Coral Sea Marine Park

Environmental Assessment of Islands, Islets and Cays of the Southern and Central Reef Systems

2023

Australian Government
Parks Australia

Australian Marine Parks

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Cover photo: Vegetation facing East of BioCondition monitoring site M08, East Diamond Islet (Tregrosse Reefs). Photograph taken by Joy Brushe ©

Contributing authors:

- Joy Brushe, Volunteer
- Larry Brushe, Volunteer
- Andrew McDougall, Queensland Parks and Wildlife Service
- Andrew Meiklejohn, Queensland Parks and Wildlife Service
- Chad Hoult, Queensland Parks and Wildlife Service
- Dan Wilkins, Parks Australia
- Martin Russell, Parks Australia
- John Prichard, Parks Australia
- Emily Jensen-Woof, Parks Australia.

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Acknowledgments

Parks Australia would like to acknowledge:

Joy Brushe and Larry Brushe (Parks Australia official volunteer botanists), Andrew McDougall, Andrew Meiklejohn and Chad Hoult (QPWS), Dan Wilkins (on temporary transfer from the Australian Antarctic Division), Glyn Hunt (Parks Australia) and Ian Anderson (Tangaroa Blue Foundation) for providing their expertise and for their tireless work and flexibility while on voyage in difficult weather conditions.

Martin Russell (Manager, Coral Sea Marine Park) for planning and coordination of the project. John Prichard (Senior Marine Park Officer) for planning, coordination, and as voyage leader. Emily Jensen-Woof (Marine Park Officer) for compiling and editing this report. Fiona Hagger (Senior Marine Park Officer) for editing and aligning report with strategic planning.

Blue Planet Marine and the skipper, Ben Neylan, and crew of *M.V. Infamis* for transporting all passengers safely and expeditiously, especially through difficult sea and weather conditions.

The Bureau of Meteorology staff, particularly the Willis Island Weather Station staff, for their assistance, hospitality and great company during our visit to South Islet.

Queensland Herbarium for identification of plant specimens and processing the duplicate specimens for the National Herbarium and the Australian Tropical Herbarium.

Ralph Dowling from the Queensland Herbarium for examining (and identifying where possible) the approximately 400 drift seed specimens collected during the 2021 to 2023 voyages.

Chris Burwell from the Queensland Museum for identifying the 234 invertebrate specimens.

Steritech Pty Ltd at Nerangba for carrying out the required gamma irradiation treatments.

Staff of Tondoon Botanic gardens in Gladstone for taking delivery of and looking after our plant specimens in our absence.

David Appleton and his team from the University of Queensland School of Agriculture and Food Sciences for analysing the soil samples.

Dr Bianca Kallenberg (Environment Data and Analysis Branch) for sourcing and supplying WorldView Imagery to support mission planning prior to the voyage.

The Office of the Chief Remote Pilot for their work enabling and supporting safe drone operations across the Department.

Professor Arko Lucieer and Dr Darren Turner from the University of Tasmania for the loan of the Micasense RedEdge Mx Dual sensor, and for their ongoing collaboration and passion for supporting quality remote sensing with drones.

Executive Summary

In May and June 2023, Parks Australia undertook a 14-day voyage in the Coral Sea Marine Park (CSMP), to assess the health of islands, islets and cays (here-on called cays) in the southern, eastern and central regions of the CSMP. Due to poor weather and challenging sea states for much of the voyage, only 7 out if the proposed 13 cays were visited, of which 6 were vegetated.

The cays visited and assessed were:

- Herald Beacon Islet (vegetated) – Mellish Reef
- North Cay (unvegetated) – Mellish Reef
- East Diamond Islet (vegetated) – Tregrosse Reefs
- South Islet (vegetated) – Willis Islets
- North East Cay (vegetated) – Herald Cays
- Chilcott Islet (vegetated) – Coringa Islets
- Magdelaine Cay South (vegetated) – Magdelaine Cays.

These assessments are a continuation of Coral Sea Island Health assessment voyages to the 60+ cays undertaken in November/December 2019 (Hemson et al. 2020), July 2021 (Chapman et al. 2022) and May/June 2022 (McDougall and Brushe 2023) and represent a critical ongoing assessment and evaluation process that informs good management of these near pristine ecosystems. Several cays (Cato Island; South East and South West Cays Saumarez Reef; and Magdelaine Cay North) have not yet been fully assessed because of adverse weather conditions during the voyages.

The Island Health project is a collaboration of agencies (Parks Australia (PA) and Queensland Parks and Wildlife Service (QPWS) under the Joint Field Management program agreement) and expertise, bringing a suite of specialist skills to provide observational and real time assessments to determine ecosystem health and identify change and emerging pressures across a number of indicator areas including:

- Description and mapping of vegetation communities.
- Establishing permanent vegetation health monitoring sites.
- Compiling comprehensive plant species lists.
- Collecting soil and plant samples.
- Obtaining high resolution drone photogrammetry of cays and their adjoining reefs.
- Collecting data on bird breeding, population demographics and species diversity.
- Surveying for introduced and invasive species.
- Removing marine debris and recording source data.
- Understanding of island and cay geomorphology.

The CSMP Islands and cays play a significant ecosystem service role in the broader health of the marine park. As an example, the islands and cays support globally significant seabird breeding populations that in turn service the health and requirements of the adjacent coral and fish ecosystem communities by providing a nutrient source (guano) that is critical to maintaining the diversity in these systems.

Projects associated with vegetation communities inlcude understanding the complex relationships between species (e.g. migratory shearwaters and remnant *Pisona* forest); the critical need to manage invasive plants due to their negative impacts, including reducing the preferred nesting and roosting habitats for birds; the near natural state of the CSMP cays is clearly significant in comparison to the highly anthropomorphically modified islands and cays of the adjacent Great Barrier Reef Marine Park (GBRMP) with their weed and intriduced species issues.

Health Check monitoring was undertaken in a range of vegetation communities across each of the 7 cays visited. The overall condition rating for almost all communities was ‘Good’.

Figure 1: Joy Brushe and Larry Brushe undertaking vegetation assessments.
Credit: Andrew Meiklejohn ©, QPWS.

Nine introduced plant (weed) species have been recorded on two islands (two species on Bird Islet and nine species on South Islet). Although initially all weeds are likely to have been introduced by human activity (these two cays have a history of human use), the distribution of two weed species suggests they are now being spread around South Islet by shearwater activity (and possibly other birds). If these weeds continue to spread at these locations, habitat of sooty terns (and possibly other bird species) will be reduced or lost in entirety. These weeds are replacing areas of geographically restricted native cay vegetation and their presence on South Islet is a fire risk from lightning stike or unortharised camp fires. All weeds on South Islet are also a biosecurity risk to other CSMP islands and cays.

Soil samples were collected from each of the new permanent BioCondition monitoring sites for analysis and comparisons with other cays in the CSMP and southern GBRMP cays.

Soil samples were also collected from the site adjacent to the grey water outlet on South Islet (Willis Islets), as previous analysis of soil samples from this site had high to very high levels of iron, aluminium, manganese, copper and zinc. Levels were still very high at this site compared with other sample sites, although phosphorus levels have dropped from 2020 sample levels to a much lower level, comparable to those in similar vegetation on other cays (the 0-20cm samples from this site had 2.3% phorphorous in 2020, compared to the 2023 samples which were 1.69% for the first 0-10cm and 2.21% for 10-20cm depth). pH levels at this site were lower in the 2023 sample.

Sulphur levels in all 2022 and 2023 CSMP samples were considerably higher than in all pre-2022 samples and may reflect other external influences such as the acid rain from the volcanic eruption of the Hunga Tonga-Hunga Ha’apai volcano in January 2022.

Important, contemporary data were collected for 27 seabird and shorebird/migrant species observed on, or adjacent to, the cays, with an additional 6 species observed at sea. Of particular note were the breeding populations of red-tailed tropicbirds (860 pairs) on North East Cay (Herald Cays) and the sooty terns (approximately 40,000 pairs) on Herald Beacon Islet.

No breeding of New Caledonian fairy terns (*Sternula nereis exsul*) or Herald petrels (*Pterodroma heraldica*) was observed during this voyage.

Figure 2: Queensland Parks and Wildlife staff undertaking an island Health Check.
Credit: Andrew McDougall ©, QPWS.

Rodent and invertebrate detection surveys were conducted on each of the vegetated cays. No rodents were detected, however due to trip logistics the rodent tracking tunnels were deployed for a shorter than ideal duration (preferably over 24 hours). Ant bait stations were established at each rodent tunnel and other invertebrates were collected from vegetated and unvegetated cays to confirm native status. Inspections were also undertaken on all unvegetated cays. A total of 5739 invertebrates were recorded across all cays.

72.6% (170) of the voucher specimens were identified to be native, coming from 34 different families and at least 29 different genera. Some voucher specimens could only be identified to Order, Family or Genus level.

An additional eight introduced ant/invertebrate species were identified across five cays:

- East Diamond Islet – German cockroach (*Blattella germanica*) and a *Tetramorium species* likely *Tetramorium simillimum.*
- South Islet – African big-headed ant (*Pheidole megacephala)* (Introduced) and a *Pycnoscelis* species likely to be Surinam cockroach (*Pycnoscelis surinamensis).*
- North East Cay (Herald Cays) – bicoloured pennant ant (*Tetramorium bicarinatum)* and Saunders' Webspinner (*Oligotoma saudersii)*.
- Chilcott Islet – Pharaoh ant *(Monomorium pharaonis)*.
- Magdelaine Cay South – Pharaoh ant *(Monomorium pharaonis) and* wooly ant *(Tetramorium lanuginosum)* (exotic status under speculation).

Of the species identified, the presence of African big-headed ant (*Pheidole megacephala)* and biocoloured pennant ant (*Tetramorium bicarinatum*) are of concern due to their known invasive nature.

Four new marine park signs were also installed on the vegetated cays: Herald Beacon Islet, South Islet, Chilcott Islet, and Magdelaine Cay South. These signs inform both recreational and commercial visitors of island access conditions.

A total of 4,104 individual marine debris items (approximately 5 cubic metres) were removed from 5 cays. These items were weighed, identified and databased using existing (Tangaroa Blue Foundation) methodology.

Figure 3: Martin Russell (left) and John Prichard (right) removing marine debris.
Credit: Parks Australia.

Recommendations

Recommendations contained in previous reports Hemson et al. (2020), Chapman et al. (2022) and McDougall and Brushe (2023) are also relevant to this report.

- Develop straegies for the CSMP, covering weed management on South Islet and Bird Islet (Wreck Reefs), invasive species (such as ants), and bird health. The weed management for South Islet will need to be prepared in collaboration with the Bureau of Meteorology (the Bureau).
- Continued monitoring of high priority cays based on: vegetation communities; priority birds, presence/absence of invasives; ecosystem service provision; Health Check recommendations and further assessment requirements identified in the 2023 Island Health Report.
- Continue gathering seasonal, baseline bird data for all cays. Comprehensive baseline information may take years to ensure seasonal variations, species diversity and habitat requirements are fully understood.
- Continue ground-based counts complemented with drone imagery. This will benefit bird and vegetation monitoring.
- Use contemporary bird data to inform management actions.

Other targeted research opportunities:

- Catalogue the presence and diversity of pelagic seabirds along the chain of seamounts from the Fraser Guyot to the Mellish Plateau.
- Mark/recapture and/or satellite tracking studies on red-tailed tropicbirds in the Herald Cays. As for the 2022 voyage, survey results from this voyage produced data on previously unrecorded numbers of breeding adults. Similar research on other species may be relevant.
- Workshop potential research opportunities identifying foraging areas for species and understanding population interactions between the CSMP and adjoining marine areas.

Other general recommendations:

- Additional permanent BioCondition monitoring sites be established to obtain, where possible, three reference sites for each of the major CSMP vegetation communities. Table 5 contains a list of locations of potentially suitable additional reference sites.
- Document data through formal reports and scientific papers and share broadly.
- Collate an audio and photographic library of all bird species and their habitats.
- Ensure biosecurity requirements are outlined and followed by researchers, and guidelines are promoted to other visitors via publications such as *Island Access Guidelines.*
- Continue to collect both invertebrate and rodent data, and if feasible set rodent tunnels for a sufficient amount of time (24 hours) to detect presence of rodents.
- Continue to collect and identify voucher specimens to understand the biodiversity on the CSMP cays and any impact introduced species may have.
- Consideration should be given to assessing the feasibility and likely benefits of eradicating introduced ant species.
- Cays with introduced species, like South Islet (Willis Islets), should be the last location visited during a Coral Sea voyage. Alternately biosecurity measures leaving this island should be enhanced to ensure these species are not introduced to other cays subsequently visited.
- If there is a monitoring need to accurately track changes in island morphometry with time, particularly shoreline erosion (such as pre and post cyclone), then consideration should be given to establishing benchmarks on the cays, and collecting data with a static GNSS receiver. Best results would be obtained from 24 hours of data acquisition and using a service such as AUSPOS.
- Tracking debris loads and composition may help Parks Australia to better understand localised currents within the CSMP beyond the major South Equatorial Current.

Understanding localised currents has benefits with respect to better understanding of marine life and dispersal/migration through the CSMP.

- The June 2023 voyage and previous voyages (November 2022, May-June 2022 and July 2021) have identified North East Cay (Herald Cays), East Diamond Islets and Chilcott Islet to have relatively high accumulation rates of marine debris. These cays should be specifically targeted by Parks Australia in future voyages to build a more comprehensive understanding of the flow of marine debris through the CSMP.
- Continued collection and analysis of marine debris is recommended for further comparison against baseline data; for example, the four visits to East Diamond Islet has provided Parks Australia with a better understanding of the varying rates and potential causes of marine debris accumulation. Identification of the debris such as through labels and bar codes is important to better understand the sources of the debris.

Figure 4: Marine debris collection and drone mapping. Credit: Chad Hoult ©, QPWS.

Introduction

The Coral Sea Marine Park (CSMP) is located east of the Great Barrier Reef Marine Park, and abuts Papua New Guinea, Solomon Islands and New Caledonia waters (Figure 6). It extends from Cape York Peninsula to just north of Bundaberg in Queensland, Australia, encompassing an area of 989, 836 square kilometres. There are approximately 34 vast reef areas and over 60 cays and islets in the CSMP.

Parks Australia 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/Queensland Parks and Wildlife Service Reef Joint Field Management Program (RJFMP) has been assisting PA with the delivery of field management activities in the CSMP, such as monitoring and managing cay ecosystems.

In 2019 a collaborative trip to 6 islands in the Coringa-Herald section of the CSMP was undertaken. During the voyage a team of experts from PAD and the Queensland Government piloted methods to collect, analyse and document the health status of cay ecosystems, to establish baseline data for future trend analysis. 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. As a result, this same methodology was used on subsequent island health voyages in July 2021 and May/June 2022. Reports for these voyages can be found on the Australian Marine Parks website.

Using the same methodology, a fourth CSMP Island Heath Voyage was undertaken between 25 May and 9 June 2023. Staff from PAD, Queensland Parks and Wildlife Services (QPWS), Tangaroa Blue Foundation and botanist volunteers, were scheduled to visit 13 cays in the southern, eastern and central regions of the CSMP. Due to poor weather conditions for much of voyage, only 7 cay's were visited.

The cays visited were Herald Beacon Islet, North Cay (Mellish Reef), East Diamond Islet (Tregrosse Reefs), South Islet (Willis Islets), North East Cay (Herald Cays), Chilcott Islet (Coringa Islets) and Magdelaine Cay South (Magdelaine Cays) (Figure 6). Despite not going ashore at Saumarez Reef, bird surveys were conducted from the vessel for both the South West and North East Cays.

The results of the island health assesesments are detailed within this report.

Figure 5: Queenland Parks and WidlifeService staff carrying Island health check gear onto a CSMP cay. Credit: Chad Hoult ©, QPWS.

