Tregrosse Reefs), and South West (Nellie) Cay, Georgina Cay, Edna Cay, Helen Cay, Fanny Cay, Dianna Cay, Carol Cay, Phoenix Cay, Hermit Crab Islet, Betty Cay, Frankie Cay, Observatory Cay, Middle Cay, Turtle Islet, Margaret Cay, Little Margaret Cay, Lorna Cay, Kathy Cay, Juliette Cay and two small unnamed cays.

Birds

The CSMP is a critically important location for Australian seabirds. It represents major populations on the eastern seaboard for great frigatebird *Fregata minor*, lesser frigatebird *Fregata ariel*, red-footed booby *Sula*, red-tailed tropicbird *Phaethon rubricauda*, sooty tern *Onychoprion fuscatus*, wedge-tailed shearwater *Ardenna pacifica*, New Caledonian fairy tern *Sternula nereis exsul* and at least one colony of Herald petrel *Pterodroma heraldica*.

The islets and cays offer pest and weed free breeding sites with minimal human disturbance. Minimal human disturbance is particularly important for small tern species.

Access to the islets and cays for research is limited due to logistics, resources and often weather conditions. Where possible further exploration to all sites and subsequent targeted exploration of a handful of more important sites is recommended to understand the overall ecological values and their use by birds.

Drone imagery was very useful and provided a more comprehensive picture of overall numbers than ground counts alone. Imagery was designed to capture vegetation values, so was occasionally less suitable for bird surveys. Further focused drone use specific to bird surveys is encouraged for future trips.

Vegetation

- The vegetation of nine vegetated cays (four Diamond Islets and five Lihou Reef cays) was thoroughly surveyed.
- Vegetation was generally in good condition at the time of the surveys.
- Data was recorded at approximately 200 sites across the nine vegetated cays for the purposes of:
  - describing all the vegetation communities present
  - obtaining a terrestrial plant species inventory for each cay
  - interpreting spatially rectified aerial imagery to map the extent of each of the vegetation communities

Recorded data includes GPS coordinates and site photographs for each site:

- High resolution drone imagery captured during the voyage was used to refine the vegetation mapping and produce accurate current vegetation maps for each of the vegetated cays visited.
- Plant species richness on the cays was low with a total of 16 plant species native to Coral Sea cays recorded during the voyage.
- Species richness was lower on the Lihou Reef cays (total of 8 species recorded) than the Diamond Islets (total of 16 species recorded).
- No weeds were observed growing on any of the cays visited.
- Despite the abundant numbers of *Cocos nucifera* (coconut) drift fruits observed on the cays (including the unvegetated cays), no plants of this species were observed successfully growing on any of the cays (Only two fruit showed evidence of recent germination).
- The total number of native cay plant species on the Diamond Islets varied between nine (South Diamond Islet) and fifteen (East Diamond Islet).

- The total number of native cay plant species on the vegetated Lihou Reef cays varied between five (Georgina Cay) and seven (all other vegetated Lihou Reef cays).
- Three species previously recorded from Turtle Islet were not found there during the current survey despite thorough searching.
- Triplicate specimens of 80 plants (all species from each cay) were collected and pressed for incorporation into the Qld Herbarium in Brisbane, the Tropical Herbarium in Cairns and the National Herbarium in Canberra together with the data collected at their collection sites to provide verified records of their current locations and habitat. There are currently few herbarium records for most cays visited, no records at all for Central Diamond Islet and Lorna Cay and only two specimen records for West Diamond Islet. Existing Herbarium records from the other cays are not recent except for the 2016 Bush Blitz records for East Diamond Islet (Westaway, 2016).
- Vegetation of the Lihou Reef cays consisted of only herblands, grasslands and occasional low ephemeral shrublands with no trees or large woody shrubs. These vegetation communities currently provide preferred habitat for ground nesting seabirds - huge numbers of nesting sooty terns (*Onychoprion fuscatus*) and large numbers of common noddies (*Anous stolidus*) and brown boobies (*Sula leucogaster*).
- On the Diamond Islets, in addition to grasslands and herblands, vegetation communities containing *Argusia argentea* (octopus bush) shrubs provided preferred habitat for red-footed boobies (*Sula sula)*, frigatebirds (*Fregata* spp.), black noddies (*Anous minutus)* and red-tailed tropicbird (*Phaethon rubricauda*).
- The unvegetated cays as well as beaches and vegetation free shorelines and spits of the vegetated cays provided preferred habitat for predominantly black-naped terns (*Sterna sumatrana*) and masked boobies (*Sula dactylatra*). Nesting New Caledonian fairy terns (*Sternula nereis exsul*) were present in this habitat.
- Eleven marked permanent vegetation monitoring sites were established in a range of vegetation communities on six of the vegetated cays (one on West Diamond Islet, three on East Diamond Islet, one on South Diamond Islet, two on Hermit Crab Islet, two on Turtle Islet and two on Lorna Cay). Detailed vegetation surveys (including photo-monitoring) of these sites were completed to:
  - monitor changes over time
  - provide benchmark reference data for BioCondition assessment for the same vegetation communities throughout the Coral Sea cays
- Vegetation survey data obtained in July 2021 was compared with vegetation survey data recorded on previous surveys where suitable previous data was available.
- Soil samples were collected from the eleven permanent monitoring sites for analysis.
- The soil analysis data obtained was compared with previous soils data from other CSMP and southern Great Barrier Reef cays.
- Drift seeds washed up on the beaches were collected for identification.
- Potential issues pending further discussion with relevant experts:
  - Abundance of locust grasshoppers on Turtle Islet
  - Dieback of *Cordia subcordata* (sea trumpet) on West Diamond and parts of East Diamond Islets.
  - Scale insects tended by ants on *Cordia subcordata* on West Diamond Islet
  - Prevalence of scale insects on *Achyranthes aspera* (chaff flower) and *Abutilon albescens* (lantern bush) – particularly prevalent on *Achyranthes aspera* on South West Cay and to a lesser extent on Hermit Crab Islet.

Health checks

The Health Checks undertaken during the July 2021 Coral Sea trip were the first Health Checks for these small, remote and weather prone coral cay environments.

The overall condition rating for all the vegetated cays in the Tregrosse and Lihou Reefs was Good. The exception was on West and East Diamond Islets where the overall condition rating was Good but there was Significant Concern for one vegetation community – 13 *Cordia subcordata* open shrubland to closed shrub. On West Diamond Islet a small patch of this community was heavily infested by scale tended by ants. On East Diamond Islet a number of patches of *Cordia* communities showed evidence of dieback with numerous dead mature plants.

The unvegetated cays in the Lihou Reefs ranged from small intertidal sand mounds to larger cays. Unvegetated cays are known to be more mobile. The unvegetated cays surveyed appeared to be subject to varying levels of inundation. Drone photography to monitor cay size and movement over time and geomorphological research would provide valuable knowledge into the nature of these cays and their management.

Introduced pests

Rodents

No signs of invasive rats or mice were detected on any of the cays.

Ants and invertebrates

Three species of invasive (non-native) ants were found on only three cays - one species each for Central Diamond Islet, East Diamond Islet and Turtle Islet. Two of these islets had supported current or past infrastructure - Central Diamond Islet has a current navigational aid and a tower has since been removed from Turtle Islet.

No invasive ants were found on the other islets and cays.

The first invasive ant *Monomorium pharaonis* found on Central Diamond Islet was the most common and abundant ant species recorded on three of the six islands in the 2019 voyage to the Coringa-Herald cays (Hemson et al. 2020). *M. pharoanis* have polygynous colonies (nests contain more than one productive queen) so colonies can be prolific hence the scale of potential ecological impact and or human nuisance can be widespread. (Chris Burwell 2021, pers. comm.).

The second invasive ant species *Tetramorium simillimum* found on East Diamond Islet is a tramp species that is now pantropically distributed. It even occurs in some temperate areas, albeit in protected locations such as heated greenhouses. Unlike some other exotic myrmicines in Australia, this species does not seem to adversely affect the native ant fauna. *Tetramorium simillimum* tends to invade natural environments however it is innocuous and does not occur in huge numbers. Based on current knowledge of this particular species, it does not raise any red flags. In contrast to other invertebrates that inhabit coral cays that can appear and then disappear, ants are known to persist (Chris Burwell 2021, pers. comm.).

The third invasive ant found on Turtle Islet is a very small species that is difficult to identify hence the ‘cf’. It is possibly *Monomorium* cf *intrudens* or *Monomorium insolens* both non-native species.

Other invertebrates collected from both vegetated and unvegetated cays with confirmed identification are all native species.

Recommendations

Recommendations in Hemson et al. 2020 are relevant to the islets and cays of the Tregrosse and Lihou Reefs. The following contains extracts from the 2019 recommendations.

Managing visitation to islets and cays of the Tregrosse and Lihou Reefs

Visitation frequency by free and independent travellers is low in number and probably concentrated to a handful of sites with sufficient anchorages.

Low visitation rates by themselves are not sufficient to ensure the values of the CSMP cays are protected. Biosecurity concerns (see Biosecurity below) and threats to seabird breeding events should be managed to ensure ongoing health and maintenance of island values.

Many sites will be self-protected due to difficulties of access by vessel, weather conditions and lack of interest by perceived aesthetic values of a site.

Formulating standard operating procedures and zoning via a series of workshops for each cay are recommended. The workshops should consider:

- Specific island values and their protection needs (vegetation, disturbance levels to seabird species, biosecurity considerations, fire threats)
- Access to a cay or cays representing an example of overall values for the enjoyment of free and independent travellers
- Access safety – prohibiting access to those areas deemed as generally unsafe (currents, reef structure, swells)
- No access (apart from approved research) for the protection of sensitive species e.g. New Caledonian fairy tern

Birds

The CSMP and associated land is critically important for Australian seabirds. It represents significant Australian populations of great frigatebird, lesser frigatebird, red-footed booby, red-tailed tropicbird, sooty tern, black-naped tern, New Caledonian fairy tern, wedge-tailed shearwater and at least one colony of Herald petrel.

The islets and cays offer pest and weed free breeding sites with minimal human disturbance. Minimal human disturbance is particularly important for small tern species.

Recommendations:

- Continue gathering seasonal and temporal baseline bird data for all islets and cays. Comprehensive baseline information may take years to ensure seasonal variations, species diversity and habitat requirements are fully understood. The recent discoveries of breeding New Caledonian fairy tern and Herald petrel may not have been made if standardised early winter and summer surveys were maintained.
- Determine key species, key locations and appropriate seasonal scheduling for ongoing monitoring.
- Minimising disturbance - formulate standard operating procedures relating to visitation/access to all areas (see Managing visitation to islets and cays of the Tregrosse and Lihou Reefs). One likely result of standard operating procedures will be designating no access preservation zones, at least seasonally, for threatened species during breeding events.

- Continue improving monitoring methodologies and techniques. Data collection needs to be robust, repeatable, and cause minimal disturbance to species. Methodologies must consider potential time periods between visits. Once a baseline understanding of bird values is known, several key sites, representative of general sites, may warrant focussed monitoring.
- Document data through formal reports and scientific papers. Share relevant data with bird organisations and interest groups.
- Collate an audio and photographic library of all species and their habitats.
- Investigate and discuss potential research opportunities including identifying foraging areas for species and understanding population interactions between the CSMP and adjoining marine areas.
- Ensure biosecurity requirements are outlined and followed by researchers and guidelines are promoted to other visitors.

Vegetation

Vegetation maps are foundational 'tools' for land management and ecological assessment. They can also be a means for monitoring change in the extent and distribution of vegetation communities over time. Detailed vegetation mapping is resource intensive. However, vegetation changes detectable via vegetation mapping usually occur relatively slowly and so re-mapping is unlikely to be required at intervals of less than a minimum of 10 years.

Health Checks are likely to be adequate for monitoring the condition of most vegetation communities on the islands.

Vegetation mapping and monitoring, particularly quantitative monitoring requiring intensive assessment of individual sites, should be undertaken outside of the breeding season for wedge-tailed shearwaters because of the significant risk of collapsing active burrows.

Health Checks

Health checks are a useful method to monitor the condition of key values on the vegetated and unvegetated cays over time.

Health Checks provide a simple and rapid means to regularly evaluate the condition of ecosystems and habitats on the cays. They can be undertaken by non-scientists – assessors do not require experience in scientific methods nor scientific equipment. Training in the method and concepts, and a camera, clipboard and datasheets, are sufficient.

It is recommended that 'key value' ecosystems and habitats (e.g. bird nesting/roosting and turtle nesting habitat) be selected for both vegetated and unvegetated cays for long term monitoring. Once the number of key values are determined, then decisions can be made regarding the frequency of monitoring and the season in which to monitor. It is preferable that Health Checks are undertaken in the same season each time. Post wet season in late summer through autumn is preferable for monitoring vegetation communities when it is in good condition and when weeds are likely to present, but summer months are optimal for monitoring levels of turtle nesting activity.

Values assessments - Key values

It is recommended that Values Assessments are undertaken for the islets and cays of the Tregrosse and Lihou Reefs. The Values Assessment (VA) process selects and defines the key values - those values that are most significant to individual protected areas. The values assessment also prioritises values, risks and management responses, and informs decisions around where monitoring is vital for management, useful or a low priority.

For the vegetated cays the detailed assessment work undertaken during the July 2021 voyage will inform the values assessments together with past research undertaken on similar cay environments in the CSMP. However there appears to be limited studies of the unvegetated cays of the CSMP (including the 11 unvegetated cays in the Tregrosse and Lihou Reefs). Excluding the intertidal cays (Phoenix, Frankie, Little Margaret and Unnamed Cays) the unvegetated cays visited during July 2021 ranged in size from approx. 400 m² to 8.1 ha above high water and supported important bird nesting/roosting and turtle nesting habitat. Six of the eleven cays were > 2.3 ha in area. It is documented that the two largest unvegetated cays in the Great Barrier Reef region are 4.1 ha (Sandbank No. 7) and 2.7 ha (Waterwitch Cay). All remaining unvegetated cays in the region are <1.6 ha (Hopley et al. 2007). Given the number, size and habitat values of the unvegetated cays in the Tregrosse and Lihou Reefs a study into their geomorphology would provide a better understanding of cay dynamics and stability particularly with the impacts of climate change. This knowledge will inform the value of these cays and guide future management.

Island Watch

The Island Watch tool was developed by QPWS&P as an early warning system for pest incursions (biosecurity surveillance) and the detection of other threats or changes to natural values, so that early management intervention can be undertaken. An Island Watch survey should be completed for each island visited during a trip.

Introduced pests

Pest invertebrates

Autumn is the preferred season to survey insects and detect weeds on the CSMP cays. Insects with the potential to impact on the key vegetation communities on the cays in the CSMP would be most abundant following the growth flushes induced by the summer wet season.

Invasive ants

Consideration should be given to assessing the feasibility and likely benefits of eradicating exotic ant species, all of which have known, albeit varied impacts on native Australian wildlife and may cause significant impact to native ecosystems on remote cays such as those in the CSMP.

Evaluate whether invertebrates have contributed to the decline of *Cordia subcordata* on West Diamond and East Diamond Islets. A better understanding of the impact of invertebrates on the health of this species is important for developing an effective biological control program should it be required in the future.

Drone mapping

Drones provide an efficient means to monitor cay movement, changes in island profile and area, and gross changes in vegetation structure and composition, and available habitat. The imagery is also highly valuable for bird counts and for informing ground truthing for vegetation mapping.

Consideration should be given to procuring a differential GPS and set of ground control point markers to improve spatial precision of resulting maps. Spatial precision commensurate with the very high resolution of the maps would enable detailed assessments of beach volumes, vegetation shifts and other changes.

Biosecurity

It is recommended that all camping (e.g. recreational, commercial, educational, scientific), be prohibited in the CSMP to minimise the biosecurity risk. The equipment campers typically use provides significant opportunities for invasive species to 'stow away' and be introduced to the native ecosystems of the CSMP. Camping is unnecessary given that all vessels will need to have overnight accommodation in order to legally transport visitors to the CSMP from Australian mainland ports.

It is further recommended that day visitors, for recreational and commercial purposes, be restricted to the beaches and not be permitted to take equipment (e.g. tables, chairs) ashore. Shade structures, water containers, first aid gear and other equipment that could be considered necessary from a health and safety perspective should not be taken above the highest tidemark. Ideally all such equipment should be brand new at the start of trips from the mainland or otherwise very thoroughly cleaned. All equipment must be inspected and sprayed (e.g. crawling insect surface spray) before going ashore and between each island. Multilayered containers and structures made from materials such as corflute should not be taken aboard vessels nor ashore.

No fresh food, including cooked or uncooked meats, breads, fruit and vegetables should be taken ashore. The timing and average length of stay on an island should be such that only drinking water and pre-packaged snacks (e.g. muesli bars, dried fruits, sweets etc.) are needed.

Visitors undertaking research and/or monitoring on the CSMP islands should adhere to similar protocols, as recreational and commercial visitors regarding food and equipment, but will need additional protocols, particularly when working above the high tide mark. For example, when moving between islands they must ensure that their field equipment and boots are thoroughly cleaned in VirkonS® or similar. Wearing clean clothes washed in detergent and water at >40°C for each new cay, and washing and inspecting hats and backpacks including Camelbaks will also reduce the chances of transporting pests between cays.

Signs and building materials including site and transect markers and other installations must be new and sourced from authorised/guaranteed clean suppliers. Immediately prior to installation, such material must be thoroughly cleaned and inspected before deployment and again before being redeployed or repurposed.

It is recommended that a study be commissioned to identify the most significant biosecurity risks to cay values, along with their likely sources, vectors and pathways of introduction.

Introduction

The Coral Sea Marine Park (CSMP) is located east of the Great Barrier Reef Marine Park (*Figure 1*). It extends from Cape York Peninsula to just north of Bundaberg in Queensland, Australia. There are approximately 34 vast reef areas and 67 cays and islets in the CSMP including the Coringa-Herald and Lihou Reefs and Cays Ramsar site. The Ramsar site comprises near-pristine oceanic islet and reef habitats that are representative of the Coral Sea. The undisturbed sandy habitats at several islets are nesting sites for globally threatened marine turtles, while the foreshores and vegetation support important breeding populations of seabirds (Director of National Parks, 2018).

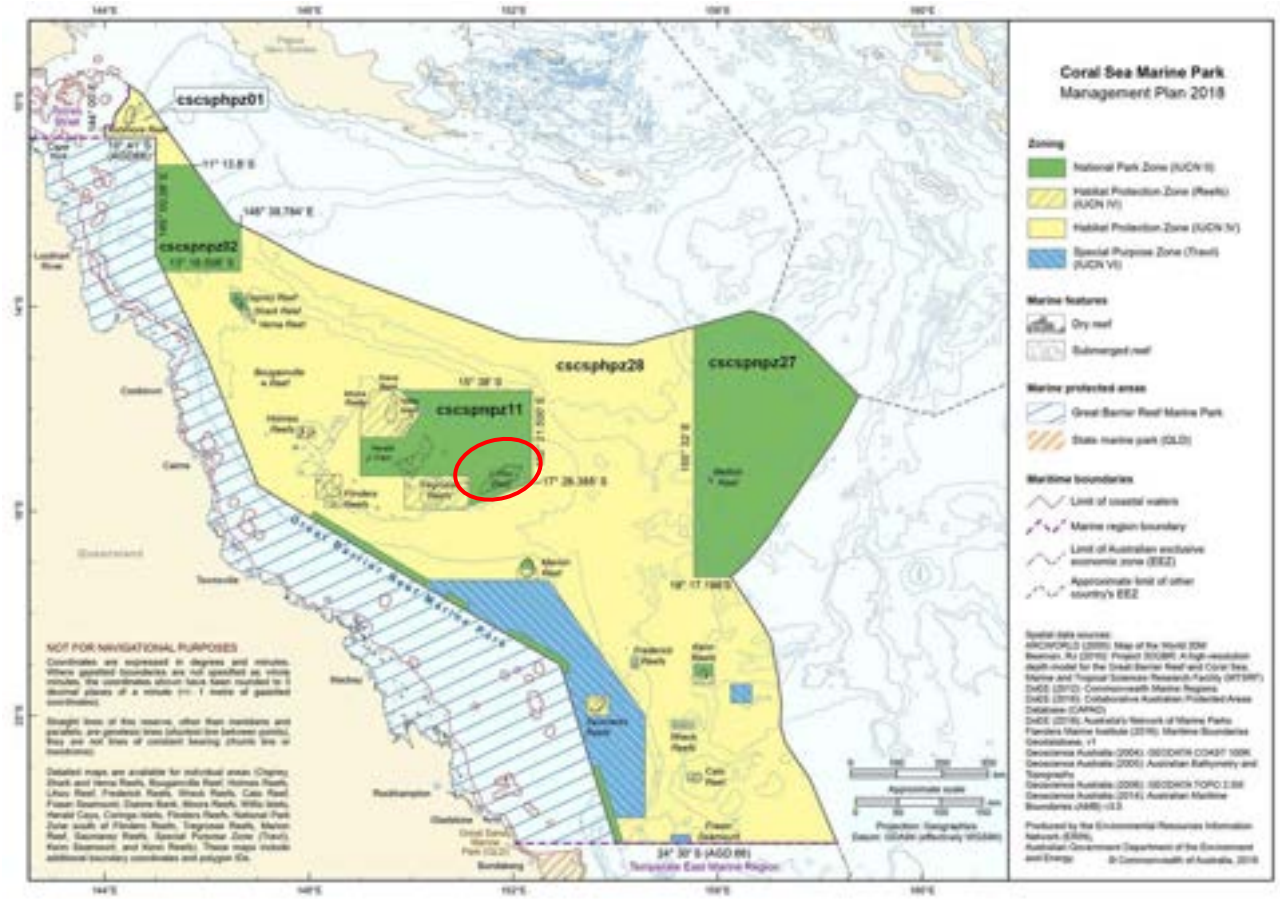


Figure 1. Coral Sea Marine Park {from CSMP Management Plan, Director of National Parks (2018)} indicating location of Island Health Monitoring.

Parks Australia Division (PAD) manages the CSMP under the *Coral Sea Marine Park Management Plan 2018.* PAD and the Great Barrier Reef Marine Park Authority (GBRMPA) have a Memorandum of Understanding (MOU) to enable management efficiencies between the two marine parks. As part of this MOU, the GBRMPA Reef Joint Field Management Program (RJFMP) has been assisting PAD with the delivery of field management activities in the CSMP, such as monitoring and managing island and cay species and habitats.

A collaborative trip to six islands in the Coringa-Herald section of the CSMP was undertaken between 28 November and 11 December 2019. During that 13-day voyage a team of experts from PAD and the Queensland Department of Environment and Science (DES), Queensland Parks and Wildlife Service and Partnerships (QPWS&P) piloted methods to collect, analyse and document the health status of terrestrial island ecosystems and species using the islands, to establish baseline data for future trend analysis. The results and discussion have been published in Hemson et al. 2020.

The success of the 2019 voyage and the subsequent *Environmental Assessment Report* proved the methodology is appropriate for the island health assessment in the CSMP.

This same assessment was undertaken for the July 2021 CSMP Island Health Voyage, which visited four vegetated Diamond Islets in the far east section of the Tregrosse Reefs and 21 cays and islets in Lihou Reef, five of which are vegetated and 16 are unvegetated sandy cays. *Figure 1* indicates the location of Tregrosse Reefs and Lihou Reef, and *Figure 2* provides a larger scale map of the Tregrosse Reefs and Lihou Reef cays and islets visited, which included: West Diamond Islet, Central Diamond Islet, East Diamond Islet and South Diamond Islet (all in the Tregrosse Reefs), and South West Cay, Georgina Cay, Helen Cay, Edna Cay, Fanny Cay, Dianna Cay, Phoenix Cay, Carol Cay, Betty Cay, Hermit Crab Islet, Frankie Cay, Observatory Cay, Middle Cay, Turtle Islet, Margaret Cay, Little Margaret Cay, Lorna Cay, Kathy Cay, Juliette Cay and two small unnamed cays.

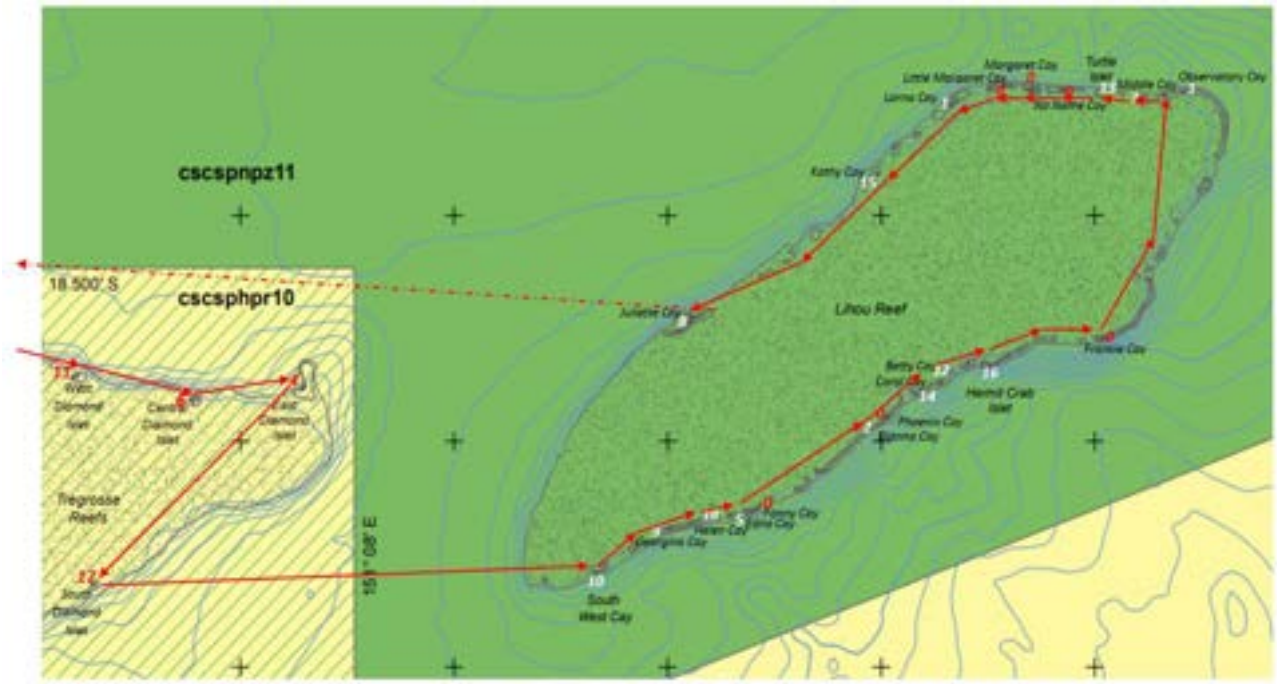


Figure 2. Tregrosse Reefs (Diamond Islets) and Lihou Reef {from CSMP Management Plan, Director of National Parks (2018)} indicating approximate track of voyage to conduct island health assessments of cays and islets.

The results of the island health assessments are detailed in this report. In addition to the island health assessments, deep reef coral research was undertaken during the voyage by James Cook University researchers utilising a remote operated vehicle (ROV), and the cays and islets were cleaned of all marine debris which was removed and brought back to the mainland for assessment.

Reports of both these activities are included in this report.

Part I: Islets and cays

Birds – Andrew McDougall

Aim

Catalogue species and breeding effort.

Methods

Formal surveys focused on cays and islets. Trip data includes sightings made at sea and on exposed reef flats.

At sea sightings were opportunistic. Species were recorded from observations made at the back of the boat. Latitude and longitude (datum GDA94) were recorded along with the species and their respective number (see Appendix 4).

Islet and cay surveys were conducted as follows:

- Record species enroute to island from main vessel. Often birds will flush from beaches and not be recorded again. This is generally visual or photographic recording.
- Check for nesting birds along beach at point of access. This way other researchers are aware of no-go areas. This protects species such as black-naped terns which have cryptic, easily disturbed or destroyed nests.
- Circumnavigate the cay, noting roosting and nesting preferences. This also provides the opportunity to record roosting shorebird species.
- Collect data on breeding species, numbers and their breeding effort i.e., nests, chicks or young. Record adolescent and adult numbers.
- Survey thoroughness is determined by available survey time, species and their breeding habitat preferences (thick vegetation might not be accessible or easy to collect accurate data), and overall numbers.
- These surveys were aided by the availability of drone footage and the ability to check counts and include areas not covered during ground counts.
- Additional data were provided by the research team.

All records were recorded into a notebook and transferred to a laptop.

Field survey equipment included 10x50 binoculars, notebook, mechanical pencil, GPS, tally counters, digital voice recorder, a compact digital camera and a full-frame DSLR camera with the equivalent of a 600mm prime lens. Reference books were available to check known distributions of species.

Drone information can be found in the relevant report section.

Data and photographs were transferred to a laptop and backed up on portable hard drives.

Nest and species numbers were checked after the completion of the voyage when stitched drone footage was available.

Results

Bird data were collected for 24 islets and cays. Four sites in the Diamond Islet group and 20 surrounding the Lihou atoll.

Appendix 4 displays the at sea records on the departure and return trip legs.

Twenty-four species were recorded (see Appendix 4):

- Eighteen seabird species (including Australian pelican), of which 15 were breeding (see summary in Appendix 1 and Appendix 2).
- Four migratory shorebird species.
- Two land species including the resident buff-banded rail, *Gallirallus philippensis*.

Breeding effort counts (reviewing photography and drone imagery) took around seven days post trip.

A summary of species and breeding effort is included in each location chapter. Relevant photographs and accompanying notes are provided with the species and breeding effort tables.

Two major highlights of the trip included the first identified Australian nests and chicks of the New Caledonian fairy tern, *Sternula nereis exsul* at Georgina Cay and Australia's second colony of Herald petrel, *Pterodroma heraldica*, at Central Diamond Islet.

Coral Sea trip reports from the 1980s noted breeding little terns, *Sternula albifrons*, at Georgina Cay. The winter records did not correlate with known breeding events of little terns elsewhere and my suspicions were they had misidentified New Caledonian fairy terns. The New Caledonian race is visually similar to little terns, particularly in non-breeding plumage. However, there are clear diagnostic, breeding plumage differences.

Discussion

The CSMP is a critically important location for Australian seabirds. It represents major populations on the eastern seaboard for great frigatebird, lesser frigatebird, red-footed booby, red-tailed tropicbird, sooty tern, wedge-tailed shearwater, New Caledonian fairy tern and at least one colony of Herald petrel.

The islets and cays offer pest and weed free breeding sites with minimal human disturbance. Minimal human disturbance is particularly important for small tern species.

Access to the islets and cays for research is limited due to logistics, resources and often weather conditions. Where possible further exploration to all sites and subsequent targeted exploration of a handful of more important sites is recommended to understand the overall ecological values and their use by birds.

Drone imagery was very useful as part of these surveys and provided a much more comprehensive picture of overall numbers than ground counts alone. Imagery was designed to capture vegetation values, so was occasionally less suitable for bird surveys. Further focused drone use specific to bird surveys is encouraged for future trips.

Acknowledgements

Sincere thanks to all involved with the voyage. My role was not possible without the professionalism of the boat crew and fellow researchers. Everyone played their part, but special thanks to Ben Sale for use of the drone imagery, Teresa Scurrah for her assistance in the field and sharing her videos and photos, Karl Goetz, Felicity Chapman and Ben Cresswell for extra bird records, and to Colleen Foelz (external expertise) for her information on hippoboscid flies.

Vegetation - Joy Brushe and Larry Brushe

Previous vegetation surveys

A report by Shaughnessy and Hill (1983) contains quantitative survey data (% cover of species in 1m x 1m quadrats) recorded by Heatwole on Turtle Islet sometime between 1967 and 1979.

A number of ecological surveys were carried out on Turtle Islet during the late 1970's and during the early 1980s (Stokes and McNamara, 1979; Stokes and Skeat, 1980; Skeat and Hill, 1982; and Shaughnessy and Hill 1983). A summary report on The Coral Sea Nature Conservation Program primarily based on the combined information in these reports was provided by Hill (1984). Most of these early field trips were undertaken in conjunction with maintenance of the automated weather stations located on CSMP islets and cays including Turtle Islet. Vegetation Information contained in some of these reports include quantitative species cover data recorded in quadrats across transects of the cay, hand drawn maps of the cays showing major vegetation types and location of quadrats along transects. Some also contain hand drawn cay profile diagrams. Other reports contain only the names of plant species recorded (and collected) during the visit. Some contain no vegetation information.

Australian Survey Officers accompanied the second voyage (Stokes and Skeat, 1980) and provided maps and contours of Turtle Islet. They also established photocontrol points to determine vegetation extent using oblique photography. Shaughnessy and Hill (1983) also used seventy mm photography with control squares to record the state of the vegetation on Turtle Islet. They also attempted to repeat the earlier surveys by Heatwole on Turtle Islet using quadrats along transects located as close to the earlier transect locations as possible.

Hill and Hogg (1984) recorded plant species and cover data on South West Cay, Georgina Cay and Hermit Crab Islet. Their report contains maps, profile diagrams and photographs. Edna Cay (unvegetated) was also visited.

Hicks (1984) recorded plant species present, cover data, hand drawn maps showing the location of transects and vegetation types and hand drawn elevation profiles for Turtle Islet, Hermit Crab Islet Georgina Cay, South West Cay, East Diamond Islet and South Diamond Islet. Enlarged aerial photographs were used to prepare the hand drawn maps and profiles contained in these reports.

Grant, Phillips and Hinchey (1986) visited South West Cay, Hermit Crab Islet, Turtle Islet and Lorna Cay. Very little information on vegetation was reported for this voyage.

Scottney and Jeffs (1987) recorded basic observational vegetation information on Turtle Islet and Hermit Crab Islet. Middle Cay and Juliette Cay (unvegetated) were also visited.

Hinchley and Stokes (1987) visited South West Cay and Georgina Cay and mapped the vegetated areas.

Donaldson (1994) reported briefly on vegetation of Turtle Islet and recorded species present on Hermit Crab Islet.

Westaway (2016) collected plant specimens from East Diamond Islet during a Bush Blitz field trip.

In addition to vegetation, these reports (and others) provided a large amount of detail on seabirds (lists, counts and nesting information) and also contained species lists and information on sea turtles, invertebrates, shells and human visitation/ impact.

Herbarium specimen records also provide information on plant species presence and species turnover since 1979 with a couple of earlier records from 1961 for specimens submitted by K. Keith (no reference). No recorded previous vegetation data was available for Central Diamond Islet or Lorna Cay and data for West Diamond Islet was limited to herbarium specimen data for two species.

Methods

Desktop preparation prior to the field trip

Prior to the field trip, spatially rectified 2019 Secure Watch images with 30 to 50 cm pixel resolution supplied by PAD were used to delineate visually distinguishable patterns of vegetation on each cay using the QGIS program. Point coordinates of suitable locations for ground-truthing of these patterns were created using the QGIS program and uploaded to a Garmin GPSMAP 66S hand-held GPS. Spatially rectified PDF maps of the delineated image patterns overlain with these coordinates were generated in QGIS and loaded onto the Avenza maps program on iPhones to accurately locate the ground-truthing sites while traversing the cays. Data was recorded in the vicinity of these locations and at other locations chosen during the field trip.

Ground truthing survey sites

Between 12 July and 23 July 2021, 25 cays were visited. Joy and Larry Brushe spent approximately 50 hours in the field (between 2 and 11.5 hours per cay) surveying the vegetation on the nine vegetated cays. This included establishing and surveying eleven permanent monitoring sites. Data was recorded in a total of 201 ground-truthing sites, 93 on the Diamond Islets and 108 on the Lihou Reef cays. The locations of these sites are shown on maps of each of the islands in Islet and Cay Summaries.

As time on each cay was limited, it was not possible to undertake comprehensive replicate site surveys in each vegetation community using the methodology of Neldner et al. (2019). To ensure sufficient data was obtained and the vegetation of the entire island was thoroughly assessed, a modified “quick” methodology was used with the following data recorded at each of 200 locations across the two island groups:

- GPS coordinates
- vegetation structure (from estimated height and cover)
- all plant species present
- cover of each species at the site - using the methodology of Daubenmire (1959)
- total weed cover
- landform
- surface soil description
- observations of nesting seabirds and other seabirds and evidence of turtle activity present

The number of square metres included in each site was not defined. The data recorded at each of the sites represented an area surrounding the recorded GPS coordinates that was homogeneous in terms of vegetation, soil, slope and aspect.

Average time taken to complete each of these sites was approximately 10 minutes including traversing time.

The site data recorded was used to:

- identify and describe all the vegetation communities present on the island and the variation within each community
- obtain a complete floristic inventory for the island
- identify the spatial extent and abundance of weed species present on the island
- attribute vegetation patterns on the drone imagery to create a vegetation map for the island
- determine habitat preferences of seabirds and turtles
- assess potential human impact on the island’s vegetation
- look for evidence of pests, diseases or any other issues affecting the vegetation of the island.

Heights and covers of total vegetation at each site were estimated to derive the structure class of the vegetation at each site as described in Neldner et al. (2019). Refer to Appendix 12.

The cover of each species at each site was recorded as one of the following cover classes as described by Daubenmire (1959):

- trace to 5%
- 6% to 25%
- 26% to 50 %
- 51% to 75%
- 75% to 95 %
- 95% to 100

This method provided a simple rapid method to document the relative dominance of each species at each site and obtain structural information required to describe the vegetation communities. The midpoints of each of these cover classes were used to obtain average % covers and for comparison with previous data.

Vegetation mapping

Following the July 2021 voyage, the accuracy of the polygon boundaries created using the Secure Watch images prior to the field trip was improved using the high-resolution drone imagery captured during the voyage. The vegetation map polygons were attributed with vegetation communities identified and described from data recorded at the ground truthing sites. The high-resolution drone imagery also improved the accuracy of image pattern delineation and interpretation, resulting in a high level of reliability and detail in both the location of the mapped vegetation polygon boundaries and the vegetation community attributed to each of the polygons. Each polygon was allocated a reliability A, B or C for both line placement and allocated vegetation type (A= confident, C= low confidence). Where patchy mosaics containing more than one vegetation type were present or vegetation communities were too difficult to distinguish, the vegetation was mapped in heterogeneous polygons, each containing up to three vegetation types with an estimate of the percentage of each vegetation community within the polygon. The line reliability, vegetation reliability and percentages of the component vegetation types for each polygon could not be shown in the vegetation maps as this would have created too much visual detail. These attributes are contained in the DBF component of the ESRI shapefiles provided to PAD and the Microsoft Excel file also provided to PAD for use outside the GIS environment.

Permanent vegetation monitoring sites

When allocated time on the island permitted, permanent monitoring sites located in representative areas within a range of vegetation communities were established. The purpose of these permanent monitoring sites is to:

- provide benchmark reference data for BioCondition* assessment for the same vegetation communities elsewhere on other Coral Sea cays and over time in the established site location
- document changes in vegetation over time
- assess the impact of climate change and other disturbances on vegetation

*BioCondition is a site-based, quantitative, and repeatable, condition assessment methodology that provides a measure (expressed as a BioCondition score between 0 and maximum of 1 and BioCondition Class of 1, 2, 3 or 4 – one being the best) of how well a terrestrial ecosystem is functioning for biodiversity values. A suite of attributes (e.g. canopy cover, coarse woody debris, native plant species richness, litter cover) are assessed at a site and evaluated against benchmarks for those attributes. The benchmarks for attributes are derived from *a reference state* for the ecosystem – the latter being the natural variability in attributes of an ecosystem relatively unmodified since the time of European settlement (Eyre et al. 2015).

Eleven 50m x 20m permanent monitoring sites were established on the cays, five on the Diamond Islets and six on the Lihou Reef cays. These sites can be re-monitored any time in the future.

Sites were permanently marked with galvanised star pickets located at the 0m and 50m ends of the 50m centre transect and labelled with cattle ear tags attached to the star pickets as shown in *Photos 1a & b.*

A better system of labelling for sites to be established on future trips would be to use 130mm X 40mm X 0.6mm aluminium tags held firmly in the recess of the star picket and attached with 290mm X 4.6mm 316 grade marine stainless cable ties passing through two 5mm holes drilled one at each end of the tag at 100mm centres to prevent movement in strong winds.

Photos 1a & 1b: Permanent Sites were marked using star pickets labelled with cattle ear tags.

The secondary site survey methodology of Neldner et al. (2019) with some slight modifications to accommodate cay vegetation was used. Time taken to complete surveying of these sites varied from one hour in sites without large old growth shrubs to 2.5 hours in sites where diameter measurements of old growth *Argusia argentea* (octopus bush) shrubs was required. The methodology used is described in Appendix 12 and Neldner et al. (2019).

One of the permanent monitoring sites, located in an *Argusia argentea* community, could not be comprehensively surveyed during the July 2021 field trip as large numbers of red-footed booby (*Sula sula*) and frigatebirds (*Fregata spp.)* nests containing chicks and eggs were present in the branches of the *Argusia argentea* shrubs throughout the site. Site survey would have caused unacceptable disturbance to these nesting birds.

To ensure long term secure data storage and accessibility, data and photographs recorded at the permanent monitoring sites will be stored digitally by PAD and also by the Queensland Herbarium in the QBEIS database and the Queensland Herbarium photo database.

Soil analyses

Soil samples were collected in each of the permanent monitoring sites for analysis. It was not possible to obtain samples at depth using a sand auger as the dry sand fell straight through the auger. Obtaining samples from depth also proved difficult using a shovel. However suitable composite samples were successfully collected from three random locations within each 50x10m site at three depths (0-10m, 10-20m and 20-30m) using a post hole shovel with the assistance of a small hand shovel. Samples were not collected at greater depth due to both difficulty of obtaining the samples and time restrictions.

Samples were analysed by David Appleton at the analytical Laboratories at the University of Queensland School of Agriculture and Food Sciences. The following previous cay soil samples were also analysed by David Appleton at this facility using the same/compatible methodology, providing opportunity for valid comparison of their analyses with the Diamond Islets and Lihou Reef cays sample analyses:

- samples collected George Batianoff et al. in October 2007 of 50 soil profiles from cays in the Coringa-Herald National Nature Reserve
- 213 soil samples collected from the Capricornia Cays by Batianoff et al. during 2007/2008

Nine soil samples collected by Joy Brushe from Willis Island in October 2020 were analysed by SGS Cairns International who advised that compatible methodologies were used to ensure valid comparison with the above data sets.

Data from the Lady Elliot Island soil samples collected in December 2019 (Brushe 2020) have not been included as Lady Elliot is a highly disturbed cay. The soils samples were analysed for: pH, electrical conductivity, total nitrogen, total carbon, total organic carbon, available phosphorus, calcium, potassium, magnesium, sodium, cation exchange capacity, total phosphorus, aluminium, calcium, copper, iron, potassium, manganese, sodium, sulphur and zinc.

Analysis of particle sizes and Munsell colour were not done **.**

Plant and drift seed collections

Triplicate plant specimens were collected of each plant species present on each cay. These plant specimens were labelled, pressed and dried and field notes recorded on the habit and habitat of each. The specimens together with recorded information will be sent to the National Herbarium in Canberra, the Queensland Herbarium in Brisbane and the Australian Tropical Herbarium in Cairns as confirmation of the presence of species in the locations recorded in this report. Where time permitted, and with the assistance of Felicity Chapman (QPWS), Teresa Scurrah (PAD) and other members of the team, samples of drift seeds were collected opportunistically from the shorelines of both vegetated and unvegetated cays. The purpose of these collections was to obtain knowledge of the plant species arriving on these cays via ocean currents. Plant and drift seed specimens were collected with the permission of The Director, PAD.

Botanical nomenclature

Scientific plant species names used in this report are according to the Census of the Queensland Flora 2020 (Brown and Bostock, 2020). Common names are included in brackets following the first use of each scientific name in the document and in some descriptive sections.

Additional digital data

In addition to this report, the following files will be supplied separately to PAD

1. An ESRI shapefile of the vegetation mapping. The database file associated with this shapefile contains additional information including the area of each polygon, the percentage of each vegetation map unit within each of the heterogeneous polygons, the reliability of the location of the polygon boundaries (a, b, c) and the reliability of the allocated vegetation unit (a, b, c).
2. An ESRI shapefile and a Microsoft Excel file of all the data recorded at each of the ground truthing sites
3. An ESRI shapefile containing the locations and GPS coordinates of the permanent monitoring sites
4. All photographs taken at the ground-truthing sites
5. All photographs taken at the permanent monitoring sites

In addition, data recorded at the permanent monitoring sites will be entered into the Queensland Herbarium QBEIS database where it will be securely stored and easily accessible when required in the future. The monitoring site photographs will also be recorded in the Queensland Herbarium photograph database.

Limitations of the vegetation survey, mapping and reporting

BioCondition scoring could not be undertaken for the permanent monitoring sites surveyed during the July 2021 voyage as there is currently insufficient data available to determine benchmarks for vegetation attributes of the vegetation communities at these sites.

BioCondition benchmarks are obtained by averaging survey data of a range of vegetation attributes from replicate benchmark reference sites located in the most pristine representative locations within each vegetation community within the bioregion. It is also desirable to include benchmark data obtained at different seasons to capture seasonal variation in the benchmarks. In addition to the 11 sites on the Diamond Islets and Lihou Reef cays, and the *Pisonia grandis* reference sites surveyed and reported by Hemson et al. (2020), additional reference sites need to be established and surveyed elsewhere on the Coral Sea cays to provide sufficient replicate reference site data to determine benchmarks for each vegetation community.

During the voyage, 24 cays were visited, nine vegetated and 13 unvegetated. To complete all the scheduled work on all these cays and to allow for steaming time between cays, time on each cay had to be limited. Allocated survey time on each vegetated cay varied between two hours and 11.5 hours. This resulted in insufficient time available on some cays to visit all the ground-truthing sites identified prior to the voyage and did not allow time to establish and survey permanent monitoring sites on a number of cays. Time spent surveying each cay and the number of ground-truthing and permanent monitoring sites surveyed on each cay are documented in Appendix 5.

Drying the pressed plant specimens proved difficult in the high humidity on board *MV Argo*, despite frequent paper changes, resulting in slow drying of the specimens and in some cases, the presence of mould on some specimens.

A number of historic reports of ecological surveys undertaken on previous voyages were researched prior to the July 2021 voyage. However not all the previous reports were able to be accessed and therefore historical data documented in this report may be incomplete. Whilst comparisons of ground cover data obtained during with July 2021 voyage with those reported previously are worthwhile, different methodologies were used for site/quadrat location. Comparisons assume that the averaged ground cover for both methods is representative of the ground cover for the entire cay. The previous surveys provided good representative data but only for a very limited section of the cays (at best one to three transects across each cay). The data recorded in the July 2021 surveys, gave better coverage of the entire cay but was focused on obtaining ground truthing data for each of the image patterns and larger patterns may be under represented. These factors must be considered when comparing the data.

While the information obtained during the voyage provided good detail on the vegetation present at the time of the July 2021 surveys, the structure and floristic composition of vegetation communities dominated or co-dominated by annual herbs, other herbaceous species and short-lived shrubs, are likely to be very dynamic, varying between seasons and in response to varying climatic regimes.

Because of the small size of the cays, the low species richness of the flora and the predominance of herbaceous species, some of which have annual growth patterns, many of the communities were quite similar, differing only in the relative dominance of component plant species. This created difficulties when deciding whether small patches of vegetation which differed from surrounding vegetation were distinct communities or whether they were just a variation of the surrounding vegetation community. There was also quite a lot of mosaicking of community types which could not be shown on the vegetation map despite the large scale and high level of detail of the mapping. Where this occurred, heterogeneous polygons containing more than one vegetation type had to be used.

At the time of writing this report, the pressed plant specimens and specimens of drift seeds have not been submitted to the Herbaria for identification, confirmation and/or incorporation. Confirmation of identifications and a list of specimens retained in each Herbarium will be forwarded to PAD as soon as this information is available.

Results and discussion

General vegetation condition

At the time of the surveys, the vegetation was generally in very good condition following wetter than average months through the preceding summer and spring. This is demonstrated by the graphs in *Figure 3* comparing 2020-2021 monthly rainfall data with long term monthly averages (1921 to 2021) recorded on Willis Island. The Bureau of Meteorology weather station at Willis Island is the closest recording station to the Diamond Islets and Lihou Reef cays, located 158 km and 245km northwest of West Diamond Islet and Turtle Islet (Lihou Reef) respectively.

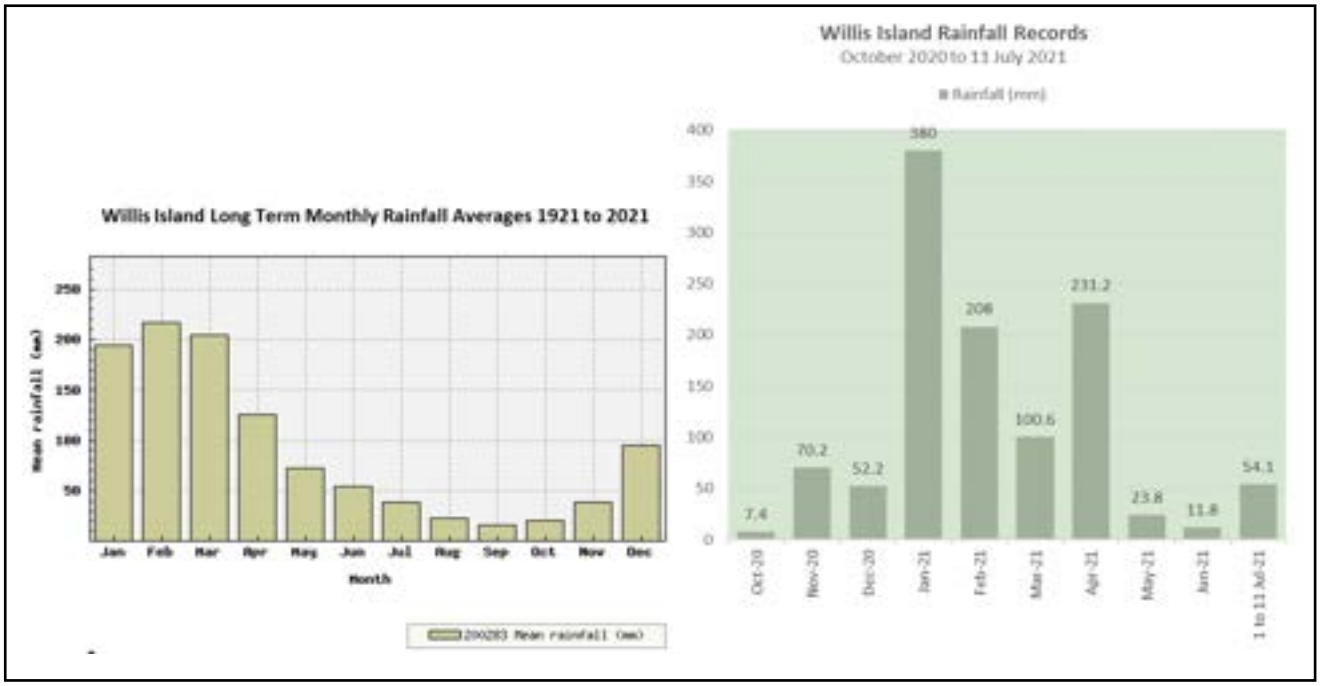


Figure 3. Comparison of recent (Oct 2020-Jul 2021) and long term (1921-2021) monthly rainfall data for Willis Island.

(Australian Bureau of Meteorology website viewed October 2021)

Floristics

Native cay plant species

Species recorded on each island and comparisons between cays are tabulated in Appendix 6. The table in Appendix 8 contains comparisons of species composition over time on the Diamond Islets and Lihou Reef cays and Appendix 9 compares recent current composition of the Diamond Islets and Lihou Reef cays with recent species records from the Coringa-Herald and Magdelaine cays and South Willis Island.

Batianoff et al. (2009a) noted that the flora of the northern CSMP is a subset of the widely distributed western Pacific low coral island flora and a high percentage of low-lying coral island floras are predominantly oceanic or seabird-dispersed littoral species. The predominant oceanic currents carrying plant propagules to the northern Coral Sea are the Pacific east to west South Equatorial Current and the north flowing Hiri Current. The South Equatorial Current flows from the Pacific towards the Australian mainland and then bifurcates into the north flowing Hiri Current and the south flowing Eastern Australian Current. Surface currents driven by the South-East Trade winds and seasonal monsoon winds also play a role in plant dispersal.

The following numbers of plant species were recorded and collected during the July 2021 surveys on cays where they have not previously been recorded:

- 11 species on West Diamond Islet
- 11 species on Central Diamond Islet
- 2 species on East Diamond Islet
- 2 species on South Diamond Islet
- 1 species on South West Cay
- 7 species on Lorna Cay.

Species recorded during the July 2021 voyage that have not been previously documented are highlighted in green in the table in Appendix 8 for each of these cays.

Three previously recorded species from *Turtle Islet*, one from Georgina Cay and one from West Diamond Islet were not found during the July 2021 survey. These are highlighted in yellow in the table in Appendix 8.

Species turnover is a usual event on cays and this may explain some of the differences in species records over time, reflecting the balance between immigration, survival and extinction rates which in turn are influenced by bird, turtle and human activity, climatic regimes and other disturbances.

The most widely distributed species based on presence on cays were:

- *Boerhavia albiflora* var. *albiflora*, (Boerhavia)*, *Achyranthes aspera* (chaff flower), *Portulaca oleracea* (pigweed) and *Stenotaphrum micranthum* (beach buffalo grass)- present on all 9 vegetated cays
- *Abutilon albescens* (lantern bush), *Lepturus repens* (stalky grass) and *Tribulus cistoides* (bulls head burr) - present on eight of the nine vegetated cays

*There has been confusion over the taxonomy of *Boerhavia* species on the Coral Sea cays. According to Batianoff et al., *B. diffusa* and B. *glabrata* are misapplied names for *B. mutabilis* and B. *tetrandra* is a misapplied name for *B. albiflora* var. *albiflora.* Identification of *Boerhavia* specimens collected from each cay on the July 2021 survey (recorded as *B. albiflora* var. *albiflora)* have yet to be confirmed by the Queensland Herbarium. When comparing cover and abundance for each cay, *Boerhavia* species present are collectively referred to by the genus name only (*Boerhavia*).

The most abundant species across all the vegetated cays were determined based on (a) number of sites in which the species was recorded and (b) % cover in sites in which they were present. Averaged percent covers included in the dot points below refer to the average for sites in which the species was present.

- Across all the Diamond Islets, *Lepturus repens* was present in the most sites (90% of sites) in the ground layer and also had the highest average cover (44.6%).
- In the Lihou Reef cays, *Boerhavia albiflora* var. *albiflora* was present in the greatest number of sites (present in 89% of sites) in the ground layer but had a relatively low average ground cover (9.9%), *Achyranthes aspera* had the second highest frequency in sites (68%) in the ground layer with an average cover of 27.9%, followed by *Portulaca oleracea* (pigweed) (64% of sites, 6.3% cover), then by *Stenotaphrum micranthum* (beach buffalo grass) (58% of sites, 17.9% cover) and then by *Lepturus repens* (present in 49% of sites). *Lepturus repens* had the highest average cover (34.8%).
- In the Diamond Islets, *Argusia argentea* was the most abundant species in the shrub layer, occurring in 40% of the sites with an average cover per site in the shrub layer of 34.5%. *Argusia argentea* was also present as an emergent layer in 5% of the sites with an average cover of 2.5%. *Cordia subcordata* (sea trumpet) and *Ximenia americana* (yellow plum) had high covers in the shrub layer where they were present (59.6% and 85% respectively) but only occurred infrequently in the shrub layer (in 6% and 1% of sites respectively).
- *Argusia argentea, Cordia subcordata* and *Ximenia americana* were all absent from the Lihou Reef cays. The only species forming a shrub layer in the Lihou Reef cays was *Abutilon albescens* (occurring as a shrub layer in 4% of sites with an average cover of 42.5% and present as an emergent layer in 2% of the sites with an average cover of 2.5%).

Tribulus cistoides is a summer annual and is therefore likely to be present in greater abundance in the summer months.

A total of 16 vascular plant species were recorded across all the Diamond Islets and Lihou Reef vegetated cays The number of species recorded on each cay varied between five (Georgina Cay) and 15 (East Diamond Islet). Species richness is greater on the Diamond Islets (16 species) than on the Lihou Reef cays (8 species). These numbers are low compared with species richness on cays in closer proximity to the mainland and very low compared to species richness on continental islands and the adjacent mainland. Factors determining species richness include island size, remoteness (distance from nearest source of propagules), frequency and intensity of bird activity, frequency and type of human activity, and frequency, intensity and duration of drought, cyclones and other disturbances.

Figure 4 shows the variation of the species richness with vegetated area for the vegetated cays visited during the July 2021 surveys. Heatwole (1979) noted that species richness generally increases with island size. Batianoff, (2009b) found that the relationship between species richness and island size was very weak for the Capricornia Cays in the southern Great Barrier Reef and that other factors such as disturbance have more influence on species richness.

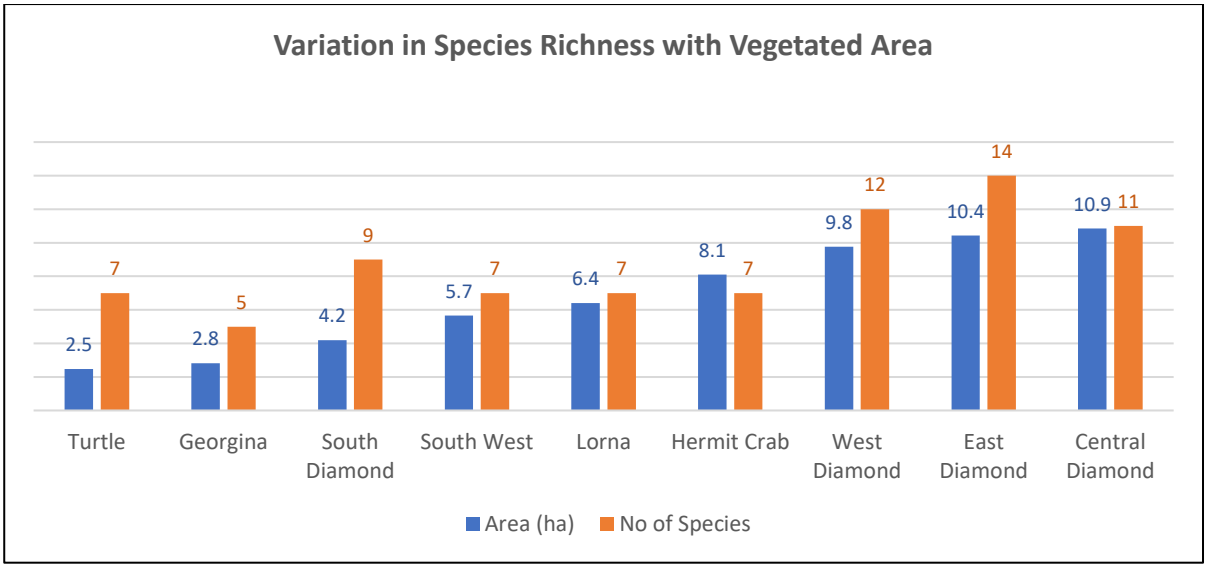


Figure 4. Variation in species richness with vegetated area of cays visited.

Considering the low frequency of human visitation, oceanic and bird dispersal are most likely to be the predominant dispersal methods on the Diamond Islets and Lihou Reef cays. Predominant dispersal mechanisms of the Coral Sea native species recorded during the July 2021 survey are included in the table in Appendix 6.

Relative frequency on islands and median cover at sites in which they occur are tabled in Appendix 7.

Weeds

No weeds were recorded in the July 2021 surveys of the Diamond Islets and Lihou Reef cays and all species recorded are native to the Coral Sea cays. Although some are considered to be relatively recent introductions (e.g., *Plumbago zeylanica*) and some are considered to be naturalised exotics on the mainland (e.g., *Portulaca oleracea* and *Lepidium englerianum*), none are considered to be weeds on the Coral Sea cays.

Coconuts

Coconuts were among the most abundant fruit found amongst the drift seeds found on the shorelines of all the cays. Despite the large number arriving on the shorelines, no well-established plants were observed on any of the cays visited, nor are there any records of their natural establishment elsewhere on the Coral Sea cays, suggesting that they are not part of the natural Coral Sea flora. The reasons for this may be that they are either no longer viable on arrival or conditions on these cays do not favour their longer-term establishment, possibly due to properties of the cay soils, unsuitable climatic regime, or disturbance by cay fauna such as turtles or hermit crabs. Planting of coconuts on human use cays in the region such as Willis Island could result in increase in viability of coconuts reaching the shorelines of other Coral Sea cays due to reduced time in the ocean, facilitating establishment on cays where they were not previously present. During the July 2021 voyage, only two germinated coconuts were seen. One of these was in a location where it could not establish and the other, shown in *Photo 2* was located on a sandy shoreline on Lorna Cay, exposed to wave and turtle disturbance where establishment is unlikely.

Photo 2: Germinated coconut on Lorna Cay.

Vegetation communities

Vegetation communities present on the Diamond Islets and Lihou Reef cays

Twenty-five vegetation communities were identified, described and mapped for the Diamond Islets and Lihou Reef cays using the ground truthing and monitoring site data and drone imagery obtained during the July 2021 voyage. *Table 1* lists these vegetation communities and the vegetation map unit allocated to each. Appendix 10 compares the vegetation communities present on each of the cays, the respective areas on each cay. and equivalent or similar communities described and mapped on other Coral Sea and southern Great Barrier Reef cays. Islet and cay summaries contains vegetation maps and more detailed descriptions of the structure and floristic composition of the vegetation communities for each of the cays.

The most abundant vegetation communities in the interior of the Diamond Islets were mixed grasslands dominated by *Lepturus repens* (stalky grass) with *Argusia argentea* (octopus bush) communities most abundant along the shoreline as well as scattered throughout the interior of some cays. The most abundant vegetation communities on the Lihou Reef Cays were *Lepturus repens/Achyranthes* closed grasslands and herblands with a complete absence of trees and large shrubs on the Lihou Reef cays.

As many of the vegetation communities of the Diamond Islets and Lihou Reef cays are dominated by herbaceous vegetation and short-lived shrubs (*Abutilon albescens*), it is expected that the floristic composition and spatial extent of each of these communities will be dynamic, varying with prevailing and recent rainfall. There will also be considerable variation between seasons in the abundance of annual species such as *Achyranthes aspera* and *Tribulus cistoides*. Communities that are co-dominated by annual herbs such as *Achyranthes aspera* and perennial herbaceous species such as *Lepturus repens* are likely to vary between grasslands and herblands depending on season and climatic conditions. This would certainly be the case for vegetation map unit 3b.

The following vegetation communities present on some of the other Coral Sea cays were absent from both the Diamond Islets and the Lihou Reef cays:

- *Sporobolus virginicus* open to closed grassland
- *Abutilon albescens* open shrubland to shrubland with emergent dead *Cordia subcordata*
- *Pisonia grandis* closed scrub
- *Pisonia grandis* wind-sheared closed scrub
- *Pisonia* open shrubland to shrubland
- *Pisonia grandis* closed scrub to low closed forest
- *Colubrina asiatica* open heath

Table 1. Vegetation communities of the Diamond Islets and Lihou Reef cays.

Map Unit	Vegetation Community
	Unvegetated Areas
A	Sandy shores
B	Lithified shores
C	Rubble banks
	Shoreline and Sandspit Vegetation
1a	Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines
1b	Littoral sparse herbland on shoreline rubble banks
2	*Argusia argentea* open shrubland/isolated shrubs on shorelines and sandy spits
11a	*Argusia argentea* shrubland/ tall shrubland/ open scrub/ closed scrub with a ground layer typically of *Lepturus repens*, *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea* +/- *Achyranthes aspera* +/- *Stenotaphrum micranthum* +/- *Tribulus cistoides*
	Grasslands and Herblands
3a	*Lepturus repens* grassland/ closed grassland +/- *Achyranthes aspera* +/- *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*
3b	*Lepturus repens*/ *Achyranthes aspera* closed grassland/herbland/closed herbland (seasonally variable) with *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*
3c	*Lepturus repens*/*Ipomoea violacea* viny grassland/ closed grassland with *Boerhavia albiflora* var. *albiflora*, +/- *Abutilon albescens* +/- *Achyranthes aspera* +/- *Tribulus cistoides*
3d	*Lepturus repens* closed grassland with *Achyranthes aspera*, *Canavalia rosea* +/- *Abutilon albescens*, +/- *Plumbago zeylanica*
4	*Lepturus repens*/*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea*
5	*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora* +/- *Achyranthes aspera* +/-*Portulaca oleracea*
6a	*Boerhavia albiflora* var. *albiflora* sparse herbland/ open herbland/ herbland with *Portulaca oleracea*
6b	*Boerhavia albiflora* var. *albiflora*/ *Stenotaphrum micranthum* open herbland/herbland with *Portulaca oleracea*
6c	*Boerhavia albiflora* var. *albiflora*/ *Achyranthes aspera* open herbland/ herbland with *Portulaca oleracea* +/ *Lepturus repens* +/- *Stenotaphrum micranthum*
7	*Plumbago zeylanica*/ mixed closed herbland/dwarf shrubland with *Achyranthes aspera*, *Lepturus repens*, +/- *Abutilon albescens* +/- *Canavalia rosea*
8a	*Achyranthes aspera* herbland/closed herbland with *Boerhavia albiflora* var. *albiflora*
8b	*Achyranthes aspera*/*Stenotaphrum micranthum*/ *Boerhavia albiflora* var. *albiflora* herbland/ closed herbland +/- *Abutilon albescens* +/- *Portulaca oleracea*
8c	*Achyranthes aspera* mixed herbland/closed herbland with *Lepturus repens* and *Plumbago zeylanica* +/- *Abutilon albescens* +/- *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*
9	*Ipomoea violacea*/ *Achyranthes aspera*/ *Lepturus repens* closed vineland with *Canavalia rosea* and *Plumbago zeylanica*
10	*Ipomoea pes-caprae* vineland with *Lepturus repens*, *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*
	Interior Shrublands
11b	*Argusia argentea* open shrubland /tall open shrubland/open scrub with a ground layer of *Lepturus repens* and *Boerhavia albiflora* var. *albiflora* +/- *Achyranthes aspera* +/- *Ipomoea violacea* +/- *Portulaca oleracea*
11c	*Argusia argentea* shrubland with ground layer of *Lepturus repens*, *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*
12	*Argusia argentea* shrubland with occasional *Cordia subcordata* and a ground layer dominated by *Lepturus repens*
13	*Cordia subcordata* open shrubland to closed scrub
14	*Ximenia americana* closed scrub
15	*Abutilon albescens* dwarf shrubland to shrubland with a mid- dense to dense ground layer of *Abutilon albescens*, *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* +/- *Lepturus repens* +/- *Plumbago zeylanica* +/- *Stenotaphrum micranthum*

The selection of photographs on the following pages show the typical vegetation of each of the vegetation communities listed in Table 1.

Photographs of each of the vegetation communities on the Diamond Islets and Lihou Reef cays, July 2021

Shoreline and sandspit vegetation

Shoreline communities, particularly vegetation map units 1a and 1b consist of newly established vegetation on shorelines just above the high tide level. The vegetation in these areas is highly dynamic, with plants constantly recruiting and establishing during periods of accretion and low intensity wave action and then disappearing as a consequence of high energy wave action, beach erosion and turtle nesting activity. Note the evidence of turtle nesting in *Photo 3*.

1a Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines

Photo 3: Vegetation Map Unit 1a, Site 35 Central Diamond Islet.

Photo 4: Vegetation Map Unit 1a, Site 72 South Diamond Islet.

1a Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines

Photo 5: Vegetation Map Unit 1a, Site 121 Georgina Cay sand spit.

Photo 6: Vegetation Map Unit 1a, Site 182 Lorna Cay.

1b Littoral sparse herbland on shoreline rubble banks

Photo 7: Vegetation Map Unit 1b, Site 101 South West Cay.

2 *Argusia argentea* open shrubland/isolated shrubs on shorelines and sandy spits

Photo 8: Vegetation Map Unit 2, Site 23 West Diamond Islet.

11a ***Argusia argentea*** **shrubland/ tall shrubland/ open scrub/ closed scrub with a ground layer typically of** ***Lepturus repens*****,** ***Boerhavia albiflora*** **var.** ***albiflora*****,** ***Portulaca oleracea*** **+/-** ***Achyranthes aspera*** **+/-** ***Stenotaphrum micranthum*** **+/-** ***Tribulus cistoides***

Photo 9: Vegetation Map Unit 11a, Site 46 East Diamond Islet.

Photo 10: Vegetation Map Unit 11a, Frigatebirds (Fregata spp.) and red-footed boobies (Sula sula) nesting in Argusia argentea in this vegetation community.

3a *Lepturus repens* grassland/ closed grassland +/- *Achyranthes aspera* +/- *Boerhavia albiflora* var. *albiflora* +/-

Photo 11: Vegetation Map Unit 3a, Site 51 East Diamond Islet.

Photo 12: Vegetation Map Unit 3a, Monitoring Site M12, Turtle Islet.

3b ***Lepturus repens/ Achyranthes aspera*** **closed grassland/herbland/closed herbland (seasonally variable) with** ***Boerhavia albiflora*** **var.** ***albiflora*** **+/-** ***Portulaca oleracea***

Photo 13: Vegetation Map Unit 3b, Site 97 South West Cay.

Photo 14: Vegetation Map Unit 3b, Site 141 Frigatebirds (Fregata spp.) nesting in vegetation community 3b on Hermit Crab Islet.

3c ***Lepturus repens/Ipomoea violacea*** **viny grassland/ closed grassland with** ***Boerhavia albiflora*** **var.** ***albiflora*****, +/- *Abutilon albescens* +/- *Achyranthes aspera* +/- *Tribulus cistoides***

Photo 15: Vegetation Map Unit 3c, Monitoring Site M05 West Diamond Islet.

Photo 16: Vegetation Map Unit 3c, Site 20 West Diamond Islet.

3d ***Lepturus repens*** **closed grassland with** ***Achyranthes aspera*****,** ***Canavalia rosea +/- Abutilon albescens*****,** ***+/- Plumbago zeylanica***

Photo 17: Vegetation Map Unit 3d, Monitoring Site M08, East Diamond Islet.

Photo 18: Vegetation Map Unit 3d, Site 31 Central Diamond Islet.

4 ***Lepturus repens/Stenotaphrum micranthum*** **grassland with** ***Boerhavia albiflora*** **var.** ***albiflora*****,** ***Portulaca oleracea***

Photo 19: Vegetation Map Unit 4, Site 164 Turtle Islet.

5 ***Stenotaphrum micranthum*** **grassland with** ***Boerhavia albiflora*** **var** ***albiflora +/- Achyranthes aspera +/-Portulaca oleracea***

Photo 20: Vegetation Map Unit 5, Site 113 Georgina Cay.

5 ***Stenotaphrum micranthum*** **grassland with** ***Boerhavia albiflora*** **var** ***albiflora +/- Achyranthes aspera +/-Portulaca oleracea***

Photo 21: Vegetation Map Unit 5, Site 160 Turtle Islet.

6a ***Boerhavia albiflora*** **var.** ***albiflora*** **sparse herbland/ open herbland/ herbland with** ***Portulaca oleracea***

Photo 22: Vegetation Map Unit 6a, Site 64 East Diamond Islet.

6a *Boerhavia albiflora* var. *albiflora* sparse herbland/ open herbland/ herbland with *Portulaca oleracea*

Photo 23: Vegetation Map Unit 6a, Site 190 Lorna Cay.

6b *Boerhavia albiflora* var. *albiflora/ Stenotaphrum micranthum* open herbland/herbland with *Portulaca oleracea*

Photo 24: Vegetation Map Unit 6b, Site 126 Georgina Cay.

6b *Boerhavia albiflora* var. *albiflora*/ *Stenotaphrum micranthum* open herbland/herbland with *Portulaca oleracea*

Photo 25: Vegetation Map Unit 6b, Site 143 Hermit Crab Islet.

Photo 26: Vegetation Map Unit 6b, Site 187 Lorna Cay.

6c ***Boerhavia albiflora* var. *albiflora*/ *Achyranthes aspera* open herbland/ herbland with *Portulaca oleracea* +/ *Lepturus repens* +/- *Stenotaphrum micranthum***

Photo 27: Vegetation Map Unit 6c, Site 170 Lorna Cay.

7 ***Plumbago zeylanica*/ mixed closed herbland/dwarf shrubland with *Achyranthes aspera*, *Lepturus repens*, +/- *Abutilon albescens* +/- *Canavalia rosea***

Photo 28: Vegetation Map Unit 7, Site 28 Central Diamond Islet.

8a ***Achyranthes aspera*** **herbland/closed herbland with** ***Boerhavia albiflora*** **var.** ***albiflora***

Photo 29: Vegetation Map Unit 8a, Site 96 South West Cay.

Photo 30: Vegetation Map Unit 8a, Site 140 Hermit Crab Islet.

8a ***Achyranthes aspera*** **herbland/closed herbland with** ***Boerhavia albiflora*** **var.** ***albiflora***

Photo 31: Vegetation Map Unit 8a, Monitoring Site M10 Hermit Crab Islet.

8b ***Achyranthes aspera/Stenotaphrum micranthum/ Boerhavia albiflora*** **var.** ***albiflora*** **herbland/ closed herbland +/-** ***Abutilon albescens*** **+/-** ***Portulaca oleracea***

Photo 32: Vegetation Map Unit 8b, Site 112 Georgina Cay.

8c ***Achyranthes aspera*** **mixed herbland/closed herbland with** ***Lepturus repens*** **and** ***Plumbago zeylanica +/- Abutilon albescens +/- Boerhavia albiflora*** **var.** ***albiflora +/- Portulaca oleracea***

Photo 33: Vegetation Map Unit 8c, Site 39 Central Diamond Islet.

Photo 34: Vegetation Map Unit 8c, Site 67 South Diamond Islet.

9 ***Ipomoea violacea/ Achyranthes aspera/ Lepturus repens*** **closed vineland with** ***Canavalia rosea*** **and** ***Plumbago zeylanica***

Photo 35: Vegetation Map Unit 9, Site 33 Central Diamond Islet.

Photo 36: Vegetation Map Unit 9, Site 54 East Diamond Islet.

10 *Ipomoea pes-caprae* vineland with *Lepturus repens*, *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*

Photo 37: Vegetation Map Unit 10, Site 61 East Diamond Islet.

Argusia argentea communities in the interior of the cays

Argusia argentea is most commonly found on the seaward edge of the vegetation with seedling establishment on bare accreting sand along shorelines and sand spits. It is also present in the interior of some of the Diamond Islet cays (map units 11b and 11c). Its presence in the interior could indicate the location of earlier shorelines or more recent establishment in areas bared by cyclones and, in lower areas, assisted by wave surge over wash.

11b ***Argusia argentea*** **open shrubland /tall open shrubland/open scrub with a ground layer of** ***Lepturus repens*** **and** ***Boerhavia albiflora*** **var.** ***albiflora*** **+/-** ***Achyranthes aspera*** **+/-** ***Ipomoea violacea*** **+/-** ***Portulaca oleracea***

Photo 38: Vegetation Map Unit 11b, Site 81 South Diamond Islet.

11c ***Argusia argentea*** **shrubland with ground layer of** ***Lepturus repens***, ***Achyranthes aspera***, ***Boerhavia albiflora*** **var.** ***albiflora*** **and** ***Portulaca oleracea***

Photo 39: Vegetation Map Unit 11c, Site 73 South Diamond Islet.

13 *Cordia subcordata* open shrubland to closed scrub

Photo 40: Vegetation Map Unit 13, Site 40 East Diamond Islet.

Photo 41: Vegetation Map Unit 13, taken from Site 47 on East Diamond Islet - wind sheared patch of Cordia subcordata in distance.

14 *Ximenia americana* closed scrub

Photo 42: Vegetation Map Unit 14, Site 27a West Diamond Islet.

Photo 43: Vegetation Map Unit 14, Leaves and branchlets of Ximenia americana Site 27a West Diamond Islet.

Bird habitat provided by vegetation

The grassland and herbland communities were the preferred nesting habitat for large numbers of ground nesting seabirds, particularly sooty tern (*Onychoprion fuscatus)*, common noddies (*Anous stolidous)* and brown boobies (*Sula leucogaster)* with the largest numbers nesting in bare or sparsely vegetated patches within these communities. The *Stenotaphrum micranthum*/*Boerhavia albiflora* var. *albiflora* open grasslands just landward of the shoreline were also favoured nesting sites for these species. Wedge tailed shearwater burrows were most abundant on the crests, plateaus and upper slopes in the grasslands and herblands. Nesting red-footed boobies (*Sula sula*) and frigate birds (*Fregata* spp.) were abundant on the branches of the *Argusia argentea* shrubs on the Diamond Islets. Frigate birds also nested on the ground on both the Diamond Islets and Lihou Reef cays. Large numbers of frigate birds were nesting in the protection offered by the slight depression on the eastern end of Hermit Crab Islet. Black noddies (*Anous minutus*) were also present on the branches of the *Argusia argentea* shrubs. Masked boobies (*Sula dactylatra*) and brown boobies commonly nested in the sparse shoreline vegetation (vegetation unit 1a) and masked boobies also nested on the bare sand seaward of the vegetation. Nesting red-tailed tropic birds (*Phaethon rubricauda*) favoured nest sites under low bushy *Argusia argentea* shrubs but were also observed nesting under low shrubs and herbaceous plants in the interior of the cays. Nesting roseate terns (*Sterna dougalli*), black-naped terns (*Sterna sumatrana*) and New Caledonian fairy terns (*Sternula nereis exsul*) were not dependent on vegetation cover, nesting on vegetation free areas on sand spits and on unvegetated cays.

Photo 44: Frigatebird (Fregata spp.) chick in Argusia argentea on East Diamond Islet.

Photo 45: Frigatebird (Fregata spp.) nests in Argusia argentea shrubs (foreground) and sooty terns (Onychoprion fuscatus) nesting in bare patches amongst grassland/herbland vegetation (background) on East Diamond Islet.

Photo 46: Sooty terns nesting in open grassland adjacent to the shoreline on Lorna Cay.

Ecological values of the vegetation communities

In addition to the ecological value of providing habitat for seabirds, the vegetation communities of the Coral Sea Cays have significant biodiversity value in their own right.

The "dry" tropical vegetation of the Coral Sea cays are an important link with Indo-Pacific region and the Melanesian Islands with the assistance of seabirds and prevailing east-to-west South Equatorial Currents (Batianoff et al*., 2*008 and 2009a).

The cay communities are unique to the coral cays, differing from those on the mainland and continental islands in substrate and prevailing climatic conditions as well as structure and floristic composition of the vegetation. The vegetation communities on the Coral Sea cays differ from those of both the Pacific/Melanesian cays and those of the Great Barrier Reef.

Similar vegetation communities in the southern Great Barrier Reef have all been allocated a Queensland Biodiversity Status of "Of Concern" because of their limited geographic extent. The Coral Sea cay cays are under Commonwealth management and the vegetation of these cays has therefore not been assessed using the Queensland biodiversity classification framework. Given the small size of the Coral Sea cays and the small total area of each of the vegetation communities, these communities would also qualify for an "Of Concern" Biodiversity Status based on limited geographic extent using the Queensland framework. The vegetation on the cays plays a role in soil development and by accumulating, cycling and releasing nutrient to the surrounding reef. It also helps to stabilise the cays.

Drift seeds

The most common drift seeds found on the shorelines of the cays were:

- *Barringtonia asiatica,* (box fruit)
- *Calophyllum inophyllum* (Alexandrian laurel)
- *Cocos nucifera* (coconut)
- *Entada phaseoloides* (matchbox bean)
- *Heritiera littoralis* (looking glass mangrove),
- *Mucuna* sp.
- *Rhizophora* sp.(mangrove)
- *Terminalia catappa* (beach almond)

These seeds have most likely originated from Pacific islands and travelled to the Coral Sea via ocean currents. Although most of these species were numerous and widely distributed on the shores of the Diamond Islets and Lihou Reef cays during the July 2021 voyage, none are currently growing on these cays and none have been reported growing on any Coral Sea cays in previous reports, indicating that conditions on Coral Sea cays are not suitable or the seeds are non-viable by the time they reach the shorelines.

Photographs of samples of drift seeds collected on each cay during the voyage are shown in Appendix 13.

An update to this section will be provided to PAD when identifications have been completed.

Soils

Results of soil analyses for all sites are tabulated in Appendix 11. Soil analysis of individual sites is discussed for each cay in Islet and Cay Summaries.

Soil analyses data used for comparisons with Coringa-Herald cays, Willis Island and the Capricornia Cays National Park in the Southern Great Barrier Reef are data reported by Batianoff et al. (2008 and 2010), Brushe (2021) and Batianoff et al. (2012) respectively. These citations will not be used again in the comparisons with these locations.

Batianoff et al. found that most nutrient levels in the Capricornia Cays were well below those of the Coringa-Herald cays.

Soil nutrient levels are affected by recent and prevailing climatic regime (input and leaching of nutrient) and time of the year (seasonal bird nesting). Levels also vary between vegetation communities and with depth of soil sampled. Because of all these variables, valid comparison and interpretation of data sets can be difficult.

Like the soils of low coral cays generally, the soils of the Diamond Islets and Lihou reef cays have little to no profile development beyond some accumulation of organic matter in the A-horizon. Together with the soils of the other cays in the Coral Sea and Great Barrier Reef, belong to the soil group described by Batianoff et al. (2008) as 'inceptic coral calcarosols' a classification that describes soils that are recent, organic, dominated by calcium carbonate derived from coral reef ecosystems and within the order of calcarosols. Essentially, inceptic coral calcarosols are neutral to strongly alkaline, lacking a 'B' horizon, with loose surface soils, no consolidation of particles and homologous parent material derived from marine organisms. Clay is absent from cay soils. Coral cay substrates are calcareous due to their high calcium carbonate mineralogy (Batianoff 2008).

Calcareous sands are very low in nutrient. Soil nutrients on cays are derived from the marine biosphere (bird excreta, fish, etc.), the atmosphere (aerosols), and the sea (dissolved nutrients). Organic material is particularly important both for moisture retention and for the concentration and cycling of plant nutrients. According to Morrison (1990), most of the soil fertility on cays is related to accumulated organic material with nitrogen and cation exchange values closely related to organic content. Batianoff et al. (2010) found that all soil nutrients were strongly positively correlated with organic carbon content

Batianoff, 2010 demonstrated that soil nutrient concentrations were higher in the surface soils than in deeper horizons for each profile. This higher fertility in the surface soils was evident, even in the top 30 cm of the soil profile in the Diamond Islet and Lihou Reef cay samples for levels of nitrogen, total carbon, organic carbon, phosphorus, potassium, magnesium, sodium, sulphur, copper iron, manganese, and zinc with a corresponding increase in pH and decrease in CEC.

Analyses of both Coral Sea and Capricornia Cay soils (Batianoff 2010 and Batianoff et al. 2012) demonstrated that there is a relationship between soil properties and the associated vegetation community.

Soils on all Diamond Islet and Lihou Reef cays consistently showed increasing development with distance from the shoreline from white sand +/- coral rubble fragments on and adjacent to the shoreline to light coloured /grey brown sandy soil on the slopes and darker coloured sandy soils with increasing organic content closer to the centre of the cay.

pH

Soil pH on cays is typically alkaline, highest on the beach and shorelines and lower in the interior soils. pH also decreases with distance from the shoreline, decreasing with increasing organic content. The results of the soil analysis of Diamond Islets and Lihou Reef cay sol samples also show these trends even though only the top 30 cm of soil was sampled. Average pH for the three soil depths sampled were:

- Diamond Islets sites = 8.61 (0-10 cm). 8.77 (10-20 cm), 8.92 (10-20cm)
- Lihou Reef cays sites =8.31 (0-10cm), 8.63 (10-20cm), 8.91 (20-30cm)

The decrease in pH with distance from the shoreline was evident in the Diamond Islet soil samples with the averaged pH for the shoreline *Argusia argentea* shrubland sites (9.1) higher than the averaged pH of the interior grassland and herbland sites (8.7) and the *Abutilon albescens* shrubland site (8.4). None of the Lihou Reef cay sites were located on the shoreline so the difference in pH between coastline and interior soils could not be compared.

pH of the samples was similar in both island groups ranging from 7.8 to 9.5 and values were generally similar to pH values previously obtained for the Coringa-Herald cays, Willis Islets and the Capricornia Cays in similar vegetation communities. *Pisonia grandis* communities have lower pH values.

Alkaline pH can make several of the trace elements, particularly iron, manganese and zinc, unavailable to plants.

Electrical conductivity (EC)

Averaged electrical conductivity was slightly lower than the previous values obtained on the other Coral Sea and Capricornia Cays.

Nitrogen

Nitrogen levels in cay soils are typically low and are related to organic content. Total nitrogen levels were generally low in all data sets. Levels in the Diamond Islets and Lihou Reef cay samples were similar to those in similar communities in the Coringa-Herald cays. Levels at Willis Island and the Capricornia Cays were lower than those in the Diamond Islets and Lihou Reef cays.

Carbon

Except for a couple of sites, organic carbon levels in both the Diamond Islets and Lihou Reef cays as well as those of Willis Island were generally quite low, compared to those from the Coringa-Herald and Capricornia Cays.

Total carbon levels were high in all data sets as would be expected with the calcium carbonate mineralogy of the cays. Levels were higher on the Diamond Islets and Lihou Reef cays than all other previous soils data.

Phosphorus

Phosphorus levels are high, highest in the 0-10cm depth (surface soils) as would be expected with deposition of guano by large populations of nesting seabirds. Levels were similar to those in the Coringa-Herald and Willis Island samples. The Capricornia Cays had lower levels.

Calcium

The calcium levels on the Diamond Islets and Lihou Reef cays were similar for the two island groups and similar to those of the Coringa-Herald cays and Capricornia Cays in similar vegetation communities. Willis Island had higher calcium values than the other Coral Sea cays.

Potassium

Potassium levels were low in all data sets. Levels were lower in the Diamond Islets, Lihou Reef cays and Willis Island than those in similar vegetation communities in the Coringa-Herald cays. Levels in the Capricornia Cays samples were lower than those in all the Coral Sea samples.

Magnesium

Magnesium levels were similar to previous samples from the Coral Sea sites and the Capricornia Cay samples.

Sodium

The Diamond Islets and Lihou Reef cays had similar levels of sodium to similar communities in the Coringa-Herald and Capricornia Cays. Willis Island had slightly higher levels of sodium than the other Coral Sea cays.

Cation exchange capacity (CEC)

No data was available for the Coringa-Herald cays. Values obtained in the Diamond Islets and Lihou Reef cays were lower than those obtained at Willis Island and similar to those of the Capricornia Cays.

According to Morrison (1990) CEC is closely related to organic content.

Aluminium

The Diamond Islets and Lihou reef cays had similar levels of aluminium to similar communities in the Capricornia Cays (No data available for the Coringa-Herald cays). Willis Island data was recorded differently but it appears that aluminium levels may have been higher than the Diamond Islet/Lihou Reef cay levels.

Sulphur

Sulphur levels were similar in all Coral Sea datasets. Levels in similar communities in the Capricornia Cays are slightly lower. Levels are higher in mature *Pisonia grandis* forests.

Calcium domination of the exchange complex can result in a low capacity to retain sulphur, however some sulphur is made available continuously by solution of the coralline materials plus atmospheric sulphur derived from sea-spray (Morrison 1990).

Trace elements (copper iron, manganese, and zinc)

Levels of trace elements were generally quite low. Levels were variable but were generally lower than levels in similar communities on the other Coral Sea cays. Copper and zinc levels were similar in shoreline communities and higher in the herbland communities than those in similar communities in the Capricornia Cays. Iron levels in shoreline communities were lower than those of the Capricornia Cays but similar in herblands. Manganese levels were similar in herbland communities and lower in shoreline communities than those of the Capricornia Cays.

Health checks – Felicity Chapman

Introduction

Health checks are a tool for efficiently and routinely assessing the condition of key values on protected areas.

Key values are those values that are most significant to individual protected areas, selected and defined through a Values Assessment (VA). As part of the VA the current condition and desired condition for each key value are determined by a professional panel together with the management direction, key threats, required actions and the priority of those actions.

Health checks are the basis for the evaluation of condition of natural values through time.

Long term information from Health Checks will provide a good indication of the trend in condition (health), and hence alignment with the stated desired condition for the key value, and so help determine whether the current management approach is appropriate. In addition to Health Checks, where highly significant values require management intervention on a high priority protected area, detailed, targeted monitoring may be required.

In the context of a Health Check a key natural value is an ecosystem or plant community.

Health Checks use simple visual cues, require no specialist skills and have been designed to apply to all ecosystems. The criteria evaluate threatening processes and impacts (e.g. pest plants, trampling, cyclone impacts, dieback) or parameters (e.g. faunal habitat features, ground cover, recruitment of canopy species) that are good indications of condition. The Health Check assessor scores the condition of the key value (e.g. a plant community or ecosystem) at representative sites. The Health Check report uses the International Union for Conservation of Nature condition categories (Good, Good with Some Concern, Significant Concern, Critical) and definitions (Osipova *et al.* 2014) to describe the overall condition of a value across a reserve based on all the Health Check indicators relevant to the value (Melzer et al. 2019).

The guide for undertaking Natural Values Health Checks (Melzer 2019) is available at https://parks.des.qld.gov.au/managing/framework/monitoring/

Methods

For each Health Check, the GPS location was recorded and photographs were taken on each of the compass points N, E, S and W. Photos were taken with an iPad Air using a Context Camera app which provides details stamped on the photo including Lat, Long, direction, date and time. Duplicate photos were taken at each Health Check with a Nikon Coolpix P900 for higher resolution images.

Vegetated cays

The Health Checks undertaken during the July 2021 Coral Sea trip were baseline Health Checks for these small, remote and weather prone coral cay environments. The purpose of the Health Checks was to assess the condition of as many of the main vegetation communities around the perimeter and interior of each cay. In addition sites were selected with as much separation as possible and consideration given to locations on both windward and lee sides of the cays and sandspits.

Vegetation mapping is often part of planning the number and location of Health Check sites prior to fieldwork. Without available mapping for the vegetated cays, Health Check sites were chosen through a rapid assessment on site of vegetation communities present and with advice from J. Brushe. In an effort to achieve good representation of the vegetation communities present additional Health Checks were undertaken with some cays resulting in multiple Health Checks of the same community.

The vegetated cays in the Lihou and Tregrosse Reefs support globally important habitats for seabirds, shorebirds and marine turtles. These values were noted in the Health Check table for the vegetated cays as together with the vegetation represent integral values of these islands. The condition of these habitat values can be inferred from the detailed vegetation assessment (condition of suitable habitat for breeding seabirds and nesting turtles) and bird species and breeding surveys both undertaken by expert personnel during the trip. Marine turtle monitoring during the breeding season will further inform the value of the vegetated cays for marine turtles - breeding numbers, suitability of nesting habitat and nesting success.

Unvegetated cays

In the context of a Health Check a key natural value is an ecosystem or plant community. In the absence of a Values Assessment, the Health Check values of the unvegetated cays assumed overall values of the CSMP - supporting important habitats for breeding and roosting populations of migratory seabirds, shorebirds and nesting marine turtles. In choosing sites on the unvegetated cays the focus of the Health Checks was to identify habitat values for birds and marine turtles, habitat features and threatening processes.

The Health Check table for unvegetated cays does include detail of the bird species and breeding survey work undertaken by A. McDougall to support the assessment. This detail has been kept to a minimum to avoid unnecessary duplication.

The record of the condition class for each vegetation community type (vegetated cays) and marine and turtle values (unvegetated cays) is provided in the individual islet and cay summaries.

Results

The overall condition rating for all the vegetated cays in the Lihou and Tregrosse Reefs was Good. The exception was on West and East Diamond Islets where the overall condition rating was Good but there was Significant Concern for the vegetation community – *13 Cordia subcordata open shrubland to closed shrub.* A small patch of this community on West Diamond Islet was heavily infested by scale tended by ants. On East Diamond Islet a number of patches of *Cordia* communities showed evidence of dieback with numerous dead, mature plants.

The report contains summarised results and representative photos of Health Checks for each vegetated and unvegetated cay. Given the good condition of all vegetated cays it was not necessary to include all Health Check forms and photos. For the unvegetated cays relevant detail and observations are recorded in each table with representative photos to support the Health Check assessments. The unvegetated cays ranged from small intertidal sand mounds to larger cays. Unvegetated cays are known to be more mobile. The unvegetated cays surveyed in the Tregrosse Reefs also appeared to be subject to varying levels of inundation. Drone photography to monitor the cay area and movement over time and an understanding of their geomorphology would provide further insight into the nature of these unvegetated cays. The full record of Health Checks, GPS data and photos will be provided to PAD.

Discussion

Health Checks provide a simple means to regularly evaluate the condition of ecosystems and associated habitats on the cays. Assessors do not require experience in scientific methods nor scientific equipment. Training in the method and concepts, and a camera, GPS/iPad, clipboard and datasheets, are sufficient.

Whilst there is overlap between Health Checks and the detailed vegetation assessment by J. Brushe Health Checks remain an important component of the overall monitoring undertaken during the July 2021 trip. The Health Check sites will continue to allow monitoring of fixed locations over time and can be undertaken

by personnel without specialist skills especially useful for trips when botanists are not available or where time is constrained.

Most vegetation communities were assessed during the July 2021 trip. It is recommended that further Health Checks be undertaken to pick up any vegetation communities that were missed during the July 2021 voyage. Whilst the time of the year for subsequent monitoring is not critical it is preferable it is undertaken at the same time of year each time, ideally following the wet season when vegetation is in its best condition and when weeds are more likely to be present.

Island Watch – Felicity Chapman

The Island Watch tool (Armstrong 2017) was developed by Queensland Parks and Wildlife Service as an early warning system for pest incursions and for the detection of other threats or changes to natural values to allow early management intervention.

Island Watch is a simple and rapid tool intended to be used by rangers on park on scheduled field management activities. Field locations can include high public use areas such as campgrounds and sites for recreational use, or significant value ecosystems where rangers undertake specific programs such as seabird surveys or weed control. All the above are a priority for high biosecurity surveillance as they represent either the most likely sites for pest incursion, or locations where new pests will cause the most serious impacts.

In addition, the Island Watch tool is used to document change or concern about other factors affecting island health such as tidal intrusion encroaching further into low lying wetlands or new sites for seabird nesting activity. Another application of the tool, particularly for seldom-visited islands, is the ability for users to retrieve information about recommended future works when preparing for subsequent visits. The tool prompts staff to be vigilant and to report on observations relevant to park management.

Methods

The Island Watch tool is available electronically on the Field Reporting Software application developed by the Great Barrier Reef Joint Field Management Program. It is also available as a questionnaire style, double-sided A4 hardcopy page to make it convenient to carry on a clipboard. The prompts to "check for change" are in text boxes that refer to observations about new or changing (spreading) weeds, pest animals, fires, seabirds, turtle tracks and nests, any monitoring or collections that took place, and where spatial data and photographs will be stored.

The form is self-explanatory, as the intent is for anyone to be able to answer the questions without special training. All information that would normally be entered into current QPWS&P data management systems must still be entered (e.g. WildNet for bird surveys), adding a note in Island Watch to refer to relevant data systems for additional detail. This procedure prevents the loss of detailed information that can retrieved from data management systems at any time. It is not intended for the Island Watch tool to replace existing systems or databases.

The Island Watch tool was completed in paper format and is presented in Appendix 14.

Discussion

Marine debris was prevalent on all the cays in the Tregrosse and Lihou Reefs. Pollution of the world's oceans by anthropogenic marine debris is a global issue with an estimated 250,000 tonnes afloat in 2018 (Roman et al 2018). Ingestion of buoyant debris directly from the water during foraging and from their prey species is an emerging threat to seabirds. Seabirds utilising marine debris as nesting material on cays was also a common occurrence for some species e.g. common noddies and brown boobies. The threats of marine debris are well documented and PAD monitor marine debris on the cays with the data collated and analysed by Tangaroa Blue Foundation.

The Island Watch tool provided a useful snapshot of the condition of the islands, and the work undertaken during the July 2021 trip. It is recommended that this tool continues to be used by PAD and researchers to the island to build a database into the future. Little expertise is required, and information can be supplemented by photographs and collections for later identification if required.

Introduced pests – Karl Goetze and Felicity Chapman

A. Rodents

Rodents are a major threat to seabird and turtle nesting islands and may significantly impact on the reproductive potential of breeding populations by consuming eggs and hatchlings and may attack and kill adult seabirds. While rats (*Rattus* spp.) are widely acknowledged as the most significant rodent threat, mice have also been found to have major impacts (*Mus* spp.) (Caravaggi *et al.* 2018, Wanless *et al*. 2007). Rodents are a significant biosecurity threat, readily stowing away on vessels and/or in transported equipment. In preceding centuries, it is highly likely that any landing by a vessel or shipwreck would have carried with it a very high probability of rodents getting ashore. Rodents could be introduced by private or commercial charter vessels. The highest risk lies in any activity where gear and equipment is brought ashore. Pests and rodents could also reach cays that are in proximity to passing ships navigating via shipping channels within discarded rubbish or items washed or fallen overboard.

This monitoring component was to detect whether rodents were established on any of the vegetated cays. This information can be used to inform and prioritise future management options.

Methods

Rodent tracking tunnels baited with peanut butter, honey and/or oats were deployed for up to 1 night. Each tunnel contained a thin card tracking pad with a waterproof section in the middle. This waterproof area was liberally covered in a slow drying ink and a bolus of peanut butter was placed in the centre of this ink. The tunnels work on the principal that rodents attracted to the bait must walk through the ink and on leaving the tunnel its tracks are imprinted on the outer sections of white card.

The duration that tunnels were deployed was determined by trip logistics.

Tunnels were placed in habitat niches found on the vegetated perimeter and interior of the nine vegetated cays. Spaced across each cay the placement of tunnels was determined by locations that supported the most favourable shelter and foraging conditions for rodents. For example, tunnels were hidden under vegetation in a range of community types, against logs, adjacent to shearwater burrows, in rock crevices and adjacent to seabird nesting activity (available food source). Desktop locations distributed tunnel sites at ~100m intervals across cays. Once ashore locations were fine tuned to suit the habitat conditions. Any structures or areas of disturbance were also targeted as likely locations for pest activity. All tunnels were collected at the end of the deployment and the cardboard tracking pads were examined for rodent tracks.

Results

No rodent tracks were observed on any tunnels. Hermit crab tracks and droppings were observed in a number of the tunnels. Piles of droppings on shelter logs identified as hermit crab droppings confirmed the source of the droppings found in the tunnels.

Discussion

Despite tunnels being set on some islands for less than the preferred three nights the sampling across every vegetation type, the often less complex vegetation structure found on the cays (no Pisonia forest and often no shrublands), the absence of rodent tracks in all tunnels, the absence of any sightings of rodents, tracks or droppings during the visits, and the absence of any evidence of rodent impacts to abundant seabird breeding, supports the conclusion that there were no rodents on any of the cays surveyed.

The deployment of rodent tracking tunnels is a rapid and cost-effective way of surveying for the presence of rodents. We recommend that all islands be surveyed for rodents every few years. The frequency of surveys could be informed by the frequency of visitation by all vessels. Island Watch, Health Checks and seabird surveys are also good opportunities to check for signs of rodent presence. Any tracks or droppings of unknown provenance, gnawed bird carcasses or other materials, and unexplained declines in seabird presence or nesting could all be used as cues to deploy rodent tracking tunnels. Tunnels should not be redeployed between islands before they have been re-cleaned.

Photo: K. Goetze checking ink pads for rodent tracks on East Diamond Islet.

Photo: Rodent tunnels were placed in diversity of vegetation and habitat types that provided favourable shelter or foraging conditions for rodents. Photo taken on West Diamond Islet.

B. Ants (and other invertebrates)

The presence/absence of ant species was assessed on all vegetated islands by using baits comprised of peanut paste, oats, honey and/or tuna (cat food). Inspections were undertaken on all unvegetated cays for the presence of invertebrates.

Ant bait stations were established at each rodent tunnel. The baits were left for at least 30 minutes, after which they were checked. Abundance scores: 0; 1-50; 50-100; 100-500; and >500 were recorded for each ant species attending the bait. Voucher specimens of all species were collected and stored in vials of alcohol for identification by Queensland Museum.

Incidental hand collecting of ants and other invertebrates was also undertaken on the cays.

Ants collected at ant bait stations and opportunistic collection of invertebrates is presented for each cay. A summary of invertebrate species for all cays is presented in Appendix 15. This summary will be updated as further identification by the Queensland Museum is received.

Photo: In addition to ant bait stations, surveys for ants (and other invertebrates) was undertaken by looking under logs and debris.

Results

Three species of invasive (non-native) ants were found on only three cays - one species each for Central Diamond Islet, East Diamond Islet and Turtle Islet. Two of these islets contained infrastructure - Central Diamond Islet has a current navigational aid and Turtle Islet has supported infrastructure in the past.

No invasive ants were found on the other islets and cays.

The first invasive ant *Monomorium pharaonis* found on Central Diamond Islet was the most common and abundant ant species recorded on three of the six islands in the 2019 voyage to the Coringa-Herald cays (Hemson et al. 2020). *M. pharoanis* have polygynous colonies (nests contain more than one productive queen) so colonies can be prolific hence the scale of potential ecological impact and/or human nuisance can be widespread. (Chris Burwell 2021, pers. comm.).

The second invasive ant *Tetramorium simillimum* found on East Diamond Islet is a tramp species that is now pantropically distributed. It even occurs in some temperate areas, albeit in protected locations such as heated greenhouses. Unlike some other exotic myrmicines in Australia, this species does not seem to adversely affect the native ant fauna. *Tetramorium simillimum* tends to invade natural environments however it is innocuous and does not occur in huge numbers. Based on current knowledge of this particular species, it does not raise any red flags. In contrast to other invertebrates that inhabit coral cays that can appear and then disappear, ants are known to persist (Chris Burwell 2021, pers. comm.).

The third invasive ant found on Turtle Islet is a very small species that is difficult to identify hence the 'cf'. It is possibly *Monomorium* cf *intrudens* or *Monomorium insolens* both non-native species.

Other invertebrates collected from both vegetated and unvegetated cays with confirmed identification are all native species. Some specimens are yet to be identified by the Queensland Museum.

Drone imagery – Ben Sale

PAD requested high definition orthomosaic maps of the vegetated and non-vegetated islands visited during the voyage. These maps were used primarily to provide an accurate record of the vegetation and morphology of the islands at high resolution and to assist with validating observed bird counts.

A DJI Phantom 4 Real-Time Kinematic (RTK) (DJI-P4RTK) was utilised to survey 22 of the vegetated and non-vegetated islands visited over the duration of the voyage. The DJI-P4RTK is equipped with a 24mm wide angle camera, high precision and anti-shake gimbal, 1-inch CMOS sensor, mechanical shutter (DJI 2021). The DJI-P4RTK has the advantage of a multi-frequency on-board GNSS receiver providing high precision for cm level accuracy. The resolution of the imagery for each survey was determined by the ground sampling distance between the camera and the object being photographed.

Mission planning involved creating KML survey files for each island which were taken from either the best satellite imagery available from PAD or polygons drawn in ArcMap using the only imagery available at the time which was very low resolution sourced from Allens Coral Atlas. Some of the KMLs developed in this way proved to be insufficiently accurate for the needs of RTK drone mission planning. This resulted, in the case of East Diamond Island and Georgina Cay, with an unfortunate loss of data capture as the mission footprint fell short of the footprint of the required dataset.

To address this issue an alternate approach was devised in the field and implemented for the remaining survey missions. This involved a crew member completing a lap of each island with a GARMIN handheld GPS unit which was used to generate a .gpx file of the walked track plot. The .gpx file was then loaded into Google Pro to produce an accurate KML of the island footprint for mission planning. In some instances, depending on the time available an additional buffer of between 50 and 200 metres was added to this footprint to enable the survey mission to capture imagery of the nearshore coastal features.

The GSD for each site varied due to the amount of time available to spend on each island as some days as many as three cays were required to be surveyed. In addition other key factors such as imagery overlap (set between 70% and 85%), height and drone flight speed were adapted to ensure the drone captured at least 12 minutes of GNSS data during its flight. This approach ensured maximum accuracy of geocoded drone imagery while ensuring the maximum number of surveys was achieved over the duration of the voyage.

These factors were integrated into the mission plans prior to each flight depending on time available and key outcomes required. Some of the islands were surveyed as low as 50 metre to maximise the resolution of the images obtained to assist with bird counts. The resolution for the survey imagery varied between 1.5 and 2.9 cm/ pixel the details of which are presented in Drone imagery results below.

At each survey location at least one Propeller Aeropoint (a smart ground control point developed by Propeller) was used to collect a ground based GPS data log 45 mins prior to and for the duration of each of the DJI-P4RTK surveys. This will allow for repeated follow up surveys to be conducted accurately (to within 0.5m) and consistent over time when the DJI-P4RTK survey dataset is processed using the Propeller platform.

In addition to the survey imagery captured using the RTK drone an additional DJI Mavic 2 Enterprise (Mavic) was used to capture 4K resolution video imagery suitable for multimedia applications. Mavic missions were flown whenever possible after the priority survey imagery had been captured using the RTK drone.

Drone imagery results

Table 2. Drone imagery results.

Cay	Vegetated	Obvious evidence of turtle nesting	Resolution of Imagery (cm/pixel)
West Diamond Islet	Y	Y – NW corner	2.2
Central Diamond Islet	Y	Y – NW corner	2.3
East Diamond Islet	Y	N	2.7
South Diamond Islet	Y	Y – NW corner	2.1
South West (Nellie) Cay	Y	N	1.4
Georgina Cay	Y	N	2.6
Edna Cay	N	N	2.9
Fanny Cay	N	Y	1.6
Dianna Cay	N	Y	2.4
Carol Cay	N	Y	2.0
Phoenix Cay	N	N	2.6
Hermit Crab Islet	Y	Y – NW corner	2.0
Betty Cay	N	Y	1.8
Frankie Cay	N	N	1.7
Observatory Cay	N	N	2.0
Middle Cay	N	Y	1.9
Turtle Islet	Y	N	1.6
Margaret Cay	N	N	1.5
Little Margaret Cay	N	N	1.5
Lorna Cay	Y	N	1.7
Kathy Cay	N	Y	1.8
Juliette Cay	N	Y	2.0

General discussion and recommendations – Martin Russell

Drone imagery – suggest inclusion of proposal to:

1. A key learning from the voyage is that the best available satellite imagery was not sufficiently accurate to inform the drone mission flight plans. An in field alternative approach to creating drone flight plan KMLs was developed during the voyage for producing a fit for purpose KML which can be used on future voyages to minimise the risk of data loss.
2. Formalise operational procedures for drone mapping mission planning including the inclusion of an RTK Base Station for future trips to obtain survey accurate positions for ground control points.
3. Consider inclusion of fixed wing airframe to improve flight time efficiencies and ability to swap payloads to include capture of multispectral imagery to assist in plant health assessment and coral regrowth within lagoon immediately adjacent to islands.
4. Consider using the Propeller aeropoint datasets collected on the July 2021 voyage to work up a research paper on climate change baseline for the islands noting the limitation of the accuracy of the ground control points without having a fixed/ known/ survey mark on each of the islands (accurate and repeatable to within 0.5 m).

   DJI 2021 – Phantom 4 RTK User Manual (https://dl.djicdn.com/downloads/phantom_4_rtk/20210716/Phantom_4_RTK_User_Manual_v2.4_EN.pdf last accessed 26/11/2021)

Marine debris – John Prichard (data provided by Tangaroa Blue Foundation)

Introduction

One of the core undertakings of this Island Health Assessment voyage was to collect and remove any and all marine debris that was found on each of the cays/islets so as to return each of them to as near a pristine condition as possible, as far as being free from marine debris/rubbish was concerned. Collected marine debris was bagged, fumigated, sealed, named (by cay/islet) and dated before being removed from the cay/islet out to the voyage vessel.

Items of marine debris that were too large to be bagged (such as fishing nets, crates, fish attracting devices (FADS) or large lengths of ropes) were washed in the sea in situ and then sprayed/fumigated on shore before being taken out to the vessel.

All marine debris was stored as compactly as possible on the upper deck of the vessel and netted and secured for the return passage back to port at Yorkey's Knob (Cairns region); this amounted to a large pile covering a space of over 12 cubic metres.

On return to port the vessel was met by members of the Tangaroa Blue Foundation, an Australia-wide not-for-profit organisation dedicated to the removal and prevention of marine debris.

All of the marine debris was removed from the vessel and loaded into a large capacity, fully enclosed truck and transported toTangaroa Blue headquarters in Cairns where, over the course of a number of weeks, each marine debris bag was weighed, emptied, sorted and meticulously analysed and recorded by Tangaroa Blue workers.

Tangaroa Blue Foundation forwarded its highly detailed analysis of the marine debris to PAD on 14 October 2021, which provided information down to individual types, numbers and source of origin of marine debris per cay/islet and an overall count and weight of marine debris collected of each cay/islet.

Utilising Tangaroa Blue Foundation's highly detailed data this paper aims to simply show the uneven distribution of marine debris through the Diamond Islets and Lihou Reef, indicating the heavy and low marine debris loads (by total items, rather than weight[1]) and examine possible reasons for this distribution.

Note:

1. The total number of marine debris items on a cay/islet has been chosen over the weight (kg) of marine debris collected as it provides a more accurate measure of the level of marine debris 'pollution' on the cays and islets. For example, hundreds of empty plastic bottles and other items might weigh just a portion of the weight of a single large item, such as a heavy rudder with metal rudderpost from a stricken vessel, as was found on the voyage.

Summary of marine debris collected

Tangaroa Blue Foundation's report was provided in the form of an extensive Excel spreadsheet workbook. The spreadsheet detailed 260 separate categories of marine debris, with a numerical value (number of items) assigned to each category from each of the individual cays and islets.

A summary of the key debris information:

- A total of 16,613 individual items with a combined weight of 2,035.8 kg were collected from the Diamond Islets and Lihou Reef.
- Items made of synthetic materials such as plastics, rubber and PVC accounted for 16,250 items collected or 97.8 percent of the total number of items, broken down into the following categories:
- Degrading hard pieces of plastic - 7,614.
- Plastic lids and bottle tops - 3,487.
- Plastic bottles - 1,166.
- Rubber thongs - 607.
- 1,099 metres of synthetic rope of varying sized diameter and individual lengths was collected, with the longest single rope length being 238 metres, while 131 square metres of synthetic fishing nets from FADs was collected.
- 78 plastic fishing floats of varying sizes and 803 separate items were identified as originating in foreign countries.
- 415 glass wine, spirit and other drink bottles and jars.

Marine debris loads on individual cays and islands

As detailed above 16,613 individual items weighing almost 2,039 kg were collected from the 25 cays and islets visited in the Diamond Islets (Tregrosse Reefs) and the Lihou Reef. However, the dispersal of the marine debris around the four Diamond Islets and the 21 Lihou Reef cays and islets was not uniform or necessarily in proportion to the size of the cays and islets (except the very small sand cays which would be swept clean by the sea vitually on each high tide), or whether they were vegetated or not.

The results of Tangaroa Blue Foundation's marine debris analysis by cay/islet, detailed in *Table 3*, *Figure 5* and *Figure 6*, highlights the following:

Cays/islets marine debris load comparisons

- Lorna Cay (approximately 1.4 km long) in the north-west corner of Lihou Reef was by far the most marine debris polluted of the 25 cays/islets, carrying almost 33 percent of the total marine debris load and was over 2 ½ times more polluted than the next highest polluted cays, (Dianna Cay and Observatory Cay in Lihou Reef). Lorna Cay's length relative to other islets and cays would be a contributing factor, although the similar length and vegetated Georgina Cay at the south-west corner of Lihou Reef carried just over 9 percent of the pollution load of Lorna Cay.
- Dianna Cay (central south coast of Lihou Reef) and Observatory Cay (north east corner of Lihou Reef), both unvegetated, were the second most polluted islands, carrying identical marine debris loads by item number, each accounting for almost 12.7 percent of the total marine debris load.
- East and Central Diamond Islets, both vegetated, were the 4th and 6th most polluted cays/islets respectively. Combined, they accounted for over 12.5 percent of the total marine debris items.
- Edna Cay (south west Lihou Reef), unvegetated, was the 5th most polluted cay/islet carrying almost 6.8 percent of the total marine debris load.
- Middle Cay (immediately adjacent to Observatory Cay in north east Lihou Reef) and Juliette Cay (south west northern fringe of Lihou Reef), both unvegetated, were the 7th and 8th most polluted cays/islets respectively, carrying approximately 5 percent and almost 4.0 percent of the total marine debris load.

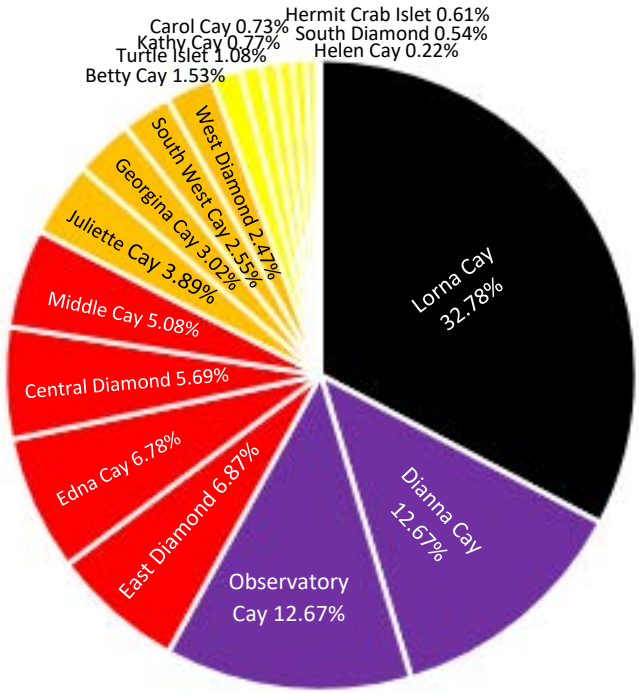


Figure 5. Comparison of individual cays/islets and percentage of total marine debris load (by number of individual items).

Other observations

- Lorna Cay (5,445 items), and Observatory and Middle Cays (2,105 items each), all located in the northeast corner of Lihou Reef, carried 58 percent of the total marine debris load of the 25 cays/islets. By comparison, Turtle Islet and Margaret Cay (similar in size to Observatory Cay), which are situated between Lorna Cay to the west and Observatory Cay/Middle Cay to the east, carried little to no marine debris.
- Dianna Cay (central southern fringe of Lihou Reef) and Edna Cay (southern fringe Lihou Reef) were the 2nd and 5th most polluted cays/islets with 2,105 and 1,126 marine debris items respectively, while sizeable cays/islets to the north east (Hermit Crab Islet) and south west (Georgina Cay) carried significantly lighter marine debris loads of 101 and 502 items respectively.
- In the Diamond Islets, the East and Central Diamond Islets were the 4th and 6th most polluted cays/islets respectively, carrying 1,142 and 946 marine debris items respectively, while West Diamond Islet ranked 10th most polluted cay/islet with 423 marine debris items and South Diamond Islet ranked 17th with only 90 marine debris items.
- There appears to be no correlation between whether a cay/islet is vegetated or not and its marine debris load. This dispels an hypothesis that vegetation on islands would capture and hold marine debris in situ, while bare unvegetated cays would be swept by the wind and sea and thus carry or hold less marine debris. Vegetated cays account for 1 in the top 3 most polluted cays/islets, 3 in the top 7, 6 in the top 11 and 9 in the top 18, which is an even split between vegetated and unvegetated cays/islets (*Table 3*).
- There appears to be a direct correlation between the length, elongated shape and direction of axis (lie of the island) in respect to presenting a broad/long coast to the predominant westward flowing current stream of the South Equatorial Current (as detailed in the Effects of currents and winds below).

- Lorna Cay, Dianna Cay, East Diamond Islet and Edna Cay, 4 of the first 5 most polluted islands, all present a long coastline either side on or at a broad angle to the westward flowing current streams, while Observatory Cay and Middle Cay are at the easternmost point of Lihou Reef and take the first initial brunt of marine debris in the westward flowing current stream.
- These 6 cays and islets are in the top 7 most polluted islets and cays in the Diamond Islets and Lihou Reef.

Effects of currents and winds

A combination of the characteristics of floating objects and the patterns of currents and winds all have an effect on the movement of marine debris in the ocean. Currents are the main determinents on where marine debris moves from and arrives at across the ocean.

Figure 7 provides a diagram/maps of the major currents impacting on the CSMP, these being: (1) the westward flowing South Equatorial Current (SEC), the generally northward flowing Hiri or Gulf of Papua Current (GPC) and the southward flowing East Australian Current (EAC).

The SEC enters the Coral Sea as a series of separate current streams between the Solomon Islands, Vanuatu and New Caledonia to the west. After the SEC has passed through the majority of the CSMP it divides or 'forks' to form the northern flowing Hiri Current (or GPC) and the southerly EAC.

As depicted in *Figure 7* the major current(s) impacting on the Diamond Islets and Lihou Reef area are the westward flowing streams of the SEC, particularly the more southerly SEC streams from between Vanuatu and New Caledonia.

With respect to winds the Coral Sea weather is extremely dynamic, dominated by southeasterly tradewinds through all areas and all seasons (*Figure 7*).

In the central region, which includes the Diamond Islets and Lihou Reef, the monsoon winds may occur in January and the area is often subject to the violent winds of cyclones, especially between January and April. Wind generally has a significantly lesser effect on floating objects than currents and is impacted by the characteristics of floating objects.

Dependent upon whether a floating object is virtually submerged, partially submerged, or floating high on the surface, determines the amount of 'windage' that those object will have and how much effect prevailing winds will have on them. Objects that are virtually submerged will experience little to no wind effect; those that are partially submerged will experience a small wind effect, while objects that are floating high (and lightly) on the surface, with very little surface area submerged (e.g. sealed plastic drink bottles, fishing floats) will experience the most wind effect.

Table 4 examines the plastic bottle component of the collected marine debris and examines these items dispersion among the cays/islets in relation to the total marine debris load, acknowledging that of all the marine debris items, plastic bottles, especially those sealed with lids (not an actual data point), would be the items most likely to float high (and lightly) on the ocean's surface and be subject to the vagaries of wind.

This examination of plastic bottles as a componenet of marine debris has produced some interesting facts:

- All plastic bottles made up 7 percent of the total marine debris load collected from the Diamond Islets and Lihou Reef cays/islets.
- The relative loading of plastic bottles on individual cays and islets was almost the reverse of the total marine debris load on all the cays and islets.
- Cays and islets that most closely approximated the 7 percent average plastic bottle load included (in descending order from closest down):
  Kathy Cay (7.03 %), Edna Cay (6.75 %), Lorna Cay (7.82 %), Central Diamond Islet (5.60 %), East Diamond Islet (5.52 %) and Juliette Cay (9.60 %).
- Cays and islets that carried significantly more than the 7 percent average plastic bottle load included (in descending order from heaviest to lightest):
  Helen Cay (29.73 %), Hermit Crab Islet (22.77%), South West Cay (17.97 %), Turtle Islet (15.64 %), Georgina Cay (13.55 %), West Diamond Islet (13.38 %) and Betty Cay (11.42 %). Six of these seven cays and islets are situated in Lihou Reef and of these, all, apart from Turtle Islet, were on the southern fringing weather coast of Lihou Reef (exposed to the predominant southeasterly tradewinds). West Diamond Islet in the Tregrosse Reefs similarly, is not protected by any fringing barrier reefs to its southeast.
- While there are discrepancies to the rule that can be picked out from this minor survey, it does suggest that the predominant southeasterly tradewinds have an effect upon high (and light) floating marine debris, such as plastic bottles.
- All debris marine debris would be carried westward in the South Equatorial Current. When this current contacted Lihou Reef and the Diamond Islets much of it would end up on the shore; however, for the extent of the SEC stream running to the south of Lihou Reef and the Diamond Islet most of it would continue westward in the stream until it turned south-east to the east of the Great Barrier Reef.
- Noting that high (and light) floating plastic bottles would be affected by the southeasterly tradewinds and blown ashore onto the cays and islets of the southern weather coasts of Lihou Reef (in particular), resulting in a significantly higher proportion of plastic bottles as a percentage of total marine debris load than elsewhere.

Conclusion

There appear to be major ocean currents in the vicinity of Diamond Islets and Lihou Reef, which are influenced by the South Equatorial Current originating from between Vanuatu and New Caledonia.

Given the apparent limited impact of the predominant southeastery tradewinds on the majority of the marine debris, it could be postulated that the majority of marine debris removed from the Diamond Islets and Lihou Reef has come from the Vanuatu and New Caledonia regions.

There are also likely further sources from foreign fishing vessels operating to the east of the CSMP and commercial shipping transiting to eastward of the Diamond Islets and Lihou Reef.

From this very limited analysis, a recommended strategy to reduce marine debris loads accumulating on the Diamond Islets and Lihou Reef and indeed throughout the majority of cays, islets and reefs of the CSMP (and the Great Barrier Reef Marine Park) would include educational activities targeting marine debris points of entry in Vanuatu and New Caledonia and commercial vessels, particularly foreign fishing fleets, operating to the east of the CSMP.

Table 3. Marine debris collected from the Diamond Islets and Lihou Reef cays and islets.

Cay / Islet	Total count of marine debris items	Total weight of marine debris Kg	Ranking of most impacted cay/islet to least % percentage of total marine debris
1. Lihou Reef - Lorna Cay (vegetated)	5445	152.10	1 32.78 %
2. Lihou Reef - Dianna Cay	2105	101.75	2 12.67 %
3. Lihou Reef - Observatory Cay	2105	102.40	2 12.67 %
4. Diamond Islet - East (vegetated)	1142	60.45	4 6.87 %
5. Lihou Reef - Edna Cay	1126	154.75	5 6.78 %
6. Diamond Islet - Central (vegetated)	946	77.05	6 5.69 %
7. Lihou Reef - Middle Cay	845	36.35	7 5.08 %
8. Lihou Reef - Juliette Cay	646	83.55	8 3.89 %
9. Lihou Reef - Georgina Cay (vegetated)	502	39.70	9 3.02 %
10. Lihou Reef – South West Cay (vegetated)	423	50.50	10 2.55 %
11. Diamond Islet - West (vegetated)	411	42.05	11 2.47 %
12. Lihou Reef - Betty Cay	254	24.80	12 1.53 %
13. Lihou Reef - Turtle Islet (vegetated)	179	6.90	13 1.08 %
14. Lihou Reef - Kathy Cay	128	41.60	15 0.77 %
15. Lihou Reef - Carol Cay	121	5.50	14 0.73 %
16. Lihou Reef - Hermit Crab Islet (vegetated)	101	9.45	16 0.61 %
17. Diamond Islet - South (vegetated)	90	43.70	17 0.54 %
18. Lihou Reef - Helen Cay	37	7.50	18 0.22 %
19. Lihou Reef - Fanny Cay	4	5.50	-
20. Lihou Reef - Margaret Cay	3	0.10	-
21. Lihou Reef - Phoenix Cay	1	0.01	-
22. Lihou Reef - Little Margaret Cay	0	0	-
23. Lihou Reef - Frankie Cay (awash)	0	0	-
24. Lihou Reef - No Name Cay (submerged)	0	0	-
Total rope/hawser length: 1,099 metres. Combined weight of ropes and FADs		999.45	
Totals	16,613	2,045.05	

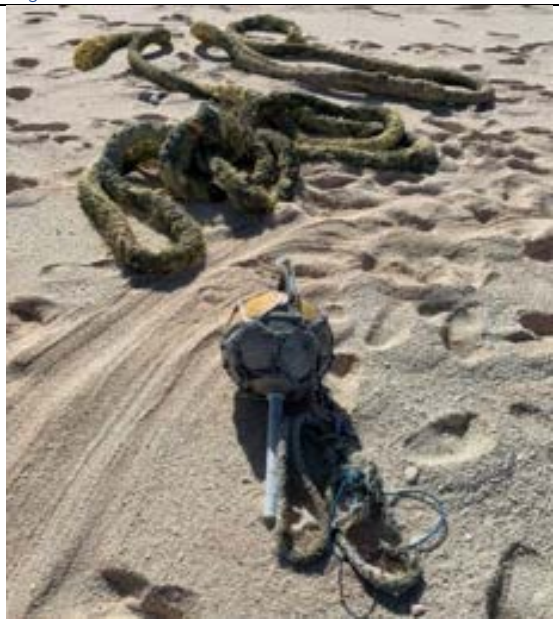
Note: Colour coding has been used to capture quantum leaps in marine debris loads on cays/islets with no colour shading indicating the grouping of lowest marine debris load and **BLACK** shading indicating the grouping of highest marine debris load.

Credit: Andrew McDougall (QPWS)
QPWS Field Ranger Karl Goetze gathering degraded synthetic rope

Credit: Andrew McDougall (QPWS)
A photogenic Hermit crab … when any shell will do

Credit: Teresa Scurrah (PAD)
A fishing FAD (fish aggregating device) made of buoys and netting

Credit: Teresa Scurrah (PAD)
284 metres of abandoned rope on Lorna Cay



Credit: Teresa Scurrah (PAD)
Synthetic shipping hawser (berthing line) and fishing float

Credit: Teresa Scurrah (PAD)
Masked booby surrounded by marine debris

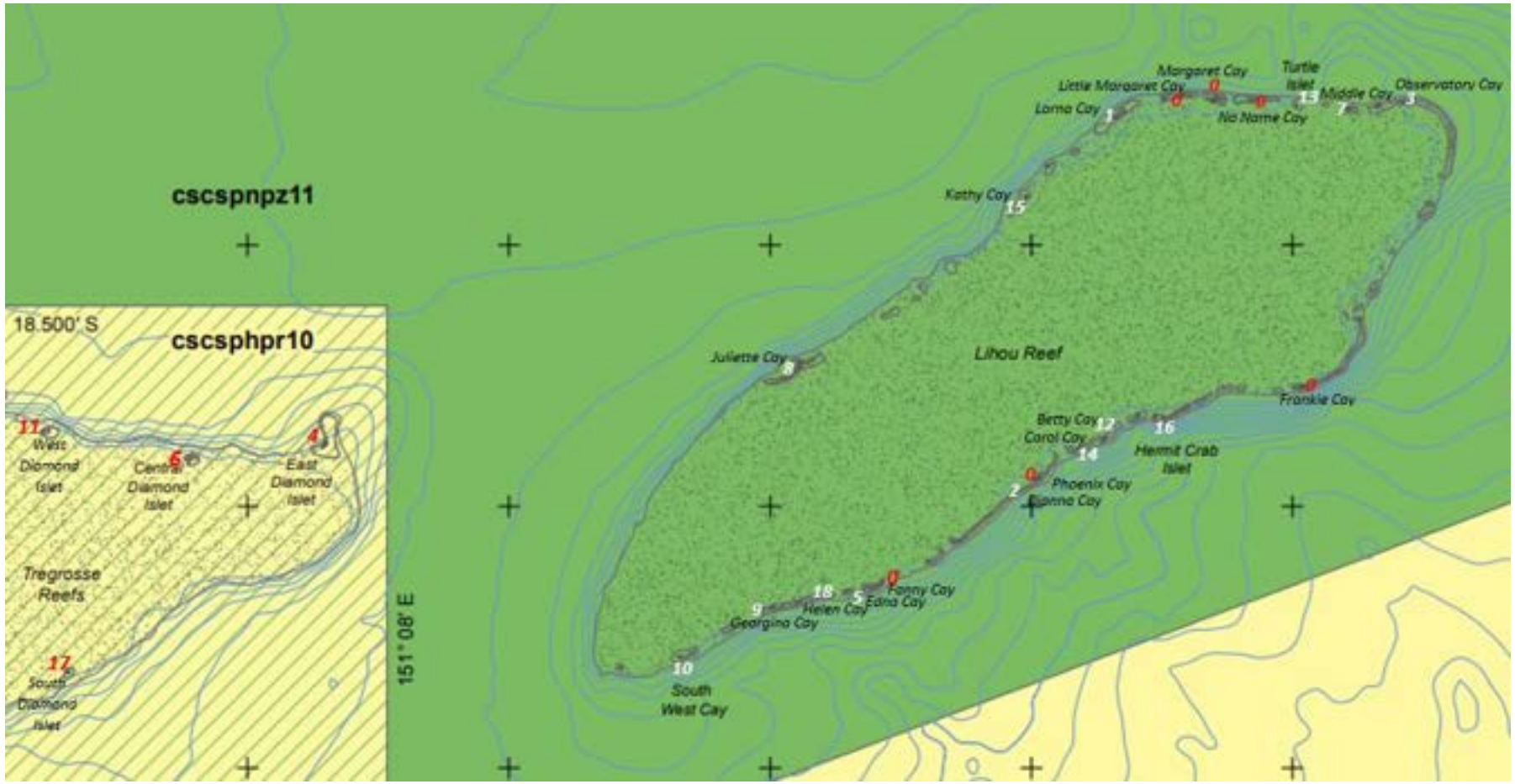


Figure 6. Distribution of marine debris around Diamond Islets and Lihou Reef in numerical order of descending marine debris load by number of items.

Notes:

- The number assigned to each cay/islet indicates the level of marine debris collected and removed from that cay/islet in descending order, with #1 being the highest level of marine debris and #19 being the lowest level of marine debris collected.
- Five cays marked with **0** had negligible or no marine debris on them, specifically: Frankie, Little Margaret, Margaret, No Name and Phoenix cays. Frankie Cay, No Name Cay and Phoenix Cay were or would be submerged at high tide.

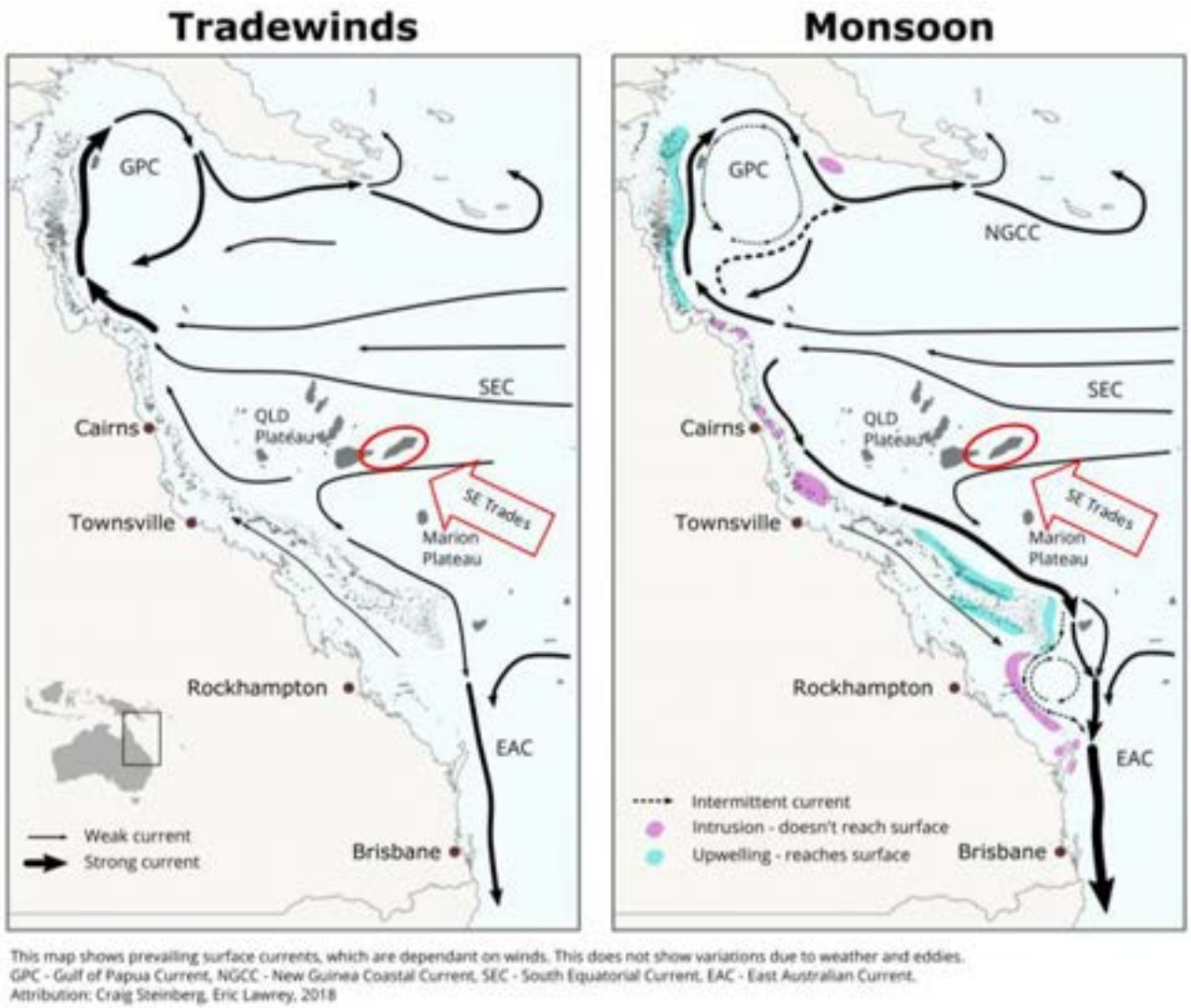


Figure 7. Currents impacting the Coral Sea Marine Park.

Note: The Diamond Islets and Lihou Reef areas are circled in red.

*Table 4. *Plastic bottles collected from the Diamond Islets and Lihou Reef cays and islets.*

***Marine debris more likely to be subject to wind and current and not just current**

Cay / Islet	Total count of plastic bottles	Total count of marine debris items	Plastic bottles as a percentage of total marine debris items
Lihou Reef - Lorna Cay (vegetated)	426	5445	7.82 %
Lihou Reef - Dianna Cay	53	2105	2.52 %
Lihou Reef - Observatory Cay	106	2105	5.03 %
Diamond Islet - East (vegetated)	63	1142	5.52 %
Lihou Reef - Edna Cay	76	1126	6.75 %
Diamond Islet - Central (vegetated)	53	946	5.60 %
Lihou Reef - Middle Cay	24	845	2.84 %
Lihou Reef - Juliette Cay	62	646	9.60 %
Lihou Reef - Georgina Cay (vegetated)	68	502	13.55 %
Lihou Reef – South West Cay (vegetated)	76	423	17.97 %
Diamond Islet - West (vegetated)	55	411	13.38 %
Lihou Reef - Betty Cay	29	254	11.42 %
Lihou Reef - Turtle Islet (vegetated)	28	179	15.64 %
Lihou Reef - Kathy Cay	9	128	7.03 %
Lihou Reef - Carol Cay	1	121	0.82 %
Lihou Reef - Hermit Crab Islet (vegetated)	23	101	22.77 %
Diamond Islet - South (vegetated)	3	90	3.33 %
Lihou Reef - Helen Cay	11	37	29.73 %
Lihou Reef - Fanny Cay	0	4	-
Lihou Reef - Margaret Cay	0	3	-
Lihou Reef - Phoenix Cay	0	1	-
Lihou Reef - Little Margaret Cay	0	0	-
Lihou Reef - Frankie Cay (awash)	0	0	-
Lihou Reef - No Name Cay (submerged)	0	0	-
Unknown Locations	0		0
Totals	**1,166**	**16,613**	**Average 7.02 %**

Note: Colour coding has been used to capture quantum leaps in marine debris loads on cays/islets with no colour shading indicating the grouping of lowest marine debris load (column 3) or lowest percentage of plastic bottles to total debris count (column 4) and **BLACK** shading indicating the grouping of highest marine debris load (column 3) and highest percentage of plastic bottles to total debris count (column 4).

Credit: Martin Russell (PAD)
An assortment of marine debris on the weather coast of Dianna Cay – Lihou Reef

Credit: Martin Russell (PAD)
An assortment of marine debris on the working deck of M.V. Argo halfway through the voyage

Part II: Reefs

Deep reef ROV survey post-trip summary – Gemma Galbraith and Ben Cresswell

Diamond Islets and Lihou Reef Islets and Cays (Coral Sea Marine Park)

July 2021

Coral Sea Islands Health Project

PARKS AUSTRALIA DIVISION – QUEENSLAND DEPARTMENT OF ENVIRONMENT & SCIENCE/QUEENSLAND PARKS & WILDLIFE SERVICE

High coral cover at Juliette Cay, Lihou Reef. 98m

Deep Reef ROV Survey Post-trip Summary

ARC Centre of Excellence for Coral Reef Studies, James Cook University

Prepared by Gemma Galbraith and Ben Cresswell

Background and Objectives

In February 2021 a 21-day voyage in the northern and central Coral Sea Marine Park (CSMP) was undertaken to sample deep reef habitats as part of “Diving into the Deep: the unique habitats of the Coral Sea” (Our Marine Parks Round 2). This project initiated a new survey effort to explore and quantify, for the first time, mesophotic coral reef habitats below the upper 30m. Using a Remotely Operated Vehicle (ROV) to conduct deep reef transects, the project has begun to significantly extend current knowledge of coral reef habitats in the CSMP. This Coral Sea Island Health trip in July 2021, led by Parks Australia was a fantastic opportunity to enhance the deep reef survey effort and collect data at multiple sites around the Diamond Islets and Lihou Reef system.

This post-trip summary is intended to provide an overview of the ROV survey work conducted specifically on the Coral Sea Islands Health Project Voyage. We present some highlights from the ROV footage and share some interesting ecological observations made. Surveys from this trip will be incorporated with the quantitative analysis for Diving into the Deep, Our Marine Parks Grant Round 2. The primary objectives for ROV surveys were:

1. Increase the number of deep (30-100m) ROV surveys conducted in the CSMP.
   To date, there have been very few studies that have quantified mesophotic coral ecosystems (MCEs) in the CSMP. Of these, mesophotic habitat has only been examined in a few locations and these studies have mostly focused on benthic communities only (Englebert et al. 2017; Bridge et al. 2019). To enable comparisons between shallow and deep ecological community surveys by ROV, we also extended ROV survey effort to the 0-30m-depth band. This will also allow for cross-validation with in-situ surveys of shallow reef habitats and further development of the ROV methodology.

2. Survey multiple habitat types across larger spatial scales at individual reefs.
   Many of the reefs in the CSMP are composed of multiple islets and cays that extend over significant spatial scales. The potential for high variability in habitat types makes it likely that one reef possesses multiple ecological systems in relative isolation. Knowledge of different habitat types present at individual reefs in the CSMP not only enhances our baseline biodiversity knowledge but is an important factor when considering recovery potential and ecological resilience to disturbances, such as cyclones and coral bleaching. Surveys conducted on this trip therefore targeted lower mesophotic slopes of exposed windward reefs, deep backreef slopes, lagoonal habitats and isolated bommies/pinnacles. Of particular interest on this trip was the inclusion of surveys specifically looking for seagrass beds in deep lagoons.

3. Field-testing of side mounted benthic image cameras.
   The ROV survey methodology to date has been able to quantify benthic habitat based on broad complexity scales and benthic cover estimates. To enhance the quantity and quality of the data collected on each ROV deployment, two deep-rated (150m) GoPro housings were fitted facing outwards from each side of the ROV unit. We aimed to establish a working methodology for the collection of benthic photos on this trip. This will allow percentage cover estimates of benthic substrate to be made more accurately and should align well with in-situ shallow water benthic surveys.

Methods

ROV Details: Project Specific Modifications

The BlueRobotics BlueROV2 is a consumer-grade Remotely Operated Vehicle (ROV). It is highly adaptable in terms of components and configurations (https://bluerobotics.com/). This has made modifications to suit mesophotic coral ecosystem surveys effective and flexible. On the previous trip in Feb-March 2021 the JCU team trialed a 3D-printed mounting for a stereo-video system. Whilst the main ROV navigational camera is essential for piloting, the addition of two small dive cameras (https://www.paralenz.com/), calibrated in stereo, makes it possible for length estimates to made from video footage collected by the ROV. This system has primarily been implemented to estimate fish lengths that can then be translated to biomass using length-weight equations. The addition of the stereo-video system aligns the ROV survey methodology with in-situ underwater survey methods that estimate fish lengths.

Field-testing of the stereo-video system has yielded good results so far, however, this method is primarily designed to enhance data collected for fish communities and has limitations in terms of surveying the benthos. While broad scale benthic habitat types can be assessed using the stereo-video footage, it is difficult to obtain more accurate percentage cover estimates of benthic cover types using this method. Percentage cover estimates are particularly useful for monitoring changes in community composition over time and also makes datasets more comparable with in-situ data surveys. To address this, the ROV team utilized the opportunity to field-test two side-mounted deep camera housings (https://actionpro.de/?lang=en). The main objectives of this field-test were:

- To assess how the ROV configuration may need to be adjusted to carry the extra load.
- Establish the best camera settings to obtain high resolution, spatially separated, benthic photos.
- Assess the camera housing mounting position.
- Assess suitability of current transect methodology (video) for simultaneously gathering benthic cover still images.

Figure 1 - Side mounted GoPro housing deep-rated to 150m (left) and the Blue Robotics BlueROV unit with 200m tether (right).

Daily Survey Operations

Basic operations for ROV survey required a minimum of three people; one ROV pilot, one ROV tether manager (dual role as scribe) and a tender driver. Sites of interest for survey were initially identified using the recreational sailing app “Navionics” in conjunction with appropriate nautical charts. The team aimed to conduct surveys on steep drop-offs (walls), gently sloping aspects (banks) and lagoon habitats (including isolated bommies). Feasibility to survey depended on daily tide and weather conditions that were often not concurrent between the surface and conditions at depth. This required an adaptable approach to sea conditions and location as well as consideration for broader trip activities.

The requirement for maximum light conditions set ROV operations between 0800-1600 daily. This time period also aligns with accepted methodologies for other remote camera surveys as detailed in the scientific literature (e.g. Baited Remote Underwater Video Stations, Autonomous Underwater Vehicles) (Sward et al. 2019; Langlois et al. 2020). Two dives were conducted on one battery, with a return to the main vessel to change batteries. The aim was to begin each ROV dive between 90-100m deep and conduct 30m transects at steady depth intervals (Fig 3). Transect length is based on timed swims at a known speed, controlled by the ROV pilot. Between 1-3 transects were conducted in each 10m depth interval. With two batteries, the ROV team was able to conduct two dives in the morning and two in the afternoon.

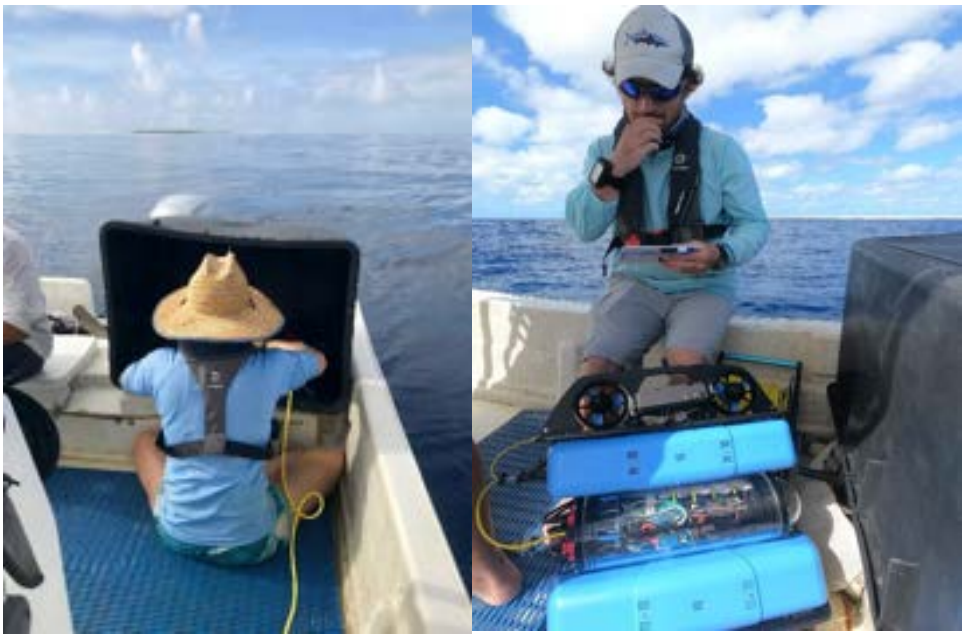


Figure 2 – ROV pilot at work to the stern of the boat (left) and tether/ROV management to the bow (right).

Trip Summary and Notable Highlights

273 transects were conducted at depths between 0-110m across 21 sites at 16 of the visited islands and cays at Diamond Islets and Lihou Reef (Fig 3).

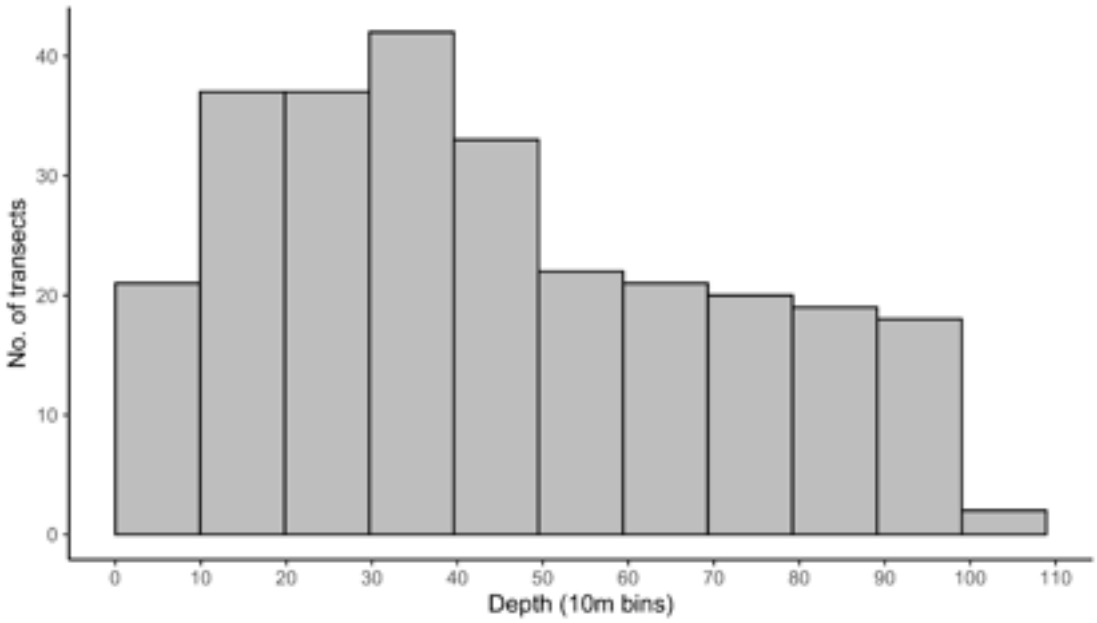


Figure 3 – Histogram of the number of transects conducted in each 10m depth interval (0-10m, 10-20m, 20-30m etc.) during the voyage to Diamond Islets and Lihou Reef, CSMP, July 2021.

These surveys revealed multiple new ecological observations from habitats that have either never been observed or are yet to be scientifically quantified. Additionally, the trial of the new side-mounted benthic cameras proved to be a success and will be incorporated into future survey work. Some highlights from the surveys are listed below in this summary.

Seagrass in mesophotic lagoon habitat

Seagrass was found at two sites at East Diamond Islet in the leeward lagoon (Figs 4 and 5). One survey found a small patch at 42m and another found multiple patches between 33-35m. In both observations, patches were relatively sparse and consisted of short (approximately 5-8cm) paired blade leaves. These patches were also associated with groups of garden eels (*Heterocong or Gardiasa* sp.) and a solitary burrowing blenny species. Given the enhanced clarity of the oligotrophic waters in the lagoons of many Coral Sea islets and cays it is likely that more extensive areas of seagrass are present in the marine park. These may exist at considerable depths (30-60m) at some lagoon locations, rather than shallower sites which likely experience high disturbance by wave and storm action.

Figure 4 – Video still from ROV mounted Paralenz camera. Depth 42m at "Barracuda Bommie", East Diamond Islet, Tregrosse Reefs.

Figure 5 – Close up video still from ROV mounted Paralenz camera. Depth 34.6m at East Diamond Islet, Tregrosse Reefs. The Seagrass monitoring unit at TropWater JCU Cairns has identified the species as *Halophila decipiens.* Garden eels, likely *Heteroconger hassi*, can also be seen in the background.

Mesophotic reefs extend to significant depths along suitable gradients

Extensive areas of Mesophotic Coral Ecosystems (MCEs) were found at both the Diamond Islets and Lihou Reef (Figs 6 and 7). Very high coral cover (80-100%) was observed at several of these sites at considerable depth (70-100+m), as well as other key reef building benthic organisms (e.g. coralline crustose algae). It was noted that the areas of highest coral cover were found on deep slopes (>70m) with relatively gentle gradients (~ <35^{o}). Whilst these MCEs do not initially appear high in scleractinian (i.e., hard coral) diversity, mainly consisting of the genera *Leptoseris, Pachyseris, Montipora,* these observations may yield some expansion of known depth ranges in the Coral Sea. Certainly the high coral cover alone is a remarkable result and if this is a consistent trend across multiple reefs, this would significantly increase the amount of coral reef habitat present in the CSMP.

At sites with wall drop-offs or steep gradients, habitat was mostly characterized by sediment-covered limestone, often with bare patches of rock, sediment ledges and large gorgonian sea fans. Although hard coral cover was low, large individual colonies were still observed at lower mesophotic depths at many sites.

There have been few detailed mesophotic surveys in the Coral Sea (but see Englebert et al. 2017). Preliminary observations from sites at Dimond Islets and Lihou Reef highlight the presence of MCEs on low profile slopes. The ROV surveys conducted on this voyage, in conjunction with primary surveys conducted in Feb 2021, provide further evidence of the extent of MCEs in the CSMP. Formal analysis will provide some of the most detailed data on Coral Sea MCEs to date.

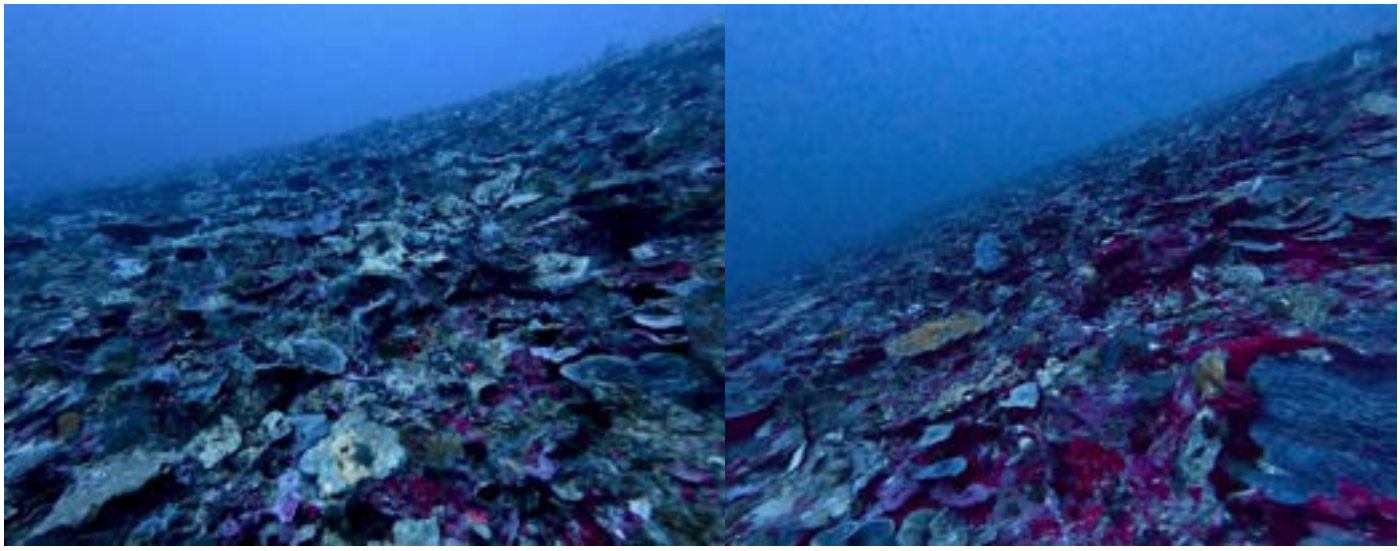


Figure 6 – A mesophotic coral ecosystem (MCE) found at 80-100m on Juliette Cay, Lihou Reef.

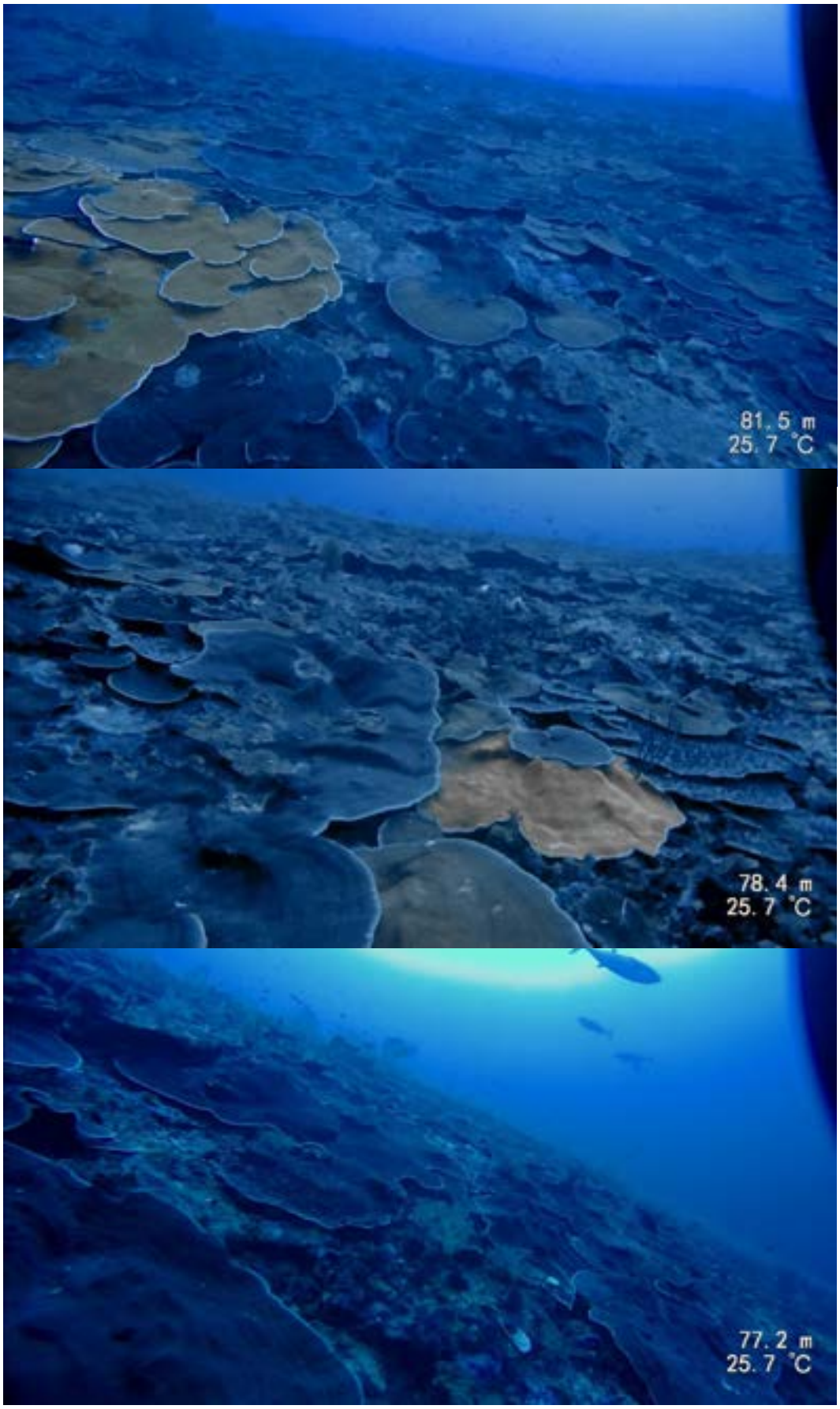


Figure 7 - An extensive MCE was found on a submerged bank at Edna Cay.

Lagoon bommies: high coral cover and abundant fish assemblages

Surveys were conducted around chart-mapped bommies at multiple lagoon sites. Typically, these bommies rose from depths of ~30-50m at the base to within <10m of the surface. Of the bommies surveyed, many were observed to support high fish abundance and were often characterized by high coral cover (~70-80%).

Patch reef bommies are known to be important habitats for fishes, particularly in-lagoons which otherwise typically consist of predominantly sandy, soft or unconsolidated substrate (Sale et al. 1994; Adams et al. 2002). Patch reefs have been well studied by coral reef ecologists primarily because they provide discrete units for experimental manipulation. However, across large reef systems, the combined reef habitat afforded by large, deep lagoon bommies has the potential to significantly increase the total coral reef area. Additionally, coral reef lagoons experience different hydrodynamic regimes compared to exposed outer slopes and sheltered back reefs or flats (Monismith 2007; Green et al. 2018). Diversity and spatial arrangement of these auxiliary coral reef habitats may be important during thermal stress events and also provide stepping-stones for connectivity within and between CSMP reefs.

Figure 8 – Mixed reef fish assemblage at a deep bommie in Middle Cay Lagoon. Depth 25m.

Figure 9 – A pair of *Chaetodon linolatus* and school of *Siganus argenteus* at a deep bommie site at Dianna Cay, Lihou Reef. Depth 30m.

Figure 10 – Large mixed schools of predatory fishes observed at “Barracuda Bommie”, East Diamond Islet. Species included *Caranx sexfaciatus (foreground), Sphryaena qunie, Caranx melampygus* and *Carcharhinus amblyrhynchos***. NOTE**: depth and temperature sensor readings are not calibrated on this dive! Depth 35m.

Fishing line at depth

Fishing line (at mesophotic depths) was observed at two sites at Diamond Islets and Edna Cay, Lihou Reef respectively. Although the high biomass and abundance of sharks in the CSMP suggests that fishing pressure is low (see below references and Hoey et al. 2021) lost fishing gear can cause physical damage to sessile benthic organisms like tissue loss and fragmentation and can also increase the prevalence of disease (Valderrama Ballesteros et al. 2018; Lamb et al. 2020). The extent and possible effects of lost fishing gear and other debris on MCEs and ecological processes in the CSMP is largely unknown. Whilst other marine debris was not readily observed by ROV surveys, these observations highlight that mesophotic coral habitats in the CSMP are not immune from fishing pressure or other potential impacts associated with debris accumulation.

High abundance of sharks

Sharks were observed on every dive conducted by the ROV. Three species were seen on this trip: *Carcharhinus albimarginatus*, *Triaenodon obesus* and *Carcharhinus amblyrhynchos*. Although the ROV video surveys have not yet been formally analysed, the notable high abundance of sharks in deeper reef habitats is consistent with other studies of shallow reef habitats in the CSMP (Ceccarelli et al. 2013; Hoey et al. 2020), and further highlights the unique nature of the reefs in the CSMP.

Figure 11 – A silver tip shark (*Carcharhinus albimarginatus*) with three accompanying remoras (family Echeneidae) at Juliette Cay outer bank. Depth 44m.

Trial of side-facing benthic survey

The trial of the deep-rated T-housings on the ROV was successful. Ballast and thrust gain adjustments were made to the ROV to accommodate the extra weight. GoPro Hero 7 cameras were set on time-lapse mode at a rate of one photo every 10 seconds. Based on the ROV survey speed (0.2 m/s) this attained a still photo of the benthos every 2m along the transect. High-resolution stills were produced from the time-lapse photos that will allow for accurate identification of benthic substrate types (Fig 12). Further improvements to this method include:

- The addition of a scaling reference (e.g. laser pointers) would enable a known field of view to be calculated and size measurements of individual colonies to be made.

- Although light attenuation in The Coral Sea is high even at depths of up to 100m, additional lights would enhance the photo quality.

- One downward facing camera would also be beneficial to allow collection of benthic stills over all gradients encountered on a given transect. The method trialed on this trip was suited well to walls and steeper gradients but does not capture benthic images directly below the ROV.

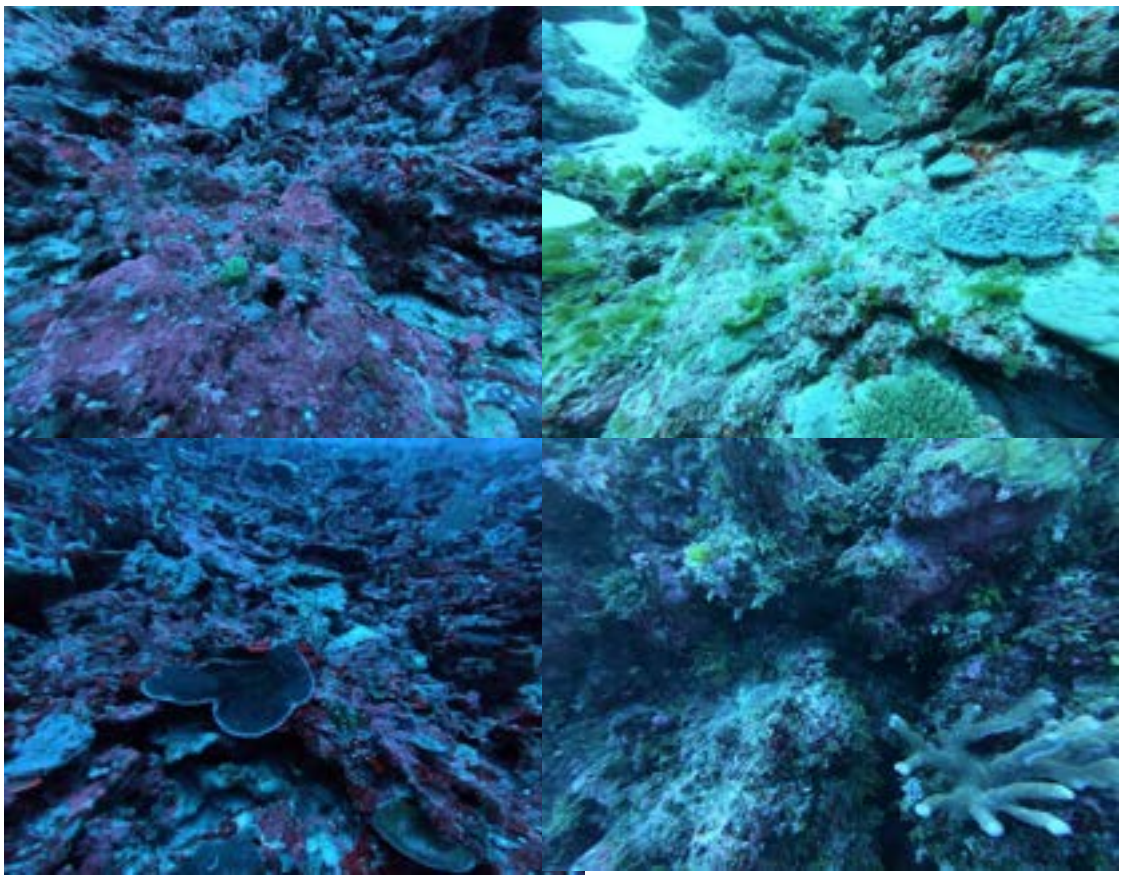


Figure 12 – Example stills taken by side-mounted GoPro time lapse. Images can be further enhanced by post processing photo-editing software.

Dive recovery of ROV and unusual currents

One minor and one major tether entanglement occurred during this trip. The minor entanglement resulted in some damage to the low-drag ROV tether. This was repaired in the field in order for survey work to continue. The major entanglement required diver recovery (conducted by the Argo crew). Further provision will be made on future trips to facilitate diver recovery if at safe working depths.

The unusual currents and water movements observed on several occasions highlight the importance of further knowledge of fine-scale hydrodynamics on CSMP reefs. For example, cold-water upwelling, enhanced flushing and regional circulations have important implications for coral reef thermal stress tolerance, nutrient provision and larval connectivity between reefs (Andrews and Gentian 1982; Koweek et al. 2015; Rogers et al. 2016; Bode et al. 2019). Due to the large spatial scale of reefs such as Lihou, variability in currents and hydrodynamic conditions between sites is likely to be high.

Acknowledgements

We would like to thank Parks Australia for the opportunity to join this voyage, specifically Martin Russell and John Prichard. This trip significantly extended the deep reef surveys already underway and continued the development of ROV survey methodology in the CSMP. Other members of the experienced and hard working team made this trip both highly productive and incredibly memorable. The crew of MV Argo ensured safe passage around the CSMP. The ROV team is particularly indebted to the tender driving skills of Jono Stewart.

This work was conducted as part of Diving into the Deep: the unique habitats of The Coral Sea, an Our Marine Parks Round 2 Project.

References

Adams AJ, John P Ebersole (2002) Use of back-reef and lagoon habitats by coral reef fishes . Mar Ecol Prog Ser 228:213–226

Andrews, J. C. , and Gentian, P. (1982). Upwelling as a source of nutrients for the Great Barrier Reef ecosystems: a solution to Darwin's question. Marine Ecology Progress Series 8, 257–269.

Atkinson, M. J, Kotler, E & Newton, P, 1994, „Effects of Water Velocity on Respiration, Calcification, and Ammonium Uptake of a Porites compressa Community", Pacific Science, vol. 48, pp. 296-303

Bode M, Leis JM, Mason LB, Williamson DH, Harrison HB, Choukroun S, Jones GP (2019) Successful validation of a larval dispersal model using genetic parentage data. PLOS Biol 17:e3000380

Bridge TCL, Beaman RJ, Bongaerts P, Muir PR, Ekins M, Sih T (2019) The Great Barrier Reef and Coral Sea. In: Loya Y., Puglise K.A., Bridge T.C.L. (eds) Mesophotic Coral Ecosystems. Springer International Publishing, Cham, pp 351–367.

Ceccarelli, D.M., McKinnon, A.D., Andrefouet, S., et al. (2013) The coral sea: physical environment, ecosystem status and biodiversity assets. Advances in Marine Biology 66: 213-290.

Englebert N, Bongaerts P, Muir PR, Hay KB, Pichon M, Hoegh-Guldberg O (2017) Lower Mesophotic Coral Communities (60-125 m Depth) of the Northern Great Barrier Reef and Coral Sea. PLoS One 12:e0170336.

Green RH, Lowe RJ, Buckley ML (2018) Hydrodynamics of a Tidally Forced Coral Reef Atoll. J Geophys Res Ocean 123:7084–7101

Hoey A.S. et al. (2020) Coral reef health in the Coral Sea Marine Park. Report on reef surveys April 2018 – March 2020. Report prepared for Parks Australia. Pp. 171.

Hoey AS, Harrison HB, McClure EC, Burn D, Barnett A, Cresswell B, Doll P, Galbraith G, Pratchett MS (2021) Coral Sea Marine Park Coral Reef Health Survey 2021. Report prepared for Parks Australia.

Koweek, D. A., Dunbar, R. B., Monismith, S. G., Mucciarone, D. A., Woodson, C. B., and Samuel, L. (2015). High-resolution physical and biogeochemical variability from a shallow back reef on Ofu, American Samoa: an end-member perspective. Coral Reefs 34, 979–991. doi: 10.1007/s00338-015-1308-9

Lamb JB, Willis BL, Fiorenza EA, Couch CS, Howard R, Rader DN, True JD, Kelly LA, Ahmad A, Jompa J, Harvell CD (2018) Plastic waste associated with disease on coral reefs. Science (80-) 359:460–462

Langlois, T, Goetze, J, Bond, T, et al. A field and video annotation guide for baited remote underwater stereo-video surveys of demersal fish assemblages. Methods Ecol Evol. 2020; 11: 1401– 1409. https://doi.org/10.1111/2041-210X.13470

Monismith SG (2007) Hydrodynamics of Coral Reefs. Annu Rev Fluid Mech 39:37–55

Rogers JS, Monismith SG, Koweek DA, Torres WI, Dunbar RB (2016) Thermodynamics and hydrodynamics in an atoll reef system and their influence on coral cover. Limnol Oceanogr 61:2191–2206

Sale, P.F., Guy, J.A. & Steel, W.J. Ecological structure of assemblages of coral reef fishes on isolated patch reefs. Oecologia 98, 83–99 (1994). https://doi.org/10.1007/BF00326094

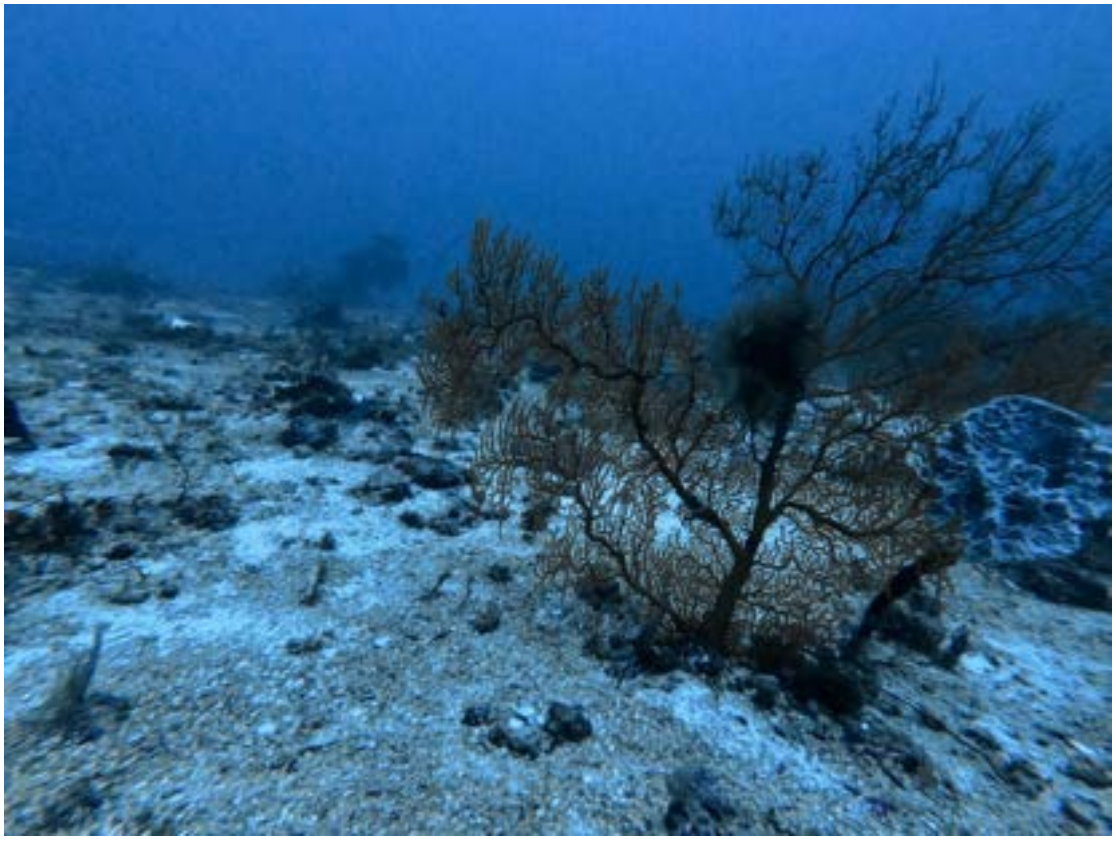
Sward D, Monk J and Barrett N (2019) A Systematic Review of Remotely Operated Vehicle Surveys for Visually Assessing Fish Assemblages. Front. Mar. Sci. 6:134. doi: 10.3389/fmars.2019.00134

Turner JA et al. 2019 Key questions for research and conservation of mesophotic coral ecosystems and temperate mesophotic ecosystems. In Mesophotic coral ecosystems (eds Y Loya, KA Puglise, TCL Bridge), pp. 989–1003. Berlin, Germany: Springer. 15.

Valderrama Ballesteros L, Matthews JL, Hoeksema BW (2018) Pollution and coral damage caused by derelict fishing gear on coral reefs around Koh Tao, Gulf of Thailand. Mar Pollut Bull 135:1107–1116

Additional images

All taken at Juliette Cay, Lihou Reef by side-mounted GoPro cameras. Depths are between 60-100m.



Part III: Islet and cay summaries

Tregrosse Reefs

1. West Diamond Islet (vegetated)
2. Central Diamond Islet (vegetated)
3. East Diamond Islet (vegetated)
4. South Diamond Islet (vegetated)

Lihou Reef

5. South West (Nellie) Cay (vegetated)
6. Georgina Cay (vegetated)
7. Edna Cay
8. Helen Cay
9. Fanny Cay
10. Dianna Cay
11. Carol Cay
12. Phoenix Cay
13. Hermit Crab Islet (vegetated)
14. Betty Cay
15. Frankie Cay
16. Observatory Cay
17. Middle Cay
18. Turtle Islet (vegetated)
19. Margaret Cay
20. Little Margaret Cay
21. Lorna Cay (vegetated)
22. Kathy Cay
23. Unnamed cay near Juliette Cay
24. Juliette Cay

1. West Diamond Islet

Birds

Table 5. Species and breeding effort – West Diamond Islet.

West Diamond Islet Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial Breeding: **Y**es, **P**artial, **N**o
12/07/2021	black noddy				Present	Present	V, Y
12/07/2021	bridled tern				3	8	G, N
12/07/2021	brown booby				42	51	G, N
12/07/2021	buff-banded rail				0	2	G, N
12/07/2021	common noddy				175	196	G, P
12/07/2021	crested tern				0	4	
12/07/2021	great frigatebird				214	191	V, P
12/07/2021	lesser frigatebird				1350	1170	G/V, Y
12/07/2021	masked booby				34	48	G, N
12/07/2021	Pacific golden plover				0	2	
12/07/2021	red-footed booby				612	580	V, P
12/07/2021	red-tailed tropicbird				1	4	G, N
12/07/2021	sooty tern				10870	11560	G, Y
12/07/2021	wandering tattler				0	1	

- Lesser frigatebird – colonies in trees and on-ground. Majority of nests in trees.
- Great frigatebirds breeding with lesser frigatebirds in trees.
- Only one red-tailed tropicbird nest found (Martin Russell). Possibility of others in very low numbers if present.
- Bridled terns present along southern rocky shoreline.
- Most sooty tern counts aided by drone imagery.
- Inactive wedge-tailed shearwater burrows from previous season observed.

Figure 8. Red-footed booby, Sula Adult white morph.

Figure 9. Red-footed booby, Sula. White-tailed dark morph.

Figure 10. Great frigatebird, Fregata minor. Adult female.

Female great frigatebirds showing the blue orbital skin associated with birds of eastern Australia. Note the fly on the bird's head. Further discussion below.

Figure 11. Hippoboscid fly on frigatebird host.

Hippoboscid flies, also known as louse flies or keds are blood sucking, obligate parasites requiring a host to complete their lifecycle. Some hippoboscid flies are specific to an individual species of bird. The flies aren't often visible as they are under feathers extracting blood.

Figure 12. Lesser frigatebird, Fregata ariel. Adult female on ground platform nest.

Lesser frigatebirds will nest on the ground in colonies or colonially in trees. Most lesser frigatebirds on West Diamond Islet nested in trees.

Figure 13. Brown booby, Sula leucogaster. Adult male at nest. Adult females have yellow facial skin and bills.

Vegetation

Cay description

West Diamond Islet, shown in *Figure 15* is located on Tregrosse Reefs at -17.428 degrees latitude and 150.808 degrees longitude. The cay slopes from low dunes on the shoreline to a central plateau. An area of low dunes forms an undulating platform above the level of the shoreline landward of the northwest spit. The total vegetated area is 9.8 hectares.

Figure 14 contains surface elevation profiles of West Diamond Islet.

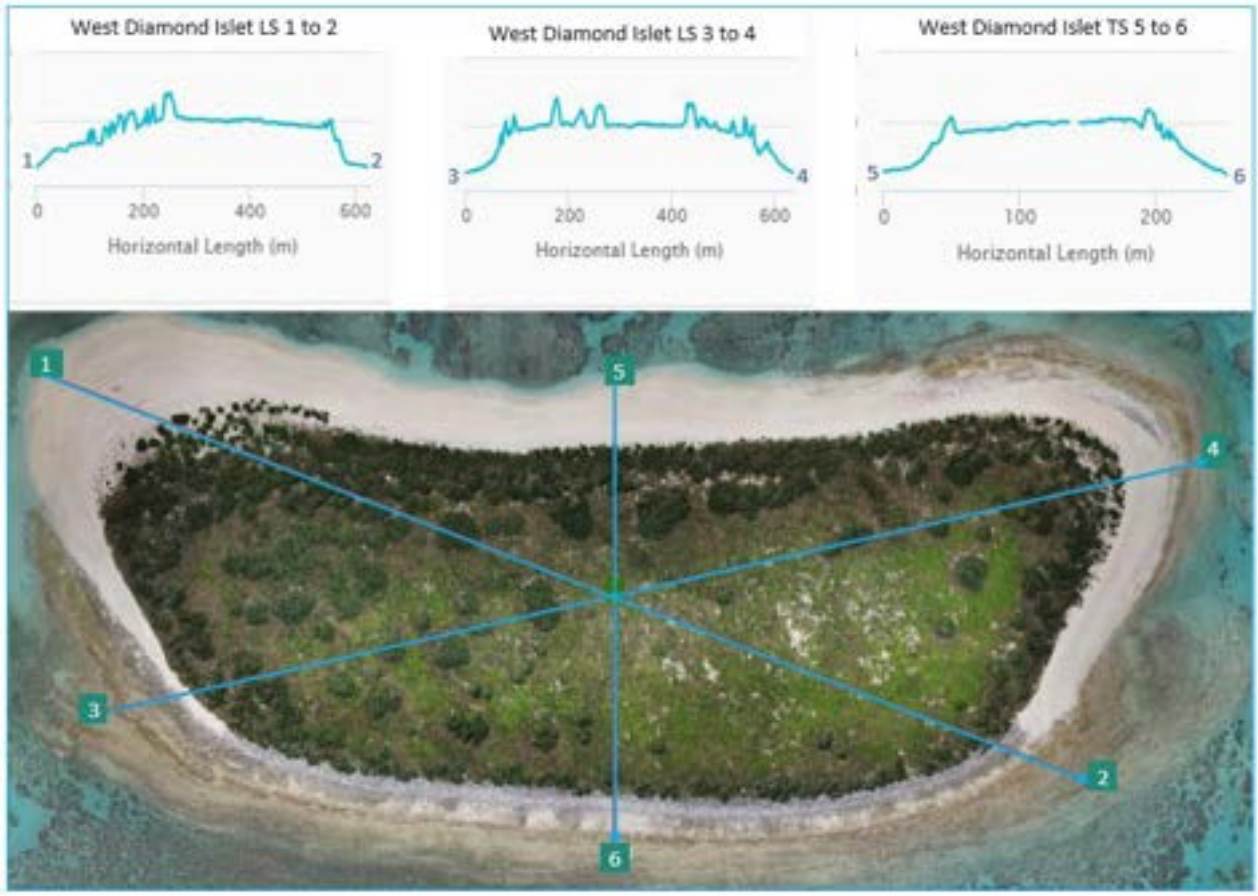


Figure 14. Surface profiles of West Diamond Islet.

Note: Maximum height is approximately six metres above sea level (ASL). Vertical heights and scale are not included in surface profile diagrams as accurate datum information was not available.

Survey intensity

Two people spent six hours surveying the vegetation of West Diamond Island. Vegetation data was recorded at 28 ground-truthing sites and one permanent monitoring site (M05). Locations of these sites are shown in *Figure 15*. The blue lines are the boundaries of the vegetation communities shown on the vegetation map in *Figure 16*.

Figure 15. West Diamond Islet showing the number and location of ground-truthing sites and the permanent monitoring site relative to the vegetation map unit boundaries.

Vegetation condition

The vegetation was in good condition in most sites. An exception was a small patch of *Cordia subcordata* on the southeastern interior of the cay, landward of the coastal *Argusia argentea* shrubland. The *Cordia subcordata* shrubs were heavily infested with scale insects which were tended by ants. Refer to the photo of scale on *Cordia subcordata* in the Health Check for West Diamond Islet.

There was also a small area with dead *Argusia argentea* close to the shoreline of the eastern spit. There was no obvious cause for this. Given its location and the good condition of the vegetation elsewhere on the cay, it was likely caused by saltwater inundation or saltwater infiltration of the root zone.

Floristic data

Twelve plant species were recorded on West Diamond Islet. These are listed in *Table 6* in order of frequency in sites together with the averaged cover for each species for sites in which the species was present and their averaged cover over the entire cay. Data for species cover at each site plus occurrence of each species in relation to vegetation community and landform are contained in *Table 8*.

Table 6. Plant species recorded on West Diamond Islet, 12-13/07/2021.