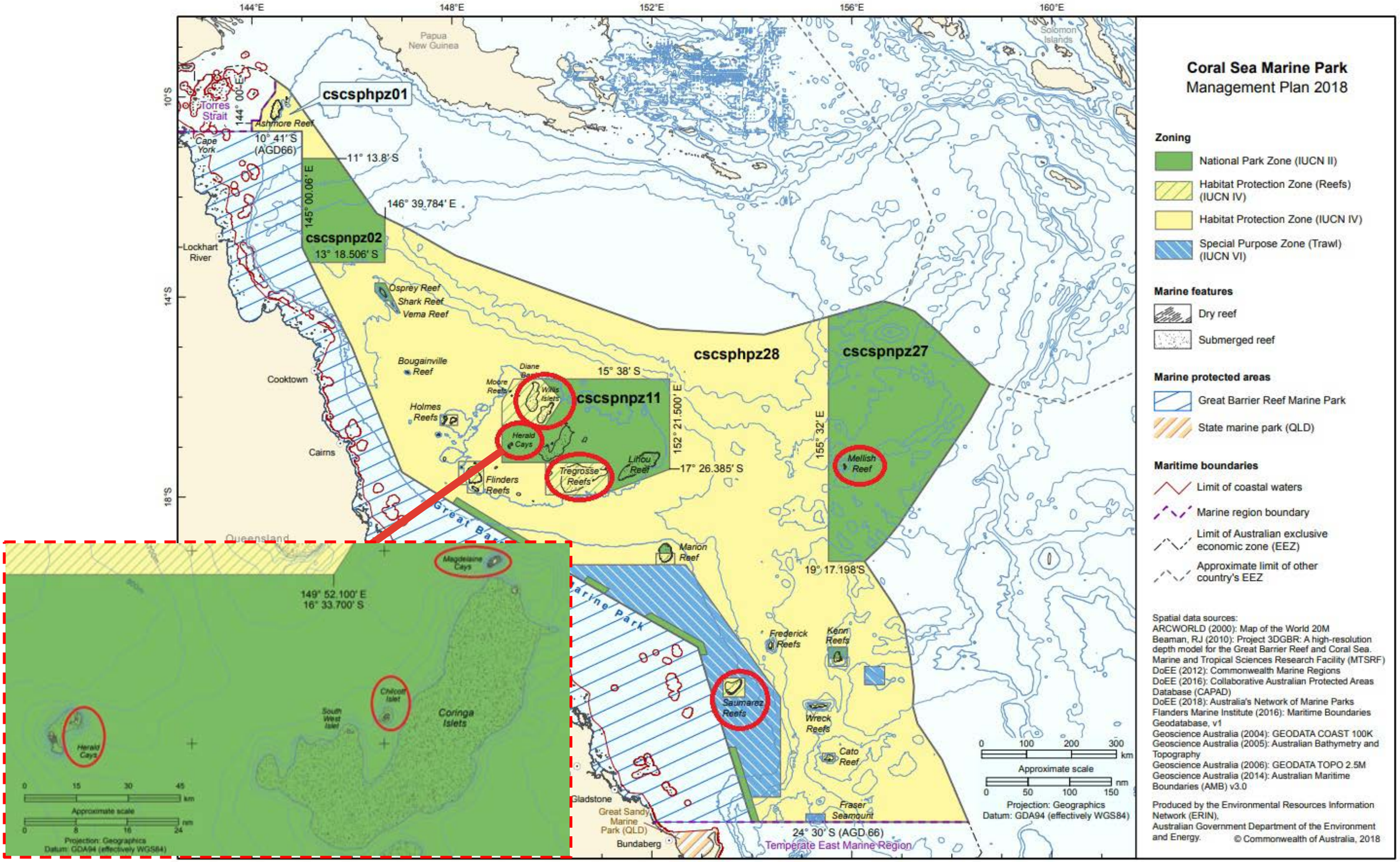

Figure 6. Coral Sea Marine Park map. Red circles indicate the sites assessed in the Island Health Monitoring in 2023. Credit: Director of National Parks, 2018.

Part I - Methodologies, General Results and Discussion

1.1 Vegetation and Soils - Joy Brushe and Larry Brushe

Methods

Field Surveys

The following six vegetated cays underwent vegetation and soil assessment:

- Herald Beacon Islet
- East Diamond Islet
- South Islet
- North East Cay (Herald Cays)
- Chilcott Islet
  Magdelaine Cay South.

Two people each spent approximately 35 hours in the field (between 4 and 8.5 hours per cay) surveying the vegetation on these cays and collecting plant specimens and soil samples (Figure 7).

Figure 7: John Prichard (left) assisting Joy Brushe (middle) and Larry Brushe (right) undertake vegetation assessments Credit: Martin Russell ©, Parks Australia.

The longest visits were to Herald Beacon Islet and South Islet (Willis Islets), 7 hours and 8.5 hours of survey time respectively. The vegetation on these two cays was thoroughly surveyed to describe the vegetation communities present, document all plant species currently present and provide data for preparation of vegetation maps. Visits to the other 4 cays were shorter and survey time on these cays ranged from 4 to 5.75 hours, with limited time available for traversing, condition assessment, plant collecting, establishing and surveying new permanent BioCondition monitoring sites.

Data was recorded at 50 ground-truthing sites: 20 on Herald Beacon Islet and 30 on South Islet.

Four new permanent BioCondition monitoring sites were established and surveyed, one each on Herald Beacon Islet, East Diamond Islet, North East Cay (Herald Cays) and Magdelaine Cay South. The locations of these sites are shown on maps of each of these cays under the *Part II: Cay Summaries* of this report.

Parks Australia labeled monitoring tags were attached to the BioCondition monitoring sites on South Islet to replace the plastic cattle ear tags previously used.

Ground truthing sites

Prior to the field trip, spatially rectified recent satellite images of Herald Bacon Islet and South Islet (Willis Islets) with 30 cm pixel resolution supplied by Parks Australia, were used to identify visually distinguishable patterns of vegetation using the QGIS program. Point coordinates of suitable locations for ground-truthing of these patterns were created using QGIS and uploaded to a Garmin GPSMAP 66S hand-held GPS. Spatially rectified PDF maps of the images 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. Data was recorded digitally onto iPhones and was backed up daily onto a laptop computer during the voyage.

As time on each cay was limited, it was not possible to undertake comprehensive replicate site surveys in each vegetation community using the standard methodology of Neldner et al. (2019).

To ensure sufficient data was obtained and the vegetation of the entire cay was thoroughly assessed, a modified “quick” methodology was used with the following data recorded at each of the ground truthing sites:

- GPS coordinates
- vegetation structure (from estimated height and cover)
- all plant species present
- estimated cover of each species and litter at the site
- estimated total weed cover
- landform
- aspect and slope (if applicable)
- estimated altitude
- surface soil description
- observations of seabirds and evidence of marine turtle activity
- site number
- site photographs

The site data recorded was used to:

- Identify and describe all the vegetation communities present on each cay and the variation within each community.
- Obtain a complete floristic inventory for each cay.
- Identify the spatial extent and abundance of weed species if these were present.
- Attribute vegetation patterns on the drone imagery to create vegetation maps.
- Note habitat preferences of seabirds and turtles.
- Assess potential human impact on vegetation.
- Document evidence of introduced species, diseases or any other threats to the vegetation.

Heights and covers of vegetation at each site were estimated to derive the structure class of the vegetation as per Table A1 in Appendix 1. Plot orientation and data recorded at permanent monitoring sites.

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%

These cover classes 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 percentage covers and for comparison with previous data.

Surface profiles

Surface profiles showing relative elevation were generated for Herald Beacon Islet and South Islet from the drone image captured using Drone Deploy (Dan Wilkins, 2023).

Vegetation mapping

Following the voyage, vegetation maps were created in QGIS by delineating polygon boundaries around patterns distinguishable on the high-resolution orthorectified drone image mosaics, generated in DroneDeploy from the drone images captured during the 2023 voyage. Vegetation communities identified from the ground truthing site data were assigned to each polygon. Each polygon was allocated a reliability A, B or C for both line placement and allocated vegetation type (A= confident, B = medium confidence, C= low confidence). Where patchy mosaics containing more than one vegetation type were present, the vegetation was mapped in heterogeneous polygons, with an estimate of the relative percentage of each vegetation community within the polygon. The line reliability, vegetation reliability and percentages of the component vegetation types for each polygon cannot be shown in the vegetation maps in this report as this would create too much visual detail. These attributes are contained in the DBF component of the ESRI shapefiles provided to Parks Australia.

BioCondition monitoring sites

When allocated time on the cay permitted, permanent BioCondition monitoring sites located in representative areas within a range of vegetation communities were established.

Four permanent BioCondition monitoring sites were established and surveyed on the cays during the 2023 voyage: One on Herald Beacon Islet, one on East Diamond Islet, one on North East Cay (Herald Cay) and one on Magdelaine Cay South.

The purpose of these BioCondition monitoring sites is to:

- Provide benchmark reference data for BioCondition[1] assessment for the same vegetation communities elsewhere on other Coral Sea cays.
- Document changes in vegetation over time.
- Assess the impact of climate change and other disturbances on vegetation.

BioCondition benchmarks are obtained by averaging survey data for each vegetation attribute from replicate benchmark reference sites located in pristine representative locations within each vegetation community within the CSMP. It is also desirable to include benchmark data obtained across different seasons to capture seasonal variation in the benchmarks. The 2019-2023 survey

[1] 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 , reference state being the natural variability in attributes of an ecosystem relatively unmodified since the time of European settlement (Eyre et al. 2015).

data from BioCondition reference sites will be used to determine benchmarks for future BioCondition assessments.

Sites were permanently marked with galvanised star pickets (Figure 8) located at the start (0m) and end of the 50m transect (30m on M21 on Mid Islet (Willis Islets). The star pickets were labelled with engraved identification tags made of 316 grade stainless steel firmly attached with two 304 grade stainless steel cable ties to prevent movement in strong winds. To minimise visual impact, posts were driven deeply into the ground to an above ground height of approximately 0.7 metre.

Figure 8. Permanent sites were marked using star pickets labelled with Parks Australia stainless steel identification tags. Credit: Joy Brushe ©

The secondary site survey methodology of Neldner et al. (2019b) with some slight modifications to accommodate cay vegetation was used. Time taken to complete surveying of these sites varied from 30 minutes (simple grassland/herbland sites) to 3.75 hours (shrubland sites where dense vines and shrubs as well as bird nesting made traversing difficult). The methodology used is described in Appendix 1. Plot orientation and data recorded at permanent monitoring sites and Neldner et al. (2019b). Data was recorded digitally onto iPhones and was backed up daily onto a laptop computer during the voyage.

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

Soil analyses

Soil samples were collected from depths of 0-10cm, 10-20cm, 20-30 cm and 30-40cm in each of the permanent monitoring sites for analysis (Figure 9). A sand auger was used where possible. Where the sand was dry and could not be picked up with the auger, samples were collected using a post hole shovel with the assistance of a small hand shovel. Samples were not collected at greater depth due to difficulty of obtaining the samples and time restrictions.

Import restrictions, due to visiting South Islet required all soil specimens collected during the voyage to undergo gamma irradiation on return to the mainland. Specimens were sent to Steritech Pty Ltd at Narangba, Queensland where they received gamma irradiation treatment at 50 kGray.

Figure 9: Glyn Hunt collecting soil samples for vegetation BioCondition assessment.
Credit: Andrew McDougall ©, QPWS.

The following analyses were undertaken by the analytical laboratories at the University of Queensland School of Agriculture and Food Sciences:

- pH
- electrical conductivity
- total nitrogen
- total carbon and organic carbon
- total phosphorus and Colwell phosphorus
- total and exchangeable calcium
- total and exchangeable potassium
- total and exchangeable magnesium
- total and exchangeable sodium
- cation exchange capacity
- aluminium
- sulphur
- copper
- iron
- manganese
- zinc

Analysis of particle sizes and Munsell colour were not done.

The following previous cay soil samples were also analysed by this facility using the same/compatible methodology, providing opportunity for valid comparison of their analyses with those of samples collected during the 2023 voyage:

- 18 soil samples collected from the BioCondition monitoring sites established and surveyed during the 2022 voyage.
- 33 soil samples collected from the BioCondition monitoring sites on the Diamond Islets and Lihou Reef cays during the July 2021 voyage.
- Samples collected in 2006/2007 of 50 soil profiles from cays in the Coringa-Herald (Batianoff et al. 2008).
- 213 soil samples collected from the Capricornia Cays (Great Barrier Reef) in 2007/2008 (Batianoff et al. 2012).

Nine soil samples collected from South Islet in October 2020 (Brushe 2021) were analysed by SGS Cairns International who advised that compatible methodologies were used to ensure valid comparison with the University of Queensland data sets.

Plant and drift seed collections

Specimens of all plant species growing on Herald Beacon Islet and South Islet were collected. Plant specimens were also collected on North East Cay (Herald Cays), Chilcott Islet and Magdelaine Cay South to complement specimen collections during the 2019 voyage. Visits to these three cays were short and there was insufficient time to complete specimen collections on these cays. Plant specimens were labelled, pressed and dried. Field notes were recorded on the location, habit, and habitat of each. The specimens, together with recorded information, have been sent to the Queensland Herbarium in Brisbane, the National Herbarium in Canberra and the Australian Tropical Herbarium in Cairns, as confirmation of the presence of the species in the locations recorded in this report.

During previous voyages, samples of drift seeds were collected opportunistically from the shorelines of cays. The purpose of these collections was to obtain knowledge of the plant species arriving on Coral Sea cays via ocean currents. Very little time was available on cays during the 2023 voyage to search for drift seeds and relatively few seeds were collected (Appendix 2. Photographs of drift seeds collected during 2023 voyage).

Import restrictions, due to visiting South Islet (Willis Islets), required all plant and drift seed specimens collected during the voyage to undergo gamma irradiation on return to the mainland. Specimens were sent to Steritech Pty Ltd at Narangba, Queensland where they received gamma irradiation treatment at 25 kGray.

Botanical nomenclature

Scientific plant species names used in this report are according to the Census of the Queensland Flora 2022 (Laidlaw 2022). Scientific names are included in brackets following the common names.

Limitations of the 2023 vegetation survey, mapping and reporting

BioCondition scoring could not be undertaken for the BioCondition monitoring sites surveyed during the 2023 voyage, as benchmarks for vegetation attributes of the vegetation communities at these sites have not yet been determined.

To complete all the scheduled work on all these cays and to allow for steaming time between cays, time and consequently thoroughness of survey on each cay was limited. Time spent surveying each cay and the number of ground-truthing and BioCondition monitoring sites surveyed on each cay are documented in Appendix 3. Comparisons of vegetation survey intensity.

The 2023 surveys of Herald Beacon Islet and South Islet provided good detail on the vegetation present at the time of the surveys. The structure and floristic composition of vegetation communities (dominated or co-dominated by annual herbs and other herbaceous species) 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.

Due to limited time available and the difficulty of collecting samples of dry sand at specified depths, soil samples were collected from only the top 40 cm of the soil profile (0-10cm, 10-20cm, 20-30 cm

and 30-40cm). No data was obtained for comparison with previous samples taken at depths greater than this.

Vegetation condition in May/June 2023

The graph in Figure 10 compares the 2022-2023 monthly rainfall data with long term monthly averages (1921 to 2023) recorded at the Willis Island Bureau recording station.

Following the wetter than average years in 2021 and 2022, the autumn monthly rainfall totals recorded by the Bureau station for 2023 were lower than the long-term autumn monthly averages.

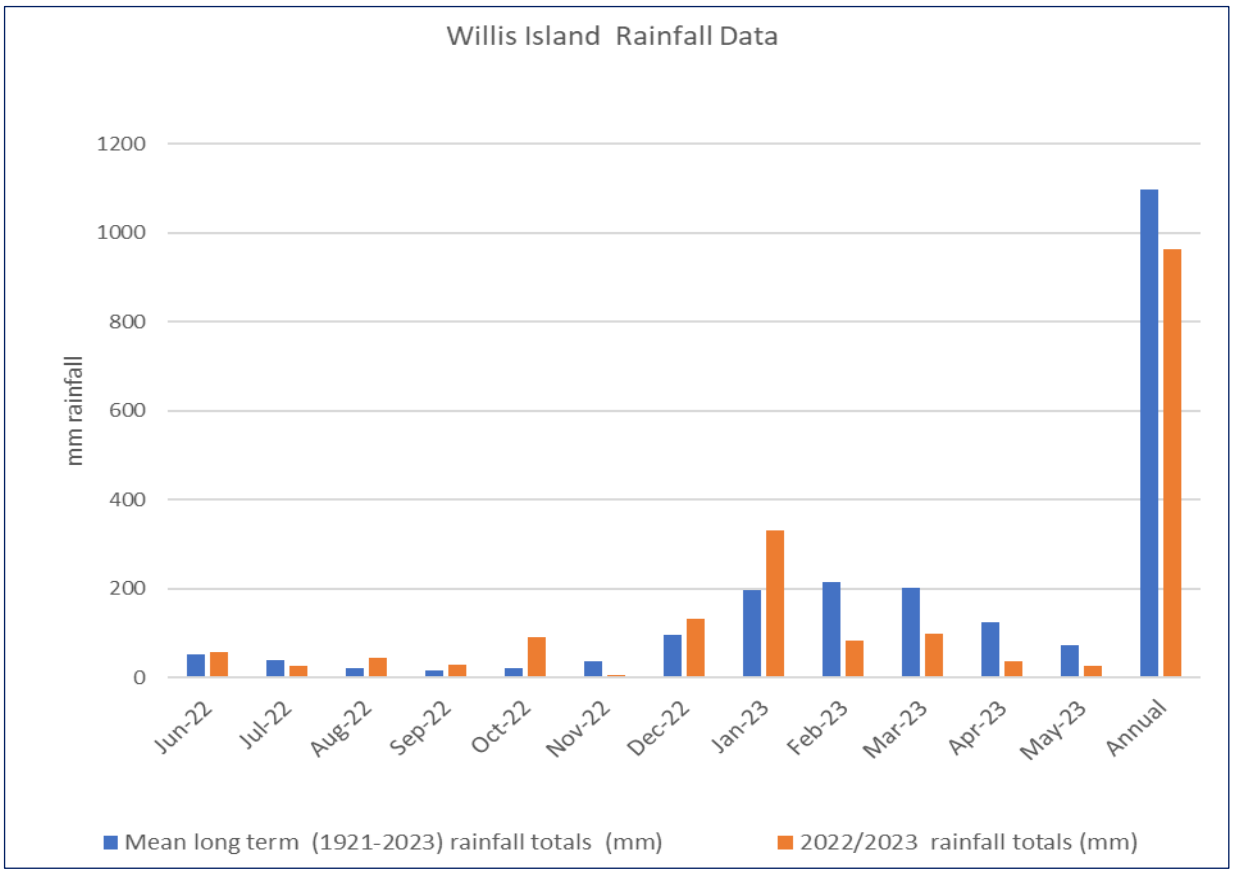

Figure 10. Comparison of recent (June 2022 to May 2023) and long-term monthly rainfall data for South Islet (Australian Bureau of Meteorology, 2023).