Layers: (E) = emergent, (S1) =upper shrub, (S2) = lower shrub, (G) = ground

Scientific Name	Common Name	Family	Presence in Sites (% of sites)	Average % Cover Average % Cover in Each Layer (Only sites containing the species were averaged)	Overall Average % Cover in Each Layer – (average includes all sites)
Lepturus repens	stalky grass	Poaceae	88%	59.5% (G)	52.6% (G)
Boerhavia albiflora var. *albiflora*	boerhavia	Nyctaginaceae	77%	8.1(G)	6.3% (G)
Argusia argentea	octopus bush	Boraginaceae	57%	2.5% (E), 33.2% (S1), 2.5 (G)	0.2% (E), 17.9% (S1), 0.1% (G)
Achyranthes aspera	chaff flower	Amaranthaceae	58%	3.3% (G)	1.9% (G)
Tribulus cistoides	bulls head burr	Zygophyllaceae	58%	4.2% (G)	2.4% (G)
Ipomoea violacea	moon flower	Convolvulaceae	54%	5.6% (S1), 19.6% (G)	0.9% (S1), 10.6 (G)
Abutilon albescens	lantern bush	Malvaceae	36%	8.8% (E), 15% (S2), 6.9%(G)	0.7% (E), 1.2% (S2), 2.1% (G)
Portulaca oleracea	pig weed	Portulacaceae	38%	10% (G)	3.8% (G)
Stenotaphrum micranthum	beach buffalo grass	Poaceae	12%	18.3% (G)	2.1% (G)
Cordia subcordata	sea trumpet	Boraginaceae	7%	43.8% (S1)	3.4% (S1)
Plumbago zeylanica	native plumbago	Plumbaginaceae	4% (=one site)	2.5% (G)	0.1% (G)
Ximenia americana	yellow plum	Olacaceae	4% (=one site)	85% (S1)	3.3% (S1)
Total no of species = 12					

West Diamond Islet was the only location that the native species, *Ximenia americana* was recorded during the July 2021 voyage. This species formed a closed scrub community in the northeast of the cay between the coastal *Argusia argentea* shrubland and the interior grassland/herbland communities. *Ximenia americana* has been recorded previously on West Diamond Islet by Keith in 1961 and Walker in 1991. and has been recorded on NE Herald Cay on a number of occasions although it was not recorded in the December 2019 survey of NE Herald. There are also a few patches of *Ximenia* scrub present on Tryon Island in the Capricornia Cays National Park. The distribution of this species is not restricted to cays. The species has a patchy distribution in both coastal and inland sites on the Australian mainland.

The herbaceous summer annual, *Tribulus cistoides* dies back in winter and would have a higher cover during the summer months.

Vegetation communities on West Diamond Islet

Vegetation communities present on West Diamond Islet in July 2021, the area of each and representative survey sites within each vegetation community are listed in *Table 7*. The spatial distribution and extent of the vegetation communities are shown in the vegetation map in *Figure 16.*

The vegetation of the cay consists of vegetation communities dominated by shrubs, grasses, forbs and low vines. No *Pisonia grandis* or other tree communities were present.

Map unit 1a was present along the sandy leeward (northern) shoreline. Seedlings of *Argusia argentea* (octopus bush) were establishing in this unit on the western spit. Map unit 1b was present on the outer margins of the vegetation on rubble banks on the southern shoreline.

Argusia argentea shrublands (map unit 11a) were the predominant vegetation adjacent to the shoreline around the entire cay. The ground layer of this vegetation community was dominated by *Lepturus repens* (stalky grass) with *Portulaca oleracea* (pigweed) present in lower abundance.

Patches of *Lepturus repens* grassland were present adjacent to the shoreline and on slopes at the western end of the cay.

Grasslands co-dominated by the grass, *Lepturus repens* and the vine *Ipomoea violacea* (moonflower) were the most prevalent vegetation on the slopes and central plateau in the interior of the cay. The short -lived shrub *Abutilon albescens* (lantern bush) was also present in this community in lower abundances. The herbaceous species *Boerhavia albiflora* var. *albiflora* (boerhavia), *Achyranthes aspera* (chaff flower) and *Tribulus cistoides* (bulls head burr) were also typically present in low abundance in these communities.

Patches of *Argusia argentea* tall open shrubland (map unit 11b) and *Argusia argentea* shrubland (map unit 11c) on the upper slopes and edges of the central plateau were a feature of the vegetation of West Diamond Islet.

West Diamond Islet had the only *Ximenia americana* (yellow plum) community in the Diamond Islets and Lihou Reef cays, restricted to a small patch in the northeast of the cay.

Photo 47: Argusia argentea establishing in the sandy western spit on West Diamond Islet.

Table 7. Vegetation communities on West Diamond Islet.

Veg Map Unit Code	Vegetation Community	Hectares on West Diamond Islet	ID of Sites on West Diamond Islet
	Unvegetated Areas		
A	Sandy shores	2.7 (approx.)	
B	Lithified shores	2.6 (approx.)	
C	Rubble banks	0.6	
	Shoreline and Sandspit Vegetation		
1a	Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	0.188	nil
1b	Littoral sparse herbland on shoreline rubble banks	0.067	nil
2	*Argusia argentea* open shrubland/isolated shrubs on shorelines and sandy spits	0.360	2, 11, 23, 25
11a	*Argusia argentea* shrubland/ tall shrubland/ open scrub/ closed scrub with a ground layer typically of *Lepturus repens*, *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea* +/- *Achyranthes aspera* +/- *Stenotaphrum micranthum* +/- *Tribulus cistoides*	2.401	1, 8, 12, 15, 24, 26b
	Grasslands and Herblands		
3a	*Lepturus repens* grassland/ closed grassland +/- *Achyranthes aspera* +/- *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	0.534	13
3c	*Lepturus repens*/*Ipomoea violacea* viny grassland/ closed grassland with *Boerhavia albiflora* var. *albiflora*, +/- *Abutilon albescens* +/- *Achyranthes aspera* +/- *Tribulus cistoides*	4.108	5, 6, 14, 16, 17, 18, 20, 26, M05
6a	*Boerhavia albiflora* var. *albiflora* sparse herbland/ open herbland/ herbland with *Portulaca oleracea*	0.008	nil
	Interior Shrublands		
11b	*Argusia argentea* open shrubland /tall open shrubland/open scrub with a ground layer of *Lepturus repens* and *Boerhavia albiflora* var. *albiflora* +/- *Achyranthes aspera* +/- *Ipomoea violacea* +/- *Portulaca oleracea*	1.855	3, 4, 7, 9, 19
11c	*Argusia argentea* shrubland with ground layer of *Lepturus repens*, *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*	0.183	nil
12	*Argusia argentea* shrubland with occasional *Cordia subcordata* and a ground layer dominated by *Lepturus repens*	0.003	22
13	*Cordia subcordata* open shrubland to closed scrub	0.002	21
14	*Ximenia americana* closed scrub	0.049	27a

Note: Areas of sandy shores and rocky shores, particularly those of the rocky shores are only approximate due to the difficulty in determining the location of the boundary between the edge of the shoreline and the surrounding reef flat using the imagery.

Comparison with previous vegetation surveys

Only two plant species (*Canavalia rosea* and *Ximenia americana*) had been previously recorded on West Diamond Islet. These were again recorded in the July 2021 survey. Ten additional species were also recorded in the July 2021 survey. No other previous data was available for West Diamond Islet.

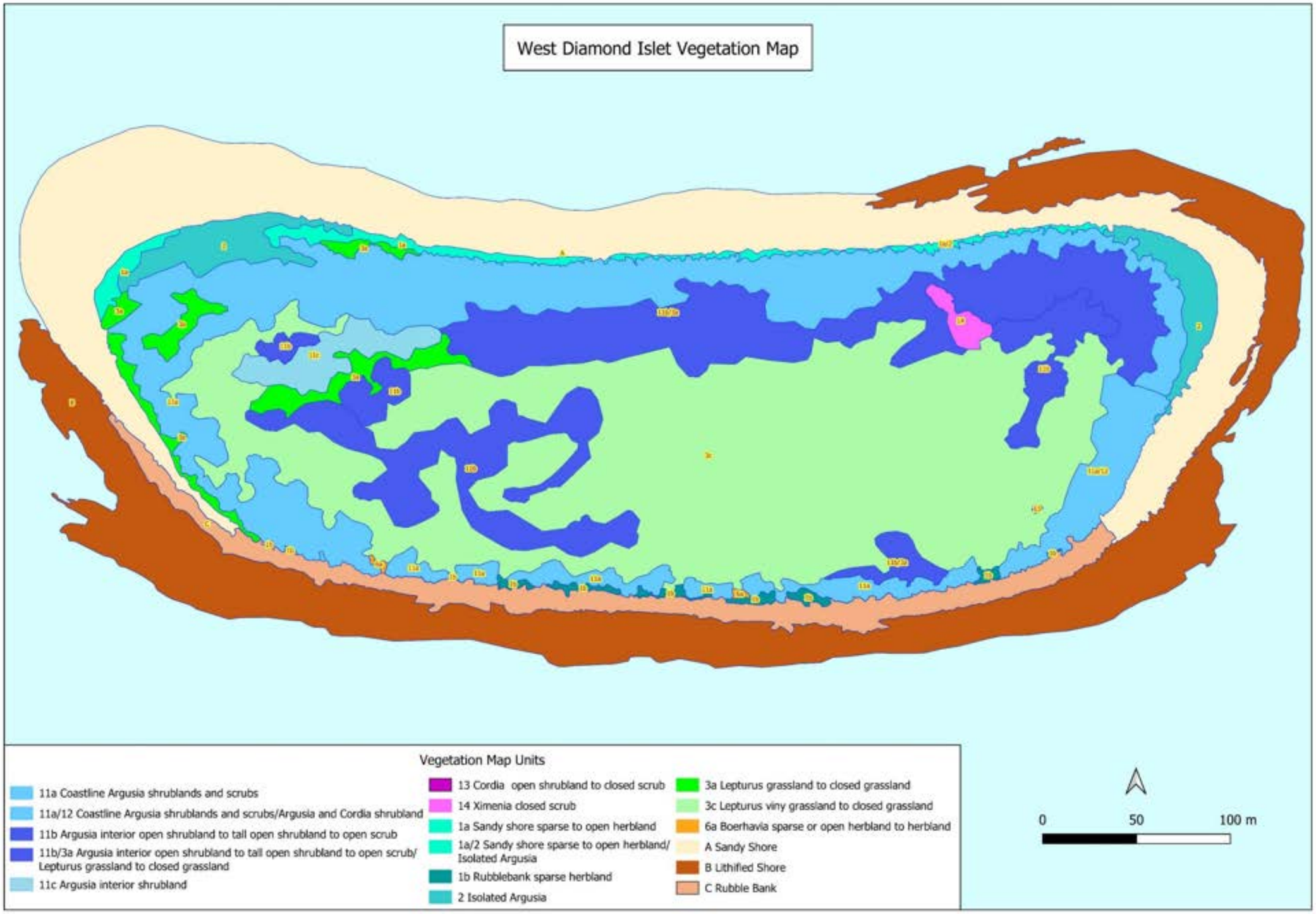


Figure 16. West Diamond Islet vegetation map.

Table 8. Site data recorded at West Diamond Islet.
Datum = WGS 84; green shading = site dominants

Site	Latitude	Longitude	Date	No. of photos	Landform	Veg Map Unit	Vegetation Community	Emergents		Upper Shrub Layer				lower Shrub Layer	Ground Layer										Plant Specimens Collected	Notes
								Abutilon albescens	*Argusia argentea*	*Argusia argentea*	Cordia subcordata	*Ipomoea violacea*	Ximenia americana	*Abutilon albescens*	*Abutilon albescens*	*Achyranthes aspera*	*Argusia argentea*	*Boerhavia albiflora* var. *albiflora*	*Ipomoea violacea*	*Lepturus repens*	*Plumbago zeylanica*	*Portulaca oleracea*	*Stenotaphrum micranthum*	*Tribulus cistoides*		
2	-17.4268	150.806065	12/07/2021	1	Undulating dunes	2	*Argusia argentea* open shrubland with a very sparse ground layer of *Stenotaphrum micranthum*, *Boerhavia albiflora* var. *albiflora*, and *Argusia argentea* seedlings			5-25%							trace-5%	trace-5%					trace-5%			
11	-17.42692	150.805551	12/07/2021	2	Base of the slope	2	*Argusia argentea* dwarf open shrubland with a sparse ground layer dominated by *Stenotaphrum micranthum*			5-25%										trace-5%			5-25%		*Argusia argentea*, *Stenotaphrum micranthum*	
23	-17.42731	150.810702	12/07/2021	2	Immediately adjacent to the shoreline	2	*Argusia argentea* open shrubland with a mid dense ground layer of *Stenotaphrum micranthum* and *Lepturus repens*			5-25%										5-25%			25-50%			
25	-17.42685	150.810555	12/07/2021	1	Adjacent to shoreline	2																				low *Argusia* less than 1 m tall
13	-17.42723	150.805821	12/07/2021	3	lower slope	3a	grassland dominated by *Lepturus repens*, *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*											5-25%		50-75%		5-25%		trace-5%		
5	-17.42756	150.807094	12/07/2021	1	High point of central plateau	3c	closed grassland dominated by *Lepturus repens*, *Ipomoea violacea*, *Boerhavia albiflora* var. *albiflora*, and *Tribulus cistoides*									trace-5%		5-25%	5-25%	50-75%				5-25%		
6	-17.4274	150.808621	12/07/2021	2	Central plateau	3c	closed grassland dominated by *Lepturus repens*, *Ipomoea violacea*, *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*									5-25%		5-25%	5-25%	50-75%				trace-5%		
14	-17.42745	150.805953	12/07/2021	2		3c	closed grassland dominated by *Lepturus repens* and *Ipomoea violacea*								trace-5%			trace-5%	5-25%	75-95%		trace-5%		trace-5%		
16	-17.42777	150.806082	12/07/2021	1	Slope to the W	3c	closed grassland dominated by *Lepturus repens*, *Boerhavia albiflora* var. *albiflora* and *Ipomoea violacea* with occasional emergent *Argusia argentea* and *Abutilon albescens*	trace-5%	trace-5%						trace-5%			5-25%	5-25%	50-75%				trace-5%		
17	-17.42789	150.806384	12/07/2021	2		3c	closed grassland dominated by *Lepturus repens*/ *Ipomoea violacea* and *Boerhavia albiflora* var. *albiflora*								trace-5%	trace-5%		5-25%	5-25%	50-75%						
18	-17.42827	150.807025	12/07/2021	1	Mid slope	3c	closed grassland dominated by *Lepturus repens* and *Ipomoea violacea* with occasional emergent *Abutilon albescens* and *Argusia argentea*	5-25%	trace-5%						trace-5%	trace-5%		trace-5%	25-50%	25-50%				trace-5%		
20	-17.42804	150.809262	12/07/2021	2	Slight slope to SE	3c	closed herbland dominated by *Lepturus repens*, *Ipomoea violacea* and *Abutilon albescens*								25-50%	trace-5%		trace-5%	25-50%	25-50%	trace-5%				*Ipomoea violacea*, *Abutilon albescens*	
26	-17.42703	150.81018	12/07/2021	1	low depression	3c	grassland dominated by *Lepturus repens* and *Ipomoea violacea*								trace-5%	trace-5%		trace-5%	5-25%	50-75%						Pocket of grassland surrounded by *Argusia*
M05	-17.42813	150.808768	13/07/2021	8		3c	closed grassland dominated by *Lepturus repens*, *Boerhavia albiflora* var. *albiflora* and *Ipomoea violacea*								trace-5%	trace-5%		5-25%	5-25%	50-75%				trace-5%		
1	-17.42696	150.806224	12/07/2021	1	Undulating area adjacent to low dunes	11a	*Argusia argentea* tall shrubland with a dense ground layer dominated by *Lepturus repens*, *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea* and *Tribulus cistoides*			25-50%						trace-5%		5-25%		50-75%		5-25%		5-25%	*Tribulus cistoides*, *Portulaca oleracea*, *Boerhavia albiflora* var. *albiflora*	
8	-17.42709	150.807883	12/07/2021	2	Slope	11a	*Argusia argentea* tall shrubland with a dense ground layer dominated by *Lepturus repens* and *Portulaca oleracea*			25-50%						trace-5%				75-95%		5-25%				
12	-17.42725	150.805689	12/07/2021	2	lower slope	11a	*Argusia argentea* tall shrubland with a dense ground layer dominated by *Lepturus repens* and *Portulaca oleracea*			25-50%										50-75%		5-25%		trace-5%		
15	-17.42773	150.805828	12/07/2021	2	lower slopes adjacent to shoreline	11a	*Argusia argentea* tall shrubland with *Abutilon albescens* in the sparse lower shrub layer and a dense ground layer dominated by *Lepturus repens*, *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*			25-50%				5-25%		trace-5%		5-25%		50-75%		5-25%		trace-5%		

Site	Latitude	Longitude	Date	No. of photos	Landform	Veg Map Unit	Vegetation Community	Emergents		Upper Shrub Layer				lower Shrub Layer	Ground Layer											Plant Specimens Collected	Notes
								Abutilon albescens	*Argusia argentea*	*Argusia argentea*	Cordia subcordata	*Ipomoea violacea*	Ximenia americana	*Abutilon albescens*	*Abutilon albescens*	*Achyranthes aspera*	*Argusia argentea*	*Boerhavia albiflora* var. *albiflora*	*Ipomoea violacea*	*Lepturus repens*	*Plumbago zeylanica*	*Portulaca oleracea*	*Stenotaphrum micranthum*	*Tribulus cistoides*		
24	-17.42711	150.810601	12/07/2021	2	Base of slope	11a	*Argusia argentea* shrubland with a mid-dense ground layer dominated by *Boerhavia albiflora* var. *albiflora*, *Lepturus repens* and *Portulaca oleracea*; *Argusia argentea* seedlings present			25-50%							trace-5%	5-25%		5-25%		5-25%		trace-5%		Dead and dying *Argusia* here. ? Salt water inundation
26b	-17.4285	150.807746	13/07/2021	0		11a	*Argusia argentea* shrubland with ground layer dominated by *Lepturus repens* and *Ipomoea violacea*																			Vegetation on the S side adjacent to the shoreline is *Argusia* shrubland with *Lepturus* reopens and *Ipomoea violacea*
3	-17.42706	150.806734	12/07/2021	1	Undulating platform landward of dunes	11b	*Argusia argentea* open scrub with *Ipomoea violacea* present in canopy and a dense ground layer dominated by *Lepturus repens*			50-75%		trace-5%				trace-5%		trace-5%	trace-5%	75-95%				trace-5%	*Achyranthes aspera*, *Lepturus repens*	
4	-17.4272	150.807209	12/07/2021	3	Upper slope	11b	*Argusia argentea* tall open shrubland with *Ipomoea violacea* present in the canopy and a dense ground layer dominated by *Lepturus repens* and *Ipomoea violacea*			5-25%		trace-5%				trace-5%		trace-5%	5-25%	50-75%		trace-5%		trace-5%		
7	-17.42725	150.808138	12/07/2021	2	Top edge of slope to central plateau	11b	*Argusia argentea* tall open shrubland with *Ipomoea violacea* present in the canopy and a dense ground layer dominated by *Lepturus repens*			5-25%		trace-5%			trace-5%	trace-5%		trace-5%	trace-5%	75-95%				trace-5%		
9	-17.42688	150.809644	12/07/2021	2	lower slopes	11b	*Argusia argentea* open scrub with a dense ground layer dominated by *Lepturus repens*			50-75%						trace-5%		trace-5%		75-95%		trace-5%				
19	-17.42784	150.8071	12/07/2021	2	Upper slope on the edge of the plateau	11b	*Argusia argentea* tall open shrubland with *Abutilon albescens* in the sparse lower shrub layer and a dense ground layer dominated by *Lepturus repens* and *Ipomoea violacea*			5-25%				5-25%		trace-5%		trace-5%	5-25%	50-75%				trace-5%	*Ipomoea violacea*, *Abutilon albescens*	*Argusia* Approximately 5.5 m tall
22	-17.4277	150.810305	12/07/2021	2	lower slope adjacent to shoreline	12	*Argusia argentea* shrubland with occasional Cordia subcordata and *Ipomoea violacea* in the canopy and a dense ground layer dominated by *Lepturus repens* and *Ipomoea violacea*			50-75%	trace-5%	5-25%						trace-5%	5-25%	50-75%		trace-5%				*Argusia* is lower here around 2 m
21	-17.42811	150.809907	12/07/2021	0		13	Cordia subcordata closed scrub				75-95%														Cordia subcordata	Small patch of Cordia. Egging scale tended by ants on Cordia
27a	-17.42706	150.809475	13/07/2021	6		14	Ximenia americana closed scrub						75-95%												Ximenia americana	GPS 0030 to 0041 delineates a patch of Ximenia americana- closed dense impenetrable shrubland approximately 3m tall.

Permanent monitoring site data

One permanent monitoring site (M05) was established and surveyed on West Diamond Islet. The location of the centre transect of this site is shown as the red line in *Figure 15*. *Table 9* contains the data recorded at this site. The photographs included with the data in this section are four of the 10 site photographs. These are taken from the centre point of the site in four different directions (facing 0, 90, 180 and 270 degrees from the transect bearing respectively).

Table 9. BioCondition attribute data recorded in the permanent monitoring site on West Diamond Islet.

Site M05	
Vegetation Community Description	Closed grassland dominated by *Lepturus repens, Boerhavia albiflora* var. *albiflora* and *Ipomoea violacea*
Transect start (WGS 84)	-17.428198 150.808531
Transect centre (WGS84)	-17.42813 150.808768
Transect end (WGS 84)	-17.428094 150.808999
Transect bearing	70^0
Median canopy height (range)	0.5 (0.2 to 0.8)m
Tree canopy cover %	n/a
Shrub canopy cover %	n/a
Basal area m^2/ha (at 30 cm height, calculated from stem diameters)	nil
Total number of large trees/ha	nil
Total no of trees per ha	nil
Total number of tree stems/ha	nil
Total no. shrubs/ha	nil
Total no. shrub stems/ha	nil
Large shrubs - mean diameter at 30 cm height	n/a
Recruitment of ecologically dominant layer (%)	n/a
Tree species richness	0
Tree species present	n/a
Shrub species richness	0
Shrub species present (layer in brackets)	*Abutilon albescens* (G)
Median ground layer height (range)	G= canopy
Total ground layer cover of native cay species (%)	97.6%
Grass species richness	1
Grass cover (%)	58.6%
Grass species present in order of decreasing cover - most abundant first (cover in brackets)	*Lepturus repens* (58.6%)
Forb (including vines) species richness	4
Forb species cover (%)	36.2%
Forb species present in order of decreasing cover - most abundant first (Cover in Brackets)	*Boerhavia albiflora var. albiflora* (20%), *Ipomoea violacea* (16.2%), *Achyranthes aspera (<0.2%), Tribulus cistoides (<0.2%)*
Native shrub ground cover (%)- *Abutilon albescens*	2.8%
Non-native plant cover (all strata) (%)	0%
Litter cover (%)	0%
Bare ground (%)	2.4%
Woody debris (m/ha of Logs >0.5m long and >10cm wide)	Nil
Soil pH	8.61(0-10cm), 8.85(10-20cm), 8.89 (20-30cm)

Photo 48: Monitoring site M05, West Diamond Islet facing E.

Photo 49: Monitoring site M05, West Diamond Islet facing S.

Photo 50: Monitoring site M05, West Diamond Islet facing W.

Photo 51: Monitoring site M05, West Diamond Islet facing N.

Soils data

Soil on and adjacent to the shoreline was coarse white sand +/- small coral rubble fragments.

The interior soils are predominantly coarse light-coloured sand with varying amounts of litter content. In some places soils are brown with more organic content.

The table in Appendix 11 contains the results of the analysis of soil samples collected from monitoring site M05 during the vegetation survey. Refer to the general Vegetation Results and discussion for further discussion on the soil analyses results.

The closed grassland (M05) had the lowest levels of soil magnesium of all the permanent monitoring sites on the Diamond Islets and Lihou Reef cays. Levels of trace elements were relatively high at this site compared with the other permanent monitoring sites on the Diamond Islets.

Figure 17. West Diamond Islet - Health check, rodent tunnel and ant bait station monitoring sites.

Health checks

West Diamond Islet						
Ecosystems and biodiversity	**Health Checks**					
Value - Coral cay communities (Communities present listed below)	**Veg map unit**	Dominant Sub-dominant Remaining veg (ha)		Photomonitoring: N - North photo E - East photo S - South photo W - West photo		**Overall condition class**[1]
Shoreline and sandspit vegetation						
Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	1a	0.188				
Littoral sparse herbland on shoreline rubble banks	1b	0.067				
Isolated plants of *Argusia argentea*	2	HC5E	HC9			G
Grasslands and Herblands						
Grassland communities dominated by *Lepturus repens*	3a	HC1W	HC7			G
	3b					G
	3c	HC2	HC3	HC4		G
Shrublands						
Argusia argentea shrubland communities	11a	HC1	HC5	HC6	HC8	G
	11b	1.855				
	11c	0.183				
Argusia argentea shrubland with occasional *Cordia subcordata*	12	0.003				
Cordia subcordata open shrubland to closed scrub	13	0.002				SC
Ximenia americana closed scrub	14	0.049				
Habitats and species						
Value - Seabird and shorebird habitat						G
Value -Turtle rookery (Green turtle *Chelonia mydas)*						G

[1]Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

Results

11 Health Checks were undertaken on West Diamond Islet to assess the condition of shoreline, grassland and shrubland communities. These Health Checks assessed the condition of four vegetation communities.

The overall condition rating for each of the vegetation communities was Good however there was Significant Concern for a small patch of *Cordia subcordata* which was heavily infested by scale tended by ants. For further detail refer Vegetation, West Diamond Islet, Vegetation condition. It was evident that West Diamond Islet had received good rainfall as the vegetation on the cay was consistently lush, green with high plant biomass and coverage.

Photo: Scale detected on Cordia subcordata (with vine Ipomoea violacea climbing the stem).

A. Overall vegetation condition

*Photo: Looking west along the lush band of **11a** Argusia argentea shrubland/ tall shrubland/ closed scrub on the northern side of West Diamond Islet.*

*Photo: View looking from the beach at Rodent tunnel 11 towards the cay interior showing healthy **11a** Argusia argentea shrubland/ tall shrubland/ closed scrub.*

*Photo: Looking in a northwest direction across the cay interior from Rodent tunnel 13 with **3c** Lepturus repens/Ipomoea violacea viny grassland/ closed grassland/ closed herbland with Boerhavia albiflora var. albiflora, +/- Abutilon albescens, Achyranthes aspera, Tribulus cistoides.*

*Photo: Looking north from Rodent tunnel 15 with **11b** Argusia argentea open shrubland /tall open shrubland/open scrub on the RHS of photo and **3c** Lepturus repens/Ipomoea violacea viny grassland/ closed grassland/ closed herbland with Boerhavia albiflora var. albiflora, +/- Abutilon albescens, Achyranthes aspera, Tribulus cistoides on the LHS of photo.*

B. Health Check photo monitoring - sample photo of each vegetation type

*Photo: HC9 **2** Isolated plants of Argusia argentea.*

*Photo: HC7 **3a** Lepturus repens grassland/closed grassland +/- Achyranthes aspera, Boerhavia albiflora var. albiflora, Portulaca oleracea.*

*Photo: HC4 **3c** Lepturus repens/Ipomoea violacea viny grassland/ closed grassland/ closed herbland with Boerhavia albiflora var. albiflora, +/- Abutilon albescens, Achyranthes aspera, Tribulus cistoides.*

*Photo: HC8 **11a** Argusia argentea shrubland/tall shrubland/closed scrub.*

Introduced pests

A. Rodents

Table 10. Rodent tunnel monitoring – West Diamond Islet.

West Diamond Islet			
No. of rodent tunnels	Date deployed	Date collected	Evidence of rodents (tracks, droppings)
15[1]	12/7/21	13/7/21	Nil

[1] Refer *Figure 17*.

B. Ants and other invertebrates

Table 11. Invertebrate species summary - West Diamond Islet.

West Diamond Islet					
Specimen no.	Date	Site	Specimen	Identification	Native / introduced
1	12/7/21	RT 2 & 3	Ants	*Nylanderia 'obscura'*[1]	Native
2	12/7/21	RT1	Ants	*Nylanderia 'obscura'*	Native
3	12/7/21	NA	Scale	TBA	TBA
4	12/7/21	RT 3 & 4	Ants	*Nylanderia 'obscura'*	Native
5	13/7/21	RT 13 & 14	Ants	*Nylanderia 'obscura'*	Native
6	13/7/21	NA	Ants	*Nylanderia 'obscura'*	Native
7	13/7/21	RT11	Ants	*Nylanderia 'obscura'*	Native

[1] There is a species of *Nylanderia* that was present in samples from three islands - South Diamond, Central Diamond and West Diamond Islets. This species is believed to be native to the mainland and is most likely *Nylanderia obscura*. However, this is a difficult genus of ants and not been revised for Australia so this identification is tentative, hence the quotation marks around the species name (Chris Burwell 2021 pers. comm.)

2. Central Diamond Islet

Birds

Table 12. Species and breeding effort - Central Diamond Islet.

Central Diamond Islet Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
13/07/2021	black noddy				0	P	
13/07/2021	brown booby				5	5	G,N
13/07/2021	buff-banded rail				0	2	
13/07/2021	common noddy				P	P	G,P
13/07/2021	crested tern				0	10	
13/07/2021	great frigatebird				33	30	V,P
13/07/2021	Herald petrel				*3	4	*See below entry
13/07/2021	masked booby				5	6	G,N
13/07/2021	red-footed booby				322	303	V,P
13/07/2021	red-tailed tropicbird				43	33	G,N
13/07/2021	sooty tern				5340	5460	G,Y
15/07/2021	Herald petrel				3	6	G, 3 bonded pairs.

Figure 18. Herald petrel, Pterodroma heraldica. Adult preparing to land for the evening.

Figure 19. Herald petrel, Pterodroma heraldica. Adult during evening display.

Figure 20. Central Diamond Islet. Herald petrel activity on windward corner of islet.

Herald petrels (see *Figure 18* and *Figure 19*) were observed late afternoon on 13 and 15 July 2021. The birds displayed typical breeding season behaviour by pairing up before landing and swooping low over the island. One bird was observed emerging from low *Argusia* bushes surrounded by thick grasses.

An attempt to find an active nest was unsuccessful due to the limited search time. Birds were heard calling as they are known to do over their breeding areas. A poor-quality recording was made as I was leaving the islet.

These bonded pairs represent a new and second breeding site for this species in Australia, after Raine Island in the northern Great Barrier Reef Marine Park. Most petrel activity was focussed on the south-east corner of the cay (see *Figure 20*). Both the island aspect used and the timing of breeding is similar to Raine Island.

There was a dearth of nesting activity by any species through the middle of the islet. See Vegetation (Central Diamond Islet) for details on species composition. Central Diamond Islet may have suited Herald petrels due to the lack of competition and disturbance with other species.

An unidentified bird call was heard while I was in the middle of the islet. I could not determine the location of the call or which species was responsible for it.

Sooty terns nested within a strip up to 90m inland from the outside edge of the vegetation.

Red-tailed tropicbirds nested on the eastern and northern vegetated edges of the islet.

Vegetation

Cay description

Central Diamond Islet is located on Tregrosse Reefs at -17.453 degrees latitude and 150.944 degrees longitude. There is a slight depression in the SW interior. It was the largest vegetated cay visited during the July 2021 survey with a total vegetated area of 10.9 hectares, just slightly larger than East Diamond Islet (10.4 hectares). The size and shape of the cay is shown in *Figure 23.*

Figure 21 contains surface elevation profiles of Central Diamond Islet.

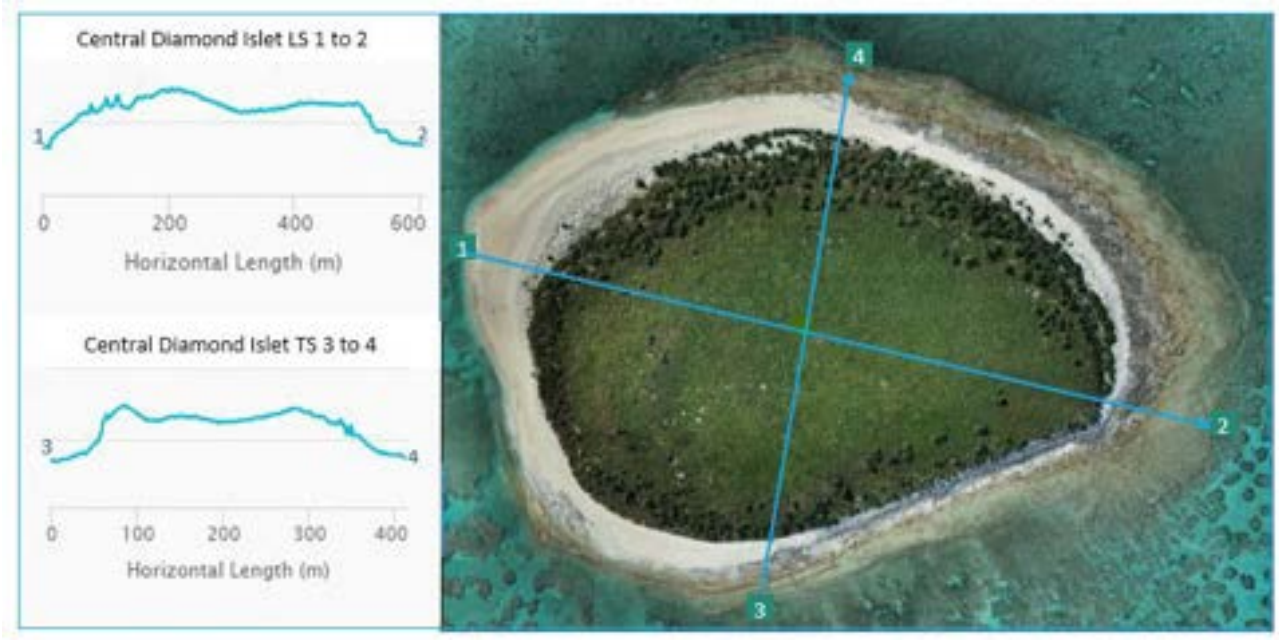


Figure 21. Surface profiles of Central Diamond Islet.

Note: Maximum height is approximately eight metres ASL. Vertical heights and scale are not included in the surface profile diagram as accurate datum information was not available.

Survey intensity

Three and a half hours was spent surveying the vegetation of Central Diamond Island. Vegetation data was recorded at 13 ground-truthing sites. The locations of these sites are shown in *Figure 22*. The blue lines are the boundaries of the vegetation communities shown on the vegetation map in *Figure 23*.

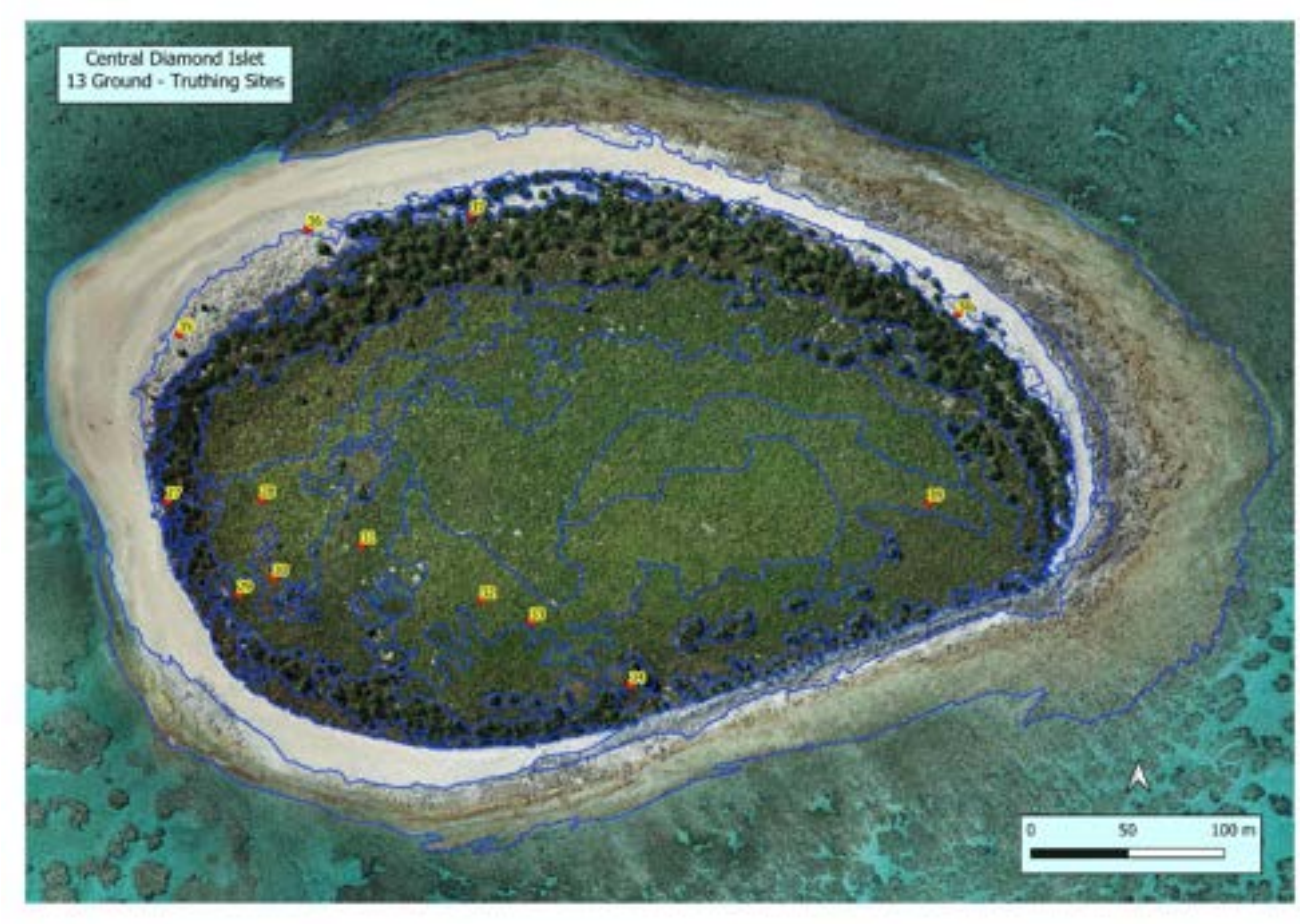


Figure 22. Central Diamond Islet showing the number and location of ground-truthing sites relative to the vegetation map unit boundaries.

Vegetation condition

The vegetation on the cay was all in good condition.

Floristic data

Eleven plant species were recorded on Central Diamond Islet. These are listed in *Table 13* in order of frequency in sites together with the averaged cover for each species for sites in which the species was present and their averaged cover over the entire cay. Data for species cover at each site plus occurrence of each species in relation to vegetation community and landform are contained in *Table 15.*

Table 13. Plant species recorded on Central Diamond Islet, 13/07/2021

Layers: (E) = emergent, (S1) = upper shrub, (S2) = lower shrub, (G) = ground

Species	Common Name	Family	Presence in Sites (% of sites)	Average % Cover in Each Layer - (only sites containing the species averaged)	Overall Average % Cover in Each Layer – (average includes all sites)
Lepturus repens	stalky grass	Poaceae	100%	33.8% (G)	33.8% (G)
Achyranthes aspera	chaff flower	Amaranthaceae	77%	11% (G)	8.5% (G)
Canavalia rosea	coastal jack bean	Fabaceae	62%	7.2% (G)	4.4% (G)
Plumbago zeylanica	native plumbago	Plumbaginaceae	62%	22.2% (G)	13.7% (G)
Boerhavia albiflora var. *albiflora*	boerhavia	Nyctaginaceae	54%	2.5% (G)	1.3% (G)
Argusia argentea	octopus bush	Boraginaceae	46%	2.5% (E), 20.6% (S1), 2.5 (G)	0.2% (E), 6.3% (S1), 0.6% (G)
Abutilon albescens	lantern bush	Malvaceae	38%	5% (G)	1.9% (G)
Portulaca oleracea	pig weed	Portulacaceae	31%	2.5% (G)	0.8% (G)
Stenotaphrum micranthum	beach buffalo grass	Poaceae	31%	2.5% (G)	0.8% (G)
Ipomoea violacea	moon flower	Convolvulaceae	8%	62.5% (G)	4.8% (G)
Tribulus cistoides	bulls head burr	Zygophyllaceae	8%	2.5% (G)	0.2% (G)
Total no of species = 11					

Vegetation communities on Central Diamond Islet

Vegetation communities present on Central Diamond Islet in July 2021, the area of each and representative survey sites within each vegetation community are listed in *Table 14*. The spatial distribution and extent of the vegetation communities on Central Diamond Islet in July 2021 are shown in the vegetation map in *Figure 23*.

The vegetation of the cay consisted of vegetation communities dominated by shrubs, grasses, forbs and low vines. No *Pisonia grandis* or other tree communities were present on the cay.

Map unit 1a was present on the seaward edge of the vegetation along the sandy leeward (northern) shoreline. The vegetation in this unit consisted of sparse or isolated establishing plants of predominantly *Stenotaphrum micranthum* (beach buffalo grass) and *Lepturus repens* (stalky grass). There was recruitment of *Argusia argentea* (octopus bush) seedlings in site 36 on the northwestern shoreline and in site 38 on the northeastern shoreline in this community,

Argusia argentea shrublands (map unit 11a) and *Lepturus repens* grasslands (map unit 3a) dominated the shoreline vegetation.

The abundance of the perennial herb, *Plumbago zeylanica* (native plumbago) was a feature of the interior vegetation of Central Diamond Islet, either as a dominant, forming a *Plumbago zeylanica* herbland (map unit 7) or as a component of *Lepturus repens/Achyranthes aspera* mixed grassland/herbland communities (map units 3d and 8c) which dominated much of the interior vegetation. *Canavalia rosea* (coastal jack bean) was also present in all these communities.

Ipomoea violacea (moon flower) was also present in the interior vegetation and dominated a mixed herbland (map unit 9) composed of the same species as the other communities in the cay interior at site 33 and other locations

Table 14. Vegetation communities on Central Diamond Islet.

Veg Map Unit Code	Vegetation Community	Hectares on Central Diamond Islet	ID of Sites on Central Diamond Islet
	Unvegetated Areas		
A	Sandy shores	2.7 (approx.)	
B	Lithified shores	5.1 (approx.)	
C	Rubble banks	0.4	
	Shoreline and Sandspit Vegetation		
1a	Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	0.544	35, 36
1b	Littoral sparse herbland on shoreline rubble banks	0.005	nil
2	*Argusia argentea* open shrubland/isolated shrubs on shorelines and sandy spits	0.045	37, 38
11a	*Argusia argentea* shrubland/ tall shrubland/ open scrub/ closed scrub with a ground layer typically of *Lepturus repens*, *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea* +/- *Achyranthes aspera* +/- *Stenotaphrum micranthum* +/- *Tribulus cistoides*	2.031	27, 34
	Grasslands and Herblands		
3a	*Lepturus repens* grassland/ closed grassland +/- *Achyranthes aspera* +/- *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	0.821	nil
3d	*Lepturus repens* closed grassland with *Achyranthes aspera*, *Canavalia rosea* +/- *Abutilon albescens*, +/- *Plumbago zeylanica*	2.718	29, 30, 31
7	*Plumbago zeylanica*/ mixed closed herbland/dwarf shrubland with *Achyranthes aspera*, *Lepturus repens*, +/- *Abutilon albescens* +/- *Canavalia rosea*	1.804	28, 32
8c	*Achyranthes aspera* mixed herbland/closed herbland with *Lepturus repens* and *Plumbago zeylanica* +/- *Abutilon albescens* +/- *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	2.300	39
9	*Ipomoea violacea*/ *Achyranthes aspera*/ *Lepturus repens* closed vineland with *Canavalia rosea* and *Plumbago zeylanica*	0.248	33
10	*Ipomoea pes-caprae* vineland with *Lepturus repens*, *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*		
	Interior Shrublands		
11b	*Argusia argentea* open shrubland /tall open shrubland/open scrub with a ground layer of *Lepturus repens* and *Boerhavia albiflora* var. *albiflora* +/- *Achyranthes aspera* +/- *Ipomoea violacea* +/- *Portulaca oleracea*	0.270	nil
11c	*Argusia argentea* shrubland with ground layer of *Lepturus repens*, *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*	0.071	nil

Note: Areas of sandy shores and rocky shores, particularly those of the rocky shores are only approximate due to the difficulty in determining the location of the boundary between the edge of the shoreline and the surrounding reef flat using the imagery.

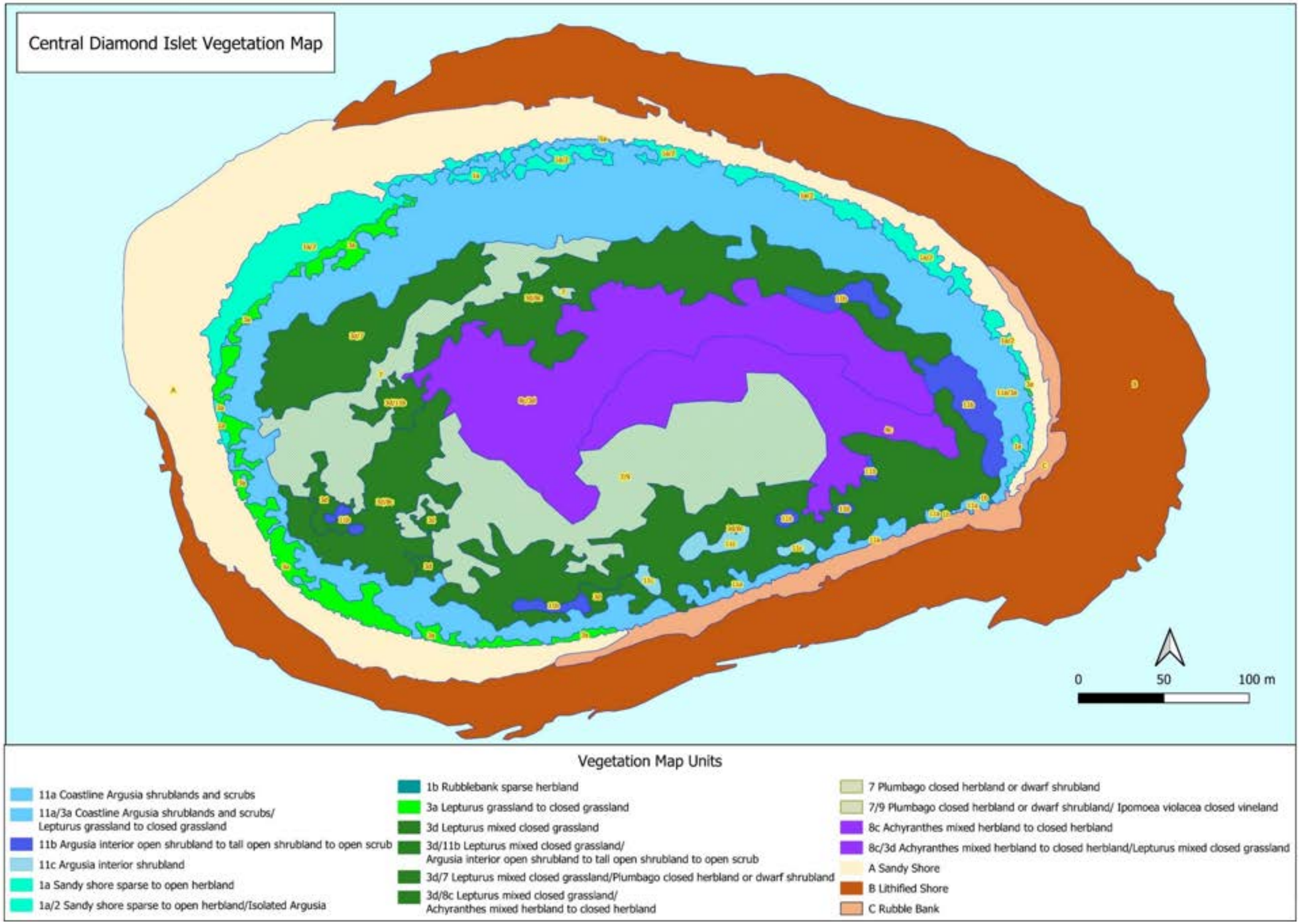


Figure 23. Central Diamond Islet vegetation map.

Table 15. Site data recorded on Central Diamond Islet.

Datum = WGS 84; Green shading = site dominants

Site	Latitude	Longitude	Date	No. of photos	Landform	Veg Map Unit	Vegetation Community	Emergents	Upper Shrub Layer	Ground Layer										Plant Specimens Collected	Notes
								Argusia argentea	*Argusia argentea*	*Abutilon albescens*	*Achyranthes aspera*	*Argusia argentea*	*Boerhavia albiflora* var. *albiflora*	*Canavalia rosea*	*Ipomoea violacea*	*Lepturus repens*	*Plumbago zeylanica*	*Portulaca oleracea*	*Stenotaphrum micranthum*	*Tribulus cistoides*		
35	-17.45282	150.9424	13/07/2021	1		1a	Sparse grassland dominated by *Lepturus repens* and *Stenotaphrum micranthum*; *Argusia argentea* seedlings present with emergent *Argusia argentea*	trace-5%				trace-5%				trace-5%			trace-5%		*Stenotaphrum micranthum*	*Argusia* seedlings
36	-17.45233	150.943	13/07/2021	0		1a	Sparse grassland dominated by *Lepturus repens* and *Stenotaphrum micranthum*; *Argusia argentea* seedlings present					trace-5%				trace-5%			trace-5%			*Argusia* seedling recruitment; gps taken from edge of the vegetation
37	-17.45226	150.94376	13/07/2021	2	Dunes between beach and shore	2	*Argusia argentea* Open Shrubland with a sparse ground layer dominated by *Lepturus repens*		5-25%				trace-5%			5-25%			trace-5%			
38	-17.45272	150.94602	13/07/2021	3		2	*Argusia argentea* open shrubland with a very sparse ground layer of *Stenotaphrum micranthum*, *Achyranthes aspera*, *Lepturus repens* and *Argusia argentea* seedlings		5-25%		trace-5%	trace-5%				trace-5%			trace-5%			*Argusia*= 0.5 to 2m: lots of recruitment of *Argusia*
29	-17.45402	150.94268	13/07/2021	2	lower slope to W	3d	closed grassland dominated by *Lepturus repens*, *Plumbago zeylanica* and *Canavalia rosea*			trace-5%	trace-5%		trace-5%	5-25%		50-75%	5-25%	trace-5%		trace-5%	*Tribulus cistoides*	
30	-17.45395	150.94284	13/07/2021	1	Ridge top	3d	closed grassland dominated by *Lepturus repens*, *Achyranthes aspera* and *Plumbago zeylanica*				5-25%			trace-5%		50-75%	5-25%					More *Lepturus* here
31	-17.4538	150.94325	13/07/2021	2	Depression	3d	closed grassland dominated by *Lepturus repens*, *Achyranthes aspera* and *Plumbago zeylanica*			trace-5%	5-25%			trace-5%		50-75%	5-25%	trace-5%				
28	-17.45358	150.94278	13/07/2021	2	Gentle slope to the NW	7	closed herbland dominated by *Plumbago zeylanica*, *Lepturus repens* and *Canavalia rosea*			5-25%	trace-5%		trace-5%	5-25%		5-25%	50-75%	trace-5%			*Abutilon albescens*, *Canavalia rosea*, *Plumbago zeylanica*, *Portulaca oleracea*	
32	-17.45405	150.94381	13/07/2021	3	Depression	7	herbland dominated by *Plumbago zeylanica*/ *Lepturus repens*/ *Canavalia rosea*/ *Achyranthes aspera*				5-25%			5-25%		5-25%	25-50%					
39	-17.4536	150.94589	13/07/2021	2	Flat plateau	8c	closed herbland dominated by *Achyranthes aspera*, *Lepturus repens* and *Plumbago zeylanica*			trace-5%	25-50%		trace-5%	trace-5%		5-25%	5-25%					
33	-17.45415	150.94404	13/07/2021	2	Depression	9	mixed closed herbland dominated by *Ipomoea violacea*, *Achyranthes aspera*, *Lepturus repens* and *Plumbago zeylanica*				5-25%		trace-5%	trace-5%	50-75%	5-25%	5-25%				*Ipomoea violacea*, *Boerhavia albiflora*, *Achyranthes aspera*	
27	-17.45359	150.94235	13/07/2021	2	Dunes adjacent to the shoreline	11a	*Argusia argentea* shrubland with a dense ground layer dominated by *Lepturus repens*		25-50%		trace-5%		trace-5%			75-95%					*Argusia argentea*, *Lepturus repens*	
34	-17.45445	150.9445	13/07/2021	2	Slope to the beach	11a	*Argusia argentea* Tall shrubland with a dense ground layer dominated by *Lepturus repens*		5-25%	trace-5%	trace-5%		trace-5%	trace-5%		75-95%	trace-5%	trace-5%				

Comparison with previous vegetation surveys

No previous vegetation survey data is available for Central Diamond Islet.

Permanent monitoring site data

No permanent monitoring sites were established on Central Diamond Islet.

Soils data

The soil on and adjacent to the shoreline was coarse white sand.

On the slopes and plateau the sand was generally light-coloured sand with some organic content of leaf litter in places.

The surface soil in the depression in the southwest interior is brown sandy soil with high organic content.

No soil samples were collected for analyses on Central Diamond Islet.

Figure 24. Central Diamond Islet - Health check, rodent tunnel and ant bait station monitoring sites.

Health checks

Central Diamond Islet						
Ecosystems and biodiversity	**Health Checks**					
Value - Coral cay communities (Communities present listed below)	**Veg map unit**	Dominant Sub-dominant Remaining veg (ha)		Photomonitoring: N - North photo E - East photo S - South photo W - West photo		**Overall condition class**[1]
Shoreline and sandspit vegetation						
Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	1a	HC16NW				G
Littoral sparse herbland on shoreline rubble banks	1b	0.005				
Isolated plants of *Argusia argentea*	2	0.045				
Grasslands and Herblands						
Grassland communities dominated by *Lepturus repens*	3a	HC10	HC15	HC16ES		G
	3d	HC11NSW	HC12NE	HC13ESW	HC14	G
Herbland communities dominated by *Plumbago zeylanica*	7	HC11E	HC12NE			G
Herbland communities dominated by *Achyranthes aspera*	8c	HC12SW	HC13ESW	HC14	HC14SW	G
Herbland communities dominated by *Ipomoea violacea*	9	0.248				
Shrublands						
Argusia argentea shrubland communities	11a	HC10	HC15	HC16ES		G
	11b	HC13N				G
	11c	0.071				
Habitats and species						
Value - Seabird and shorebird habitat						G
Value -Turtle rookery (Green turtle *Chelonia mydas)*						G

[1]Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

Results

Seven Health Checks were undertaken on Central Diamond Islet to assess the condition of shoreline, grassland, herbland and shrubland communities. Health Checks assessed the condition of seven vegetation communities. The overall condition rating for each of the vegetation communities was Good. As mentioned it was evident that the Diamond Islets had received good rainfall as the vegetation on all cays was consistently lush, green with high plant biomass, height and coverage.

A. Overall vegetation condition

*Photo: Northeast corner of cay on the windward side showing revegetation by grasses and small Argusia after plants destroyed by turtle nesting activity (**1a** Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines). Note vegetation now supports habitat for sooty tern colony.*

*Photo: Northwestern spit of cay with **1a** Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines and **2** Isolated plants of Argusia argentea.*

*Photo: Central Diamond Islet supported healthy communities of **11a** Argusia argentea shrubland/ tall shrubland/ closed scrub along its shorelines providing important seabird habitat and buffer for vegetation communities in the cay interior. Photo taken facing northwest from the northeast corner of the cay.*

*Photo: Good plant biomass, height and coverage on the windward side of the cay (**3d** Lepturus repens closed grassland with Achyranthes aspera, Canavalia rosea +/- Abutilon albescens, Plumbago zeylanica). Photo taken facing west from HC13.*

*Photo: Lush green growth was found throughout the cay interior. Photo facing east from HC12 with a view of **7** Plumbago zeylanica/ mixed closed herbland with Lepturus repens, Canavalia rosea, Achyranthes aspera +/- Abutilon albescens.*

Photo: View of lush vegetation in the cay interior. Photo taken from HC14 looking westwards across ***8c*** *Achyranthes aspera mixed herbland/closed herbland with Lepturus repens and Plumbago zeylanica +/- Abutilon albescens, Boerhavia albiflora var. albiflora, Portulaca oleracea.*

Photo: View of almost the entire length of Central Diamond on slightly elevated ground at the western end ***7*** *Plumbago zeylanica/ mixed closed herbland with Lepturus repens, Canavalia rosea, Achyranthes aspera +/- Abutilon albescens. Photo taken from HC11 facing northeast.*

*Photo: Close view of vegetation showing high plant biomass, height and coverage at HC11 (**3d** Lepturus repens closed grassland with Achyranthes aspera, Canavalia rosea +/- Abutilon albescens, Plumbago zeylanica).*

B. Health Check photo monitoring - sample photo of each vegetation type

*Photo: HC16 **1a** Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines.*

*Photo: HC10 **3a** Lepturus repens grassland/ closed grassland +/- Achyranthes aspera, Boerhavia albiflora var. albiflora, Portulaca oleracea (Sub-dominant).*

*Photo: HC11 **3d** Lepturus repens closed grassland with Achyranthes aspera, Canavalia rosea +/- Abutilon albescens, Plumbago zeylanica.*

Photo: HC11 7 Plumbago zeylanica/ mixed closed herbland with Lepturus repens, Canavalia rosea, Achyranthes aspera +/- Abutilon albescens.

Photo: HC14 8c Achyranthes aspera mixed herbland/closed herbland with Lepturus repens and Plumbago zeylanica +/- Abutilon albescens, Boerhavia albiflora var. albiflora, Portulaca oleracea (Sub-dominant).

Photo: HC15 11a Argusia argentea shrubland/ tall shrubland/ closed scrub.

Photo: HC13 ***11b*** *Argusia argentea open shrubland /tall open shrubland/open scrub.*

Introduced pests

A. Rodents

Table 16. Rodent tunnel monitoring - Central Diamond Islet.

Central Diamond Islet			
No. of rodent tunnels	Date deployed	Date collected	Evidence of rodents (tracks, droppings)
10[1]	13/7/21	13/7/21	Nil

[1] Refer *Figure 24*.

B. Ants and other invertebrates

Table 17. Invertebrate species summary - Central Diamond Islet.

Central Diamond Islet					
Specimen no.	Date	Site	Specimen	Identification	Native / introduced
8	13/7/21	NA	Ants	*Nylanderia 'obscura'*[1]	Native
9	13/7/21	NA	Fly	TBA	TBA
10	13/7/21	RT12	Fly	TBA	TBA
11	13/7/21	RT2	Ants	*Nylanderia 'obscura'*	Native
12	13/7/21	RT 10 & 11	Ants	*Nylanderia 'obscura'*	Native
13	13/7/21	RT5	Ants (ginger coloured)	*Monomorium pharaonis*[2]	Introduced (Africa)

[1] There is a species of *Nylanderia* that was present in samples from three islands - South Diamond, Central Diamond and West Diamond Islets. This species is believed to be native to the mainland and is most likely *Nylanderia obscura*. However, this is a difficult genus of ants and not been revised for Australia so this identification is tentative, hence the quotation marks around the species name (Chris Burwell 2021 pers. comm.)

[2] *Monomorium pharoanis* was recorded on three of the six islands surveyed in the Coringa-Herald islets and cays in 2019 and was the most common and abundant ant species found (Hemson *et al*. 2020). In 2019 these were new species record for CSMP having previously been recorded as *Monomorium* sp. (Smith *et. al*. 2004). Although exotic to Australia, the ant has most likely been on the CSMP cays for a long time as it is an 'old world' species and has been in Queensland since early European settlement (Chris Burwell, pers. comm.). The species is a known symbiont and the abundance and monospecificity of the ants found at SW Coringa Islet indicates that *M. pharaonis* was almost certainly the ant species associated with *P. urbicola* and the subsequent loss of the *Pisonia* forest on that island.

Monomorium pharaonis is essentially world-wide in distribution, and is well known as a household, hospital and store pest capable of nesting within buildings and ships. On the islets and cays of the Tregrosse and Lihou Reefs where there is no *Pisonia* the potential problem of *M. pharoanis* is more likely to be of a human nuisance due to their sting. Of note *M. pharoanis* have polygynous colonies (nests contain more than one productive queen) so colonies can be prolific hence the scale of potential ecological impact and or human nuisance can be widespread (Chris Burwell 2021 pers. comm.).

3. East Diamond Islet

Birds

Table 18. Species and breeding effort - East Diamond Islet.

East Diamond Islet Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
15/07/2021	black noddy				215	197	V,Y
15/07/2021	black-naped tern				0	21	
15/07/2021	brown booby				13	39	G,N
15/07/2021	common noddy				P	P	G,P
15/07/2021	crested tern				4	29	G,Y
15/07/2021	great frigatebird				54	62	V,P
15/07/2021	lesser frigatebird				1234	1098	V,Y
15/07/2021	masked booby				33	31	G,N
15/07/2021	red-footed booby				133	305	G/V,Y
15/07/2021	red-tailed tropicbird				19	9	G,N
15/07/2021	ruddy turnstone				0	3	
15/07/2021	sooty tern				12870	12990	G,Y

Figure 25. Black-naped terns, Sterna sumatrana (foreground), mixed with crested terns, Thallaseus bergii (background).

Figure 26. Masked booby, Sula dactylatra. Adolescent.

Figure 27. Sooty tern, Onychoprion fuscatus. Young with unusual brown colour morph.

Figure 28. Sooty tern. Onychoprion fuscatus. Young, typical colour morph.

Figure 29. Red-tailed tropicbird, Phaethon rubricauda. Chick with attached tick.

Lesser frigatebirds nesting on the ground were difficult to detect. Nest level was lower than vegetation level so locating them meant you were nearly on top of the nest. Drone imagery is a much better way to determine nest numbers for this species in this situation.

Black-naped terns (see *Figure 25*) roosting on the beach spit showed evidence of a breeding flush through their plumage. No nests were located.

Vegetation

Cay description

East Diamond Islet is located on Tregrosse Reefs at -17.441 degrees latitude and 151.075 degrees longitude. The cay has a total vegetated area of 10.4 hectares.

Figure 30 contains surface elevation profiles of East Diamond Islet.

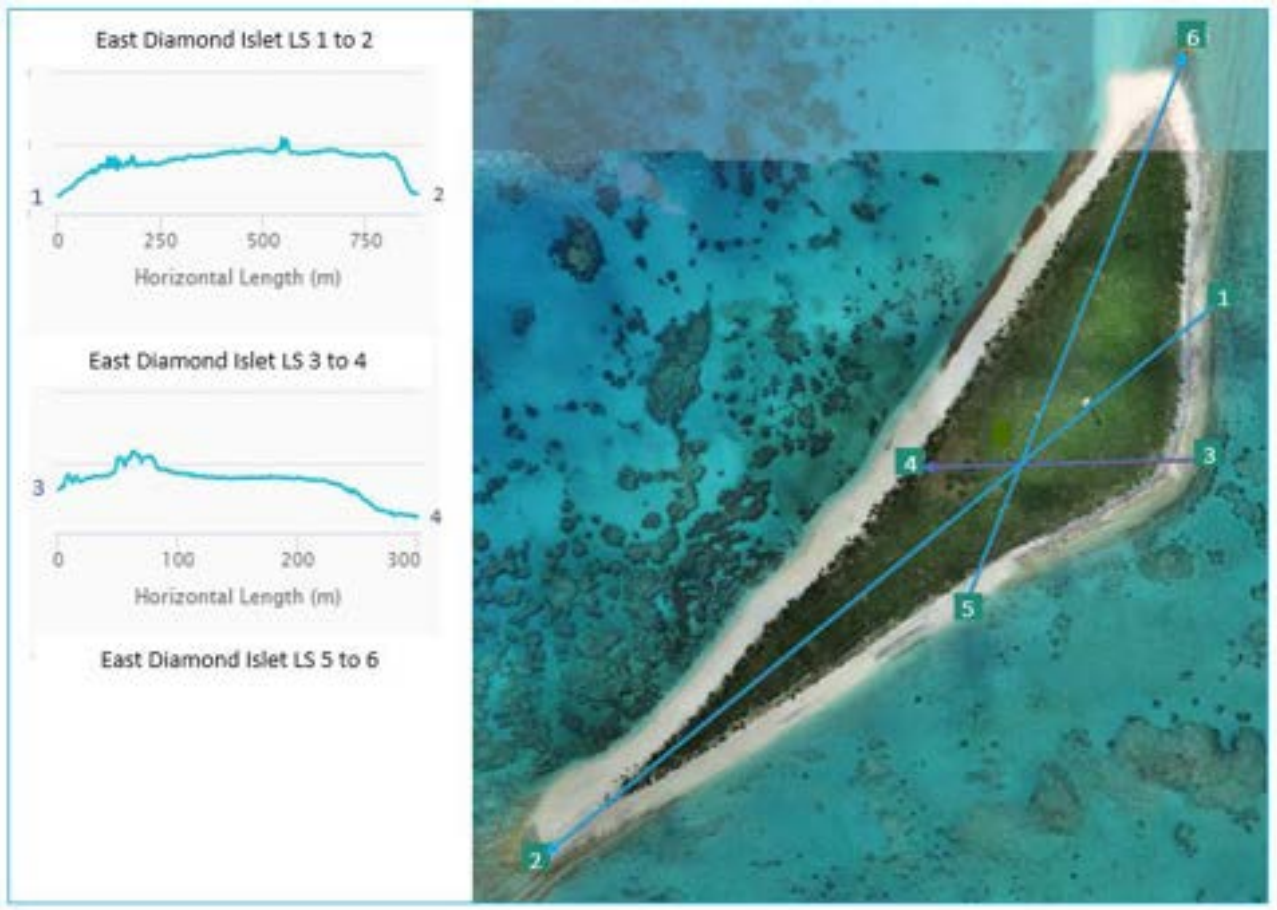


Figure 30: Surface profiles of East Diamond Islet.

Note: Maximum height is approximately eight metres ASL. Vertical heights and scale are not included in the surface profile diagram as accurate datum information was not available.

Survey intensity

Eleven and a half hours were spent surveying the vegetation of East Diamond Islet. Vegetation data was recorded at 25 ground-truthing sites and three permanent monitoring sites (M06, M07, M08). The locations of these sites are shown in *Figure 31*. The blue lines are the boundaries of the vegetation communities shown on the vegetation map in *Figure 32*.

Figure 31. East Diamond Islet showing the number and location of ground-truthing sites and permanent monitoring sites relative to the vegetation map unit boundaries.

Vegetation condition

Dieback was present in the *Cordia subcordata* patches in the central interior of East Diamond Islet. There were numerous dead *Cordia* plants in these patches. Other vegetation communities on the cay were healthy with no death or dieback recorded. Dieback was also reported on North East Herald, South West Coringa, Chilcott and South East Magdelaine cays by Hemson et al. in the 2019 survey with swaths of fallen, dead and dying *Cordia subcordata* on these cays. It was suggested in the report (Hemson et al., 2020) that the *Cordia* may have been blown or washed over by a storm surge from a tropical cyclone, possibly cyclone Yasi. The location of the dead *Cordia* on East Diamond Islet was close to the highest point on the island, well above the range of tidal surges. The site is, however, very exposed to strong winds. Hemson et al. also suggested that insect attack may be responsible or partly responsible for the dieback. Freebairn (2007) also observed defoliation of *Cordia subcordata* on NE Herald and reported on a number of insect species he observed that may be responsible including giant grasshoppers (*Valanga* sp.) similar to those present on Turtle Islet during the July 2021 survey. These were not observed on East Diamond Islet during our visit.

Photo 48: Dead Cordia subcordata at site 49 on East Diamond Islet.

Other vegetation on East Diamond was in good condition.

There is a navigation light tower in the interior of the cay. The tower also has a RACON radar beacon. Regular access for routine maintenance is a potential biosecurity risk to the cay via inadvertent introduction of weeds or insect pests. Although there was no evidence of weeds or other impacts of human activity in the vicinity of the tower or elsewhere on the cay at the time of the July 2021 vegetation survey, implementation of appropriate biosecurity protocols should remain an ongoing high priority.

Photo 49: Light tower on East Diamond Islet.
Photo by Martin Russell

Floristic data

Fifteen plant species were recorded on East Diamond Islet. This is the highest species richness of all the cays visited during the July 2021 voyage. Species recorded on East Diamond Islet are listed in *Table 19* in order of frequency in sites together with the averaged cover for each species for sites in which the species was present and their averaged cover over the entire cay. Data for species cover at each site plus occurrence of each species in relation to vegetation community and landform are contained in *Table 21*.

Table 19. Plant species recorded on East Diamond Islet, 14-15/07/2021

Layers: (E) = emergent, (S1) = upper shrub, (S2) = lower shrub, (G) = ground

Species	Common Name	Family	Presence in Sites (% of sites)	Average % Cover in Each Layer (Only sites containing the species were averaged)	Overall Average % Cover in Each Layer – (average includes all sites)
Boerhavia albiflora var. *albiflora*	boerhavia	Nyctaginaceae	89%	13.3% (G)	11.9% (G)
Lepturus repens	stalky grass	Poaceae	86%	28.4% (G)	24.4% (G)
Achyranthes aspera	chaff flower	Amaranthaceae	82%	17.5% (G)	14.4% (G)
Tribulus cistoides	bulls head burr	Zygophyllaceae	71%	4.4% (G)	3.1% (G)
Portulaca oleracea	pig weed	Portulacaceae	54%	4.2% (G)	2.2% (G)
Stenotaphrum micranthum	beach buffalo grass	Poaceae	46%	11.7% (G)	5.4% (G)
Canavalia rosea	coastal jack bean	Fabaceae	36%	19.3% (G)	6.9% (G)
Argusia argentea	octopus bush	Boraginaceae	36%	2.5% (E), 56.7% (S1), 2.5% (G)	0.1% (E), 18.2% (S1), 0.1% (G)
Abutilon albescens	lantern bush	Malvaceae	29%	2.5% (E), 2.5% (G)	0.1% (E), 0.7% (G)
Plumbago zeylanica	native plumbago	Plumbaginaceae	18%	5.0% (G)	0.9% (G)
Cordia subcordata	sea trumpet	Boraginaceae	14%	67.5% (S1)	9.6% (S1)
Ipomoea violacea	moon flower	Convolvulaceae	11%	14.2% (G)	1.5% (G)
Ipomoea pes-caprae subsp. *brasiliensis*	goats foot convolvulus	Convolvulaceae	4%	15% (G)	0.5% (G)
Lepidium englerianum	peppercress	Brassicaceae	4%	2.5% (G)	0.1% (G)
Scaevola taccada	Cardwell cabbage	Goodeniaceae	4%	2.5% (G)	0.1% (G)
Total no of species = 15					

East Diamond Islet was the only location that *Ipomoea pes-caprae* subsp. *brasiliensis (*goats foot convolvulus), *Lepidium englerianum* (peppercress) and *Scaevola taccada* (Cardwell cabbage*)* were recorded during the July 2021 voyage.

Ipomoea pes-caprae subsp. *brasiliensis* was well established and formed a small but distinct community (vegetation community 10) on the southeastern shoreline. This species is common on the Great Barrier Reef Cays and Coastal Queensland, but it is rare on the Coral Sea cays. It dominates a small vegetation community on South Islet (Willis Islets) and has been recorded in the past on Turtle Islet (Lihou Reef). It has not been observed on Turtle Islet since 1984.

Lepidium englerianum plants were present on the shoreline of the southern spit in vegetation community 1a. This vegetation community is very susceptible to erosion by waves and storm surges which may result in either complete loss of the species or alternatively, it may spread to other shoreline locations and become more widely established. *Lepidium englerianum is* a recognised native cay species.

Scaevola taccada was observed as a juvenile single plant growing on the northeastern shoreline. Although this species is common on Great Barrier Reef cays and the adjacent mainland in northern Queensland, it has not been recorded as part of the Coral Sea cay flora, although it is dispersed by ocean currents and isolated plants such as the one on East Diamond Islet are observed periodically. It is likely that this species will not persist.

Vegetation communities on East Diamond Islet

Vegetation communities present on East Diamond Islet in July 2021, the area of each and representative survey sites within each vegetation community are listed in *Table 20*. The spatial distribution and extent of the vegetation communities on East Diamond Islet in July 2021 are shown in the vegetation map in *Figure 32.*

The vegetation of the cay consists of vegetation communities dominated by shrubs, grasses, forbs and low vines. No *Pisonia grandis* or other tree communities were present on the cay.

Map unit 1a was present along the leeward (northwestern) sandy shoreline on the seaward edge of the more established vegetation. Species present were a mixture of predominantly *Stenotaphrum micranthum* (beach buffalo grass), *Lepturus repens* (stalky grass), *Boerhavia albiflora* var. *albiflora* (boerhavia) and *Portulaca oleracea* (pigweed). *Lepidium englerianum* (peppercress) was present at Site 43 in this map unit on the southwestern spit. *Argusia argentea* (octopus bush) seedlings were also establishing at this site. Small patches of map unit 1b were present on the rubble banks on the eastern shoreline.

Shoreline vegetation along the sandy shores landward of map unit 1a consisted of *Argusia argentea* shrublands (map unit 11a) and/or grasslands dominated by *Lepturus repens* (map unit 3a) or mixed grasslands co-dominated by *Lepturus repens* and *Stenotaphrum micranthum* (map unit 4). The latter dominated the vegetation on the exposed southeastern shoreline. *Argusia argentea* shrublands were less common on rubble bank shorelines. The vegetation on these rubble banks was predominantly *Boerhavia albiflora* var. *albiflora* herblands (map unit 6a).

The dominant vegetation community in the interior of the cay was *Lepturus repens* mixed closed grassland with *Achyranthes aspera*, (chaff flower) and *Canavalia rosea* (coastal jack bean) (map unit 3d). Also typically present but less abundant in this community were *Abutilon albescens* (lantern bush), *Boerhavia albiflora* var *albiflora* and *Tribulus cistoides* (bulls head burr). *Ipomoea violacea* was also present in this community in some places and formed a vineland community at site 54 and other locations (map unit 9).

Cordia subcordata (sea trumpet) closed scrub (map unit 13) was present at three locations on East Diamond. The only other location where this vegetation community was present was a small patch and a few isolated plants growing in a nearby *Argusia argentea* community on West Diamond Islet. These *Cordia subcordata* scrubs were located in very exposed positions on East Diamond and were quite wind sheared in some places. Dieback was present in this community in the centre of the cay. There was almost a complete absence of ground layer vegetation in healthy stands.

Small patches of open vegetation dominated by *Boerhavia albiflora* var. *albiflora*, *Achyranthes aspera and Portulaca oleracea* (map unit 6c) were present in numerous locations throughout the cay but most were located just landward of the shoreline *Argusia argentea* communities along the NW shoreline. East Diamond was the only cay surveyed during the July 2021 voyage with an *Ipomoea pes-caprae* (goats foot convolvulus) vineland community (map unit 10). It was growing as a small patch on the southeastern shoreline.

Table 20. Vegetation communities on East Diamond Islet.

Veg Map Unit Code	Vegetation Community	Hectares on East Diamond Islet	ID of Sites on East Diamond Islet
	Unvegetated Areas		
A	Sandy shores	4.8 (approx..)	
B	Lithified shores	2.5 (approx.)	
C	Rubble banks	0.3	
	Shoreline and Sandspit Vegetation		
1a	Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	0.298	43, 58
2	*Argusia argentea* open shrubland/isolated shrubs on shorelines and sandy spits	0.218	nil
11a	*Argusia argentea* shrubland/ tall shrubland/ open scrub/ closed scrub with a ground layer typically of *Lepturus repens*, *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea* +/- *Achyranthes aspera* +/- *Stenotaphrum micranthum* +/- *Tribulus cistoides*	0.935	41, 42, 44, 45, 46, 59, M06, 63, M07
	Grasslands and Herblands		
3a	*Lepturus repens* grassland/ closed grassland +/- *Achyranthes aspera* +/- *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	0.362	51, 52, 60
3b	*Lepturus repens*/ *Achyranthes aspera* closed grassland/herbland/closed herbland (seasonally variable) with *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	0.012	nil
3d	*Lepturus repens* closed grassland with *Achyranthes aspera*, *Canavalia rosea* +/- *Abutilon albescens*, +/- *Plumbago zeylanica*	6.452	47, 48, 53, 55, 57, 62, M08
4	*Lepturus repens*/*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea*	0.195	nil
6a	*Boerhavia albiflora* var. *albiflora* sparse herbland/ open herbland/ herbland with *Portulaca oleracea*	0.419	64
6c	*Boerhavia albiflora* var. *albiflora*/ *Achyranthes aspera* open herbland/ herbland with *Portulaca oleracea* +/ *Lepturus repens* +/- *Stenotaphrum micranthum*	0.367	nil
8a	*Achyranthes aspera* herbland/closed herbland with *Boerhavia albiflora* var. *albiflora*	0.085	nil
8b	*Achyranthes aspera*/*Stenotaphrum micranthum*/ *Boerhavia albiflora* var. *albiflora* herbland/ closed herbland +/- *Abutilon albescens* +/- *Portulaca oleracea*	0.020	nil
9	*Ipomoea violacea*/ *Achyranthes aspera*/ *Lepturus repens* closed vineland with *Canavalia rosea* and *Plumbago zeylanica*	0.717	54
10	*Ipomoea pes-caprae* vineland with *Lepturus repens*, *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*	0.010	61
	Interior Shrublands		
11b	*Argusia argentea* open shrubland /tall open shrubland/open scrub with a ground layer of *Lepturus repens* and *Boerhavia albiflora* var. *albiflora* +/- *Achyranthes aspera* +/- *Ipomoea violacea* +/- *Portulaca oleracea*	0.064	nil
11c	*Argusia argentea* shrubland with ground layer of *Lepturus repens*, *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*	0.076	nil
13	*Cordia subcordata* open shrubland to closed scrub	0.199	40, 49, 50, 56

Note: Areas of sandy shores and rocky shores, particularly those of the rocky shores are only approximate due to the difficulty in determining the location of the boundary between the edge of the shoreline and the surrounding reef flat using the imagery.

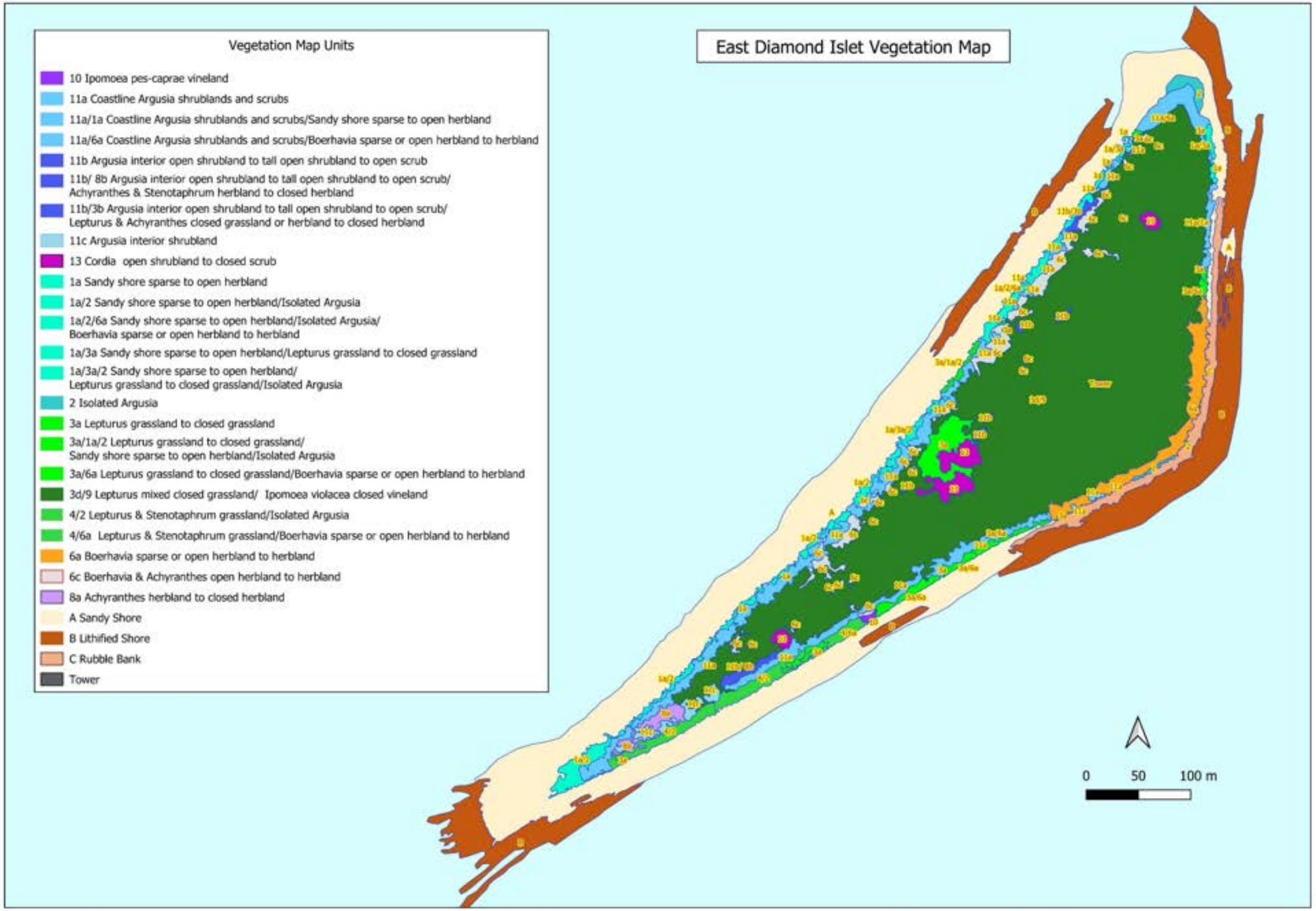


Figure 32. East Diamond Islet vegetation map.

Table 21. Site data recorded on East Diamond Islet.

Datum = WGS 84; green shading = site dominants

Site	Latitude	Longitude	Date	No. of photos	Landform	Veg Map Unit	Vegetation Community	Emergents		Shrub Layer		Ground Layer														Plant Specimens Collected	Notes
								Abutilon albescens	*Argusia argentea*	*Argusia argentea*	Cordia subcordata	*Abutilon albescens*	*Achyranthes aspera*	*Argusia argentea*	*Boerhavia albiflora* var. *albiflora*	*Canavalia rosea*	Ipomoea pes-caprae subsp. brasiliensis	*Ipomoea violacea*	Lepidium englerianum	*Lepturus repens*	*Plumbago zeylanica*	*Portulaca oleracea*	Scaevola taccada	*Stenotaphrum micranthum*	*Tribulus cistoides*		
43	-17.44409	151.07093	14/07/2021	2	Crest of spit	1a	sparse grassland dominated by *Stenotaphrum micranthum*; *Argusia argentea* seedlings and Lepidium englerianum present in the ground layer and occasional emergent *Argusia argentea* also present		trace-5%					trace-5%						trace-5%					5-25%		Lepidium englerianum	
58	-17.43858	151.076424	14/07/2021	2	Frontal dunes, base of slope to beach	1a	sparse grassland dominated by *Lepturus repens*; Single plant of Scaevola taccada present								trace-5%					5-25%		trace-5%	trace-5%	trace-5%		Scaevola taccada	
51	-17.4415	151.07397	14/07/2021	1	NW facing slope	3a	closed grassland dominated by *Lepturus repens*						trace-5%		trace-5%					75-95%					trace-5%		
52	-17.44115	151.074198	14/07/2021	1	NW facing slope	3a	closed grassland dominated by *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*						trace-5%		5-25%					75-95%	trace-5%						
60	-17.44306	151.072923	14/07/2021	1	Frontal dunes	3a	grassland dominated by *Lepturus repens*, *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*						5-25%		5-25%					50-75%		trace-5%		trace-5%	trace-5%	*Portulaca oleracea*	
47	-17.44231	151.073155	14/07/2021	2	Slope to NW	3d	closed herbland/grassland dominated by *Achyranthes aspera*, *Lepturus repens*, *Canavalia rosea* and *Boerhavia albiflora* var. *albiflora* with occasional emergent *Abutilon albescens*	trace-5%				trace-5%	25-50%		5-25%	5-25%				25-50%					trace-5%		
48	-17.44207	151.073752	14/07/2021	2	Crest	3d	closed herbland/grassland dominated by *Achyranthes aspera*, *Lepturus repens*, *Canavalia rosea* and *Tribulus cistoides*						25-50%		trace-5%	5-25%				25-50%	trace-5%				5-25%	*Plumbago zeylanica*, *Tribulus cistoides*	
53	-17.44109	151.07492	14/07/2021	2	Upper SE facing slope	3d	closed herbland/grassland dominated by *Achyranthes aspera*, *Canavalia rosea*, *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*					trace-5%	5-25%		5-25%	5-25%				5-25%					trace-5%	*Boerhavia albiflora*, *Achyranthes aspera*, *Lepturus* reopens, *Canavalia rosea*	
55	-17.44018	151.075803	14/07/2021	2	Upper slope	3d	closed herbland dominated by *Achyranthes aspera*, *Canavalia rosea*, *Lepturus repens* and *Plumbago zeylanica*					trace-5%	25-50%		trace-5%	25-50%		trace-5%		5-25%	5-25%				trace-5%		
57	-17.43905	151.07598	14/07/2021	2	Crest	3d	closed Tussock grassland dominated by *Lepturus repens*, *Achyranthes aspera* and *Canavalia rosea*					trace-5%	5-25%		trace-5%	5-25%				25-50%					trace-5%		
62	-17.44246	151.073687	14/07/2021	2	Base of slope	3d	closed herbland dominated by *Achyranthes aspera*, *Canavalia rosea* , *Tribulus cistoides* and *Lepturus repens*					trace-5%	25-50%		trace-5%	25-50%				5-25%					5-25%	*Abutilon albescens*	
M08	-17.43988	151.075664	15/07/2021	8		3d	closed herbland dominated by *Achyranthes aspera*, *Canavalia rosea*, *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*					trace-5%	25-50%		5-25%	25-50%		trace-5%		5-25%	trace-5%	trace-5%			trace-5%		
64	-17.44027	151.076344	14/07/2021	2	Slope to beach	6a	herbland dominated by dominated by *Boerhavia albiflora* var. *albiflora*						trace-5%		50-75%							trace-5%		trace-5%	trace-5%		
54	-17.44078	151.075469	14/07/2021	2	Crest	9	Mixed closed herbland dominated by *Achyranthes aspera*, *Ipomoea violacea* and *Lepturus repens*					trace-5%	25-50%			trace-5%		25-50%		5-25%	trace-5%	trace-5%			trace-5%	*Ipomoea violacea*	Site of light tower
61	-17.44275	151.073489	14/07/2021	1	Frontal dunes	10	herbland dominated by Ipomoea pes-caprae subsp. brasiliensis, *Lepturus repens*, *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*						trace-5%		5-25%		5-25%			5-25%		trace-5%		5-25%	trace-5%	Ipomoea pes-caprae	
41	-17.4441	151.071139	14/07/2021	2	low frontal dunes	11a	*Argusia argentea* shrubland with a mid dense ground layer dominated by *Stenotaphrum micranthum*, *Boerhavia albiflora* var. *albiflora* and *Lepturus repens*			25-50%			trace-5%		5-25%					5-25%		trace-5%		25-50%	trace-5%		*Argusia* is approximately 1.5m
42	-17.44398	151.071229	14/07/2021	2	Crest of low dunes	11a	*Argusia argentea* tall shrubland with a mid dense ground layer dominated by *Stenotaphrum micranthum*, *Boerhavia albiflora* var. *albiflora* and *Lepturus repens*			25-50%			trace-5%		5-25%					5-25%		trace-5%		25-50%	trace-5%		*Argusia argentea* is older, approximately 2m tall with large trunks
44	-17.44351	151.071787	14/07/2021	2	low dunes	11a	*Argusia argentea* open scrub with a mid-dense ground layer dominated by *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* and *Tribulus cistoides*			50-75%			5-25%		5-25%					trace-5%		trace-5%		trace-5%	5-25%		Narrow extension of herbland on crest
45	-17.44287	151.072264	14/07/2021	2	low dunes	11a	*Argusia argentea* shrubland with a mid dense ground layer dominated by *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea* and *Stenotaphrum micranthum*			50-75%			5-25%		5-25%							5-25%		5-25%	trace-5%		
46	-17.44254	151.072575	14/07/2021	2	low dunes	11a	*Argusia argentea* shrubland with a mid-dense ground layer dominated by *Boerhavia albiflora* var. *albiflora*, *Achyranthes aspera*, *Lepturus repens* and *Portulaca oleracea*			50-75%			5-25%		25-50%					5-25%		5-25%		trace-5%	trace-5%		
59	-17.43824	151.07625	14/07/2021	0	Frontal dunes, base of slope to beach	11a	*Argusia argentea* shrubland with ground layer dominated by *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*			25-50%			trace-5%		5-25%					25-50%		trace-5%		trace-5%			
63	-17.44204	151.074702	14/07/2021	1	Frontal dunes	11a	*Argusia argentea* shrubland with a dense ground layer dominated by *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*			50-75%					5-25%					50-75%		trace-5%				*Argusia argentea*,	
M06	-17.44282	151.072333	14/07/2021	8		11a	*Argusia argentea* shrubland with a mid dense ground layer dominated by *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora*, *Stenotaphrum micranthum* and *Lepturus repens*			50-75%			5-25%		5-25%					5-25%		trace-5%		5-25%	trace-5%	*Stenotaphrum micranthum*	

Site	Latitude	Longitude	Date	No. of photos	Landform	Veg Map Unit	Vegetation Community	Emergents		Shrub Layer		Ground Layer														Plant Specimens Collected	Notes
								Abutilon albescens	*Argusia argentea*	*Argusia argentea*	Cordia subcordata	*Abutilon albescens*	*Achyranthes aspera*	*Argusia argentea*	*Boerhavia albiflora* var. *albiflora*	*Canavalia rosea*	Ipomoea pes-caprae subsp. brasiliensis	*Ipomoea violacea*	Lepidium englerianum	*Lepturus repens*	*Plumbago zeylanica*	*Portulaca oleracea*	Scaevola taccada	*Stenotaphrum micranthum*	*Tribulus cistoides*		
M07	-17.44325	151.072508	15/07/2021	8		11a	*Argusia argentea* closed scrub with a mid-dense ground layer dominated by *Lepturus repens*, *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*			75-95%			5-25%		5-25%	trace-5%				25-50%		trace-5%		trace-5%	trace-5%		
40	-17.44292	151.07265	14/07/2021	3	Crest	13	Cordia subcordata closed scrub with a very sparse ground layer of *Boerhavia albiflora* var. *albiflora* and *Lepturus repens*				75-95%				trace-5%					trace-5%							Wind shearing; almost no plants in ground layer
49	-17.44164	151.074066	14/07/2021	4	Crest	13	Cordia subcordata open shrubland with a mid-dense ground layer dominated by *Achyranthes aspera*, *Lepturus repens* and *Canavalia rosea*				5-25%	trace-5%	25-50%		trace-5%	5-25%				5-25%					trace-5%		Cordia dieback; Lots of dead Cordia subcordata; some live approx. 2m tall
50	-17.44142	151.074209	14/07/2021	2	Upper slope	13	Cordia subcordata closed scrub with a sparse ground layer dominated by *Lepturus repens*				75-95%		trace-5%		trace-5%					5-25%						Cordia subcordata	Dieback in Cordia
56	-17.43945	151.075915	14/07/2021	1	Gentle upper slope	13	Cordia subcordata closed scrub				75-95%																

Comparison with previous vegetation surveys

The vegetation of East Diamond Islet was surveyed by Hicks in October 1984. John Westaway visited East Diamond Islet during a Bush Blitz excursion in June 2016. Vegetation work during this visit was restricted to collection of plant specimens for incorporation into the Australian Tropical Herbarium in Cairns.