Despite the drier than average autumn months preceding the 2023 voyage, the vegetation was generally in good condition at the time of the 2023 surveys.

The exceptions to this were:

- Weed infestations in both the natural areas and the Bureau's Operational Area on South Islet.
- Patches of sea trumpet (*Cordia subcordata*) on East Diamond Islet had windburn in the upper canopy and scale attack. Evidence of flying insects chewing on sea trumpet was found on North East Cay (Herald Cays).
- Standing and fallen dead sea trumpet (*Cordia subcordata*) on North East Cay (Herald Cays) in areas of previous sea trumpet shrublands which have now been replaced by lantern bush (*Abutilon albescens*) shrublands.

Credit: Martin Russell ©, Parks Australia

Results and Discussion

This section is an overview of the combined results and observations from the 2020 to 2023 voyages. Results, observations and discussions of the surveys undertaken on the cays visited during the 2023 voyages are contained in the *Part II: Cay Summaries* section.

Floristic data

The tables in Appendix 4. Plant species recorded on all Coral Sea cays list all plant species recorded on each of the vegetated Coral Sea cays during the 2019 to 2023 voyages, together with the locations, growth forms and dispersal mechanisms for each species. Species that were recorded on a cay for the first time during the 2019 to 2023 voyages are highlighted in bright green in the table. Latest dates recorded for those species previously recorded on a cay but not recorded during the 2019 to 2023 surveys are also included in this table.

Native CSMP cay plant species

Origin, dispersal and turnover of the CSMP cay plant species have been described by Batianoff et al. (2009a) and previously summarized in the 2021 and 2022 voyage reports.

Table 1 displays the records of species numbers by cay. Climatic conditions on the Coringa, Herald and Magdelaine cays were very dry at the time of the 2019 survey so previously recorded plants that were not obvious then may still be present. There was insufficient time to thoroughly search for these species during the short visits to North East and South West Herald Cays, Chilcott Islet and Magdelaine Cay South during the 2022 and 2023 voyages.

Table 1. Number of native plant species recorded during the 2019 to 2023 voyage, the number of species not previously recorded and the number previously recorded but not currently present for each cay.

Cay	Total number of species recorded during 2019 to 2023 surveys	Number of species not previously recorded	Number of previously recorded species not currently present (excluding transient[2] species)
Magdelaine Cay South	17	1	2
NE Herald Cay	13	0	3
South West Herald Cay	11	1	2
Chilcott Islet (Coringa Islets)	12	1	1
South West Islet (Coringa Islets)	12	1	3
East Diamond Islet (Tregrosse Reef)	14	3	0
Central Diamond Islet (Tregrosse Reef)	11	11	0
West Diamond Islet (Tregrosse Reef)	12	11	1
South Diamond Islet (Tregrosse Reef)	9	3	0
South Islet (Willis Islets)	11	3	0
Mid Islet (Willis Islets)	9	2	0
North Cay (Willis Islets)	8	8	0
SW Cay (Lihou Reef)	7	1	0
Hermit Crab Cay (Lihou Reef)	7	0	0
Turtle Islet (Lihou Reef)	7	0	3
Lorna Cay (Lihou Reef)	7	7	0
Georgina Cay (Lihou Reef)	5	1	1
Cato Island	7	0	0
Bird Islet (Wreck Reefs)	6	1	0
Porpoise Cay (Wreck Reefs)	4	3	0
Herald Beacon Islet (Mellish Reef)	3	1	1
Total species on cays records	192	59	17

[2] Propagules of a small number of transient species arrive on a cay and grow for a short period but do not persist and do not establish beyond the location of the original plant.

A total of 19 native cay plant species have been recorded across the 21 vegetated Coral Sea cays during the 2019 to 2023 Parks Australia voyages.

Native cay species richness in the Coral Sea cays varied from 17 species on Magdelaine Cay South to 3 species on Herald Beacon Islet with a median species richness of 9 species.

While native species richness on the CSMP cays does seem to be related to total vegetated area and distance from the mainland to some degree (Figure 11 and 12), it is likely that other factors such as disturbance history, maximum elevation of the cay, location in relation to ocean currents and time since vegetation establishment began, also influence the number of species currently present on each cay.

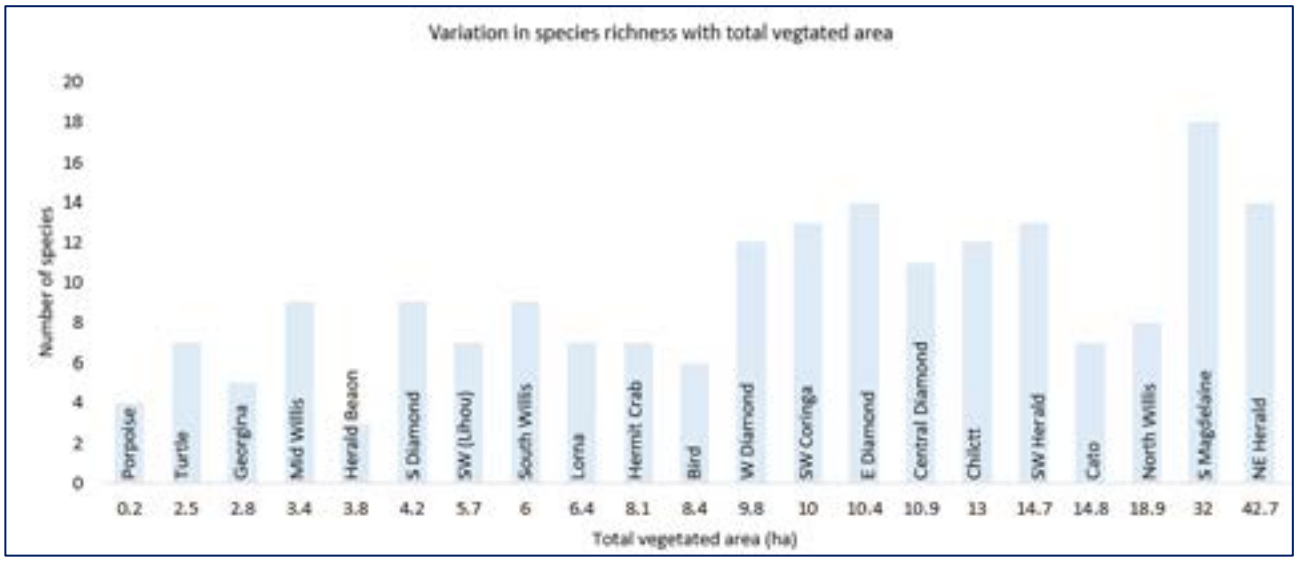

Figure 11. Variation in species richness with vegetated area of each Coral Sea cay.

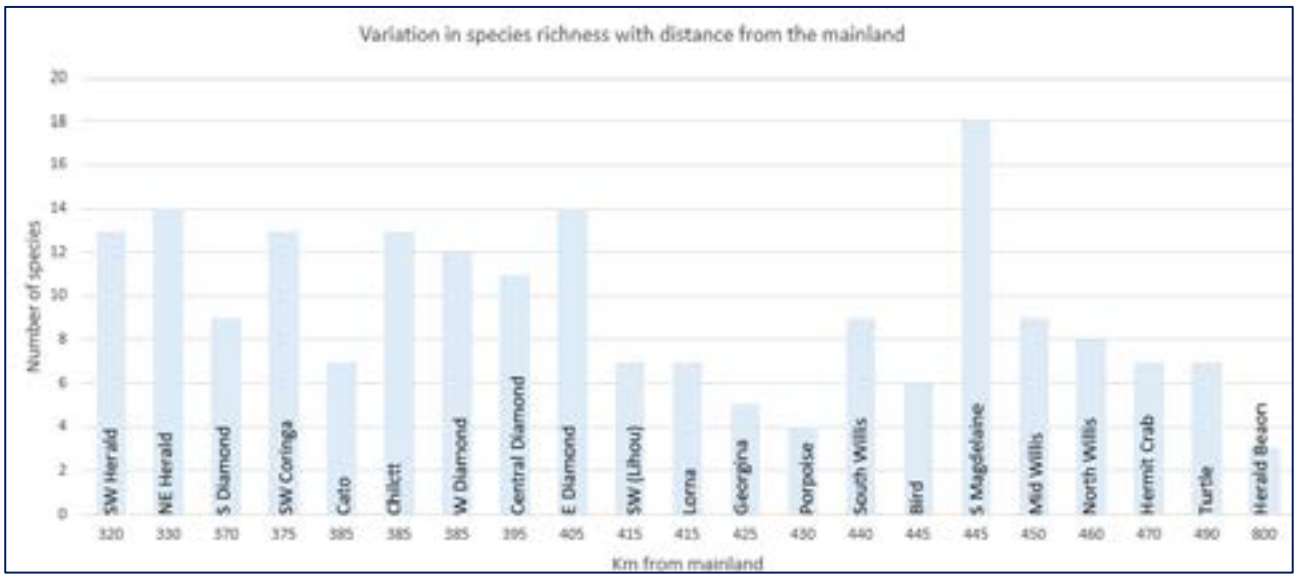

Figure 12. Variation in species richness for each Coral Sea cay with respect to distance (km) from the mainland.

The most abundant native cay species across all the vegetated cays were determined based on:

- Number of cays on which the species was present.
- Number of sites in which the species was recorded.
- Percent 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.

The only tree species in the CSMP is pisonia (*Pisonia grandis*). This was present on only 2 Coral Sea cays - North East Cay (Herald Cays) and Magdelaine Cay South.

The woody shrub octopus bush (*Argusia argentea*) was present on 13 of the 21 cays. The other large woody shrub, sea trumpet (*Cordia subcordata*) currently forms part of the cay vegetation on 6 cays.

The short-lived shrub, lantern bush (*Abutilon albescens*) was present on 15 cays.

The most widespread and abundant herbaceous species recorded during the 2019 to 2023 surveys were:

- Chaff flower (*Achyranthes aspera*) and white flowered tar vine (*Boerhavia albiflora var. albiflora),* both present on all 21 Coral Sea cays.
- The succulent herb, pigweed (Portulaca oleracea) and the perennial stalky grass (*Lepturus repens*), were each present on 20 of the cays.
- Other frequently occurring herbaceous species were bulls head bur (*Tribulus cistoides*) and the annual beach buffalo grass (*Stenotaphrum micranthum*), currently present on 16 and 18 cays respectively.

The grass, marine couch (*Sporobolus virginicus*) was only present on those cays located in the northern CSMP (on Mid and South Islets (Willis Islets), Magdelaine Cay South and North East and South West Herald Cays). This species does grow on the southern GBR cays.

Two previously recorded native species, comb finger grass (*Digitaria ctenantha*) – previously recorded on Magdelaine Cay South (1987), North East Cay (Herald Cays) (1997) and South west Coringa Islet (1984) – and Asian naked wood (*Colubrina asiatica*), previously recorded on Magdelaine Cay South (2007), were not recorded during the 2019 to 2023 voyages.

Bulls head burr (*Tribulus cistoides*) is a summer annual and although it was quite abundant in some locations, it is likely to be more abundant in the summer months.

Comparisons of species with previous records can be confusing where changes in taxonomy have occurred. Table 2 lists species where this has occurred.

Table 2. Synonyms of previously reported vegetation species that have since been renamed.

Synonym used in previous reports	Current name	Current Family
Abutilon asiaticum var. *australiense*	*Abutilon albescens*	Malvaceae
Caesalpinia bonduc (Family Caesalpiniaceae)	*Guilandina bonduc*	Leguminosae subfamily Caesalpinioideae
Coronopus integrifolia	*Lepidium englerianum*	Brassicaceae
Ipomoea macrantha	*Ipomoea violacea*	Convolvulaceae
Messerschmidia argentea	*Argusia argentea*	Boragnaceae

Some names have also been incorrectly used in some previous reports and publications. These are shown in Table 3 together with their correct current names.

Table 3. Previously misapplied vegetation names (Batianoff et al. 2008).

Misapplied name	Correct current name	Family
Abutilon indicum - Listed in ANPWS (1989) and Environment Australia (2001).	*Abutilon albescens* (lantern bush)	Malvaceae
Boerhavia tetrandra - Listed by ANPWS (1989) and Environment Australia (2001).	*Boerhavia albiflora* var. *albiflora* (white flowered tar vine)	Nyctaginaceae
Boerhavia diffusa - Listed by Heatwole (1979).	*Boerhavia mutabilis* (pink flowered tar vine)	Nyctaginaceae
Boerhavia glabrata - Listed by Telford (1993).		
Commicarpus chinensis - Listed by Heatwole (1979).		
Commicarpus insularum (gum fruit) - Listed by Heatwole (1979) and Telford (1993b).	There are no herbarium specimens confirming the presence of this species on Coral Sea cays. It is likely that it was a misapplied name for *Boerhavia mutabilis*	
*Suaeda australis (*austral seablite*)* listed for Chilcott Islet (ANPWS, 1989).	Erroneous records according to Telford (1993)	
Thuarea involuta (birds beak grass) listed in Environment Australia (2001) at CHNNR		

Weeds

Weeds were present on only 2 of the 21 vegetated cays in the CSMP during the 2019 to 2023 Parks Australia voyages. The other nineteen cays were completely free of weeds.

Eleven weed species were recorded, 9 on South Islet and 3 on Bird Islet (Wreck Reefs). These include the following 2 weed species which have not been previously recorded in the CSMP:

- The exotic herb, nightshade (*Solanum americanum*), recorded on Bird Islet during the 2022 voyage. Nightshade is a problem invasive weed on the southern GBR cays.
- The exotic annual summer grass (*Digitaria ciliaris*), recorded on South Islet (Willis Islets) during the 2023 voyage. Summer grass is present on cays in the southern GBR.

Green amaranth (*Amaranthus viridis*) was recorded on Bird Islet during the 2022 voyage. The only previous collections and records for this species in the CSMP were from South Islet by George Batianoff in 2007 and Donaldson in 1994.

Two weed species, khaki weed (*Alternanthera pungens*) and tridax daisy (*Tridax procumbens*), both previously recorded on South Islet (Willis Islets) in 1995 and 2007 respectively, were not recorded during the 2019 to 2023 voyages.

Mexican poppy (*Argemone ochroleuca*), documented as present South Islet in the *Willis Island Building Rectification Environmental Plan for Contractors* (Bureau of Meteorology, 2013), was not seen in either 2020 or 2023. There are no herbarium records for this species confirming its presence on any Coral Sea cay and its presence has not been documented in any available previous reports.

Potential impacts of weeds include:

- loss of bird nesting habitat
- increased fire risk
- reduction in total area of already restricted vegetation communities
- increased biosecurity risk to other cays.

Plant collections

Specimens of all plant species on cays comprehensively surveyed during the 2021-2023 voyages were collected. These specimens have been incorporated into state and national herbarium collections and associated specimen records databases as verification of the current presence of each of these species in each location. Specimens were collected in duplicate or triplicate. All specimens were sent to the Queensland Herbarium in Brisbane and the National Herbarium in Canberra. Specimens collected on the northern cays were also sent to the Australian Tropical Herbarium in Cairns. Due to prevailing dry conditions during the 2019 surveys of the Coringa/Herald/Magdelaine cays, collections of suitable specimens from some of these cays was not possible at the time of the surveys. Although additional specimens were collected from some of these cays during the brief visits during the 2022 and 2023 voyages, contemporary collections for some of these cays has not yet been completed. Plant species collected on each of the CSMP cays during each of the 2019 to 2023 voyages are listed in Appendix 5. Plant species collected on all CSMP cays.

Coconuts

Coconuts were among the most abundant of the drift fruit and seeds observed 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, indicating that they are not part of the natural Coral Sea cay 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, or a combination of these factors. Coconuts should not be planted on Willis Island or other cays in the region as this could result in an increase in viability of coconuts reaching the shorelines of other CSMP cays due to reduced time in the ocean.

Other drift seeds

Collection of drift seeds and fruit from the beaches was done opportunistically. No systematic searching was done. Time restrictions prevented collection on some cays and limited the comprehensiveness of searching on other cays. Relatively few seeds were collected during the 2023 voyage. The low number collected reflects the lack of time available for searching rather than the presence of less seeds. Appendix 2. Photographs of drift seeds collected during 2023 voyage in this report contains photographs of seeds collected during the 2023 voyage. Photographs of drift seeds collected on the 2021 and 2022 voyages are contained in the appendices of the voyage reports for those years. Species of drift fruit, seeds and other plant material collected during the 2021 to 2023 voyages as identified by the Queensland Herbarium are shown in Table 4.