Species recorded during the July 2021 survey included all of the species previously recorded by Hicks in October 1984. Four additional species that were not recorded in 1984 were recorded in the July 2021 survey:- *Portulaca oleracea, Stenotaphrum micranthum, Ipomoea pes-caprae* subsp. *brasiliensis* as well as the single plant of *Scaevola taccada.* Two of these, *Portulaca oleracea* and *Stenotaphrum micranthum* were collected by Westaway in 2016.

Locations of a total of 16 quadrats positioned along 4 transects with species present, percent cover and height data for each quadrat are shown on a hand drawn map in the Hicks report but averaged data is not included.

Comparison of the data shown on the 1984 map with the July 2021 vegetation map and data indicates that the width of the *Argusia argentea* shrubland on the leeward side has decreased since 1984 and there are differences in the presence or mapped location of the *Cordia subcordata* shrublands, although the total area of the patches is similar. Otherwise the vegetation does not appear to have changed significantly since 1984.

Permanent monitoring site data

Three permanent monitoring sites (M06, M07, M08) were established and surveyed on East Diamond Islet. The locations of the centre transects of these sites are shown as the red lines in *Figure 31*. *Table 22* contains the data recorded at these sites. The photographs included with the data in this section are 4 of the 10 site photographs for each site. These are taken from the centre point of each site in four different directions (facing 0, 90, 180 and 270 degrees from the transect bearing respectively).

Site M07, located in an *Argusia argentea* community, could not be comprehensively surveyed during the October 2021 field trip as large numbers of red-footed boobies (*Sula sula*) and frigatebirds (*Fregata spp.)* including chicks were sitting on nests in the branches of the *Argusia* shrubs throughout the site and running the transect tape through the site would have caused unacceptable disturbance to these nesting birds.

Table 22. BioCondition attribute data recorded in permanent monitoring sites on East Diamond Islet.

	Site M06	Site M07	Site M08
Vegetation community description	*Argusia argentea* shrubland with a mid dense ground layer dominated by *Achyranthes aspera, Boerhavia albiflora* var. *albiflora, Stenotaphrum micranthum* and *Lepturus repens*	*Argusia argentea* closed scrub with a mid-dense ground layer dominated by *Lepturus repens, Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*	Closed herbland dominated by *Achyranthes aspera, Canavalia rosea, Lepturus repens* and *Boerhavia albiflora* var. *albiflora*
Transect start (WGS 84)	-17.442672 151.072474	-17.443344 151.072302	-17.44008 151.075571
Transect centre (WGS84)	-17.442822 151.072333	-17.443249 151.072508	-17.439878 151.075664
Transect end (WGS 84)	-17.443009 151.072141	-17.443103 151.072692	-17.439681 151.075759
Transect bearing	215^0	53^0	14^0
Median canopy height (range)	not measured*	2.5 (1.5 to 3.0)m	0.4 (0.15 to 0.7)m
Tree canopy cover %	n/a	n/a	n/a
Shrub canopy cover %	not measured*	81%	n/a
Basal area m^2/ha (at 30 cm height, calculated from stem diameters)	not measured*	22.2m^2/ha	nil
Total number of large trees/ha	0	0	0
Total no of trees per ha	n/a	n/a	n/a
Total number of tree stems/ha	n/a	n/a	n/a
Total no. shrubs/ha	not counted*	960	n/a
Total no. shrub stems/ha	not counted*	1440	n/a
Large shrubs - mean diameter at 30 cm height	not measured*	12.8cm	n/a
Recruitment of ecologically dominant layer (%)	nil	nil	n/a
Tree species richness	0	0	0
Tree species present	n/a	n/a	n/a
Shrub species richness	1	1	1
Shrub species present (layer in brackets)	*Argusia argentea* (G)	*Argusia argentea* (S1)	*Abutilon albescens* (G)
Median ground layer height (range)	0.4 (0.1 to 0.5)m	0.2 (0.1 to 0.5)m	G=canopy
Total ground layer cover of native cay species (%)	45.8%	62.8%	97.4%
Grass species richness	2	2	1
Grass cover (%)	18%	32.4%	12.2%
Grass species present in order of decreasing cover - most abundant first (cover in brackets)	*Stenotaphrum micranthum* (10%) , *Lepturus repens* (8%)	*Lepturus repens* (31.6%), *Stenotaphrum micranthum* (0.8%)	*Lepturus repens* (12.2%)
Forb (including vines) species richness	4	5	7
Forb species cover (%)	27.8%	30.4%	84.2%
Forb species present in order of decreasing cover - most abundant first (Cover in Brackets)	*Achyranthes aspera, (14.4%) Boerhavia albiflora* var. *albiflora (10.4%), Portulaca oleracea (3%0, Tribulus cistoides (<0.2%)*	*Achyranthes aspera (17.7%), Boerhavia albiflora* var. *albiflora (7.8%), Portulaca oleracea (5%), Tribulus cistoides (0.6%), Canavalia rosea (<0.2%),*	*Achyranthes aspera, (45.4%) Canavalia rosea (25%), Boerhavia albiflora* var. *albiflora (6.4%), Tribulus cistoides (3.2%), Plumbago zeylanica (2.6%), Ipomoea violacea (1.6%)*
Native shrub ground cover (%)- *Abutilon albescens*	0%	0%	1%
Non-native plant cover (all strata) (%)	0%	0%	0%
Litter cover (%)	10.4%	24.2%	2.6%
Bare ground (%)	43.8%	13%	0%
Woody debris (m/ha of Logs >0.5m long and >10cm wide)	nil	nil	nil
Soil pH	9.25 (0-10cm), 9.36 (10-20cm), 9.17 (20-30cm)	8.76 (0-10cm), 8.75 (10-20 cm), 9.02 (20-30cm)	8.3 (0-10cm), 8.47 (10-20cm), 8.82 (20-30cm)

Photo 54: Monitoring site M06, East Diamond Islet facing SW.

Photo 55: Monitoring site M06, East Diamond Islet facing NW.

Photo 56: Monitoring site M06, East Diamond Islet facing NE.

Photo 57: Monitoring site M06, East Diamond Islet facing SE.

Photo 58: Monitoring site M07, East Diamond Islet facing NE.

Photo 58: Monitoring site M07, East Diamond Islet facing SE.

Photo 60: Monitoring site M07, East Diamond Islet facing SW.

Photo 61: Monitoring site M07, East Diamond Islet facing NW.

Photo 62: Monitoring site M08, East Diamond Islet facing N.

Photo 63: Monitoring site M08, East Diamond Islet facing E.

Photo 64: Monitoring site M08, East Diamond Islet facing S.

Photo 65: Monitoring site M08, East Diamond Islet facing W.

Soils Data

Soils on and adjacent to the shoreline was white coarse sand.

Soils on the grasslands adjacent to the shoreline varied from white sand to organic brown sandy soil.

Crests and upper slopes had brown organic sandy soil.

The table in Appendix 11 contains the results of the analysis of soil samples collected from monitoring sites M06, M07 and M08 during the vegetation survey. Refer to the general Vegetation Results and discussion for further discussion on the soil analyses results.

The pH in both of the *Argusia* shrubland sites (M05, M06) was higher than the pH of all of the other soil samples collected in July 2021. Total organic carbon. electrical conductivity, total nitrogen, phosphorus, calcium and trace elements (copper, iron, manganese and zinc) levels were lower in soil samples from the shoreline *Argusia argentea* communities than in samples from the other sites in the Diamond Islets and Lihou Reef cays.

Total organic carbon organic carbon was much lower in the shoreline *Argusia argentea* shrubland sites, ranging from 0.01 to 0.12% with an average of 0.05% for the six samples than in the interior closed herbland site where organic carbon levels ranged from 0.04 to 3.24% with an average of 1.64% for the three samples.

Total nitrogen and phosphorus levels were high in the surface soil of the closed herbland site (M08).

Figure 33. East Diamond Islet - Health check, rodent tunnel and ant bait station monitoring sites.

Health checks

East Diamond Islet						
Ecosystems and biodiversity	**Health Checks**					
Value - Coral cay communities (Communities present listed below)	**Veg map unit**	Dominant Sub-dominant Remaining veg (ha)		Photomonitoring: N - North photo E - East photo S - South photo W - West photo		**Overall condition class**[1]
Shoreline and sandspit vegetation						
Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	1a	HC20W	HC24			G
Isolated plants of *Argusia argentea*	2	HC20NW	HC21NE	HC24		G
Grasslands and Herblands						
Grassland communities dominated by *Lepturus repens*	3a	0.362				
	3b	0.012				
	3d	HC18, HC22	HC23, HC25	HC26	HC27	G
Grassland communities co-dominated by *Lepturus repens* and *Stenotaphrum micranthum*	4	H21NE				G
Herbland communities dominated by *Boerhavia albiflora* var. *albiflora*	6a	0.419				
	6c	0.367				
Herbland communities dominated by *Achyranthes aspera*	8a	HC21SW				G
	8b	0.020				
Herbland communities dominated by *Ipomoea violacea*	9	HC18, HC19	HC22, HC23	HC25, HC26	HC27	G
Herbland communities dominated by *Ipomoea pes-caprae*	10	0.010				
Shrublands						
Argusia argentea shrubland communities	11a	HC17	HC19	HC20		G
	11b	0.064				
	11c	0.076				
Cordia subcordata open shrubland to closed scrub	13	0.199				SC
Habitats and species						
Value - Seabird and shorebird habitat						G
Value -Turtle rookery (Green turtle *Chelonia mydas)*						G

[1]Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

Results

11 Health Checks were undertaken on East Diamond Islet to assess the condition of shoreline, grassland, herbland and shrubland communities. Health Checks assessed the condition of seven vegetation communities. Some of the vegetation communities not assessed by Health Checks are included in A. Overall vegetation condition.

The overall condition rating for each of the vegetation communities was Good however there was significant concern for *Cordia subcordata* communities. *Cordia* communities showed evidence of dieback with numerous dead, mature plants. For further detail of *Cordia* dieback refer Vegetation, East Diamond Islet, Vegetation condition.

As mentioned above it was evident that the Diamond Islets had received good rainfall as the vegetation on all cays was lush and green with high plant biomass, height and coverage.

Figure 34. Map of East Diamond Islet hand drawn from an aerial photograph (Hicks 1984). Note estimated vegetated area 10 ha, entire cay 15.5ha (5m ASL).

A. Overall vegetation condition

Photo: View of the cay interior from the tower to the northern end. Note vegetation condition and plant coverage (supporting habitat for breeding seabirds)

Photo: View of the cay interior from the tower to the southwestern end.

*Photo: Argusia argentea and grasses (**2** Isolated plants of Argusia argentea) encroaching onto bare sand providing cay stability and bird nesting habitat (photos taken between Rodent tunnel 33 and 34).*

*Photo: Healthy herbland communities dominated by Boerhavia albiflora var. albiflora (**6a**) at the northern spit with Argusia argentea shrubland community (**11a**) on the LHS of photo (photos taken between Rodent tunnel 33 and 34).*

*Photo: **8c** Achyranthes aspera mixed herbland/closed herbland with Lepturus repens and Plumbago zeylanica +/- Abutilon albescens, Boerhavia albiflora var. albiflora, Portulaca oleracea (Photo taken from Rodent tunnel 26).*

*Photo: The windward side of the cay showing seabird breeding habitat in **11a** Argusia argentea shrubland/ tall shrubland/ closed scrub with **1a** Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines (Photo taken from Rodent tunnel 35).*

*Photo. Good plant biomass, height and coverage of **3d** Lepturus repens closed grassland with Achyranthes aspera, Canavalia rosea +/- Abutilon albescens, Plumbago zeylanica (Photos taken from HC22: L photo - facing west and R photo facing east).*

*Photo. Aerial view of **3d** looking west from the tower. Inset photo. Close view of **3d** at HC22. Note overall good vegetation condition.*

Photo. View showing vegetation growing amongst large blocks of beach rock lining the windward side of the cay of ***6a*** *Boerhavia albiflora var. albiflora herbland/ open herbland/sparse herbland with Portulaca oleracea, Stenotaphrum micranthum (photo looking south from Rodent tunnel 36).*

Photo: Close view of Boerhavia growing over beach rock rubble.

Cordia subcordata dieback

Photo: Cordia subcordata with flowers.

Site 1. *Cordia subcordata* - Rodent tunnel 32

Photo: Patch of Cordia subcordata at Rodent tunnel 32. Photo taken facing east.

Photo: Healthy tips on the side of Cordia community facing the cay interior. Photo taken facing east.

Photo: The same Cordia community on the side facing the windward shore of the cay. Note widespread dieback of branches. Inset photo. Close view of the same side of the Cordia community.

Photo: Close view of dieback on Cordia branches.

Photo: Dead Cordia in the interior of the Cordia community at Rodent tunnel 32.

Site 2. *Cordia subcordata* - Rodent tunnel 29/HC23

Photo: The largest patch of Cordia subcordata on East Diamond Islet is located at the site of Rodent tunnel 29 (background of photo). Note visible dead stems and branches from dieback. (Photo taken from the tower facing in a southwesterly direction.)

Photo: Cordia subcordata at Rodent tunnel 29. Note leafless branch tips on top of Cordia clumps. Photo taken facing northeast towards the tower.

Photos: Areas with numerous dead Cordia plants were observed at the site of Rodent tunnel 29.

Photos: Close view of dead Cordia and plant dieback.

Site 3. *Cordia subcordata* - Rodent tunnel 27

Photo: Cordia subcordata community at the site of Rodent tunnel 27. Inset photo: Close view of branch dieback.

Photo. Cordia community at Rodent tunnel 27.

B. Health Check photo monitoring - sample photo of each vegetation type

*Photo: HC20 **1a** Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines.*

*Photo: HC20 **2** Isolated plants of Argusia argentea.*

*Photo: HC26 **3d** Lepturus repens closed grassland with Achyranthes aspera, Canavalia rosea +/- Abutilon albescens, Plumbago zeylanica.*

*Photo: HC21 **4** Lepturus repens/Stenotaphrum micranthum grassland with Boerhavia albiflora var. albiflora, Portulaca oleracea.*

*Photo: HC21 **8a** Achyranthes aspera Herbland/closed herbland with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea.*

*Photo: HC18 **9** Ipomoea violacea/ Achyranthes aspera/ Lepturus repens viny closed herbland with Achyranthes aspera, Canavalia rosea, Lepturus repens, Plumbago zeylanica (Sub-dominant).*

*Photo: HC20 **11a** Argusia argentea shrubland/ tall shrubland/ closed scrub.*

Introduced pests

A. Rodents

Table 23. Rodent tunnel monitoring - East Diamond Islet.

East Diamond Islet			
No. of rodent tunnels	Date deployed	Date collected	Evidence of rodents (tracks, droppings)
16[1]	14/7/21	15/7/21	Nil

[1] Refer *Figure 33*.

B. Ants and other invertebrates

Table 24. Invertebrate species summary - East Diamond Islet.

East Diamond Islet					
Specimen no.	Date	Site	Specimen	Identification	Native / introduced
14	14/7/21	NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*	Native
15	14/7/21	NA	Grasshopper	*Aiolopus thalassinus* (Acrididae)	Native
16	15/7/21	RT15	Ants	*Tetramorium simillimum*[1]	Introduced (Africa)
17	15/7/21	RT6	Ants	not ants, small flies	Native
18	15/7/21	RT1	Ants	*Tetramorium simillimum*	Introduced (Africa)
19	15/7/21	NA	Slaters	TBA	TBA
20	15/7/21	RT6	Ants	*Tetramorium simillimum*	Introduced (Africa)
21	15/7/21	RT12	Ants	*Tetramorium simillimum*	Introduced (Africa)
22	15/7/21	NA	Tick	*Amblyomma loculosum*[2]	Native
23	15/7/21	RT14	Ants	*Tetramorium simillimum*	Introduced (Africa)
24	15/7/21	NA	Cockroach	TBA	TBA
25	15/7/21	RT5	Ants	*Tetramorium simillimum*	Introduced (Africa)

[1] *Tetramorium simillimum* is a tramp species that is now pantropically distributed. It even occurs in some temperate areas, albeit in protected locations such as heated greenhouses.

Unlike some other exotic myrmicines in Australia, this species does not seem to adversely affect the native ant fauna. https://antwiki.org/wiki/Tetramorium_simillimum

Tetramorium simillimum tends to invade natural environments however it is innocuous and does not occur in huge numbers. Based on the current knowledge of this particular specie, it this does not raise any red flags. In contrast to other invertebrates that inhabit coral cays that can appear and disappear, ants are known to persist (Chris Burwell 2021 pers. comm.).

[3]*Amblyomma loculosum* was first described by Neumann in 1907 from specimens found in Mauritius (Uilenbero 1977). This specie is now known from Seychelles, Cocos Keeling, Australia, Carolines, New Caledonia, Indian Ocean, Pacific Ocean and the Coral Sea where adult and immature ticks parasitise seabirds and also humans. A new arbovirus was isolated from *Amblyomma loculosum* taken from the feet of two dead Roseate terns *Sterna dougalli arideensis* in the Seychelles (Hoogstraal et al.1976). Hoogstraal (1976) considered that the role of *Amblyomma loculosum* as a reservoir and vector of bird and human infections was worthy of further studies.

In Hoogstraal et al (1976) *Amblyomma loculosum* was recorded in the Coral Sea at SW Diamond Islet, Wreck Reef, Cato Island (Hindwood et al. 1963); South Diamond Islet (Roberts 1969); Bird Island (Wreck Reef), Northeast Island, Diamond Cay No. 1 (Gregory 1964).

In 1961 specimens of *Amblyomma loculosum* were collected in the Coral Sea by K.A. Hindwood from a human at Wreck Reef, Bird Island; Great frigate bird *Fregata minor peninsulae* (great frigatebird *Fregata minor*) at Northeast Is., Harald (Herald) Cay; Lesser frigate bird *Fregata ariel* (lesser frigatebird *Fregata ariel*) at Diamond Cay No.1; Wedge-tailed shearwater *Puffinicus pacificus chlorohynchus* (*Ardenna pacifica*) and Common noddy *Anous stolidus antelius* (*Anous stolidus*) at Wreck Reef, Bird Island; and Red faced bobby *Sula rubripes* (red-footed booby *Sula sula*) in (Hoogstraal et al. 1976).

4. South Diamond Islet

Birds

Table 25. Species and breeding effort – South Diamond Islet.

South Diamond Islet Date:	Species		Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
16/07/2021	black noddy					Present	18	V,Y
16/07/2021	brown booby					41	42	G,N
16/07/2021	buff-banded rail					0	P	
16/07/2021	common noddy					0	168	
16/07/2021	crested tern					0	1	
16/07/2021	great frigatebird					0	1	V,P
16/07/2021	lesser frigatebird					382	208	G/V,Y
16/07/2021	masked booby					20	22	G,N
16/07/2021	Pacific golden plover					0	1	
16/07/2021	red-footed booby					120	270	V,P
16/07/2021	red-tailed tropicbird					0	2	
16/07/2021	ruddy turnstone					0	1	
16/07/2021	sooty tern					260	1545	G,Y
16/07/2021	wandering tattler					0	1	

Figure 35. Pacific golden plover, Pluvialis fulva. Non-breeding plumage.

Figure 36. Spotted grass-blue butterfly, Zizeera karsandra (approximately 177km from the nearest record at Willis Island).

Figure 37. Sooty tern, Onychoprian fuscatus. Roosting.

The value of ground-truthing data – *Figure 37* shows an aggregation of sooty terns that could easily be recorded as nests. These birds were only roosting at the time. They may have been preparing for nesting, but at the time of the survey there was no indication of nest scrapes and certainly no eggs. Breeding effort did consist of already hatched chicks and young crèched among grasses on the northwest section of the islet.

Vegetation

Cay description

South Diamond Islet is located on Tregrosse Reefs at -17.658 degrees latitude and 150.827 degrees longitude. The cay has a total vegetated area of 4.2 hectares. The interior of the cay sloped steeply from the shoreline to an interior plateau with a depression in the central area of the plateau.

Figure 38 contains surface elevation profiles of South Diamond Islet.

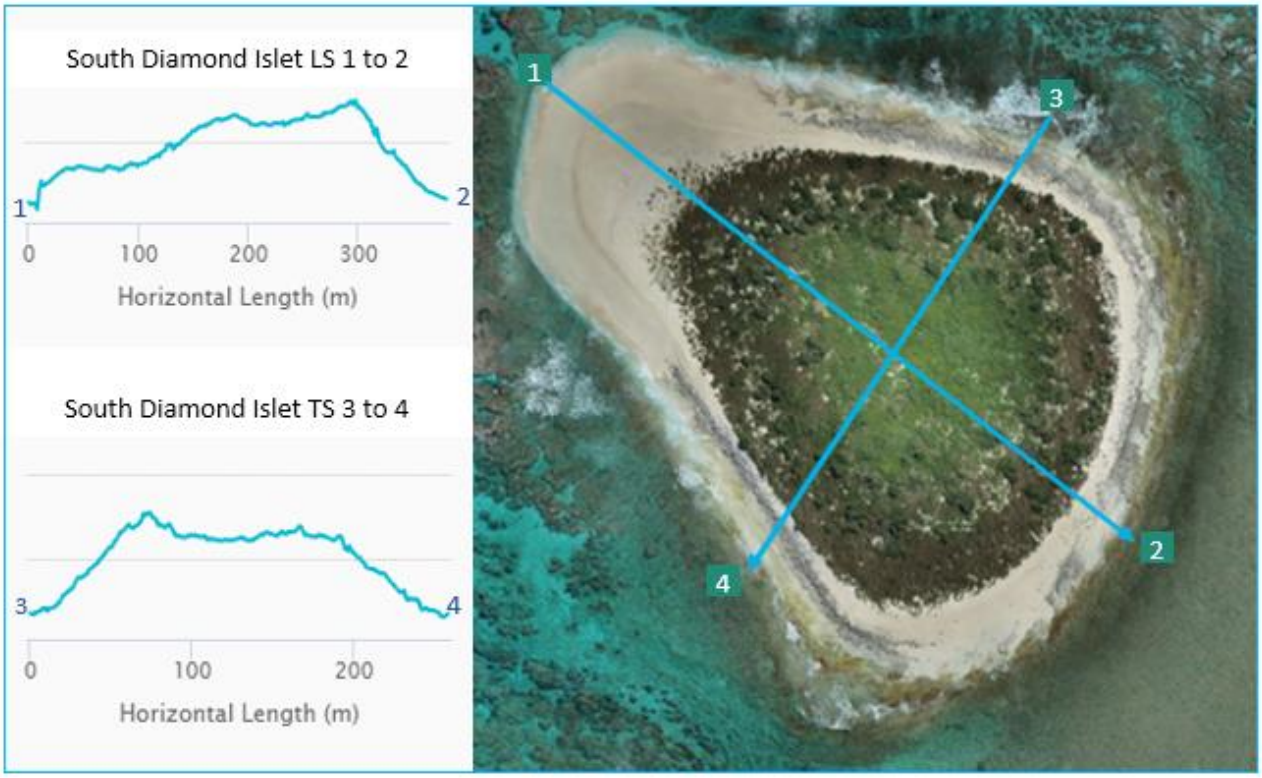


Figure 38. Surface profiles of South Diamond Islet.

Note: Maximum height is approximately ten to twelve metres ASL. Vertical heights and scale are not included in surface profile diagrams as accurate datum information was not available.

Survey intensity

Six and a half hours was spent surveying the vegetation of South Diamond Islet. Vegetation data was recorded at 28 ground-truthing sites and one permanent monitoring site (M09). The locations of these sites are shown in *Figure 39.* The blue lines are the boundaries of the vegetation communities shown on the vegetation map in *Figure 40.*

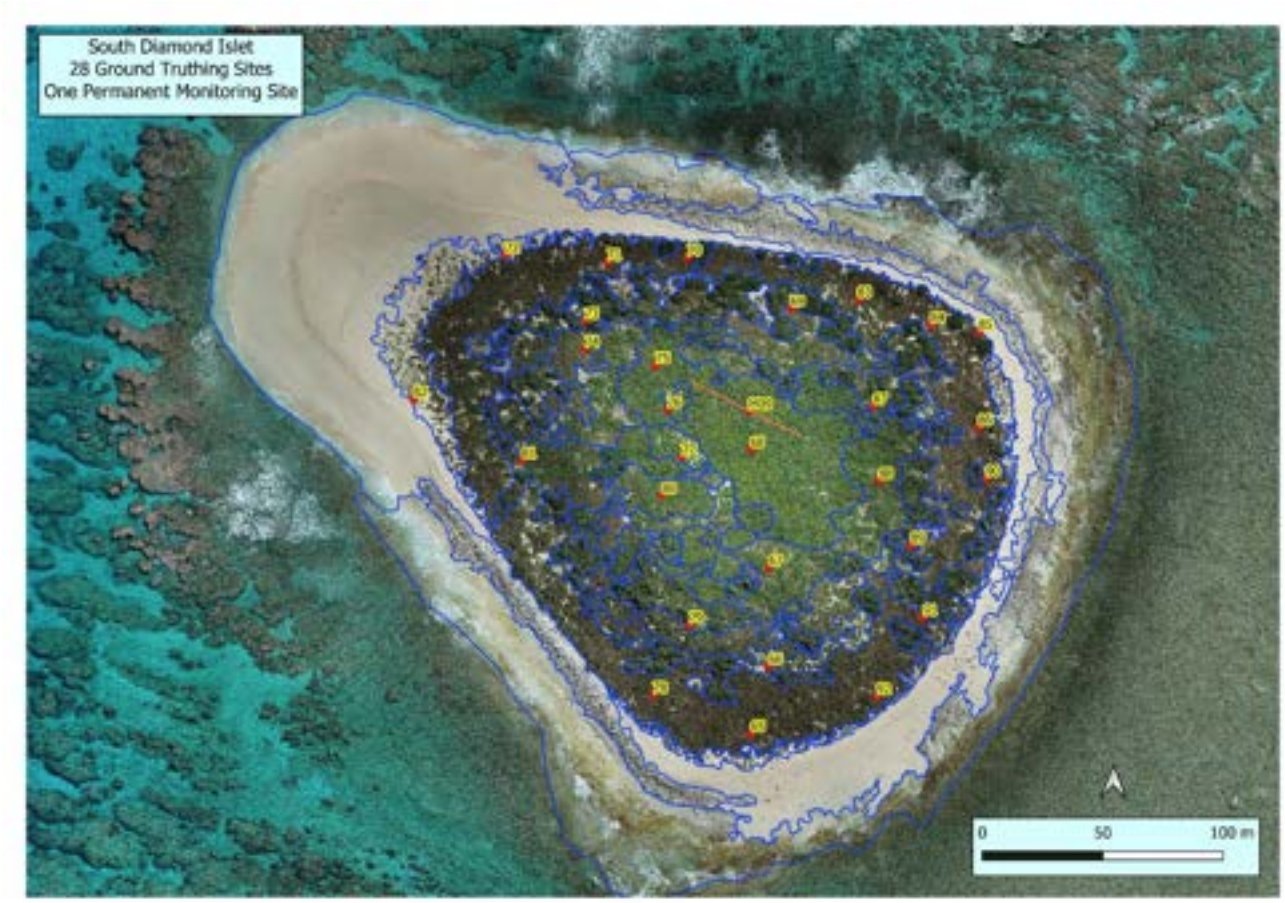


Figure 39. South Diamond Islet showing the number and location of ground-truthing sites and the permanent monitoring sites relative to the vegetation map unit boundaries

Vegetation condition

The vegetation on the cay was all in good condition.

Floristic data

Nine plant species were recorded on South Diamond Islet. These are listed in *Table 26* in order of frequency in sites together with the averaged cover for each species for sites in which the species was present and their averaged cover over the entire cay. Data for species cover at each site plus occurrence of each species in relation to vegetation community and landform are contained in *Table 28*.

Table 26. Plant species recorded on South Diamond Islet, 16/07/2021.

Layers: (E) = emergent, (S1) = upper shrub, (S2) = lower shrub, (G) = ground

Species	Common Name	Family	Presence in Sites (% of sites)	Average % Cover in Each Layer (Only sites containing the species were averaged)	Overall Average % Cover in Each Layer – (average includes all sites)
Lepturus repens	stalky grass	Poaceae	97%	50.4% (G)	48.6% (G)
Boerhavia albiflora var. *albiflora*	boerhavia	Nyctaginaceae	83%	5.6% (G)	4.7% (G)
Portulaca oleracea	pig weed	Portulacaceae	76%	5.9%	4.5% (G)
Achyranthes aspera	chaff flower	Amaranthaceae	55%	24.2% (G)	13.4% (G)
Argusia argentea	octopus bush	Boraginaceae	48%	2.5% (E), 23.2% (S1), 2.5% (G)	0.1% (E), 8.8% (S1), 0.2% (G)
Stenotaphrum micranthum	beach buffalo grass	Poaceae	28%	6.9%	1.9% (G)
Tribulus cistoides	bulls head burr	Zygophyllaceae	24%	2.5% (G)	0.6% (G)
Plumbago zeylanica	native plumbago	Plumbaginaceae	21%	20.4% (G)	4.2% (G)
Abutilon albescens	lantern bush	Malvaceae	17 %	37.5% (S1), 10% (G)	2.6% (S1), 1.7% (G)
Total no of species = 9					

Vegetation communities on South Diamond Islet

Vegetation communities present on South Diamond Islet in July 2021, the area of each and representative survey sites within each vegetation community are listed in *Table 27*. The spatial distribution and extent of the vegetation communities on South Diamond Islet in July 2021 are shown in the vegetation map in *Figure 40.*

The vegetation of the cay consists of vegetation communities dominated by shrubs, grasses, forbs and low vines. No *Pisonia grandis* or other tree communities were present on the cay.

Map unit 1a was present along the sandy shorelines forming an expanding seaward edge to the vegetation of the cay. This vegetation community consisted of small, isolated plants of predominantly *Lepturus repens* (stalky grass) and *Stenotaphrum micranthum* (beach buffalo grass).

Only small patches of *Argusia argentea* (octopus bush) (map unit 11a) were growing adjacent to the shoreline, with *Argusia argentea* communities (map units 11b and 11c) more common on the mid to upper slopes on South Diamond Islet.

A wide zone of *Lepturus repens* grassland (map unit 3a) was present on the lower slopes landward of the shoreline dunes.

Vegetation in the centre of the cay was dominated by *Plumbago zeylanica* (native plumbago) closed herblands (map unit 7) and *Abutilon albescens* (lantern bush) shrublands (map unit 15), surrounded by mixed *Achyranthes aspera* (chaff flower) herblands (map unit 8c) and *Lepturus repens/Achyranthes aspera* grassland/herbland (map unit 3b). *Achyranthes aspera* and *Lepturus repens* were present in all the interior communities and *Plumbago zeylanica*, *Boerhavia albiflora* var. *albiflora* (boerhavia) and *Portulaca oleracea* (pigweed) were also present in most sites in these communities.

Table 27. Vegetation communities on South Diamond Islet.

Veg Map Unit Code	Vegetation Community	Hectares on South Diamond Islet	ID of Sites on South Diamond Islet
	Unvegetated Areas		
A	Sandy shores	2.0 (approx.)	
B	Lithified shores	1.8 (approx.)	
C	Rubble banks	0.4	
	Shoreline and Sandspit Vegetation		
1a	Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	0.279	72, 82
2	*Argusia argentea* open shrubland/isolated shrubs on shorelines and sandy spits	0.048	70, 83, 85, 90
11a	*Argusia argentea* shrubland/ tall shrubland/ open scrub/ closed scrub with a ground layer typically of *Lepturus repens*, *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea* +/- *Achyranthes aspera* +/- *Stenotaphrum micranthum* +/- *Tribulus cistoides*	0.077	91
	Grasslands and Herblands		
3a	*Lepturus repens* grassland/ closed grassland +/- *Achyranthes aspera* +/- *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	1.812	65, 71, 74, 78, 84, 86, 92
3b	*Lepturus repens*/ *Achyranthes aspera* closed grassland/herbland/closed herbland (seasonally variable) with *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	0.151	80
5	*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora* +/- *Achyranthes aspera* +/-*Portulaca oleracea*	0.079	nil
6c	*Boerhavia albiflora* var. *albiflora*/ *Achyranthes aspera* open herbland/ herbland with *Portulaca oleracea* +/ *Lepturus repens* +/- *Stenotaphrum micranthum*	0.032	nil
7	*Plumbago zeylanica*/ mixed closed herbland/dwarf shrubland with *Achyranthes aspera*, *Lepturus repens*, +/- *Abutilon albescens* +/- *Canavalia rosea*	0.263	M09
8a	*Achyranthes aspera* herbland/closed herbland with *Boerhavia albiflora* var. *albiflora*	0.158	88
8c	*Achyranthes aspera* mixed herbland/closed herbland with *Lepturus repens* and *Plumbago zeylanica* +/- *Abutilon albescens* +/- *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	0.413	67, 76, 77
	Interior Shrublands		
11b	*Argusia argentea* open shrubland /tall open shrubland/open scrub with a ground layer of *Lepturus repens* and *Boerhavia albiflora* var. *albiflora* +/- *Achyranthes aspera* +/- *Ipomoea violacea* +/- *Portulaca oleracea*	0.169	79, 81, 87
11c	*Argusia argentea* shrubland with ground layer of *Lepturus repens*, *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*	0.441	69, 73, 89
15	*Abutilon albescens* dwarf shrubland to shrubland with a mid-dense to dense ground layer of *Abutilon albescens*, *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* +/- *Lepturus repens* +/- *Plumbago zeylanica* +/- *Stenotaphrum micranthum*	0.263	68, 75

Note: Areas of sandy shores and rocky shores, particularly those of the rocky shores are only approximate due to the difficulty in determining the location of the boundary between the edge of the shoreline and the surrounding reef flat using the imagery.

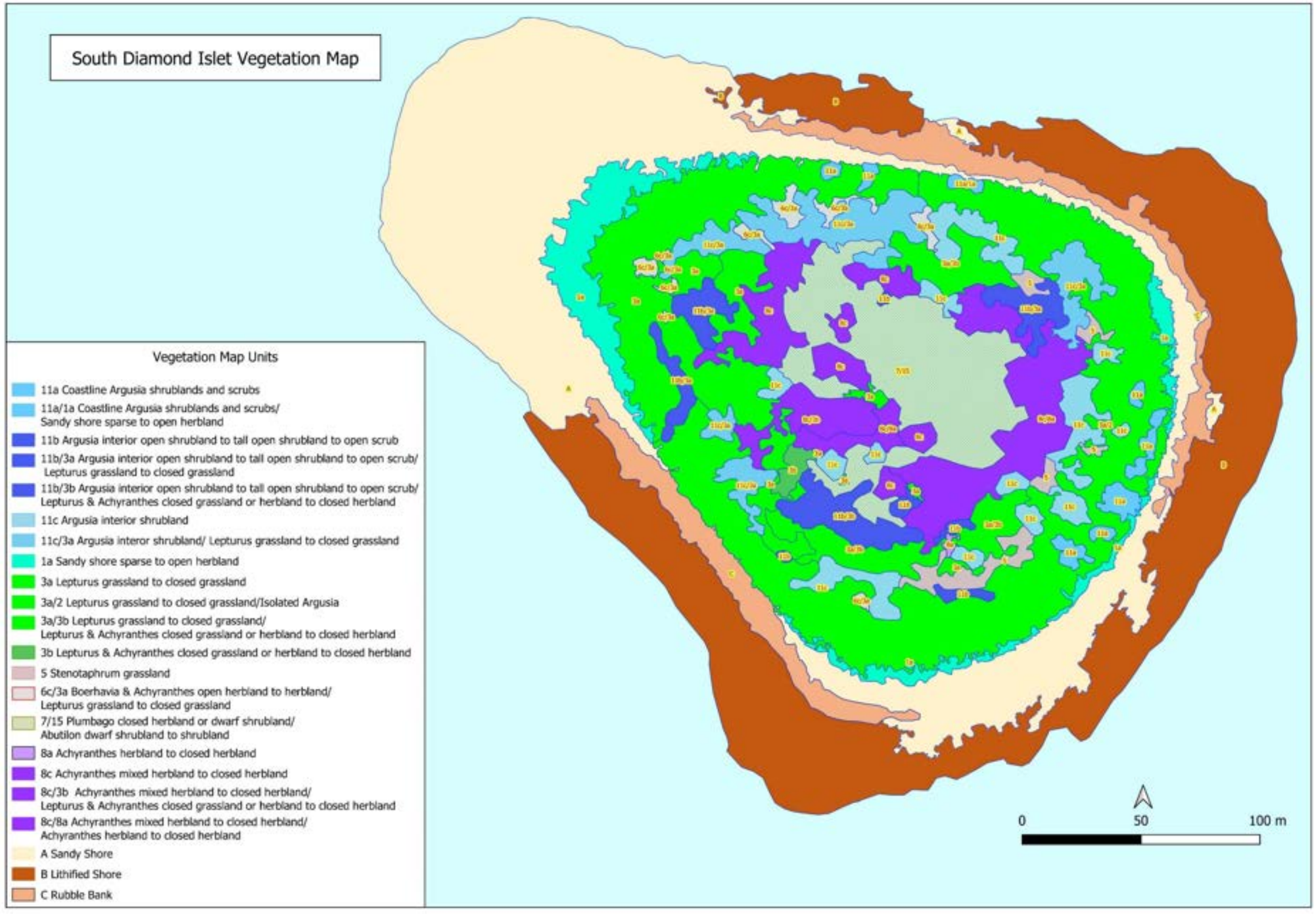


Figure 40. South Diamond Islet vegetation map.

Table 28. Site data recorded on South Diamond Islet.
Datum = WGS 84; green shading = site dominants

Site	Latitude	Longitude	Date	No. of photos	Landform	Veg Map Unit	Vegetation Community	Emergent	Upper Shrub Layer		Ground Layer									Plant Specimens Collected	Notes
								Argusia argentea	*Abutilon albescens*	*Argusia argentea*	*Abutilon albescens*	*Achyranthes aspera*	*Argusia argentea*	*Boerhavia albiflora* var. *albiflora*	*Lepturus repens*	*Plumbago zeylanica*	*Portulaca oleracea*	*Stenotaphrum micranthum*	*Tribulus cistoides*		
72	-17.657567	150.825823	16/07/2021	3	Shoreline	1a	sparse grassland dominated by *Lepturus repens*; *Argusia argentea* seedlings present						trace-5%		5-25%			trace-5%			OTG on landward edge and STG on seaward edge
82	-17.658104	150.825479	16/07/2021	1	Shoreline	1a	sparse grassland dominated by *Lepturus repens*; *Argusia argentea* seedlings present						trace-5%		5-25%			trace-5%			
70	-17.657575	150.826503	16/07/2021	2	Base of slope adjacent to shore	2	*Argusia argentea* open shrubland with a dense ground layer dominated by *Lepturus repens*			5-25%					75-95%						*Lepturus* reopens 0.5m tall
83	-17.657732	150.827139	16/07/2021	2	Slope to beach	2	*Argusia argentea* open shrubland with a dense ground layer dominated by *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*			5-25%				5-25%	50-75%		trace-5%				OS with patches of CG
85	-17.657853	150.82759	16/07/2021	1	Shoreline	2	*Argusia argentea* open shrubland with a mid-dense ground layer dominated by *Lepturus repens*			5-25%				trace-5%	50-75%						
90	-17.6584	150.827617	16/07/2021	2	Lower slopes adjacent to beach	2	*Argusia argentea* open shrubland with a dense ground layer dominated by *Lepturus repens*			5-25%					75-95%		trace-5%				
65	-17.659351	150.82674	16/07/2021	2	Lower slope	3a	closed grassland dominated by *Lepturus repens*							trace-5%	75-95%		trace-5%	trace-5%			
71	-17.657592	150.826205	16/07/2021	2		3a	closed grassland dominated by *Lepturus repens*							trace-5%	75-95%		trace-5%	trace-5%			
74	-17.657916	150.826121	16/07/2021	2	Slope to NW	3a	closed grassland dominated by *Lepturus repens*, *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*					5-25%		5-25%	75-95%		trace-5%		trace-5%		
78	-17.659208	150.826375	16/07/2021	2	Base of slope adjacent to shoreline	3a	closed grassland dominated by *Lepturus repens*							trace-5%	75-95%		trace-5%				
84	-17.657827	150.82741	16/07/2021	1	Bottom of slope adjacent to shoreline	3a	grassland dominated by *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*							5-25%	50-75%		trace-5%				Narrow strip
86	-17.658209	150.827589	16/07/2021	2	Base of slope adjacent to shoreline	3a	closed grassland dominated by *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*							5-25%	75-95%		trace-5%	trace-5%			
92	-17.659213	150.82721	16/07/2021	2	Base of slope adjacent to shoreline	3a	grassland dominated by *Lepturus repens* with occasional emergent *Argusia argentea*	trace-5%						trace-5%	75-95%		trace-5%				
80	-17.658464	150.826408	16/07/2021	1	Slope to central depression	3b	closed herbland dominated by *Achyranthes aspera* and *Lepturus repens*					25-50%		trace-5%	25-50%		trace-5%				
66	-17.659101	150.826805	16/07/2021	2	Steep slope to S	5 - on ecotone with 3a	grassland dominated by *Lepturus repens*, *Stenotaphrum micranthum* and *Portulaca oleracea*					trace-5%		trace-5%	25-50%		5-25%	25-50%		*Stenotaphrum micranthum*	
M09	-17.658149	150.826732	16/07/2021	8		7	*Abutilon albescens* shrubland with a dense ground layer dominated by *Plumbago zeylanica Achyranthes aspera*		50-75%		trace-5%	5-25%		trace-5%	trace-5%	50-75%	trace-5%	trace-5%			

Site	Latitude	Longitude	Date	No. of photos	Landform	Veg Map Unit	Vegetation Community	Emergent	Upper Shrub Layer		Ground Layer									Plant Specimens Collected	Notes
								Argusia argentea	*Abutilon albescens*	*Argusia argentea*	*Abutilon albescens*	*Achyranthes aspera*	*Argusia argentea*	*Boerhavia albiflora* var. *albiflora*	*Lepturus repens*	*Plumbago zeylanica*	*Portulaca oleracea*	*Stenotaphrum micranthum*	*Tribulus cistoides*		
88	-17.658409	150.827218	16/07/2021	1	Flat plateau	8a	herbland dominated by *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*				trace-5%	50-75%		5-25%	trace-5%		5-25%		trace-5%	*Boerhavia albiflora* var. *albiflora*, *Tribulus cistoides*	
67	-17.658733	150.826807	16/07/2021	2		8c	herbland dominated by *Achyranthes aspera* and *Lepturus repens*					25-50%		trace-5%	5-25%	trace-5%			trace-5%		
76	-17.658143	150.826428	16/07/2021	2	Flat	8c	herbland dominated by *Achyranthes aspera* and *Abutilon albescens*				5-25%	50-75%			trace-5%	trace-5%	trace-5%				
77	-17.658321	150.826481	16/07/2021	3	Flat	8c	herbland dominated by *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*					5-25%		5-25%	trace-5%	trace-5%	5-25%				
91	-17.658918	150.827383	16/07/2021	2	Lower slopes adjacent to beach	11a	*Argusia argentea* shrubland with a dense ground layer dominated by *Lepturus repens*			5-25%		trace-5%		trace-5%	75-95%		trace-5%	trace-5%			
79	-17.658946	150.82651	16/07/2021	2	Top of S facing slope	11b	*Argusia argentea* open scrub with a dense ground layer dominated by *Lepturus repens* and *Achyranthes aspera*			25-50%		5-25%		trace-5%	50-75%						Old *Argusia argentea*, 2.0 to 2.5m; Some dead and some with dieback; slope below has younger *Argusia argentea*
81	-17.658332	150.825886	16/07/2021	1	Slope to W to beach	11b	*Argusia argentea* open shrubland with a dense ground layer dominated by *Lepturus repens* and *Portulaca oleracea*			5-25%				trace-5%	50-75%		5-25%		trace-5%		
87	-17.65813	150.827196	16/07/2021	2	Upper slope to crest of ridge	11b	*Argusia argentea* open shrubland with a mid-dense ground layer dominated by *Achyranthes aspera* and *Lepturus repens*			5-25%		25-50%		trace-5%	5-25%		trace-5%		trace-5%		
69	-17.657765	150.826889	16/07/2021	3	Slope to N	11c	*Argusia argentea* shrubland with a dense ground layer dominated by *Lepturus repens* and *Portulaca oleracea*			25-50%		trace-5%		trace-5%	75-95%		5-25%		trace-5%		
73	-17.657812	150.826119	16/07/2021	2	Slope to N	11c	*Argusia argentea* shrubland with a mid-dense ground layer dominated by *Lepturus repens*, Achyranthes repens and *Portulaca oleracea*			25-50%		5-25%		trace-5%	25-50%		5-25%		trace-5%	*Argusia argentea*, *Lepturus repens*, Portulaca oleraea	*Argusia argentea* 1.5m
89	-17.658649	150.827338	16/07/2021	2	Top of ridge	11c	*Argusia argentea* shrubland with a dense ground layer dominated by *Lepturus repens* and *Achyranthes aspera*			25-50%		5-25%		trace-5%	50-75%		trace-5%				
68	-17.658292	150.826738	16/07/2021	2	Depression	15	*Abutilon albescens* shrubland with a dense ground layer dominated by *Achyranthes aspera*, *Plumbago zeylanica* and *Abutilon albescens*		25-50%		5-25%	25-50%		trace-5%		25-50%	trace-5%			*Abutilon albescens*, *Achyranthes aspera*, *Plumbago zeylanica*	*Abutilon albescens* to 1.5m
75	-17.657978	150.826384	16/07/2021	2	Ridge crest	15	*Abutilon albescens* dwarf shrubland with a mid-dense ground layer dominated by *Abutilon albescens*, *Achyranthes aspera*, and *Plumbago zeylanica*		25-50%		5-25%	5-25%		trace-5%	trace-5%	5-25%					*Abutilon albescens* are 0.5 to 1.0m

Comparison with previous vegetation surveys

The vegetation of South Diamond Islet was surveyed by Hicks in October 1984. Quadrat locations of 9 quadrats positioned along 3 transects with species present, percent cover and height data for each quadrat are shown on a hand drawn map but averaged data is not included in the report.

All species recorded in October 1984 were also recorded in July 2021 as well as two additional species, *Abutilon albescens* and *Stenotaphrum micranthum*, that were not recorded in 1984. The former species dominated a shrubland community which formed a mosaic with the grassland/herbland community in the interior of the cay in July 2021. *Abutilon albescens* is a short lived small shrub that dies back in dry conditions and therefore it may have been present only in the soil seedbank during the previous survey. Alternatively, it may be a more recent arrival to the cay and may not have been established on the cay at the time of the previous survey.

It is difficult to compare the handwritten map and data with the July 2021 data and mapping, but no significant changes are apparent and verbal description of the vegetation in the report are consistent with the July 2021 data and observations.

Permanent monitoring site data

One permanent monitoring site (M09) was established and surveyed on South Diamond Islet. The location of the centre transect of this site is shown as the red line in *Figure 39*. *Table 29* contains the data recorded at this site. The photographs included with the data in this section are 3 of the 10 site photographs. These are taken from the centre point of the site in four different directions (facing 0, 90, and 180 degrees from the transect bearing respectively).

Table 29. BioCondition attributes recorded in the permanent monitoring site on South Diamond Islet.

Site M09	
Vegetation community description	*Abutilon albescens* shrubland with a dense ground layer dominated by *Plumbago zeylanica* and *Achyranthes aspera*
Transect start (WGS 84)	-17.658041 150.826521
Transect centre (WGS84)	-17.658149 150.826732
Transect end (WGS 84)	-17.658243 150.826926
Transect bearing	112^0
Median canopy height (range)	1.0 (0.3 to 1.5)m
Tree canopy cover %	n/a
Shrub canopy cover %	60.8%
Basal area m^2/ha (at 30 cm height, calculated from stem diameters)	nil
Total number of large trees/ha	0
Total no of trees per ha	n/a
Total number of tree stems/ha	n/a
Total no. shrubs/ha	n/a
Total no. shrub stems/ha	n/a
Large shrubs - mean diameter at 30 cm height	n/a
Recruitment of ecologically dominant layer (%)	n/a
Tree species richness	0
Tree species present	n/a
Shrub species richness	1
Shrub species present (layer in brackets)	*Abutilon albescens* (S1)
Median ground layer height (range)	0.5 (0.1 to 0.7)m
Total ground layer cover of native cay species (%)	90.6%
Grass species richness	2
Grass cover (%)	<0.2%
Grass species present in order of decreasing cover - most abundant first (cover in brackets)	*Lepturus repens* (0.2%), *Stenotaphrum micranthum (<0.2%)*
Forb (including vines) species richness	4
Forb species cover (%)	87.6%
Forb species present in order of decreasing cover - most abundant first (Cover in Brackets)	*Plumbago zeylanica (63.6%), Achyranthes aspera (24%), Boerhavia albiflora* var. *albiflora (<0.2%), Portulaca oleracea(<0.2%)*
Native shrub ground cover (%)- *Abutilon albescens*	3%
Non-native plant cover (all strata) (%)	0%
Litter cover (%)	9.4%
Bare ground (%)	0%
Woody debris (m/ha of Logs >0.5m long and >10cm wide)	nil
Soil pH	8.14 (0-10cm), 8.44 (10-20cm), 8.72 (20-30cm)

Photo 66: Monitoring site M09, South Diamond Islet facing ESE.

Photo 67: Monitoring site M09, South Diamond Islet facing SSW.

Photo 68: Monitoring site M09, South Diamond Islet facing WNW.

Soils data

Soil on and adjacent to the shoreline was white sand.

Lepturus repens grassland had predominantly white/light coloured sand.

Soil on the upper slopes and crests varied between light coloured/light grey brown sand to grey brown sand with some organic content.

Soil in the central depression was brown organic sand.

The table in Appendix 11 contains the results of the analysis of soil samples collected from monitoring site M09 during the vegetation survey. Refer to the general Vegetation Results and discussion for further discussion on the soil analyses results.

The *Abutilon albescens* shrubland site (M09) on South Diamond Islet had the lowest soil pH of all the permanent monitoring sites on the Diamond Islets and Lihou Reef cays. The soils at this site also had the highest organic carbon, electrical conductivity, total carbon, calcium, potassium and sulphur levels of all of the Diamond Islet and Lihou Reef cays. These levels reflect the benefit of organic matter on soil pH and soil fertility (as previously discussed).

.

Figure 41. South Diamond Islet - Health check, rodent tunnel and ant bait station monitoring sites.

Health checks

South Diamond Islet						
Ecosystems and biodiversity	**Health Checks**					
Value - Coral cay communities (Communities present listed below)	**Veg map unit**	Dominant Sub-dominant Remaining veg (ha)		Photomonitoring: N - North photo E - East photo S - South photo W - West photo		**Overall condition class[1]**
Shoreline and sandspit vegetation						
Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	1a	0.279				
Isolated plants of *Argusia argentea*	2	HC30	HC37	HC38	HC39	G
Grasslands and Herblands						
Grassland communities dominated by *Lepturus repens*	3a	HC28, HC29	HC30, HC31	HC37, HC38	HC39, HC40	G
	3b	HC31				G
Grassland communities dominated by *Stenotaphrum micranthum*	5	HC36				G
Herbland communities dominated by *Boerhavia albiflora* var. *albiflora*	6c	0.032				
Herbland communities dominated by *Plumbago zeylanica*	7	HC32, HC33	HC34, HC35	HC41, HC42S	HC43, HC44	G
Herbland communities dominated by *Achyranthes aspera*	8a	HC28W	HC42NEW	HC45	HC46	G
	8c	HC28W	HC42NEW	HC45	HC46	G
Shrublands						
Argusia argentea shrubland communities	11a	0.077				
	11b	HC28				G
	11c	HC29				G
Abutilon albescens dwarf shrubland/ shrubland with *Achyranthes aspera*	15	HC32, HC33	HC34, HC35	HC41, HC42S	HC43, HC44	G
Habitats and species						
Value - Seabird and shorebird habitat						G
Value -Turtle rookery (Green turtle *Chelonia mydas)*						G

[1]Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

Results

18 Health Checks were undertaken on South Diamond Islet to assess the condition of shoreline, grassland, herbland and shrubland communities. Health Checks assessed the condition of ten vegetation communities. Some of the vegetation communities not assessed by Health Checks are included in A. Overall vegetation condition.

Consistent with West, Central and East Diamond Islets, the overall condition rating for each of the vegetation communities on South Diamond Islet was Good.

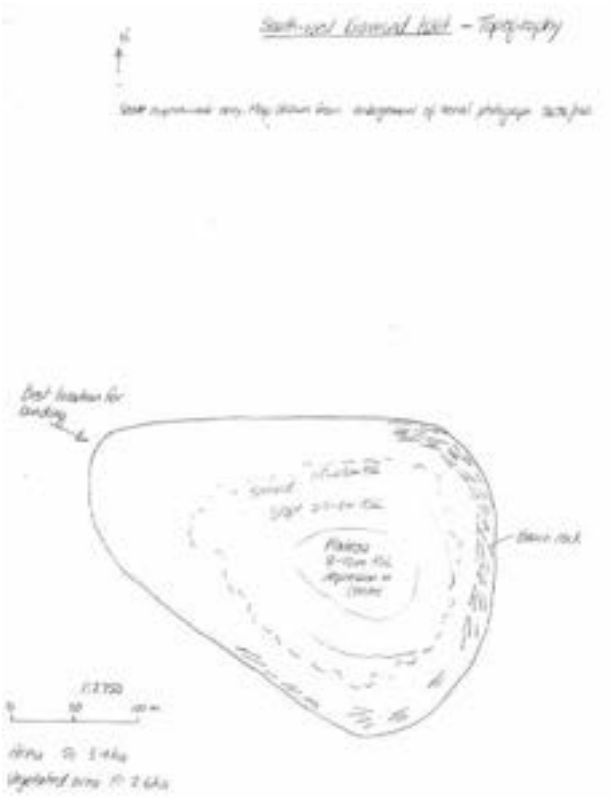


Figure 42. Map of South West Diamond Islet (South Diamond Islet) hand drawn from an aerial photograph (Hicks 1984). Note area estimated (vegetated 2.6 ha; entire cay 5.9ha) and 10-12 m ASL.

A. Overall vegetation condition

*Photo: **11a** Argusia argentea shrubland/ tall shrubland/ closed scrub on the northern side of South Diamond Islet.*

*Photo: South Diamond Islet supported healthy **3a** Lepturus repens grassland/ closed grassland +/- Achyranthes aspera, Boerhavia albiflora var. albiflora, Portulaca oleracea which occurs around the entire perimeter of the cay extending upslope towards the elevated centre of the cay. Note Lepturus growing over turtle body pit in the foreground. Photo taken facing east on the north side of the cay.*

*Photo: View looking east along **11c** Argusia argentea shrubland in the interior of the cay also occurring on the sloping areas surrounding the elevated centre of the cay. Photo taken facing east on the north side of the cay.*

*Photo: Looking across the sloping area in the interior of the cay with **3a** Lepturus repens grassland/ closed grassland +/- Achyranthes aspera, Boerhavia albiflora var. albiflora, Portulaca oleracea and **11c** Argusia argentea shrubland in interior of cay. Photo taken facing west from HC38.*

*Photo: At the northwestern spit new plant growth has restored vegetation impacts of prior turtle nesting activity (**1a** Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines). Inset photo: Close view of healthy grasses encroaching bare sand. Photos taken near HC40.*

*Photo: View looking southeast along the western shoreline showing new runners extending into sand and beach rock rubble (**3a** Lepturus repens grassland/ closed grassland +/- Achyranthes aspera, Boerhavia albiflora var. albiflora, Portulaca oleracea). Photo taken directly west of HC30.*

*Photo: **3a** Lepturus repens grassland/ closed grassland +/- Achyranthes aspera, Boerhavia albiflora var. albiflora, Portulaca oleracea with **11c** Argusia argentea shrubland on the left of the photo in the interior of the cay. Photo taken facing south at HC30.*

Photo: The elevated centre of the cay supports four herbland communities. Note the overall healthy condition of vegetation. Photo taken from HC33 facing west.

Photo: Facing south from HC38 overlooking the southern spit. Note undulations from turtle nesting activity and plant coverage (Lepturus) that has overgrown turtle body pits. Note masked booby nesting in turtle body pit (foreground).

Photo: Close view of Lepturus restoring turtle body pit scars from prior turtle nesting.

*Photo: New plant growth restoring vegetation from prior turtle nesting stabilising the shoreline and providing seabird nesting habitat. (**1a** Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines) Photo taken facing east from the southern end of South Diamond Islet.*

B. Health Check photo monitoring - sample photo of each vegetation type

*Photo: HC37 **2** Isolated plants of Argusia argentea (Sub-dominant).*

*Photo: HC38 **3a** Lepturus repens grassland/ closed grassland +/- Achyranthes aspera, Boerhavia albiflora var. albiflora, Portulaca oleracea.*

Photo: HC31 ***3b*** *Lepturus repens/ Achyranthes aspera grassland or closed grassland/herbland or closed herbland (Seasonally variable) with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea (Sub-dominant).*

Photo: HC36 ***5*** *Stenotaphrum micranthum open grassland/ grassland with Boerhavia albiflora var albiflora +/- Achyranthes aspera, Portulaca oleracea.*

Photo: HC35 ***7*** *Plumbago zeylanica/ mixed closed herbland with Lepturus repens, Canavalia rosea , Achyranthes aspera +/- Abutilon albescens.*

Photo: HC45 ***8a*** *Achyranthes aspera Herbland/closed herbland with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea (Sub-dominant).*

*Photo: HC42 **8c** Achyranthes aspera mixed herbland/closed herbland with Lepturus repens and Plumbago zeylanica +/- Abutilon albescens, Boerhavia albiflora var. albiflora, Portulaca oleracea.*

*Photo: HC28 **11b** Argusia argentea open shrubland /tall open shrubland/open scrub.*

Photo: HC29 ***11c*** *Argusia argentea shrubland in interior of cay.*

Photo: HC41 ***15*** *Abutilon albescens* dwarf shrubland/ shrubland with *Achyranthes aspera (Sub-dominant).*

Introduced pests

A. Rodents

Table 30. Rodent tunnel monitoring - South Diamond Islet.

South Diamond Islet			
No. of rodent tunnels	Date deployed	Date collected	Evidence of rodents (tracks, droppings)
7[1]	16/7/21	16/7/21	Nil

[1] Refer *Figure 41*.

B. Ants and other invertebrates

Table 31. Invertebrate species summary - South Diamond Islet.

South Diamond Islet					
Specimen no.	Date	Site	Specimen	Identification	Native / introduced
26	16/7/21	NA	Moth	TBA	TBA
27	16/7/21	NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*	Native
28	16/7/21	NA	Grasshopper	*Aiolopus thalassinus* (*Acrididae*)	Native
29	16/7/21	RT3	Ants	*Nylanderia 'obscura'*[1]	Native
30	16/7/21	RT1	Ants	*Nylanderia 'obscura'*	Native
31	16/7/21	RT5	Ants	*Nylanderia 'obscura'*	Native
32	16/7/21	NA	Tick	*Amblyomma loculosum*[2]	Native
33	16/7/21	RT7	Ants	*Nylanderia 'obscura'*	Native

[1] There is a species of *Nylanderia* that was present in samples from three islands - South Diamond, Central Diamond and West Diamond Islets. This species is believed to be native to the mainland and is most likely *Nylanderia obscura*. However, this is a difficult genus of ants and not been revised for Australia so this identification is tentative, hence the quotation marks around the species name (Chris Burwell 2021 pers. comm.)

[2]*Amblyomma loculosum* was first described by Neumann in 1907 from specimens found in Mauritius (Uilenbero 1977). This specie is now known from Seychelles, Cocos Keeling, Australia, Carolines, New Caledonia, Indian Ocean, Pacific Ocean and the Coral Sea where adult and immature ticks parasitise seabirds and also humans. A new arbovirus was isolated from *Amblyomma loculosum* taken from the feet of two dead Roseate terns *Sterna dougalli arideensis* in the Seychelles (Hoogstraal et al.1976).

Hoogstraal (1976) considered that the role of *Amblyomma loculosum* as a reservoir and vector of bird and human infections was worthy of further studies.

In Hoogstraal et al (1976) *Amblyomma loculosum* was recorded in the Coral Sea at SW Diamond Islet, Wreck Reef, Cato Island (Hindwood et al. 1963); South Diamond Islet (Roberts 1969); Bird Island (Wreck Reef), Northeast Island, Diamond Cay No. 1 (Gregory 1964).

In 1961 specimens of *Amblyomma loculosum* were collected in the Coral Sea by K.A. Hindwood from a human at Wreck Reef, Bird Island; Great frigate bird *Fregata minor peninsulae* (great frigatebird *Fregata minor*) at Northeast Is., Harald (Herald) Cay; Lesser frigate bird *Fregata ariel* (lesser frigatebird *Fregata ariel*) at Diamond Cay No.1; Wedge-tailed shearwater *Puffinicus pacificus chlorohynchus* (*Ardenna pacifica*) and Common noddy *Anous stolidus antelius* (*Anous stolidus*) at Wreck Reef, Bird Island; and Red faced bobby *Sula rubripes* (red-footed booby *Sula sula*) in (Hoogstraal et al. 1976).

5. South West Cay (Nellie Cay)

Birds

Table 32. Species and breeding effort – South West Cay.

South West Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
17/07/2021	brown booby				17	110	G,N
17/07/2021	buff-banded rail				1	2	G,N
17/07/2021	common noddy				2207	3302	G,P
17/07/2021	crested tern				12	7	G,Y
17/07/2021	lesser frigatebird				364	364	G/V,Y
17/07/2021	masked booby				28	34	G,N
17/07/2021	Pacific golden plover				0	3	
17/07/2021	red-footed booby				33	25	V,P
17/07/2021	ruddy turnstone				0	1	
17/07/2021	sooty tern				3721	5638	G,Y
17/07/2021	wandering tattler				0	1	
17/07/2021	welcome swallow				0	1	

Figure 43. Buff-banded rail, Gallirallus philippensis ssp. tounelieri. Adult with chick.

Figure 44. Buff-banded rail, adult. Coral Sea birds have a reduced buff breast band.

Figure 45. Sooty tern, Onychoprion fuscatus. Young birds regulating heat.

Vegetation

Cay description

South West Cay is located on Lihou Reef at -17.644 degrees latitude and 151.414 degrees longitude. The cay has a total vegetated area of 5.7 hectares.

Figure 46 contains surface elevation profiles of South West Cay.

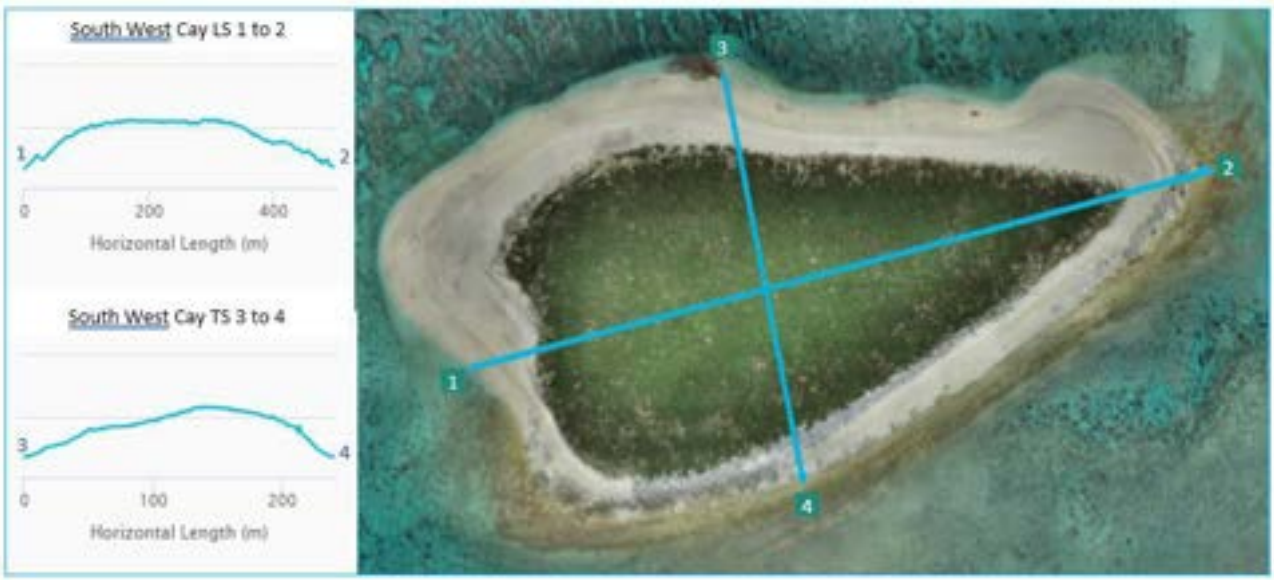


Figure 46. Surface profiles of South West Cay.

Note: Maximum height is approximately five metres ASL. Vertical heights and scale are not included in surface profile diagrams as accurate datum information was not available

The vegetation of the cay consisted predominantly of grasses and other herbaceous species. No trees or large shrubs were present. In some places, *Abutilon albescens* formed a low shrub layer.

Survey intensity

Approximately three and a half hours was spent surveying the vegetation of South West Cay. Vegetation data was recorded at 17 ground-truthing sites. The locations of these sites are shown in *Figure 47*. The blue lines are the boundaries of the vegetation communities shown on the vegetation map in *Figure 48*.

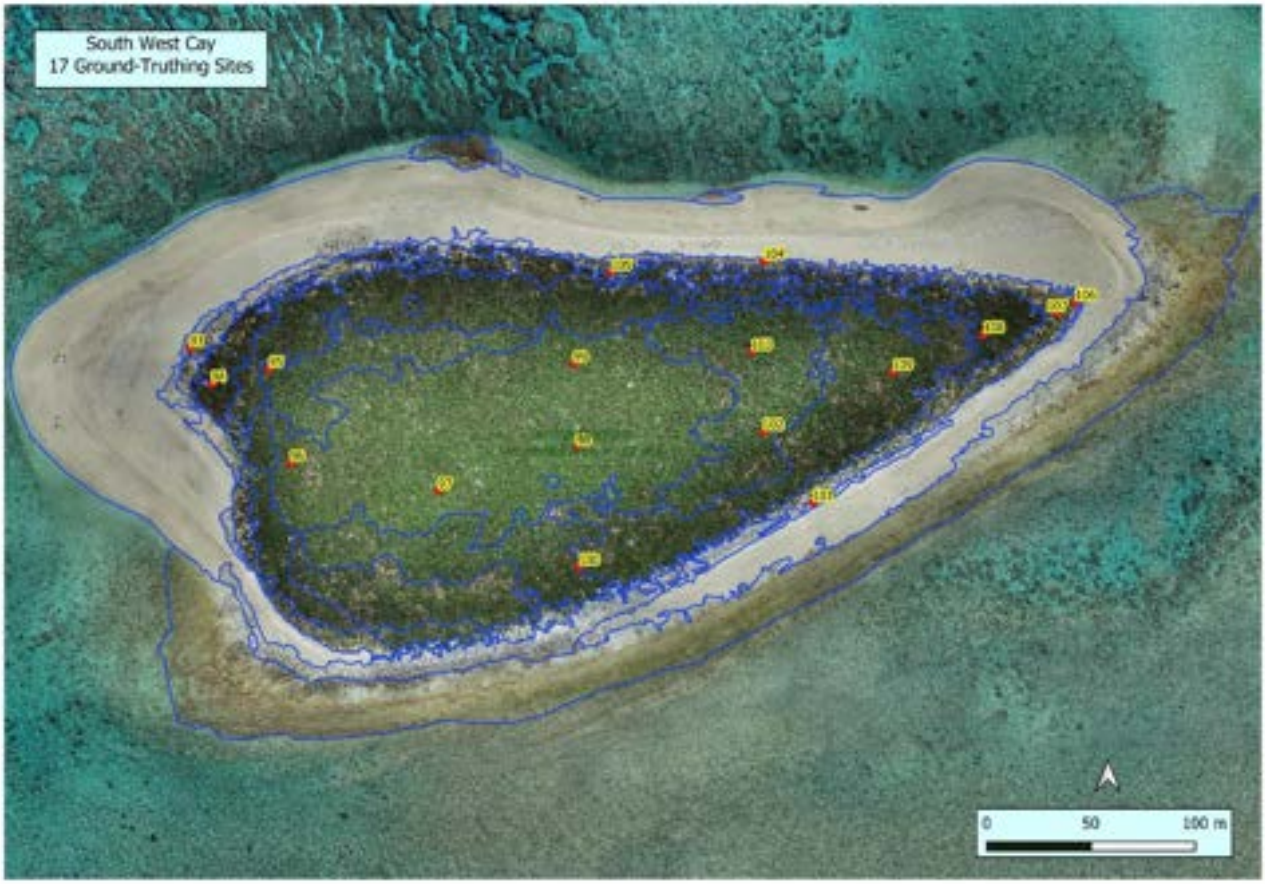


Figure 47. South West Cay showing the number and location of ground-truthing sites relative to the vegetation.

Vegetation condition

The vegetation of South West Cay at the time of the July 2021 surveys was generally good. There was quite a large amount of scale on the *Achyranthes aspera* and *Abutilon albescens* in places. There were no attending ants. It seemed to be present in patches of senescing and dying plants and most healthy *Achyranthes aspera* and *Abutilon albescens* in the vicinity were free of the scale. It could not be determined whether the scale was causing the decline of the infested plants or whether the scale was attacking plants that were naturally senescing or dying or stressed from some other cause. Whichever scenario is correct, the bare scale infested patches provided areas of decreased vegetation cover surrounded by areas of good vegetation cover - a combination which appeared to provide favoured habitat for nesting birds.

Photo 51: Bare patches where scale infestation was prevalent on South West Cay.

Photo 52: Scale and hatched scale eggs on Achyranthes aspera stems on South West Cay.

Floristic data

Seven plant species were recorded on South West Cay. These are listed in *Table 33* in order of frequency in sites together with the averaged cover for each species for sites in which the species was present and their averaged cover over the entire cay. Data for species cover at each site plus occurrence of each species in relation to vegetation community and landform are contained in *Table 35*.

Table 33. Plant species recorded on South West Cay, 17/07/2021.

Layers: (E) = emergent, (S1) = upper shrub, (S2) = lower shrub, (G) = Ground

Species	Common Name	Family	Presence in Sites (% of sites)	Average % Cover in Each Layer - (Only sites containing the species were averaged)	Overall Average % Cover in Each Layer – (average includes all sites)
Boerhavia albiflora var. *albiflora*	boerhavia	Nyctaginaceae	94%	4.1% (G)	3.8% (G)
Lepturus repens	stalky grass	Poaceae	76%	30.8% (G)	23.5% (G)
Achyranthes aspera	chaff flower	Amaranthaceae	76%	29.8% (G)	22.8% (G)
Portulaca oleracea	pig weed	Portulacaceae	47%	2.5% (G)	1.2% (G)
Abutilon albescens	lantern bush	Malvaceae	41%	2.5% (E), 43.8 (S1),18.3% (G)	0.1% (E), 10.3% (S1), 6.5% (G)
Stenotaphrum micranthum	beach buffalo grass	Poaceae	35%	18.8% (G)	6.6% (G)
Tribulus cistoides	bulls head burr	Zygophyllaceae	35%	2.5% (G)	0.9% (G)
Total no of species = 7					

Vegetation communities on South West Cay

Vegetation communities present on South West Cay in July 2021, the area of each and representative survey sites within each vegetation community are listed in *Table 34*. The spatial distribution and extent of the vegetation communities on South West Cay in July 2021 are shown in the vegetation map in *Figure 48*.

Vegetation of the cay consisted only of grasses and other herbaceous species. No trees or large shrubs were present.

Map unit 1a was present along the sandy shorelines on the north and west of the cay. The dominant species in this unit was *Stenotaphrum micranthum* (beach buffalo grass). Other species present were *Boerhavia albiflora* var. *albiflora* (boerhavia) and *Lepturus repens* (stalky grass). *Portulaca oleracea* (pigweed) was also present at some sites. This unit was not present along rubble bank shorelines where it was replaced by sparse herblands containing *Abutilon albescens* (lantern bush), *Achyranthes aspera* (chaff flower), *Portulaca oleracea* and *Stenotaphrum micranthum* (map unit 1b).

A narrow zone of *Lepturus repens*/*Stenotaphrum micranthum* grassland (map unit 4) was present adjacent to map unit 1a paralleling the sandy shorelines. A zone dominated by *Lepturus repens* grassland (map unit 3a) adjoined and paralleled the landward side of map unit 4.

Stenotaphrum micranthum grassland (map unit 5) was also present adjacent to the shoreline on the eastern spit and in smaller patches adjacent to the shoreline in several other places.

Dwarf shrublands/shrublands of *Abutilon albescens* (map unit 15) were present on the upper slopes to the interior of the cay. The ground layer of the shrublands were co-dominated by *Achyranthes aspera* and Juvenile *Abutilon albescens* with *Boerhavia albiflora* var. *albiflora* present in lower abundance.

The most abundant vegetation in the central interior of the cay was *Lepturus repens/Achyranthes aspera grassland*/herbland (map unit 3b). *Boerhavia albiflora* var. *albiflora* and *Tribulus cistoides* (bulls head burr) were also present at lower abundance at most sites in this unit.

Achyranthes aspera herbland/closed herbland with *Boerhavia albiflora* var. *albiflora* (map unit 8a) was also present in the interior vegetation. *Abutilon albescens* and *Portulaca oleracea* were also present in this unit, the latter at low abundance.

Table 34. Vegetation communities on South West Cay.

Veg Map Unit Code	Vegetation Community	Hectares on South West Cay	ID of Sites on South West Cay
	Unvegetated Areas		
A	Sandy shores	3.3 (approx.)	
B	Lithified shores	1.9 (approx.)	
C	Rubble banks	0.3	
	Shoreline and Sandspit Vegetation		
1a	Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	0.144	93, 104, 106
1b	Littoral sparse herbland on shoreline rubble banks	0.158	101
	Grasslands and Herblands		
3a	*Lepturus repens* grassland/ closed grassland +/- *Achyranthes aspera* +/- *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	0.697	94, 105, 108
3b	*Lepturus repens*/ *Achyranthes aspera* closed grassland/herbland/closed herbland (seasonally variable) with *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	1.873	97, 98, 99, 109
4	*Lepturus repens*/*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea*	0.228	nil
5	*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora* +/- *Achyranthes aspera* +/-*Portulaca oleracea*	0.264	107
6c	*Boerhavia albiflora* var. *albiflora*/ *Achyranthes aspera* open herbland/ herbland with *Portulaca oleracea* +/ *Lepturus repens* +/- *Stenotaphrum micranthum*	0.491	nil
8a	*Achyranthes aspera* herbland/closed herbland with *Boerhavia albiflora* var. *albiflora*	0.765	96
	Interior Shrublands		
15	*Abutilon albescens* dwarf shrubland to shrubland with a mid-dense to dense ground layer of *Abutilon albescens*, *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* +/- *Lepturus repens* +/- *Plumbago zeylanica* +/- *Stenotaphrum micranthum*	1.036	95, 100, 102, 103

Note: Areas of sandy shores and rocky shores, particularly those of the rocky shores are only approximate due to the difficulty in determining the location of the boundary between the edge of the shoreline and the surrounding reef flat using the imagery.

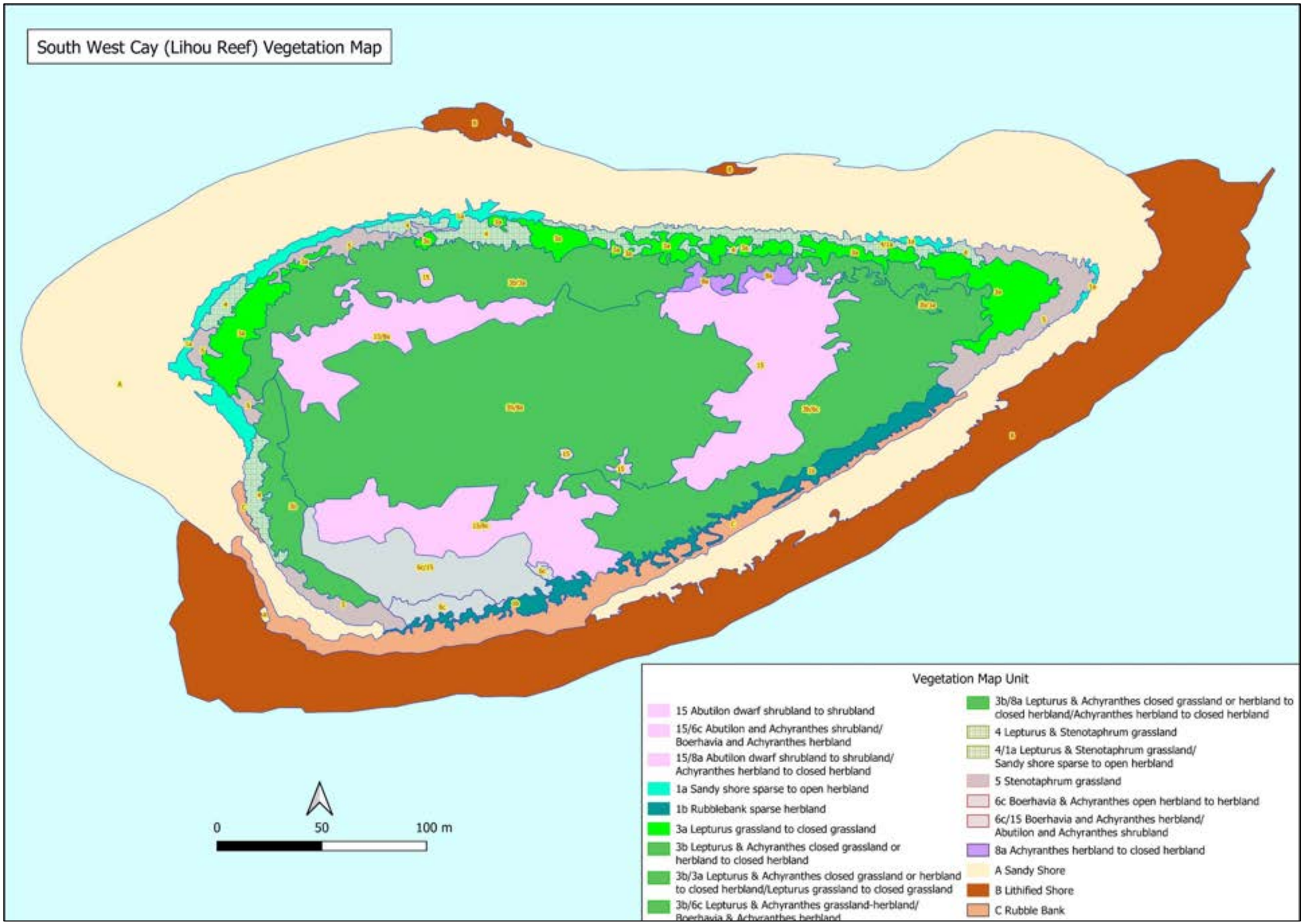


Figure 48. South West Cay vegetation map.

Table 35. Site data recorded on South West Cay.

Datum = WGS 84; green shading = site dominants

Site	Latitude	Longitude	Date	No. of photos	Landform	Veg Map Unit	Vegetation Community	Emergents	Upper Shrub Layer	Ground Layer							Plant Specimens Collected	Notes
								Abutilon albescens	*Abutilon albescens*	*Abutilon albescens*	*Achyranthes aspera*	*Boerhavia albiflora* var.	*Lepturus repens*	*Portulaca oleracea*	*Stenotaphrum micranthum*	*Tribulus cistoides*		
93	-17.643532	151.412124	17/07/2021	2	Shoreline	1a	open grassland dominated by *Stenotaphrum micranthum*					trace-5%	trace-5%		5-25%			Very narrow polygon
104	-17.643157	151.414597	17/07/2021	2	Shoreline	1a	open grassland dominated by *Lepturus repens* and *Stenotaphrum micranthum*					trace-5%	5-25%	trace-5%	5-25%		*Lepturus repens*, *Stenotaphrum micranthum*	
106	-17.643334	151.415939	17/07/2021	2	Shoreline	1a	open grassland dominated by *Stenotaphrum micranthum*					trace-5%	trace-5%		5-25%			
101	-17.644198	151.414808	17/07/2021	2	Rocky shoreline	1b	sparse herbland of *Abutilon albescens*, *Achyranthes aspera*, *Portulaca oleracea* and *Stenotaphrum micranthum* with occasional emergent *Abutilon albescens*	trace-5%		trace-5%	trace-5%			trace-5%	trace-5%		*Portulaca oleracea*	*Abutilon albescens* is approximately 0.9 m tall; Some scale present on Abutilon and *Achyranthes aspera*
94	-17.643685	151.412219	17/07/2021	2	Adjacent to shoreline	3a	closed grassland dominated by *Lepturus repens*					trace-5%	75-95%	trace-5%	trace-5%	trace-5%		
105	-17.643205	151.413939	17/07/2021	2		3a	grassland dominated by *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*				trace-5%	5-25%	25-50%			trace-5%	*Boerhavia albiflora* var. *albiflora*, *Tribulus cistoides*	
108	-17.643473	151.415544	17/07/2021	2	Base of slope to beach	3a	closed grassland dominated by *Lepturus repens*, *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*				5-25%	5-25%	50-75%	trace-5%				
97	-17.644147	151.413195	17/07/2021	2	Crest	3b	closed herbland dominated by *Achyranthes aspera* and *Lepturus repens*			trace-5%	50-75%	trace-5%	25-50%	trace-5%		trace-5%		
98	-17.643959	151.413791	17/07/2021	2	Crest	3b	closed herbland dominated by *Achyranthes aspera* and *Lepturus repens*				25-50%	trace-5%	25-50%			trace-5%		
99	-17.6436	151.413778	17/07/2021	2	Slope to N	3b	closed grassland dominated by *Lepturus repens* and *Achyranthes aspera*				25-50%	trace-5%	50-75%			trace-5%		Scale on *Achyranthes aspera*
109	-17.643635	151.415152	17/07/2021	2	Slope	3b	closed herbland dominated by *Achyranthes aspera* and *Lepturus repens*				25-50%	trace-5%	5-25%					
107	-17.643381	151.415861	17/07/2021	2	Adjacent to shoreline	5	grassland dominated by *Stenotaphrum micranthum*				trace-5%	trace-5%	trace-5%	trace-5%	50-75%			
96	-17.644027	151.412558	17/07/2021	2	lower slope	8a	closed herbland dominated by *Achyranthes aspera* and *Abutilon albescens*			5-25%	50-75%	trace-5%		trace-5%			*Abutilon albescens*, *Achyranthes aspera*	
95	-17.643622	151.412466	17/07/2021	2	lower slope	15	*Abutilon albescens* dwarf Shrubland with a dense ground layer dominated by *Achyranthes aspera* and *Lepturus repens*		25-50%		25-50%	trace-5%	25-50%	trace-5%		trace-5%		*Abutilon albescens* 65 to 70. cm
100	-17.644474	151.413801	17/07/2021	2	Slope to S	15	*Abutilon albescens* dwarf Shrubland with a dense ground layer dominated by *Abutilon albescens* and *Achyranthes aspera*		25-50%	25-50%	25-50%	trace-5%						Egging scale on *Abutilon albescens* as *Achyranthes aspera*. No evidence of parasitoids
102	-17.643891	151.414594	17/07/2021	2	Slope to beach	15	*Abutilon albescens* dwarf Shrubland with a dense ground layer dominated by *Abutilon albescens* and *Achyranthes aspera*		25-50%	25-50%	25-50%	trace-5%	trace-5%					Abutilon is approximately 1.1m tall
103	-17.643548	151.414545	17/07/2021	2	Slope to N	15	*Abutilon albescens* Shrubland with a dense ground layer dominated by *Abutilon albescens* and *Achyranthes aspera*		50-75%	5-25%	5-25%	trace-5%						Quite a lot of scale on *Achyranthes aspera* in the area between sites 91 and 105

Comparison with previous surveys

Vegetation on South West Cay has been previously described by Hill and Hogg (1984) and Hicks (1984). Species recorded on these surveys were the same as those recorded in the July 2021 survey with the exception of *Tribulus cistoides* which was recorded during the July 2021 surveys but not on previous surveys.

The following are comparisons of averaged percent covers and percent frequency in sites recorded in 14 quadrats along a single transect by Hicks (October 1984) and the 19 ground truthing sites recorded during the July 2021 surveys:

- *Boerhavia* %cover/%frequency in quadrats = 10.5% /87% Oct 1984); 3.8%/94% (July 2021)
- *Achyranthes aspera* %cover/%frequency in quadrats = 7.2% /47% (Oct 1984); 22.8%/76% (July 2021)
- *Lepturus repens* %cover/%frequency in quadrats = 4%/53% (Oct 1984); 23.5%/76% (July 2021)
- *Stenotaphrum micranthum* %cover/%frequency in quadrats = 1% /13% (Oct 1984); 6.6%/35% (July 2021)
- *Portulaca oleracea* %cover/%frequency in quadrats = 1.5% /27% (Oct 1984); 1.2%/47% (July 2021)

Although it is difficult to compare verbal descriptions with mapped data, the vegetation described in these reports seems similar to that present at the time of the July 2021 survey.

Both data sets suggest that the most widespread species on the cay is *Boerhavia* (although abundance is relatively low in most sites and that the cover of the co-dominant species, *Lepturus repens* and *Achyranthes aspera* have increased since the 1984 survey, although this increase is likely the result of differences in prevailing and recent rainfall regime.

The difference in the abundance and frequency of *Stenotaphrum micranthum* may be the result of differences in locations sampled.

Hinchey and Stokes also visited South West Cay in August 1987 and commented that there had been no significant change in the vegetation since the previous surveys.

Grant et al. reported that there appeared to be little change to the description of the vegetation given by Hicks (1984).

Permanent monitoring site data

No permanent monitoring sites were established on South West Cay.

Soils data

Soils on and adjacent to the shoreline consisted of white sand containing coral rubble.

Grasslands adjacent to the shoreline had light grey to grey brown sand.

The soils of the slopes and crests were typically grey brown sand, often with some organic content.

No soil samples were collected for analyses on South West Cay.

Figure 49. South West (Nellie) Cay - Health check, rodent tunnel and ant bait station monitoring sites.

Health checks

South West (Nellie) Cay						
(Hill and Hogg 1984 described Nellie Cay as teardrop-shaped with a tapering end pointing east, long axis generally east-west, 300m wide and 490m in length, area 10.4 ha calculated from a 1969 aerial photograph, profile 5m high.)						
Ecosystems and biodiversity	**Health Checks**					
Value - Coral cay communities (Communities present listed below)	**Veg map unit**	Dominant Sub-dominant Remaining veg (ha)		Photomonitoring: N - North photo E - East photo S - South photo W - West photo		**Overall condition class**[1]
Shoreline and sandspit vegetation						
Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	1a	0.144				
Littoral sparse herbland on shoreline rubble banks	1b	0.158				
Grasslands and Herblands						
Grassland communities dominated by *Lepturus repens*	3a	HC47NSE	HC53	HC58		G
	3b	HC48ES, HC49	HC50, HC51NEW	HC54, HC57	HC58	G
Grassland communities co-dominated by *Lepturus repens* and *Stenotaphrum micranthum*	4	0.228				
Grassland communities dominated by *Stenotaphrum micranthum*	5	HC47W				G
Herbland communities dominated by *Boerhavia albiflora* var. *albiflora*	6c	HC51S	HC52	HC54		G
Herbland communities dominated by *Achyranthes aspera*	8a	HC48, HC49	HC50	HC51NEW	HC57	G
Shrublands						
Argusia argentea shrubland communities	15	HC48, HC51S	HC52	HC55	HC56	G
Habitats and species						
Value - Seabird and shorebird habitat						G
Value -Turtle rookery (Green turtle *Chelonia mydas)*						G

[1]Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

Results

12 Health Checks were undertaken on South West Cay to assess the condition of shoreline, grassland, herbland and shrubland communities. Health Checks assessed the condition of six vegetation communities. Some of remaining vegetation communities not assessed by Health checks are included in A. Overall vegetation condition.

The overall condition rating for each of the vegetation communities was Good. The vegetation on South West Cay was lush, green with high plant biomass, height and coverage. The healthy condition was evident across the cay including the shoreline where plants were actively growing onto bare sand.