Species collected were very consistent throughout the entire extent of the Coral Sea Marine Park, although there was less species diversity and lower abundance of drift seeds on the southern cays compared with the northern cays.

According to Information supplied by Queensland Herbarium, while all the identified species occur in Queensland it is likely that the seeds originated from Melanesia (eg Papua New Guinea, New Britain, Solomon Islands, Vanuatu etc) where they are common and, in some cases, widely planted or traded. The occurrence of box fruit (*Barringtonia asiatica)* for example was common and widespread in the drift seed samples from the Coral Sea cays but is relatively rare in Queensland. The same applies for candle nut tree (*Aleurites moluccanus*)/tung oil (*Vernicia fordii),* Alexandrian laurel (*Calophyllum inophyllum*) and the various *Entada* species.

The most commonly occurring drift fruit/seeds collected were:

- coconut (*Alexandrian laurel*) – these were abundant on most cays but were not collected.
- candle nut tree (*Aleurites moluccanus*)/tung oil (*Vernicia fordii*)[3]
- box fruit (*Barringtonia asiatica*)
- Alexandrian laurel (*Calophyllum inophyllum*)
- hamburger bean (*Mucuna* sp.)
- beach almond (*Terminalia catappa*) Some specimens of Terminalia could only be identified to genus level. These may have been other species of Terminalia.
- matchbox bean (*Entada phaseoloides*)
- African dream herb, snuff box (*Entada rheedei*)
- beach milkwood, sea mango (*Cerbera manghas*)

The following seeds were also collected during the 2021 to 2023 voyages but were not as frequent as the species listed above:

- Nipa palm, mangrove palm (*Nypa fruticans*)
- looking glass mangrove (*Heritiera littoralis*)
- monkey ladder, sea bean (*Entada gigas*)
- cannon ball mangrove (*Xylocarpus granatum*)
- mango (*Mangifera indica*)
- golden apple (*Spondias dulcis*)
- poinciana (*Delonix regia*)
- nicker nut (probably *Caesalpinia bonduc*)
- Kennedy palm, Gebang palm (possibly *Corypha utan*)
- wing fruit (probably *Pterocarpus sp*.)
- red stilt-rooted mangrove (*Rhizophora* sp. - probably *Rhizophora stylosa*)

A section of the trunk of a cycad was also collected on East Diamond Islet. This was probably sago palm (*Cycas circinalis*).

Seventy-three drift seed specimens could not be identified from the material collected.

Drift seeds of *Erythrina* spp. and *Hibiscus tiliaceus* have also been previously documented by Batianoff et al (2008) from North East Cay (Heralds Cays).

Although most species of drift seeds collected were numerous and widely distributed on the shores of the Coral Sea cays, with the exception of octopus bush (*Argusia argentea)*, none are currently growing on these cays and none have been reported growing on any Coral Sea cay in previous reports. This information indicates that conditions are not suitable, or the seeds are non-viable by the time they reach Coral Sea cay shorelines.

[3] Note**:** It is not possible to distinguish the seeds of candlenut tree (*Aleurites moluccanus*) and tung oil (*Vernicia fordii*) - formerly called *Aleurites fordii*, hence the two names are given. According to the Queensland Herbarium, the seeds are more likely to be *Aleurites moluccanus* as tung oil hardens on exposure to air (by polymerisation and hence its use as a sealant/paint). Nearly all the seeds were still oily to the feel (and left oil stains on the paper envelopes), suggesting that polymerisation hadn't taken place as would have been expected if they were exposed to air (even for short periods of only a few hours). That suggests (implies) that the seeds were therefore candlenut tree (*Aleurites moluccanus)*, which produces an oil that doesn't polymerise and stays liquid and can thus be used as an oil for candles (and hence its common name).

Table 4. Species of drift fruit, seeds and other plant material collected during the 2021 to 2023 voyages

Key: ? = identification likely however can't be confirmed ✓ = species observed on Reef/Island group
Indeterminate = seeds that could not be identified with the material available; numbers are given rather than just presence/absence as multiple Indeterminate for a cay means there are one or more species that could not be identified

Reef/Island Group			Wreck Reefs				Kenn Reefs	Fredericks Reef	Marion Reef			Tregrosse Reef				Lihou Reef														Mellish Reef	Coringa Islet	Herald Cays		Magdel-aine Cays	Willis Islets		Diane Bank
Species	Number of cays	Cato Island	Bird Islet	Hope Cay	Porpoise Cay	West Cay	South Cay (Boulder Cay)	Lighthouse Cay	Brodie Cay	Carola Cay	Paget Cay	Central Diamond	East Diamond Islet	South Diamond	West Diamond Islet	Betty Cay	Carol Cay	Dianna Cay	Edna Cay	Fanny Cay	Georgina Cay	Helen Cay	Hermit Crab Cay	Juliette Cay	Kathy Cay	Lorna Cay	Middle Cay	Observatory Cay	South West Cay	Turtle Islet	Herald Beacon Islet	Chilcot Islet	North East Cay	South West Cay	South Magdelaine Cay	Mid Islet	North Islet	Sand Cay (Bianca Cay)
Aleurites moluccanus/Vernicia fordii	31	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	
Aleurites moluccanus/Vernicia fordii ?	2	✓							✓																													
Barringtonia asiatica	24	✓		✓		✓		✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓			✓				✓
Barringtonia asiatica ?	1																											✓									
Calophyllum inophyllum	20	✓											✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓						✓	✓
Calophyllum inophyllum ?	5								✓											✓								✓				✓	✓				
Calophyllum inophyllum	1																																		✓		
Mucuna sp.	23	✓	✓				✓					✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓					✓	
Mucuna sp. ?	1												✓																								
Mucuna sp. ?	2								✓																												✓
Terminalia catappa	7														✓			✓							✓		✓					✓			✓		✓
Terminalia catappa ?	5												✓	✓											✓	✓			✓								
Terminalia sp.	8																✓		✓				✓		✓	✓			✓	✓						✓	
Terminalia sp. ?	1																			✓																	
Terminalia sp. ?	1									✓																											
Entada phaseoloides	18	✓	✓		✓		✓						✓			✓	✓	✓		✓	✓		✓	✓		✓			✓	✓	✓		✓	✓				✓
Entada rheedei	10												✓					✓	✓			✓			✓		✓	✓	✓				✓				✓
Entada rheedei ?	3																																✓	✓			✓
Entada gigas	3		✓									✓		✓																							
Entada gigas ?	3																														✓		✓			✓	
Cerbera manghas	11												✓					✓			✓			✓		✓	✓	✓	✓			✓				✓	✓
Cerbera manghas ?	3																		✓							✓						✓					
Cerbera manghas ?	1																											✓									
Nypa fruticans	7								✓				✓													✓					✓	✓			✓		✓
Nypa fruticans ?	2												✓					✓																			
Heritiera littoralis	6												✓						✓							✓		✓				✓				✓	
Mangifera indica ?	1																															✓					
Mangifera indica ?	3																									✓		✓								✓	
Xylocarpus granatum	4																									✓		✓					✓		✓		
Spondias dulcis	3																							✓								✓				✓	
Caesalpinia bonduc ?	1		✓																																		
Corypha utan ?	1																				✓																
Delonix regia	1																									✓											
Pterocarpus sp.?	1																							✓													
Rhizophora sp., probably *Rhizophora stylosa*	1																						✓														
trunk of *Cycas circinalis*, sago palm ?	1												✓																								
Indeterminate	23		2						1			2	13	1	1		2	3	2		3	2	1	4		3	4	9				2	6	5	2	2	2	1
Number of species per cay (excluding indeterminates)		6	5	1	2	2	3	1	5	2	1	3	13	6	5	5	6	9	7	5	8	4	6	7	5	15	8	13	6	5	7	3	11	7	1	5	9	9

Vegetation communities

Forests dominated by pisonia (*Pisonia grandis*) are present on Magdelaine Cay South and North East Cay (Herald Cays).

Octopus bush (*Argusia argentea*) shrublands typically form shrub dominated communities around the shorelines on some cays and are also found in the interior of a few of the cays.

Small patches of sea trumpet (*Cordia subcordata*) shrublands are present on five of the 21 cays. The number of sea trumpet patches has declined since earlier surveys and those remaining are prone to drought induced dieback and insect attack.

The short-lived low shrub, lantern bush (*Abutilon albescens*) forms low ephemeral shrublands on some cays. The vegetation on a number of cays where this species is present is very dynamic, transitioning between grasslands, herblands and ephemeral lantern bush shrublands, depending on timing, duration and amount of rainfall.

Many CSMP cays do not contain any woody vegetation and consist only of grassland and herbland communities. These communities are a feature and key value of the CSMP cays, providing important habitat for ground nesting seabirds. The presence of these communities on the CSMP cays is particularly important as only very small areas of grassland and herbland are present on the Capricorn Bunker cays in the Southern GBR. Further, all the vegetation (mostly grassland/herbland) on 4 of the original 6 vegetated cays on the Swains Reef has been lost due to cyclone impacts, particularly Cyclone Hamish in 2009 (Department of National Parks, Recreation, Sport and Racing 2013).

The vegetation communities identified and described on the CSMP cays during the 2019 to 2023 voyages are summarised in the table in Appendix 6. Extent and distribution of CSMP cay vegetation communities 2019 to 2023. The spatial distribution and extent of each of these communities are shown in the vegetation maps. Vegetation maps for Herald Beacon Islet and South Islet are contained in *Part II: Cay Summaries* of this report. Vegetation maps for each of the other 19 vegetated CSMP cays are contained in the cay summaries of the 2019 (Hemson et al. 2020), 2021 (Chapman et al. 2022) and 2022 (McDougall and Brushe 2023) voyage reports. An earlier version of the South Islet vegetation map is contained in Brushe (2021).

BioCondition Monitoring

Twenty-eight permanent BioCondition monitoring sites on 14 cays were established and surveyed during the 2019 to 2023 voyages. Locations and vegetation community descriptions for each of these sites are listed in Appendix 7. CSMP BioCondition monitoring sites established and monitored 2019-2023.

This report contains maps showing the location of and data recorded at sites established during the 2023 voyage. The 2019 (Hemson et al. 2020), 2020 (Brushe 2021), 2021 (Chapman et al. 2022) and 2022 (McDougall and Brushe 2023) reports contain maps showing the location of sites established during the 2019 to 2022 voyage, BioCondition attribute data and some of the photos for each of these sites. Site data and all the site photographs have been supplied to Parks Australia. The site data can also be found on the Queensland Herbarium QBEIS database.

In addition to monitoring vegetation changes over time, data obtained from most of these reference sites will be used to determine BioCondition benchmarks for future condition, health check assessment of terrestrial vegetation and to guide revegetation work within the CSMP.

It is desirable to obtain data from at least 3 pristine reference sites within the CSMP for each major vegetation community to provide representative benchmarks. In addition to data from the 28 sites already surveyed, data from 13 additional permanent BioCondition monitoring sites is needed to obtain sufficient site data. Table 5 lists potentially suitable locations for additional BioCondition monitoring sites obtained from the 2019 to 2023 vegetation mapping. It is likely that not all of these sites will be suitable, and it may not be possible to find suitable alternative locations for some communities.

Table 5. Potentially suitable locations for additional permanent BioCondition monitoring sites.

Additional sites required	Potential locations based on vegetation mapping
Interior *Argusia argentea* shrubland	South Islet (Willis Islets)
	West Diamond Islet (Tregrosse Reefs)
Lepturus repens grassland	SW Coringa Islet (Coringa Islets)
Stenotaphrum micranthum grassland	TBD
Plumbago zeylanica herbland/shrubland	South West Cay (Herald Cays)
	South West Coringa Islet (Coringa Islet)
	Chilcott Islet (Coringa Islet)
Sporobolus virginicus grassland	Magdelaine Cay South (Magdelaine Cays)
Boerhavia albiflora var. *albiflora* herbland	Chilcott Islet (Coringa Islets)
Achyranthes aspera/Ipomoea violacea herbland/vineland	Chilcott Islet (Coringa Islets)
Ipomoea violacea vineland	South West Coringa Islet (Coringa Islets)
Abutilon albescens shrubland	South West Cay (Herald Cays)
	North East Cay (Herald Cays)

Soils

Graphs in Appendix 8. Comparison of soils data compare results of soil analyses of all samples collected during the 2020 to 2023 voyages and previous soil analyses undertaken at numerous sites in the previous Coringa Herald National Nature Reserve (CHNNR) and the Capricorn Bunker cays of the southern GBR. Results of soil analyses of samples collected in BioCondition monitoring sites M22 to M25 in 2023 are contained in Appendix 9. 2023 Soil analysis results and discussed in the Part II: Cay Summaries of this report. Results for samples M01 to M21 collected in BioCondition monitoring sites during the 2020 to 2022 voyages are discussed in the yearly voyage reports (Brushe 2021, Chapman et al. 2022, McDougall and Brushe 2023).

Bird habitat provided by vegetation

Communities of pisonia (*Pisonia grandis*) on CSMP cays provide nesting habitat for the tree nesting species black noddy (*Anous minutus*), brown noddy (*Anous stolidous)*, great frigatebird (*Fregata minor)*, lesser frigatebird (*Fregata ariel)* and red-footed boobies (*Sula sula*). The seaward edge of the pisonia communities also provide cover for ground nesting red-tailed tropicbirds (*Phaethon rubricauda*).

The roots of pisonia help to stabilise wedge-tailed shearwater (*Ardenna pacifica)* burrows and the absence of plants on the forest floor provide easy access to the burrows. On cays with no pisonia forest, wedge-tailed shearwaters nest in burrows in grasslands and herblands on crests, plateaus and upper slopes.

Black noddies and great frigatebirds also nest on the branches of the octopus bush (*Argusia argentea)* shrubs.

The grassland and herbland communities are the preferred nesting habitat for large numbers of ground nesting seabirds, particularly sooty terns (*Onychoprion fuscatus)*, brown noddies (*Anous stolidous)* and brown boobies (*Sula leucogaster)* with the largest numbers nesting in bare or sparsely vegetated patches within these communities. The white flowered tar vine (*Boerhavia albiflora* var. *albiflora*)/beach buffalo grass (*Stenotaphrum micranthum*), open herblands and grasslands just landward of the shoreline were favoured nesting sites for these species.

Nesting red-footed boobies (*Sula sula*), frigatebirds (*Fregata* spp.) and black noddy (black noddy (*Anous minutus*), were abundant on the branches of the octopus bush (*Argusia argentea*) shrubs. Lesser frigatebirds also nest on the ground in depressions in the interior herblands.

Masked boobies (*Sula dactylatra*) commonly nest in the sparse shoreline vegetation dominated by stalky grass (*Lepturus repens)* &/or white flowered tar vine (*Boerhavia albiflora* var. *albiflora)* (vegetation unit 1a) and on the bare sand seaward of the vegetation.

Nesting red-tailed tropicbirds (*Phaethon rubricauda*) favoured nest sites under low octopus bush (*Argusia argentea)* shrubs and were also abundant under large flat slabs of coral rubble on various cays. They also nested under pisonia (*Pisonia grandis*) forests adjacent to shorelines.

Nesting roseate terns (*Sterna dougalli*), black-naped terns (*Sterna sumatrana*) and New Caledonian fairy terns (*Sternula nereis exsul*) are not dependent on vegetation cover, nesting on vegetation free areas on sand spits and on unvegetated cays.

The 2021, 2022 and 2023 voyages were undertaken from late May to July and therefore did not provide opportunity to observe species nesting in the spring and summer.

Other ecological values of the vegetation communities

The vegetation on the cays plays a role in soil development and in accumulating, cycling and releasing nutrients to the surrounding reef. It also helps to stabilise the cays and protect the shoreline from wind and wave erosion. In addition to the ecological value of providing habitat for seabirds, the vegetation communities of the CSMP cays have significant biodiversity value in their own right.

The ‘dry’ tropical vegetation of the CSMP cays is an important link with the 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 CSMP cays differ from those of both the Pacific/Melanesian cays and those of the GBR.

Similar vegetation communities on cays in the southern GBR have all been allocated a Queensland Biodiversity Status of ‘Of Concern’ because of their limited geographic extent. The CSMP 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 CSMP cays and the small total area of each of the vegetation communities, these communities would also qualify for an ‘Of Concern’ Biodiversity Status under the Queensland framework.

The grassland/herbland communities on the CSMP cays are significant as only very small areas of these communities are present on the Capricorn Bunker cays in the Southern GBR. Further, all the vegetation (mostly grassland/herbland) on 4 of the original 6 vegetated cays on the Swains Reef has been lost due to cyclone impacts, particularly Cyclone Hamish in 2009 (Department of National Parks, Recreation, Sport and Racing 2013).

Digital Data

In addition to reports, the following digital data was provided to Parks Australia:

- ground truthing site data including GPS coordinates (Excel file and an ESRI shapefile).
- ground truthing site photographs.
- BioCondition monitoring site data (Excel file).
- locations and GPS coordinates of the BioCondition monitoring sites (ESRI shapefiles).
- BioCondition monitoring site photographs.
- vegetation mapping (ESRI shapefile).
- vegetation map legends (Excel file)
- metadata for the vegetation map files.

1.2 Birds - Andrew McDougall

Methods

Bird surveys were conducted at each of the visited cays with the aim to catalogue species and breeding effort, as well as identify the presence of any threats.

The voyage data focused on cays, but also include sightings made at sea and on exposed reef flats. At sea sightings were opportunistic, recorded from observations made at the back of the boat. Latitude and longitude (datum GDA94) were recorded along with the species name and their respective quantity.

Cay surveys were conducted as follows:

- Record species observed whilst enroute to cay from the main vessel. Birds on cays in the vicinity of vessel access points may fly off and not be recorded again. Photographic recording is preferred when conditions allow.
- A check for nesting birds prone to disturbance was conducted on arrival at cay. Exclusion areas were identified and researchers were notified. This protects small species such as black-naped terns *(Sterna sumatrana)* which have cryptic, easily disturbed or destroyed nests.
- Circumnavigate the cay, roosting and nesting preferences were noted. This also provided the opportunity to record roosting shorebird species.
- Collect data on breeding species, quantities and their breeding effort i.e., nests, chicks and young. Record adolescent and adult quantities.

Survey thoroughness was influenced by:

- available survey time (e.g. trip scheduling requirements or access restrictions due to tides or weather conditions)
- species behavior and their breeding habitat preferences (thick vegetation might not be accessible or easy to collect accurate data)
- overall numbers (some species may dominate a site and take up most of the survey time).

These surveys were aided by the availability of drone footage to check counts and record species in areas not covered during ground counts. Additional data were provided by the research team.

Figure 13: Glyn Hunt taking photos of the seabirds and vegetation.
Credit: Andrew McDougall ©, QPWS

Field survey equipment included 12x50 binoculars, notebook, mechanical pencil, hand-held GPS (global positioning system), tally counters, 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. Photography and drone imagery were reviewed to confirm seabird numbers and breeding effort. Data will be accessible via Birdlife Australia's "Birdata" platform once it is processed by Birdlife staff.

Results

Voyage summary data includes:

- a trip total of 33 species (List of all species is contained in Appendix 10. Bird species Summary)
- 18 seabird species, of which 10 were breeding
- 3 migratory shorebird species
- 12 land and wetland species including the resident CSMP subspecies of the buff-banded rail (*Gallirallus philippensis tounelieri*).

Species and breeding effort data are included in each cay summary. Appendix 11. Pelagic Bird Records contains the results of pelagic bird records.

A standard species table, including a standard species list, has been used throughout the report.

Notable observations:

- The sooty tern colony at Herald Beacon Islet hosting 39,000 pairs
- Pelagic sightings of a providence petrel, several white-tailed tropicbirds, and two species of storm-petrels.
- The record red-tailed tropicbird breeding event on North East Cay (Herald Cays), with an observed 860 breeding pairs up to a possible 946 pairs when considering a likely undercount.
- No breeding New Caledonian fairy terns (*Sternula nereis exsul*) or Herald petrels (*Pterodroma heraldica*) were observed this voyage.

Figure 14: Joy Brushe (left) and Larry Brushe (right) undertaking vegetation assessment on Herald Beacon Islet surrounded by birds. Credit: Andrew McDougall ©, QPWS.

Discussion

Species data completeness was affected by the time available on each cay, the status of the vegetation and how many breeding species were present. A thorough overview of brown noddy breeding effort is often not possible due to their tendency to nest in a variety of habitats, particularly when they nest within thick vegetation. Brown noddy breeding effort and age class is simplified to 'present' for locations where total counts were not possible. No introduced vertebrate/invertebrate species or plant weed species appeared to be affecting any seabird breeding effort.

Pelagic (open sea) observations provided important data for rarely visited sections of the CSMP.

Digital Data

In addition to a report, photographs and an Excel table containing pelagic data (including GPS coordinates) were provided to Parks Australia.

Figure 15. Visual example of the high-density bird-life experienced on some of the cays (Herald Beacon Islet). Credit: Glyn Hunt ©, Parks Australia.

1.3 Island Health checks - Andrew Meiklejohn

Health Checks (HC) are qualitative tools for efficiently and routinely monitoring the condition of key values on reserves in Queensland. They use criteria that can be applied state-wide across a diversity of values and are based on threatening processes and their impacts (e.g. weeds, trampling, cyclone impacts, dieback), or particular parameters (e.g. faunal habitat features, ground cover, recruitment of canopy species), that are good indications of condition. The assessor scores the condition of the value (e.g. a vegetation community or regional ecosystem) for each indicator, at representative sites, using simple, predetermined visual cues.

The HC 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 HC indicators relevant to the value (Melzer et al. 2019). The guide for undertaking Natural Values Health Checks (Melzer 2019) is available at the Queensland Government Parks and Forests website.

Methods

Health Check monitoring was undertaken in a range of vegetation communities across each of the 7 cays visited during the voyage (Table 6). Some cays visited were unvegetated, in these

instances HCs focused on the broader values of the CSMP, for example supporting breeding and roosting seabirds, shorebirds and nesting marine turtles.

Vegetation communities surveyed included:

- pisonia (*Pisonia grandis*) forest/woodlands'
- sea trumpet (*Cordia subcordata*) shrubland
- octopus bush (*Argusia argentea*) shrubland
- mixed shrubland – *Plumbago zeylanica,* lantern bush *(Abutilon albescens)* shrublands ± *Ipomoea*
- moon flower (*Ipomoea)* vineland
- grassland – mix of *stalky grass (Lepturus repens),* marine couch (*Sporobolus virginicus*) and beach buffalo grass (*Stenotaphrum micranthum*).
- herbland – white flowered tar vine (*Boerhavia albiflora* var. *albiflora*), chaff flower (*Achyranthes aspera)* herblands ± stalky grass (*Lepturus repens*)
- unvegetated – habitats supporting breeding and roosting seabirds, shorebirds and nesting marine turtles.

Table 6: Number of Health Check sites per community on each cay.

Cay	*Pisonia*	*Cordia*	*Argusia*	Mixed shrubland	Vineland	Grassland	Herbland	Unvegetated
Herald Beacon Islet							**3**	**1**
North Cay (Mellish reef)								**1**
East Diamond		**3***	**3***			**1***		
South Islet			**3**		**1**	**3**		
Magdelaine Cay South	**3***	**3***	**3***					
Chilcott Islet		**1***	**3***	**3***		**3**		
North East Cay (Herald Cays)	**3***		**3***	**2***				

* Denotes sites with previous Health Check data

Health checks have been undertaken previously on 4 of these cays - Magdelaine Cay South, Chilcott, East Diamond and North East Cay (Herald Cays). In these instances, every effort was made to relocate the exact location of previous assessment sites. The lack of permanent markers, GPS inaccuracy and shifting nature of the cays environment made it impossible to exactly relocate previous sites. Despite this limitation, the follow-up assessments are likely to be an accurate reflection of previously assessed vegetation units. With GPS inaccuracies factored in, each of the site/photo-point locations are expected to be within 5 metres of previous sites. Most of the vegetation communities in question were limited in their number and extent. For instance, only three Cordia communities are present on East Diamond Island and each of these is restricted to a few hundred square metres in extent. Minor discrepancies in the exact geo-location of the 'site' are unlikely to impact the validity of comparing these sites over time.

For each Health Check, the GPS location (Table 7) was recorded and photographs were taken on each of the compass points North, East, South and West. These photographs can be found in Appendix 12. Health Check Site Photographs. The number of Health Check sites varied from 1-4 for each vegetation community on each cay.

Table 7: GSP location and site name for each Heath Check site.

Islet	Site ID	Lat	Long	Date
Chilcott Islet	Chilcott_Shrub_01	-16.937147	150.003996	4/06/2023
	Chilcott_Shrub_02	-16.936512	150.004658	4/06/2023
	Chilcott_Shrub_03	-16.93847	150.001021	4/06/2023
	Chilcot_Grass_01	-16.93592	150.004764	4/06/2023

	Chilcot_Grass_02	-16.936244	150.004156	4/06/2023
	Chilcot_Grass_03	-16.938408	150.000772	4/06/2023
	Chilcott_Arg_01	-16.936857	150.002651	4/06/2023
	Chilcott_Arg_02	-16.93753	150.000969	4/06/2023
	Chilcott_Arg_03	-16.93872	150.003236	4/06/2023
East Diamond Islet	EDiamond_Arg_01	-17.438414	151.075899	31/05/2023
	EDiamond_Arg_02	-17.443113	151.072704	31/05/2023
	EDiamond_Arg_03	-17.443141	151.072018	31/05/2023
	EDiamond_Herb_01	-17.441144	151.074201	31/05/2023
	EDiamond_Cord_01	-17.441352	151.074294	31/05/2023
	EDiamond_Cord_02	-17.439287	151.075879	31/05/2023
	EDiamond_Cord_03	-17.443143	151.072712	31/05/2023
Herald Beacon Islet	Mellish_01	-17.401933	155.869498	29/05/2023
	Mellish_02	-17.403789	155.87002	29/05/2023
	Mellish_03	-17.401918	155.87002	29/05/2023
	Mellish_04	-17.400978	155.869641	29/05/2023
	Mellish_North_01	-17.357914	155.851843	29/05/2023
North East Cay (Herald Cays)	NE_Herald_Arg_01	-16.939592	149.200517	3/06/2023
	NE_Herald_Arg_02	-16.94018	149.199764	3/06/2023
	NE_Herald_Arg_03	-16.940644	149.20228	3/06/2023
	NE_Herald_Pis_01	-16.94313	149.19754	3/06/2023
	NE_Herald_Pis_02	-16.943968	149.19945	3/06/2023
	NE_Herald_Pis_03	-16.93961	149.20116	3/06/2023
	NE_Herald_Cord_01	-16.939791	149.200687	3/06/2023
	NE_Herald_Cord_02	-16.943632	149.201253	3/06/2023
	NE_Herald_Alb_01	-16.943424	149.200398	3/06/2023
	NE_Herald_Alb_02	-16.941793	149.197731	3/06/2023
Magdelaine Cay South	SMagdelaine_Cord_01	-16.603495	150.335165	5/06/2023
	SMagdelaine_Cord_02	-16.604112	150.336349	5/06/2023
	SMagdelaine_Cord_03	-16.601136	150.337582	5/06/2023
	SMagdelaine_Arg_01	-16.604342	150.337161	5/06/2023
	SMagdelaine_Arg_02	-16.601408	150.339031	5/06/2023
	SMagdelaine_Arg_03	-16.599957	150.337588	5/06/2023
	SMagdelaine_Pis_01	-16.601795	150.338529	5/06/2023
	SMagdelaine_Pis_02	-16.60181	150.33786	5/06/2023
	SMagdelaine_Pis_03	-16.600316	150.337379	5/06/2023
South Willis	SWillis_Ipo_01	-16.287228	149.964944	2/06/2023
	SWillis_Arg_01	-16.286792	149.963203	2/06/2023
	SWillis_Arg_02	-16.288549	149.966142	2/06/2023
	SWillis_Arg_03	-16.288474	149.965698	2/06/2023
	SWillis_Grass_01	-16.286071	149.962368	2/06/2023
	SWillis_Grass_02	-16.287896	149.965691	2/06/2023
	SWillis_Grass_03	-16.28664	149.963905	2/06/2023

Results and Discussion

The overall condition rating for almost all communities was ‘good’. The record of the condition class for each community type on each cay is contained under the *Part II: Cay Summaries* in this report.

The exception was the clumps of *Cordia*, which had an overall condition rating of ‘Significant Concern’ on each of the cays. Almost all the patches of *Cordia* observed were characterised by critical levels of dieback and no recruitment was observed (Figure 16 and 17). No obvious signs of the cause of dieback (such as aphids, scale, herbivore attack) were observed. This vegetation community was also the only community to be recorded as having Significant Concern during previous Health Checks (undertaken in 2019).

Figure 16. A dead Cordia observed at Health Check Site 1, North East Cay (Herald Cays).
Credit: Andrew Meiklejohn ©, Queensland Government.

Figure 17. Dieback in Cordia observed at Health Check Site 2, East Diamond Islet.
Credit: Andrew Meiklejohn ©, Queensland Government.

Digital Data

In addition to reports, the following digital data was provided to Parks Australia:

- locations and GPS coordinates of the Health Check monitoring sites (Excel file).
- Health Check monitoring site photographs.
- Health Check monitoring site data.

1.4 Invertebrates and rodents - Chad Hoult

Methods

Rodent tracking tunnels baited with peanut butter and honey was deployed for up to one night on each vegetated cay visited. Each tunnel contained a thin card tracking pad with a waterproof section. This impervious area was liberally covered in slow-drying ink, and a bolus of peanut butter was placed in the centre of this ink. The tunnels work on the principle 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 the white card. The duration of the tunnels deployed was determined by trip logistics. Tunnels were placed on the vegetated perimeter and interior of the vegetated cays. Spaced across each cay, the 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).

Ant bait stations were established at each rodent tunnel to assess the presence of ant species on all vegetated cays by using baits comprised of peanut paste and honey. 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 was recorded for each ant species attending the bait and an opportunistic collection of invertebrates is presented for each cay. Voucher specimens of all species were collected and stored in vials of 70% alcohol solution for identification by Queensland Museum. Other invertebrates were collected from vegetated and unvegetated cays to confirm these are all native species. Inspections were undertaken on all unvegetated cays.

Voucher specimens were identified by Dr Chris Burwell from the Queensland Museum.

Results

No rodent tracks were observed on any of the tunnels. Hermit crab tracks and droppings were observed in all the tunnels.

A total of 5739 invertebrates were counted across all cays. 72.6% (170) of the voucher specimens were identified to be native, coming from 34 different families and at least 29 different genera. Some voucher specimens could only be identified to Order, Family or Genus level.

Four Introduced ant species were recorded during the voyage:

- African big-headed ant (*Pheidole megacephala),* recorded on South Islet
- Pharaoh ant *(Monomorium pharaonis)*, recorded on Chilcott Islet and Magdelaine Cay South
- bicoloured pennant ant (*Tetramorium bicarinatum*)*,* recorded on North East Cay (Herald Cays)
- A second species of *Tetramorium* recorded on East Diamond Islet, likely *Tetramorium simillimum,* however identification could only be confirmed to the genus level.

A third species of *Tetramorium,* wooly ant *(Tetramorium lanuginosum)* recorded on Magdelaine Cay South, has been considered an introduced species in Australia, however others have speculated it may be native.

Other introduced species recorded on the voyage include two cockroach species, the German cockroach (*Blattella germanica*) on East Diamond Islet and a species of *Pycnoscelis* on South Islet. The *Pycnoscelis* specimen is likely a Surinam cockroach (*Pycnoscelis surinamensis)*, however without a male specimen, identification could only be confirmed to a genus level. Three specimens of webspinners (order Embioptera) were among the samples collected from North East Cay. The identity of two couldn't be confirmed (specimens were either immatures or female) but the single winged male specimen was identified as the introduced tramp species, Saunders' Webspinner (*Oligotoma saudersii)*, which has been recorded from mainland Australia.

Results of all ant and invertebrates recorded on each cay can be found under the *Part II: Cay Summaries* of this report.

Discussion

The majority of voucher specimens were identified to be native to the CSMP. The most common native species (at the Family level) were orb-weaver spiders (Ananeidae), grasshoppers (Acrididae), leaf hoppers (Cicadellidae), flesh fly's (Sarcophagidae), true crickets (Gryllidae), wolf spider (Lycosidae), jumping spider (Salticidae) and darkling beetles (Tenebrioidae).

Voucher specimen identification also revealed 5 of the 7 cays visited have introduced ants/invertebrate species.

Of concern is the identification of African big-headed ants on South Islet. This species has previously been identified in the CSMP on Cato Island during the 2022 Island health voyage, where over half the ant station surveyed recorded African big-headed ants. It is one of the world's 100 worst invasion specie and is one of the six ant species to have national priority for management because of their impact, or potential impact, on Australian biodiversity (Commonwealth of Australia 2006). African big-headed ants are predators and are known to decrease the diversity and abundance of native ants and invertebrates in areas they colonise, as

well as cause indirect negative effects on *Pisonia* trees (Burwell et al. 2012). Research in the Capricornia region of the Southern Great Barrier Reef has confirmed African big-headed ants have been introduced to 11 coral cays, with establishment mainly attributed to the frequency of human visitation (Burwell et al. 2012). In 1984, Farrow conducted surveys on South Islet that recorded 337 specimens of African big-headed ant, confirming the species has been present on the cay for over 40 years. During the 2023 voyage, South Islet (Willis Islet) recorded the greatest number of ants of all the cays and identification has confirmed a conservative estimate of at least 1050 to be Arican big-headed ants.

All ant specimens collected on North East Cay (Heralds Cay) were identified to be the introduced biocoloured pennant ant (*Tetramorium bicarinatum*). This species has been recorded on North East Cay in high numbers since 2006, with research finding the relative abundance of *Tetramorium bicarinatum* on the Cay to be at 99.7% (Greenslade 2010). Greenslade's results also suggest that that this species is so dominant on the Cay that it has suppressed numbers of other ant and invertebrate species. Research based on a 2006-2007 survey suggests, biocoloured pennant ants may be harvesting stalky grass seeds in such masses that lead to a reduced soil seed bank and potentially be the cause behind declines in annual grass species (Batianoff et al. 2010). Surveys undertaken during a previous voyage in 2019 suggested the abundance has greatly reduced since these earlier studies (Olds et al. 2019). Although it remains unclear what exact year between 1997 and 2006 the ant was introduced to North East Cay, at a minimum this ant species has been on the cay for 18 years.