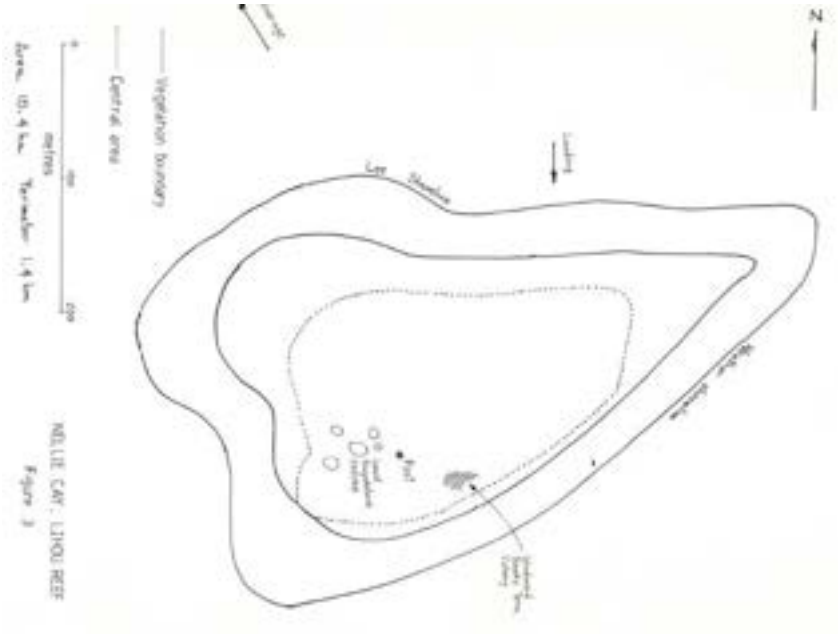


Figure 50. Map of Nellie Cay (South West Cay) (Hill and Hogg 1984). Note area of cay estimated 10.4 ha.

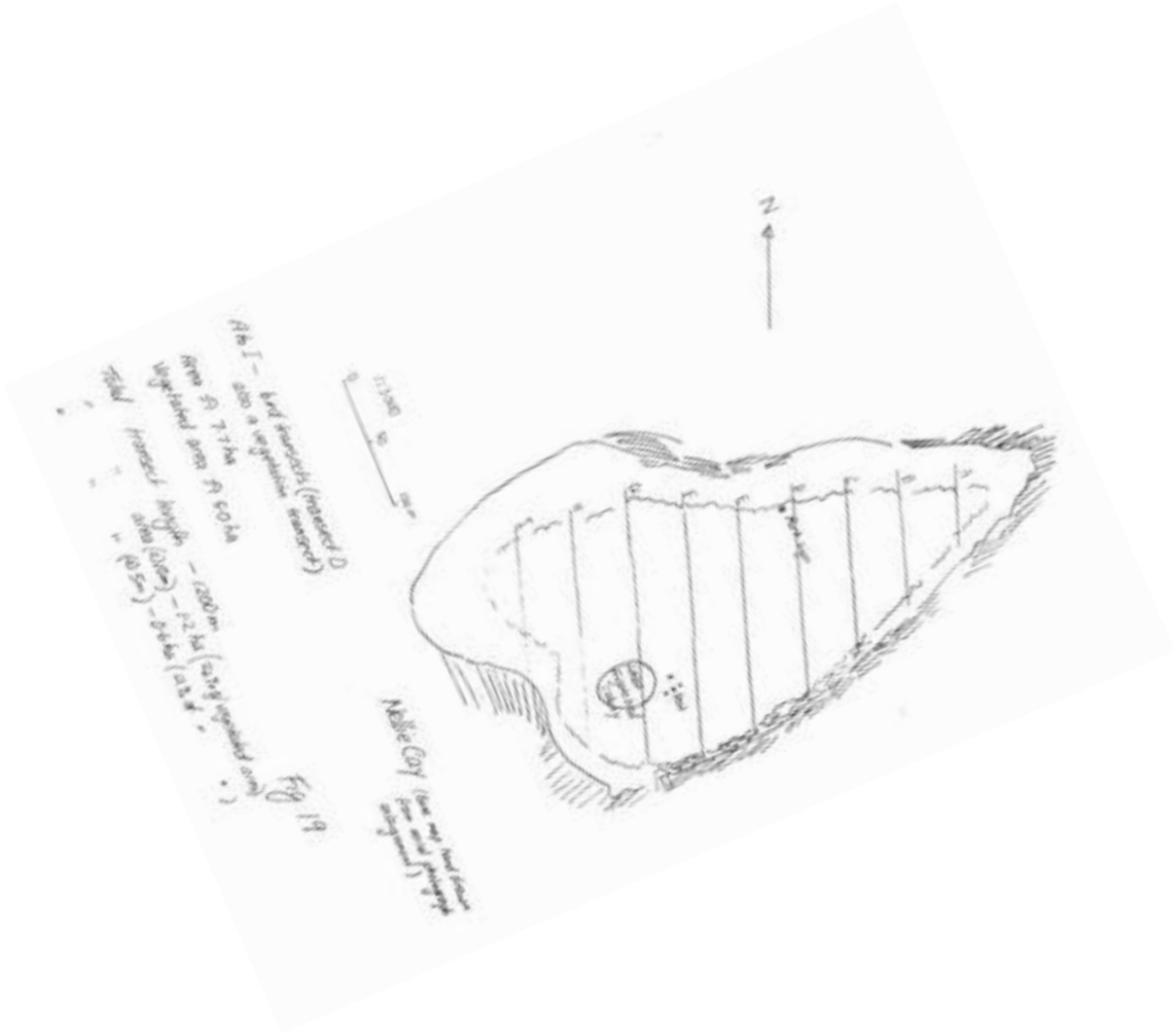


Figure 51. Map of Nellie Cay (South West Cay) hand drawn from aerial photograph (Hicks 1984). Note area of cay estimated (vegetated area 5 ha; entire cay 7.7 ha).

Plate 16: Nellie Cay, Lihou Reef NNR: showing vegetated area and large numbers of seabirds.

Photo: Photo of shoreline of South West Cay from Grant et al. (1986).

Photo: Estimated general area and aspect of 1986 photo in Grant et al. (1986). Photo taken adjacent to HC58 on the north side of the cay facing east.

A. Overall vegetation condition

*Photo: A brown booby nest established on new growth of Boerhavia, Portulaca, and Stenotaphrum spp in **1a** Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines. Photo taken at the northwestern spit of South West Cay.*

*Photo: Thick, tall growth of **3a** Lepturus repens grassland/ closed grassland +/- Achyranthes aspera, Boerhavia albiflora var. albiflora, Portulaca oleracea supports seabird nesting habitat. Photo facing south from HC47.*

*Photo: View of healthy Lepturus grassland community **3b** and herbland community dominated by Achyranthes aspera **8a** in the interior of the cay. Photo facing north from HC49.*

Photo: Close view showing lush, fertile growth of Achyranthes aspera.

Photo: Photo showing scale on stems of Achyranthes. Scale was present on Achyranthes and Abutilon spp.in some areas of the cay interior.

Photo: Close view showing healthy growth of Abutilon albescens in the cay interior.

*Photo: View from the north side of the interior south looking across tall grassland communities **3a** and **3b**. Note overall green condition, plant height and coverage. Photo taken from HC58.*

*Photo: Close view showing healthy, new growth in grassland community **3b**. Photo taken at HC58.*

*Photo: Looking across **4** Lepturus repens/Stenotaphrum micranthum grassland with Boerhavia albiflora var. albiflora, Portulaca oleracea on the north side of the cay. Photo taken facing east at Rodent tunnel 45.*

*Photo: Looking west on the windward side across **5** Stenotaphrum micranthum open grassland/ grassland with Boerhavia albiflora var albiflora +/- Achyranthes aspera, Portulaca oleracea. Photo taken south of HC53/Rodent tunnel 42. Note evidence of new growth on tussocks. (Breeding seabirds were utilising this community but were disturbed at the time of the photo.)*

B. Health Check photo monitoring - sample photo of each vegetation type

Photo: HC53 ***3a*** *Lepturus repens grassland/ closed grassland +/- Achyranthes aspera, Boerhavia albiflora var. albiflora, Portulaca oleracea.*

Photo: HC54 ***3b*** *Lepturus repens/ Achyranthes aspera grassland or closed grassland/herbland or closed herbland (Seasonally variable) with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea.*

*Photo: HC47 **5** Stenotaphrum micranthum open grassland/ grassland with Boerhavia albiflora var albiflora +/- Achyranthes aspera, Portulaca oleracea.*

*Photo: HC52 **6c** Boerhavia albiflora var. albiflora/ Achyranthes aspera open herbland +/ Lepturus repens, Portulaca oleracea (Sub-dominant).*

*Photo: HC48 **8a** Achyranthes aspera Herbland/closed herbland with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea.*

*Photo: HC56 **15** Abutilon albescens dwarf shrubland/ shrubland with Achyranthes aspera.*

Introduced pests

A. Rodents

Table 36. Rodent tunnel monitoring - South West (Nellie) Cay.

South West (Nellie) Cay			
No. of rodent tunnels	Date deployed	Date collected	Evidence of rodents (tracks, droppings)
8[1]	17/7/21	17/7/21	Nil

[1] Refer *Figure 49*.

B. Ants and other invertebrates

Table 37. Invertebrate species summary - South West (Nellie) Cay.

South West (Nellie) Cay[1]					
Specimen no.	Date	Site	Specimen	Identification	Native / introduced
34	17/7/21	RT3	Small flies	TBA	TBA
35	17/7/21	NA	Ants	not ants but small flies	TBA
36	17/7/21	RT4	Ants	*Cardioconyla nuda* or *atalanta*	Native
37	17/7/21	HC56	Scale	TBA	TBA
38	17/7/21	RT4	Lady beetle	1 x *Harmonia octomaculata*	Native
39	17/7/21	NA	Scale	TBA	TBA

[1]During a previous ANPWS survey in 1984 six mites and ticks, one silverfish, two isopods, five centipede, one springtails, one roach, two crickets, seven spiders and 10 beetles were collected on Nellie Cay (South West Cay) (Hill and Hogg 1984).

6. Georgina Cay

Birds

Table 38. Species and breeding effort – Georgina Cay.

Georgina Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
17/07/2021	Australian pelican				0	1	
17/07/2021	black-naped tern				80	130	G,Y
17/07/2021	brown booby				11	25	G,N
17/07/2021	common noddy				190	400	G,Y
17/07/2021	crested tern				0	1	
17/07/2021	masked booby				27	31	G,N
17/07/2021	New Caledonian fairy tern				52	59	G,Y
17/07/2021	Pacific golden plover				0	1	
17/07/2021	roseate tern				1	2	G,Y
17/07/2021	ruddy turnstone				0	4	G,Y
17/07/2021	sooty tern				872	3181	

Figure 52. New Caledonian fairy tern, Sternula nereis exsul. Breeding adults at nesting colony.

Figure 53. New Caledonian fairy tern. Adult preparing to feed chick.

New Caledonian fairy terns, black-naped terns and a pair of roseate terns shared a breeding area on the western, unvegetated section of Georgina Cay (see *Figure 56*). The fairy terns preferred substrate consisting of worn coral rubble and shells rather than the finer sandy substrate surrounding it.

Sitting adults, nests with up to three eggs and mobile chicks were observed. Chicks were well hidden in the coarser rubble within the breeding area.

The single roseate tern nest was within the black-naped tern colony, but the fairy terns and black-naped terns did not overlap into each other's territory.

The fairy tern colony of around 50 breeding pairs (100+ adults) is significant considering the previously estimated population for this subspecies was only around 300 adults. Other non-breeding birds were recorded on several other cays during the voyage.

A further journal article will be prepared with these findings.

Most available time during this visit was dedicated to observing the fairy tern colony.

Figure 54. Roseate tern, Sterna dougalli defending nest within a black-naped tern, Sterna sumatrana and New Caledonian fairy tern, Sternula nereis exsul colony.

Figure 55. Australian pelican, Pelicanus conspicillatus and masked booby.

A surprising find: an Australian pelican displaying a breeding flush through its bill pouch.

Figure 56. Georgina Cay, New Caledonian fairy tern, black-naped tern and roseate tern breeding colony circled in yellow.

Vegetation

Cay description

Georgina Cay is located on Lihou reef at -17.595 degrees latitude and 151.503 degrees longitude. It is an elongated cay. The cay is long and thin and the 2019 image shows an unvegetated section in the southwest separated from the vegetated northeastern section by a tidally inundated strait about 140m wide. On inspection in July 2021 there was no separation between the spit and main vegetated cay. The entire length of the spit was joined to the cay. Based on the 2021 image the vegetated area is only 65 m in the widest part. The cay has a total vegetated area of 2.8 hectares. The unvegetated southwestern section is not included in the vegetation map in *Figure 59* or the map in *Figure 58*.

Figure 57 contains surface elevation profiles of Georgina Cay.

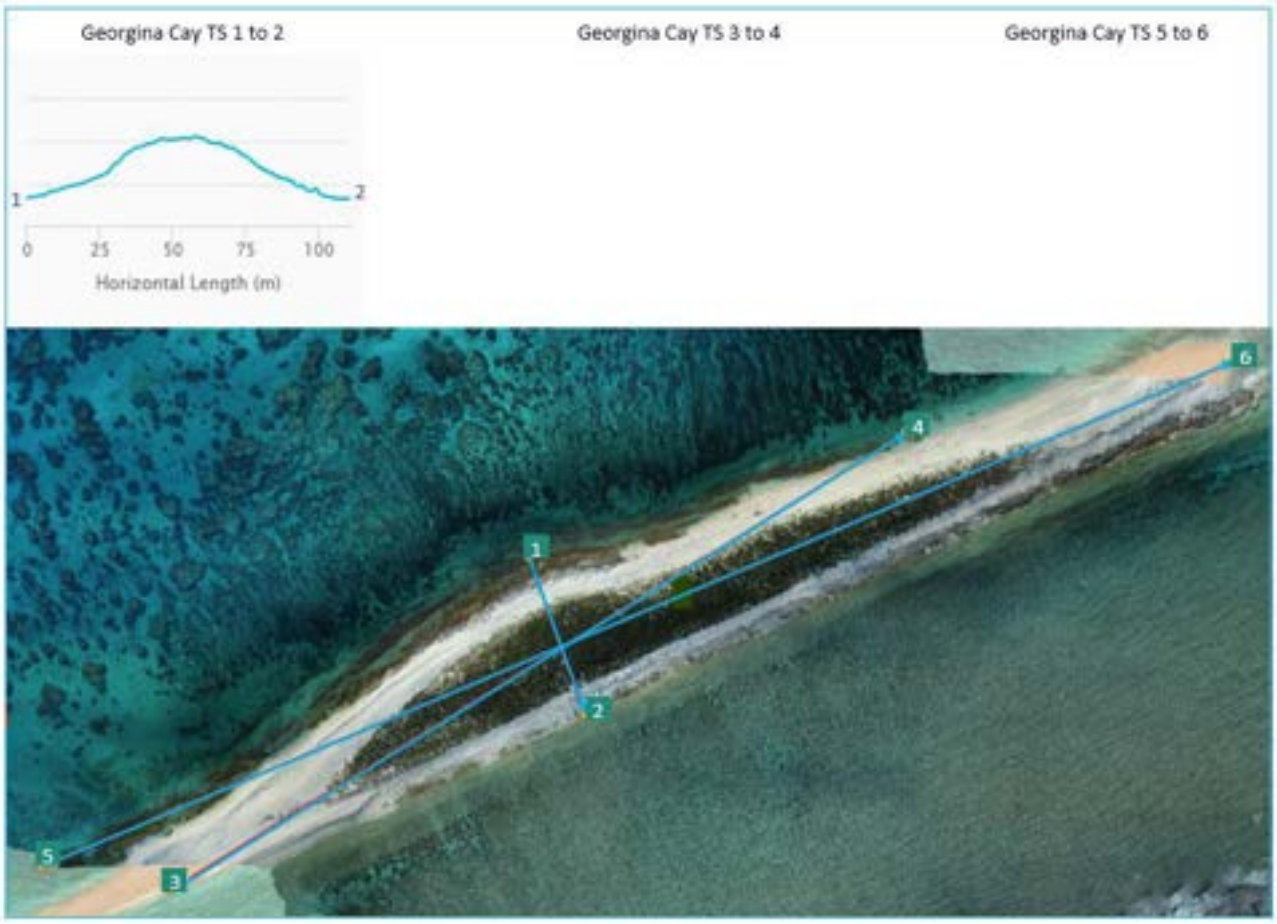


Figure 57. Surface profiles of Georgina Cay.

Note: Maximum height is approximately six metres ASL. Vertical heights and scale are not included in surface profile diagram as accurate datum information was not available

The only evidence of human activity on the cay are the remains of what is thought to have been a coral slab shelter.

The vegetation of the cay consisted predominantly of grasses and other herbaceous species. No trees or large shrubs were present. In some places, *Abutilon albescens* formed a low shrub layer.

Survey intensity

Two hours was spent surveying the vegetation of Georgina Cay. Vegetation data was recorded at 19 ground-truthing sites. The locations of these sites are shown in *Figure 58*. The blue lines are the boundaries of the vegetation communities shown on the vegetation map in *Figure 59*.

Figure 58. Georgina Cay showing the number and location of ground-truthing sites relative to the vegetation.

Vegetation condition

All the vegetation on the cay was in good condition.

Floristic data

Five plant species were recorded on Georgina Cay. These are listed in *Table 39* in order of frequency in sites together with the averaged cover for each species for sites in which the species was present and their averaged cover over the entire cay. Data for species cover at each site plus occurrence of each species in relation to vegetation community and landform are contained in *Table 40*.

Table 39. Plant species recorded on Georgina Cay, 17/07/2021.

Layers: (E) = emergent, (S1) = upper shrub, (S2) = lower shrub, (G) = Ground

Species	Common Name	Family	Presence in Sites (% of sites)	Average % Cover in Each Layer (Only sites containing the species were averaged)	Overall Average % Cover in Each Layer – (average includes all sites)
Stenotaphrum micranthum	beach buffalo grass	Poaceae	95%	23.9% (G)	22.6% (G)
Boerhavia albiflora var. *albiflora*	boerhavia	Nyctaginaceae	95%	12.1% (G)	11.4% (G)
Achyranthes aspera	chaff flower	Amaranthaceae	63%	37.1% (G),	23.4% (G)
Portulaca oleracea	pig weed	Portulacaceae	47%	3.9% (G)	1.8% (G)
Abutilon albescens	lantern bush	Malvaceae	21%	2.5% (E), 37.5% (S1), 10.8% (G)	0.1% (E), 2.0% (S1), 1.7% (G)
Total no of species = 5					

It was interesting that *Lepturus repens* which was frequent and abundant on the other cays, was entirely absent from Georgina Cay. There are no herbarium specimen records for its presence on Georgina Cay in any of the state or national Herbaria, although It was reported as being present on Georgina Cay during the 1984 voyages (Hill 1984; Hill and Hogg 1984). *Stenotaphrum micranthum* was the dominant grass on Georgina Cay, present in 95% of sites across the cay. On other cays, *Stenotaphrum* was a dominant grass in the coastal vegetation communities but was less widespread in the interior communities. The annual herbaceous *Achyranthes aspera*, also prevalent on the other cays, dominated the interior communities on Georgina Cay.

Vegetation communities on Georgina Cay

Vegetation communities present on Georgina Cay in July 2021, the area of each and representative survey sites within each vegetation community are listed in *Table 40*. The spatial distribution and extent of the vegetation communities on Georgina Cay in July 2021 are shown in the vegetation map in *Figure 59*.

Vegetation of the cay consisted only of grasses and other herbaceous species. No trees or large shrubs were present.

Vegetation Map unit 1a was present adjacent to the established vegetation along the entire shoreline on the leeward (northern) side of the cay. *Stenotaphrum micranthum* (beach buffalo grass) was the dominant species in this unit with *Boerhavia albiflora* var. *albiflora* (boerhavia) present in low abundance at most sites. This unit was absent on the windward southern side.

Stenotaphrum micranthum grassland with *Boerhavia albiflora* var. *albiflora* (map unit 5) was present on the slopes all along the windward southern side.

Herbland dominated by *Boerhavia albiflora var. albiflora* and *Stenotaphrum micranthum* (map unit 6b) was present in a few locations adjacent to the shoreline.

A single small patch of *Abutilon albescens* (lantern bush) dwarf shrubland with a sparse ground layer dominated by *Achyranthes aspera* and *Stenotaphrum micranthum* (map unit 15) was present at site 128.

The vegetation of the interior of the cay consisted of *Achyranthes aspera* (chaff flower) closed herbland with *Boerhavia albiflora* var. *albiflora* (map unit 8a) and *Achyranthes aspera*/*Stenotaphrum micranthum*/ *Boerhavia albiflora* var. *albiflora* herbland/ closed herbland (map unit 8b). *Portulaca oleracea* (pigweed) also occurred at low frequency in these units.

Table 40. Vegetation communities on Georgina Cay.

Veg Map Unit Code	Vegetation Community	Hectares on Georgina Cay	ID of sites on Georgina Cay
	Unvegetated Areas		
A	Sandy shores	3.7 (approx.)	
B	Lithified shores	2.2 (approx.)	
C	Rubble banks	0.1 (approx.)	
	Shoreline and Sandspit Vegetation		
1a	Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	0.550	110, 118, 120, 121, 125
	Grasslands and Herblands		
5	*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora* +/- *Achyranthes aspera* +/-*Portulaca oleracea*	0.800	113, 114, 117, 119, 122
6b	*Boerhavia albiflora* var. *albiflora*/ *Stenotaphrum micranthum* open herbland/herbland with *Portulaca oleracea*	0.271	126
8a	*Achyranthes aspera* herbland/closed herbland with *Boerhavia albiflora* var. *albiflora*	0.551	111, 124
8b	*Achyranthes aspera*/*Stenotaphrum micranthum*/ *Boerhavia albiflora* var. *albiflora* herbland/ closed herbland +/- *Abutilon albescens* +/- *Portulaca oleracea*	0.635	Sites: 112, 115, 116, 123, 127
	Interior Shrublands		
15	*Abutilon albescens* dwarf shrubland to shrubland with a mid-dense to dense ground layer of *Abutilon albescens*, *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* +/- *Lepturus repens* +/- *Plumbago zeylanica* +/- *Stenotaphrum micranthum*	0.010	128

Note: Areas of sandy shores and rocky shores, particularly those of the rocky shores are only approximate due to the difficulty in determining the location of the boundary between the edge of the shoreline and the surrounding reef flat using the imagery.

Comparison with previous vegetation surveys

Hicks (October, 1984) noted that *Lepturus repens*, reported by Hill and Hogg on Georgina Cay 2 August, 1984 was not seen on his visit a few months later. This species was not present on Georgina Cay in July 2021 and there are no other records (including herbarium records) of *Lepturus repens* on Georgina Cay, suggesting that the August 1984 record may be an error.

Portulaca oleracea, present in 47% of the sites in the July 2021 survey was not recorded in the abovementioned surveys.

The following are comparisons of averaged percent covers and percent frequency in sites recorded in 20 quadrats along a north to south transect by Hicks (October 1984) and the 19 ground truthing sites recorded during the July 2021 surveys:

- *Boerhavia* %cover/% frequency in quadrats = 9.45% / 80% (Oct 1984); 11.4%/95% (July 2021)
- *Achyranthes aspera* %cover/% frequency in quadrats = 0.35% /5% (Oct 1984); 23.4%/63% (July 2021)
- *Stenotaphrum micranthum* %cover/% frequency in quadrats = 6.9% /60% (Oct 1984); 22.6%/95% (July 2021)

The above data suggests that the cover and frequency of both *Achyranthes aspera* and *Stenotaphrum micranthum* has increased since 1984.

It is difficult to compare quadrat cover data from the 1984 report for specific cay landforms with those for the 2021 mapped vegetation communities, but it appears that the vegetation communities are similar in both data sets.

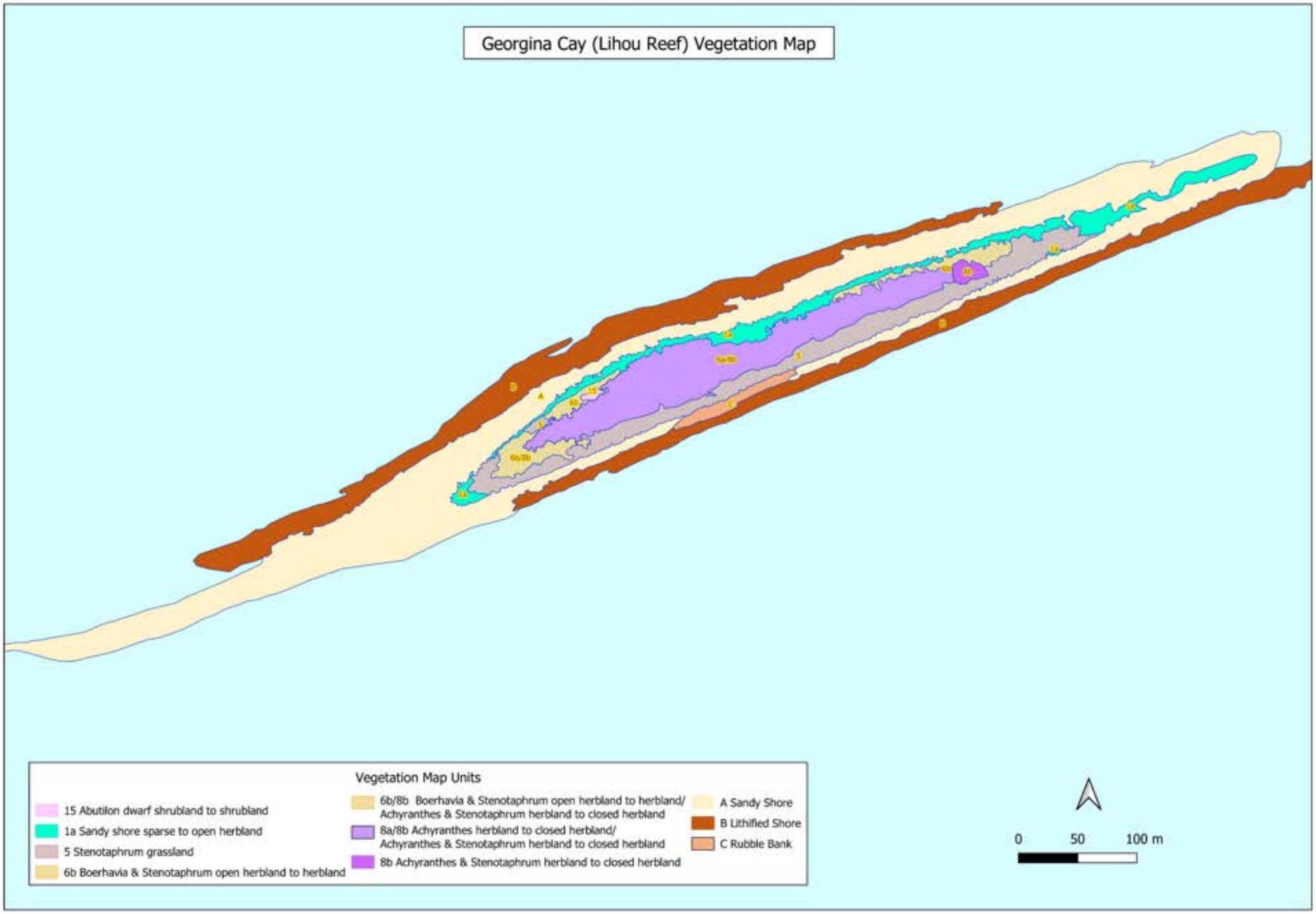


Figure 59. Georgina Cay vegetation map.

Table 41. Site data recorded on Georgina Cay.
Datum = WGS 84; green shading = site dominants

Site	Latitude	Longitude	Date	No. of photos	Landform	Veg Map Unit	Vegetation Community	Emergent	Upper Shrub Layer	Ground Layer					Plant Specimens Collected	Notes
								Abutilon albescens	*Abutilon albescens*	*Abutilon albescens*	*Achyranthes aspera*	*Boerhavia albiflora* var. *albiflora*	*Portulaca oleracea*	*Stenotaphrum micranthum*		
110	-17.594635	151.5029	17/07/2021	2	Shoreline	1a	open grassland dominated by *Stenotaphrum micranthum*				trace-5%	trace-5%	trace-5%	5-25%		
118	-17.594156	151.5044	17/07/2021	2	Shoreline	1a	open grassland dominated by *Stenotaphrum micranthum*					trace-5%		5-25%		
120	-17.594136	151.5049	17/07/2021	1	Start of NE spit	1a	open grassland dominated by *Stenotaphrum micranthum*					trace-5%		5-25%		
121	-17.593551	151.5061	17/07/2021	1	NE spit	1a	sparse grassland dominated by *Stenotaphrum micranthum*							trace-5%		Extent of the vegetation; Open grassland between this site and site 120
125	-17.596093	151.5002	17/07/2021	1	Just above high tide mark	1a	open grassland dominated by *Stenotaphrum micranthum*					trace-5%		25-50%		
113	-17.595037	151.5028	17/07/2021	2	Slope to S-east	5	grassland dominated by *Stenotaphrum micranthum*, *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*				5-25%	5-25%		50-75%		
114	-17.594706	151.5035	17/07/2021	2	Slope to SE	5	grassland dominated by *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*				trace-5%	25-50%	trace-5%	25-50%		
117	-17.594239	151.5045	17/07/2021	2	Crest	5	grassland dominated by *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*					5-25%		25-50%		
119	-17.594184	151.5047	17/07/2021	1	Crest of main ridge	5	grassland dominated by *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*					5-25%		25-50%	*Boerhavia albiflora* var. *albiflora*, *Stenotaphrum micranthum*	
122	-17.595328	151.5021	17/07/2021	2	SE slope	5	grassland dominated by *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*				trace-5%	5-25%	trace-5%	50-75%	*Portulaca oleracea*	
126	-17.595918	151.5004	17/07/2021	1	Undulating (turtle activity)	6b	herbland dominated by *Boerhavia albiflora* var. *albiflora* and *Stenotaphrum micranthum*					5-25%	trace-5%	5-25%		
111	-17.594645	151.5031	17/07/2021	2	Upper slope to beach	8a	closed herbland dominated by *Achyranthes aspera*			trace-5%	75-95%	trace-5%	trace-5%			
124	-17.595125	151.5017	17/07/2021	2	Slope to NW	8a	closed herbland dominated by *Achyranthes aspera*, *Abutilon albescens* and *Boerhavia albiflora* var. *albiflora*			5-25%	75-95%	5-25%		trace-5%	*Abutilon albescens*, *Achyranthes aspera*	Achyranthes closed herbland with *Abutilon albescens* to the NW (no site recorded in that polygon)
112	-17.5949	151.5026	17/07/2021	2	Crest	8b	closed herbland dominated by *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* and *Stenotaphrum micranthum*				50-75%	5-25%	trace-5%	5-25%		
115	-17.594523	151.5036	17/07/2021	2	Crest	8b	herbland dominated by *Achyranthes aspera*, *Abutilon albescens*, *Boerhavia albiflora* var. *albiflora* and *Stenotaphrum micranthum*	trace-5%		5-25%	25-50%	5-25%		5-25%		
116	-17.594404	151.5037	17/07/2021	1	NW slope to beach	8b	herbland dominated by *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora*, *Stenotaphrum micranthum* and *Portulaca oleracea*				5-25%	5-25%	5-25%	5-25%		
123	-17.595332	151.5017	17/07/2021	2	Crest	8b	closed herbland dominated by *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* and *Stenotaphrum micranthum*				75-95%	5-25%	trace-5%	5-25%		
127	-17.595761	151.5008	17/07/2021	0	Lower slope	8b	herbland dominated by *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora*, and *Stenotaphrum micranthum*				25-50%	5-25%	trace-5%	5-25%		
128	-17.595371	151.5011	17/07/2021	2	Slope to NW	15	*Abutilon albescens* dwarf shrubland with a sparse ground layer dominated by *Achyranthes aspera* and *Stenotaphrum micranthum*		25-50%		5-25%	trace-5%		5-25%		

Permanent monitoring site data

No permanent monitoring sites were established on Georgina Cay.

Soils data

Soil on and adjacent to the shoreline was white sand with occasional coral rubble fragments.

The grasslands on the slopes had white/light coloured sandy soil with rock outcrop at a number of sites

Soils of the herblands and shrubland on the slopes and crests were typically light grey brown to brown sandy soils, sometimes with obvious organic content.

No soil samples were collected for analyses on Georgina Cay.

Figure 60. Georgina Cay - Health check, rodent and ant bait station monitoring sites.

Health checks

Georgina Cay						
(Hill and Hogg (1984) described Georgina Cay as elongate near straight cay divided into a major eastern and minor western parts divided by 135 m wide shallow strait (1m deep). The major cay is approximately 135m wide and 1180 m in length and the minor cay approx. 60 wide and 460m in length. The profile of the major cay was 6 m high. Area of major cay 10.5 ha, minor cay 2.0 ha, perimeter of major cay 2.8 km.) (Grant et al. (1986) During 1986 ANPWS survey Grant et al. notes significant difference to previous surveys by Hill and Hogg (1984) and Hicks (1984) that major and minor cay were connected except for a few waves observed overwashing the connection on departure from the cay.) (2019 image of Georgina Cay shows vegetated northeastern section is separated from the unvegetated section in the southwest by tidally inundated strait approx. 140m wide. In July 2021 A. McDougall observed that the entire length of the unvegetated spit was intact and joined to the vegetated part of the cay. 2021 drone image verifies nil separation along its length.)						
Ecosystems and biodiversity	**Health Checks**					
Value - Coral cay communities (List of communities present)	**Veg map unit**	Dominant Sub-dominant Remaining veg (ha)		Photomonitoring: N - North photo E - East photo S - South photo W - West photo		**Overall condition class[1]**
Shoreline and sandspit vegetation						
Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	1a	HC60				G
Grasslands and Herblands						
Grassland communities dominated by *Lepturus repens*	5	HC61	HC62	HC65S		G
Herbland communities dominated by *Boerhavia albiflora* var. *albiflora*	6b	HC65NEW				G
Herbland communities dominated by *Achyranthes aspera*	8a	HC59	HC63	HC64		G
	8b	HC59	HC63	HC64		G
Shrublands						
Abutilon albescens dwarf shrubland/ shrubland with *Achyranthes aspera*	15	0.010				
Habitats and species						
Value - Seabird and shorebird habitat						G
Value -Turtle rookery (Green turtle *Chelonia mydas)*						G

[1]Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

Photo: View of the long and narrow Georgina Cay with its elongated western spit. Photo taken facing south.

Figure 61. Map of Georgina Cay hand drawn from aerial photograph (Hicks 1984). Note spit configuration. Vegetated area of cay estimated 1.8 ha.

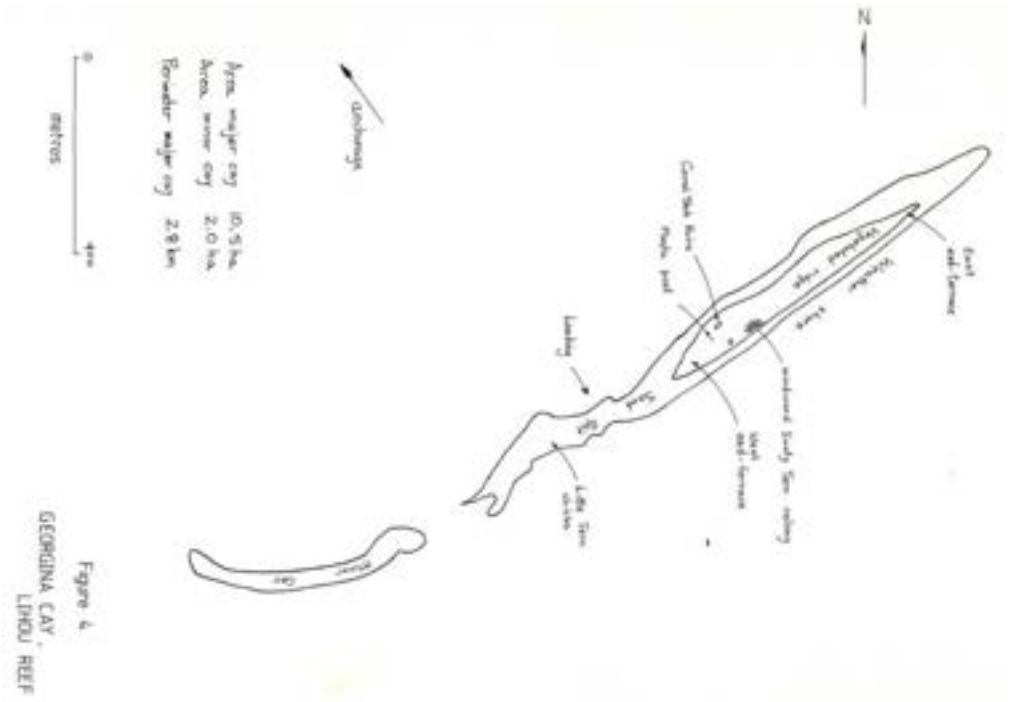


Figure 62. Hand drawn map of Georgina Cay (Hill and Hogg 1984). Note spit configuration. Entire area of major cay estimated 10.5 ha.

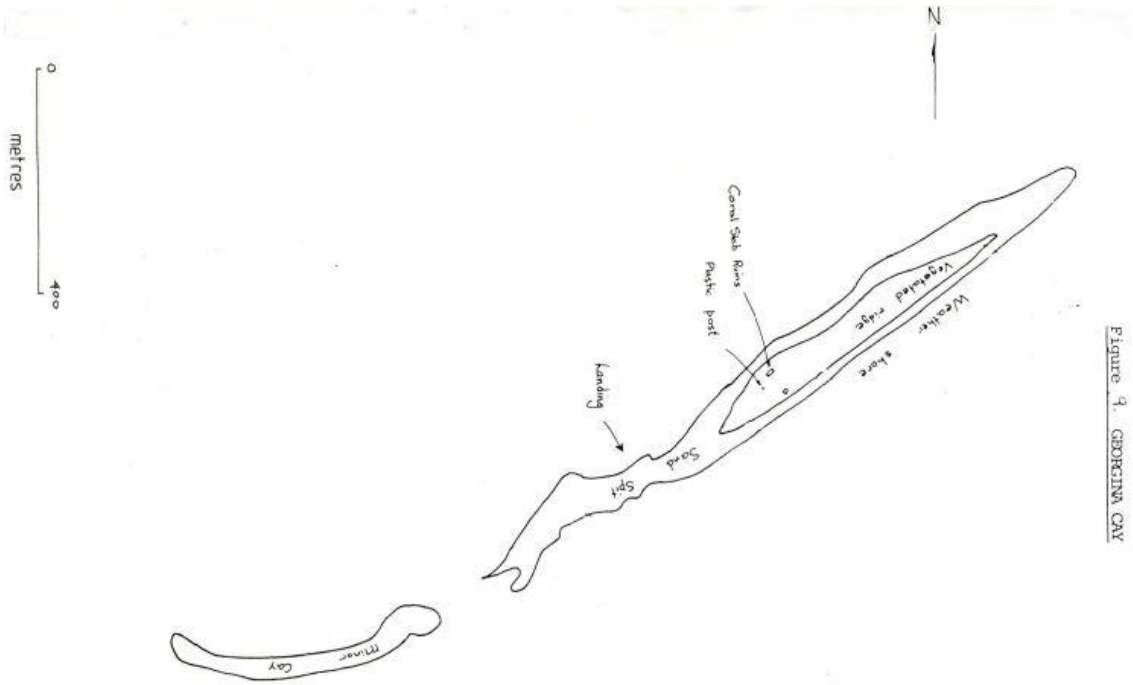


Figure 63. Hand drawn map of Georgina Cay (Grant et al. 1986). Map appears identical to Hill and Hogg (1984). During 1986 ANPWS survey Grant et al. notes significant difference to previous surveys by Hill and Hogg (1984) and Hicks (1984) that major and minor cay were connected except for a few waves observed overwashing the connection on departure from the cay.

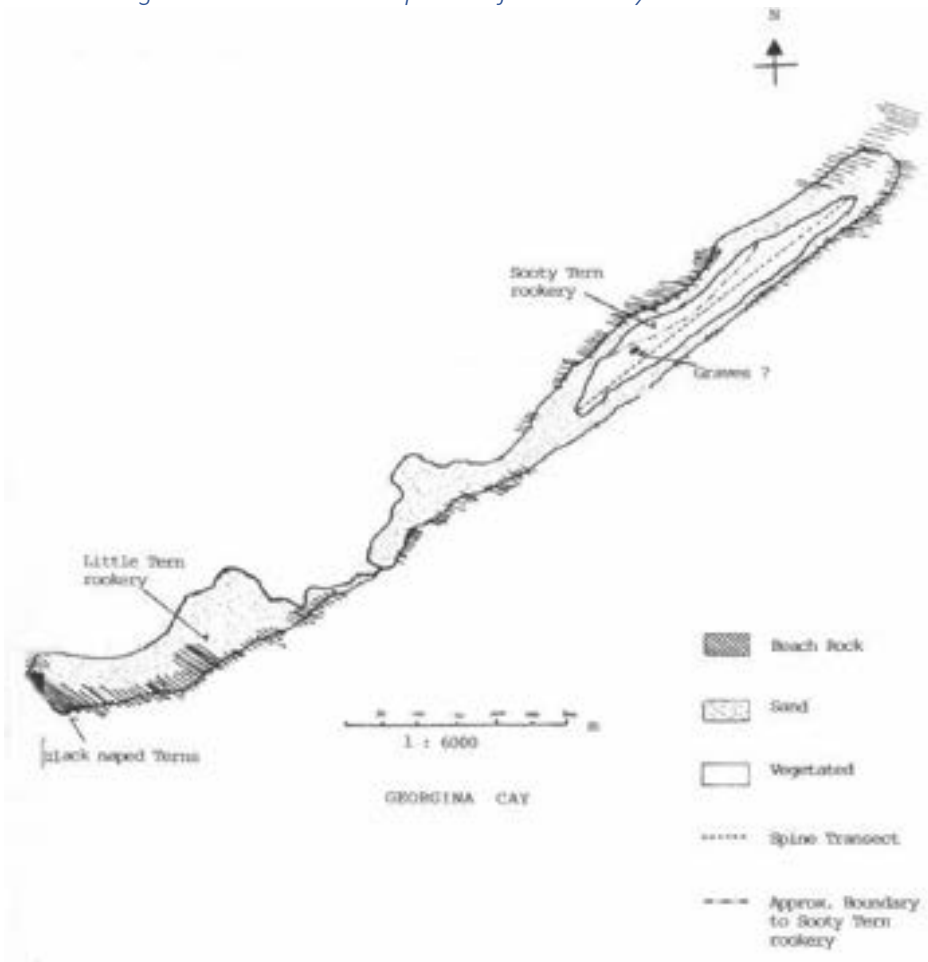


Figure 64. Hand drawn map of Georgina Cay (Hinchey and Stokes 1987). Note spit configuration.

Photo: July 2021 drone image looking along south western end of Georgina Cay showing entire length of spit joined to vegetated section of cay. Surveys conducted since 1984 (and 2019 imagery in Figure 60) document a separation of the unvegetated spit from the vegetated section of the cay.

Figure 13. Georgina Cay. Looking west from end of main ridge. End-terrace middle distance. Minor cay in distance & adjoining spit.

Figure 65. Photo of Georgina Cay looking west along spit (Hill and Hogg 1984).

Photo: Estimated location of 1984 photo looking west along spit at western end of Georgina Cay.

Seven Health Checks were undertaken on Georgina Cay to assess the condition of shoreline, grassland, herbland and shrubland communities. Health Checks assessed the condition of five vegetation communities. Remaining vegetation communities not assessed by Health Checks may be included in A. Overall vegetation condition.

The overall condition rating for each of the vegetation communities was Good. The vegetation on this long, narrow cay was green with good plant biomass and coverage. Vegetation communities around the long sandy shoreline were intact with plants actively encroaching bare sand.

A. Overall vegetation condition

*Photo: View across herbland communities **8a** and **8b** to the eastern (vegetated) spit from HC59. Note the lush condition, good height and coverage of vegetation.*

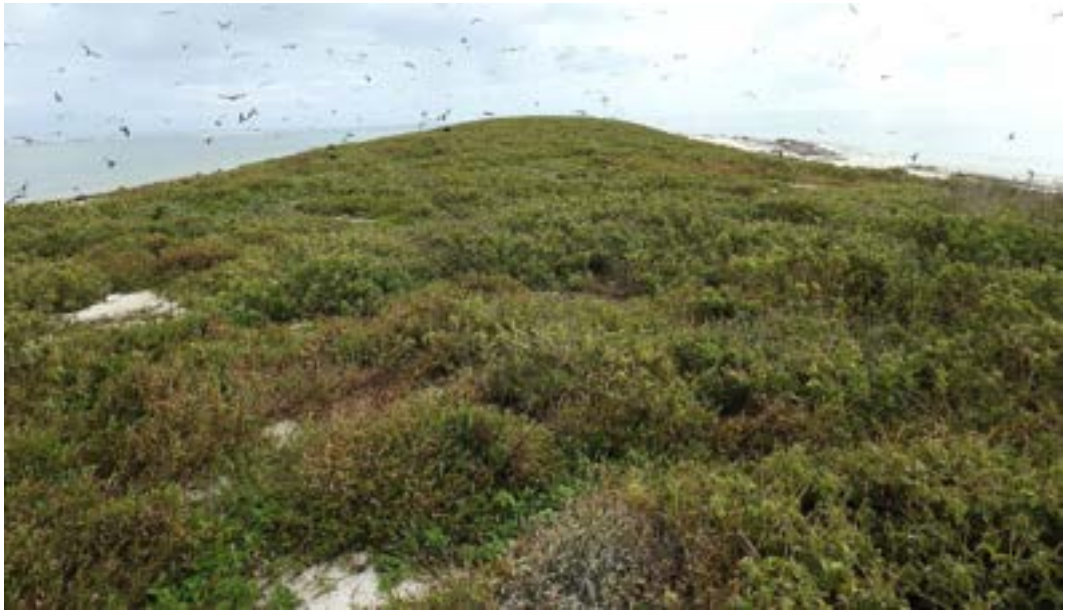


*Photo: View across herbland community **8b** (foreground) and grassland **5** (background) to the western spit from HC59.*


Photos: New plant growth was evident along shorelines encroaching onto areas of bare sand. Photo taken facing southwest on the north side of Georgina Cay.

*Photo: View of the western spit with **1a** Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines.*

*Photo: Looking to the east across green growth of **5** Stenotaphrum micranthum open grassland/ grassland with Boerhavia albiflora var albiflora +/- Achyranthes aspera, Portulaca oleracea which occurs as a band along the windward side of the cay. Photo facing east from HC61.*

*Photo: Looking in a westerly direction across grassland community **5** to the western spit. Photo taken on the windward side of the cay from HC62. Inset photo: Thick green grass borders community **5** on the windward side of the cay.*

*Photo: Looking in a northeasterly direction along the northern shoreline towards the eastern spit with lush, green littoral sparse grassland **1a** bordering **6b** Boerhavia albiflora var. albiflora/ Stenotaphrum micranthum open herbland/herbland with Portulaca oleracea. Photo taken adjacent to Rodent tunnel 61.*

*Photo: The eastern spit supports green, thick herbland communities **8a** and **8b** in the foreground and grassland community **5** in the background. Photo taken facing northeast from HC64.*

*Photo: Towards the end of the eastern spit grassland community **5** occurs across its width with **1a** littoral sparse grassland bordering the community on the northern shoreline and the eastern extremity of the spit.*

*Photo: Littoral sparse grassland **1a** on the eastern spit supports nesting habitat for sooty terns.*

B. Health Check photo monitoring - sample photo of each vegetation type

*Photo: HC60 **1a** Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines.*

*Photo: HC61 **5** Stenotaphrum micranthum open grassland/ grassland with Boerhavia albiflora var albiflora +/- Achyranthes aspera, Portulaca oleracea.*

*Photo: HC65 **6b** Boerhavia albiflora var. albiflora/ Stenotaphrum micranthum open herbland/herbland with Portulaca oleracea.*

*Photo: HC59 **8a** Achyranthes aspera Herbland/closed herbland with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea.*

*Photo: HC64 **8b** Achyranthes aspera/Stenotaphrum micranthum/ Boerhavia albiflora var. albiflora/ Portulaca oleracea open herbland/ herbland.*

Introduced pests

A. Rodents

Table 42. Rodent tunnel monitoring - Georgina Cay.

Georgina Cay			
No. of rodent tunnels	Date deployed	Date collected	Evidence of rodents (tracks, droppings)
5[1]	17/7/21	17/7/21	Nil

[1] Refer *Figure 60*.

B. Ants and other invertebrates

Table 43. Invertebrate species summary - Georgina Cay.

Georgina Cay[1]					
Specimen no.	Date	Site	Specimen	Identification	Native / introduced
50	17/7/21	NA	Grasshopper	*Aiolopus thalassinus (Acrididae*)	Native
51	17/7/21	NA	Lady beetle	2 x *Harmoinia octomaculata*	Native

[1]During a previous ANPWS survey ten mites and ticks, seven silverfish, two isopods, one centipede, 11 springtails, nine spiders, two beetles and four ants were collected on Georgina Cay (Hill and Hogg 1984).

7. Edna Cay

Birds

Table 44. Species and breeding effort – Edna Cay.

Edna Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
18/07/2021	black-naped tern				0	12	
18/07/2021	brown booby				0	5	
18/07/2021	common noddy				2	46	G,P
18/07/2021	sooty tern				0	18	

Not vegetated apart from a single *Boerhavia* seedling just above the tide line.

Evidence of an earlier common noddy breeding event. Only two remaining young birds nearly ready to fledge.

Figure 66. Common noddy, Anous stolidous. Nest showing infill of shells and coral pieces.

Vegetation

The only plant found growing on the unvegetated cays was a single plant of *Boerhavia albiflora* var. *albiflora* growing in coral rubble on the southern shoreline of Edna Cay (shown in *Photos 53a and b.* There was no other vegetation present on the cay.

Photos 53a & 53b: Juvenile Boerhavia albiflora var. albiflora growing on rubble on shoreline of Edna Cay.

This species is in the same family as *Pisonia grandis* (Nyctagonacea) and has similar sticky seeds as Pisonia which favour bird dispersal. It is a successful cay coloniser and was one of the most widespread species present on the Diamond Islets and Lihou Reef cays during the July 2021 surveys. It develops a large below ground tuber which enables it to tolerate periods of drought. In its current location it may persist or alternatively it may be washed away by waves and tidal surges. It is on a rocky section of the beach where it is less vulnerable to turtle disturbance.

Figure 67. Edna Cay - Health check monitoring sites.

Health checks

Edna Cay

Unvegetated sand cay – Approx. 7.5 ha (above high water)

(Unvegetated, flat, elongate cay slightly convex (plan) on the windward side and concave on the lee side; long axis lies roughly east-west; coarse sandy cay with a high proportion of pebbles and larger rubble over the whole surface but it is not a shingle cay. There are end terraces at each end of the cay with a large central plateau. The east end terrace is depressed centrally by 1.5m forming a triangular depression where grey pumice has accumulated. Maximum elevation of central plateau is approx. 3m; area 7.3 ha; perimeter 1.5 km, Hill and Hogg (1984))

- Sandy shores

- Lithified shores

- Sandy substrate with large lithified sediment blocks and shingle occurring in band running east west on windward side of cay

- Predominantly fine sediments on north facing side of cay

Health Checks: HC66, HC67, HC68, HC69

Habitats and species	**Health Checks** **Overall Condition class[1]**
Value - Seabird habitat	G
Breeding and roosting habitat - Refer Birds A. McDougall Evidence of prior common noddy breeding event. Empty common noddy nests. Bird species recorded: Black-naped tern Brown booby Sooty tern Common noddy	
Value – Green turtle rookery	G
High density turtle body pits on north side of cay - HC66, HC69 Low density turtle body pits on windward side – HC67, HC68 Hill and Hogg (1984) reported strongly weathered turtle depressions occurred over most of the cay including the end terraces. Approximately 934 turtle body pits were counted and several dead green turtle skeletons. NB. Survey undertaken outside turtle breeding season - unable to determine the proportion of body pits attributed to the last breeding event.	

1. Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

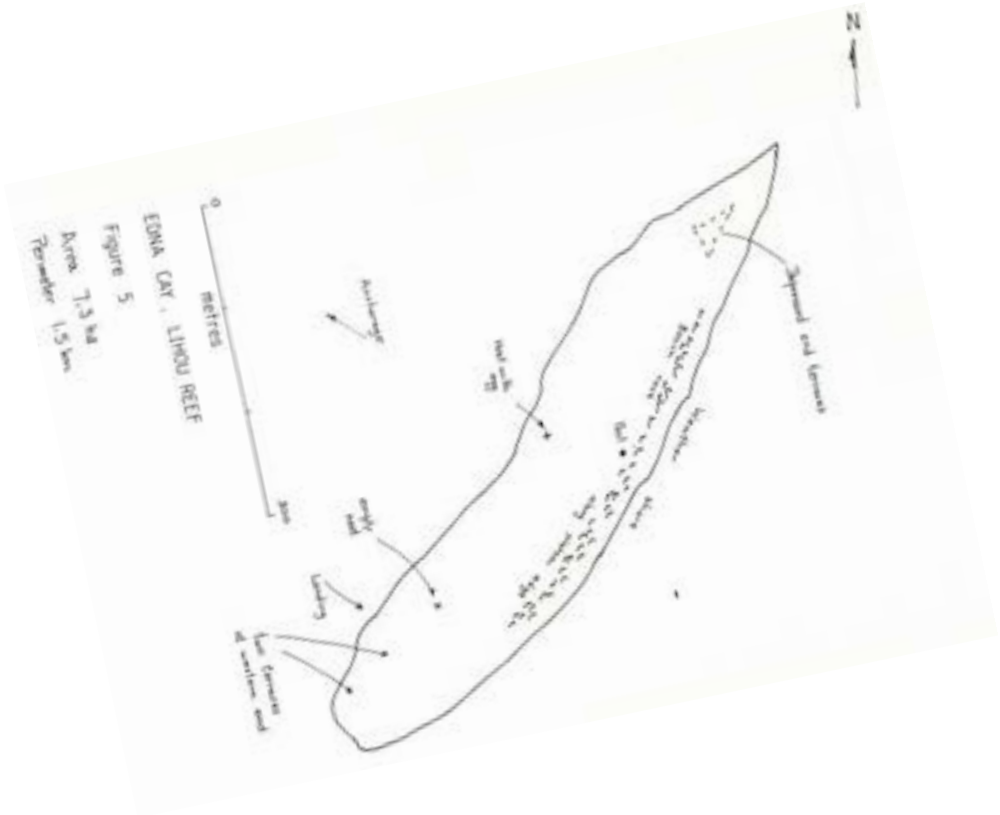


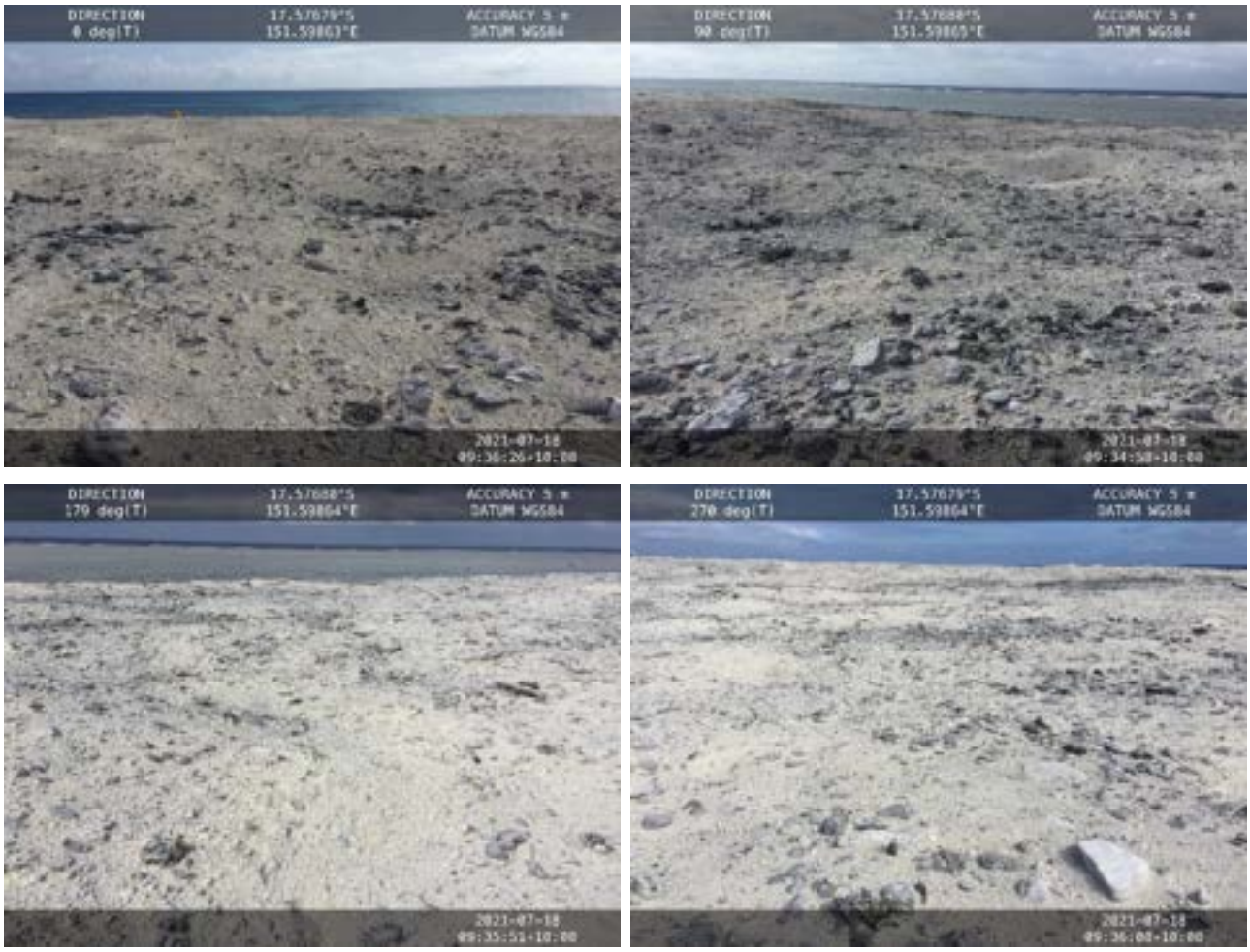
Figure 68. Map of Edna Cay hand drawn from an aerial photograph (Hill and Hogg 1984). Note estimated area of cay 7.3 ha.

Photo: Lower density turtle body pits in substrate containing large blocks of lithified sediment. Photo taken facing west at HC67.

Photos: L. Single Boerhavia albiflora var. albiflora seedling amongst rubble bank on windward side of cay. R. Common noddy nest of shells and coral in centre foreground (red arrow) immediately above high tide line.

Photos: Higher density turtle body pits in sandy substrate on north side of cay. L. and R. Photo taken facing north from HC66.

HC68 monitoring photos



Photos: HC68 photos at eastern sand spit containing extensive shingle and low occurrence of turtle body pits. Note sandy substrate and higher density of body pits in background of North photo (north side of cay).

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Table 45. Invertebrate species summary - Edna Cay.

Edna Cay[1]					
Specimen no.	Date	Site	Specimen	Identification	Native / introduced
47	18/7/21	NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*	Native

[1]During a previous ANPWS survey six silverfish, three mites and five spiders were collected on Edna Cay (Hill and Hogg 1984).

8. Helen Cay

Birds

Table 46. Species and breeding effort – Helen Cay.

Helen Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
18/07/2021	black noddy				0	1	
18/07/2021	black-naped tern				0	4	
18/07/2021	brown booby				0	2	
18/07/2021	common noddy				7	12	G,P

Small, domed and rocky cay with no vegetation. Young common noddies hiding among the rock crevices.

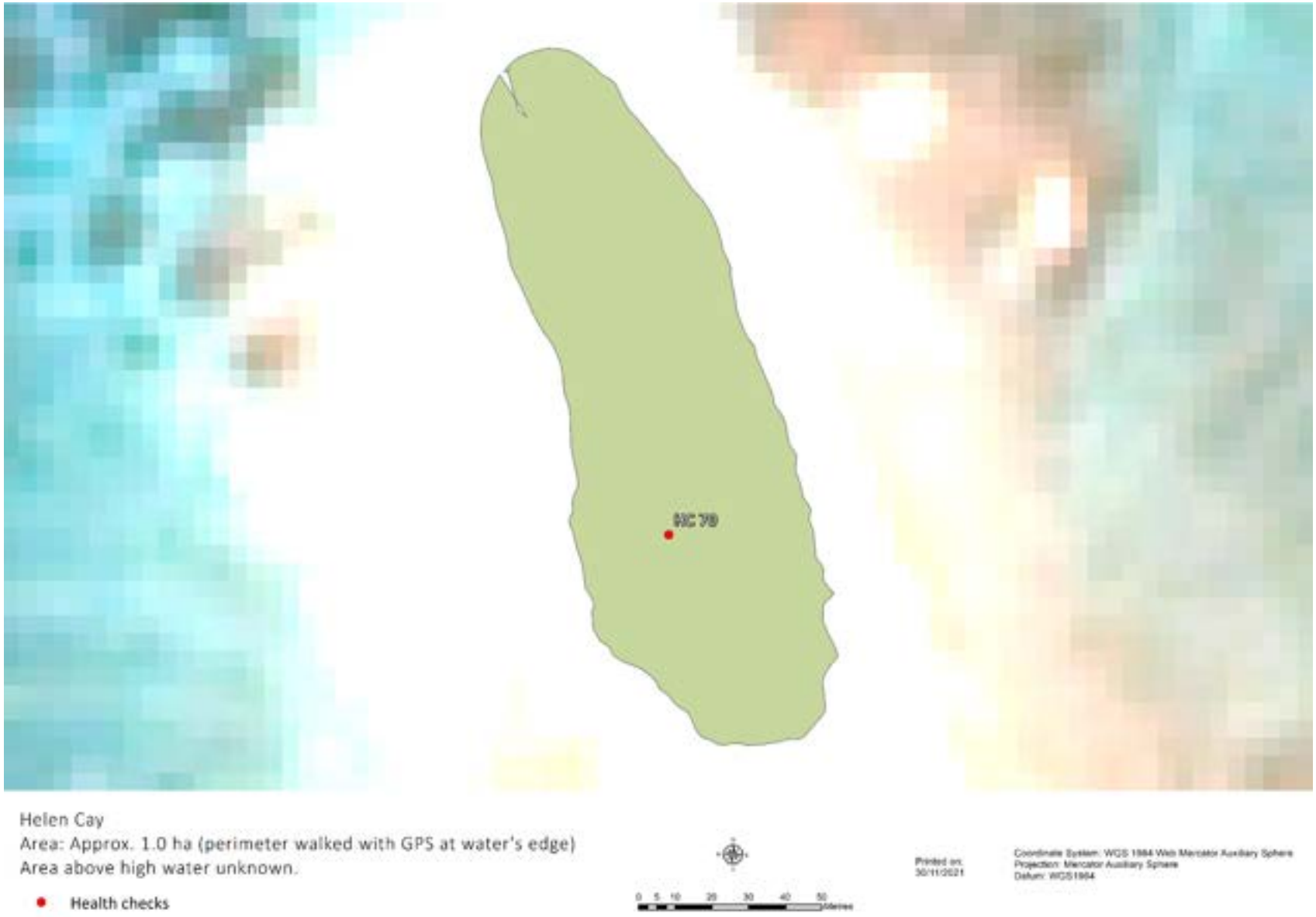


Figure 69. Helen Cay - Health check monitoring site.

Health checks

Helen Cay	
Unvegetated sand cay - Area above high water unknown. Perimeter of cay walked along water's edge with GPS – Approx. 1.0 ha. (Helen Cay was not photographed by drone. Other cays to be surveyed on the same day were prioritised for available batteries.) - Sandy shores - Lithified shores - Predominantly fine sediments on north half of cay - Lithified sediment and shingle in sand on south half of cay Health Check: HC70	
Habitats and species	**Health Checks** **Overall Condition class[1]**
Value - Seabird habitat	GC[2]
Breeding and roosting habitat - Refer Birds A. McDougall. Common noddy breeding pairs with young birds present. Empty common noddy nests. Bird species recorded: Black-naped tern Brown booby Black noddy Common noddy (Breeding)	
Value – Green turtle rookery	GC[2]
Negligible area of suitable turtle nesting habitat with small number of turtle body pits on south side of cay. Cay likely utilised as occasional nesting site by turtles in the region. Due to small size of cay, egg clutches may be susceptible to inundation. NB. Survey undertaken outside turtle breeding season.	

1. Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

2. Minor amounts of pumice and drift seeds present in interior of cay. Due to small size, cay is likely to be susceptible to tidal inundation and overtopping during king tides, strong winds, storms and cyclones.

Photo: Looking across Helen Cay to the northern end. Photo facing north from HC70.

Photo: Looking across Helen Cay to the southern end. Photo facing south from HC70.

HC70 monitoring photos

Photos: HC70 at south end of cay. Note small number of turtle body pits and pumice (black dots) and drift seeds (with coconut in third photo) in depressions.

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Nil pests/invertebrates detected.

9. Fanny Cay

Birds

Table 47. Species and breeding effort – Fanny Cay.

Fanny Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
18/07/2021	black-naped tern				0	33	
18/07/2021	brown booby				0	3	
18/07/2021	common noddy				0	8	
18/07/2021	New Caledonian fairy tern				0	7	
18/07/2021	sooty tern				0	3	
18/07/2021	wedge-tailed shearwater				0	1	

Unvegetated cay with limited ground above high water. Seven New Caledonian fairy terns observed. These birds were in full breeding plumage. The cay is unlikely to provide the correct substrate for breeding. Five of the birds were seen loafing with black-naped terns (see *Figure 70*).

A single wedge-tailed shearwater was seen flying adjacent to the cay.

Figure 70. Drone imagery size comparison of New Caledonian fairy terns (below yellow markers) and black-naped terns.

Fanny Cay
Area: Approx. 0.0400 ha (above high water)
Approx. 0.914 ha (sand exposed in drone image)

● Health checks

Figure 71. Fanny Cay - Health check monitoring site.

Health checks

Fanny Cay	
Unvegetated sand cay - Approx. 400 sq metres (0.04 ha) above high tide - Sandy shores - Lithified shores - Sandy substrate - Predominantly fine sediments with coral pieces Health Check: HC71	
Habitats and species	**Health Checks** **Overall Condition class[1]**
Value - Seabird habitat	SC[2]
Roosting habitat. Unlikely breeding site - refer Birds A. McDougall. Bird species recorded: Black-naped tern Brown booby New Caledonian fairy tern Sooty tern Common noddy Wedge-tailed shearwater	
Value – Green turtle rookery	SC[2]
Negligible area available for turtle nesting. Turtle body pits on elevated portion of cay. >80% body pits contained pumice and drift seeds. Cay likely utilised as occasional nesting site by turtles in the region. Due to very small area above high water, highly likely that all egg clutches would be susceptible to flooding. NB. Survey undertaken outside turtle breeding season.	

1. Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

2. Pumice and drift seeds present in >80% of turtle body pits across the area of cay above high water. Due to very small size of cay it is likely to be inundated and overtopped during king tides, strong winds, storms and cyclones.

Photos: Aerial images of Fanny Cay showing the limited area above high water.

HC71 monitoring photos

Photos: Health Check HC71 on area of cay above high water. Note accumulation of pumice and drift seeds in depressions and turtle body pits in interior of cay.

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Nil pests/invertebrates detected.

10. Dianna Cay

Birds

Table 48. Species and breeding effort – Dianna Cay.

Dianna Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
18/07/2021	black-naped tern				52	95	G,Y
18/07/2021	brown booby				0	2	
18/07/2021	crested tern				0	1	
18/07/2021	grey-tailed tattler				0	1	
18/07/2021	Herald petrel				0	1	
18/07/2021	New Caledonian fairy tern				0	5	
18/07/2021	Pacific golden plover				0	1	
18/07/2021	ruddy turnstone				0	5	
18/07/2021	sooty tern				0	5	

Figure 72. Herald petrel. Still image taken from video supplied by Teresa Scurrah.

Possible nesting habitat for New Caledonian fairy terns on this unvegetated cay. Five birds in breeding plumage observed, but no nests seen.

A Herald petrel (*Figure 72*) was seen late afternoon. It briefly alighted before being chased off by black-naped terns from an adjacent nesting colony.

Figure 73. Marine debris alongside eggs of a black-naped tern (photo by Teresa Scurrah).

Marine debris was the only blight on the cays. No other pest or weed threats were observed. *Figure 73* shows debris (also used as a perch) within a black-naped tern nesting area. Glass may not pose much of a threat, however plastics could entangle unlucky birds.

Where debris was encountered, it was quickly removed if safe to do so, and then the area exited so birds could immediately return to their nests. Debris was not removed from the middle of larger colonies as eggs were often too difficult to locate by untrained observers.

Figure 74. Dianna Cay - Health check monitoring sites.

Health checks

Dianna Cay

Unvegetated sand cay – Approx. 3.2 ha (above high water)

(During a previous ANPWS survey Grant et al. (1986) recorded a cay area of 1.6 ha (approx. 1km long and 120m wide). Grant et al. states large amount of exposed beach rock suggests the cay was reducing in size. It was also reported that the prominent feature of the cay was extensive exposed rock platform on the south east margin. An extensive beach rock platform can seen in the 2021 drone image however 1986 map shows beach rock along entire length of south side of cay.)

- Sandy shores
- Lithified shores
- Elevated area of cay predominantly fine sediments – small coral shingle in areas prone to inundation

(In contrast to July 2021 observations Grant et al. (1986) describes sand on Dianna Cay as comprised of small to medium sized coral rubble)

Health Checks: HC72, HC73, HC74, HC75

Habitats and species	**Health Checks** **Overall Condition class[1]**
Value - Seabird and shorebird habitat	G
Breeding and roosting habitat - Refer Birds A. McDougall Nine bird species recorded including: • Six seabirds • Three shorebirds • 52 breeding pairs of black-naped terns • New records – Herald Petrel, New Caledonian fairy tern	
Value – Turtle rookery (green)	G
Most turtle body pits occurred in wider section of cay towards the western end. The drone image shows a band of pumice along the length of the cay on the windward side. A zone of inundation extends from this pumice line into the interior of the cay marked by lines of coral rubble found during ground inspection. The drone image shows evidence of turtle pits within this zone. Drone image shows old turtle tracks. Quality of nesting habitat and nesting success on Dianna Cay was unable to be determined. Monitoring during the breeding season is required to determine suitable nesting area and nesting success. (Turtle nesting habitat must support a suitable medium for digging both the body pit and egg chamber in elevated areas where nests are not subject to flooding or erosion during severe weather. Nesting success was extremely low in 2019/20 season in the Coringa-Herald cays due to very dry sand conditions and collapse of attempted egg chambers (Hemson et al 2020).) NB. Survey undertaken outside turtle breeding season.	

1. Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

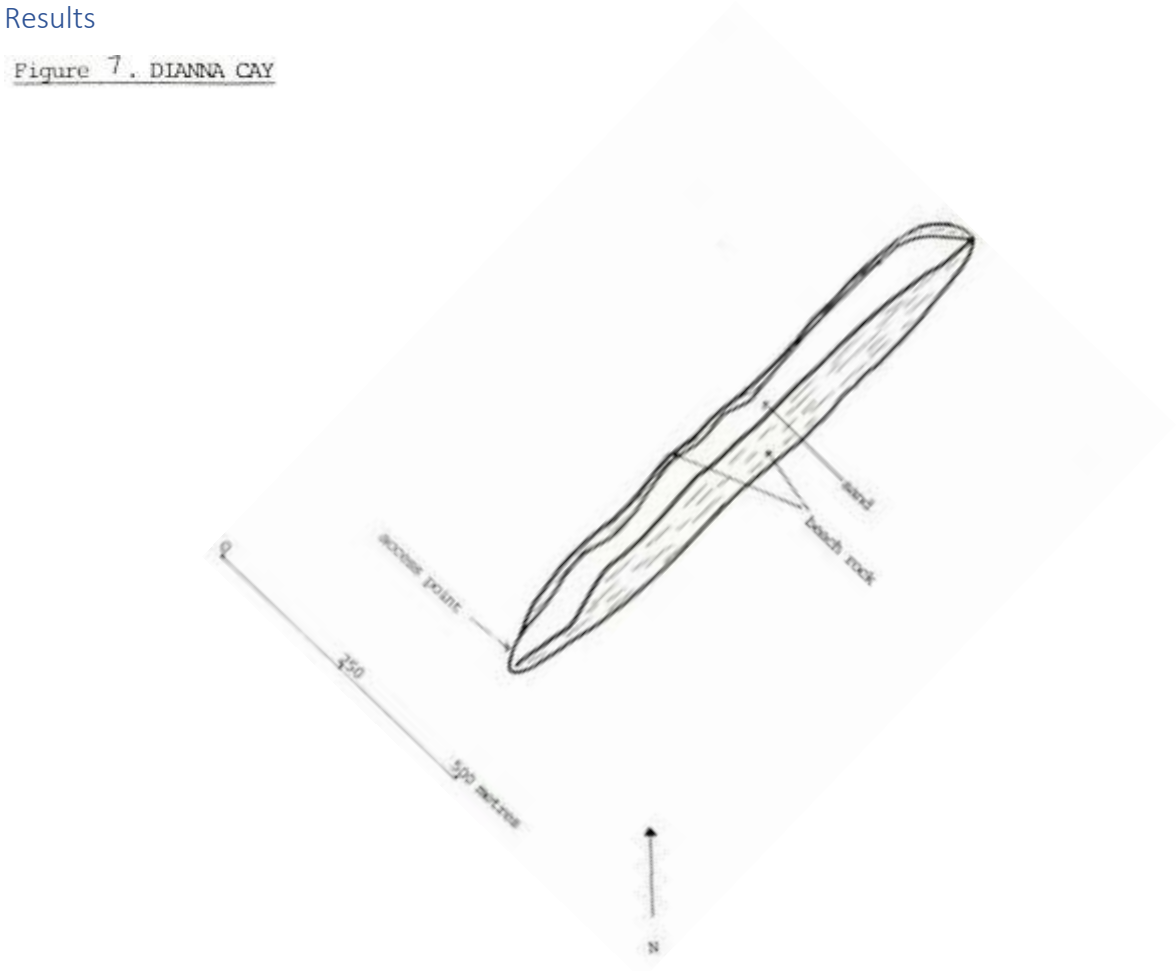


Figure 75. Hand drawn map of Dianna Cay from ANPWS survey in 1986 (Grant et al. 1986) Cay area estimated at 1.6 ha.

Photo: Aerial image showing evidence of inundation on both sides of the cay. Note band of smooth sand on edge of terrace (likely that turtle body pits were present and subsequently flooded) and pumice lines.

Photo: Majority of turtle body pits were found in the widest section of the cay at the western end. Photo taken facing south west.

Photos: Views of high density turtle body pits at western end of cay. Photos taken facing south.

Photo: Looking along the windward side of Dianna Cay to the northeast of area showing evidence of inundation along length of the cay. Extending into the interior the area is marked by tidal lines of coral rubble visible on the left foreground and centre of the photo and pumice line to the right. Note large items of debris in interior of cay.

Photo: Looking in northeasterly direction from HC74 showing the narrow width of Dianna Cay (at a point approx. two thirds along its length) and turtle body pits in a zone of inundation. Note several items of timber and coconuts including one in turtle body pit on left centre of photo.

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Table 49. Invertebrate species summary - Dianna Cay.

Dianna Cay					
Specimen no.	Date	Site	Specimen	Identification	Native / introduced
49	18/7/21	NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*	Native

11. Carol Cay

Birds

Table 50. Species and breeding effort – Carol Cay.

Carol Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
19/07/2021	black noddy				0	7	
19/07/2021	black-naped tern				140	195	G,Y
19/07/2021	brown booby				0	2	
19/07/2021	common noddy				0	105	
19/07/2021	crested tern				0	2	
19/07/2021	masked booby				0	2	
19/07/2021	roseate tern				3	5	G,Y
19/07/2021	ruddy turnstone				0	6	
19/07/2021	sooty tern				0	4	
19/07/2021	wandering tattler				0	1	

Large black-naped tern colony spread along the southern rim of the cay in two distinct locations (see *Figure 76*.). Scattered roseate tern nests within the larger colony on the western end.

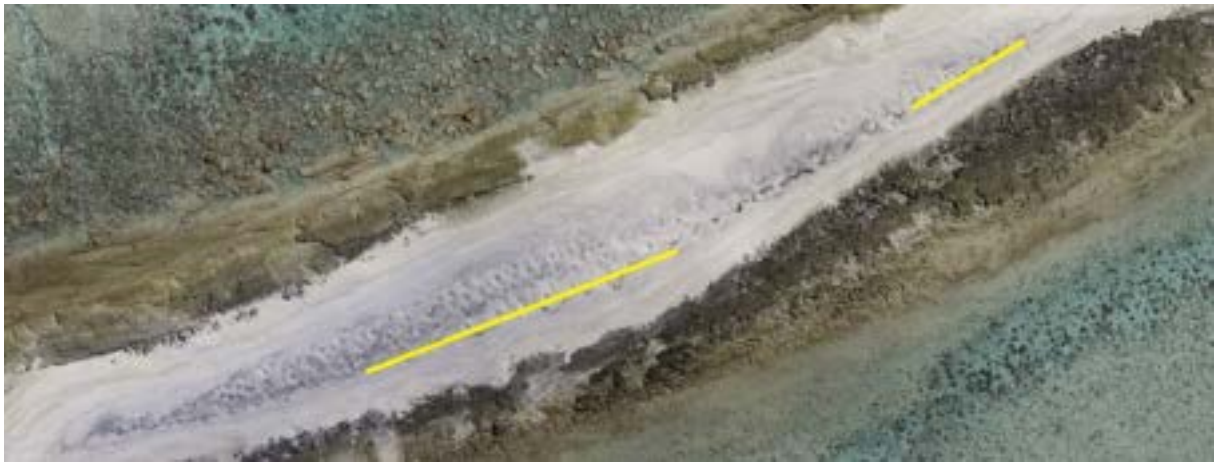


Figure 76. Black-naped tern and roseate tern nest locations in yellow.

Figure 77. Carol Cay - Health check monitoring site.

Health checks

Carol Cay	
Unvegetated sand cay – Approx. 0.19 ha (above high water) (During a previous ANPWS survey Grant et al. (1986) records cay area at 0.5 ha (approx. 530m long and 80m wide).) - Sandy shores - Lithified shores - Elevated area of cay predominantly sand and shingle (Similar to July 2021 observations Grant et al. (1986) sand on Carol Cay is described as comprising of coarse coral rubble.) Health Checks: HC76	
Habitats and species	**Health Checks** **Overall Condition class[1]**
Value - Seabird and shorebird habitat	G
Breeding and roosting habitat - Refer Birds A. McDougall. Ten bird species recorded: • Eight seabird species • Two shorebird species • Breeding colony of black-naped terns • Breeding colony of roseate terns	
Value – Turtle rookery (Green turtle *Chelonia mydas*)	G
Limited area for turtle nesting due to size and narrow width of cay. Turtle body pits occur on elevated section of cay however on the eastern half of the cay there is evidence that inundation has occurred where turtles have nested. Drone image shows old turtle tracks. Survey undertaken outside turtle breeding season. Quality of nesting habitat and nesting success on Carol Cay is unable to be determined. Monitoring during the breeding season is required to determine nesting success.	

1. Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

Plate 14: Carol Cay, Lihou Reef NNR: course coral rubble with little bird life and no breeding activity.

Photo: Photo of Carol Cay from Grant et al. (1986). Cay area estimated at 0.5 ha compared to 0.19 ha in 2021. Note. Photo direction not available.

Photo: View of Carol Cay facing west taken from the eastern end of the elevated area of the cay – possibly the same aspect as 1986 photo above.

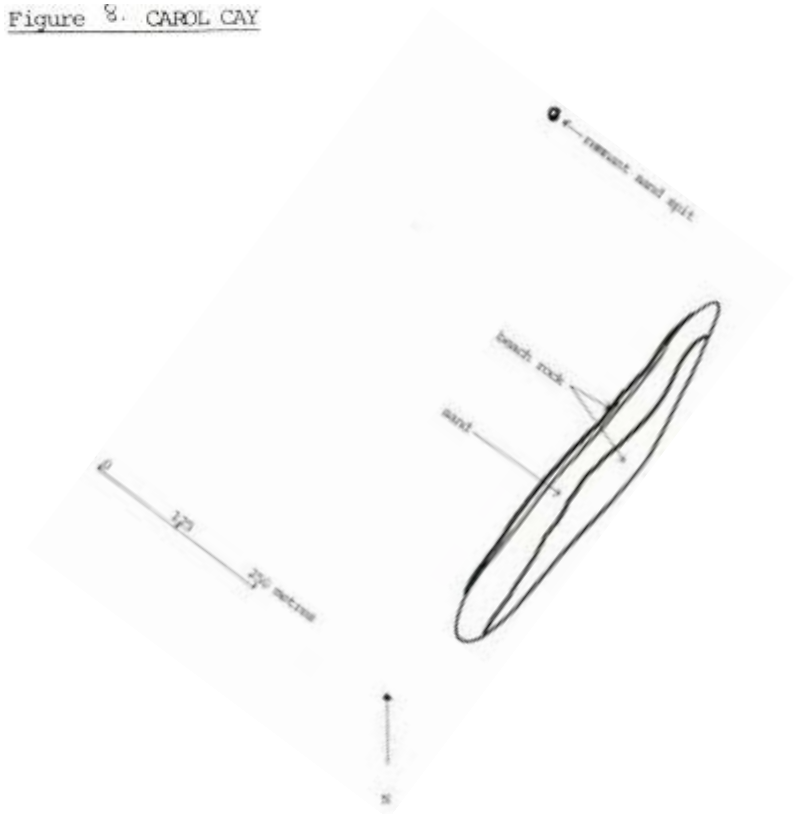


Figure 78. Hand drawn map of Carol Cay from 1986 ANPWS survey (Grant et al. 1986). Cay area estimated at 0.5 ha.

Photo: View of Carol Cay from HC76 facing west showing colony of black-naped and roseate terns in left foreground and turtle body pits.

Photo: Drone image of area in vicinity of HC76 showing wash patterns (slightly darker bands of coral rubble on north side of cay (over wash) into areas used by nesting turtles. Note turtle track (yellow arrow).

Photo: View of Carol Cay looking towards the east showing turtle body pits and evidence of tides extending into interior marked by smoother sand profile on left half of photo and rubble tide line in centre of photo. Note same turtle track (yellow arrow) as above drone image.

HC76 monitoring photos

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Nil pests/invertebrates detected.

12. Phoenix Cay

Birds

Table 51. Species and breeding effort – Phoenix Cay.

Phoenix Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
19/07/2021	black-naped tern				0	8	
19/07/2021	brown booby				0	2	
19/07/2021	common noddy				0	27	
19/07/2021	sooty tern				0	2	

Figure 79. Phoenix Cay is used as an intertidal roosting site.

Figure 80. Phoenix Cay.

Photos: View of Phoenix Cay taken from the western intertidal cay.

Photo: View of western intertidal cay – launch site for drone flight.

Health checks

Due to small, intertidal cay a Health Check was not undertaken. As mentioned above the cay has value as an intertidal roosting site.

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Nil pests/invertebrates detected.

13. Hermit Crab Islet

Birds

Table 52. Species and breeding effort – Hermit Crab Islet.

Hermit Crab Islet (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
19/07/2021	Australian pelican				0	1	
19/07/2021	black noddy				0	4	
19/07/2021	black-naped tern				0	13	
19/07/2021	brown booby				383	440	G,N
19/07/2021	common noddy				660	1795	G,P
19/07/2021	crested tern				0	1	
19/07/2021	lesser frigatebird				473	415	G,Y
19/07/2021	masked booby				75	81	G,N
19/07/2021	red-footed booby				37	39	G,N
19/07/2021	sooty tern				2929	3090	G,Y

Figure 81. Masked booby, adult and chick.

Hermit Crab Islet, along with others in the Lihou group showed evidence of exhausted and deceased black noddies. There have been similar birds found across the Great Barrier Reef Marine Park from August through to October 2021. Without any formal evidence, I believe there may have been adverse weather, and therefore lack of available feeding conditions enroute through migration to their breeding grounds. It appears to be a rarer event for black noddies, however there have been similar well documented cases of short-tailed shearwaters succumbing to exhaustion and starvation during migration.

This cay hosted the largest lesser frigatebird colony in the Lihou group.

Figure 82. Common noddies and black noddy.

Vegetation

Cay description

Hermit Crab Islet is located at on Lihou Reef at -17.415 degrees latitude and 151.873 degrees longitude. The cay has a total vegetated area of 8.1 hectares. There is a slight depression on the eastern end adjacent to the shoreline.

Figure 83 contains surface elevation profiles of Hermit Crab Islet.

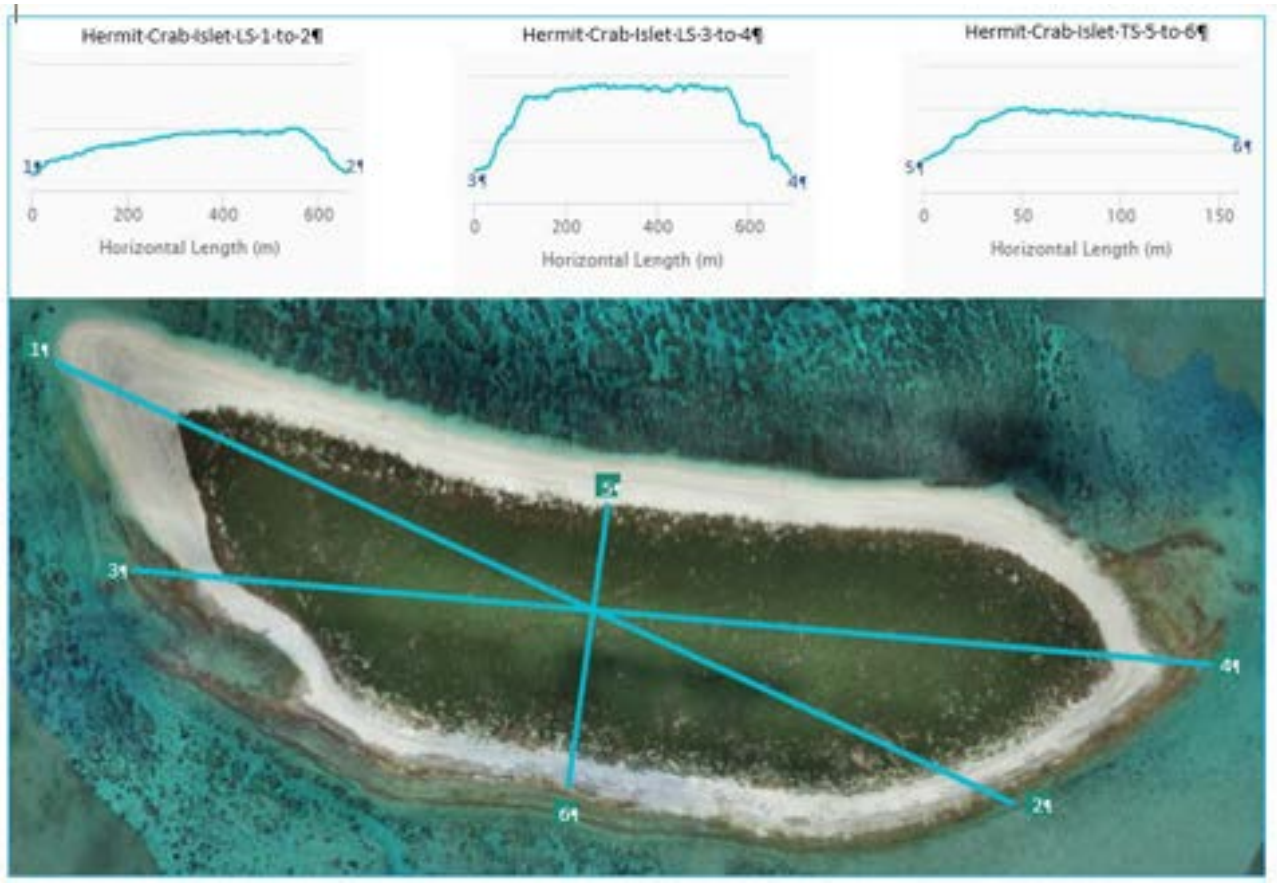


Figure 83. Surface profiles of Hermit Crab Islet.

Note: Maximum height is approximately five metres ASL. Vertical heights and scale are not included in surface profile diagrams as accurate datum information was not available

Survey intensity

Five hours was spent surveying the vegetation of Hermit Crab Islet. Vegetation data was recorded at 21 ground-truthing sites and two permanent monitoring sites (M10 and M11). The locations of these sites are shown in *Figure 84*. The blue lines are the boundaries of the vegetation communities shown on the vegetation map in *Figure 85*.

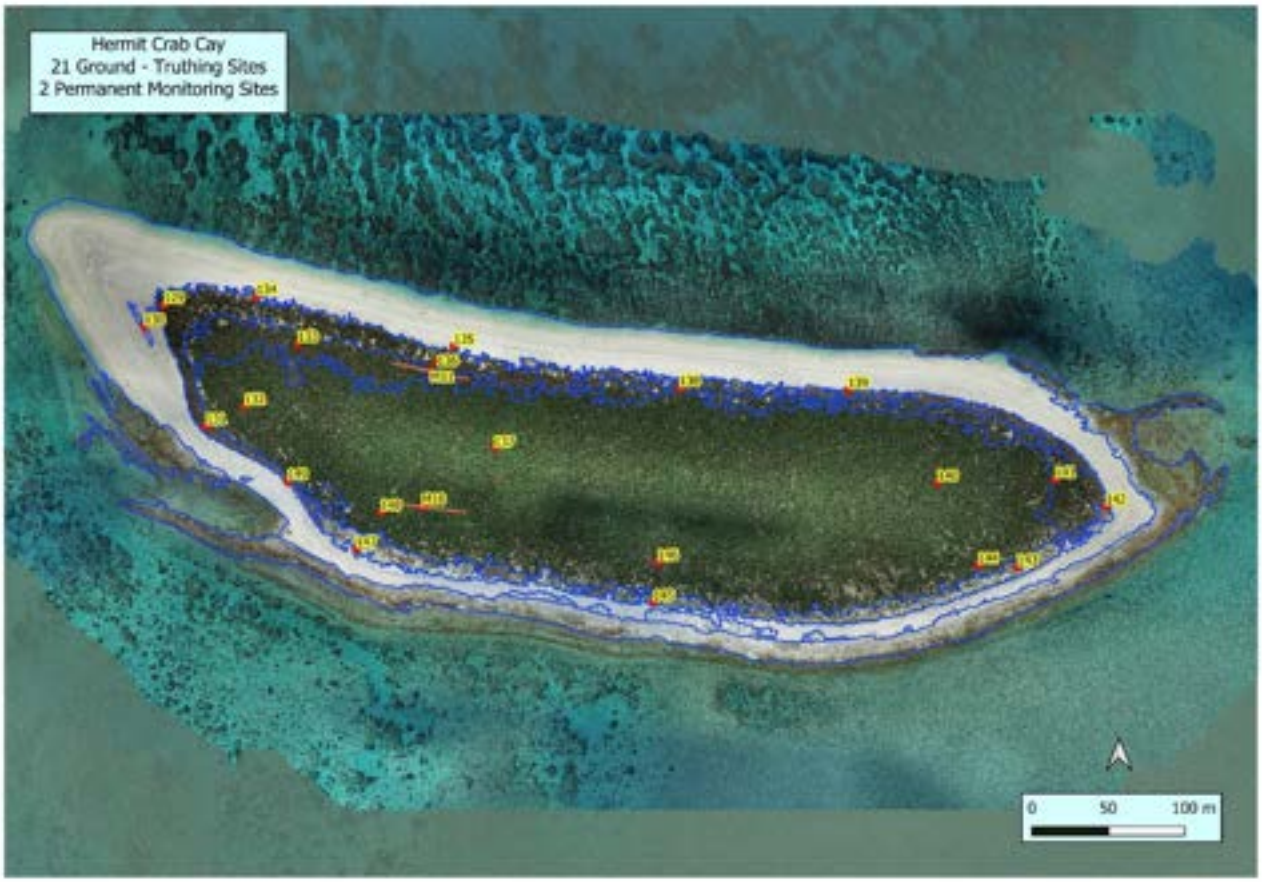


Figure 84. Hermit Crab Islet showing the number and location of ground-truthing sites and permanent monitoring sites relative to the vegetation map boundaries.