Tetramorium simillimum has been recorded on East Diamond Islet in previous years. As stated in the 2021 Voyage report, unlike some other introduced 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 this species is not of concern. Similarly, whether wooly ants *(Tetramorium lanuginosum)* are native or introduced, Wetterer 2010 states *'it appears unlikely that T.lanuginosum will ever become a significant exotic pest species, except perhaps on small tropical islands'.* Only 20-60 specimens were recorded on the one cay - Magdelaine Cay South – and no adverse effects have been observed through this health assessment, based on current knowledge this species is not of concern.

Pharaoh ant *(Monomorium pharaonis)* have previously been recorded on Central Diamond Islet during the 2021 voyage and on three Coringa-Herald cays visited during the 2019 voyage. Although introduced 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 (Olds et al. 2019). The 2019 voyage report suggests that this species was almost certainly in a symbiotic relationship with a scale insect (*Pulvinaria urbicola*) which led to the loss of *Pisonia* forest on South West Coringa Islet.

The German cockroach (*Blattella germanica*) is a worldwide invasive species that can be found across all of Australia.

Despite rodent tunnels being set on cays for less than the preferred three nights, the sampling across every vegetation type, the absence of rodent tracks in all tunnels, the lack of any sightings of rodents, tracks or droppings during the visits, and no evidence of rodent impacts to abundant seabird breeding, supports the conclusion that there were no rodents on any of the cays surveyed.

1.5 Drone Imagery - Dan Wilkins

Methods

The DJI M300 RTK quadcopter drone was used for all mapping missions, running firmware version 06.01.01.00. A DJI Zenmuse P1 35mm RGB camera was used for all mapping missions, and flights over 2 cays South Islet and North East Cay (Herald Cays) also utilised a Micasense

RedEdge MX Dual camera (10 band multispectral camera kit), installed on the secondary gimbal mount (DJI dual downwards facing gimbal).

All drone flights were conducted under the Department's (DCCEW) Remote Operators Certificate (ReOC), following the procedures outlined in the DCCEEW Remotely Piloted Aircraft (Drone) Operations Manual. As per the DCCEEW Operations Manual, the safety of people, wildlife, and the drone equipment was prioritised over mapping objectives. Nearly all cays had large quantities of nesting and active birds in the airspace. Consequently, flights were only undertaken when the wind was relatively steady (minimal gusts) and blowing at a speed of 20 knots or below, near ground level.

Except for the flight at South Islet, all flights were launched from the leeward side of the cays, as far away from the main mass of birds as possible. The flight at South Islet utilised a concrete pad on the northern side of the station (Figure 18).

Figure 18. Dan Wilkins using the DJI M300 RTK drone to commence a mission from the concrete pad at South Islet. Credit: Glyn Hunt ©, Parks Australia.

All flights had a dedicated spotter in addition to the pilot. In order to minimise risk of bird-strike, the aircraft was flown downwind and 'up', to a height of approximately 70m, before commencing each mapping mission. Increasing the height of the aircraft would have increased the wind experienced by the drone, but also decreased the resolution of the maps. Decreasing the height of the aircraft would have potentially decreased wind speeds but increased the likelihood of a negative interaction with birds, particularly the chances of a bird-strike (with subsequent implications for the safety of people and wildlife on the ground). After the completion of each mapping mission, or when battery level dropped to below 30%, the aircraft was bought quickly back to the launch location, with minimal lingering.

The airspace in the first 30 or 40 m above each cay was very dense with bird traffic, particularly in those areas disturbed by voyage personnel undertaking other monitoring tasks. Some birds did fly

and/or hover up to 80m height (the height of most mapping missions), and a brown noddy was filmed (through the M300 POV camera) approaching close to the drone (Figure 19). There were no obvious attempts to mob or attack the drone during the mapping missions, but this kind of behaviour has been observed in the past (with a Phantom 4 drone at lower altitude).

Figure 19. Screenshot from the M300 remote controller showing the POV camera (with instrument overlay) with a brown noddy approaching close to the drone, South Islet.
Credit: Dan Wilkins ©, Parks Australia.

Photogrammetry

Photogrammetry is the science of taking measurements from photographs, and requires taking many photos with high amounts of overlap between adjacent pictures. Structure from Motion is a photogrammetry technique that estimates the shape of three dimensional objects by combining different perspectives of the same object from multiple overlapping images. Multi-view stereo, or 'bundling' takes the sparse point cloud generated by SfM to create a denser point cloud. It does this by using computer vision algorithms and the structures found in multiple overlapping image pairs.

Photogrammetric processing was undertaken with several different packages. Most processing was performed in ESRI SiteScan (which utilises a Pix4D processing engine), or with Pix4D Mapper. Some processing was also done with DroneDeploy (which utilises a different processing engine), and for the purposes of comparative analysis, one cay (and shallow water surrounds) was also processed with OpenDroneMap.

Multispectral Imagery

In addition to the 'basic' RGB imagery, the Micasense RedEdge MX Dual camera was deployed at Willis Island and North-East Herald cay. Pix4D mapper v4.8.4 was used to process the multi-spectral imagery, and to produce an NVDI reflectance map. The radiometric processing was done using a camera calibration reference photo (taken prior to the flight), and sun-irradiance (from the down-welling light sensor). The green band was used as the primary reference channel.

Results

Drone mapping flights were conducted over 4 cays, resulting in the acquisition of 3,410 nadir colour photographs, and the mapping of 73 hectares at 1cm spatial resolution. Multispectral data was collected over 2 cays, resulting in the acquisition of 9,935 single band images and the mapping of 46 hectares at 5.4cm spatial resolution (in 10 spectral bands). A summary of the flights is in Table 8.

Table 8. Summary of Drone flights.

Reef System	Cay	Flight Date	Mapped Area	Datasets
Mellish Reef	Herald Beacon Islet	29/05/2023	19 ha	RGB
Mellish Reef	North Cay	29/05/2023	8 ha	RGB
Willis Islet	South Islet	02/06/2023	16 ha	RGB + 10 Band
Herald Cays	North East Cay	02/06/2023	30 ha	RGB + 10 Band

Digital Data

In addition to reports, the following digital data was provided to Parks Australia:

- drone imagery
- processing information
- point cloud
- Digital Surface Models (DMS)
- Digital Elevation Model (DEM)
- Digital Terrain Model (DTM)
- orthomosaic
- derived produces (e.g. NDVI and SAVI's).

Raw images can be re-processed using different, or future, versions of photogrammetric software.

Figure 20: Dan Wilkins carrying the drone equipment upon arrival to South Islet.
Credit: Andrew McDougall ©, QPWS.

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

To help maintain each cay in as natural state as possible, marine debris was collected from the following cays:

- Chilcott Islet
- East Diamond Islet

- North East Cay (Herald Cays)
- Herald Beacon Islet
- Magdelaine Cay South.

There was no evidence of marine debris on North Cay (Mellish Reef), likely because of regular high tide wash-over. South Islet is the only cay in the CSMP which is inhabited, and the 4 staff regularly remove and incinerate marine debris off the surrounding beaches, therefore Parks Australia did not undertake marine debris collection.

Method

Collected marine debris was bagged, fumigated, sealed and tagged with cay name and dated, before being removed from each cay to the voyage vessel (Figure 21). Items of marine debris that were too large to be bagged (such as fishing nets, crates, fish attracting devices (FADS) and large lengths of ropes) were washed in the sea in situ and then sprayed/fumigated on shore before being taken to the vessel.

All marine debris was then unbagged, sorted to type and examined on board the vessel, catagorised and recorded by Ian Anderson of Tangaroa Blue Foundation[4], before being re-bagged and resealed. The collected marine debris was stored on the vessel for disposal in port at Gladstone; this amounted to approximately 5 cubic metres. Upon returning to Gladstone, the marine debris was handled as biosecurity waste because the voyage visited South Islet, which involved it being double-bagged in bulker bags before being removed from the vessel and placed into lined and lidded biosecurity containers. These containers were then loaded on to a commercial waste disposal truck for transport to Townsville for deep burial, in accordance with Departmental biosecurity waste handling.

Figure 21: Bagged and tagged marine debris ready to be removed from the cay.
Credit: Martin Russell ©, Parks Australia.

Tangaroa Blue provided a detailed analysis of the marine debris collected from each cay to Parks Australia. The report provided information on 176 separate categories, including details down to individual types, numbers and source of origin of each marine debris, as well as an overall count and weight collected off each cay. The total number of marine debris items collected from an island has been used in this summary rather than the weight collected because it provides a more accurate comparison of the level of marine debris ‘pollution’ on the islands. 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 boat rudder or a length of a large diameter ship’s rope. Using the analysis by

[4] Tangaroa Blue Foundation (TBF) is an Australia-wide not-for-profit organisation dedicated to the removal and prevention of marine debris. TBF has been assisting Parks Australia with the removal and analysis of marine debris from the Coral Sea Marine Park since 2016.

Tangaroa Blue, this report summarises the distribution and loads of marine debris collected from 5 cays and examines possible reasons for this distribution.

Results

The analysis of the marine debris by Tangaroa Blues details 176 separate categories of marine debris, with a numerical value (number of items) assigned to each category from each of the cays.

A summary of the key debris information

- 4,104 individual items were collected from 5 cays.
- 93 percent of the items (3,897) were made of synthetic materials such as plastics, rubber and PVC as follows:
  - hard pieces of plastic – 2,016
  - plastic lids and bottle tops – 801
  - plastic bottles – 914
  - rubber thongs – 383
  - rubber items – 54
  - polystyrene foam items – 155.
- 89 metres of synthetic rope of varying diameter and lengths was collected.
- 10 square metres of synthetic fishing nets from lost or discarded fish aggregating devices (FADs) was also collected.
- 94 plastic and foam fishing floats of varying sizes.
- 92 glass bottles and jars.

Of the 914 plastic bottles, 75% were from foreign origin. Free-floating/drifting fish aggregating devices (FADs) are not permitted for use in Australia and therefore must be coming from the broader Pacific Ocean.

Marine debris loads on individual cays

The analysis of the 4,104 individual marine debris items removed from the 5 cays (Table 9) highlights the following:

- Herald Beacon Islet: a vegetated, elongated island, (approximately 0.57 km long x 0.19 km wide), lying on a predominantly north/south axis with a south-easterly weather coastline of approximately 0.2 km, carried 20.7 percent (849 items) of the marine debris load.
- East Diamond Islet: a vegetated, elongated island, (approximately 0.92 km long x 0.23 km wide), lying on a predominantly north-east to south-west axis with a south-easterly weather coastline of approximately 1.3 km, carried 22.1 percent (905 items) of the marine debris load.
- Chilcott Islet: a vegetated, roughly semi-circular shaped island, (approximately 0.74 km long x 0.37 km wide), lying on a predominantly north-east to south-west axis with a south-easterly weather coastline of approximately 1.0 km, carried 27.1 percent (1113 items) of the marine debris load.
- Magdelaine Cay South: a vegetated, roughly oval shaped island, (approximately 0.93 km long x 0.46 km wide), lying on a south-east to north-west axis with a south-easterly weather coastline of approximately 0.4 km, carried 8.4 percent (346 items) of the marine debris load.
- North East Cay (Herald Cays): vegetated, semi-circular shaped island (approximately 1.2 km long x 0.5 km wide), lying on a north-east to south-west axis, with a long south-easterly facing weather coastline of approximately 1.6 km, carried 21.7 percent (891 items) of the marine debris load.

Table 9. Summary of marine debris loads per cay visited.

Visited cays and islets (ranked greatest marine debris laod to least)	Total count of marine debris items	Percentage of total marine debris	Length of south-easterly facing weather coastline	Time since last marine debris clean up
1. Chilcott Islet	1,113	27.1 %	1.0 km	7 years
2. East Diamond Islet	905	22.1 %	1.3 km	~ 0.6 years
3. North East Cay (Herald Cays)	891	21.7 %	1.6 km	1 year
4. Herald Beacon Islet	849	20.7 %	0.2 km	No record of any clean up
5. Magdelaine Cay South	346	8.4 %	0.4 km	7 years
Totals	4,104	100 %		

Discussion

Previous marine debris collections from the CSMP has shown there may be a correlation between those cays with a relatively longer south-east weather coast having greater marine debris loads.

Herald Beacon Islet is the furthest east of all the CSMP cay's, lying approximately 800 km off Queensland coast. Parks Australia has not conducted a marine debris clean up on this cay previously. The 849 items collected may represent many years of marine debris accumulation on this remote cay. It's likely the cay's north-south axis, and a relatively small (0.2 km) south-easterly weather coast, contributes to the relatively lower marine debris load.

East Diamond Islet was cleaned of marine debris by Parks Australia during the voyages in June 2016, July 2021, June 2022 and November 2022 (a Tangaroa Blue voyage undertaken under the 'Our Marine Parks' Grants program). In the 7-months since the last clean up (November 2022), 905 marine debris items were reported to have accumulated on the cay.

Chilcott Islet and Magdelaine Cay South, were last cleaned of marine debris by Parks Australia in June 2016. Over this period Chilcott Islet had accumulated a marine debris load of 1,113 items, and 346 items were removed from Magdelaine Cay. In contrast, 891 items were collected from North East Cay (Herald Cay), despite being cleaned just one year prior (June 2022). These 3 cays are all in relative proximity to each other, separated in total by 37 km of latitude and 130 km of longitude: Chilcott Islet lies roughly in the middle, with North East Cay (Herald Cay) 85 km to the west and Magdelaine Cay South 51 km to the north-east of it (Figure 22). The varying marine debris loads on these 3 cays may indicate where currents acting as main conveyor of marine debris run through the CSMP.

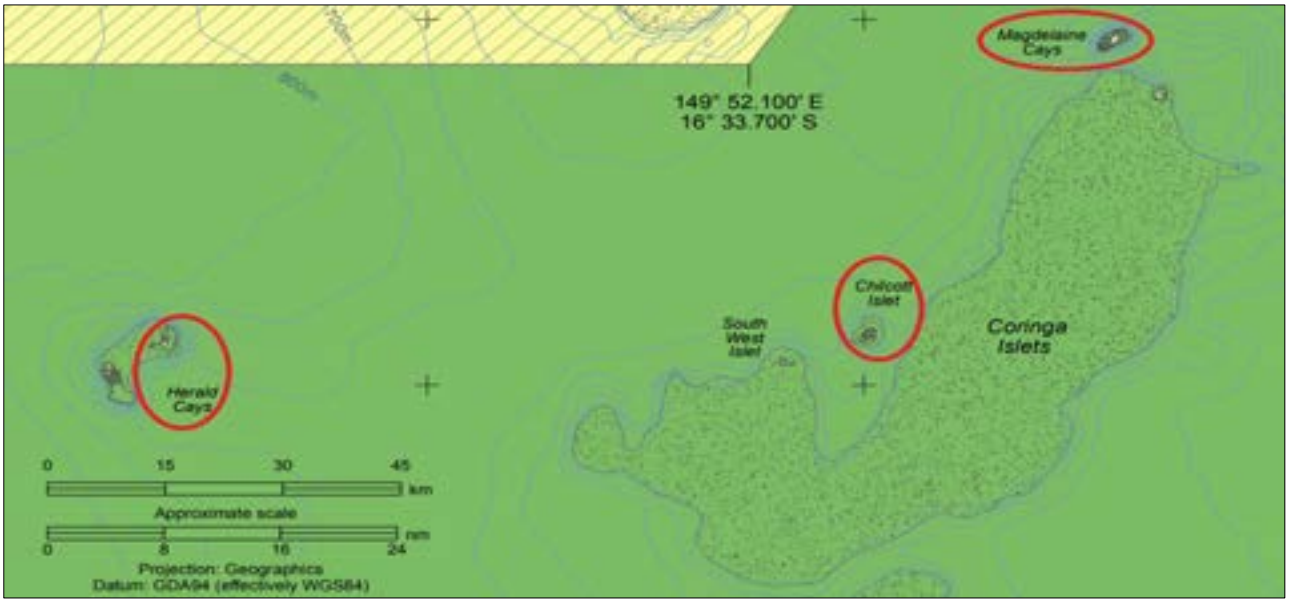

Figure 22. Location and proximity of Chilcott Islet, North East Cay (Herald Cays) and Magdelaine Cay South.

Both Chilcott Islet and North East Cay (Herald Cays) have a very similar elongated shape and axis, with relatively long south-easterly weather coasts (Figure 23). In contrast, Magdelaine Cay South is different in shape, being oval rather than elongated, with a relatively short 0.4 km south-easterly facing weather coast (Figure 24).

Figure 23. Images showing the shape of cays with the highest marine debris load. From left to right: North East Cay (Herald Cays), East Diamond Islets and Chilcott Islet. Note these maps are not to scale

.

Figure 24. Images of cays with the lowest marine debris loads. Left: Magdelaine Cay South, Right: Herald Beacon Islet. Note these maps are not to scale.

The 2023 results indicate that relatively high quantities of marine debris were removed from those cays with long south-easterly facing weather coastline – Diamonds Islet; 1.3km and North East Cay (Herald Cays); 1.6km – both undergoing clean ups within 12 months prior to the 2023 voyage.

Although, Chilcott Islet also has a relatively long south-easterly facing weather coastline and had the highest marine debris load (Table 9), the marine debris load is actually relatively low when emphasis is put on the long accumulation time (7 years). In contrast, relatively low quantities of marine debris were removed from those cays with short south-easterly facing weather coastline – Herald Beacon Islet; 0.2km and Magdelaine Cay South; 0.4km.

Digital Data

Tangaroa Blue provided a detailed analysis of the marine debris collected from each cay to Parks Australia.

Case Study: East Diamond Islet marine debris data - July 2021 to June 2023

East Diamond Islet was cleaned of marine debris by Parks Australia in June 2016, July 2021, June 2022, November 2022 and June 2023, providing a dataset and insight into marine debris accumulation rates on this islet. On each of the 4 most recent voyages, East Diamond Islet has had relatively high marine debris loads.

East Diamond Islet is a vegetated, elongated cay (approximately 0.92 km long x 0.23 km wide), lying on a predominantly north-east to south-west axis, with a south-easterly weather coastline of approximately 1.3 km. East Diamond Islet's location on the eastern extremity of the Tregrosse Reefs, its axis, its relatively long south easterly weather coast, and localized currents, are likely to be reasons for its relatively high marine debris load. Figure 25 shows the accumulation of marine debris on East Diamond Islet.

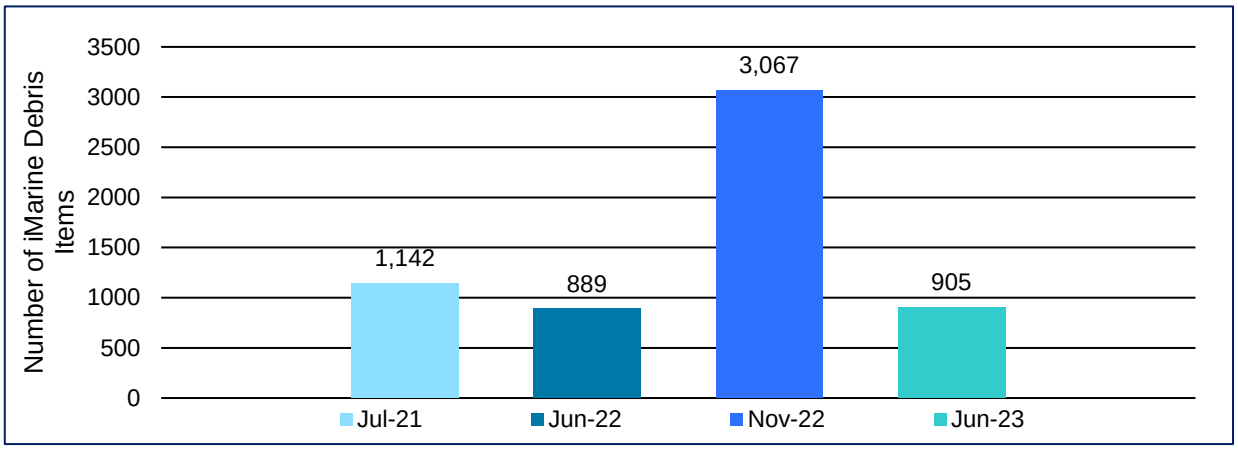

Figure 25. Marine debris items accumulation on East Diamond Islet between July 2021 and June 2023.

The relatively high marine debris accumulation between July 2021 and November 2022 was not unique to East Diamond Islet, as it was also observed across most of 20 cays in the Tregrosse Reef and Lihou Reef systems during the same period. Table 10 details the accumulation of marine debris on these cays over this 16-month period, noting that before the July 2021 clean-up the cays had not undergone a marine debris clean up in 5 years.

Table 10. Marine debris items removed from the Diamond Islets and Lihou Reef between July 2021 and November 2022

Cay/Islet name	July 2021 Number of marine debris items removed after 5 years	November 2022 Number of marine debris items removed after 16 months	Percentage difference between November 2022 & July 2021
Lorna Cay (Lihou Reef)	5,445	6,183	(+) 14 %
Dianna Cay (Lihou Reef)	2,105	4,822	(+) 129 %
Observatory Cay (Lihou Reef)	2,105	2,009	(-) 5 %
East Diamond Islet (Diamond Islets)	1,142	3,956	(+) 246 %
Edna Cay (Lihou Reef)	1,126	2,566	(+) 126%
Central Diamond Islet (Diamond Islets)	946	1,150	(+) 22 %
Middle Cay (Lihou Reef)	845	641	(-) 24 %
Juliette Cay (Lihou Reef)	646	547	(-) 15 %
Georgina Cay (Lihou Reef)	502	3,166	(+) 531 %
South West Cay (Lihou Reef)	423	726	(+) 72 %
West Diamond Islet (Diamond Islets)	411	601	(+) 46 %
Betty Cay (Lihou Reef)	254	278	(+) 9 %
Turtle Islet (Lihou Reef)	179	129	(-) 28 %
Kathy Cay (Lihou Reef)	128	264	(+) 6 %
Carol Cay (Lihou Reef)	121	310	(+) 156 %
Hermit Crab Islet (Lihou Reef)	101	376	(+) 272 %
South Diamond Islet (Diamond Islets)	90	132	(+) 47 %
Helen Cay (Lihou Reef)	37	21	(-) 43 %
Fanny Cay (Lihou Reef)	4	155	(+) 3,775 %
Margaret Cay (Lihou Reef)	3	64	(+) 2,033 %
Total Items	**16,613**	**28,095**	**(+) 69 %**

The data obtained from the 4 marine debris clean-ups on East Diamond Islet indicate that a significant increase in marine debris load occurred in the 5 month period between June and November 2022.

Significant catchment and river flooding associated with ongoing rain events occurred along the east coast of Australia between February to May 2022, affecting coastal communities and areas from Maryborough to Sydney. The volumes of terrestrial origin marine debris that entered the ocean during these events may have been carried down the East Australian Current (EAC), flowing through to the South Pacific Gyre and eventually flowing back onto the Coral Sea cays causing the spike in marine debris observed between June and November 2022. This hypothesis has not been confirmed by analysis of debris type or ocean current effects and may represent opportunities for future park protection and management projects.

Credit: Chad Hoult ©, QPWS.

Part II: Cay Summaries

2.1 Saumarez Reefs - South West Cay and North East Cay

2.1.1 Drone imagery

The combined rocking and rolling of the vessel meant that the aircraft IMU (Inertial Measurement Unit) would not pass calibration, hence it was not safe to fly-off the vessel to map the nearby cays at Saumarez Reef (Figure 26).

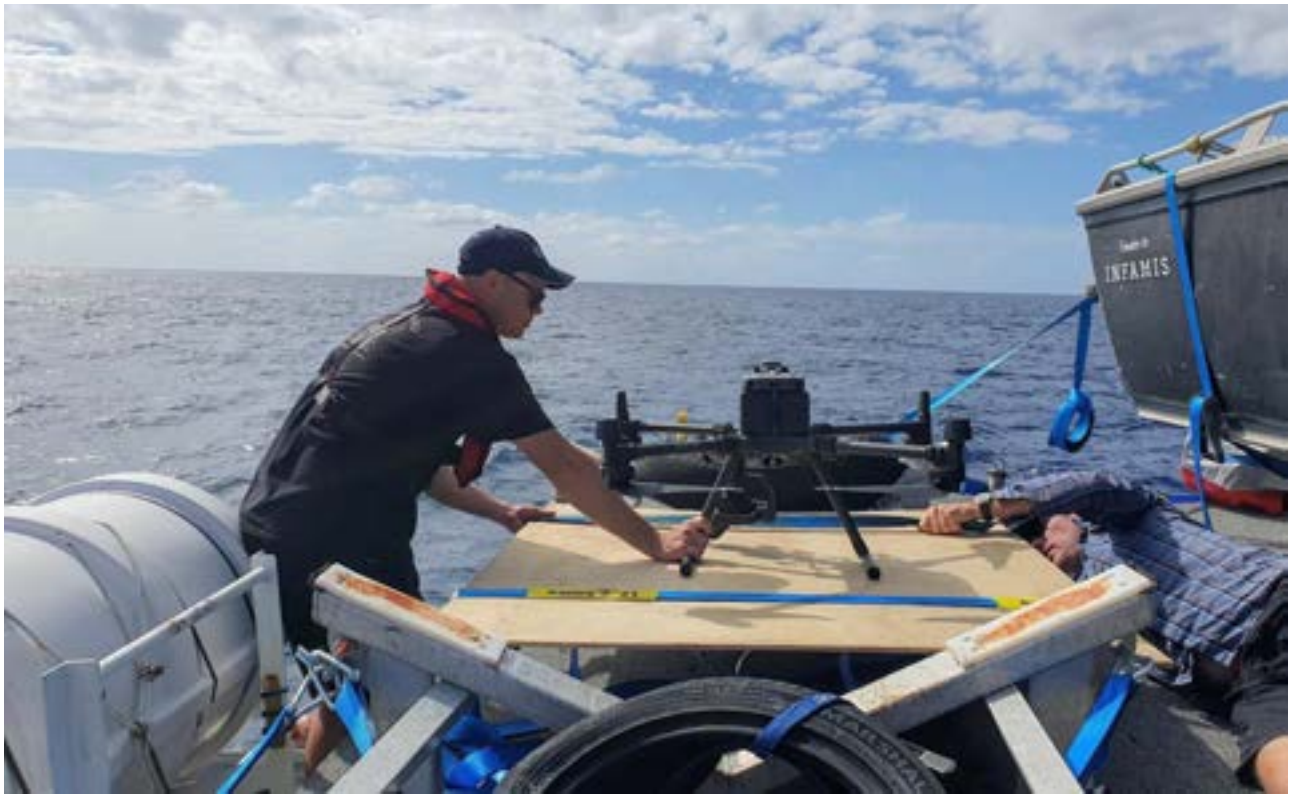

Figure 26. The M300 RTK on a temporary helipad constructed on the (vacant) tender cradle on the helideck of the RV Infamis. Credit: Glyn Hunt ©, Parks Australia.

2.1.2 Physical description

South West Cay

Located approximately 318km north east of Yeppoon, Queensland, and 82km north east from the eastern edge of the Swain Reefs. Unvegetated sand and rubble cay, approximately 140m x 80m in size.

North East Cay

Located approximately 350km north east of Yeppoon, Queensland, and 114km north east from the edge of the Swain Reefs. Unvegetated sand and rubble cay, approximately 243m x 166m in size. Finer visible substrate than South West Cay (Saumarez Reefs).

2.1.3 Vegetation

A vegetation assessment was not undertaken at either of the Saumarez Reef cays.

2.1.4 Soil

Soil samples were not taken at either of the Saumarez Reef cays.

2.1.5 Birds

South West Cay

A boat-based survey was conducted as low tides prevented access to the cay. The cay has sufficient land above high tide for larger seabirds, with longer breeding cycles (egg-laying to fledging), to successfully breed at this time (Figure 27). Table 11 contains the bird data for South West Cay.

Table 11. Bird species and breeding effort on South West Cay, Saumarez Reef.
Key: P= Present, U= Unknown, NR= Not recorded
*wedge-tailed shearwaters flying close to cay

South West Cay, Saumarez Reefs 27/05/2023		Breeding status				
Common name	Scientific name	Nests	Chicks	Young	Breeding pairs	Adolescents and adults
red-tailed tropicbird	*Phaethon rubricauda roseotinctus*	0	0	0	0	0
Herald petrel	*Pterodroma heraldica*	0	0	0	0	0
wedge-tailed shearwater*	*Ardenna pacifica*	0	0	0	0	12
great frigatebird	*Fregata minor*	0	0	0	0	0
lesser frigatebird	*Fregata ariel*	0	0	0	0	1
masked booby	*Sula dactylatra dactylatra*	1	U	U	1	6
brown booby	*Sula leucogaster*	P	4	U	4-10	37
red-footed booby	*Sula sula*	0	0	0	0	0
sooty tern	*Onychoprion fuscatus*	0	0	0	0	0
bridled tern	*Onychoprion anaethetus*	0	0	0	0	0
crested tern	*Thalasseus bergii*	0	0	0	0	5
roseate tern	*Sterna dougallii*	0	0	0	0	0
black-naped tern	*Sterna sumatrana*	0	0	0	0	0
New Caledonian fairy tern	*Sternula nereis exsul*	0	0	0	0	0
black noddy	*Anous minutus*	0	0	0	0	0
brown noddy	*Anous stolidus*	P	U	U	P	230
buff-banded rail	*Gallirallus philippensis tounelieri*	0	0	0	0	0
purple swamphen	*Porphyrio melanotus*	0	0	0	0	0
sacred kingfisher	*Todiramphus sanctus*	0	0	0	0	0
masked lapwing	*Vanellus miles novaehollandiae*	0	0	0	0	0
white-faced heron	*Egretta novaehollandiae*	0	0	0	0	0
eastern reef egret	*Egretta sacra*	0	0	0	0	0
Pacific golden plover	*Pluvialis fulva*	0	0	0	0	0
ruddy turnstone	*Arenaria interpres*	0	0	0	0	0
wandering tattler	*Tringa incana*	0	0	0	0	0
grey-tailed tattler	*Tringa brevipes*	0	0	0	0	0
lesser sand plover	*Charadrius mongolus*	0	0	0	0	0
welcome swallow	*Hirundo neoxena*	0	0	0	0	0
tree martin	*Petrochelidon nigricans*	0	0	0	0	0
magpie-lark	*Grallina cyanoleuca*	0	0	0	0	0
hardhead	*Aythya australis*	0	0	0	0	0
eastern great egret	*Ardea alba*	0	0	0	0	0
little pied cormorant	*Microcarbo melanoleucos*	0	0	0	0	0

Figure 27. Brown booby and brown noddy breeding effort South West Cay, Saumarez Reefs.
Credit: Andrew McDougall, Queensland Government.

North East Cay

A boat-based survey was conducted as low tides prevented access to the cay (Figure 28). Overall breeding effort could not be determined due to distance from vessel to cay. It is likely this cay is becoming of greater importance to masked boobys (*Sula dactylatra dactylatra)* as some of the nearby southern Swain Reefs cays have become less suitable for breeding in recent times. Table 12 contains the bird data for North East Cay.

Table 12. Bird species and breeding effort on North East Cay, Saumarez Reef.
Key: P= Present, U= Unknown, NR= Not recorded

North East Cay, Saumarez Reefs 27/05/2023		**Breeding status**				
Common name	**Scientific name**	**Nests**	**Chicks**	**Young**	**Breeding pairs**	**Adolescents and adults**
red-tailed tropicbird	*Phaethon rubricauda roseotinctus*	0	0	0	0	0
Herald petrel	*Pterodroma heraldica*	0	0	0	0	0
wedge-tailed shearwater	*Ardenna pacifica*	0	0	0	0	0
great frigatebird	*Fregata minor*	0	0	0	0	0
lesser frigatebird	*Fregata ariel*	0	0	0	0	0
masked booby	*Sula dactylatra dactylatra*	P	P	P	P	107
brown booby	*Sula leucogaster*	U	P	U	P	30
red-footed booby	*Sula sula*	0	0	0	0	0
sooty tern	Onychoprion fuscatus	0	0	0	0	1
bridled tern	*Onychoprion anaethetus*	0	0	0	0	0
crested tern	*Thalasseus bergii*	U	U	U	U	24
roseate tern	*Sterna dougallii*	0	0	0	0	0
black-naped tern	*Sterna sumatrana*	0	0	0	0	0
New Caledonian fairy tern	*Sternula nereis exsul*	0	0	0	0	0
black noddy	*Anous minutus*	0	0	0	0	0
brown noddy	*Anous stolidus*	0	0	0	0	0
buff-banded rail	*Gallirallus philippensis tounelieri*	0	0	0	0	0
purple swamphen	*Porphyrio melanotus*	0	0	0	0	0
sacred kingfisher	*Todiramphus sanctus*	0	0	0	0	0
masked lapwing	*Vanellus miles novaehollandiae*	0	0	0	0	0
white-faced heron	*Egretta novaehollandiae*	0	0	0	0	0
eastern reef egret	*Egretta sacra*	0	0	0	0	0
Pacific golden plover	*Pluvialis fulva*	0	0	0	0	0
ruddy turnstone	*Arenaria interpres*	0	0	0	0	0
wandering tattler	*Tringa incana*	0	0	0	0	0

grey-tailed tattler	*Tringa brevipes*	0	0	0	0	0
lesser sand plover	*Charadrius mongolus*	0	0	0	0	0
welcome swallow	*Hirundo neoxena*	0	0	0	0	0
tree martin	*Petrochelidon nigricans*	0	0	0	0	0
magpie-lark	*Grallina cyanoleuca*	0	0	0	0	0
hardhead	*Aythya australis*	0	0	0	0	0
eastern great egret	*Ardea alba*	0	0	0	0	0
little pied cormorant	*Microcarbo melanoleucos*	0	0	0	0	0

Figure 28. North East Cay, Saumarez Reefs. Credit: Andrew McDougall, Queensland Government.