Vegetation condition

The vegetation of Hermit Crab Islet was generally in good condition at the time of the July 2021 vegetation survey.

Scale insects on dead and senescing patches of *Achyranthes aspera* as described for South West Cay were also present on Hermit Crab Islet. *Photos 54 a & b* show egging scale on the stems of *Achyranthes aspera* on Hermit Crab Islet.

Photos 54a & 54b: Egging Scale on Achyranthes aspera on Hermit Crab Islet.

Floristic data

Seven plant species were recorded on Hermit Crab Islet. These are listed in *Table 53* in order of frequency in sites together with the averaged cover for each species for sites in which the species was present and their averaged cover over the entire cay. Data for species cover at each site plus occurrence of each species in relation to vegetation community and landform are contained in *Table 55*.

Table 53. Plant species recorded on Hermit Crab Islet, 19-20/07/2021.
Layers: (E) = emergent, (S1) = upper shrub, (S2) = lower shrub, (G) = Ground

Species	Common Name	Family	Presence in Sites (% of sites)	Average % Cover in Each Layer (Only sites containing the species were averaged)	Overall Average % Cover in Each Layer (average includes all sites)
Achyranthes aspera	chaff flower	Amaranthaceae	87%	34.4% (G)	29.9% (G)
Boerhavia albiflora var. *albiflora*	boerhavia	Nyctaginaceae	83%	10.4% (G)	8.6% (G)
Lepturus repens	stalky grass	Poaceae	78%	33.5% (G)	26.2% (G)
Portulaca oleracea	pig weed	Portulacaceae	35%	4.1% (G)	1.4% (G)
Stenotaphrum micranthum	beach buffalo grass	Poaceae	22%	17.0% (G)	3.7% (G)
Abutilon albescens	lantern bush	Malvaceae	13%	2.5% (G)	0.3% (G)
Tribulus cistoides	bulls head burr	Zygophyllaceae	9%	2.5% (G)	0.2% (G)
Total no of species = 7					

Vegetation communities on Hermit Crab Islet

Vegetation communities present on Hermit Crab Islet in July 2021, the area of each and representative survey sites within each vegetation community are listed in *Table 54*. The spatial distribution and extent of the vegetation communities on Hermit Crab Islet in July 2021 are shown in the vegetation map in *Figure 85*.

Vegetation of the cay consisted only of grasses and other herbaceous species. No trees or large shrubs were present.

Map unit 1a was most abundant on the southwestern shoreline and was also present in a few other locations along the shoreline. The vegetation in this unit consisted of individual small plants of predominantly *Lepturus repens* (stalky grass) +/- *Stenotaphrum micranthum* (beach buffalo grass)+/- *Boerhavia albiflora* var. *albiflora* (boerhavia).

Boerhavia albiflora var. *albiflora* open herbland with *Portulaca oleracea* (pigweed) (map unit 6a), *Boerhavia albiflora* var. *albiflora*/ *Stenotaphrum micranthum* herbland (map unit 6b) and small areas of *Lepturus repens*/*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea* (map unit 4) were present along the more rocky and rubbly southeastern shoreline.

Lepturus repens closed grassland (map unit 3a) was present at the base of the landward slope adjacent to most of the northern and southwestern sandy shoreline. *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora* were also present with low abundance in this unit. *Lepturus repens*/ *Achyranthes aspera* closed grassland/herbland (map unit 3b) adjoined the landward edge of 3a in some places.

The entire interior of the cay was covered in closed herbland of *Achyranthes aspera*. *Boerhavia albiflora* var. *albiflora* was also present throughout this vegetation community.

Table 54. Vegetation communities on Hermit Crab Islet.

Veg Map Unit Code	Vegetation Community	Hectares on Hermit Crab Islet	ID of Sites on Hermit Crab Islet
	Unvegetated Areas		
A	Sandy shores	3.6 (approx.)	
B	Lithified shores	1.5 (approx.)	
C	Rubble banks	0.1	
	Shoreline and Sandspit Vegetation		
1a	Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	0.148	130, 134, 135, 139, 147
	Grasslands and Herblands		
3a	*Lepturus repens* grassland/ closed grassland +/- *Achyranthes aspera* +/- *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	0.821	129, 131, 136, 138, 149
3b	*Lepturus repens*/ *Achyranthes aspera* closed grassland/herbland/closed herbland (seasonally variable) with *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	0.777	133, 141, M11
4	*Lepturus repens*/*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea*	0.104	142
5	*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora* +/- *Achyranthes aspera* +/-*Portulaca oleracea*	0.001	nil
6a	*Boerhavia albiflora* var. *albiflora* sparse herbland/ open herbland/ herbland with *Portulaca oleracea*	0.054	145
6b	*Boerhavia albiflora* var. *albiflora*/ *Stenotaphrum micranthum* open herbland/herbland with *Portulaca oleracea*	0.162	143
8a	*Achyranthes aspera* herbland/closed herbland with *Boerhavia albiflora* var. *albiflora*	6.042	132, 137, 140, 144, 146, 148, M10

Note: Areas of sandy shores and rocky shores, particularly those of the rocky shores are only approximate due to the difficulty in determining the location of the boundary between the edge of the shoreline and the surrounding reef flat using the imagery.

Comparison with previous vegetation surveys

Hill and Hogg (1984) and Hicks (October 1984) both surveyed and reported on the vegetation of Hermit Crab Islet. Scottney and Jeffs also visited Hermit Crab Islet in 1987 and provided a basic vegetation map similar to that previously produced by Hicks.

The seven plant species recorded by Hill and Hogg (1984) were the same seven species recorded during the July 2021 survey. Hicks (1984) also recorded 6 of the same species but did not record *Portulaca oleracea*.

Achyranthes aspera dominated the interior vegetation in both the August, 1984 and the July 2021 surveys whilst *Lepturus repens* dominated the interior vegetation in the October 1984 survey. All three surveys recorded grasses more prevalent closer to the leeward shorelines and on the end terraces and the windward side dominated by *Boerhavia*.

The data reported by Hill and Hogg is difficult to compare with the July 2021 survey data. The following are comparisons of averaged percent covers and percent frequency in sites recorded in 16 quadrats along a single transect by Hicks (October 1984) and the 19 ground truthing sites recorded during the July 2021 surveys:

- *Lepturus repens* % cover/%frequency in quadrats = 49.1% /93.8% (Oct 1984); 26.2%/78% (July 2021)
- *Achyranthes aspera* % cover/%frequency in quadrats = 10.9%/75% (Oct 1984); 29.9%/87% (July 2021
- *Boerhavia* % cover/%frequency in quadrats = 1.3% / 31.3% (Oct 1984); 8.6%/83% (July 2021)
- *Stenotaphrum micranthum* % cover/%frequency in quadrats = 0.6% /63% (Oct 1984); 3.7%/22%
- *Abutilon albescens* % cover/%frequency in quadrats = 3.3% /31.3% (Oct 1984); 0.03%/13% (July 2021)
- *Tribulus cistoides* was a minor component in both surveys

These data as well as those reported by Hill and Hogg (1984) suggest that the frequency and abundance of *Lepturus repens* and *Abutilon albescens* have decreased since the 1984 surveys with a corresponding increase in frequency and abundance of *Achyranthes aspera* and *Boerhavia*. It is impossible to be certain from the available data if there has been a real change in species dominance or if the differences reflect climatic and seasonal variations.

Other data, maps and verbal descriptions of vegetation by both Hill and Hogg (1984) and Hicks (1984) were otherwise consistent with the July 2021 data and observations.

Grant et al. (1986) reported that *Stenotaphrum micranthum* covered 90% of the cay. This is a very high percentage compared with other reports. The overall cover for *Stenotaphrum micranthum* in the July 2021 survey was 3.7%. During the July 2021 survey, *Stenotaphrum micranthum* was a component of communities on or adjacent to the shorelines but not in the *Achyranthes aspera* herblands in the interior of the cay. *Lepturus repens* was the dominant grass in the interior communities. Otherwise the vegetation described by Grant et al. was consistent with vegetation recorded in July 2021 and previous reports.

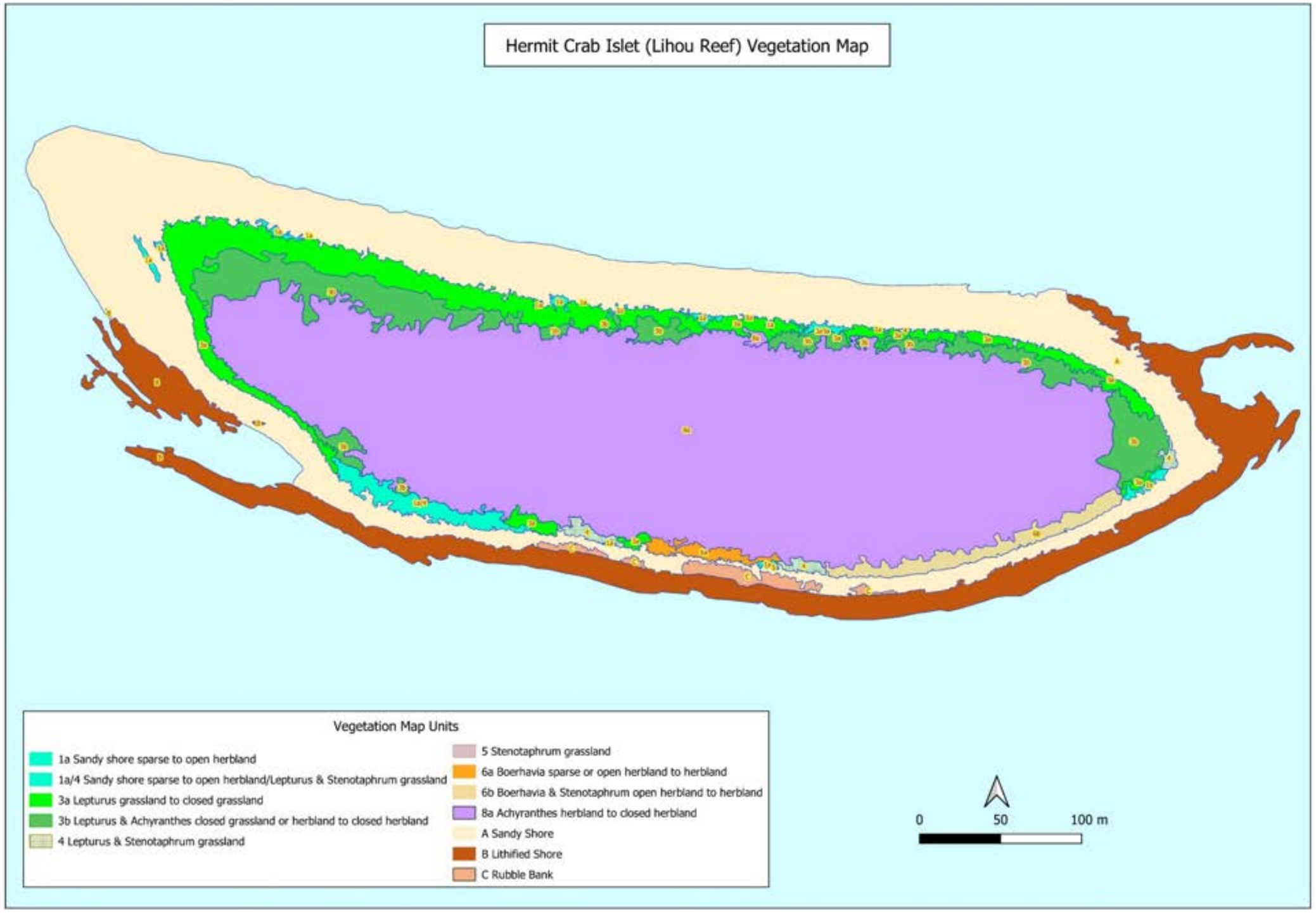


Figure 85. Hermit Crab Islet vegetation map.

Table 55. Site data recorded on Hermit Crab Islet.
Datum = WGS 84; Green shading = site dominants

Site	Latitude	Longitude	Date	No. of photos	Landform	Veg Map Unit	Vegetation Community	Ground Layer							Plant Specimens Collected	Notes
								Abutilon albescens	*Achyranthes aspera*	*Boerhavia albiflora* var. *albiflora*	*Lepturus repens*	*Portulaca oleracea*	*Stenotaphrum micranthum*	*Tribulus cistoides*		
130	-17.41453	151.86985	19/07/2021	1	On Beach	1a	sparse grassland of *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*			trace-5%	trace-5%					
134	-17.41435	151.870509	19/07/2021	1	Shoreline	1a	sparse grassland of *Lepturus repens*, *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*			trace-5%	trace-5%		trace-5%			
135	-17.41464	151.871667	19/07/2021	1	Beach	1a	sparse grassland of *Lepturus repens*				trace-5%					
139	-17.4149	151.873984	19/07/2021	1	Shoreline	1a	open grassland dominated by *Stenotaphrum micranthum*		trace-5%		trace-5%		5-25%			Very narrow veg polygon–here - approximately 2m wide
147	-17.41583	151.871095	19/07/2021	2	Shoreline	1a	sparse herbland dominated by *Boerhavia albiflora* var. *albiflora* and *Stenotaphrum micranthum*		trace-5%	5-25%	trace-5%	trace-5%	5-25%			
129	-17.4144	151.869965	19/07/2021	2	Adjacent to shoreline	3a	closed grassland dominated by *Lepturus repens*		trace-5%		75-95%					
131	-17.41511	151.870212	19/07/2021	2	Base of slope adjacent to shoreline	3a	closed grassland dominated by *Lepturus repens*		trace-5%		75-95%					
136	-17.41472	151.871572	19/07/2021	2	Base of slope adjacent to shoreline	3a	closed grassland dominated by *Lepturus repens*		trace-5%	trace-5%	50-75%					
138	-17.41489	151.872995	19/07/2021	2	Lower slope adjacent to shoreline	3a	closed grassland dominated by *Lepturus repens*		trace-5%	trace-5%	75-95%					
149	-17.41544	151.870691	19/07/2021	1	Adjacent to shoreline	3a	closed grassland dominated by *Lepturus repens*		trace-5%	trace-5%	50-75%					Very narrow polygon
133	-17.41463	151.870751	19/07/2021	2	Gentle slope to NW	3b	closed grassland dominated by *Lepturus repens*, *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*		25-50%	5-25%	50-75%	trace-5%				
141	-17.41542	151.8752	19/07/2021	5	Depression adjacent to E shore line	3b	herbland dominated by *Achyranthes aspera*, *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*		25-50%	5-25%	25-50%			trace-5%	*Tribulus cistoides*, *Lepturus repens*	
M11	-17.41479	151.871534	20/07/2021	8		3b	closed grassland dominated by *Lepturus repens* and *Achyranthes aspera*		5-25%	trace-5%	50-75%	trace-5%		trace-5%		
142	-17.41558	151.875498	19/07/2021	1	Shoreline	4	grassland dominated by *Lepturus repens*, *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*		trace-5%	5-25%	25-50%	trace-5%	25-50%		*Portulaca oleracea*, *Boerhavia albiflora*, *Stenotaphrum micranthum*	
145	-17.41615	151.872841	19/07/2021	1	Shoreline	6a	open herbland dominated by *Portulaca oleracea* and *Boerhavia albiflora* var. *albiflora*		trace-5%	5-25%		5-25%				
143	-17.41594	151.87498	19/07/2021	1	Shoreline	6b	herbland dominated by *Boerhavia albiflora* var. *albiflora* and *Stenotaphrum micranthum*		trace-5%	5-25%	trace-5%	trace-5%	5-25%			
132	-17.415	151.870438	19/07/2021	2	Upper slope to SW	8a	closed herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*		75-95%	5-25%						
137	-17.41524	151.871904	19/07/2021	2	Central plateau	8a	closed herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*		75-95%	5-25%	trace-5%					
140	-17.41544	151.87451	19/07/2021	2	Slight slope to NE	8a	closed herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*	trace-5%	75-95%	5-25%					*Abutilon albescens*	Some egging scale on *Achyranthes aspera*
144	-17.41593	151.874749	19/07/2021	2	Lower slopes to SW	8a	closed herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*		75-95%	5-25%		trace-5%			*Achyranthes aspera*	
146	-17.41591	151.872866	19/07/2021	2	Crest	8a	closed herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*	trace-5%	50-75%	5-25%						
148	-17.41562	151.871239	19/07/2021	2	Crest	8a	closed herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*		75-95%	5-25%	trace-5%					Egging scale on *Achyranthes aspera*, no tending ants, no evidence of parasitoids or predators
M10	-17.41558	151.871482	20/07/2021	8		8a	closed herbland dominated by *Achyranthes aspera*	trace-5%	75-95%	trace-5%	trace-5%	trace-5%				

Permanent monitoring site data

Two permanent monitoring sites (M10 and M11) were established and surveyed on Hermit Crab Islet. The locations of the centre transects of these sites are shown as the red lines in *Figure 84*. *Table 56* contains the data recorded at these sites. The photographs included with the data in this section are 4 of the 10 site photographs for each site. These are taken from the centre point of each site in four different directions (facing 0, 90, 180 and 270 degrees from the transect bearing respectively).

Table 56. BioCondition attribute data recorded in permanent monitoring sites on Hermit Crab Islet.

	Site M10	**Site M11**
Vegetation community description	Closed herbland dominated by *Achyranthes aspera*	Closed grassland dominated by *Lepturus repens* and *Achyranthes aspera*
Transect start (WGS 84)	-17.415559 151.871255	-17.414737 151.871298
Transect centre (WGS84)	-17.415581 151.871482	-17.414787 151.871534
Transect end (WGS 84)	-17.415619 151.871733	-17.414835 151.871759
Transect bearing	90^0	98^0
Median canopy height (range)	0.5 (0.01 to 0.7)m	0.5 (0.02 to 0.75)m
Tree canopy cover %	n/a	n/a
Shrub canopy cover %	n/a	n/a
Basal area m^2/ha (at 30 cm height, calculated from stem diameters)	nil	nil
Total number of large trees/ha	0	0
Total no of trees per ha	n/a	n/a
Total number of tree stems/ha	n/a	n/a
Total no. shrubs/ha	n/a	n/a
Total no. shrub stems/ha	n/a	n/a
Large shrubs - mean diameter at 30 cm height	n/a	n/a
Recruitment of ecologically dominant layer (%)	n/a	n/a
Tree species richness	0	0
Tree species present	n/a	n/a
Shrub species richness	1	0
Shrub species present (layer in brackets)	*Abutilon albescens* (G)	nil
Median ground layer height (range)	G=canopy	G=canopy
Total ground layer cover of native cay species (%)	90.8%	97.2%
Grass species richness	1	1
Grass cover (%)	<0.2%	73.2%
Grass species present in order of decreasing cover - most abundant first (cover in brackets)	*Lepturus repens* (<0.2%)	*Lepturus repens* (73.2%)
Forb (including vines) species richness	3	4
Forb species cover (%)	90.8%	24%
Forb species present in order of decreasing cover - most abundant first (Cover in brackets)	*Achyranthes aspera* (90.8%), *Boerhavia albiflora* var. *albiflora* (<0.2%), *Portulaca oleracea* (<0.2%)	*Achyranthes aspera* (23.6%), *Boerhavia albiflora* var. *albiflora* (0.4%), *Portulaca oleracea (<0.2%), Tribulus cistoides (<0.2%)*
Native shrub ground cover (%)- *Abutilon albescens*	<0.2%	0%
Non-native plant cover (all strata) (%)	0%	0%
Litter cover (%)	9.2	1.4%
Bare ground (%)	0%	1.4%
Woody debris (m/ha of logs >0.5m long and >10cm wide)	nil	nil
Soil pH	8.36 (0-10cm), 8.26 (10-20cm), 8.41 (20-30cm)	8.9 (0-10cm), 8.94 (10-20cm), 9.15 (20-30cm)

Photo 72: Monitoring site M10, Hermit Crab Islet facing E.

Photo 73: Monitoring site M10, Hermit Crab Islet facing S.

Photo 74: Monitoring site M10, Hermit Crab Islet facing W.

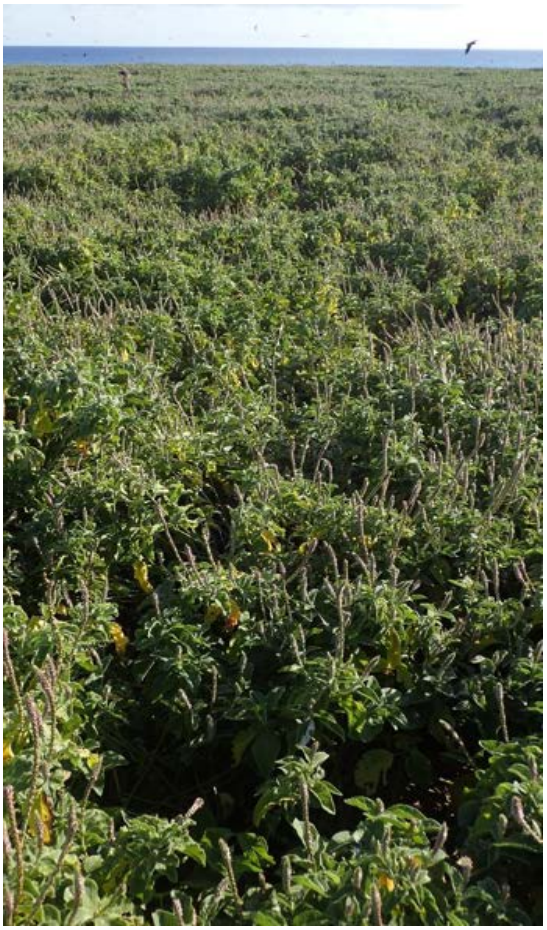


Photo 75: Monitoring site M10, Hermit Crab Islet facing N.

Photo 76: Monitoring site M11, Hermit Crab Islet facing E.

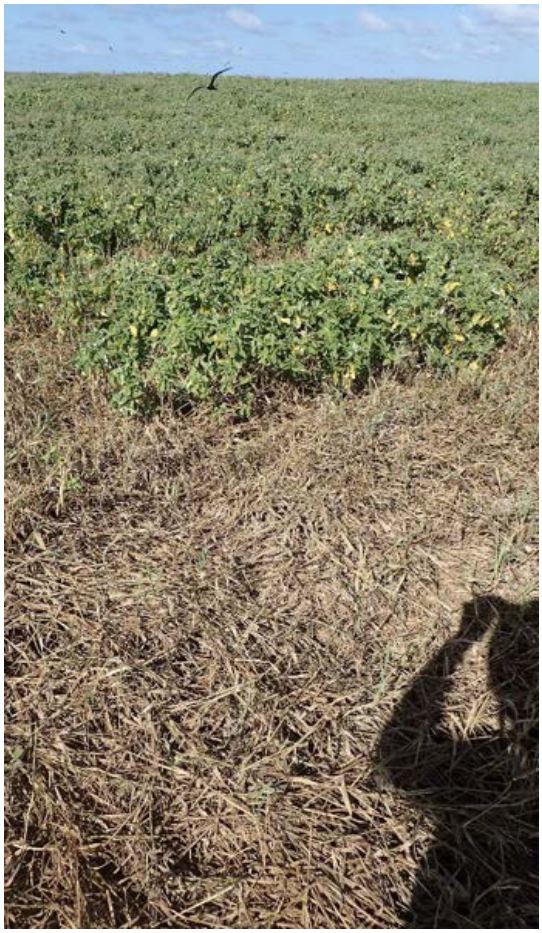


Photo 77: Monitoring site M11, Hermit Crab Islet facing S.

Photo 78: Monitoring site M11, Hermit Crab Islet facing W.

Photo 79: Monitoring site M11, Hermit Crab Islet facing N.

Soils data

Shoreline soils consists of white sand and coral rubble.

Grasslands at the base of the slopes have light coloured to light grey sand with coral rubble in some places.

The depression at the eastern end of the cay had grey brown sandy soil.

The slopes and crests and plateau in the interior of the cay had grey brown coarse sand with some organic content.

The table in Appendix 11 contains the results of the analysis of soil samples collected from monitoring sites M10 and M11 during the vegetation survey. Refer to the general Vegetation Results and discussion for further discussion on the soil analyses results.

Magnesium levels were high and aluminium levels and trace element levels were quite low in soils collected in the closed grassland site (M11).

Figure 86. Hermit Crab Islet - Health check, rodent tunnel and ant bait station monitoring sites.

Health checks

Hermit Crab Islet						
Anne Cay (Hermit Crab Islet) is an oblong vegetated cay with long axis lying east-west. The windward side of the cay is convex and the lee slightly concave. A sandy spit occurs at the western end with a small bay occurs on the windward shore. The maximum elevation is 5m with vegetated end terraces. Area 11.2 ha (Hill and Hogg 1984).						
Ecosystems and biodiversity	**Health Checks**					
Value - Coral cay communities (Communities present listed below)	**Veg map unit**	Dominant Sub-dominant Remaining veg (ha)		Photomonitoring: N - North photo E - East photo S - South photo W - West photo		**Overall condition class**[1]
Shoreline and sandspit vegetation						
Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	1a	HC82NE				G
Grasslands and Herblands						
Grassland communities dominated by *Lepturus repens*	3a	HC77	HC80	HC82		G
	3b	HC80N				G
Grassland communities co-dominated by *Lepturus repens* and *Stenotaphrum micranthum*	4	0.104				
Grassland communities dominated by *Stenotaphrum micranthum*	5	0.001				
Herbland communities dominated by *Boerhavia albiflora* var. *albiflora*	6a	0.054				
	6b	0.162				
Herbland communities dominated by *Achyranthes aspera*	8a	HC78	HC79	HC81		G
Habitats and species						
Value - Seabird and shorebird habitat						G
Value -Turtle rookery (Green turtle *Chelonia mydas)*						G

[1]Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

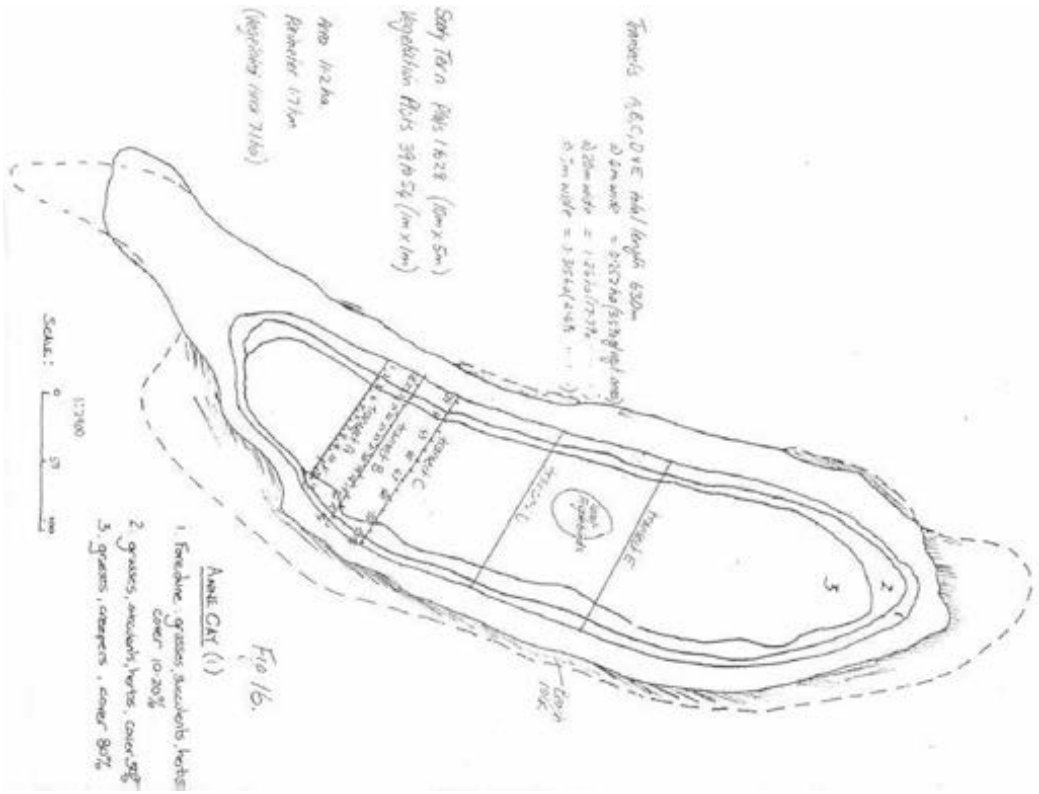


Figure 87. Anne Cay (Hermit Crab Islet) hand drawn from an aerial photograph. Note vegetated area of cay estimated 7.1 ha (Hicks 1984).

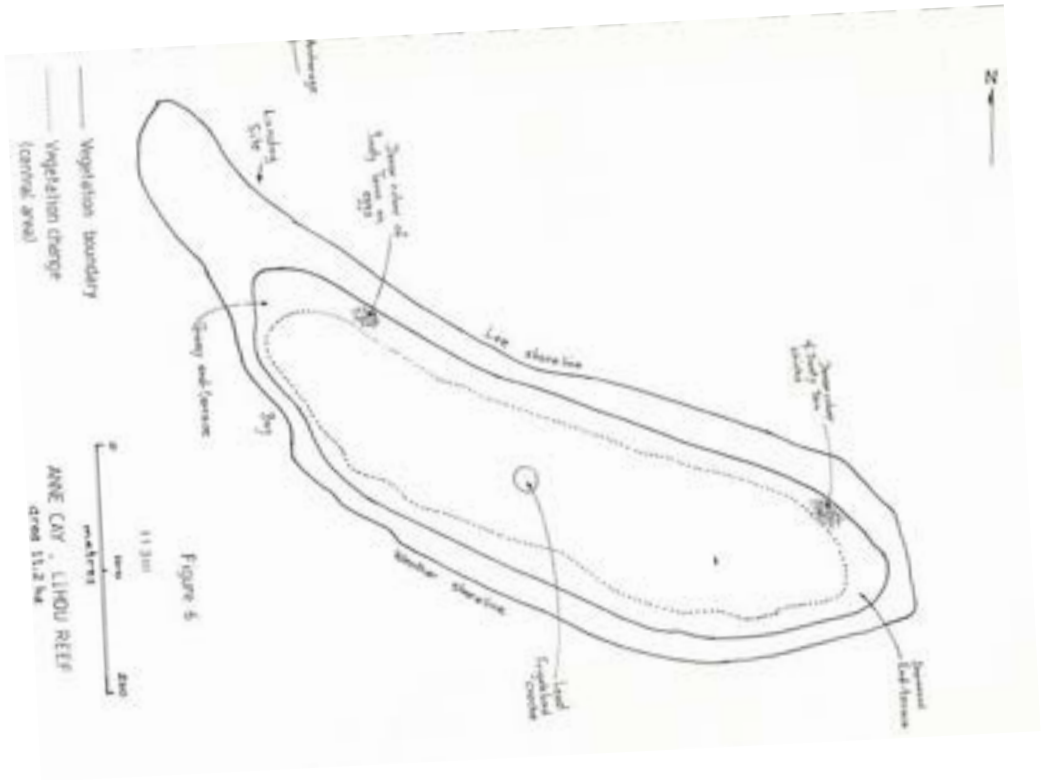


Figure 88. Map of Anne Cay (Hermit Crab Islet). Note area estimated 11.2 ha (Hill and Hogg 1984).

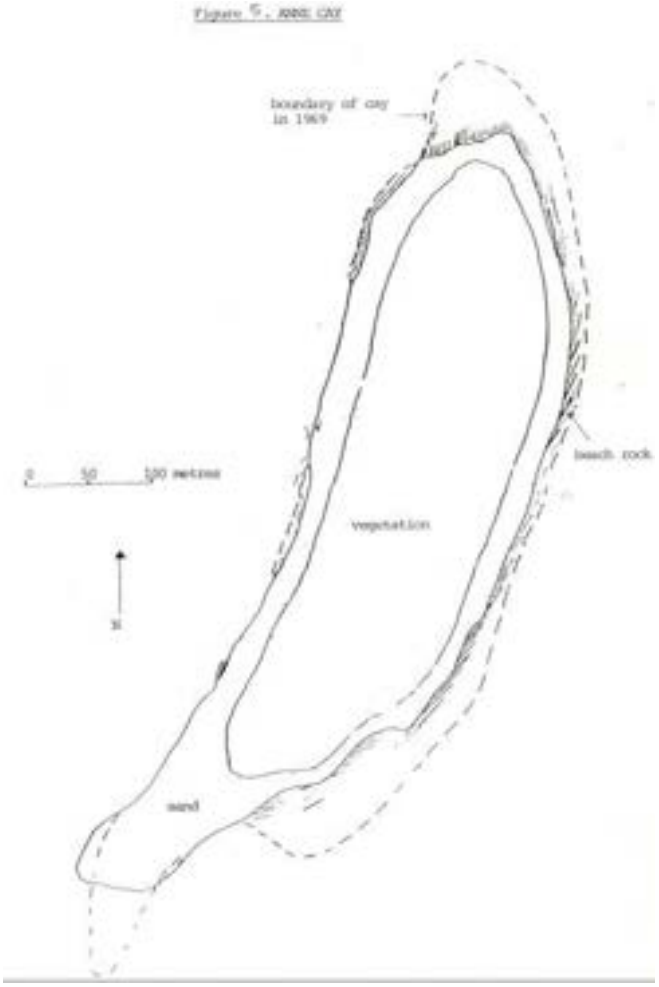


Figure 89. Map of Anne Cay (Hermit Crab Islet) hand drawn from 1969 aerial photograph (Grant et al. 1986).Note difference in North orientation.

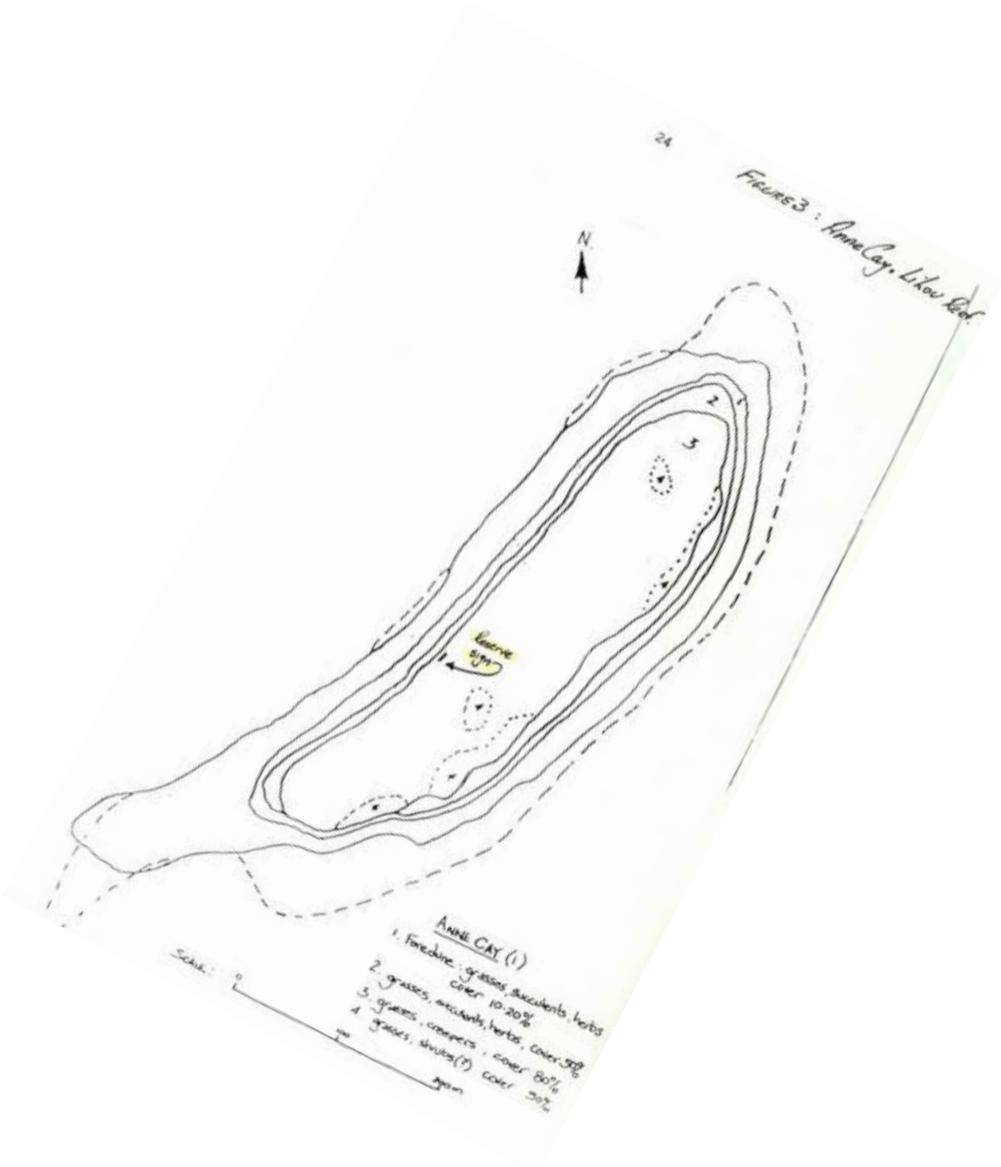


Figure 90. Map of Anne Cay (Hermit Crab Islet) (Scottney and Jeffs 1987). Note North orientation.

BELOW
Figure 26: Anne Cay showing the wooden sign erected on this patrol

Figure 91. Photo of sign at Anne Cay (Hermit Crab Islet) (Hill and Hogg 1984). Note vegetation community and condition.

*Photo: Photo of old sign posts presumably from sign in 1984 photo with **3a** Lepturus repens grassland/ closed grassland +/- Achyranthes aspera, Boerhavia albiflora var. albiflora, Portulaca oleracea.*

ABOVE
Figure 27: Anne Cay
Sooty Tern adults on the upper beach and
Common Noddies lining the water's edge

Figure 92. Photo of Anne Cay (Hermit Crab Islet) shoreline (Hill and Hogg 1984).

Photo: Possible location of above 1984 photo. Looking in an easterly direction along the north side of Hermit Crab Islet from the north western corner.

Results

Seven Health Checks were undertaken on Hermit Crab Islet to assess the condition of shoreline, grassland, and herbland communities. Health Checks assessed the condition of four vegetation communities. Remaining communities not assessed by Health checks may be included in A. Overall vegetation condition.

The overall condition rating for each of the vegetation communities was Good. The vegetation was lush and green with high plant biomass and coverage. Vegetation communities on the shoreline were intact with plants actively encroaching bare sand.

A. Overall vegetation condition

*Photo: Looking along the north side of the cay from the northwestern corner across **3a** Lepturus repens grassland/ closed grassland +/- Achyranthes aspera, Boerhavia albiflora var. albiflora, Portulaca oleracea. Photo taken facing east from HC82.*

*Photo: Grassland community **1a** that encroaches onto spits and the perimeter of cays stabilises shorelines. Photo taken from the northwestern corner facing east.*

*Photo: Grassland community **1a** restores bare sand impacted by turtle nesting and provides seabird habitat. Photo taken facing north from HC82. Note the brown booby nest (brown patch) in the grass clump in the centre foreground.*

*Photo: Lepturus grassland community **3a** in good condition provides important nesting habitat for sooty terns. Photo taken facing southwest from HC82.*

*Photo: View of **3b** Lepturus repens/ Achyranthes aspera grassland or closed grassland/herbland or closed herbland (Seasonally variable) with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea from the northwestern spit. Photo taken facing south from HC82.*

*Photo: The central interior of Hermit Crab Islet was dominated by **8a** Achyranthes aspera Herbland/closed herbland with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea. Note the green condition and coverage. Photo taken looking across the interior of the cay from HC78 facing east.*

Photo: Photo taken looking across the length of the cay from HC78 facing west.

*Photo: View from the eastern end of the cay on the windward side looking towards the cay interior with **3b** Lepturus repens/ Achyranthes aspera grassland or closed grassland/herbland or closed herbland (Seasonally variable) with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea in the foreground and the green herbland community **8a** that encompasses the cay interior in the background. Photo taken facing west from HC80.*

Photo: Close view of Achyranthes herbland showing the lush, green fertile growth in the interior of the cay.

B. Health Check photo monitoring - sample photo of each vegetation type

Photo: HC82 ***1a*** *Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines.*

Photo: HC82 ***3a*** *Lepturus repens grassland/ closed grassland +/- Achyranthes aspera, Boerhavia albiflora var. albiflora, Portulaca oleracea.*

*Photo: HC80 **3b** Lepturus repens/ Achyranthes aspera grassland or closed grassland/herbland or closed herbland (Seasonally variable) with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea.*

*Photo: HC81 **8a** Achyranthes aspera Herbland/closed herbland with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea.*

Introduced pests

A. Rodents

Table 57. Rodent tunnel monitoring - Hermit Crab Islet.

Hermit Crab Islet			
No. of rodent tunnels	Date deployed	Date collected	Evidence of rodents (tracks, droppings)
14[1]	19/7/21	19/7/21	Nil

[1] Refer *Figure 86*.

B. Ants and other invertebrates

Table 58. Invertebrate species summary - Hermit Crab Islet.

Hermit Crab Islet[1]					
Specimen no.	Date	Site	Specimen	Identification	Native / introduced
46	20/7/21	NA	Caterpillar	TBA	TBA

[1]During a previous ANPWS survey five mites, one centipede, five spiders, 16 beetles including lady beetles ex *Ab. indicum* shrub, scale insects ex *Ab. indicum* were collected on Anne Cay (Hermit Crab Islet) (Hill and Hogg 1984).

14. Betty Cay

Birds

Table 59. Species and breeding effort – Betty Cay.

Betty Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
20/07/2021	black noddy				0	3	
20/07/2021	black-naped tern				0	11	
20/07/2021	brown booby				0	53	
20/07/2021	common noddy				0	2	
20/07/2021	masked booby				2	3	G,N
20/07/2021	sooty tern				0	8	

Somewhat surprising there was not more brown booby or masked booby breeding activity on this unvegetated cay.

Figure 93. Betty Cay - Health check monitoring locations.

Health check

Betty Cay

Unvegetated sand cay – Approx. 2.4 ha (above high water)

(Grant et al. (1986) stated the cay was covered in deep depressions and mounds giving it the appearance of a minefield and with a cay area of 3.7 ha (300m long and 120m wide).)

- Sandy shores
- Lithified shores
- Elevated area of cay predominantly sand with shingle

Health Checks: HC83, HC84, HC85

Habitats and species	**Health Checks** **Overall Condition class[1]**
Value - Seabird and shorebird habitat	G
Breeding and roosting habitat - Refer Birds A. McDougall. Empty common noddy nests present. Six bird species recorded: • Six seabird species • Single breeding pair of masked boobies	
Value – Turtle rookery (Green turtle *Chelonia mydas*)	G
Turtle body pits concentrated in a wide band around the perimeter of the cay where the substrate is comprised predominantly of sand with pieces of coral. As the proportion of shingle increases toward the interior body pits are more widely spaced apart with no body pits in central areas of the cay. It is possible that nesting attempts failed in the areas of hard sediment and high shingle content. Widespread occurrence of pumice in the interior of the cay including in body pits. Some logs and large blocks of lithified sediment are also present in the central interior. This debris may have resulted from single or multiple events e.g. cyclones or severe weather. Where the substrate is hard and compacted and predominantly shingle in the central region of the cay there is no evidence of turtle nesting activity. The elevated area of Betty Cay is an oval shape approximately 125m across its breadth and 300m in length providing more available nesting area to shoreline ratio compared to long narrow cays such as Carol and Dianna Cays. Survey undertaken outside turtle breeding season. Quality of nesting habitat and nesting success on Betty Cay is unable to be determined. Monitoring during the breeding season is required.	

1. Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

Figure 94. Map of Betty Cay drawn from 1969 aerial photograph (Grant et al., 1986). Estimated cay area at 3.7 ha.

Photo: View looking across Betty Cay from the north side with fine sediments on the perimeter (with turtle body pits) in foreground of photo and hard, shingle and sand substrate (not utilised by nesting turtles) in the central area of the cay (darker area) in the background. (Photo facing east with Hermit Crab Islet in the background.)

Photo: Turtle body pits were found primarily in sandy areas occurring as a wide band around the perimeter of Betty Cay.

Photo: Widespread pumice occurred in the interior of Betty Cay.

Photo: View of interior of Betty Cay with hard, shingle and sand substrate. Note presence of blocks of lithified sediment and logs. Note Hermit Crab Islet in background of photo.

Photo: View looking along the windward side of Betty Cay showing tide lines encroaching into areas used by nesting turtles. Note presence of rows/piles of pumice in turtle body pits in foreground and mid background of photo.

Photo: Empty common noddy nests were present on Betty Cay.

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Nil pests/invertebrates detected.

15. Frankie Cay

Birds

Table 60. Species and breeding effort – Frankie Cay.

Frankie Cay (Lihou) Date:	Species		Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
20/07/2021	black-naped tern					0	4	
20/07/2021	common noddy					0	42	

Tiny, unvegetated intertidal roosting cay.

Figure 95. Frankie Cay.

Health check

Due to small, intertidal cay a Health Check was not undertaken. As mentioned above the cay has value as an intertidal roosting site.

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Nil pests/invertebrates detected.

16. Observatory Cay

Birds

Table 61. Species and breeding effort – Observatory Cay.

Observatory Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
21/07/2021	black-naped tern				0	31	
21/07/2021	brown booby				9	13	G,N
21/07/2021	common noddy				0	13	
21/07/2021	crested tern				0	2	
21/07/2021	masked booby				51	64	G,N
21/07/2021	ruddy turnstone				0	3	
21/07/2021	sooty tern				0	3	
21/07/2021	wandering tattler				0	2	

Figure 96. Ruddy turnstone, Arenaria interpres. Adult.

Figure 97. Brown booby, female. Nest surrounded by marine debris.

Figure 98. Observatory Cay - Health check monitoring sites.

Health check

Observatory Cay

Unvegetated sand cay - Approx. 8.1 ha (above high water)

(During an ANPWS survey in 1986 Observatory Cay was estimated at 8.8 ha in area and 700m long and 225m wide (Grant et al., 1986).)

- Sandy shores
- Lithified shores
- Elevated area of cay predominantly sand

Health Checks: HC87, HC88, HC89, HC90

Habitats and species	**Health Checks** **Overall Condition class[1]**
Value - Seabird and shorebird habitat	G
Breeding and roosting habitat - Refer Birds A. McDougall Empty common noddy nests Eight bird species recorded: • Six seabird species • Two shorebird species • Breeding masked and brown boobies The elevated area of Observatory Cay is an oval shape approximately 200m wide and 500m in length providing good habitat area to shoreline ratio compared to the long narrow cays such as Carol and Dianna Cays. Drone image shows evidence of past inundation on the windward side with evidence of pumice and flows into the interior extending from the mid point to the western end of the cay.	
Value – Turtle rookery (Green turtle *Chelonia mydas*)	NA
Only occasional turtle body pits were found on Observatory Cay.	

1. Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

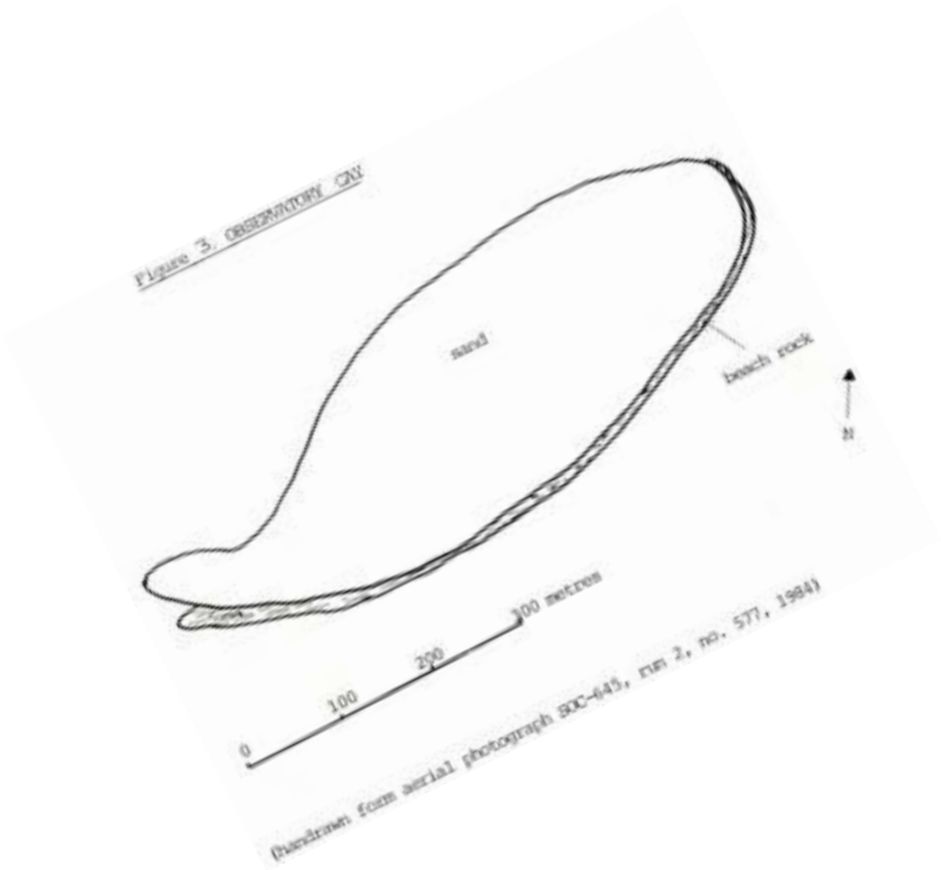


Figure 99. Map of Observatory Cay drawn from 1984 aerial photograph during 1986 ANPWS survey (Grant et al. 1986). Area estimated at 8.8 ha.

Photo: View looking west of masked boobies nesting on Observatory Cay with Middle Cay in the background and Turtle Islet on the far distant right.

Photo: View looking in an easterly direction across Observatory Cay. Note uniform substrate and flat topography with only slight undulations across the cay.

Photos: Observatory Cay supports extensive flat areas suitable for nesting by masked boobies.

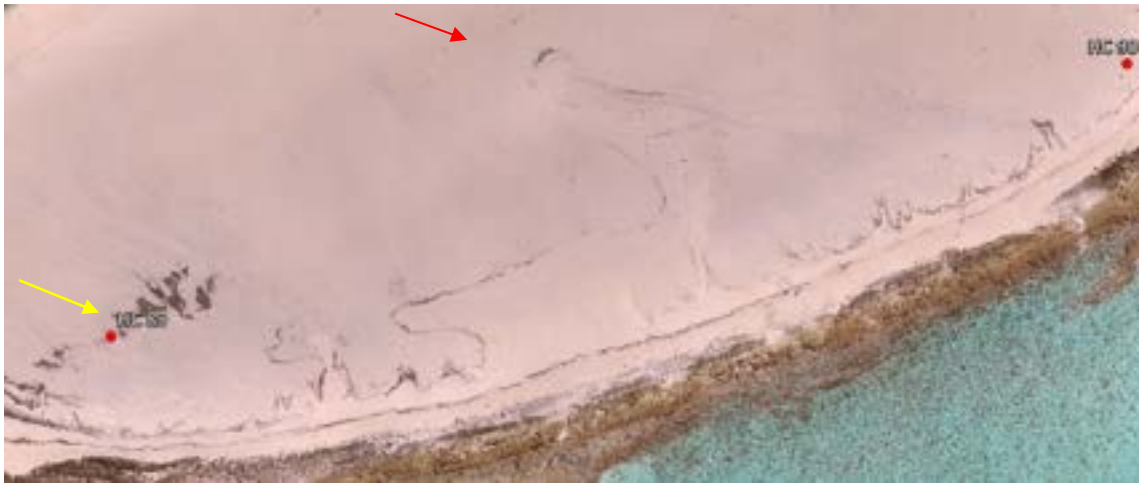


Photo: Drone image showing evidence of prior inundation on the windward side from the midpoint to the western end of the cay. Red arrow and yellow arrows – refer photos below.

Photo: View of inundation into interior of cay. Photo taken from red arrow in above drone image.

Photo: Photo showing areas of pumice in the cay interior. Photo taken from HC89 (marked by yellow arrow in above drone image)

Photos: Observatory Cay supported nesting for brown boobies in pumice and debris on the margins and bare terrain for masked boobies.

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Nil pests/invertebrates detected.

17. Middle Cay

Birds

Table 62. Species and breeding effort – Middle Cay.

Middle Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
21/07/2021	black-naped tern				5	44	G,Y
21/07/2021	brown booby				20	17	G,N
21/07/2021	common noddy				0	6	
21/07/2021	masked booby				38	53	G,N
21/07/2021	Pacific golden plover				0	4	
21/07/2021	red-tailed tropicbird				0	1	
21/07/2021	sooty tern				0	2	

Large unvegetated cay with loose sand substrate. Probably not suitable for small tern nesting unless pumice banks form along outside edges.

Figure 100. Middle Cay. Beach rock is currently exposed within the cay's interior.

Figure 101. Middle Cay - Health check monitoring sites.

Health check

Middle Cay

Unvegetated cay – Approx. 4.7 ha (above high water)

Unvegetated sand cay with long axis running northwest-southeast

(Middle Cay is a banana shaped cay approximately 7.8 ha with the long axis of Middle Cay running east-west, approx. 180m wide and 630m long, maximum elevation 2m ASL and cay apparently overwashed at times (Hicks 1984).)

- Sandy shores
- Lithified shores
- Elevated area of cay predominantly sand with middle section of exposed beach rock

Health Checks: HC91, HC92, HC93, HC94, HC95

Habitats and species	**Health Checks** **Overall Condition class**[1]
Value - Seabird and shorebird habitat	G

Breeding and roosting habitat - Refer Birds A. McDougall.

Empty common noddy nests

Seven bird species recorded:

- Six seabird species
- One shorebird specie
- Breeding masked boobies, brown boobies and black-naped terns

Value – Turtle rookery (Green turtle *Chelonia mydas*)	G

Old turtle body pits throughout most of sandy area of the cay. Grant et al. (1986) recorded that the cay was covered with old turtle craters.

Exposed beach rock in the middle of the cay forms a central depression with the remainder of the cay at a higher elevation with a high foredune around the perimeter.

Around the cay there is evidence that tides are washing over the berm encroaching into areas used by nesting turtles. The drone image also shows evidence of tide lines inside the outer berm.

A number of turtle skeletons were found in the interior resulting from disorientated nesting turtles.

The elevated area of Middle Cay is an 'oval' shape approximately 140m wide and 500m in length providing good nesting area to shoreline ratio compared to long, narrow cays where there is an increased risk of flooding of turtle nests.

Only minor evidence of old turtle tracks in the drone image in the area of the exposed beach rock depression. Low incidence of tracks may be due to the effects of wind and fine sediments found on cay.

Survey undertaken outside turtle breeding season. Quality of nesting habitat and nesting success was not able to be determined. Monitoring during the breeding season is required to determine nesting success.

1. Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

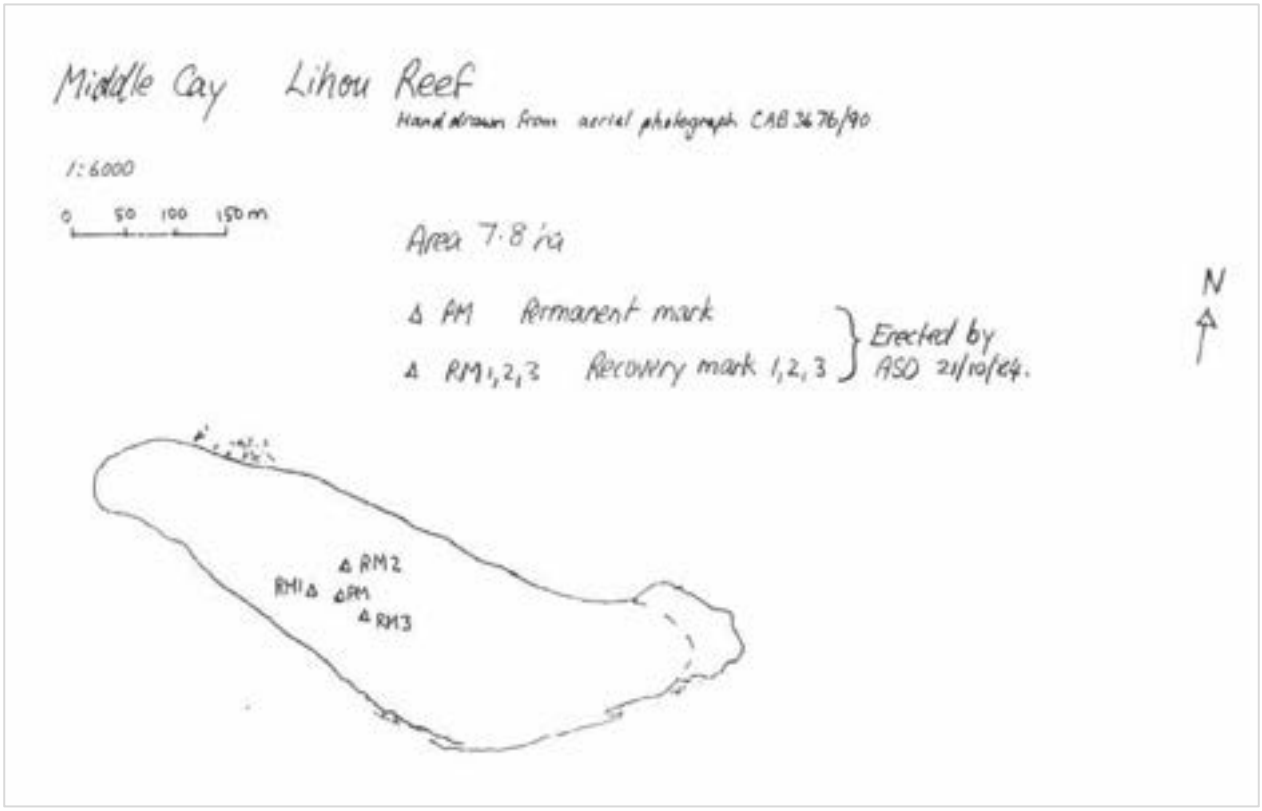


Figure 102. Drawing of Middle Cay from aerial photograph (Hicks 1984). Note area of cay estimated 7.8 ha.

Photo: Looking eastwards across the terrain of Middle Island with Observatory Cay in the distance.

Photo: Looking along the southern side of Middle Cay showing pumice in body pits where tides have encroached into areas used by nesting turtles. Note central depression of exposed beach rock in the background and Observatory Cay on the distant left.

Photo: Looking along the northern side of Middle Cay where tides have encroached into areas used by nesting turtles leaving pumice in body pits.

Photo: Close up view of exposed beach rock and remains of a green turtle on the right of the photo. Note. Pumice was found in the immediate area.

Photo: View from the depression in the cay interior showing the difference in elevation to the surrounding area of the cay.

Photo: Looking from the perimeter of the cay facing west across the windward side of the cay showing the high berm around the perimeter and the exposed beach rock depression.

Photo: A number of dead green turtles' remains were found on Middle Cay.

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Nil pests/invertebrates detected.

18.Turtle Islet

Birds

Table 63. Species and breeding effort – Turtle Islet.

Turtle Islet (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
21/07/2021	black noddy				0	1	
21/07/2021	black-naped tern				0	1	
21/07/2021	brown booby				61	68	G,N
21/07/2021	common noddy				595	760	G,Y
21/07/2021	crested tern				0	2	
21/07/2021	great frigatebird				0	1	
21/07/2021	lesser frigatebird				0	1	
21/07/2021	masked booby				32	33	G,N
21/07/2021	red-footed booby				0	2	
21/07/2021	ruddy turnstone				0	3	
21/07/2021	sooty tern				4110	2008	G,Y
21/07/2021	wandering tattler				0	1	

Figure 103. Sooty tern, young and adult.

Figure 104. Sooty tern, adult feeding young.

Figure 105. Sooty terns. Chicks and young move freely on these pest free cays.

Figure 106. Drone imagery: sooty tern young are more easily identified by their shadows during early morning and late afternoon image capture.

Vegetation

Cay description

Turtle Islet is located at on Lihou Reef at -17.116 degrees latitude and 152.004 degrees longitude. It was the smallest vegetated cay visited during the July 2021 voyage with a total vegetated area of 2.5 hectares.

Turtle Islet was surveyed by Australian Survey Office in April1980 and again in 1983. The topography of the cay shown in *Figure 108* was taken from the report by Tony Stokes and Andrew Skeat (1980).

Figure 107 contains surface elevation profiles of Turtle Islet.

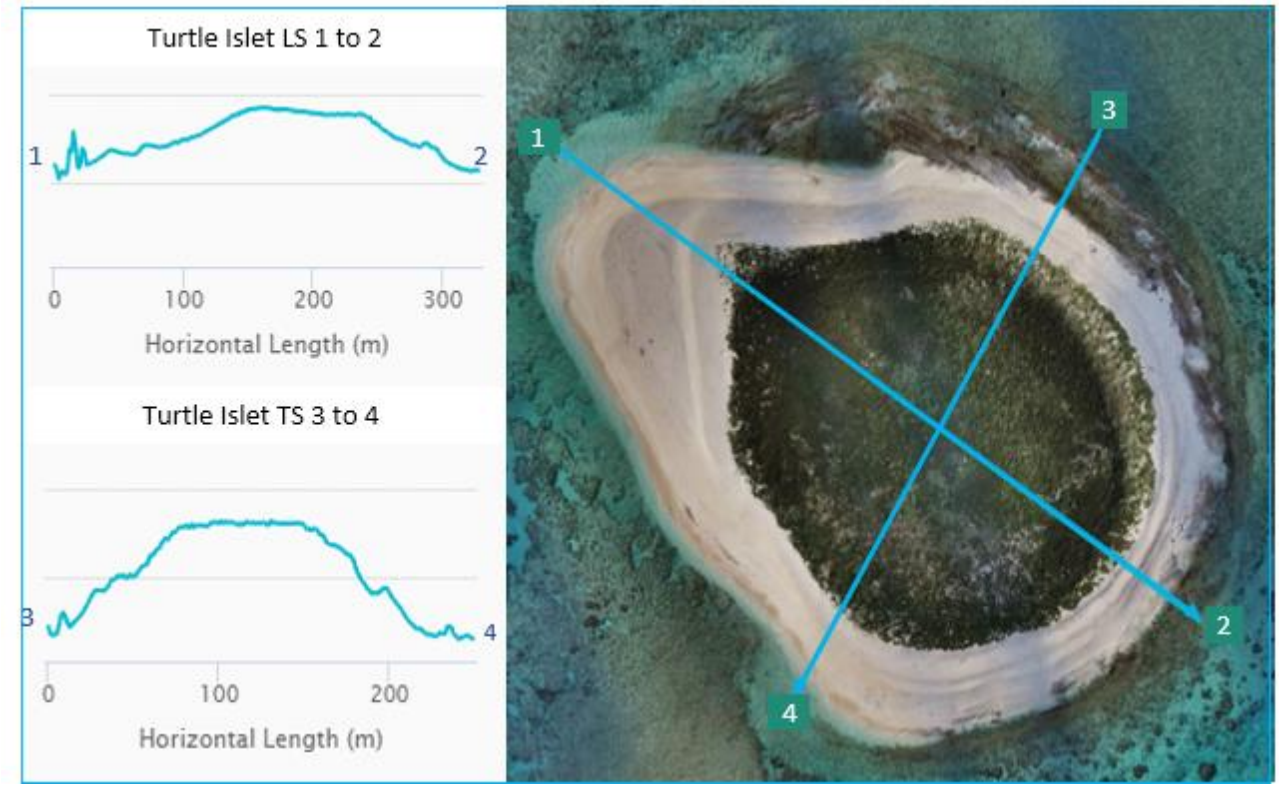


Figure 107. Elevation profiles of Turtle Islet.

Note: Maximum height is approximately 6 metres ASL. Vertical heights and scale are not included in surface profile diagrams as accurate datum information was not available

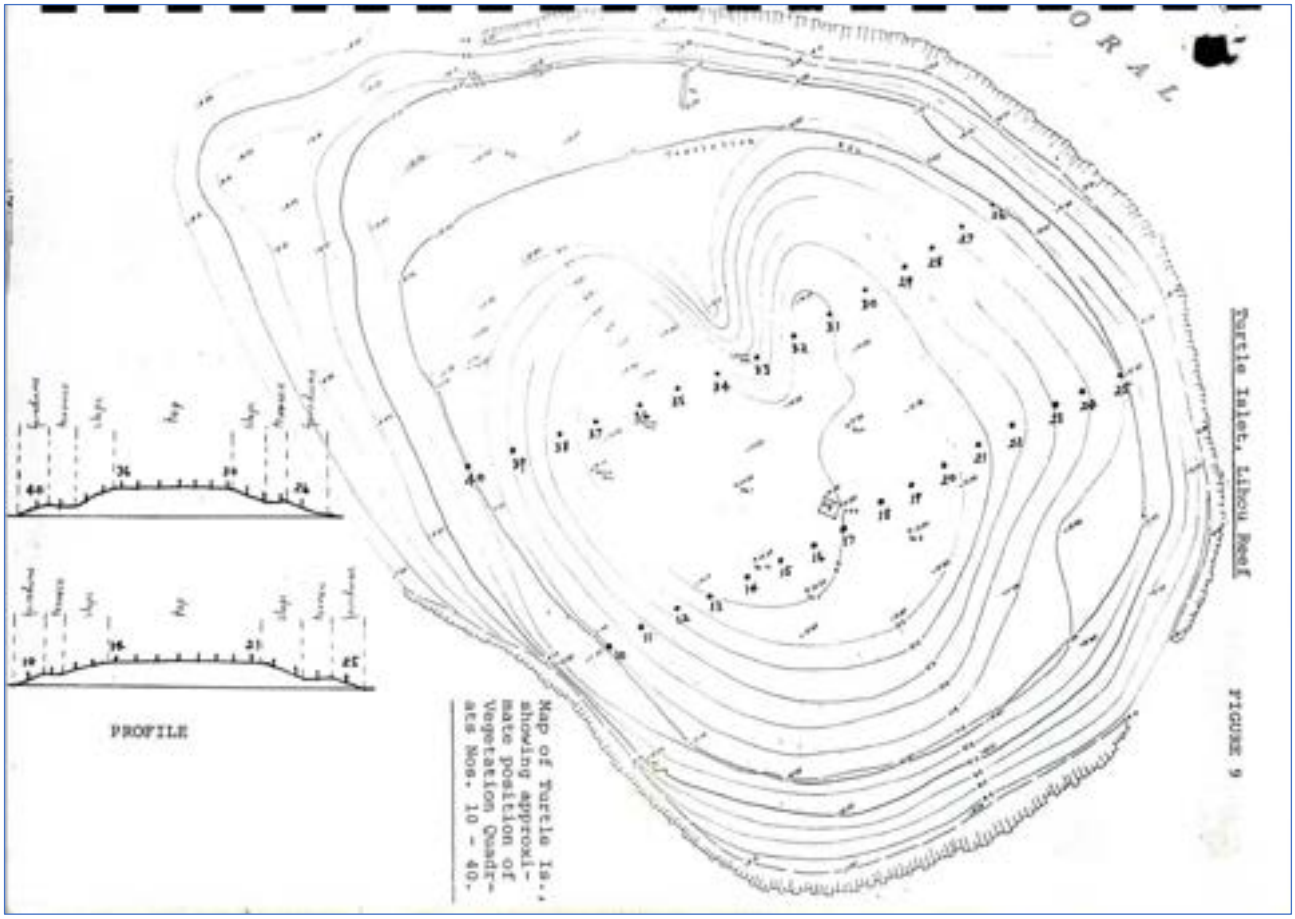


Figure 108. Australian Survey Office map of Turtle Islet in 1980 showing location of vegetation cover quadrats (from Stokes and Skeat, 1980).

Note Shaughnessy and Hill (1983) noted that the gully marked on the 1980 AS0 map was not evident in either the 6th or 7th surveys

Survey intensity

Four hours was spent surveying the vegetation of Turtle Islet. Vegetation data was recorded at 17 ground-truthing sites and two permanent monitoring sites (M12 and M13). The locations of these sites are shown in *Figure 109.* The blue lines are the boundaries of the vegetation communities shown on the vegetation map in *Figure 110*.

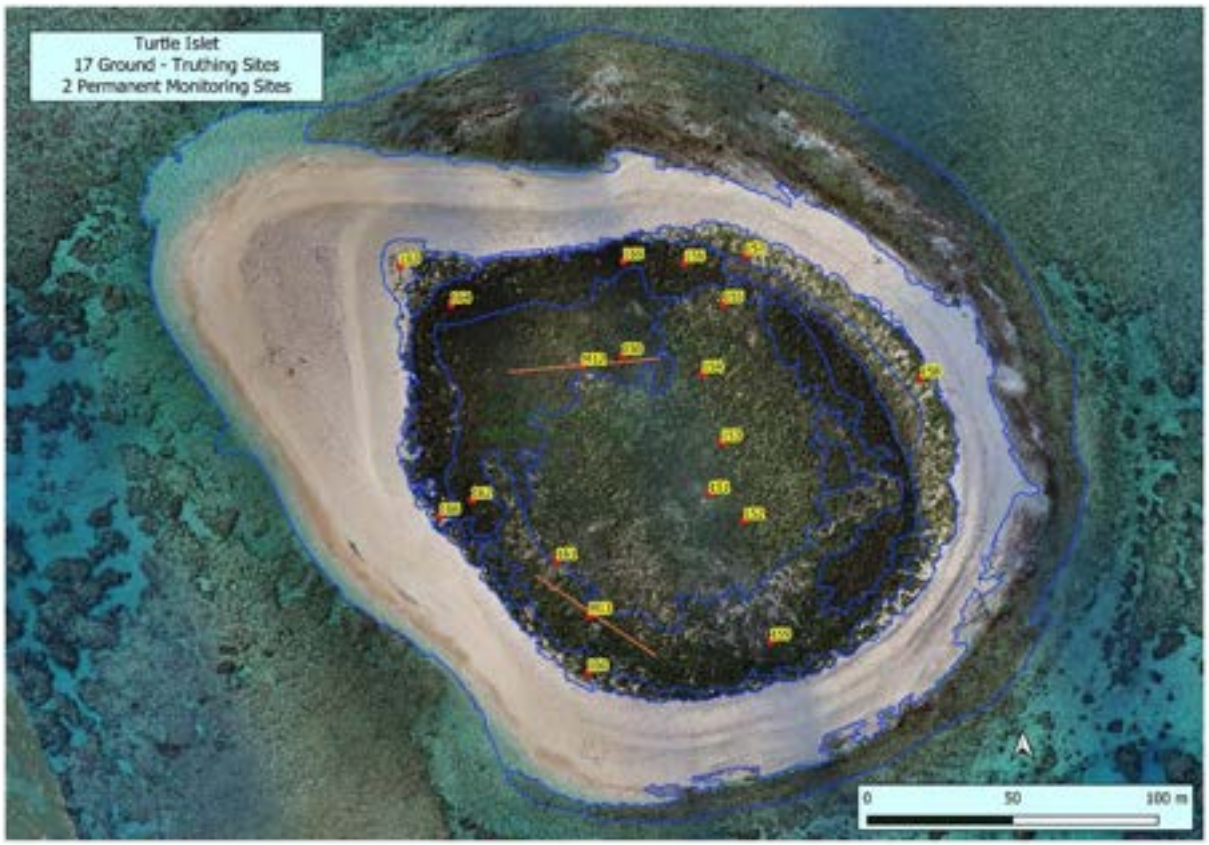


Figure 109. Turtle Islet showing the number and location of ground-truthing sites and permanent monitoring sites relative to the vegetation.

Vegetation condition

The vegetation of the cay appears to have recovered well after being completely buried by sand during a cyclone in 1990.

All the vegetation on the cay appeared to be in good condition at the time of the July 2021 survey. There was, however, reduced flowering and fruiting observed on most plant species throughout the cay compared to other cays visited during the voyage. There was an infestation of plague locusts on the cay at the time of the visit. It could not be determined whether the locusts were having any effect on the flowering and fruiting of the plants or any other detrimental effect. Plenty of foliage remained on the plants despite the large numbers of locusts. The locusts were not observed on any of the other cays visited, although Heatwole recorded a species of *Valanga* on Herald Cay in 1979. Locust grasshoppers can fly large distances especially when assisted by strong winds. It is not, therefore, unexpected to find a population on a Coral Sea cay. Peter Sayre also reported “vast numbers of grasshoppers” on Turtle Islet as well as “lower than expected bird numbers” (Sayer 2019).

Floristic data

Seven plant species were recorded on Turtle Islet. These are listed in *Table 64* in order of frequency in sites together with the averaged cover for each species for sites in which the species was present and their averaged cover over the entire cay. *Portulaca oleracea* was the most widely distributed species across the cay during the July 2021 survey (present in 84% of the surveyed sites) and *Lepturus repens* was the most abundant species on the cay with an average cover of 46.4% in sites where it was present and an overall cover of 34.2 % of the vegetated area across the entire cay. Data for species cover at each site plus occurrence of each species in relation to vegetation community and landform are contained in *Table 66*.

Table 64. Plant species recorded on Turtle Islet, 21-22/07 2021.

Layers: (E) = emergent, (S1) = upper shrub, (S2) = lower shrub, (G) = Ground

Species	Common Name	Family	Presence in Sites (% of sites)	Average % Cover in Each Layer (Only sites containing the species were averaged)	Overall Average % Cover in Each Layer (average includes all sites)
Portulaca oleracea	pig weed	Portulacaceae	84%	11.6% (G)	9.7% (G)
Lepturus repens	stalky grass	Poaceae	74%	46.4% (G)	34.2% (G)
Stenotaphrum micranthum	beach buffalo grass	Poaceae	74%	23.6% (g)	17.4% (g)
Boerhavia albiflora var. *albiflora*	boerhavia	Nyctaginaceae	74%	7.9% (g)	5.8% (g)
Achyranthes aspera	chaff flower	Amaranthaceae	47%	21.1% (g)	10% (g)
Abutilon albescens	lantern bush	Malvaceae	21%	2.5% (g)	0.5% (g)
Tribulus cistoides	bulls head burr	Zygophyllaceae	5%	2.5% (g)	0.1
total no of species = 7					

Floristic comparison with previous vegetation surveys

An automated weather station (AWS) was constructed on Turtle Islet in the 1970's (located at site 151 on the map in *Figure 108*). Regular maintenance trips during its period of operation provided opportunities for ANPWS personnel to join maintenance voyages and undertake a number of biological surveys.

Shaughnessey et al. (1983) recorded species cover in 31 quadrats positioned along two transects across the cay located as closely as possible to those used in a survey undertaken sometime between 1967 and 1979, by Heatwole (reference not available). This survey and methodology were also repeated by Hicks in October 1984. The following is a comparison of the averaged % cover and % presence in quadrats of each species recorded during these surveys:

- *Achyranthes aspera* % cover/% frequency in quadrats varied from 40%/NA- (Heatwole survey) to 11%/55% (June 1983) to 15.2%/66% (Oct 1984) to 10%/47% (July. 2021)
- *Boerhavia* % cover/% frequency in quadrats varied from 14%/NA (Heatwole survey) to 12%/65% (June 1983) to 3.5 %/60% (Oct 1984) to 5.8%/74% (July 2021).
- *Lepturus repens* % cover/% frequency in quadrats varied from 13%/NA (Heatwole survey), 16%/52% (June 1983) to 49.6% /63% (1984) to 34.2% /74% (July 2021).
- *Stenotaphrum micranthum* % cover/% frequency in quadrats varied from 5%/39% (June 1983) to 7.8%/26% (Oct 1984) to 17.4%/74% (July 2021) (not recorded by Heatwole).

- *Portulaca oleracea* has possibly become more widely distributed with % cover/% frequency in quadrats varying from 3%/32% (June 1983) to 0.6% /16% (Oct 1984) to 9.7%/84% (July 2021).
- *Abutilon albescens* has remained at relatively low abundance and frequency throughout (not recorded by Heatwole).

The above data suggests there has been an increase in abundance and distribution of the grasses, *Lepturus repens* and *Stenotaphrum micranthum*, a decrease in abundance and distribution of *Boerhavia* and an increase in the distribution of *Portulaca oleracea* across the cay since the Heatwole survey data was recorded. Although relative abundance varies, the dominant plant species of the cay have consistently been *Lepturus repens, Achyranthes aspera* and *Boerhavia*.

Ipomoea pes-caprae subsp. *brasiliensis* was recorded during the first Australian National Parks and Wildlife Service (ANPWS) biological survey of Turtle Islet in December 1979 (Stokes and McNamara, 1979) and also by Shaughnessy and Hill in June 1983 (7th Survey) and Hicks in 1984. This species appears to be no longer present on the cay as it was not present in the April 1994 survey (Donaldson 1994) or the July 2021 survey despite thorough searching of its previous location in the vicinity of the AWS. The reason for loss of this species is not known. Possible contributing causes may be the 1990 cyclone or damage during maintenance of the AWS. According to Hill (1984), *Ipomoea pes-caprae* was present as a single patch adjacent to the weather station and was occasionally driven over by the LARC amphibious truck.

Tribulus cistoides, previously thought to have disappeared from the cay (Hill, 1983), was recorded in low abundance in the permanent monitoring site, M13, in July 2021. Prior to 1983, this species was recorded as low abundance and frequency on the cay. This species is a summer annual and therefore more likely to be observed in the summer months.

These differences may be partly due to differences in survey locations and methodology as discussed in the Limitations of the vegetation survey, mapping and reporting. Climatic variation and natural dynamics (including species turnover) of cay vegetation are also likely to contribute to changes in cay vegetation over time.

Comparison of the Heatwole and 1983 surveys for Turtle Islet showed a 10 metre recession of vegetation on the northern side and a five metre expansion on the southwestern side with little change elsewhere.

Vegetation communities on Turtle Islet

Vegetation communities present on *Turtle Islet* in July 2021, the area of each and representative survey sites within each vegetation community are listed in *Table 65*. The spatial distribution and extent of the vegetation communities on Turtle Islet in July 2021 are shown in the vegetation map in *Figure 110*.

Vegetation of the cay consisted only of grasses and other herbaceous species. No trees or large shrubs were present.

Map unit 1a was not as abundant on Turtle Islet as it was on other cays. It was most prevalent on the leeward (northwestern) shoreline. The dominant species in this unit was *Stenotaphrum micranthum* beach buffalo grass).

Lepturus repens (stalky grass)/*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora*(boerhavia), *Portulaca oleracea* (pigweed) (map unit 4) was present adjacent to the northwestern shoreline at the base of the landward slope adjacent to the dunes. In other parts of the shoreline, the vegetation was dominated by *Stenotaphrum micranthum* grassland (map unit 5). *Boerhavia albiflora* var. *albiflora* was present throughout this unit in low abundance.

Lepturus repens closed grassland (map unit 3a) was present at the edges of the plateau crest and also in patches in the central interior of the cay.

Lepturus repens/ *Achyranthes aspera* closed grassland/herbland (map unit 3b) dominated the centre of the cay interior. *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea* were present in low abundance throughout this unit. *Boerhavia albiflora* var. *albiflora* sparse herbland/ open herbland/ herbland with *Portulaca oleracea* formed a mosaic with map unit 5a on the slopes (southwest to southeast).

Table 65. Vegetation communities on Turtle Islet.

Veg Map Unit Code	Vegetation Community	Hectares on Turtle Islet	ID of Sites on Turtle Islet
	Unvegetated Areas		
A	Sandy shores	2.4 (approx.)	
B	Lithified shores	1.4 (approx.)	
	Shoreline and Sandspit Vegetation		
1a	Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	0.053	163, 166
	Grasslands and Herblands		
3a	*Lepturus repens* grassland/ closed grassland +/- *Achyranthes aspera* +/- *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	0.680	150, 152, 153, 162, M12
3b	*Lepturus repens*/ *Achyranthes aspera* closed grassland/herbland/closed herbland (seasonally variable) with *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	0.666	151, 154, 155
4	*Lepturus repens*/*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea*	0.260	156, 164, 165
5	*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora* +/- *Achyranthes aspera* +/-*Portulaca oleracea*	0.686	157, 158, 159, 160, 161, M13
6a	*Boerhavia albiflora* var. *albiflora* sparse herbland/ open herbland/ herbland with *Portulaca oleracea*	0.132	nil

Note: Areas of sandy shores and rocky shores, particularly those of the rocky shores are only approximate due to the difficulty in determining the location of the boundary between the edge of the shoreline and the surrounding reef flat using the imagery.

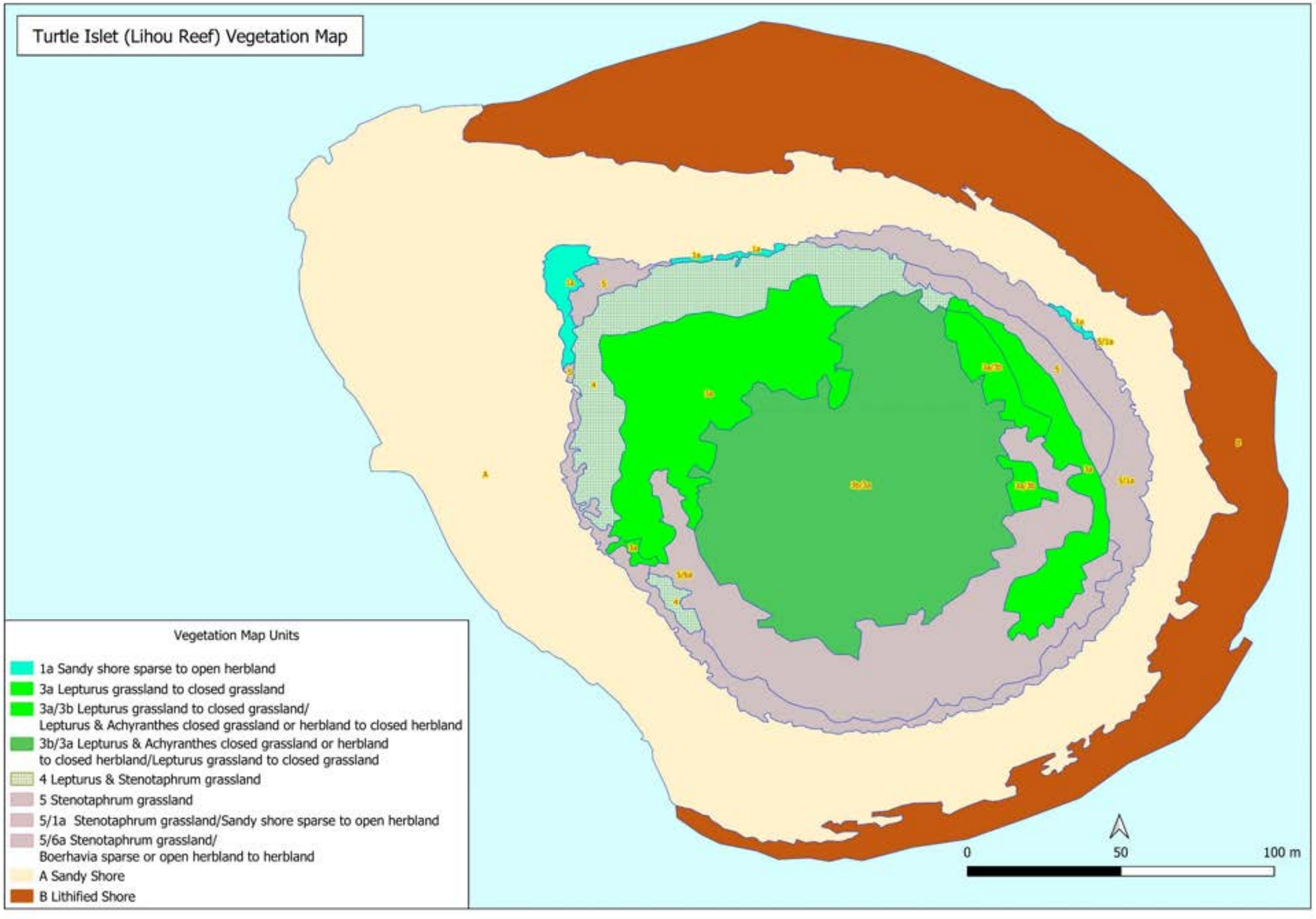


Figure 110. Turtle Islet vegetation map.

Table 66. Site data recorded on Turtle Islet.

Datum = WGS 84; green shading = site dominants

Site	Latitude	Longitude	Date	No of photos	Landform	Veg Map Unit	Vegetation Community	Ground Layer							Plant Specimens Collected	Notes
								Abutilon albescens	*Achyranthes aspera*	*Boerhavia albiflora* var. *albiflora*	*Lepturus repens*	*Portulaca oleracea*	*Stenotaphrum micranthum*	*Tribulus cistoides*		
163	-17.11589	152.002989	22/07/2021	1	Shoreline	1a	open grassland dominated by *Stenotaphrum micranthum*						5-25%			
166	-17.11667	152.003113	22/07/2021	2	Adjacent to shoreline	1a	grassland dominated by *Lepturus repens* and *Stenotaphrum micranthum*			trace-5%	5-25%	trace-5%	5-25%			
150	-17.11617	152.003676	21/07/2021	2	Plateau crest	3a	closed grassland dominated by *Lepturus repens*		trace-5%		95-100%					Lots of locust grass hoppers (plague)
152	-17.11668	152.004053	21/07/2021	2	Plateau crest	3a	closed grassland dominated by *Lepturus repens* and *Achyranthes aspera*	trace-5%	5-25%		50-75%		trace-5%			
153	-17.11644	152.003982	21/07/2021	2	Plateau crest	3a	closed grassland dominated by *Lepturus repens* and *Achyranthes aspera*	trace-5%	5-25%		75-95%	trace-5%			*Abutilon albescens*, *Achyranthes aspera*	
162	-17.11662	152.003212	22/07/2021	2	Flat to undulating at base of slope to beach	3a	closed grassland dominated by *Lepturus repens*				75-95%	trace-5%	trace-5%			
M12	-17.1162	152.003554	22/07/2021	8		3a	closed grassland dominated by *Lepturus repens*	trace-5%	trace-5%	trace-5%	95-100%	trace-5%				
151	-17.1166	152.003946	21/07/2021	2	Plateau crest	3b	closed herbland dominated by *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora*, *Lepturus repens* and *Portulaca oleracea*		50-75%	5-25%	5-25%	5-25%			*Portulaca oleracea*, *Lepturus repens*	Concrete footings for old weather station
154	-17.11623	152.003924	21/07/2021	1	Plateau crest	3b	closed herbland dominated by *Lepturus repens*, *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*	trace-5%	25-50%	5-25%	25-50%	5-25%				
155	-17.11601	152.003989	21/07/2021	2	Slope to NNEast	3b	herbland dominated by *Achyranthes aspera*, *Lepturus repens*, *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*		25-50%	5-25%	25-50%	5-25%	trace-5%		*Boerhavia albiflora*	
156	-17.11588	152.003869	21/07/2021	2	Base of slope adjacent to beach	4	grassland dominated by *Lepturus repens*, *Portulaca oleracea*, *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*			5-25%	25-50%	25-50%	25-50%			
164	-17.11601	152.003147	22/07/2021	1	Base of slope flat to undulating	4	grassland dominated by *Lepturus repens* and *Stenotaphrum micranthum*			trace-5%	25-50%	trace-5%	25-50%			
165	-17.11588	152.00368	22/07/2021	2	Flat to undulating	4	grassland dominated by *Lepturus repens*, *Portulaca oleracea* and *Stenotaphrum micranthum*			trace-5%	25-50%	5-25%	5-25%			
157	-17.11586	152.004056	21/07/2021	2	Adjacent to shoreline	5	open grassland dominated by *Stenotaphrum micranthum*			trace-5%		trace-5%	25-50%			
158	-17.11624	152.004599	21/07/2021	1	Adjacent to shoreline	5	grassland dominated by *Stenotaphrum micranthum*			trace-5%		trace-5%	25-50%		*Stenotaphrum micranthum*	
159	-17.11705	152.004135	21/07/2021	2	Slope to SE	5	grassland dominated by *Portulaca oleracea*, *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*			5-25%	trace-5%	25-50%	25-50%			
160	-17.11715	152.00357	22/07/2021	2	Adjacent to shoreline	5	grassland dominated by *Stenotaphrum micranthum*			trace-5%		trace-5%	25-50%			
161	-17.1168	152.003474	22/07/2021	1	Slope to SW	5	grassland/herbland dominated by *Stenotaphrum micranthum*, *Achyranthes aspera*, *Portulaca oleracea* and *Boerhavia albiflora* var. *albiflora*		5-25%	5-25%		5-25%	5-25%			
M13	-17.11697	152.003574	22/07/2021	8		5	grassland dominated by *Stenotaphrum micranthum* and *Portulaca oleracea*		trace-5%	trace-5%	trace-5%	5-25%	25-50%	trace-5%	*Tribulus cistoides*	

Permanent monitoring site data

Two permanent monitoring sites (M12 and M13) were established and surveyed on Turtle Islet. The locations of the centre transects of these sites are shown as the red lines in *Figure 109*. *Table 67* contains the data recorded at these sites. The photographs included with the data in this section are 4 of the 10 site photographs for each site. These are taken from the centre point of each site in four different directions (facing 0, 90, 180 and 270 degrees from the transect bearing respectively).

Table 67. BioCondition attributes recorded at permanent monitoring sites on Turtle Islet.

	Site M12	**Site M13**
Vegetation community description	Closed grassland dominated by *Lepturus repens*	Grassland dominated by *Stenotaphrum micranthum* and *Portulaca oleracea*
Transect start (WGS 84)	-17.116218 152.00332	-17.117094 152.003779
Transect centre (WGS84)	-17.116203 152.003554	-17.116973 152.003574
Transect end (WGS 84)	-17.116176 152.003794	-17.11685 152.003412
Transect bearing	73^0	300^0
Median canopy height (range)	0.4 (0.25 to 0.5)m	0.25 (0.02 to 0.35)m
Tree canopy cover %	n/a	n/a
Shrub canopy cover %	n/a	n/a
Basal area m^2/ha (at 30 cm height, calculated from stem diameters)	nil	nil
Total number of large trees/ha	0	0
Total no of trees per ha	n/a	n/a
Total number of tree stems/ha	n/a	n/a
Total no. shrubs/ha	n/a	n/a
Total no. shrub stems/ha	n/a	n/a
Large shrubs - mean diameter at 30 cm height	n/a	n/a
Recruitment of ecologically dominant layer (%)	n/a	n/a
Tree species richness	0	0
Tree species present	n/a	n/a
Shrub species richness	1	0
Shrub species present (layer in brackets)	*Abutilon albescens* (G)	nil
Median ground layer height (range)	G=canopy	G=canopy
Total ground layer cover of native cay species (%)	98.2%	51.2%
Grass species richness	1	2
Grass cover (%)	97.6%	26.2%
Grass species present in order of decreasing cover - most abundant first (cover in brackets)	*Lepturus repens* (97.6%)	*Stenotaphrum micranthum* (25.8%) , *Lepturus repens* (0.4%)
Forb (including vines) species richness	3	4
Forb species cover (%)	0.6%	25%
Forb species present in order of decreasing cover - most abundant first (Cover in brackets)	*Boerhavia albiflora* var. *albiflora* (0.6%), *Achyranthes aspera* (<0.2%) , *Portulaca oleracea* (<0.2%)	*Portulaca oleracea* (22.8%), *Boerhavia albiflora* var. *albiflora* (2.2%), *Achyranthes aspera* (<0.2%), *Tribulus cistoides* (<0.2%),
Native shrub ground cover (%)- *Abutilon albescens*	<0.2%	0%
Non-native plant cover (all strata) (%)	0%	0%
Litter cover (%)	1.4%	5.4%
Bare ground (%)	0.4%	43.4%
Woody debris (m/ha of logs >0.5m long and >10cm wide)	nil	nil
Soil pH	8.2 (0-10cm), 8.55 (10-20 cm), 8.78 (20-30cm)	8.36 (0-10cm), 8.54 (10-20cm), 8.56 (20-30cm)

Photo 80. Monitoring site M12, Turtle Islet facing ENE

Photo 81. Monitoring site M12, Turtle Islet facing SSE

Photo 82. Monitoring site M12, Turtle Islet facing WSW

Photo 83. Monitoring site M12, Turtle Islet facing NNW

Photo 84. Monitoring site M13, Turtle Islet facing NW

Photo 85. Monitoring site M13, Turtle Islet facing NE

Photo 86. Monitoring site M13, Turtle Islet facing SE

Photo 87. Monitoring site M13, Turtle Islet facing SW

Soils data

Soils on and adjacent to the shoreline consisted of white sand and coral rubble.

Soils in grasslands at the base of slopes adjacent to the shore were light coloured/ light brown sand.

Slopes had brown sandy soils.

Soils of the plateau crests were typically brown organic sandy soils.

The table in Appendix 11 contains the results of the analysis of soil samples collected from monitoring sites M12 and M13 during the vegetation survey. Refer to the general Vegetation Results and discussion for further discussion on the soil analyses results.

The topsoil in the closed grassland site on Turtle Islet (M12) had the highest levels of total carbon, organic carbon and phosphorus and the lowest levels of magnesium of all of the sites on the Lihou Reef cays and the highest levels of aluminium and all trace elements (copper, iron, manganese and zinc) of all the samples collected in the Diamond Islets and Lihou Reef cays.

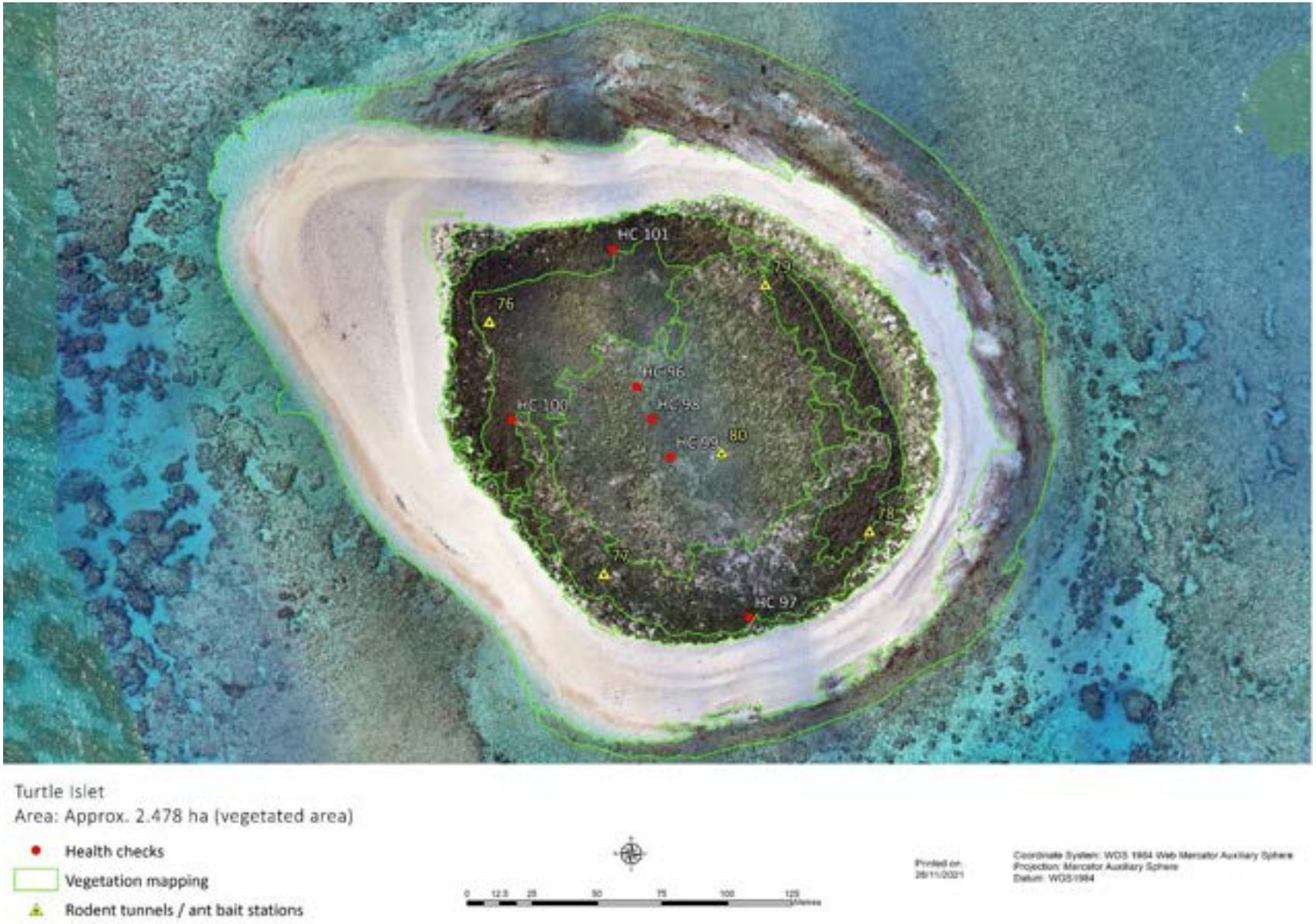


Figure 111. Turtle Islet - Health check, rodent tunnel and ant bait station monitoring sites.

Health check

Turtle Islet						
Ecosystems and biodiversity	**Health Checks**					
Value - Coral cay communities (Communities present listed below)	**Veg map unit**	Dominant Sub-dominant Remaining veg (ha)		Photomonitoring: N - North photo E - East photo S - South photo W - West photo		**Overall condition class**[1]
Shoreline and sandspit vegetation						
Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	1a	0.053				
Grasslands and Herblands						
Grassland communities dominated by *Lepturus repens*	3a	HC96	HC98	HC99	HC100 NSW	G
	3b	HC96	HC98	HC99		G
Grassland communities co-dominated by *Lepturus repens* and *Stenotaphrum micranthum*	4	HC101				G
Grassland communities dominated by *Stenotaphrum micranthum*	5	HC97	HC100E			G
Herbland communities dominated by *Boerhavia albiflora* var. *albiflora*	6a	HC97	HC100E			G
Habitats and species						
Value - Seabird and shorebird habitat						G
Value -Turtle rookery (Green turtle *Chelonia mydas)*						G

[1]Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

Results

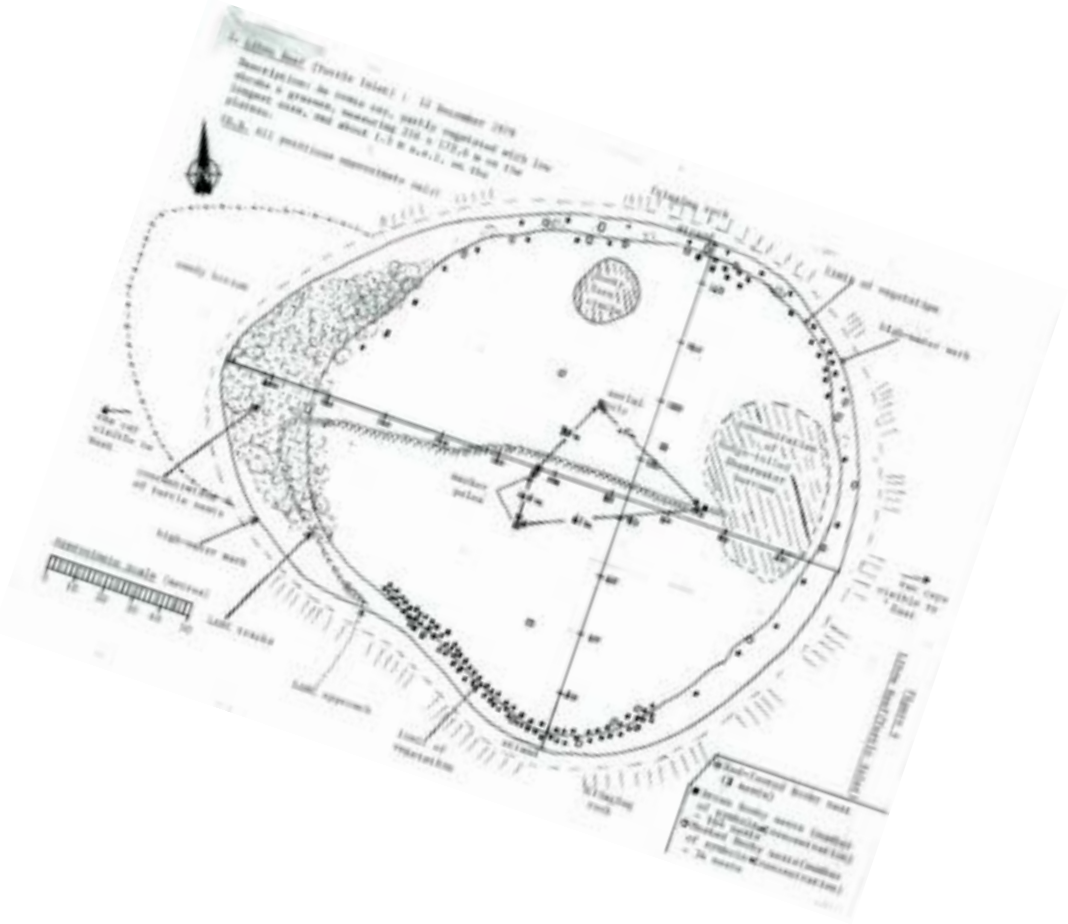


Figure 112. Drawing of Turtle Islet (Stokes and McNamara 1979). Note. Long axes measured above high water 216m x 172.6m (3.73 ha), cay estimated 1.5m above sea level.

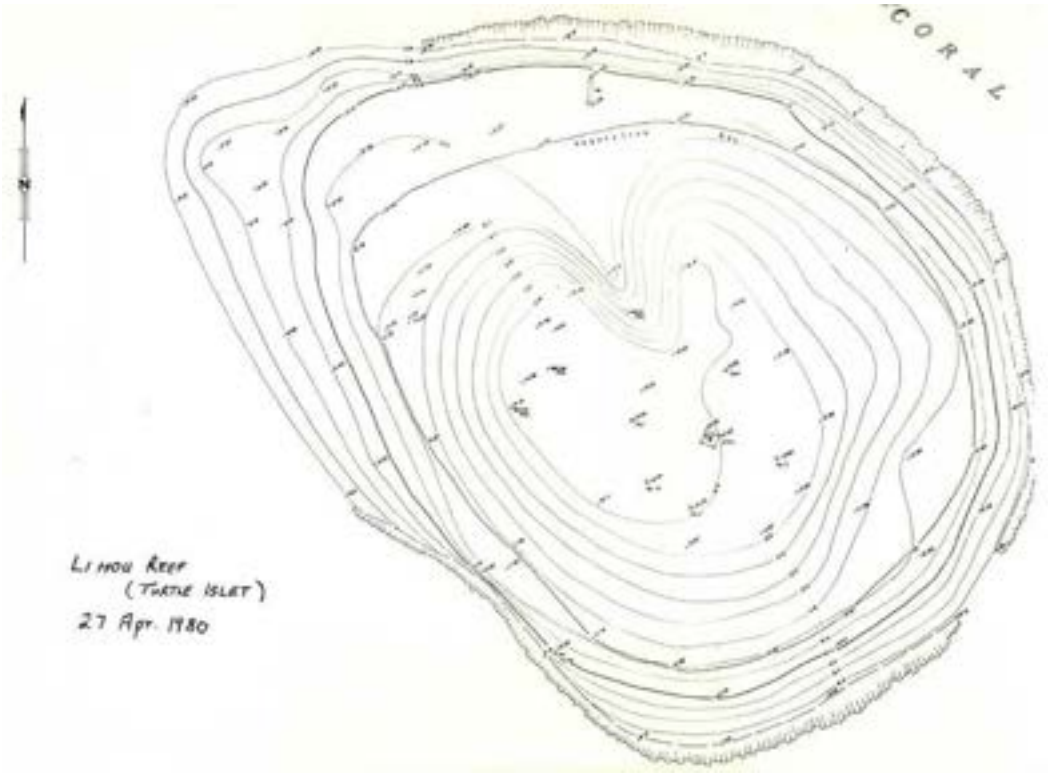


Figure 113. Turtle Islet was surveyed by the Australian Survey Office in 1979 (Stokes and Skeat 1980).

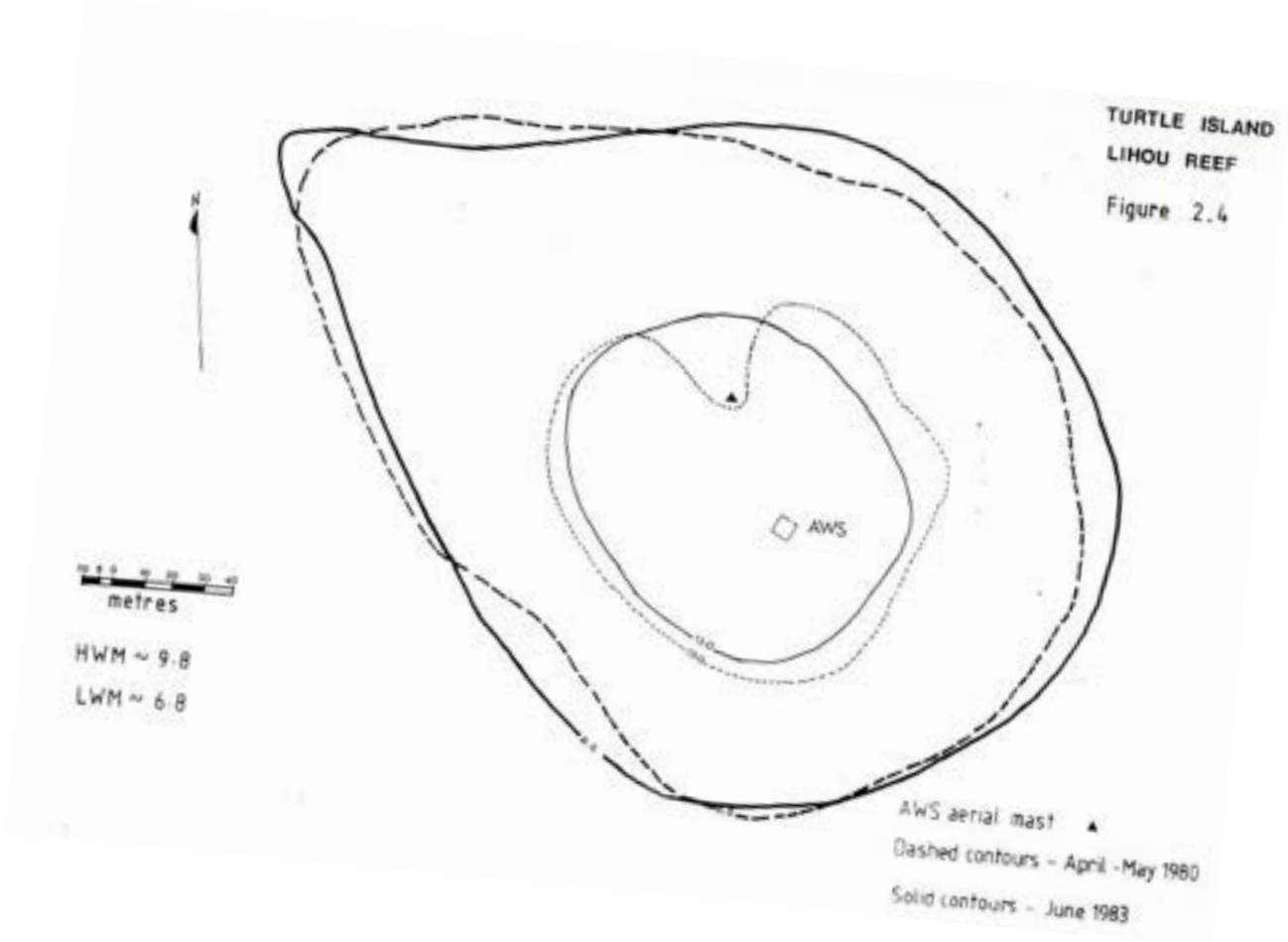


Figure 114. Hill (1984) estimated the area of Turtle Islet (vegetated area 2.4 ha, entire cay 3.1 ha).

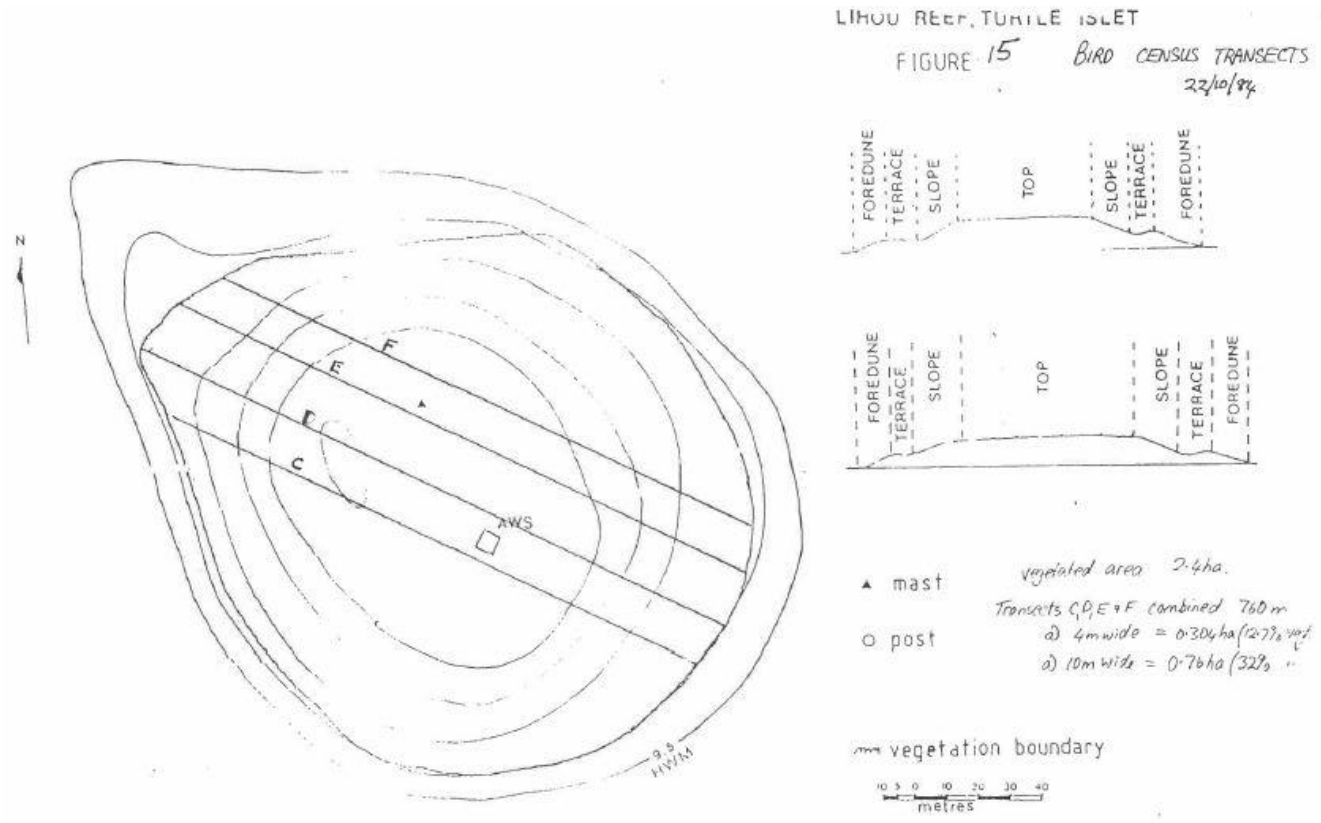


Figure 115. Hicks (1984) estimated vegetated area of Turtle Islet at 2.4 ha.

BELOW
Figure 12: Turtle Islet

Figure 116. Photo of tower on Turtle Islet (Scottney and Jeffs 1987).

Photo: Photo taken of general area of 1987 photo. Note overall vegetation type and condition compared to 1987 photo. Photo taken facing south from HC101 (looking from the north western corner towards the interior of Turtle Islet). Donaldson (1994) reported that Turtle Islet was very sparsely vegetated due to the 1990 cyclone with Portulaca comprising 70% of the total vegetation, a 100-150mm moist, spongy humus layer under 20-50mm layer of sand deposited by the cyclone.

Seven Health Checks were undertaken on Turtle Islet to assess the condition of shoreline, grassland, and herbland communities. Health Checks assessed the condition of five vegetation communities. Remaining communities not assessed by Health Checks may be included in A. Overall vegetation condition.

The overall condition rating for each of the vegetation communities was Good. The vegetation lush and green with high plant biomass and coverage. Vegetation communities on the shoreline were intact with plants actively encroaching bare sand.

A. Overall vegetation condition

*Photo: Turtle Islet supported vigorous grassland communities colonising the northwestern spit and shorelines. View of sparse grassland community **1a** in the foreground and (thick, green) grassland **5** in the background. Photo taken from northwest corner looking southeast.*

Photo: New growth of Stenotaphrum and herbs colonising open areas of bare sand on the northwestern spit. Photo taken from the northwestern spit looking south.

*Photo: Lush green growth of **5** Stenotaphrum micranthum open grassland/ grassland with Boerhavia albiflora var albiflora +/- Achyranthes aspera, Portulaca oleracea supports habitat for nesting seabirds.*

*Photo: Turtle Islet was dominated by grassland communities – in good condition. View looking across **4** Lepturus repens/Stenotaphrum micranthum grassland with Boerhavia albiflora var. albiflora, Portulaca oleracea on the western side of the cay facing north. Inset: Close view of new growth of Stenotaphrum colonising bare sand.*

Photos: On Turtle Islet there was widespread evidence of seeds and flowers of grasses (and other plant species) being grazed by grasshoppers. Photos showing Stenotaphrum (low clump) and Lepturus grasses with grazed tips.

Photo: Large grasshoppers up to 8cm in length were prevalent across the cay. Photo. A. McDougall.

*Photo: View of the thick grassland community **3a** that occurred in the interior of the cay. Photo taken at the western end of Turtle Islet facing west.*

*Photo: Thick growth of grassland community **3a** on the lee side of the cay extending towards the shoreline. Photo taken from HC101 facing north.*

*Photo: Green, lush grassland communities **3a** and **3b** dominated the central interior of the cay however widespread evidence of grazing of seed and flower material by the numerous grasshoppers present. Photo taken from HC96 facing northeast.*

*Photo: View showing dominance of grass in the communities **3a** and **3b** Photo taken facing north from HC99 north.*

Photo: View looking across the southern end of Turtle Islet with widespread thick, lush grassland and communities on the southern side of the cay. Photo taken in a westerly direction from the southern end.

Photo: Close view of thick, lush growth. Note Boerhavia and Portulaca amongst Stenotaphrum.

*Photo: Lush grassland (**5**) and herbland (**6a**) on the windward side of the cay provides habitat for nesting brown boobies and sooty terns. L photo taken facing east adjacent to Rodent tunnel 77. R photo facing southwest from Rodent tunnel 78.*

Photo: Grassland communities providing seabird nesting habitat on the windward southwestern side of the cay. Photo taken facing north near Rodent tunnel 77.

*Photo: Nesting seabirds utilise grassland community **5** on the windward side of the cay. Photo taken facing east from the southern end of the cay at HC97.*

B. Health Check photo monitoring - sample photo of each vegetation type

*Photo: HC100 **3a** Lepturus repens grassland/ closed grassland +/- Achyranthes aspera, Boerhavia albiflora var. albiflora, Portulaca oleracea.*

*Photo: HC96 **3b** Lepturus repens/ Achyranthes aspera grassland or closed grassland/herbland or closed herbland (Seasonally variable) with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea.*

*Photo: HC101 **4** Lepturus repens/Stenotaphrum micranthum grassland with Boerhavia albiflora var. albiflora, Portulaca oleracea.*

*Photo: HC100 **5** Stenotaphrum micranthum open grassland/ grassland with Boerhavia albiflora var albiflora +/- Achyranthes aspera, Portulaca oleracea.*

*Photo: HC97 **6a** Boerhavia albiflora var. albiflora herbland/ open herbland/sparse herbland with Portulaca oleracea, Stenotaphrum micranthum (Sub-dominant).*

Introduced pests

A. Rodents

Table 68. Rodent tunnel monitoring - Turtle Islet.

Turtle Islet			
No. of rodent tunnels	Date deployed	Date collected	Evidence of rodents (tracks, droppings)
4[1]	21/7/21	22/7/21	Nil

[1] Refer *Figure 111*.

B. Ants and other invertebrates

Table 69. Invertebrate species summary - Turtle Islet.

Turtle Islet[1]					
Specimen no.	Date	Site	Specimen	Identification	Native / introduced
40	22/7/21	NA	Grasshopper	*Valanga sp.* (female) (Likely *Valanga irregularis* - Chris Burwell 2021 pers. comm.)	Native
41	22/7/21	NA	Beetles	5 x *Gonocephalum* sp. A	Native
42	22/7/21	NA	Cricket	*Gryllidae*	Native
43	22/7/21	NA	Ants	*Monomorium* cf *intrudens*[2]	Introduced (Japan)
44	22/7/21	NA	Grasshopper	*Valanga sp*. (male) (Likely *Valanga irregularis* - Chris Burwell 2021 pers. comm.)	Native
45	22/7/21	NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*	Native

[1]During the 1987 ANPWS survey ticks were reported present in very large numbers, particularly under litter (Scottney and Jeffs 1987).

[2]There is a very small species of *Monomorum* which may be introduced and is perhaps *Monomorium insolens*, but it is hard to be sure, hence the 'cf *intrudens*' (Chris Burwell 2021 pers. comm.)

19. Margaret Cay

Birds

Table 70. Species and breeding effort – Margaret Cay.

Margaret Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
22/07/2021	black-naped tern				4	81	G,Y
22/07/2021	brown booby				0	3	
22/07/2021	common noddy				0	5	
22/07/2021	lesser frigatebird				0	1	
22/07/2021	red-footed booby				0	1	
22/07/2021	red-tailed tropicbird				0	1	
22/07/2021	ruddy turnstone				0	1	
22/07/2021	sooty tern				0	7	

Limited nesting area. Black-naped terns nesting in pumice rock wash on south-east corner of cay. Many other black-naped terns present, the four nests observed may be the first nests of a developing colony.

Figure 117. Margaret Cay - Health check monitoring site.

Health check

Margaret Cay	
Unvegetated sand cay – Approx. 0.04 ha (above high water) (During an ANPWS survey 1986, Margaret Cay was estimated at 300m long and 75m wide and examination of 1969 and 1984 aerial photographs showed considerable change in cay shape with further changes observed during 1986 survey (Grant et al. 1986).) - Sandy shores - Lithified shores. Note extent of beach rock to the south and the east - Elevated area of cay comprised of sand Health Checks: HC102	
Habitats and species	**Health Checks** **Overall Condition class[1]**
Value - Seabird and shorebird habitat	G
Breeding and roosting habitat - Refer Birds A. McDougall Eight bird species recorded: • Seven seabird species • One shorebird species • Breeding black-naped terns The elevated area of Margaret Cay is very limited and approximately 65m long and 15m in wide. Drone image and survey shows several tides have washed over the highest berm toward the cay interior.	
Value – Turtle rookery (Green turtle *Chelonia mydas*)	NA
Nil turtle body pits were found on Margaret Cay.	

1. Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

Results

Photo: Aerial view of elevated portion of Margaret Cay. Note multiple wash lines throughout the elevated area.

Photo: View of Margaret Cay. Note evidence of tidal wash (smoothed sand and tide lines) around entire cay.

Photo: Cay profile on the north side of Margaret Cay.

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Nil pests/invertebrates detected.

20. Little Margaret Cay

Birds

Table 71. Species and breeding effort – Little Margaret Cay.

Little Margaret Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
22/07/2021	black-naped tern				0	31	
22/07/2021	brown booby				0	1	
22/07/2021	common noddy				0	4	
22/07/2021	sooty tern				0	7	

Intertidal roosting island.

Figure 118. Little Margaret Cay.

Photo: View of Little Margaret Cay from MV Argo.

Plate 8: Little Margaret Cay, Lihou Reef NNR

Photo: Photo of Little Margaret Cay from Grant et al. (1986) estimated 80m long and 30m wide.

Health check

Due to intertidal cay a Health Check was not undertaken. As mentioned above the cay has value as an intertidal roosting site.

During a previous ANPWS survey in 1986 Little Margaret Cay was approximately 80m long and 30m wide with a small amount of beach rock on the northeast tip (Grant et al. 1986).

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Nil pests/invertebrates detected.

21. Lorna Cay

Birds

Table 72. Species and breeding effort – Lorna Cay.

Lorna Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
23/01/2021	Australian pelican				0	1	
23/01/2021	black noddy				0	1	
23/01/2021	black-naped tern				0	14	
23/01/2021	brown booby				210	346	G,N
23/01/2021	common noddy				3662	5263	G,P
23/01/2021	crested tern				0	8	
23/01/2021	great frigatebird				0	1	
23/01/2021	lesser frigatebird				0	1	
23/01/2021	masked booby				73	116	G,N
23/01/2021	New Caledonian fairy tern				0	3	
23/01/2021	Pacific golden plover				0	8	
23/01/2021	red-footed booby				2	3	G,N
23/01/2021	ruddy turnstone				0	5	
23/01/2021	sooty tern				36628	37473	G,Y

Figure 119. Large breeding colony of sooty terns.

Lorna Cay hosted the highest density and highest number of breeding seabirds.

Several count transects were attempted. The density of nests, chicks and young were too great to continue this method as more time was spent ensuring minimal disturbance than being able to count birds within the transect parameters. Final counts were made from ground observations and drone imagery. It is likely the common noddy and sooty tern breeding effort totals are below actual numbers.

Observation: A sooty tern chick had a fish stolen from it by a nearby sooty tern adult. In the second between being fed and potentially swallowing its important feed, the adult had flown through and plucked it from the chick's bill.

Figure 120. Red-footed booby, white-tailed dark morph adults.

FINDING DETAILS

Band Number: 132-22079 was sighted on 23/07/2021
At: LORNA CAY, LIHOU REEF, AUSTRALIAN CORAL SEA TERRITORY
Latitude: 17deg 7min 21sec S; Longitude: 151deg 49min 35sec E;

The bird was: READABLE BAND/FLAG/NECK COL SIGHTED IN FIELD, NUMBER ON STANDARD BAND INFERRED

And: WAS ALIVE IN THE WILD WITH THE BAND.

BANDING DETAILS

The band that you found was placed on a(n): Masked Booby
or scientific name: *Sula dactylatra*
on: 17/08/2006
at: NORTH-EAST CAY HERALD CAYS CORAL SEA
Latitude: 16deg 57min 0sec S; Longitude: 149deg 11min 0sec E;
The bird was age code: FIRST YR OR OLDER, sex code: UNKNOWN
It was banded by: THE ANPWS-DOE CORAL SEA PROJECT

Figure 121. Banding information supplied by the Australian Bird and Bat Banding Scheme.

Felicity Chapman observed a metal band on an adult masked booby's leg (see *Figure 122*). We were able to record the band number without disturbing the bird. The results from the Australian Bat and Bird Banding Scheme a shown in *Figure 121*. The original banding site at North-east cay is approximately 282km from Lorna Cay.

Figure 122. Banded masked booby (left) and mate, Lorna Cay (photo by Felicity Chapman).

Vegetation

Cay description

Lorna Cay is located on Lihou Reef at -17.122 degrees latitude and 151.836 degrees longitude. It is an elongated cay with a maximum vegetated width of 130m. A long sandy "tail" measuring approximately 900m long by 45 to 80m wide extends in a southwesterly direction from the vegetated area. The cay slopes upwards from the coastal dunes and sand spits and slopes from the crest of the slopes to a central depression. The cay has a total vegetated area of 6.4 hectares.

Figure 123 contains surface elevation profiles of Lorna Cay.

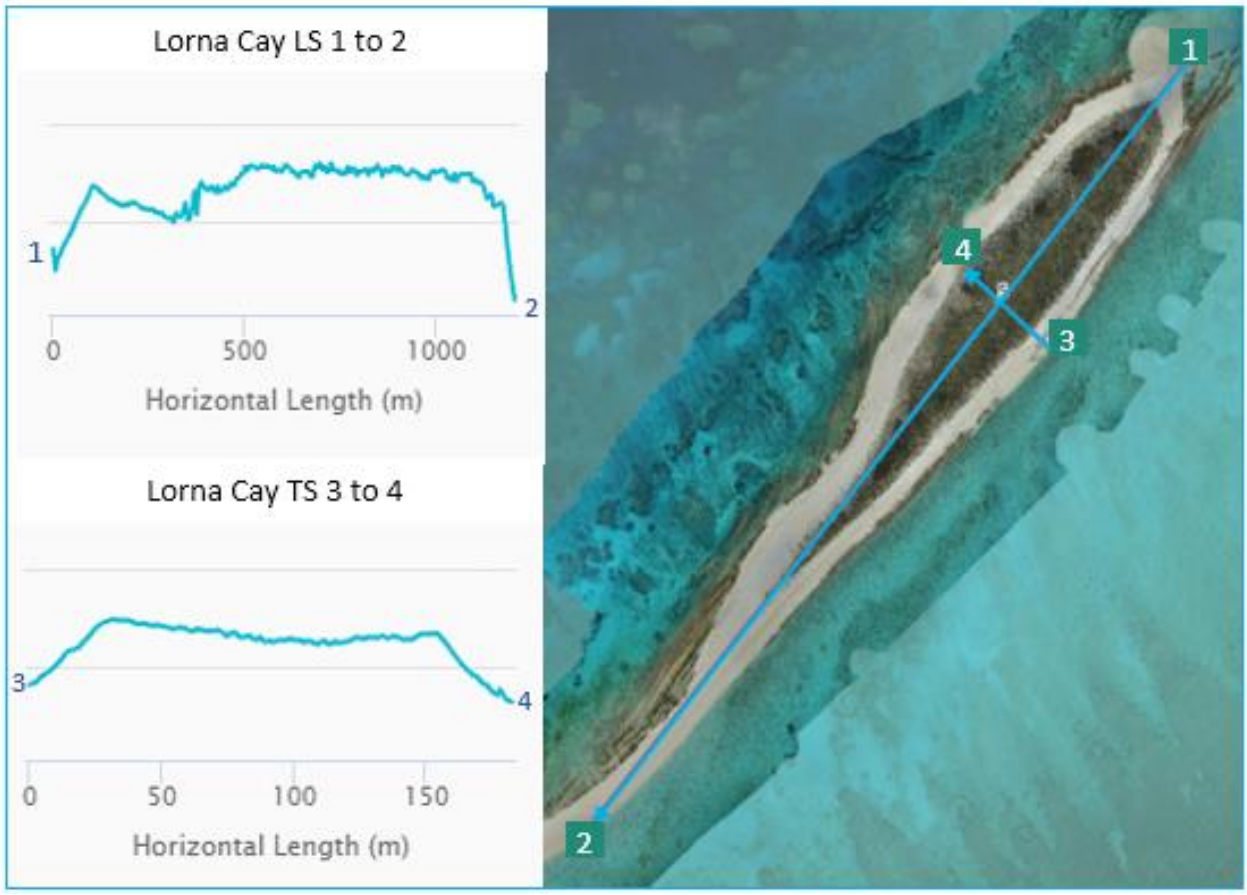


Figure 123. Surface profiles of Lorna Cay.

Note: Vertical heights and scale are not included in surface profile diagrams as accurate datum information was not available. The maximum elevation of Lorna Cay was quite low compared to the other cays visited during the July 2021 voyage.

Survey intensity

Nine and a half hours was spent surveying the vegetation of Lorna Cay. Vegetation data was recorded at 34 ground-truthing sites and two permanent monitoring sites (M14 and M15). The locations of these sites are shown in *Figure 124*. The blue lines are the boundaries of the vegetation communities shown on the vegetation map in *Figure 125*.

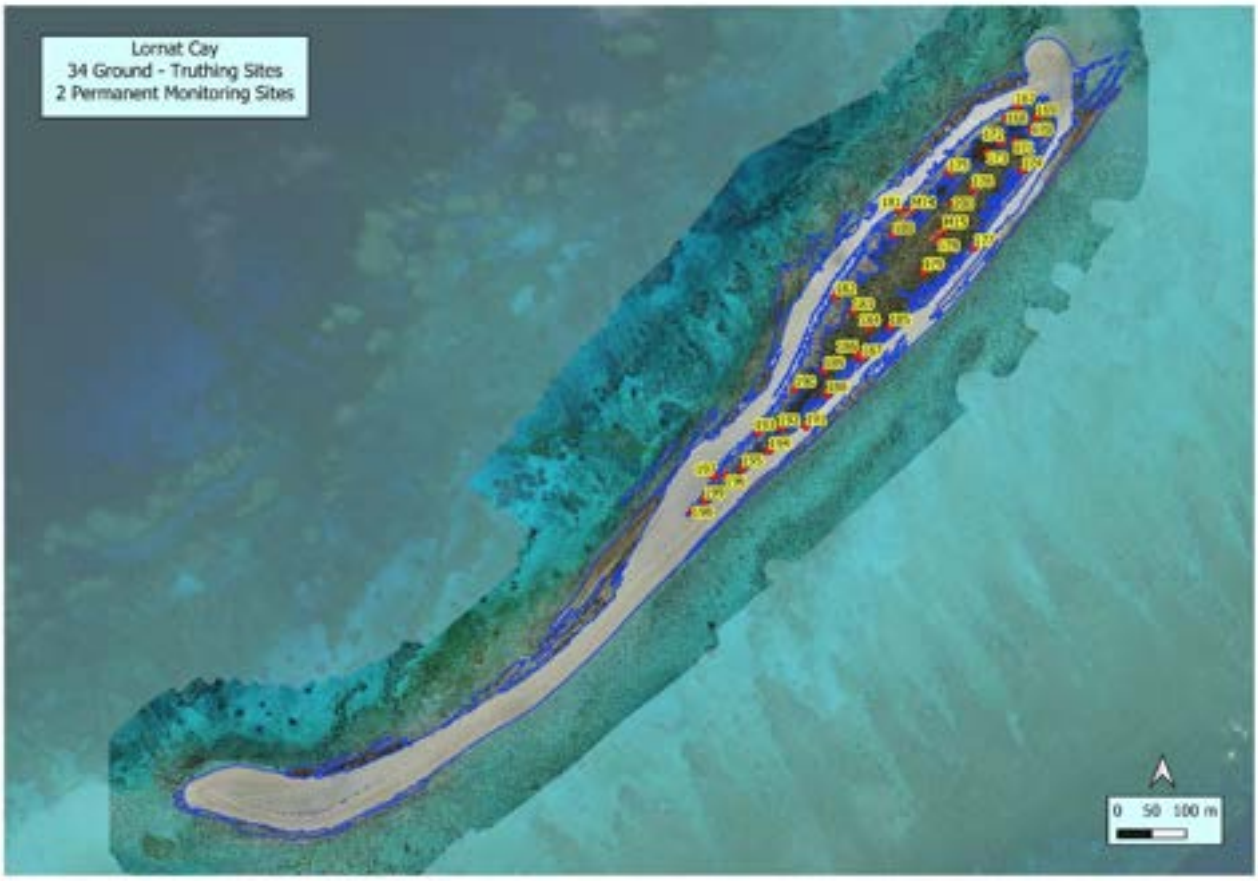


Figure 124. Lorna Cay showing the number and location of ground-truthing sites and permanent monitoring sites relative to the vegetation.

Vegetation condition

All the vegetation on the cay was in good condition.

Floristic data

Eight plant species were recorded on Lorna Cay. These are listed in *Table 73* in order of frequency in sites together with the averaged cover for each species for sites in which the species was present and their averaged cover over the entire cay. Data for species cover at each site plus occurrence of each species in relation to vegetation community and landform are contained in *Table 75*.

Table 73. Plant species recorded on Lorna Cay, 22-23/07/2021.

Layers: (E) = emergent, (S1) = upper shrub, (S2) = lower shrub, (G) = Ground

Species	Common Name	Family	Presence in Sites (% of sites)	Average % Cover in Each Layer (Only sites containing the species were averaged)	Overall Average % Cover in Each Layer (average includes all sites)
Boerhavia albiflora var. *albiflora*	boerhavia	Nyctaginaceae	97%	12.0% (G)	11.6% (G)
Portulaca oleracea	pig weed	Portulacaceae	91%	5.7% (G)	5.2% (G)
Achyranthes aspera	chaff flower	Amaranthaceae	65%	18.8% (G)	12.1% (G)
Stenotaphrum micranthum	beach buffalo grass	Poaceae	65%	9.3% (G)	6.0% (G)
Lepturus repens	stalky grass	Poaceae	29%	26.3% (G)	7.7% (G)
Tribulus cistoides	bulls head burr	Zygophyllaceae	18%	2.5% (G)	0.4% (G)
Argusia argentea	octopus bush	Boraginaceae	3% (= one site)	2.5% (G)	0.07% (G)
Cocos nucifera	coconut	Arecaceae	3% (=one site)	2.5% (G)	0.07% (G)
Total no of species = 8					

Andrew McDougall found a single plant of *Argusia argentea* while surveying birds in the interior of the cay. Despite thorough searching, no other plants of this species were located. The plant was mature with woody stems, less than 0.5 m tall (naturally bonsaied by prevailing conditions) and had no buds, flowers or fruit at the time of the survey. This species was not recorded on any of the other Lihou Reef cays during the July 2021 voyage.

A single germinated *Cocos nucifera* (coconut) plant was recorded on Lorna Cay (shown in *Photo 2*). It is not likely that this plant will establish and grow (Refer to general Vegetation Results and discussion).

Photos 55a & b. Argusia argentea plant growing on Lorna Cay.

Vegetation communities on Lorna Cay

Vegetation communities present on Lorna Cay in July 2021, the area of each and representative survey sites within each vegetation community are listed in *Table 74*. The spatial distribution and extent of the vegetation communities on Lorna Cay in July 2021 are shown in the vegetation map in *Figure 125*.

Vegetation of the cay consisted only of grasses and other herbaceous species. No trees or large shrubs were present.

Map unit 1a was present all along the leeward (northwest) shoreline but was absent from the windward (southeast) shoreline. The most frequently occurring species in this unit was *Stenotaphrum micranthum* (beach buffalo grass). Other frequently occurring species were *Boerhavia albiflora* var. *albiflora* (boerhavia) and *Portulaca oleracea* (pigweed).

Open herblands dominated by *Boerhavia albiflora* var. *albiflora* herbland communities (map units 6a and 6b) formed a continuous band parallel to and along the entire length of the leeward shoreline. Other species present in both units were *Stenotaphrum micranthum* and *Portulaca oleracea*. Small, isolated patches of map unit 6a were also present adjacent to the windward shoreline of the cay.

Stenotaphrum micranthum open grassland (map unit 5) was prevalent adjacent to the southeastern shoreline where it formed a narrow zone parallel to the narrow sandy beaches and rubble bank shorelines. Other species present in this unit were *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea.*

The interior vegetation of the cay was dominated by grassland to herbland of *Lepturus repens* (stalky grass) and *Achyranthes aspera* (chaff flower) herblands (map units 3b and 8a). *Boerhavia albiflora* var. *albiflora* was also present in these units and *Portulaca oleracea* was present at most sites. Patches of more open–vegetation - *Boerhavia albiflora* var. *albiflora*/ *Achyranthes aspera* open herbland (map unit 6c) were also present in the interior of the cay and on the seaward edge of the interior communities in the northwest. *Stenotaphrum micranthum* was also present in map unit 6c.

Table 74. Vegetation communities on Lorna Cay.

Veg Map Unit Code	Vegetation Community	Hectares on Lorna Cay	ID of Sites on Lorna Cay
	Unvegetated Areas		
A	Sandy shores	10.2 (approx.)	
B	Lithified shores	4.0 (approx.)	
C	Rubble banks		
	Shoreline and Sandspit Vegetation		
1a	Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	0.353	167, 177, 181, 182, 193, 197, 198
	Grasslands and Herblands		
3b	*Lepturus repens*/ *Achyranthes aspera* closed grassland/herbland/closed herbland (seasonally variable) with *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*	1.665	171, 173, 178, 179, M15
5	*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora* +/- *Achyranthes aspera* +/-*Portulaca oleracea*	0.499	174, 194, 195, 199
6a	*Boerhavia albiflora* var. *albiflora* sparse herbland/ open herbland/ herbland with *Portulaca oleracea*	1.105	168, 175, 190, M14
6b	*Boerhavia albiflora* var. *albiflora*/ *Stenotaphrum micranthum* open herbland/herbland with *Portulaca oleracea*	0.670	187, 188, 196
6c	*Boerhavia albiflora* var. *albiflora*/ *Achyranthes aspera* open herbland/ herbland with *Portulaca oleracea* +/ *Lepturus repens* +/- *Stenotaphrum micranthum*	1.073	169, 170, 172, 176, 180, 183, 185, 186, 192
8a	*Achyranthes aspera* herbland/closed herbland with *Boerhavia albiflora* var. *albiflora*	1.044	184, 189

Note: Areas of sandy shores and rocky shores, particularly those of the rocky shores are only approximate due to the difficulty in determining the location of the boundary between the edge of the shoreline and the surrounding reef flat using the imagery.

Comparison with previous vegetation surveys

No previous vegetation survey data is available for Lorna Cay.

Of particular note, a previous ANPWS survey in 1986 describes Lorna Cay as **unvegetated** (Grant et al., 1986). The accompanying map in the 1986 report labels the cay interior as 'sand'. Refer *Figure 127* in Health Checks, Lorna Cay.

Figure 125. Lorna Cay vegetation map.

Table 75. Site data recorded on Lorna Cay.
Datum = WGS 84; green shading = site dominants

Site	Latitude	Longitude	Date	No. of photos	Landform	Veg Map Unit	Vegetation Community	Ground layer							Plant Specimens Collected	Notes
								Achyranthes aspera	*Argusia argentea*	*Boerhavia albiflora* var. *albiflora*	Cocos nucifera	*Lepturus repens*	*Portulaca oleracea*	*Stenotaphrum micranthum*	*Tribulus cistoides*	
167	-17.119871	151.83765	22/07/2021	1	Beach	1a	open herbland dominated by *Portulaca oleracea*, *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*			5-25%			5-25%	5-25%			
177	-17.121735	151.83708	23/07/2021	2	Adjacent to shoreline	1a	open grassland dominated by *Stenotaphrum micranthum*	trace-5%		trace-5%		trace-5%	trace-5%	5-25%			
181	-17.121236	151.83609	23/07/2021	2	Shoreline	1a	sparse grassland dominated by *Stenotaphrum micranthum*			trace-5%			trace-5%	5-25%			
182	-17.122375	151.83525	23/07/2021	1	Shoreline	1a	sparse herbland dominated by *Boerhavia albiflora* var. *albiflora*			5-25%			trace-5%	trace-5%			
193	-17.124164	151.83423	23/07/2021	1	Shoreline	1a	sparse herbland dominated by *Boerhavia albiflora* var. *albiflora*			5-25%			trace-5%	trace-5%			
197	-17.12475	151.83365	23/07/2021	1	Shore	1a	sparse herbland dominated by *Boerhavia albiflora* var. *albiflora*			5-25%			trace-5%	trace-5%			
198	-17.125215	151.83337	23/07/2021	1	Seaward extent of vegetation	1a	sparse grassland dominated by *Stenotaphrum micranthum*							5-25%			
171	-17.120346	151.83760	22/07/2021	2	Flat	3b	closed grassland dominated by *Lepturus repens* and *Achyranthes aspera*	25-50%		trace-5%		50-75%	trace-5%				
173	-17.120485	151.83725	22/07/2021	2	Flat	3b	closed grassland dominated by *Lepturus repens* and *Achyranthes aspera*	25-50%		trace-5%		50-75%	trace-5%				
178	-17.121639	151.83661	23/07/2021	2	Depression in centre	3b	herbland dominated by *Achyranthes aspera*, *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*	25-50%		5-25%		25-50%					
179	-17.122052	151.83641	23/07/2021	2	Depression in centre	3b	closed herbland dominated by *Achyranthes aspera*, *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*	25-50%		5-25%		25-50%	trace-5%				
M15	-17.121498	151.83668	23/07/2021	8		3b	herbland dominated by *Lepturus repens* and *Achyranthes aspera*	25-50%		trace-5%		25-50%	trace-5%				
174	-17.120721	151.83771	22/07/2021	2	Adjacent to shoreline	5	open grassland dominated by *Stenotaphrum micranthum*	trace-5%		trace-5%			trace-5%	5-25%			
194	-17.124406	151.83438	23/07/2021	3	Shoreline	5	open grassland dominated by *Stenotaphrum micranthum*			trace-5%			trace-5%	5-25%			
195	-17.124635	151.83403	23/07/2021	2	Slightly undulating	5	open herbland dominated by *Stenotaphrum micranthum*, *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*			5-25%			5-25%	5-25%		*Portulaca oleracea*, *Stenotaphrum micranthum*	
199	-17.125058	151.83353	23/07/2021	1	Undulating	5	open grassland dominated by *Stenotaphrum micranthum*			trace-5%			trace-5%	5-25%			
168	-17.120029	151.83751	22/07/2021	2	Adjacent to shoreline	6a	open herbland dominated by *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*			5-25%			5-25%	trace-5%			
175	-17.120752	151.83674	23/07/2021	1	Slight slope away from beach to centre	6a	open herbland dominated by dominated by *Boerhavia albiflora* var. *albiflora*	trace-5%		5-25%			trace-5%	trace-5%	trace-5%		
190	-17.123594	151.83472	23/07/2021	2	Adjacent to dunes	6a	open herbland dominated by *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*			5-25%			5-25%	trace-5%		*Boerhavia albiflora* var *albiflora*	
M14	-17.121238	151.83626	23/07/2021	8		6a	open herbland dominated by *Boerhavia albiflora* var. *albiflora*	trace-5%		5-25%		trace-5%	trace-5%	trace-5%	trace-5%		
187	-17.123187	151.83560	23/07/2021	2	Slope landward from dune	6b	open herbland dominated by *Boerhavia albiflora* var. *albiflora* and *Stenotaphrum micranthum*	trace-5%		5-25%			trace-5%	5-25%			
188	-17.123664	151.83514	23/07/2021	2	Adjacent to shoreline	6b	open herbland dominated by *Boerhavia albiflora* var. *albiflora* and *Stenotaphrum micranthum*	trace-5%		5-25%			trace-5%	5-25%			

Site	Latitude	Longitude	Date	No. of photos	Landform	Veg Map Unit	Vegetation Community	Ground layer								Plant Specimens Collected	Notes
								Achyranthes aspera	*Argusia argentea*	*Boerhavia albiflora* var. *albiflora*	Cocos nucifera	*Lepturus repens*	*Portulaca oleracea*	*Stenotaphrum micranthum*	*Tribulus cistoides*		
196	-17.12474	151.83381	23/07/2021	2	Slightly undulating	6b	open herbland dominated by *Boerhavia albiflora* var. *albiflora*, *Stenotaphrum micranthum* and *Portulaca oleracea*			5-25%			5-25%	5-25%			
169	-17.120015	151.83790	22/07/2021	2	Flat	6c	open herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*	5-25%		5-25%			trace-5%	trace-5%			
170	-17.120179	151.83784	22/07/2021	2	Flat	6c	open herbland dominated by *Achyranthes aspera*, *Portulaca oleracea* and *Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*	5-25%		5-25%			5-25%	5-25%			
172	-17.120346	151.83743	22/07/2021	2	Flat	6c	open herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*	5-25%		5-25%		trace-5%	trace-5%				
176	-17.120962	151.83706	23/07/2021	2	Slight depression in centre	6c	open herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*	5-25%		5-25%		trace-5%	trace-5%		trace-5%		
180	-17.121574	151.83602	23/07/2021	2	Upward slope from depression to beach	6c	open herbland dominated by *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora*, *Lepturus repens* and *Portulaca oleracea*	5-25%		5-25%		5-25%	5-25%		trace-5%	*Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora*, *Lepturus repens*, *Tribulus cistoides*	
183	-17.122575	151.83548	23/07/2021	2	Slight slope to very shallow internal depression	6c	herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*	5-25%		5-25%			trace-5%		trace-5%		
185	-17.122778	151.83597	23/07/2021	2	Landward of coastal dune	6c	open herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*	5-25%		5-25%			trace-5%	trace-5%			
186	-17.123131	151.83554	23/07/2021	1	Landward of coastal dune	6c	herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*	5-25%		5-25%			trace-5%				
192	-17.124102	151.83455	23/07/2021	2	Slight depression	6c	open herbland dominated by *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea*	5-25%		5-25%			5-25%	trace-5%	trace-5%		
184	-17.122787	151.83570	23/07/2021	2	Slight slope to very shallow internal depression	8a	herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*	25-50%		5-25%							
189	-17.123349	151.83510	23/07/2021	1	Slight depression	8a	herbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*	25-50%		5-25%			trace-5%				
191	-17.124087	151.83487	23/07/2021	1	Beach wash line with pumice						trace-5%						Coconut seedling; only coconut germinated in ground observed during the entire voyage; poor condition - unlikely to survive
200	-17.121157	151.83680	23/07/2021	2					trace-5%								Single plant of *Argusia argentea*; Only plant of *Argusia* seen on the–Lihou cays - very stunted - less than 0.5m tall and no evidence of fertile structures

Permanent monitoring site data

Two permanent monitoring sites (M14 and M15) were established and surveyed on Lorna Cay. The locations of the centre transects of these sites are shown as the red lines in *Figure 124*. *Table 76* contains the data recorded at these sites. The photographs included with the data in this section are 4 of the 10 site photographs for each site. These are taken from the centre point of each site in four different directions (facing 0, 90, 180 and 270 degrees from the transect bearing respectively).

Table 76. BioCondition attributes recorded in permanent monitoring sites on Lorna Cay.

	Site M14	Site M15
Vegetation community description	Open herbland dominated by *Boerhavia albiflora* var. *albiflora*	Herbland dominated by *Lepturus repens* and *Achyranthes aspera*
Transect start (WGS 84)	-17.121068 151.836403	-17.121625 151.836492
Transect centre (WGS84)	-17.121238 151.836264	-17.121498 151.836687
Transect end (WGS 84)	-17.12141 151.836102	-17.121352 151.83685
Transect bearing	211^0	43^0
Median canopy height (range)	0.2 (0.01 to 0.4)m	
Tree canopy cover %	n/a	n/a
Shrub canopy cover %	n/a	n/a
Basal area m^2/ha (at 30 cm height, calculated from stem diameters)	nil	nil
Total number of large trees/ha	0	0
Total no of trees per ha	n/a	n/a
Total number of tree stems/ha	n/a	n/a
Total no. shrubs/ha	n/a	n/a
Total no. shrub stems/ha	n/a	n/a
Large shrubs - mean diameter at 30 cm height	n/a	n/a
Recruitment of ecologically dominant layer (%)	n/a	n/a
Tree species richness	0	0
Tree species present	n/a	n/a
Shrub species richness	0	0
Shrub species present (layer in brackets)	nil	nil
Median ground layer height (range)	G=canopy	G=canopy
Total ground layer cover of native cay species (%)	11.8%	62.6%
Grass species richness	2	1
Grass cover (%)	<0.2%	34.8%
Grass species present in order of decreasing cover - most abundant first (cover in brackets)	*Lepturus repens* (0.2%), *Stenotaphrum micranthum (<0.2%)*	*Lepturus repens* (34.8%)
Forb (including vines) species richness	4	3
Forb species cover (%)	11.8%	27.8
Forb species present in order of decreasing cover - most abundant first (Cover in Brackets)	*Boerhavia albiflora* var. *albiflora* (5.6%), *Portulaca oleracea* (2.2%), *Achyranthes aspera* (2%), *Tribulus cistoides* (2%)	*Achyranthes aspera* (27.4%), *Boerhavia albiflora* var. *albiflora* (0.2%), *Portulaca oleracea* (0.2%)
Native shrub ground cover (%)- *Abutilon albescens*	0%	0%
Non-native plant cover (all strata) (%)	0%	0%
Litter cover (%)	14.6%	27.6%
Bare ground (%)	73.6%	9.8%
Woody debris (m/ha of Logs >0.5m long and >10cm wide)	nil	nil
Soil pH	8.24 (0-10cm), 8.57 (10-20cm), 9.12 (20-30 cm)	7.82 (0-10cm), 8.89 (10-20 cm), 9.45 (20-30cm)

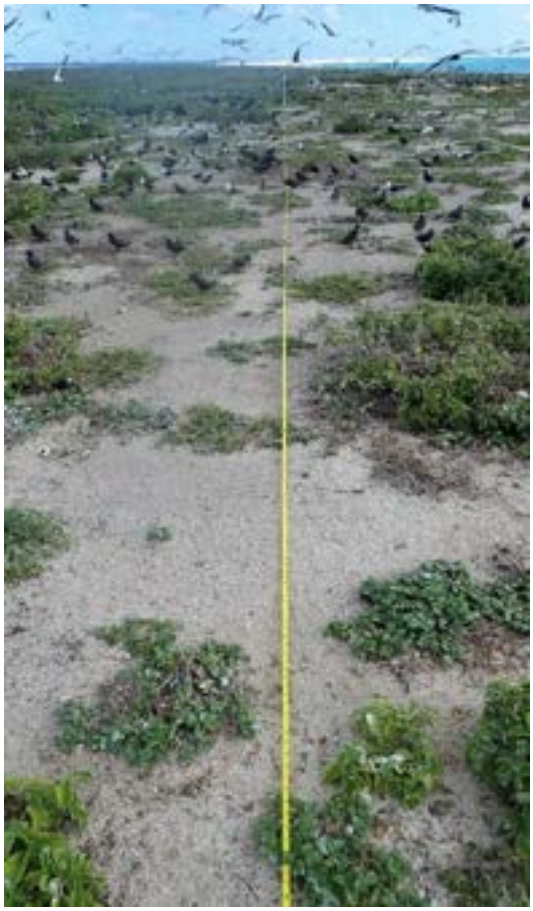


Photo 89. Monitoring site M14, Lorna Cay facing SW

Photo 90. Monitoring site M14, Lorna Cay facing NW

Photo 91. Monitoring site M14, Lorna Cay facing NE

Photo 92. Monitoring site M14, Lorna Cay facing SE

Photo 93. Monitoring site M15, Lorna Cay facing NE

Photo 94. Monitoring site M15, Lorna Cay facing SE

Photo 95. Monitoring site M15, Lorna Cay facing SW

Photo 96. Monitoring site M15, Lorna Cay facing NW

Soils data

Soil on and adjacent to the shoreline was white coarse sand containing coral rubble in some places

Flat areas adjacent to the northeastern spit generally had light coloured coarse sand.

The central depression had light brown to brown sand with organic content apparent in some places.

The table in Appendix 11 contains the results of the analysis of soil samples collected from monitoring sites M14 and M15 during the vegetation survey. Refer to the general Vegetation Results and discussion for further discussion on the soil analyses results.

The herbland (M15) on Lorna Cay had some interesting soil analysis results. The 0-10cm soil sample had the lowest pH, highest levels of nitrogen, Colwell phosphorus, calcium., potassium, magnesium and sodium and sulphur, and the highest CEC of all the Lihou Reef cays. The deeper samples (20-30cm) had the highest pH, the lowest organic carbon, total carbon, phosphorus, calcium, potassium, magnesium, sodium copper and zinc of all of the Lihou Reef cays.

These results may be explained by a combination of the following factors:

- high nutrient input from the large numbers of nesting seabirds present at the site
- high exposure to the strong prevailing winds providing atmospheric nutrient input (particularly sulphur)
- low organic content due to low vegetation biomass and therefore lack of the benefits of organic matter on soil fertility and consequent leaching away of surface nutrients

The *Boerhavia albiflora* var. *albiflora* open herbland site (M14), a low lying site in close proximity to the shoreline with a large population of nesting seabirds, had very low levels of aluminium and also low levels of sulphur and trace elements (copper, iron, manganese and zinc). This site also had the highest EC of all the Diamond Islet and Lihou Reef sites sampled.

Figure 126. Lorna Cay - Health check, rodent tunnel and ant bait monitoring sites.

Health check

Lorna Cay

(During a previous ANPWS survey Grant et al. (1986) described Lorna Cay as a long, narrow Sandy Cay with its long axis running northeast – southwest.

Of particular note is that in Grant et al. (1986) Lorna Cays is described as **unvegetated**, steep sided and fringed with beach rock. Approximately 1.8 km long and 200 m wide; cay area approximately 16.8 ha.)

Ecosystems and biodiversity	**Health Checks**					
Value - Coral cay communities (Communities present listed below)	**Veg map unit**	Dominant Sub-dominant Remaining veg (ha)		Photomonitoring: N - North photo E - East photo S - South photo W - West photo		**Overall condition class[1]**
Shoreline and sandspit vegetation						
Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	1a	HC103				G
Grasslands and Herblands						
Grassland communities dominated by *Lepturus repens*	3b	HC104	HC105	HC106		G
Grassland communities dominated by *Stenotaphrum micranthum*	5	HC108SW				G
Herbland communities dominated by *Boerhavia albiflora* var. *albiflora*	6a	HC107	HC108N			G
	6b	HC107				G
	6c	HC104	HC105	HC106	HC108E	G
Herbland communities dominated by *Achyranthes aspera*	8a	HC104	HC105	HC106		G
Habitats and species						
Value - Seabird and shorebird habitat						G
Value -Turtle rookery (Green turtle *Chelonia mydas)*						G

[1]Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

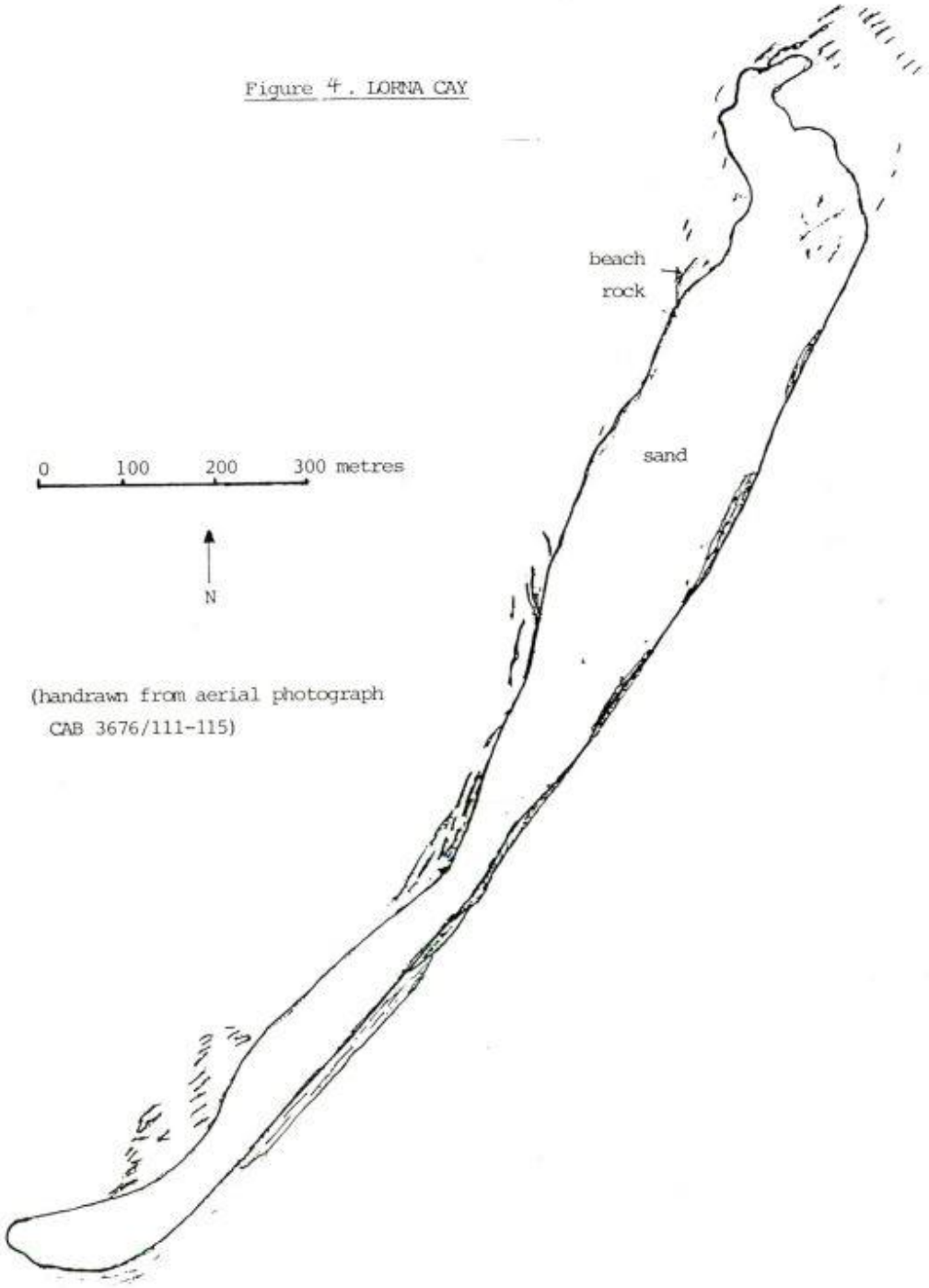


Figure 127. Map of Lorna Cay hand drawn from aerial photograph during 1986 ANPWS survey (Grant et al. 1986). Cay described as unvegetated. Note label for cay interior – 'sand'.

Six Health Checks were undertaken on Lorna Cay to assess the condition of shoreline, grassland, and herbland communities. Health Checks assessed the condition of all seven vegetation communities.

The overall condition rating for each of the vegetation communities was Good. The vegetation across the cay was lush and green with high plant biomass and good coverage. Vegetation communities on the cay perimeter were healthy with plants actively encroaching bare sand.

A. Overall vegetation condition

*Photo: View of lush, green Boerhavia herbland communities **6a** and **6b** that provide extensive nesting habitat for large colonies of sooty terns and other seabirds around the entire perimeter of the cay. Photo taken from the north side of the cay facing southwest (near Rodent tunnel 89).*

*Photo: View of Boerhavia herbland communities **6a** and **6b** in good condition at the northern spit providing important seabird nesting and shelter habitat for adults and chicks. Photo taken facing west near Rodent tunnel 87.*

*Photo: View of the eastern (windward) side of the cay where healthy grassland and herbland communities support seabird nesting habitat and restore vegetation disturbed by prior turtle nesting activity (**5** Stenotaphrum micranthum open grassland/ grassland with Boerhavia albiflora var albiflora +/- Achyranthes aspera, Portulaca oleracea and **6a** Boerhavia albiflora var. albiflora herbland/ open herbland/sparse herbland with Portulaca oleracea, Stenotaphrum micranthum). Photo taken facing southwest at Rodent tunnel 85.*

*Photo: Grassland and herbland communities **3b/6c/8a** in the interior of the cay. Photo taken facing south from HC105.*

Photo: A large, long, worm eaten log was found in the interior of the cay from a previous weather event. Note. Similarly frequent items of marine debris were found in the interior of the cay overgrown by plants.

*Photo: View looking across herbland communities **6a** and **6b** towards the southern end of the cay looking southwest from HC108/Rodent tunnel 81. Note flattened Boerhavia with white faeces where seabirds have utilised vegetation as nests.*

*Photo: View looking across Lorna Cay to the southern spit with the green patch of Stenotaphrum grassland **5** in the distant left of the photo and Boerhavia herbland communities **6a** and **6b** in the foreground and right of the photo. Photo taken facing southwest from HC108.*

Photos: Close views of Boerhavia herbland showing the lush, green growth.

*Photo: Looking across Lorna Cay from the southern end of the vegetated area showing healthy growth of Stenotaphrum colonising bare sand (**1a** Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines).*

Photo: The spit south of the vegetated area of the cay shows evidence of sand movement and inundation.

*Photo: View of littoral sparse grassland **1a** growing on hillocks above channels with pumice from weather events and inundation.*

Photo: View of channel containing pumice and marine debris.

B. Health Check photo monitoring - sample photo of each vegetation type

Photo: HC103 ***1a*** *Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines.*

Photo: HC104 ***3b*** *Lepturus repens/ Achyranthes aspera grassland or closed grassland/herbland or closed herbland (Seasonally variable) with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea.*

Photo: HC108 ***5*** *Stenotaphrum micranthum open grassland/ grassland with Boerhavia albiflora var albiflora +/- Achyranthes aspera, Portulaca oleracea.*

Photo: HC107 ***6a*** *Boerhavia albiflora var. albiflora herbland/ open herbland/sparse herbland with Portulaca oleracea, Stenotaphrum micranthum.*

*Photo: HC107 **6b** Boerhavia albiflora var. albiflora/ Stenotaphrum micranthum open herbland/herbland with Portulaca oleracea (Sub-dominant).*

*Photo: HC108 **6c** Boerhavia albiflora var. albiflora/ Achyranthes aspera open herbland +/ Lepturus repens, Portulaca oleracea.*

Photo: HC105 ***8a*** *Achyranthes aspera Herbland/closed herbland with Boerhavia albiflora var. albiflora +/- Abutilon albescens, Portulaca oleracea (Sub-dominant).*

Introduced pests

A. Rodents

Table 77. Rodent tunnel monitoring - Lorna Cay.

Lorna Cay			
No. of rodent tunnels	Date deployed	Date collected	Evidence of rodents (tracks, droppings)
11[1]	22/7/21	23/7/21	Nil

[1] Refer *Figure 126*.

B. Ants and other invertebrates

Table 78. Invertebrate species summary - Lorna Cay.

Lorna Cay					
Specimen no.	Date	Site	Specimen	Identification	Native / introduced
52	23/7/21	NA	Ants	*Cardioconyla nuda /atalanta*[1]	Native
53	23/7/21	RT6	Large fly, small flies	TBA	TBA
54	23/7/21	NA	Crickets	3 x *Gryllidae* (all nymphs)	Native
55	23/7/21	NA	Wasp	1 x *Pompilidae*	TBA
56	23/7/21	NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*	Native
57	23/7/21	NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*	Native
58	23/7/21	RT9	Beetles	1 x *Dermestes ater*; 1 x *Gonocephalum sp*. A	Native
59	23/7/21	NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*	Native
60	23/7/21	NA	Grasshopper	*Aiolopus thalassinus* (*Acrididae*)	Native

[1] Traditionally this ant would have been regarded as *Cardiocondya nuda*, however recently Seifert (2008) used high precision morphometric analysis to discriminate between *C. nuda* and its sibling species *Cardiocondyla atalanta*. *Cardiocondyla nuda* appears to prefer more mesic conditions and is distributed close to the coast in eastern and northern Australia, while *C. atalanta* is a more inland species tolerant of drier conditions and is found throughout much of Australia. However, they are sympatric in central eastern coastal Queensland and *C. atalanta* has been recorded from the Chilcott Islands in the Coral Sea (Seifert 2008). In the past, *Cardiocondyla nuda* has generally been regarded as introduced tramp (Taylor 1987, Heterick *et al*. 2002), however, according to Seifert (2003) it is probably endemic to Australasia and Polynesia. (Chris Burwell 2021, pers. comm.)

22. Kathy Cay

Birds

Table 79. Species and breeding effort – Kathy Cay.

Kathy Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
24/07/2021	black-naped tern				168	230	G,Y (2 colonies)
24/07/2021	brown booby				0	52	
24/07/2021	common noddy				0	13	
24/07/2021	crested tern				0	5	
24/07/2021	masked booby				2	3	G,N
24/07/2021	sooty tern				0	1	

Figure 128. Black-naped tern breeding colony. Note breeding flush colours (pink) on breast and belly feathers.

Kathy Cay and Georgina Cay shared similar nesting substrate, suitable for black-naped tern and New Caledonian fairy terns. This may be a potential breeding site for New Caledonian fairy terns.

The black-naped tern colony of around 170 pairs was the largest observed during the voyage.

Figure 129. Kathy Cay - Health check monitoring sites.

Health check

Kathy Cay	
Unvegetated sand cay – Approx. 0.75 ha (above high water) - Sandy shores - Lithified shores - Area of cay above high water comprised of areas of sand and an area of hard shingle/sand substrate Health Checks: HC109, HC110, HC111	
Habitats and species	**Health Checks** **Overall Condition class[1]**
Value - Seabird and shorebird habitat	G
Breeding and roosting habitat - Refer Birds A. McDougall Empty common noddy nests in hard shingle and sand substrate Six bird species recorded: • Six seabirds • Breeding colony of black-naped terns • Breeding masked boobies	
Value – Turtle rookery (Green turtle *Chelonia mydas*)	G
Turtle body pits were found in the most elevated part of the cay above high water (approx. 0.7 ha, 90m W x 100m L). The elevated area comprised of two substrates - sand or hard shingle and sand. Nesting turtles utilised the sandy areas. There were no turtle body pits in the area of hard shingle and sand substrate - darker area adjacent to HC110 in the drone image. In the elevated cay there was evidence that tides were encroaching into turtle body pits on the perimeter with pumice and marine debris in the cay interior. Drone image showed evidence of turtle tracks. Survey undertaken outside turtle breeding season. Quality of nesting habitat and nesting success unable to be determined. Monitoring during the breeding season is required to determine nesting success.	

1. Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

Photo: View of intertidal area of Kathy Cay at the northwestern end.

Photo: View of elevated area of Kathy Cay showing sandy area utilised by nesting turtles and shingle/sand area (dark band) in background (RHS) of photo.

Photo: View of area of hard shingle/sand substrate on elevated part of Kathy Cay where common noddy nests were found and nil turtle body pits. Note common noddy nest of shell and coral in foreground.

Photo: Looking along the perimeter of the elevated part of the cay aligned northwest southeast showing tidal encroachment into areas used by nesting turtles.

Photo: An example of turtle body pits on the perimeter of Kathy Cay with pumice and/or marine debris.

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Nil pests/invertebrates detected.

23. Unnamed cay near Juliette Cay

Birds

Table 80. Species and breeding effort – Unnamed cay.

Unnamed cay near Juliette Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
24/07/2021	black-naped tern				0	2	
24/07/2021	crested tern				0	2	
24/07/2021	New Caledonian fairy tern				0	1	

Intertidal roosting cay – coarse substrate.

New Caledonian fairy tern was in breeding plumage.

Figure 130. Approximate location of unnamed cay (circle) roughly 2km north east of Juliette Cay.

Health check

Due to small, intertidal cay a Health Check was not undertaken. As mentioned above the cay has value as an intertidal roosting site.

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Nil pests/invertebrates detected.

24. Juliette Cay

Birds

Table 81. Species and breeding effort – Juliette Cay.

Juliette Cay (Lihou) Date:	Species	Nests	Chicks	Young	Breeding pairs	Adolescents and Adults at time of survey	Nesting stratum: **G**round, **V**egetation Colonial breeding: **Y**es, **P**artial, **N**o
25/07/2021	black-naped tern				21	135	G,Y
25/07/2021	brown booby				22	26	G,N
25/07/2021	common noddy				138	148	G,P
25/07/2021	crested tern				0	1	
25/07/2021	masked booby				27	29	G,N
25/07/2021	sooty tern				0	2	

Figure 131. Drone imagery: masked booby and black-naped tern breeding site.

Black-naped terns were actively feeding south of the cay.

The common noddy breeding peak had passed with only soon to be fledged young present.

Figure 132. Juliette Cay - Health check monitoring sites.

Health checks

Juliette Cay

Unvegetated sand cay – Approx. 2.3 ha (above high water)

(Juliette Cay is approximately 7.8ha, oblong in shape with long axis running north-south, approximately 460m in length, 3m ASL. The central portion of the cay is flat, grading from 3m ASL at the southern end to 1m ASL at the northern end. Northern end has steeply shelvings sand beach. Large shells and flotsam in middle of cay suggesting cay is awash on occasions (Hicks 1984).)

- Sandy shores

- Lithified shores

- Elevated area of cay comprised of a hard substrate of shingle and sand with areas of algal mats. Looser, fine sediments occur on the outer edges

Health Checks: HC112, HC113, HC114

Habitats and species	**Health Checks** **Overall Condition class[1]**
Value - Seabird and shorebird habitat	G
Breeding and roosting habitat - Refer Birds A. McDougall Numerous common noddy nests Six bird species recorded: • Six seabird species • Breeding masked boobies, brown boobies, common noddies and black-naped terns	
Value – Turtle rookery (Green turtle *Chelonia mydas*)	G
Turtle body pits occurred on the outer edges of the northern half of elevated part of the cay where fine, loose sediments were found. The drone image shows several tide lines which may have flooded areas used by nesting turtles along the edge of elevated area of cay. Survey undertaken outside turtle breeding season. Quality of nesting habitat and nesting success was not able to be determined. Monitoring during the breeding season is required.	

1. Key: **G = good**; **GC = good with some concern**; SC = significant concern; **C – critical**; **NA = not applicable**

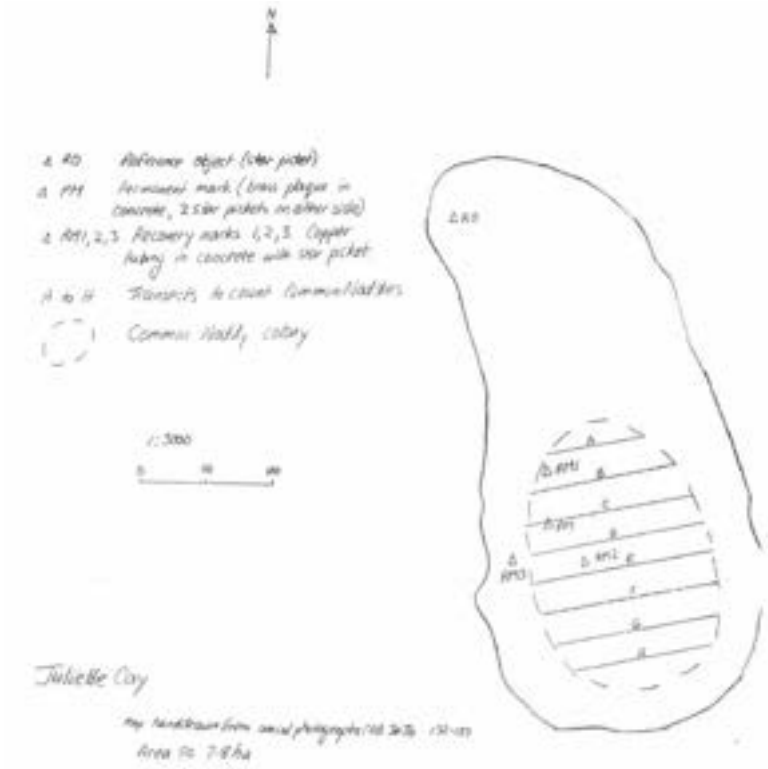


Figure 133. Hand drawn map of Juliette Cay from aerial photograph. Note area of entire cay estimated 7.8 ha (Hicks 1984).

Photo: Looking across the cay interior with single pieces of coral sitting atop very flat terrain. Note algal mats and shell scatter of common noddy nests.

Photo: Close view - Flat interior and algal mats suggests a compacted, low porosity substrate and extended period of wet conditions (fresh or salt?).

Photo: Drone image showing areas of loose, fine sediment on outer edge of elevated part of Juliette Cay used by nesting turtles.

Photo: Interior of cay with flat interior with hard substrate of shingle and sand. Note presence of algal mats and common noddy nests of shells and small coral.

Photo: Pumice, large pieces of coral and marine debris were prevalent on the southern half of the cay – on the west, south and east facing shores.

Introduced pests

A. Rodents

Rodent tunnels not deployed on unvegetated cays.

B. Ants and other invertebrates

Table 82. Invertebrate species summary - Juliette Cay.

Juliette Cay					
Specimen no.	Date	Site	Specimen	Identification	Native / introduced
48	25/7/21	NA	Silverfish[1]	TBA	TBA

[1]Silverfish were collected from dugout canoe found on cay.

References

Armstrong B. (2017) Island Watch Tool: Checking for change. Report prepared for the Department of Environment and Science, Queensland Parks and Wildlife Service, Great Barrier Reef and Marine Parks Region, Technical Support, Cairns.

Batianoff G.N., Naylor G.C. and Dillewaard H.A. (2008) Coringa-Herald National Nature Reserve: Continued assessment of vegetation conditions, ecology and resilience to environmental stressors, including climate change and pests. Report prepared for the Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA).

Batianoff G.N., Naylor G.C., Dillewaard H.A. and Neldner, V.J., (2009a) Plant strategies, dispersal and origins of flora at the northern Coral Sea Islands Territory, Australia. *Cunninghamia* 11(1):97-106.

Batianoff G.N., Naylor, G.C. Olds, J. and Neldner, V.J. (2009b) Distribution patterns, weed incursions and origins of terrestrial flora of the Capricorn-Bunker Islands, Great Barrier Reef, Australia. *Cunninghamia,* **11**, 107-120.

Batianoff G.N., Naylor G.C., Fensham R.J., and Neldner V.J. (2010) Characteristics of coral cay soils at Coringa-Herald Coral Sea Islands, Australia. Pacific Science vol. 64, no. 2:335–347. Page 47

Batianoff G.N., Neldner V.J., Naylor G.C. and Olds J.A. (2012) Mapping and evaluating Capricornia Cays vegetation and regional ecosystems. Department of Science, Information Technology, Innovation and the Arts, Queensland Government. 80 pp.

Brown G.K. & Bostock P.D. (eds) (2020) Introduction to the census of the Queensland flora 2020. Queensland Department of Environment and Science: Brisbane.

Brushe J. (in prep) Report on Lady Elliot Island soil analyses - December 2019.

Brushe, J (2021). Vegetation Assessment and Mapping of South Islet (Willis Islets), Coral Sea Marine Park, October 2020. Report to Parks Australia, Department of Agriculture, Water and Environment.

Bush Blitz (2017) Coral Sea Commonwealth Marine Reserve 2016. A Bush Blitz survey report, Commonwealth of Australia 2017. ABRS, Canberra.

Carravaggi A., Cuthbert R.J., Ryan P.G, Cooper J. and Bond A.L. (2018) The impacts of introduced house mice on breeding success of nesting seabirds on Gough Island. *IBIS*. Doi: 10.1111/ibi. 12664.

Director of National Parks 2018, *Coral Sea Marine Park Management Plan 2018*, Director of National Parks, Canberra. ISBN: 978-0-9876152-1-3

Daubenmire R. (1959) A canopy coverage method of vegetational analysis. Northwest Science 33: 43-64.

Donaldson S.R. (1994) Preliminary report on April 1994 Coral Sea National Nature Reserve patrol. Report to Environment Australia, Canberra.

Eyre T.J., Kelly A.L, Neldner V.J., Wilson B.A., Ferguson D.J., Laidlaw M.J. and Franks A.J. (2015) BioCondition: A condition assessment framework for terrestrial biodiversity in Queensland. Assessment Manual. Version 2.2. Queensland Herbarium, Department of Science, Information Technology, Innovation and Arts, Brisbane.

Eyre T.J., Kelly A.L. and Neldner V.J. (2017) Method for the establishment and survey of reference sites for BioCondition. Version 3. Queensland Herbarium, Department of Science, Information Technology and Innovation, Brisbane.

Freebairn C. (2007) The scale insect *Pulvinaria urbicola* and the hawkmoth *Hippotion velox* on *Pisonia grandis* on NE Herald Islet, Coringa-Herald National Nature Reserve: May 2007. Report to the Department of Environment and Water Resources.

Grant A., Phillips W. and Hinchey M. (1986) Report on Lihou Reef and Coringa-Herald National Nature Reserve field surveys, October 1986. Report 86/94 to ANPWS.

Gregory T.S. (1964) Division of animal health. Rep. Anim. Res. Lab., CSIRO Austral. (1963-1964), pp 31-68.

Hemson G., Melzer R. and Russell, M. eds (2020) Pilot trip to Coral Sea Islands: Report on an environmental assessment of six islands in the Coringa-Herald group of the Coral Sea Marine Park, December 2019. Queensland Parks and Wildlife Service and Partnerships, Queensland Department of Environment and Science.

Heatwole H. (1979) Report on fauna and flora of the Islands of the Coral Sea Islands Territory. Report 79/17 to the Australian National Parks and Wildlife Service, Canberra.

Hicks J. (1984) Lihou Reef and Coringa-Herald National Nature Reserves field trip October 1984 report on cay studies. Report 84/65 to Australian National Parks and Wildlife Service, Canberra.

Hill L. and Hogg S. (1984) Lihou Reef National Nature Reserve Field Trip, August 1984. Report 84/67 to Australian National Parks and Wildlife Service.

Hill L. (1984) Report on Coral Sea surveys (1979 – 1983). Report on Coral Sea Nature Conservation Program (A summary of the first seven surveys by ANPWS). Report 84/64 to Australian National Parks and Wildlife Service.

Hinchey M. D. and Stokes T. (1987) Coral Sea National Nature Reserves report on patrol to Coringa Islet, Nellie Cay and Georgina Cay. Report 87/142 to Australian Nation Parks and Wildlife Service.

Hindwood K.A., Keith K. and Serventy D.L. (1963) Birds of the south-west Coral Sea. Technical paper Division of Wildlife Research, CSIRO Austral (3): 44 pp.

Hopley D., Smithers S.G. and Parnell K.E. (2007) The geomorphology of the Great Barrier Reef Development, Diversity, and Change. James Cook University.

Hoogstraal H., Wassef H.Y., Converse J.D., Keirans J.E., Clifford C.M. and Feare C.J. (1976) *Amblyomma loculosum* (Ixodoidea: Ixodidae): Identity, marine bird and human hosts, virus infection, and distribution in the southern oceans. Annals of the Entomological Society of America, Vol 69, Issue 1, pp. 3-14. https://doi.org/10.1093/aesa/69.1.3

Melzer R. (2019) Natural Values Health Checks. A guide to undertaking Health Checks for key natural values. Version 1.6, July 2019. Ecological Assessment Unit, Queensland Parks and Wildlife Service & Partnerships, Department of Environment and Science, Queensland Government.

Morrison R.J. (1990) Pacific atoll soils: A chemistry mineralogy and classification. Issued by the National Museum of Natural History, Smithsonian Institution, Washington DC USA.

Neldner V.J., Wilson B.A., Dillewaard H.A., Ryan T.S., Butler D.W., McDonald W.J.F, Addicott E.P. and Appelman C.N. (2019) Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland. Version 5.0. Updated March 2019. Queensland Herbarium, Queensland Department of Environment and Science, Brisbane.

Osipova E., Shi Y., Kormos C., Shadie P., Zwahlen C. and Badman T. (2014) IUCN World Heritage Outlook 2014: A conservation assessment of all natural World Heritage sites. Gland, Switzerland: IUCN. 64pp.

Queensland Government Data Portal viewed September 2021. Introduction to the census of the Queensland flora, 2020. https://www.data.qld.gov.au/dataset/census-of-the-queensland-flora-2020/resource/ebca558a-c015-425a-826e-343c878ac000

Roberts F.H.S. (1963) The larvae of Austalian Ixocididae (Acarina: Ixodoidae). Journal of Australian Entomological Society. Vol 8, pp 37-78.

Roman L., Hardesty B.D., Hindell M.A. and Wilcox C. (2019) A quantitative analysis linking seabird mortality and marine debris ingestion. *Sci Rep* **9**, 3202 (2019). https://doi.org/10.1038/s41598-018-36585-9

Sayer P. (2019) Australia's Coral Sea Islands and Marine Park. Exploration beyond the Great Barrier Reef. Bianca Vessel Management Publications, Australia.

Scottney, T. and Jeffs W. (1987) Report on patrol of Coral Sea National Nature Reserves, October 1987. Australian National Parks and Wildlife Service 87/108.

Shaughnessy G. and Hill L. (1983) Report of the 7th ANPWS Coral Sea Islands Territory Survey June 1983. Report 83/31 to Australian National Parks and Wildlife Service.

Siefert B. (2003) The ant genus *Cardiocondyla* (Insecta: Hymenoptera: Formicidae) – a taxanomic revision of the *C. elegans, C. bulgarica, C. batesii, C. nuda, C. shuckardi, C. stambuloffii, C. wroughtonii, C. emeryi* and *C. minutior* species groups. Annalen des Naturhistorischen Museums in Wien, 104B, pp 203-338.

Siefert B. (2008) *Cardiocondyla atalanta* FOREL, 1915, a cryptic sister species of *Cardiocondyla nuda* (MAYR, 1866) (Hymenoptera: Formicidae). Myrmecological News, Vol 11, pp 43-48.

Skeat A. and Hill L. (1982) Report of the sixth coral cay survey in the Coral Sea Islands Territory (CSIT) November/December 1982. Report 82/37 to Australian National Parks and Wildlife Service.

Stokes A. and McNamara K. (1979) Report of the biological survey of the Coral Sea Islands Territory 9 -19 December 1979. Report 79/46 to Australian National Parks and Wildlife Service.

Stokes A. and Skeat A. (1980) Final report of the second biological survey and monitoring visit – 25 April – 3 May 1980. Report 80/81 to Australian National Parks and Wildlife Service.

Taylor R.W. (1991) Nomenclature and distribution of some Australasian ants of the Myrmicae (Hymenoptera: Formicidae). Memoirs of the Queensland Museum, 30, pp 599-614.

Ulenbero G. (1977) *Amblyomma loculosum* (Ixodidae): First record from continental Africa. Journal of Medical Entomology, Vol 13, Issue 4-5, p516, https://doi.org/10.1093/jmedent/13.4-5.516

Wanless R.M., Angel A., Cuthbert R.J., Hilton G.M. and Ryan P.G. (2007) Can predation by invasive mice drive seabird extinctions? *Biol. Lett.* 3, 241-244. Doi: 10.1098/rsbl.2007.0120.

Appendices

Appendix 1. Breeding pair summaries - Family Laridae

Breeding pair summaries – Family Laridae

Group	Location	Species	Breeding Pairs
Diamond Islets	West Diamond Islet	black noddy	Present
Diamond Islets	East Diamond Islet	black noddy	215
		Total	>215
Lihou atoll group	Kathy Cay	black-naped tern	168
Lihou atoll group	Carol Cay	black-naped tern	140
Lihou atoll group	Georgina Cay	black-naped tern	80
Lihou atoll group	Dianna Cay	black-naped tern	52
Lihou atoll group	Juliette Cay	black-naped tern	21
Lihou atoll group	Middle Cay	black-naped tern	5
Lihou atoll group	Margaret Cay	black-naped tern	4
		Total	470
Diamond Islets	West Diamond Islet	bridled tern	3
		Total	3
Diamond Islets	Central Diamond Islet	common noddy	Present
Diamond Islets	East Diamond Islet	common noddy	Present
Lihou atoll group	Lorna Cay	common noddy	3662
Lihou atoll group	South West Cay	common noddy	2207
Lihou atoll group	Hermit Crab Islet	common noddy	660
Lihou atoll group	Turtle Islet	common noddy	595
Lihou atoll group	Georgina Cay	common noddy	190
Diamond Islets	West Diamond Islet	common noddy	175
Lihou atoll group	Juliette Cay	common noddy	138
Lihou atoll group	Helen Cay	common noddy	7
Lihou atoll group	Edna Cay	common noddy	2
		Total	>7636
Lihou atoll group	South West Cay	crested tern	12
Diamond Islets	East Diamond Islet	crested tern	4
		Total	16
Lihou atoll group	Georgina Cay	New Caledonian fairy tern	52
Lihou atoll group	Fanny Cay	New Caledonian fairy tern	0
Lihou atoll group	Dianna Cay	New Caledonian fairy tern	0
Lihou atoll group	Lorna Cay	New Caledonian fairy tern	0
Lihou atoll group	U/N cay near Juliette Cay	New Caledonian fairy tern	0
		Total	52

Lihou atoll group	Carol Cay	roseate tern	3
Lihou atoll group	Georgina Cay	roseate tern	1
		Total	4
Lihou atoll group	Lorna Cay	sooty tern	36628
Diamond Islets	East Diamond Islet	sooty tern	12870
Diamond Islets	West Diamond Islet	sooty tern	10870
Diamond Islets	Central Diamond Islet	sooty tern	5340
Lihou atoll group	Turtle Islet	sooty tern	4110
Lihou atoll group	South West Cay	sooty tern	3721
Lihou atoll group	Hermit Crab Islet	sooty tern	2929
Lihou atoll group	Georgina Cay	sooty tern	872
Diamond Islets	South Diamond Islet	sooty tern	260
		Total	77600

Appendix 2. Breeding pair summaries - Fregatidae et al

Breeding pair summaries – Families Fregatidae, Phaethontidae, Procellariidae, Rallidae and Sulidae

Group	Location	Species	Breeding Pairs
Lihou atoll group	Hermit Crab Islet	brown booby	383
Lihou atoll group	Lorna Cay	brown booby	210
Lihou atoll group	Turtle Islet	brown booby	61
Diamond Islets	West Diamond Islet	brown booby	42
Diamond Islets	South Diamond Islet	brown booby	41
Lihou atoll group	Juliette Cay	brown booby	22
Lihou atoll group	Middle Cay	brown booby	20
Lihou atoll group	South West Cay	brown booby	17
Diamond Islets	East Diamond Islet	brown booby	13
Lihou atoll group	Georgina Cay	brown booby	11
Lihou atoll group	Observatory Cay	brown booby	9
Diamond Islets	Central Diamond Islet	brown booby	5
		Total	834
Lihou atoll group	South West Cay	buff-banded rail	1
		Total	>1
Diamond Islets	West Diamond Islet	great frigatebird	214
Diamond Islets	East Diamond Islet	great frigatebird	54
Diamond Islets	Central Diamond Islet	great frigatebird	33
		Total	301
Diamond Islets	Central Diamond Islet	Herald petrel	3
		Total	3
Diamond Islets	West Diamond Islet	lesser frigatebird	1350
Diamond Islets	East Diamond Islet	lesser frigatebird	1234
Lihou atoll group	Hermit Crab Islet	lesser frigatebird	473
Diamond Islets	South Diamond Islet	lesser frigatebird	382
Lihou atoll group	South West Cay	lesser frigatebird	364
		Total	3803
Lihou atoll group	Hermit Crab Islet	masked booby	75
Lihou atoll group	Lorna Cay	masked booby	73
Lihou atoll group	Observatory Cay	masked booby	51
Lihou atoll group	Middle Cay	masked booby	38
Diamond Islets	West Diamond Islet	masked booby	34
Diamond Islets	East Diamond Islet	masked booby	33
Lihou atoll group	Turtle Islet	masked booby	32
Lihou atoll group	South West Cay	masked booby	28
Lihou atoll group	Georgina Cay	masked booby	27
Lihou atoll group	Juliette Cay	masked booby	27

Diamond Islets	South Diamond Islet	masked booby	20
Diamond Islets	Central Diamond Islet	masked booby	5
Lihou atoll group	Betty Cay	masked booby	2
Lihou atoll group	Kathy Cay	masked booby	2
		Total	447
Diamond Islets	West Diamond Islet	red-footed booby	612
Diamond Islets	Central Diamond Islet	red-footed booby	322
Diamond Islets	East Diamond Islet	red-footed booby	133
Diamond Islets	South Diamond Islet	red-footed booby	120
Lihou atoll group	Hermit Crab Islet	red-footed booby	37
Lihou atoll group	South West Cay	red-footed booby	33
Lihou atoll group	Lorna Cay	red-footed booby	2
		Total	1259
Diamond Islets	Central Diamond Islet	red-tailed tropicbird	43
Diamond Islets	East Diamond Islet	red-tailed tropicbird	19
Diamond Islets	West Diamond Islet	red-tailed tropicbird	1
		Total	63

Appendix 3. Species summary

Coral Sea voyage July 2021, species summary.

Family	common name	Scientific name
Charadriidae	Pacific golden plover	*Pluvialis fulva*
Fregatidae	great frigatebird	*Fregata minor*
Fregatidae	lesser frigatebird	*Fregata ariel*
Hirundinidae	welcome swallow	*Hirundo neoxena*
Laridae	black noddy	*Anous minutus*
Laridae	black-naped tern	*Sterna sumatrana*
Laridae	bridled tern	*Onychoprion anaethetus*
Laridae	common noddy	*Anous stolidus*
Laridae	crested tern	*Thalasseus bergii*
Laridae	New Caledonian fairy tern	*Sternula nereis exsul*
Laridae	roseate tern	*Sterna dougallii*
Laridae	sooty tern	*Onychoprion fuscatus*
Oceanitidae	black-bellied storm-petrel	*Fregetta tropica*
Oceanitidae	Wilson's storm-petrel	*Oceanites oceanicus*
Pelecanidae	Australian pelican	*Pelecanus conspicillatus*
Phaethontidae	red-tailed tropicbird	*Phaethon rubricauda*
Procellariidae	Herald petrel	*Pterodroma heraldica*
Rallidae	buff-banded rail	*Gallirallus phillipensis tounelieri*
Scolopacidae	grey-tailed tattler	*Tringa brevipes*
Scolopacidae	ruddy turnstone	*Arenaria interpres*
Scolopacidae	wandering tattler	*Tringa incana*
Sulidae	brown booby	*Sula leucogaster*
Sulidae	masked booby	*Sula dactylatra*

Breeding pairs (being represented by bonded pairs, active nests, chicks or young) recorded during the voyage are highlighted blue.

Appendix 4. Incidental pelagic sightings

Incidental pelagic sightings

Date	Time – 24hr	Latitude	Longitude	Species and count
10/07/2021	1801	-16.63468	146.38091	sooty tern 19
11/07/2021	0653	-16.85509	147.7271	sooty tern 2
11/07/2021	0654	-16.85521	147.72946	sooty tern 1
11/07/2021	0654	-16.85521	147.72946	red-footed booby 1
11/07/2021	0715	-16.85898	147.76823	sooty tern 2
11/07/2021	0723	-16.8601	147.78218	sooty tern 1
11/07/2021	0738	-16.86305	147.80873	sooty tern 2
11/07/2021	0814	-16.87271	147.87322	sooty tern 2
11/07/2021	0819	-16.87426	147.88097	red-footed booby 2
11/07/2021	0827	-16.87677	147.89508	sooty tern 1
11/07/2021	0832	-16.87801	147.90402	sooty tern 2
11/07/2021	0955	-16.90147	148.02934	red-footed booby 1
11/07/2021	1009	-16.90438	148.0563	great frigatebird (female) 1
11/07/2021	1028	-16.90794	148.09494	great frigatebird (male) 1
11/07/2021	1050	-16.91236	148.13814	sooty tern 17
11/07/2021	1050	-16.91236	148.13814	red-footed booby 3
11/07/2021	1101	-16.9155	148.15924	sooty tern 2
11/07/2021	1105	-16.91678	148.16759	great frigatebird (female) 1
11/07/2021	1120	-16.92206	148.19943	sooty tern 1
11/07/2021	1134	-16.92714	148.22638	sooty tern 1
11/07/2021	1134	-16.92714	148.22638	red-footed booby 1
11/07/2021	1146	-16.93284	148.24994	sooty tern 2
11/07/2021	1154	-16.93627	148.26535	sooty tern 1
11/07/2021	1203	-16.94057	148.28236	sooty tern 1
11/07/2021	1210	-16.94401	148.29613	sooty tern 2
11/07/2021	1210	-16.94401	148.29613	black-bellied storm-petrel 1
11/07/2021	1216	-16.94669	148.30688	sooty tern 1
11/07/2021	1220	-16.9489	148.31435	sooty tern 1
11/07/2021	1336	-16.98494	148.45837	sooty tern 1
11/07/2021	1338	-16.98559	148.46204	black-bellied storm-petrel 1
11/07/2021	1403	-16.9937	148.50801	sooty tern 1
11/07/2021	1403	-16.9937	148.50801	red-footed booby 1
11/07/2021	1406	-16.995	148.51532	sooty tern 1
11/07/2021	1415	-16.99788	148.53256	black-bellied storm-petrel 1
11/07/2021	1419	-16.99896	148.53909	sooty tern 1
11/07/2021	1453	-17.01073	148.60648	red-footed booby 4 (3 white morph)
11/07/2021	1500	-17.01319	148.62032	sooty tern 1
11/07/2021	1604	-17.03367	148.7467	brown booby 4
11/07/2021	1604	-17.03367	148.7467	sooty tern 75
11/07/2021	1604	-17.03367	148.7467	red-footed booby 7
11/07/2021	1604	-17.03367	148.7467	great frigatebird 2
11/07/2021	1639	-17.04241	148.7907	Wilson's storm-petrel
11/07/2021	1639	-17.04241	148.7907	great frigatebird (female) 1
12/07/2021	0737	-17.32567	150.56802	masked booby 5
12/07/2021	0737	-17.32567	150.56802	brown booby 3
12/07/2021	0741	-17.32865	150.57561	common noddy 1

12/07/2021	0741	-17.32865	150.57561	sooty tern 1
12/07/2021	0745	-17.33217	150.584	brown booby 2
12/07/2021	0800	-17.34358	150.61398	sooty tern 1
12/07/2021	0805	-17.34677	150.62248	masked booby (adolescent) 1
12/07/2021	0829	-17.36526	150.67378	masked booby 1
12/07/2021	0829	-17.36526	150.67378	lesser frigatebird 2
12/07/2021	0829	-17.36526	150.67378	brown booby 1
12/07/2021	0829	-17.36526	150.67378	red-footed booby 2
25/07/2021	1554	-17.29326	150.89078	red-footed booby 1
25/07/2021	1554	-17.29326	150.89078	sooty tern 2
25/07/2021	1554	-17.29326	150.89078	common noddy 1
25/07/2021	1622	-17.28865	150.82985	brown booby 1
25/07/2021	1622	-17.28865	150.82985	sooty tern 1
25/07/2021	1622	-17.28865	150.82985	common noddy 1
25/07/2021	1629	-17.28765	150.81236	common noddy 115
25/07/2021	1629	-17.28765	150.81236	sooty tern 45
25/07/2021	1629	-17.28765	150.81236	red-footed booby 9
25/07/2021	1629	-17.28765	150.81236	brown booby 5
25/07/2021	1629	-17.28765	150.81236	masked booby 2
25/07/2021	1629	-17.28765	150.81236	lesser frigatebird (male) 1

Coral Sea incidental pelagic records.

Appendix 5. Comparisons of vegetation survey intensity

Cay	Number of Ground-Truthing Sites	Number of Permanently Marked Monitoring Sites	Hours Spent Surveying Cay (excluding meal breaks)
West Diamond Islet	27	1 (M05)	6
Central Diamond Islet	13	0	3.5
East Diamond Islet	25	3 (M06, M07, M08)	11.5
South Diamond Islet	28	1 (M09)	6.5
All Diamond Islets	**93**	**5**	**27.5**
South West Cay	17	0	3.3
Georgina Cay	19	0	2
Hermit Crab Islet	21	2 (M10, M11)	5
Turtle Islet	17	2 (M12, M13)	4
Lorna Cay	34	2 (M14, M15)	9.5
All Lihou Reef cays	**108**	**6**	**23.8**
TOTAL	**201**	**11**	**51.3**

Average time per site	
Ground-Truthing Site	**Permanent Monitoring Site**
Approximately 10 minutes including traversing time	1 hour (no *Argusia argentea* shrub layer present) to 2.5 hours (Old growth *Argusia* shrub layer present)

Appendix 6. Plant species recorded on Diamond Islets and Lihou Reef cays, July 2021

* = one plant only observed - not likely to persist $ = plant germinated but not yet established Dispersal mechanisms: B = Birds, O = Ocean Currents, W = Wind

Sorted by species name

Species	Common Name	Family	Dispersal mechanism	West Diamond	Central Diamond	East Diamond	South Diamond	South West	Georgina	Hermit Crab	Turtle	Lorna	Edna (unvegetated cay)	All Cays	Total no of Cays with Species
Abutilon albescens	Lantern Bush	Malvaceae	B, W	✓	✓	✓	✓	✓	✓	✓	✓				**8**
Achyranthes aspera	Chaff Flower	Amaranthaceae	B	✓	✓	✓	✓	✓	✓	✓	✓	✓			**9**
Argusia argentea	Octopus Bush	Boraginaceae	O	✓	✓	✓	✓					✓			**5**
Boerhavia albiflora var. *albiflora*	Boerhavia	Nyctaginaceae	B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓*		**9**
Canavalia rosea	Coastal Jack Bean	Fabaceae	O		✓	✓									**2**
Cocos nucifera	Coconut	Arecaceae	O									✓*$			**1**
Cordia subcordata	Sea Trumpet	Boraginaceae	O	✓		✓									**2**
Ipomoea pes-caprae subsp. *brasiliensis*	Goats Foot Convolvulus	Convolvulaceae	O			✓									**1**
Ipomoea violacea	Moon Flower	Convolvulaceae	O, B	✓	✓	✓									**3**
Lepidium englerianum		Brassicaceae	O			✓									**1**
Lepturus repens	Stalky grass	Poaceae	O, B	✓	✓	✓	✓	✓		✓	✓	✓			**8**
Plumbago zeylanica	Native Plumbago	Plumbaginaceae	B	✓	✓	✓	✓								**4**
Portulaca oleracea	Pig Weed	Portulacaceae	O, B	✓	✓	✓	✓	✓	✓	✓	✓	✓			**9**
Scaevola taccada	Cardwell Cabbage	Goodeniaceae	O			✓*									**1**
Stenotaphrum micranthum	Beach Buffalo Grass	Poaceae	O,B	✓	✓	✓	✓	✓	✓	✓	✓	✓			**9**
Tribulus cistoides	Bulls Head Burr	Zygophyllaceae	B	✓	✓	✓	✓	✓		✓	✓	✓			**8**
Ximenia americana	Yellow Plum	Olacaceae	?O	✓											**1**
Total no of species				12	11	15	9	7	5	7	7	8	**1**	**17**	

Sorted in order of frequency in sites

Species	Common Name	Family	Dispersal mechanism	East Diamond	West Diamond	Central Diamond	South Diamond	Lorna	South West	Hermit Crab	Turtle	Georgina	Edna	All Cays	Total no of Cays with Species
Boerhavia albiflora var. *albiflora*	Boerhavia	Nyctaginaceae	B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		**9**
Achyranthes aspera	Chaff Flower	Amaranthaceae	B	✓	✓	✓	✓	✓	✓	✓	✓	✓			**9**
Portulaca oleracea	Pig Weed	Portulacaceae	O, B	✓	✓	✓	✓	✓	✓	✓	✓	✓			**9**
Stenotaphrum micranthum	Beach Buffalo Grass	Poaceae	O,B	✓	✓	✓	✓	✓	✓	✓	✓	✓			**9**
Abutilon albescens	Lantern Bush	Malvaceae	B, W	✓	✓	✓	✓		✓	✓	✓	✓			**8**
Lepturus repens	Stalky grass	Poaceae	O, B	✓	✓	✓	✓	✓	✓	✓	✓				**8**
Tribulus cistoides	Bulls Head Burr	Zygophyllaceae	B	✓	✓	✓	✓	✓	✓	✓	✓				**8**
Argusia argentea	Octopus Bush	Boraginaceae	O	✓	✓	✓	✓	✓							**5**
Plumbago zeylanica	Native Plumbago	Plumbaginaceae	B	✓	✓	✓	✓								**4**
Ipomoea violacea	Moon Flower	Convolvulaceae	O, B	✓	✓	✓									**3**
Canavalia rosea	Coastal Jack Bean	Fabaceae	O	✓		✓									**2**
Cordia subcordata	Sea Trumpet	Boraginaceae	O	✓	✓										**2**
Ipomoea pes-caprae subsp. *brasiliensis*	Goats Foot Convolvulus	Convolvulaceae	O	✓											**1**
Lepidium englerianum		Brassicaceae	O	✓											**1**
Ximenia americana	Yellow Plum	Olacaceae	?O		✓										**1**
Scaevola taccada	Cardwell Cabbage	Goodeniaceae	O	✓*											**1**
Cocos nucifera	Coconut	Arecaceae	O					✓**							**1**
Total no of species				**15**	**12**	**11**	**9**	**8**	**7**	**7**	**7**	**5**	**1**	**17**	

Appendix 7. Frequency and abundance of species on each cay

Layer	Species	All Diamond			West Diamond			Central Diamond			East Diamond			South Diamond		
		Frequency (% of sites containing the species)	Average % cover in sites containing the species	Average % cover across all sites	Frequency (% of sites containing the species)	Average % cover in sites containing the species	Average % cover across all sites	Frequency (% of sites containing the species)	Average % cover in sites containing the species	Average % cover across all sites	Frequency (% of sites containing the species)	Average % cover in sites containing the species	Average % cover across all sites	Frequency (% of sites containing the species)	Average % cover in sites containing the species	Average % cover across all sites
Ground Layer	*Leptunus repens*	92	44.3	40.6	88	59.5	52.6	100	33.8	33.8	86	28.4	24.4	97	50.4	48.6
	Boerhavia albiflora var. albiflora	79	8.5	6.7	77	8.1	6.3	54	2.5	1.3	89	13.3	11.9	83	5.6	4.7
	Achyranthes aspera	67	14.8	9.9	58	3.3	1.9	77	11.0	8.5	82	17.5	14.4	55	24.2	13.4
	Portulaca oleracea	53	5.9	3.2	38	10.0	3.8	31	2.5	0.8	54	4.2	2.2	76	5.9	4.5
	Tribulus cistoides	45	4.0	1.8	58	4.2	2.4	8	2.5	0.2	71	4.4	3.1	24	2.5	0.6
	Stenotaphrum micranthum	29	9.7	2.8	12	18.3	2.1	31	2.5	0.8	46	11.7	5.4	28	6.9	1.9
	Abutilon albescens	27	5.8	1.6	31	6.9	2.1	38	5.0	1.9	29	2.5	0.7	17	10.0	1.7
	Plumbago zeylanica	21	16.4	3.4	4	2.5	0.1	62	22.2	13.7	18	5.0	0.9	21	20.4	4.2
	Canavalia rosea	19	13.9	2.6				62	7.2	4.4	36	19.3	6.9			
	Ipomoea violacea	19	21.1	4.0	54	19.6	10.6	8	62.5	4.8	11	14.2	1.5			
	Argusia argentea	8	2.5	0.2	8	2.5	0.2	23	2.5	0.6	4	2.5	0.1	7	2.5	0.2
	Ipomoea pes-caprae subsp. brasiliensis	1	15.0	0.2							4	15.0	0.5			
	Lepidium englerianum	1	2.5	0.03							4	2.5	0.1			
	Scaevola taccada	1	2.5	0.03							4	2.5	0.1			
	Cocos nucifera															
Upper Shrub (canopy) Layer	*Argusia argentea*	40	34.5	13.7	54	33.2	17.9	31	20.6	6.3	32	56.7	18.2	38	23.2	8.8
	Cordia subcordata	6	59.6	3.7	8	43.8	3.4				14	67.5	9.6			
	Ipomoea violacea	4	5.6	0.2	15	5.6	0.9									
	Abutilon albescens	3	37.5	0.8										10	37.5	2.6
	Ximenia americana	1	85.0	0.9	4	85.0	3.3									
Emergent (above canopy) Layer	*Argusia argentea*	5	2.5	0.1	8	2.5	0.2	8	2.5	0.2	4	2.5	0.1	3	2.5	0.1
	Abutilon albescens	3	6.7	0.2	8	8.8	0.7				4	2.5	0.1			
Lower Shrub Layer (below canopy & upper shrub layers)	*Abutilon albescens*	2	15.0	0.3	8	15.0	1.2									

Layer	Species	All Lihou			South West Cay			Georgina Cay			Hermit Crab Islet			Turtle Islet			Lorna Cay		
		Frequency (% of sites containing the species)	Average % cover in sites containing the species	Average % cover across all sites	Frequency (% of sites containing the species)	Average % cover in sites containing the species	Average % cover across all sites	Frequency (% of sites containing the species)	Average % cover in sites containing the species	Average % cover across all sites	Frequency (% of sites containing the species)	Average % cover in sites containing the species	Average % cover across all sites	Frequency (% of sites containing the species)	Average % cover in sites containing the species	Average % cover across all sites	Frequency (% of sites containing the species)	Average % cover in sites containing the species	Average % cover across all sites
Ground Layer	*Boerhavia albiflora var. albiflora*	89	9.9	8.8	94	4.1	3.8	95	12.1	11.4	83	10.4	8.6	74	7.9	5.8	97	12.0	11.6
	Achyranthes aspera	68	27.9	19.0	76	29.8	22.8	63	37.1	23.4	87	34.4	29.9	47	21.1	10.0	65	18.8	12.1
	Portulaca oleracea	64	6.3	4.0	47	2.5	1.2	47	3.9	1.8	35	4.1	1.4	84	11.6	9.7	91	5.7	5.2
	Stenotaphrum micranthum	58	17.9	10.4	35	18.8	6.6	95	23.9	22.6	22	17.0	3.7	74	23.6	17.4	65	9.3	6.0
	Leptunus repens	49	34.8	17.1	76	30.8	23.5				78	33.5	26.2	74	46.4	34.2	29	26.3	7.7
	Abutilon albescens	14	10.0	1.4	35	18.3	6.5	16	10.8	1.7	13	2.5	0.3	21	2.5	0.5			
	Tribulus cistoides	13	2.5	0.3	35	2.5	0.9				9	2.5	0.2	5	2.5	0.1	18	2.5	0.4
	Argusia argentea																1 plant at one location		
	Cocos nucifera																1 plant at one location		
	Canavalia rosea																		
	Ipomoea pes-caprae subsp. brasiliensis																		
	Ipomoea violacea																		
	Lepidium englerianum																		
	Plumbago zeylanica																		
	Scaevola taccada																		
Upper Shrub (canopy) Layer	*Abutilon albescens*	4	42.5	1.9	24	43.8	10.3	5	37.5	2.0									
	Argusia argentea																		
	Cordia subcordata																		
	Ipomoea violacea																		
	Ximenia americana																		
Emergent (above canopy) Layer	*Abutilon albescens*	2	2.5	0.0	6	2.5	0.1	5	2.5	0.1									
	Argusia argentea																		
Lower Shrub Layer (below canopy & upper shrub layers)	*Abutilon albescens*																		

Appendix 8. Comparison of species recorded during the July 2021 surveys with previous species records for the Diamond Islets and Lihou Reef cays

Species not previously recorded are highlighted in green
Species recorded previously but absent in July 2021 are highlighted in yellow

BRI = specimen currently held in the Queensland Herbarium, Brisbane
CANB = specimen currently held in the Australian National Herbarium, Canberra
CNS = Specimen currently held in the Australian Tropical Herbarium, Cairns
MEL = Specimen currently held in National Herbarium of Victoria, Melbourne
NSW = Specimen Currently held in the National Herbarium of New South Wales, Sydney
DNA = Specimen Currently held in the Northern Territory Herbarium

Group	Islands	Area (ha)	Area calculated from Allen Coral Atlas Images (Ha)	Record Source	Species																	
					Abutilon albescens	Achyranthes aspera	Argusia argentea	Boerhavia albiflora var. albiflora	? Boerhavia tetrandra (B. diffusa) or B. albiflora	Canavalia rosea	Cocos nucifera	Cordia subcordata	Ipomoea pes-caprae subsp. brasiliensis	Ipomoea violacea	Lepidium englerianum	Lepturus repens	Plumbago zeylanica	Portulaca oleracea	Scaevola taccada	Stenotaphrum micranthum	Tribulus cistoides	Ximenia americana
Diamond Islets	West Diamond Islet	7.9	8.7	Keith 1961						BRI												BRI
				Walker 1991																		BRI
				July 2021 survey	Y	Y	Y	Y				Y		Y		Y	Y	Y		Y	Y	Y
	Central Diamond Islet	8.4	9.3	July 2021 survey	Y	Y	Y	Y		Y				Y		Y	Y	Y		Y	Y	
	East Diamond Islet	8.2	9.0	Hicks 1984	P	P	P		P	CANB, CNS		CANB, CNS		CANB	P	P	P				CANB	
				Westaway 2016	CNS		CNS	CNS		CNS		CNS				CNS	CNS	CNS		CNS, NSW	CNS	
				July 2021 survey	Y	Y	Y	Y		Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	South Diamond Islet	3	3.5	Hicks 1984		P	CANB		P							P	P	P			P	
				July 2021 survey	Y	Y	Y	Y								Y	Y	Y		Y	Y	
Lihou Cays	South West Cay	4.1	5.0	Hicks 1984	P	P			CANB							CANB		P		CANB		
				Hogg 1884	P	CANB			CANB							CANB		CANB		CANB, NSW		
				July 2021 survey	Y	Y		Y								Y		Y		Y	Y	
	Georgina Cay	1.2	1.9	Hicks 1984	P	P			P									P		P		
				Hogg 1984	CANB	CANB			CANB							P				CANB		
				July 2021 survey	Y	Y		Y										Y		Y		
	Hermit Crab	5.9	6.9	Hicks 1984	P	P			CANB							CANB		P		CANB	P	
				Hogg 1984	P	CANB, MEL			CANB							CANB		CANB		CANB	CANB	
				Donaldson 1994	P	P		P								P		P		P	P	
				July 2021 survey	Y	Y		Y								Y		Y		Y	Y	
	Turtle Islet	1.2	1.7	Stokes & McNamara 1979		CANB			CANB				CANB			CANB				CANB	CANB	
				Stokes 1980	CANB	CANB			CANB								CANB			CANB	CANB	
				Veenstra 1981	BRI	BRI		BRI														
				Skeat 1981	CANB	CANB			CANB							CANB		CANB		CANB		
				Shaughnessy 1983	P	CANB			CANB				?	CANB		CANB		CANB		CANB		
				Hicks 1984	P	P			CANB				CANB			CANB		CANB		CANB		
				Scotney 1987		CANB			CANB											CANB	BRI, CANB	
				Donaldson 1994	P	P		P								P		P		P	P	
				July 2021 survey	Y	Y		Y								Y		Y		Y	Y	
	Lorna Cay	4.4	6.1	July 2021 survey		Y	Y	Y				Y				Y		Y		Y	Y	
	Edna Cay			July 2021 survey				y														
	Observation Cay	?	?	McNamara 1979												CANB						
				July 2021 survey																		
	Lihou Island (Somewhere in Lihou Reef)	?		Serventy 1960				BRI												BRI		

Note: There has been some confusion with the taxonomy of *Boerhavia* in the past and differences in the accepted taxonomy between States

Appendix 9. Comparison of species recorded on the Diamond Islets and Lihou Reef cays with those recently recorded on the Coringa Herald cays, Magdelaine cays and Willis South Islet

1= Batianoff *et al.*, 2008; 2= Hemson *et al.*, 2020; Willis South Islet = Brushe 2020

Scientific name	Common name	Family	NE Herald	SW Herald	Chilcott	SW Coringa	SE Magdelaine	Willis South Islet	West Diamond	Central Diamond	East Diamond	South Diamond	South West	Georgina	Hermit Crab	Turtle	Lorna
Abutilon albescens	coastal lantern flower	Malvaceae	1,2	1,2	1,2	1,2	1,2		✓	✓	✓	✓	✓	✓	✓	✓	
Achyranthes aspera	chaff flower	Amaranthaceae	1	1,2	1,2	1,2	1,2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Argusia argentea	octopus bush	Boraginaceae	1,2	1,2	1,2	1,2	1,2	✓	✓	✓	✓	✓					✓
Boerhavia albiflora var. *albiflora*	white flower tar vine	Nyctaginaceae	1	1,2	1,2	1,2	1,2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Boerhavia mutabilis	pink flower tar vine	Nyctaginaceae	1,2	2		1,2	1,2										
Canavalia rosea	beach bean	Fabaceae					1,2			✓	✓						
Colubrina asiatica	Asian naked wood	Rhamnaceae					1										
Cordia subcordata	sea trumpet	Boraginaceae	1,2		1,2	1,2	1,2		✓		✓						
Digitaria bicornis		Poaceae				2	2										
Ipomoea pes-caprae subsp. *brasiliensis*	Goats Foot Convolvulus	Fabaceae						✓			✓						
Ipomoea violacea	coast moon flower	Convolvulaceae	1,2	1,2	1,2	1,2	1,2		✓	✓	✓						
Lepidium englerianum	beach peppercress	Brassicaceae	1	1	1	1				✓							
Lepturus repens	*stalky grass*	*Poaceae*	*1*	*1,2*	*1,2*	*1,2*	*1,2*	✓	✓	✓	✓	✓	✓		✓	✓	✓
Pisonia grandis	pisonia	Nyctaginaceae	1,2				1,2										
Plumbago zeylanica	native plumbago	Plumbaginaceae		1,2	1,2	1,2	1,2		✓	✓	✓	✓					
Portulaca oleracea	common purslane	Portulaceae	1,2	1,2	1,2	1,2	1,2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Scaevola taccada	Cardwell Cabbage	Goodeniaceae								✓							
Sporobolus virginicus	sand couch	Poaceae	1,2	1,2	1		1,2	✓									
Stenotaphrum micranthum	beach buffalo grass	Poaceae	1	1	1,2		1,2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tribulus cistoides	beach caltrop	Zygophyllaceae	1,2	1,2	1,2	1,2	1,2	✓	✓	✓	✓	✓	✓		✓	✓	✓
Ximenia americana	yellow plum	Olacaceae							✓								

Appendix 10. Vegetation communities on the Diamond Islets and Lihou Reef cays -July 2021

The most extensive vegetation communities on each cay are highlighted in yellow

Veg Map Unit Code	Vegetation Community		Equivalent or Similar Vegetation Communities Currently Described for Coral Sea and Capricorn Bunker Cays			Area (hectares)										
	Vegetation Map Legend Summary Description	Detailed Description	Coringa-Herald Islets and Cays Coral Sea Marine Park 1 = Batianoff et al., 2008), 2 = Hemson et al., 2020	South Islet (Willis Islets) Coral Sea Marine Park (Brushe 2020)	Capricorn Bunker Cays Capricornia Cays National Park (Batianoff et al., 2012)	Central Diamond	East Diamond	South Diamond	West Diamond	Total for all Diamond Islets	Georgina	Hermit Crab	Lorna	South West	Turtle	Total for all Lihou Cays
	Unvegetated Areas															
A	Sandy shores		A - Sandy Shores (1), Sandy Shores (2)	A = Sandy Shores	A - Sandy Shores	2.687	4.842	1.971	2.685	12.184	3.702	3.587	10.156	3.325	2.391	23.161
B	Lithified shores		B - Lithified Sores (1), Lithified Shores (2)	B - Lithified Shores	B - Lithified Shores	5.116	2.543	1.760	2.622	12.041	2.169	1.498	4.030	1.888	1.390	10.976
C	Rubble banks					0.411	0.343	0.404	0.618	1.775	0.098	0.096		0.304		0.498
	Shoreline and Sandspit Vegetation															
1a	Sandy shore sparse to open herbland	Littoral sparse to open-grassland/sparse to open herbland on sandy shorelines	1 - Littoral open-grassland/herbland (1), Littoral grassland/herbland (2)	1 - Open herblands, herblands and open forblands 2 - Sparse herbland and open forblands	1e - Very sparse herbland, mainly sand (Regional Ecosystem 12.2.14g), 1d - Seashore mixed herbland (Regional Ecosystem 12.2.14i)	0.544	0.298	0.279	0.188	1.309	0.550	0.148	0.353	0.144	0.053	1.247
1b	Rubblebank sparse herbland	Littoral sparse herbland on shoreline rubble banks			D - Shingle shores with sparse vegetation e.g. *Canavalia rosea* (Regional Ecosystem 12.2.14h)	0.005			0.067	0.072				0.158		0.158
2	Isolated *Argusia*	*Argusia argentea* open shrubland/isolated shrubs on shorelines and sandy spits				0.045	0.218	0.048	0.360	0.671						
11a	Coastline *Argusia* communities	*Argusia argentea shrubland/ tall shrubland/ open scrub/ closed scrub with a ground layer typically of Lepturus repens, Boerhavia albiflora var. albiflora, Portulaca oleracea +/- Achyranthes aspera +/- Stenotaphrum micranthum +/- Tribulus cistoides*	*10a - Argusia* shrubland to open-scrub (1), *Argusia argentea* open shrubland to open scrub; (2)	*6 - Argusia argentea* dwarf open shrublands to dwarf shrublands	*2a and 2b - Argusia argentea* open scrub (Regional Ecosystem 12.2.19)	2.031	0.935	0.077	2.401	5.443						
	Grasslands and Herblands															
3a	*Lepturus* grassland to closed grassland	*Lepturus repens* grassland/ closed grassland +/- *Achyranthes aspera +/- Boerhavia albiflora* var. *albiflora +/- Portulaca oleracea*	*2 - Lepturus* open-grassland (1), *Lepturus repens* open to closed grassland (2)	3 - *Lepturus repens* open grassland to grassland with patches of open forblands and herblands	4 - Mixed tussock grassland/herbland (Regional Ecosystem 12.2.17a)	0.821	0.362	1.812	0.534	3.529		0.821		0.697	0.680	2.199
3b	*Lepturus* & *Achyranthes* closed grassland or herbland to closed herbland	*Lepturus repens/ Achyranthes aspera closed grassland/herbland/closed herbland (Seasonally variable) with Boerhavia albiflora var. albiflora +/- Portulaca oleracea*					0.012	0.151		0.163		0.777	1.665	1.873	0.666	4.981
3c	*Lepturus viny* grassland to closed grassland	*Lepturus repens/Ipomoea violacea* viny grassland/ closed grassland with *Boerhavia albiflora* var. *albiflora*, +/- *Abutilon albescens +/- Achyranthes aspera +/- Tribulus cistoides*							4.108	4.108						
3d	*Lepturus mixed* closed grassland	*Lepturus repens* closed grassland with *Achyranthes aspera, Canavalia rosea +/- Abutilon albescens*, +/- *Plumbago zeylanica*				2.718	6.452			9.171						

Veg Map Unit Code	Vegetation Community		Equivalent or Similar Vegetation Communities Currently Described for Coral Sea and Capricorn Bunker Cays			Area (hectares)										
	Vegetation Map Legend Summary Description	Detailed Description	Coringa-Herald Islets and Cays Coral Sea Marine Park 1 = Batianoff et al., 2008), 2 = Hemson et al., 2020	South Islet (Willis Islets) Coral Sea Marine Park (Brushe 2020)	Capricorn Bunker Cays Capricornia Cays National Park (Batianoff et al., 2012)	Central Diamond	East Diamond	South Diamond	West Diamond	Total for all Diamond Islets	Georgina	Hermit Crab	Lorna	South West	Turtle	Total for all Lihou Cays
4	*Lepturus & Stenotaphrum grassland*	*Lepturus repens/Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora, Portulaca oleracea*	Component of Units 1 - Littoral open-grassland/herbland (1) and 2 - *Lepturus* open-grassland (1), Component of Littoral grassland/herbland (2)and *Boerhavia albiflora* herbland (2).		Component of 1d - Seashore mixed herbland (Regional Ecosystem 12.2.14i) and other foreshore beach vegetation communities		0.195			0.195		0.104		0.228	0.260	0.592
5	*Stenotaphrum* grassland	*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var *albiflora* +/- *Achyranthes aspera* +/-*Portulaca oleracea*	Component of 1 - Littoral open-grassland/herbland (1), Component of Littoral grassland/herbland (2)and *Boerhavia albiflora* herbland (2).	5 - *Stenotaphrum micranthum* grassland	Component of 1d - Seashore mixed herbland (Regional Ecosystem 12.2.14i) and other foreshore beach vegetation communities			0.079		0.079	0.800	0.001	0.499	0.264	0.686	2.251
6a	*Boerhavia* sparse or open herbland to herbland	*Boerhavia albiflora* var. *albiflora* sparse herbland/ open herbland/ herbland with *Portulaca oleracea*	4 - *Boerhavia* herbland, *1 - Littoral open-grassland/herbland (1),* *Boerhavia albiflora* herbland (2)	1 - Open herblands, herblands and open forblands	1d - Seashore mixed herbland (Regional Ecosystem 12.2.14i), Component of 4 - Mixed tussock grassland/herbland (Regional Ecosystem 12.2.17a)		0.419		0.008	0.426		0.054	1.105		0.132	1.292
6b	*Boerhavia* & *Stenotaphrum* open herbland to herbland	*Boerhavia albiflora* var. *albiflora/ Stenotaphrum micranthum* open herbland/herbland with *Portulaca oleracea*									0.271	0.162	0.670			1.103
6c	*Boerhavia* & *Achyranthes* open herbland to herbland	*Boerhavia albiflora* var. *albiflora/ Achyranthes aspera* open herbland/ herbland with *Portulaca oleracea* +/ *Lepturus repens* +/- *Stenotaphrum micranthum*					0.367	0.032		0.399			1.073	0.491		1.564
7	*Plumbago* closed herbland or dwarf shrubland	*Plumbago zeylanica*/ mixed closed herbland/dwarf shrubland with *Achyranthes aspera*, *Lepturus repens*, +/- *Abutilon albescens* +/- *Canavalia rosea*	7 - *Plumbago* mixed open-heath (1), *Plumbago zeylanica* shrubland to closed shrubland (2)		5b - *Plumbago zeylanica / Canavalia rosea / Lepturus repens* herbland Regional Ecosystem 12.2.18b)	1.804		0.263		2.067						
8a	*Achyranthes* herbland to closed herbland	*Achyranthes aspera h*erbland/closed herbland with *Boerhavia albiflora* var. *albiflora*	6 - *Achyranthes* mixed herbland (1), *Achyranthes aspera* herbland (2)	9 - *Achyranthes aspera* open herbland to herbland	Small patches of *Achyranthes aspera* are present within vegetation community 4 - Mixed tussock grassland/herbland (Regional Ecosystem 12.2.17a) and vegetation community 5c - *Abutilon albescens* shrubland (Regional Ecosystem 12.2.18c) as well as recently disturbed areas within other units.		0.085	0.158		0.243	0.551	6.042	1.044	0.765		8.401
8b	*Achyranthes* & *Stenotaphrum* herbland to closed herbland	*Achyranthes aspera/Stenotaphrum micranthum/ Boerhavia albiflora var. albiflora herbland/ closed herbland +/- Abutilon albescens +/- Portulaca oleracea*					0.020			0.020	0.635					0.635
8c	*Achyranthes* mixed herbland to closed herbland	*Achyranthes aspera* mixed herbland/closed herbland with *Lepturus repens* and *Plumbago zeylanica* +/- *Abutilon albescens* +/- *Boerhavia albiflora* var. *albiflora* +/- *Portulaca oleracea*				2.300		0.413		2.712						
9	*Ipomoea violacea* closed vineland	*Ipomoea violacea/ Achyranthes aspera/ Lepturus repens* closed vineland with *Canavalia rosea* and *Plumbago zeylanica*	5 - *Ipomoea* viny-herbland (1), *Ipomoea violacea* vineland (2)			0.248	0.717			0.965						
10	*Ipomoea pes-caprae* vineland	*Ipomoea pes-caprae* vineland with *Lepturus repens, Stenotaphrum micranthum* and *Boerhavia albiflora* var. *albiflora*		10 - *Ipomoea pes-caprae* subsp. *brasiliensis/Sporobolus virginicus* closed herbland	This vegetation community is a component of Vegetation Community 4 - Mixed tussock grassland/herbland (Regional Ecosystem 12.2.17a)		0.010			0.010						

Veg Map Unit Code	Vegetation Community		Equivalent or Similar Vegetation Communities Currently Described for Coral Sea and Capricorn Bunker Cays			Area (hectares)										
	Vegetation Map Legend Summary Description	Detailed Description	Coringa-Herald Islets and Cays Coral Sea Marine Park 1 = Batianoff et al., 2008), 2 = Hemson et al., 2020	South Islet (Willis Islets) Coral Sea Marine Park (Brushe 2020)	Capricorn Bunker Cays Capricornia Cays National Park (Batianoff et al., 2012)	Central Diamond	East Diamond	South Diamond	West Diamond	Total for all Diamond Islets	Georgina	Hermit Crab	Lorna	South West	Turtle	Total for all Lihou Cays
Veg Map Unit Code	Vegetation Community		Equivalent or Similar Vegetation Communities Currently Described for Coral Sea and Capricorn Bunker Cays			Area (hectares)										
	Vegetation Map Legend Summary Description	Detailed Description	Coringa-Herald Islets and Cays Coral Sea Marine Park 1 = Batianoff et al., 2008), 2 = Hemson et al. 2020	South Islet (Willis Islets) Coral Sea Marine Park (Brushe 2020)	Capricorn Bunker Cays Capricornia Cays National Park (Batianoff et al., 2012)	Central Diamond	East Diamond	South Diamond	West Diamond	Total for all Diamond Islets	Georgina	Hermit Crab	Lorna	South West	Turtle	Total for all Lihou Cays
	Interior shrublands															
11b	*Argusia* interior open shrubland to tall open shrubland to open scrub	*Argusia argentea* open shrubland /tall open shrubland/open scrub with a ground layer of *Lepturus repens* and *Boerhavia albiflora var. albiflora +/- Achyranthes aspera +/- Ipomoea violacea +/- Portulaca oleracea*	*10b. Argusia tall open-shrubland (dieback) (1),* *Argusia argentea* tall open shrubland to closed scrub(2); *Argusia argentea* open to closed scrub (2)	11 - *Argusia argentea* shrubland	2a and 2b - *Argusia argentea* open scrub (Regional Ecosystem 12.2.19)	0.270	0.064	0.169	1.855	2.359						
11c	*Argusia* interior shrubland	*Argusia argentea shrubland with ground layer of Lepturus repens, Achyranthes aspera, Boerhavia albiflora var. albiflora and Portulaca oleracea*		*12 - Argusia argentea dwarf shrubland with mid dense ground stratum dominated by Sporobolus virginicus*		0.071	0.076	0.441	0.183	0.770						
12	*Argusia* & *Cordia* shrubland	*Argusia argentea* shrubland with occasional *Cordia subcordata* and a ground layer dominated by *Lepturus repens*							0.003	0.003						
13	Cordia open shrubland to closed scrub	*Cordia subcordata* open shrubland to closed scrub	*11. Cordia* closed-scrub to low closed-forest (1), *Cordia subcordata* open shrubland to tall shrubland (2); *Cordia subcordata* closed shrubland to closed scrub (2)		*Cordia subcordata* low closed-forest		0.199		0.002	0.201						
14	*Ximenia* closed scrub	*Ximenia americana* closed scrub			*Ximenia americana* closed-scrub				0.049	0.049						
15	*Abutilon* dwarf shrubland to shrubland	*Abutilon albescens* dwarf shrubland to shrubland with a mid-dense to dense ground layer of *Abutilon albescens, Achyranthes aspera, Boerhavia albiflora* var. *albiflora +/- Lepturus repens +/- Plumbago zeylanica +/- Stenotaphrum micranthum*	*8 - Abutilon shrubland to open-heath (1),* *Abutilon albescens* open shrubland to shrubland (2)		5c - *Abutilon albescens* shrubland (Regional Ecosystem 12.2.18c)			0.263		0.263	0.010			1.036		1.046
Infrastructure							0.006			0.006						
					Total Area	19.1	18.2	8.3	15.7	61.2	8.8	13.3	20.6	11.2	6.3	60.1
					Total Vegetated Area	10.9	10.4	4.2	9.8	35.2	2.8	8.1	6.4	5.7	2.5	25.5

Appendix 11. Soil analyses

Sample	Site	Depth	pH	EC	TN	TC	TOC	Col P	Ca	K	Mg	Na	CEC	P	Al	Ca	Cu	Fe	K	Mg	Mn	Na	S	Zn
		cm		dS/m	Wt %	Wt %	Wt %	mg/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	Wt %	mg/kg	Wt %	mg/kg	mg/kg	mg/kg	Wt %	mg/kg	Wt %	Wt %	mg/kg
1	M05	0-10	8.61	0.224	0.374	13.73	1.61	736	14.03	0.19	1.62	0.37	16.22	1.32	42	37.8	11.7	44	111	0.670	6	0.243	0.195	54
2	M05	10-20	8.85	0.118	0.268	12.91	0.74	539	12.41	0.06	1.21	0.17	13.84	1.13	28	39.0	8.7	31	63	0.776	4	0.246	0.187	44
3	M05	20-30	8.89	0.102	0.149	12.19	0.07	572	11.65	0.04	1.08	0.16	12.93	1.01	14	39.6	5.6	22	52	0.800	3	0.247	0.183	36
4	M06	0-10	9.25	0.091	0.108	12.12	0.05	226	11.67	0.04	1.40	0.13	13.24	0.15	2	39.1	0.7	3	62	1.569	2	0.250	0.199	4
5	M06	10-20	9.36	0.086	0.071	12.14	0.01	191	11.51	0.03	1.37	0.10	13.01	0.13	30	35.8	0.6	6	45	1.303	2	0.229	0.186	4
6	M06	20-30	9.17	0.093	0.102	12.14	0.03	280	12.16	0.03	1.45	0.12	13.76	0.20	27	36.8	0.8	6	46	1.381	2	0.233	0.190	6
7	M07	0-10	8.76	0.307	0.144	12.30	0.12	576	12.74	0.06	1.64	0.32	14.76	0.19	17	36.3	0.6	8	61	1.258	2	0.238	0.194	5
8	M07	10-20	8.75	0.291	0.195	12.17	0.09	453	12.50	0.07	1.80	0.43	14.80	0.23	44	33.4	1.1	16	59	1.102	2	0.226	0.187	6
9	M07	20-30	9.02	0.208	0.103	12.13	0.02	303	12.60	0.05	1.50	0.30	14.45	0.13	12	34.4	0.5	7	53	1.167	2	0.233	0.181	3
10	M08	0-10	8.30	0.298	0.416	13.85	1.70	901	13.79	0.20	1.87	0.16	16.02	0.74	9	37.7	4.3	16	105	0.881	4	0.225	0.198	28
11	M08	10-20	8.47	0.200	0.342	15.31	3.24	699	14.56	0.14	1.69	0.14	16.53	0.89	20	38.3	7.9	24	81	0.820	4	0.231	0.201	37
12	M08	20-30	8.82	0.106	0.189	12.08	0.04	476	13.33	0.07	1.35	0.07	14.82	0.89	14	40.3	6.2	20	59	0.935	3	0.235	0.202	33
13	M09	0-10	8.14	0.455	0.337	20.00	7.93	585	15.23	0.24	2.55	0.41	18.42	0.92	17	37.2	8.5	27	139	1.055	5	0.283	0.243	47
14	M09	10-20	8.44	0.238	0.256	14.01	1.95	405	12.78	0.14	2.00	0.25	15.18	0.74	17	37.2	7.9	24	129	0.993	4	0.278	0.229	39
15	M09	20-30	8.72	0.161	0.160	12.53	0.37	290	11.62	0.08	1.34	0.15	13.19	0.36	3	40.2	2.5	8	77	1.062	2	0.290	0.209	12
16	M10	0-10	8.36	0.346	0.788	13.40	1.26	1052	14.88	0.25	2.24	0.23	17.61	1.56	24	37.3	13.4	45	150	1.368	6	0.229	0.262	65
17	M10	10-20	8.26	0.445	0.564	13.42	1.42	1059	16.00	0.21	2.24	0.24	18.70	1.42	22	36.9	11.6	41	124	1.487	6	0.218	0.247	59
18	M10	20-30	8.41	0.244	0.021	12.93	0.86	814	13.75	0.13	1.79	0.08	15.75	1.04	8	38.6	5.9	21	82	1.655	4	0.220	0.217	35
19	M11	0-10	8.90	0.134	0.122	12.64	0.57	327	12.19	0.05	1.52	0.11	13.86	0.14	5	38.8	1.2	3	65	1.965	2	0.225	0.216	4
20	M11	10-20	8.94	0.107	0.109	12.47	0.31	392	11.77	0.02	1.41	0.09	13.29	0.23	1	38.6	0.7	4	42	1.820	2	0.224	0.197	6
21	M11	20-30	9.15	0.096	0.076	12.56	0.47	237	11.93	0.02	1.37	0.07	13.40	0.18	0	38.5	0.5	3	40	1.839	2	0.217	0.196	5
22	M12	0-10	8.20	0.416	0.906	16.15	4.13	923	17.23	0.21	2.73	0.31	20.47	2.06	173	30.9	22.4	171	159	0.751	12	0.219	0.269	107
23	M12	10-20	8.55	0.193	0.339	12.55	0.37	718	12.62	0.07	1.58	0.14	14.41	1.27	40	36.9	11.2	36	81	1.209	4	0.248	0.218	42
24	M12	20-30	8.78	0.122	0.200	12.19	0.04	478	12.68	0.03	1.42	0.12	14.25	0.89	5	38.8	7.5	18	51	1.631	3	0.244	0.212	27
25	M13	0-10	8.36	0.315	0.511	13.30	1.13	832	14.08	0.12	2.11	0.20	16.51	1.44	13	38.8	11.5	32	87	1.357	4	0.261	0.245	49
26	M13	10-20	8.54	0.207	0.185	12.16	0.02	498	12.86	0.06	1.56	0.16	14.64	1.04	5	39.2	7.9	21	63	1.448	3	0.258	0.215	30
27	M13	20-30	8.56	0.198	0.229	12.17	0.02	550	13.56	0.05	1.51	0.15	15.27	1.01	12	39.3	6.6	21	56	1.492	3	0.254	0.225	29
28	M14	0-10	8.24	0.732	0.417	12.74	0.56	901	12.57	0.21	1.85	0.44	15.07	0.26	4	39.5	1.4	5	145	1.368	2	0.258	0.209	7
29	M14	10-20	8.57	0.346	0.266	12.56	0.42	484	12.46	0.07	1.55	0.37	14.45	0.16	2	33.0	0.7	3	52	1.060	2	0.199	0.168	3
30	M14	20-30	9.12	0.179	0.091	12.20	0.06	147	12.36	0.04	1.17	0.22	13.80	0.07	8	36.9	0.7	3	54	1.163	2	0.233	0.184	2
31	M15	0-10	7.82	0.124	1.307	14.39	2.28	1080	18.71	0.55	4.02	0.51	23.78	1.05	29	34.7	8.7	39	238	1.311	6	0.234	0.275	34
32	M15	10-20	8.89	0.176	0.086	12.13	0.05	190	12.41	0.05	1.05	0.11	13.62	0.07	30	40.2	0.8	15	67	1.366	2	0.242	0.205	1
33	M15	20-30	9.45	0.082	0.056	12.10	0.01	110	11.82	0.02	1.02	0.05	12.92	0.03	15	34.5	0.2	10	36	1.125	2	0.202	0.182	0

Soil analyses methodologies

Provided by Queensland University Analytical Laboratory, School of Agriculture and Food Sciences

Methodology abstracts

Handbook section refers to "Soil Chemical Methods - Australasia"

Rayment GE and Lyons DJ, CSIRO publishing 2011

pH / EC

1: 5 soil water extracts are prepared and mixed for 1 hour. Conductivity and pH electrodes are used to measure the respective properties.

Handbook section: 3A1, p20 and 4A1, p38.

Colwell P

1: 50 soil solution extracts in 0.5 M sodium bicarbonate are prepared and mixed for 16 hrs, with the extracted phosphorous present being determined colorimetrically on centrifuged and filtered extracts using a SEAL AQ2+ discreet analyser and the ammonium molybdate / ascorbic acid colour reaction with potassium antimonyl tartrate added to control the reaction rate.

Calculation: Sample concentrations obtained above in mg/L are converted to mg/kg by multiplying by the volume and dividing by the weight.

Handbook section: 9B1, p162.

Exchangeable bases (Ca, K, Mg and Na) and CEC

1: 10 soil solution extracts are prepared in 1 M ammonium chloride and mixed for 1 hr, with the exchangeable bases being determined on centrifuged and filtered extracts using a Thermo iCAP ICPOES instrument.

Calculation: Sample concentrations obtained above in mg/L are converted to mg/kg by multiplying by the volume and dividing by the weight. Conversion to meqv or centimoles per unit charge is done by dividing the mg/kg results by the atomic molecular weight and then by dividing again by either 10 for monovalent species (Na and K) or 5 for divalent species (Ca and Mg).

The CEC result is the summation of the meqv results for each of the 4 cations. ESP is the sodium percentage of the CEC result, while SAR is the sodium concentration divided by the square root of half the combined results for calcium and magnesium.

Handbook section: 15A1, p293.

Carbon and nitrogen

1.0 g of sample is weighed out into a ceramic boat which is placed into the induction furnace of a LECO 928 CN combustion analyser set at 1200 degrees C and calibrated on EDTA. The carbon present is combusted to CO2 which is determined with an infra-red detection cell. The nitrogen present is combusted to N2, NO2 and NO. The oxides are reduced to N2 which is determined quantitatively using a thermal conductivity cell.

For organic carbon the samples are treated with acid to remove inorganic carbonates prior to combustion.

Calculation: Results are automatically expressed as weight percentages. To convert to mg/kg multiply the Wt % result by 10000.

Handbook section: 6B2, p75.

Total Elemental (microwave digestion)

500 mg of sample is weighed out into a teflon vessel. To this is added 10 mL of water, 5 mL of conc nitric acid, 4 L of conc hydrofluoric acid and 2 mL of conc hydrochloric acid. The samples are left to predigest for 16 hours prior to closed vessel digestion using a Milestone Ethos-1 microwave digestor at 200°C power for 40 minutes.

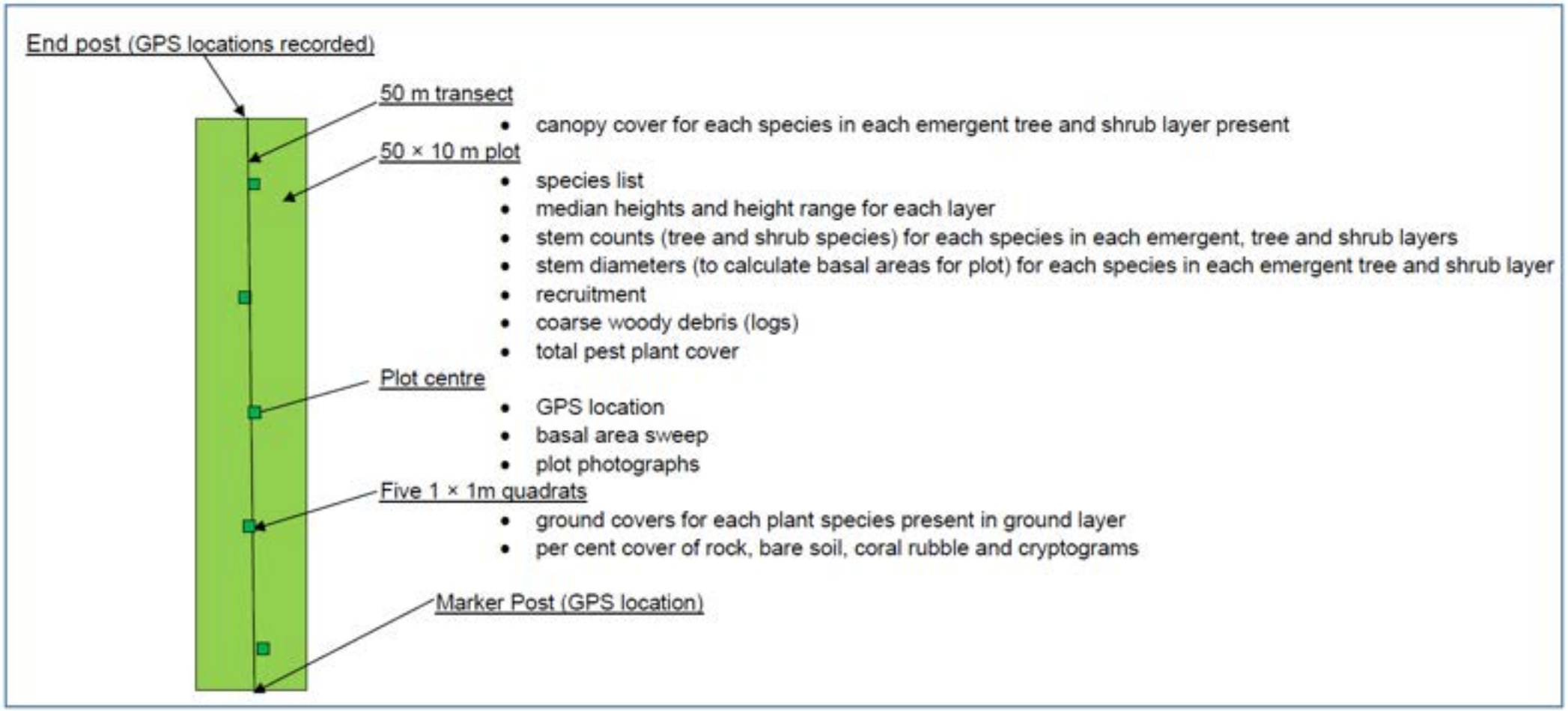
The digests are then made to a volume of 50 mL with 4 mL of saturated boric acid added to each digest to react with excess HF. The digests are then analysed using a Thermo iCAP ICPOES instrument running at 1150 W forward power.

Reference: Based on USEPA method 3052 titled "Microwave Assisted Acid Digestion of Silaceous and Organically Based Matrices", Kingston HM and Walter PJ.

Handbook section: 17A2, p369.

Appendix 12. Plot orientation and data recorded at permanent monitoring sites

Plots are located in representative areas within a vegetation community.



Data recorded at each site (using methodology of Neldner et al. 2019 for secondary sites)

Site descriptions

Site descriptions for each site are documented. These descriptions include all site attributes that do not change including GPS coordinates and location description, area/width of the vegetation represented by the plot, a position in landscape diagram, landform element, landform pattern, slope, altitude, substrate, plot size and plot orientation.

Other data recorded

- site number, recorder names, date, start and finish time
- GPS location of plot centre and end points (WGS84 datum), location description, transect bearing
- vegetation structural layers present, median height and height range of each layer
- comprehensive species list for each layer
- ground layer per cent foliage projected cover for each vascular plant species, litter, bare ground, rock outcrop and cryptograms
- per cent crown cover by species for each layer for the emergent, tree and shrub layers (if present)
- from the species list and cover measurements, the following can be derived:
    - total vegetation cover in each layer
    - native cover in each layer
    - non-native cay cover in each layer
    - species richness – total and differentiated by growth form
    - native species richness – total and differentiated by growth form
    - non-native cay species richness – total and differentiated by growth form
    - species richness in each layer present – total and differentiated by growth form
    - native species richness in each layer present – total and differentiated by growth form
    - non-native cay species richness in each layer present – total and differentiated by growth form
    - estimate of overall non-native cay plant cover (including herbaceous and woody weeds and plantings)
- stem counts of woody species (if present) per species per layer in the tree and shrub layers; including standing dead plants (count per hectare can be calculated for each species, growth form and layer)
- basal area sweep measurements of woody species (if present) per species per layer
- girth measurements for woody species if present to obtain average diameter of large trees or shrubs (basal area per hectare can be calculated for each species, growth form and layer)
- evidence of recruitment of woody species
- topsoil depth, colour and texture
- soil samples are collected for full nutrient analysis
- total length of logs (coarse woody debris)
- presence of shearwater burrows or other evidence of bird nesting
- evidence of turtle nesting
- other disturbance type (e.g., evidence of wind damage to vegetation, wind erosion, saltwater inundation, fire, mowing/slashing, other human disturbance) and severity
- patch size

- community extent
- community area
- community context (extent of connectivity to other native vegetation communities)
- evidence of disease, death, dieback, presence of scale, insect attack and leaf drop
- recent mean monthly climatic data
- ten site photographs- a landscape and portrait from 0m looking along the transect and eight from the plot centre – a landscape and portrait photo facing the direction of the bearing and at 90, 180 and 270 degrees from the direction of the bearing

Structure of vegetation communities was determined using *Table 83* (Neldner et al., 2019)

Table 83. Vegetation structure classifications based on growth form, height and cover.

Proj. foliage cover	>70%	>30–70%	10–30%	<10%
Crown class	Dense/closed	Mid-dense	Sparse	Very sparse
Crown cover %[1]	>80%	>50–80%	20–50%	<20%
GROWTH FORM[2]	**Structural formation classes (qualified by height)**			
Trees >30 m	tall closed forest TCF	tall open forest TOF	tall woodland TW	tall open woodland TOW
Trees 10–30 m	closed forest CF	open forest OF	woodland W	open woodland OW
Trees 2–10 m	low closed forest LCF	low open forest LOF	low woodland LW	low open woodland LOW
Shrubs 2– 8 m	closed scrub CSC	open scrub OSC	tall shrubland TS	tall open shrubland TOS
Shrubs 1–2 m	closed heath CHT or closed shrubland CS	open heath OHT or shrubland S	shrubland S	open shrubland OS
Shrubs <1 m	dwarf closed shrubland DCS	dwarf open heath DOHT	dwarf shrubland DS	dwarf open shrubland DOS
Succulent shrub	NA	succulent shrubland	succulent shrubland SS	open succulent shrubland OSS
Hummock grasses	NA	NA	hummock grassland HG	open hummock grassland
Tussock grasses	closed tussock grassland CTG	tussock grassland TG	open tussock grassland OTG	sparse tussock grassland STG
Herbs[3]	closed herbland CH	herbland H	open herbland OH	sparse herbland SH
Forbs	closed forbland CFB	forbland FB	open forbland OFB	sparse forbland SFB
Rush	closed rushland CR	rushland R	open rushland OR	sparse rushland SR
Vines	closed vineland CVI	vineland VI	open vineland OVI	sparse vineland SVI
Ferns	closed fernland CFN	fernland FN	open fernland OFN	sparse fernland SFN
Sedges	closed sedgeland CV	sedgeland V	open sedgeland OV	sparse sedgeland SV

Appendix 13. Photographs of drift seeds

Appendix 14. Island watch summary

Cays 1 – 12

Island Watch – Summary												
	Tregrosse Reef				Lihou Reef							
Island Watch category	1. West Diamond Islet	2. Central Diamond Islet	3. East Diamond Islet	4. South Diamond Islet	5. South West (Nellie) Cay	6. Georgina Cay	7. Edna Cay	8. Helen Cay	9. Fanny Cay	10. Dianna Cay	11. Carol Cay	12. Phoenix Cay
Birds												
Formal bird survey by A. McDougall	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Any new or unusual sightings, or any changes to condition of nesting/roosting habitat?	N (Initial survey) ALL cays	New breeding site (Aust) Critically endangered Herald Petrel (Refer Birds A. McDougall)	N	N	N	Nesting colony of New Caledonian fairy terns Australian pelican (Refer Birds A. McDougall)	N	N	New Caledonian fairy terns in breeding plumage (Refer Birds A. McDougall)	New Caledonian fairy terns in breeding plumage Herald petrel sighting (Refer Birds A. McDougall)	N	N
Turtles												
Turtles seen on island	Nil (Outside breeding season) ALL cays	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Number of nests/body pits												
Any new or unusual sightings, or any changes to the condition of nesting habitat?	N (Initial survey) ALL cays	N	N	N	N	N	N	N	N	N	N	N
Crocodiles												
Crocodile sightings & other observations	N	N	N	N	N	N	N	N	N	N	N	N
Weeds												
Does the island appear weed-free?	Y (Verified by J. Brushe) ALL cays	Y	Y	Y	Y	Y	Unvegetated	Unvegetated	Unvegetated	Unvegetated	Unvegetated	Unvegetated

Island Watch category	1. West Diamond Islet	2. Central Diamond Islet	3. East Diamond Islet	4. South Diamond Islet	5. South West (Nellie) Cay	6. Georgina Cay	7. Edna Cay	8. Helen Cay	9. Fanny Cay	10. Dianna Cay	11. Carol Cay	12. Phoenix Cay
Weeds												
Species observed and brief description.	Conducted detailed survey – nil weeds detected ALL cays	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Likely risk of future weed invasion?	Low if visitation remains low. Low if gear and equipment is not taken onto cays – all visitors. ALL cays	Low	High risk of pest introduction in machinery, gear and equipment for site maintenance of Nav aid	Low	Low	Low	Low	Low	Low	Low	Low	Low
Future actions needed.	Prevention Biosecurity formalised ALL cays	Biosecurity formalised	Formal biosecurity framework for Nav Aid maintenance	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised
Wildfire												
Signs of wildfire?	N	N	N	N	N	N	Unvegetated	Unvegetated	Unvegetated	Unvegetated	Unvegetated	Unvegetated
Is management action required – mitigation, especially for seabird and turtle habitat?	N	N	N	N	N	N	Unvegetated	Unvegetated	Unvegetated	Unvegetated	Unvegetated	Unvegetated
Pest animals												
Any signs of pest animals? Includes invertebrates.	Nil signs of rodents	Nil signs of rodents	Nil signs of rodents	Nil signs of rodents	Nil signs of rodents	Nil signs of rodents						
Species observed and brief description.												
Pest monitoring or control work done?	Ant baiting stations Rodent tunnels placed overnight	Ant baiting stations Rodent tunnels placed overnight	Ant baiting stations Rodent tunnels placed overnight	Ant baiting stations Rodent tunnels placed overnight	Ant baiting stations Rodent tunnels placed overnight	Ant baiting stations Rodent tunnels placed overnight	Ant survey	Ant survey	Ant survey	Ant survey	Ant survey	Ant survey
Any new pest animals for this site, or has the previous extent changed (bigger or smaller)?												

Island Watch category	1. West Diamond Islet	2. Central Diamond Islet	3. East Diamond Islet	4. South Diamond Islet	5. South West (Nellie) Cay	6. Georgina Cay	7. Edna Cay	8. Helen Cay	9. Fanny Cay	10. Dianna Cay	11. Carol Cay	12. Phoenix Cay
Native flora & fauna												
Anything of interest, and changes or concerns?												
Other risks												
Any other changes or concerns	Note. Marine debris impacts – Ingestion by birds, turtles and other marine organisms and visual impact of debris on remote, high conservation value cays ALL cays						Refer note	Refer note	Refer note	Refer note	Refer note	Refer note
Cultural values												
Anything observed, anything new or of concern?	N	N	N	N	N	N	N	N	N	N	N	N
Infrastructure												
Condition of infrastructure, any work required?	N	N	N	N	N	N	N	N	N	N	N	N
Monitoring and collections												
Any other monitoring or surveys undertaken	Note. Vegetation survey and mapping, botanical specimens, soil samples, drift seeds – J. Brushe Health Checks – F. Chapman Opportunistic invertebrates collected – K. Goetze, F. Chapman Drone mapping – B. Sale											
By whom and where is information stored?	Note. Botanical specimens and drift seeds lodged with Qld Herbarium Soil samples Invertebrates lodged with Qld Museum for ID All other information provided to PAD and stored in QPWS systems. Contact person – F. Chapman											
Areas of island visited												
	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed

Cays 13 -24

Island Watch – Summary												
Lihou Reef												
Island Watch category	13. Hermit Crab Islet	14. Betty Cay	15. Frankie Cay	16. Observatory Cay	17. Middle Cay	18. Turtle Islet	19. Margaret Cay	20. Little Margaret Cay	21. Lorna Cay	22. Kathy Cay	23. Unnamed Cay	24. Juliette Cay
Birds												
Formal bird survey by A. McDougall	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Any new or unusual sightings, or any changes to condition of nesting/roosting habitat?	N (Initial survey) ALL cays	N	N	N	N	N	N	N	Highest density and number of breeding seabirds. Banded masked booby (Refer Birds A. McDougall)	Largest black-naped tern colony	N	1 New Caledonian fairy tern in breeding plumage
Turtles												
Turtles seen on island	Nil (Outside breeding season) ALL cays	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Number of nests/body pits												
Any new or unusual sightings, or any changes to the condition of nesting habitat?	N (Initial survey) ALL cays	N	N	N	N	N	N	N	N	N	N	N
Crocodiles												
Crocodile sightings & other observations	N	N	N	N	N	N	N	N	N	N	N	N
Weeds												
Does the island appear weed-free?	Y (Verified by J. Brushe) ALL cays	Unvegetated	Unvegetated	Unvegetated	Unvegetated	Y	Unvegetated	Unvegetated	Y	Unvegetated	Unvegetated	Unvegetated
Species observed and brief description.	Conducted detailed survey – nil weeds detected ALL cays	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Island Watch category	13. Hermit Crab Islet	14. Betty Cay	15. Frankie Cay	16. Observatory Cay	17. Middle Cay	18. Turtle Islet	19. Margaret Cay	20. Little Margaret Cay	21. Lorna Cay	22. Kathy Cay	23. Unnamed Cay	24. Juliette Cay
Weeds												
Likely risk of future weed invasion?	Low if visitation remains low. Low if gear and equipment is not taken onto cays – all visitors. ALL cays	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Future actions needed.	Prevention Biosecurity formalised ALL cays	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised	Biosecurity formalised
Wildfire												
Signs of wildfire?	N	Unvegetated	Unvegetated	Unvegetated	Unvegetated	N	Unvegetated	Unvegetated	N	Unvegetated	Unvegetated	Unvegetated
Is management action required – mitigation, especially for seabird and turtle habitat?	N	Unvegetated	Unvegetated	Unvegetated	Unvegetated	N	Unvegetated	Unvegetated	N	Unvegetated	Unvegetated	Unvegetated
Pest animals												
Any signs of pest animals? Includes invertebrates.	Nil signs of rodents					Nil signs of rodents			Nil signs of rodents			
Species observed and brief description.												
Pest monitoring or control work done?	Ant baiting stations Rodent tunnels placed overnight	Ant survey	Ant survey	Ant survey	Ant survey	Ant baiting stations Rodent tunnels placed overnight	Ant survey	Ant survey	Ant baiting stations Rodent tunnels placed overnight	Ant survey	Ant survey	Ant survey
Any new pest animals for this site, or has the previous extent changed (bigger or smaller)?	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Native flora & fauna												
Anything of interest, and changes or concerns?												

Island Watch category	13. Hermit Crab Islet	14. Betty Cay	15. Frankie Cay	16. Observatory Cay	17. Middle Cay	18. Turtle Islet	19. Margaret Cay	20. Little Margaret Cay	21. Lorna Cay	22. Kathy Cay	23. Unnamed Cay	24. Juliette Cay
Other risks												
Any other changes or concerns	Marine debris impacts – Ingestion by birds, turtles and other marine organisms and visual impact of debris on remote, high conservation value cays ALL cays											
Cultural values												
Anything observed, anything new or of concern?	N	N	N	N	N	N	N	N	N	N	N	N
Infrastructure												
Condition of infrastructure, any work required?	N	N	N	N	N	N	N	N	N	N	N	N
Monitoring and collections												
Any other monitoring or surveys undertaken	Note. Vegetation survey and mapping, botanical specimens, soil samples, drift seeds – J. Brushe Health Checks – F. Chapman Opportunistic invertebrates collected – K. Goetze, F. Chapman Drone mapping – B. Sale											
By whom and where is information stored?	Note. Botanical specimens and drift seeds lodged with Qld Herbarium Soil samples Invertebrates lodged with Qld Museum for ID All other information provided to PAD and stored in QPWS systems. Contact person – F. Chapman											
Areas of island visited												
	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed	Whole island surveyed

Appendix 15. Invertebrate species summary

Tregrosse and Lihou Reefs, Coral Sea Marine Park

Invertebrates - Ants and opportunistic collection of invertebrate species

Specimen no.	Date	Cay	Area (ha)	Vegetated / unvegetated	Site	Specimen	Identification	Notes	Native / introduced
1	12/7/21	West Diamond Islet	9.756	Vegetated	RT 2 & 3	Ants	*Nylanderia 'obscura'*		Native
2	12/7/21	West Diamond Islet			RT1	Ants	*Nylanderia 'obscura'*		Native
3	12/7/21	West Diamond Islet			NA	Scale	TBA		TBA
4	12/7/21	West Diamond Islet			RT 3 & 4	Ants	*Nylanderia 'obscura'*		Native
5	13/7/21	West Diamond Islet			RT 13 & 14	Ants	*Nylanderia 'obscura'*		Native
6	13/7/21	West Diamond Islet			NA	Ants	*Nylanderia 'obscura'*		Native
7	13/7/21	West Diamond Islet			RT11	Ants	*Nylanderia 'obscura'*		Native
8	13/7/21	Central Diamond Islet	10.857	Vegetated	NA	Ants	*Nylanderia 'obscura'*		Native
9	13/7/21	Central Diamond Islet			NA	Fly	TBA		TBA
10	13/7/21	Central Diamond Islet			RT12	Fly	TBA		TBA
11	13/7/21	Central Diamond Islet			RT2	Ants	*Nylanderia 'obscura'*		Native
12	13/7/21	Central Diamond Islet			RT 10 & 11	Ants	*Nylanderia 'obscura'*		Native
13	13/7/21	Central Diamond Islet			RT5	Ants (ginger coloured)	*Monomorium pharaonis*		Introduced (Africa)
14	14/7/21	East Diamond Islet	10.427	Vegetated	NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*		Native
15	14/7/21	East Diamond Islet			NA	Grasshopper	*Aiolopus thalassinus* (Acrididae)	1 male, 1 female	Native
16	15/7/21	East Diamond Islet			RT15	Ants	*Tetramorium simillimum*		Introduced (Africa)
17	15/7/21	East Diamond Islet			RT6	Ants	not ants, small flies		Native
18	15/7/21	East Diamond Islet			RT1	Ants	*Tetramorium simillimum*		Introduced (Africa)
19	15/7/21	East Diamond Islet			NA	Slaters	TBA		TBA
20	15/7/21	East Diamond Islet			RT6	Ants	*Tetramorium simillimum*		Introduced (Africa)
21	15/7/21	East Diamond Islet			RT12	Ants	*Tetramorium simillimum*		Introduced (Africa)
22	15/7/21	East Diamond Islet			NA	Tick	*Amblyomma loculosum*		Native
23	15/7/21	East Diamond Islet			RT14	Ants	*Tetramorium simillimum*		Introduced (Africa)
24	15/7/21	East Diamond Islet			NA	Cockroach	TBA		TBA
25	15/7/21	East Diamond Islet			RT5	Ants	*Tetramorium simillimum*		Introduced (Africa)

Invertebrate species summary cont.,

Specimen no.	Date	Cay	Area (ha)	Vegetated / unvegetated	Site	Specimen	Identification	Notes	Native / introduced
26	16/7/21	South Diamond Islet	4.187	Vegetated	NA	Moth	TBA		TBA
27	16/7/21	South Diamond Islet			NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*		Native
28	16/7/21	South Diamond Islet			NA	Grasshopper	*Aiolopus thalassinus* (Acrididae)	male	Native
29	16/7/21	South Diamond Islet			RT3	Ants	*Nylanderia 'obscura'*		Native
30	16/7/21	South Diamond Islet			RT1	Ants	*Nylanderia 'obscura'*		Native
31	16/7/21	South Diamond Islet			RT5	Ants	*Nylanderia 'obscura'*		Native
32	16/7/21	South Diamond Islet			NA	Tick	*Amblyomma loculosum*		Native
33	16/7/21	South Diamond Islet			RT7	Ants	*Nylanderia 'obscura'*		Native
34	17/7/21	Southwest Cay (Nellie Cay, No. 9 Cay)	5.657	Vegetated	RT3	Small flies	TBA		TBA
35	17/7/21	Southwest Cay (Nellie Cay, No. 9 Cay)			NA	Ants	Not ants but small flies		TBA
36	17/7/21	Southwest Cay (Nellie Cay, No. 9 Cay)			RT4	Ants	*Cardioconyla nuda or atalanta*		Native
37	17/7/21	Southwest Cay (Nellie Cay, No. 9 Cay)			HC56	Scale	TBA		TBA
38	17/7/21	Southwest Cay (Nellie Cay, No. 9 Cay)			RT4	Lady beetle	1 x *Harmonia octomaculata*		Native
39	17/7/21	Southwest Cay (Nellie Cay, No. 9 Cay)			NA	Scale	TBA		TBA
40	22/7/21	Turtle Islet	2.478	Vegetated	NA	Grasshopper	Valanga sp. (female) - Likely *Valanga irregularis*		Native
41	22/7/21	Turtle Islet			NA	Beetles	5 x Gonocephalum sp. A		Native
42	22/7/21	Turtle Islet			NA	Cricket	Gryllidae		Native
43	22/7/21	Turtle Islet			NA	Ants	*Monomorium* cf *intrudens*		Introduced (Japan)
44	22/7/21	Turtle Islet			NA	Grasshopper	*Valanga* sp. (male) - Likely *Valanga irregularis*		Native
45	22/7/21	Turtle Islet			NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*		Native
46	20/7/21	Hermit Crab Islet (Anne Cay, No. 1 Cay)	8.108	Vegetated	NA	Caterpillar	TBA		TBA
47	18/7/21	Edna Cay (No. 6 Cay)	7.502	Unvegetated	NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*		Native
48	25/7/21	Juliette Cay	2.348	Unvegetated	NA	Silverfish	TBA		TBA
49	18/7/21	Dianna Cay (No. 4 Cay)	3.254	Unvegetated	NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*		Native

Invertebrate species summary cont.,

Specimen no.	Date	Cay	Area (ha)	Vegetated / unvegetated	Site	Specimen	Identification	Notes	Native / introduced
50	17/7/21	Georgina Cay (No. 8 Cay)	2.816	Vegetated	NA	Grasshopper	*Aiolopus thalassinus* (Acrididae)	1 female	Native
51	17/7/21	Georgina Cay (No. 8 Cay)			NA	Lady beetle	2 x *Harmoinia octomaculata*		Native
52	23/7/21	Lorna Cay	6.409	Vegetated	NA	Ants	*Cardioconyla nuda/atalanta*		Native
53	23/7/21	Lorna Cay			RT6	Large fly, small flies	TBA		TBA
54	23/7/21	Lorna Cay			NA	Crickets	3 x Gryllidae (all nymphs)		TBA
55	23/7/21	Lorna Cay			NA	Wasp	1 x Pompilidae		TBA
56	23/7/21	Lorna Cay			NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*		Native
57	23/7/21	Lorna Cay			NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*		Native
58	23/7/21	Lorna Cay			RT9	Beetles	1 x *Dermestes ater*; 1 x *Gonocephalum sp*. A		Native
59	23/7/21	Lorna Cay			NA	Spider	Wolf spider *Hogna crispipes* Family *Lycosidae*		Native
60	23/7/21	Lorna Cay			NA	Grasshopper	*Aiolopus thalassinus* (Acrididae)	1 female, 1 nymph	Native

Appendix 16. Biosecurity checklist

Coral Sea Marine Park. Island biosecurity checklist
Joint Parks Australia and QPWS field trips

Trip date: _____

Officer in Charge (OIC) name and position: _____

Person responsible for overseeing biosecurity for this trip : _____

Vessel owner (QPWS, Federal government, other): _____

Vessel name: _____

Working version: 21/10/2019

Updates:

1) PRE-TRIP PLANNING AND LOADING:

Action	Date achieved	Comments
Professional fumigation of vessel prior to the trip. The closer to departure date, the better. Target insects, arachnids, rodents.		
Personal biosecurity instructions provided • Before leaving home (vessel joining instructions) • onboard vessel briefing and induction • pre-island transfer briefing * If not using a QPWS vessel, supply participants with extract from Reef Ranger joining instructions (in appendix)		.
All clothes, including hats, are freshly washed in water hotter than 40^0C with detergent before leaving home. Or wash on board before accessing Coral Sea Marine Park islands and between island 'groups'.		
Equipment and materials, including gear normally stored at ranger bases, is thoroughly cleaned of soil, plant material etc. and sterilised with Virkon. Includes camping chairs, tools, cameras, acoustic gear.		
Avoid rust preventatives that are sticky and attract seeds.		
No timber or cardboard packaging to be used for materials and equipment – too hard to ensure it is pest-free. Take special note if transporting fencing, scaffolding, etc. • Purchase materials such as cement in plastic bags, rather than in paper or cardboard packaging. • Repackage goods that are on timber pallets – either on to plastic pallets or bundle with plastic strapping. • If no other option, ensure high-risk packaging is left on vessel and not brought onto the island. Spray with insecticide at last minute when removing from high-risk packaging.		
Pest control (e.g. baiting for rodents and ants) conducted in ranger sheds, and other storage areas, including outdoor storage areas if used, prior to departure.		
Last minute inspection of all project gear and equipment, including spraying with insecticide, prior to loading. Includes tripods, all sampling gear, camping chairs.		
Outwardly inspect all personal bags and gear before loading (where possible, otherwise do on back deck of vessel) and spray interiors with insecticide. Can put several bags in a large garbage bag, spray and hold closed for a few minutes. Ensure all zips and pockets are open so that spray can penetrate. Although intrusive, this method has flushed out several insects on previous trips. Ask people to first remove any food or gear sensitive to sprays, such as personal cameras.		

2) DAILY, WORKING ON ISLANDS:

Action	Achieved	Comments
Note – if working between islands, the "departure" actions below in step 3 must be undertaken between each island and at the end of each trip.		
Ensure all clothes, including hats, have been washed in water hotter than 40^{0}C with detergent before the first working day. (Best way to minimise risk of seeds, or air- or soil-borne pathogens on clothes).		
Before first visit, clean footwear and submerge in the Virkon bath and leave to drip dry in the shade. Do not rinse with fresh water. See instructions in appendix		
Inspect all clothes bags and field equipment on back deck before first visit to island. Spray everything with insecticide even if already sprayed prior to loading. Can put several bags in a large garbage bag, spray and hold closed for a few minutes. Ensure all zips and pockets are open so that spray can penetrate.		
Every time you leave or arrive back at the vessel: • Clean hands with soap and very hot water • Place footwear in nominated container on back deck for re-use later, or clean and disinfect with Virkon • Keep all gear, including backpacks, used on the island in a nominated area on back deck as a 'quarantine area'		
Have a large bottle of alcohol gel on back deck and provide each person with a personal use small bottle to keep in backpack. (Not a replacement for washing with hot water and soap on the vessel)		
Disinfect hands with alcohol gel before and after eating or toileting on the island, for protection of personal health as well as that of the turtles and seabirds.		
Bring rubbish back to the vessel each day. Do not stockpile rubbish on the island as it creates a food source for pests (e.g. rodents, ants and cockroaches) already there, and may attract or interfere with native animals.		
Fumigate daily rubbish brought back to the vessel before storing. Inspect and fumigate marine debris brought back to the vessel. Consider spraying with Virkon if appropriate. Alert AQIS (Australian Quarantine and Inspection Service) and Biosecurity Queensland of any pests or diseases that could be a risk.		
Fumigate or otherwise sterilise plant or animal material brought back to the vessel.		
Don't dispose of any food matter on the island including seeds and peel.		
Do not bury human waste. No human waste or toilet paper to remain on island. Use a portable toilet or otherwise store in plastic packaging and dispose of back on vessel.		
No raw meats (especially chicken), raw eggs or unpasteurised cheeses to be brought onto the island – risk of introducing new salmonella strains and other bacteria.		
Remain alert/ aware to potential incursions when on the island and report any suspicious pest sightings (e.g. rodents, reptiles, ant congregations, weeds) to the Officer in Charge for earliest possible intervention if required. Take photos and GPS marks, and collect a sample for verification.		

3) MOVING BETWEEN ISLANDS:

Action	Achieved	Comments
Inspect all clothes, bags and field equipment and spray everything with insecticide on the back deck. Can put several bags in a large plastic garbage bag, spray and hold closed for at least 3 minutes. Ensure all zips and pockets are open so that spray can penetrate. (Insects have crawled into gear on previous island trips and been brought back to the vessel.)		
Wash all clothing and footwear in water hotter than 40^{o}C with detergent or Virkon. Wash equipment and soak or spray down or soak with Virkon between islands and before visiting any other special areas.		
Thoroughly wash out all sand and debris from back deck and tenders. Spray surfaces with Virkon if travelling to other special areas		

4) AT FINAL DEPARTURE:

Action	Achieved	Comments
Spray long-lasting surface spray insecticide in and around containers and any equipment remaining on island. Place ant, cockroach, and rodent tunnels around these areas when trip is completed. Use lethal baits when there is no risk to native populations.		
Inspect all clothes, bags and field equipment before departing and spray everything with insecticide on the back deck. Can put several bags in a large plastic garbage bag, spray and hold closed for at least 3 minutes. Ensure all zips and pockets are open so that spray is able to penetrate. (Insects have crawled into gear on previous island trips and been brought back to the vessel.)		
Wash all clothing and footwear in water hotter than 40^{o}C with detergent or wash with Virkon. Wash equipment and soak or spray down or soak with Virkon between islands and before visiting any other special areas.		
Thoroughly wash out all sand and debris from back deck and tenders. Spray surfaces with Virkon if travelling to other special areas		
OIC to hold a post-trip review each time with all trip participants and communicate any biosecurity issues to PAD.		
During debrief, directly ask participants if any weeds or other pests were detected on the island. Document any observations or concerns for future pest control.		

5) EVERY TRIP, RESOURCES NEEDED.

Item	Obtained	Comments
Professional fumigation of vessel		
Virkon or equivalent (powder or liquid form) – lots, sufficient to disinfect all machinery and tools		
Small spray bottles for Virkon		
Large backpack sprayer for Virkon to disinfect large areas, including tenders		
Large containers to store used Virkon until it can be appropriately disposed of. Suggested minimum of 2 x 35 litre drums.		
Large funnel to dispense Virkon from footbath into disposal container.		
Two footbaths – one for water, one for Virkon		
Long handled brushes for footbaths (at least 2)		
Large bin or container for footwear to store on island and on back deck		
Alcohol gel, large bottle and personal sizes		
Insecticide spray - lots, both knockdown and long-lasting surface spray types		
If any gear will be left on islands: ant bait stations cockroach bait stations rodent bait stations sufficient baits for the stations – lethal bait if appropriate		
Portable toilets and environmentally-sensitive toilet chemicals (or other toileting arrangements e.g. plastic bags). Two toilets may be needed to allow swopping over and cleaning each day, depending on type used.		
Toilet tent - pop up camping 'ensuite' for privacy on the island, regardless of whether a portable toilet is provided or not.		
Low-risk packaging materials (such as plastic pallets or straps) to replace timber pallets or any wood or cardboard packaging