2.1.6 Invertebrates and rodents

Invertebrate and rodent sampling was not completed at either of the Saumarez Reef cays.

2.1.7 Health Checks

A Health Check assessment was not completed at either of the Saumarez Reef cays.

2.2 Mellish Reef - Herald Beacon Islet and North Cay

Figure 29: Martin Russell and John Prichard installing the Herald Beacon Islet Coral Sea Marine Park sign. Credit: Parks Australia.

2.2.1 Drone Imagery

Herald Beacon Islet

A total of 861 nadir images were acquired with the Zenmuse P1 35mm camera, at a target height of 80m above take-off (the northern tip of the island, distal to the largest bird concentrations).

Imagery was processed in both Drone Deploy (proprietary photogrammetry engine) and ESRI SiteScan with Pix4DengineSDK version 5.0.45. In addition, a third orthomosaic was processed in SiteScan, using the same input photographs, but with the GNSS data corrected via Post-Processed Kinematic positioning (Figure 30).

Figure 30. Herald Beacon Islet Orthomosaic preview showing the entire cay as well as the surrounding reef. Credit: Dan Wilkins ©, Parks Australia.

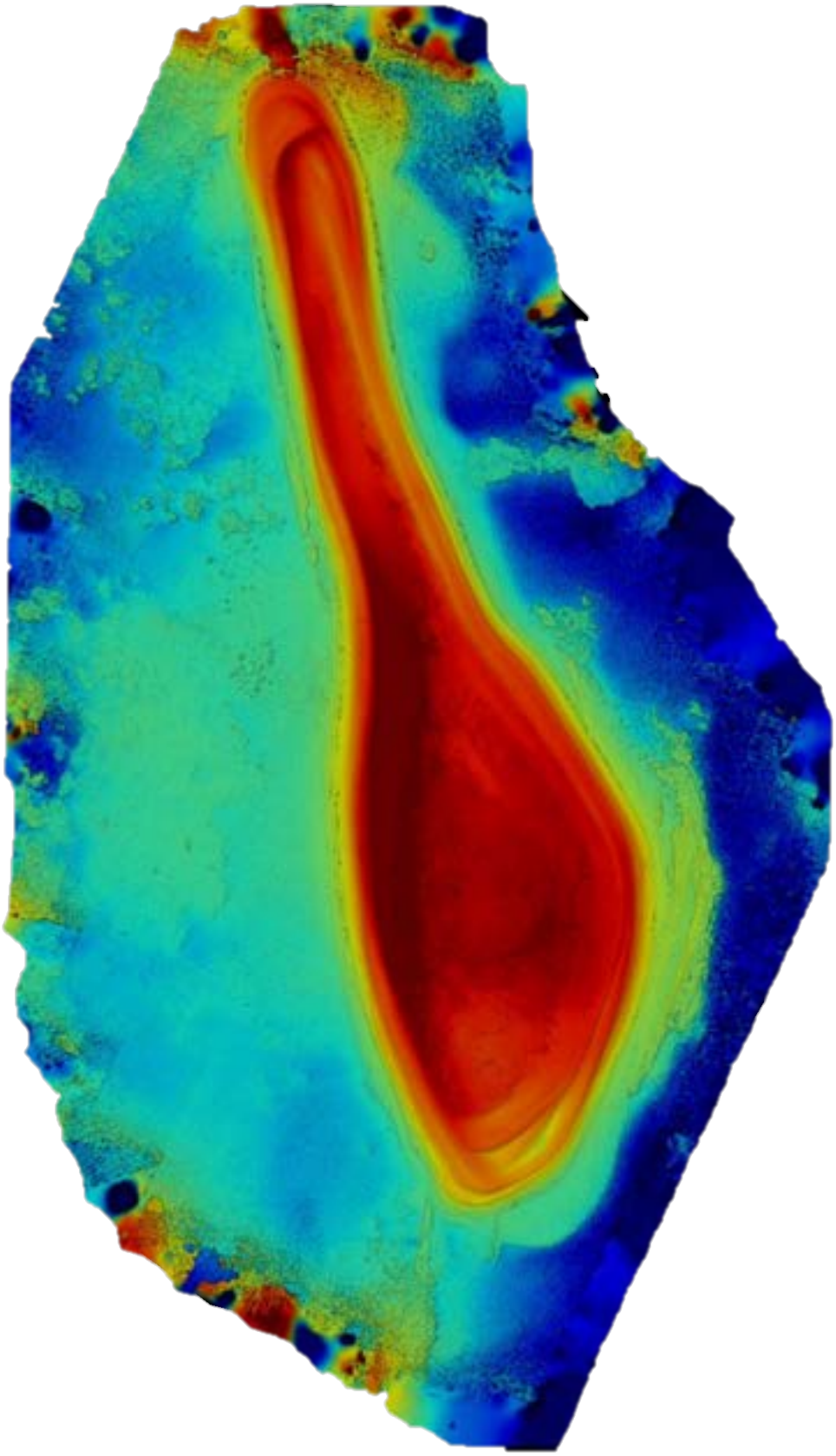

Figure 31. Digital elevation model of Herald Beacon Islet (Drone Deploy).
Credit: Dan Wilkins ©, Parks Australia.

North Cay

A total of 363 nadir photographs were acquired. Orthomosaics were generated using SiteScan, DroneDeploy and OpenDroneMap (Figure 32).

Figure 32: North Cay (Mellish Reef) Orthomosaic Preview, showing the exposed cay as well as the surrounding reef. Credit: Dan Wilkins ©, Parks Australia.

2.2.2 Physical description

Herald Beacon Islet

Herald Beacon Islet is located approximately 900 km northeast of Gladstone at -17.4023 degrees latitude and 155.8704 degrees longitude. It has a vegetated area of 3.8 ha.

Surface elevation profiles of Herald Beacon Islet were prepared by Dan Wilkins (Figure 33 and 3). As no survey marks exist, raw elevation was adjusted by adding 62 metres to bring all values into an approximate sea level metric (dubbed 'above low tide'). Note that this is not "mean sea level". This digital elevation model is based off the surface, as reconstructed by photogrammetry. Buildings structures, and trees/bushes are featured in the elevation model and subsequent transect outputs.

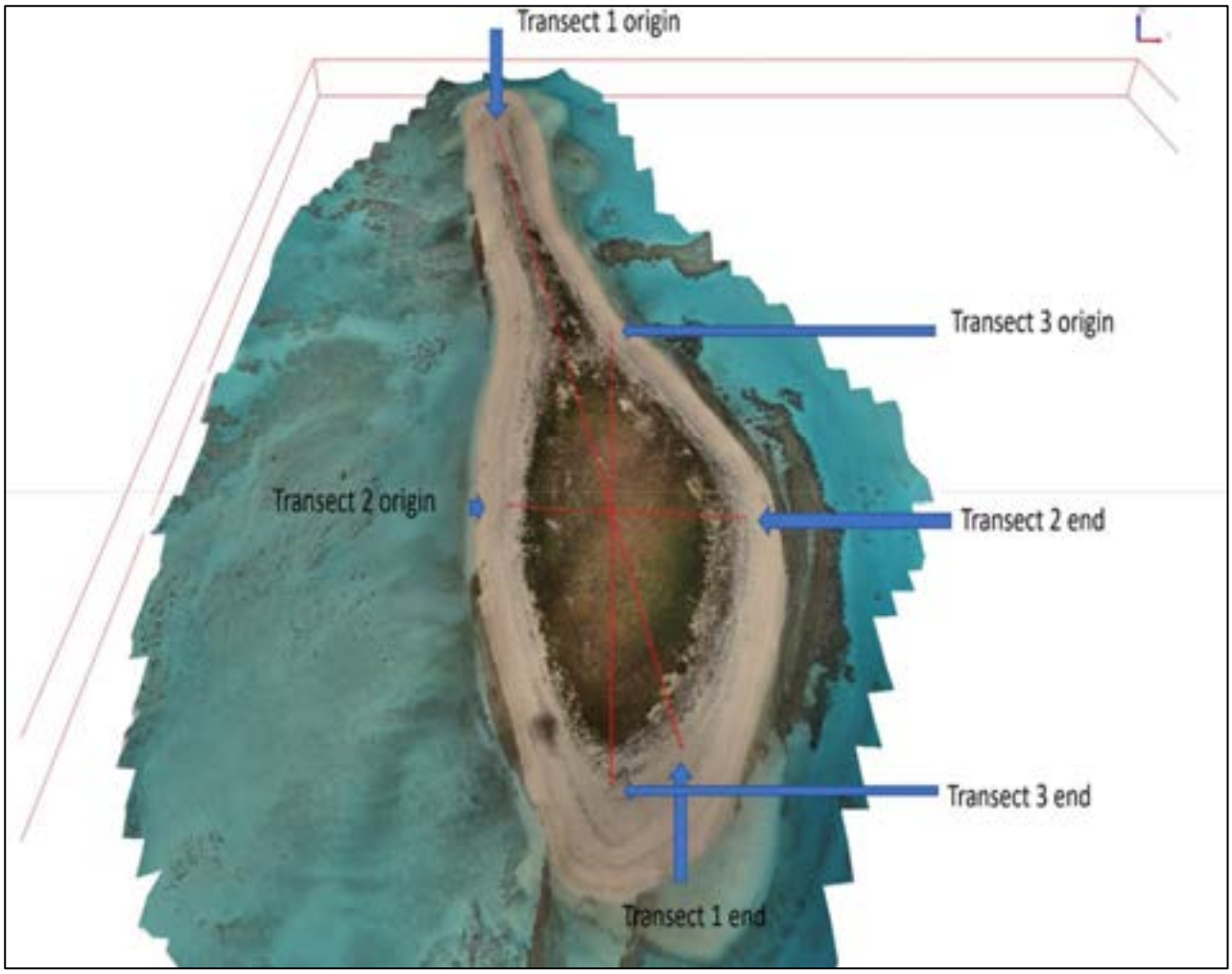

Figure 33. Transect locations used to undertake surface elevation profiles of Herald Beacon Islet. Credit: Dan Wilkins ©, Parks Australia.

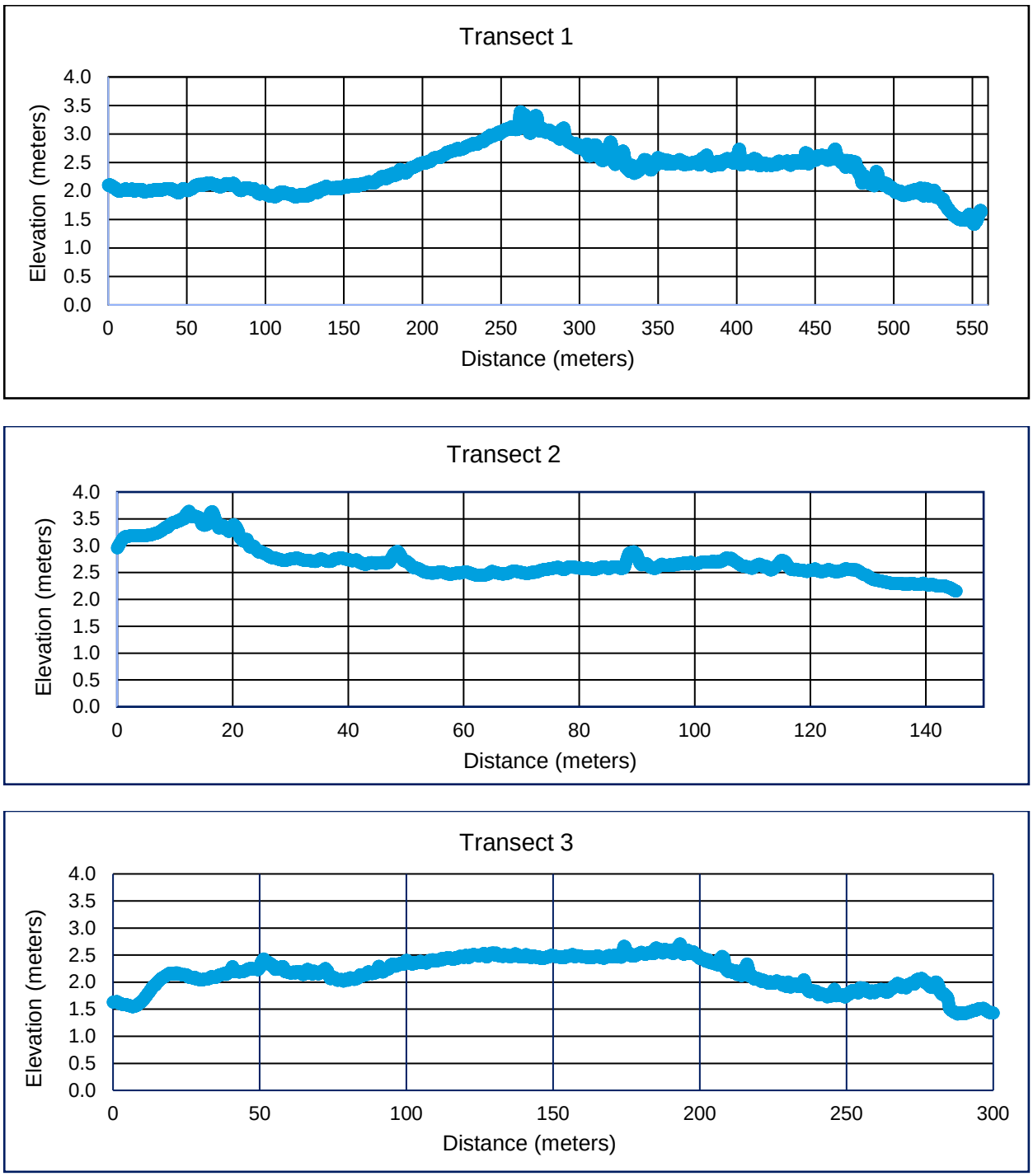

Figure 34. Surface elevation profiles of 3 transects from Herald Beacon Islet. Each transect location can be found on Figure 33.

North Cay

At the time of image acquisition, North Cay consisted of approximately 129 m of exposed sand (north to south), and was up to 22m wide, with a total area of about 2,300 m^2. The cay was unvegetated, with prominent tidelines and coarse clasts pushed to the middle of the cay. The height difference between the tide-line and the middle of the cay was approximately 3m. Areas of what appears to be phosphate rock run parallel to the current sand cay and the sand appears quite dynamic. A volume calculation performed on the area of island above the tideline using the SiteScan Digital Terrain Model (DTM) suggested an exposed sand volume of approximately 4,100 m^3.

2.2.3 Vegetation

Survey intensity

On May 29, 2023, two people each spent approximately 7 hours surveying the vegetation of Herald Beacon Islet. Vegetation data was recorded at 20 ground-truthing sites and one permanently marked BioCondition monitoring site (M22) (Figure 35). The yellow lines in Figure 35 are the boundaries of the vegetation communities shown on the vegetation map in Figure 46.

Figure 35. Herald Beacon Islet showing the number and location of ground-truthing vegetation survey sites and the BioCondition monitoring site relative to the vegetation map unit boundaries.

Vegetation condition

The vegetation on the cay was in very good condition at the time of the survey.

Floristic data

Only 3 native cay species (listed in Table 13) were present on Herald Beacon Islet at the time of the 2023 visit. Specimens of all 3 species were collected for incorporation into national and state herbaria. These 3 species are also the most widespread and abundant plant species present throughout the CSMP.

No weeds were present.

White flowered tar vine (*Boerhavia albiflora* var. *albiflora*) was the most widespread species on the cay (present in all sites), however stalky grass (*Lepturus repens*) had the highest average cover.

Table 13 contains the frequency in sites, the averaged cover for each species for sites in which the species was present and their averaged cover over the entire cay for each of the species present on the cay.

Table 13. Native plant species recorded on Herald Beacon Islet.
Lifeform: Gp= perennial grass, Ha = annual or short-lived herb, Hp = perennial herb

Scientific Name	Common name	Family	Life form	Presence in sites (% of sites)	Average % cover (averaged cover – includes only sites in which species was present)	Overall average % cover (averaged cover over all sites including 0% covers at sites where species was absent)
Achyranthes aspera	chaff flower	Amaranthaceae	Ha	32%	14.6%	4.6%
Boerhavia albiflora var. *albiflora*	white flowered tar vine	Nyctaginaceae	Hp	100%	14.7%	14.7%
Lepturus repens	stalky grass	Poaceae	Gp	84%	41.1%	30.1%
Total number of species = 3						

Vegetation communities

The vegetation on the cay at the time of the 2023 visit was dominated by herblands and grasslands. No pisonia (*Pisonia grandis*) or other tree or shrub communities were present. The vegetation communities, area of each and representative survey sites on Herald Beacon Islet are listed in Table 14.

Comparisons with equivalent and similar communities on other CSMP cays are shown in Appendix 6. Extent and distribution of CSMP cay vegetation communities 2019 to 2023.

Table 14. Vegetation communities found on Herald Beacon Islet.

Vegetation Map Unit		Total Area (ha)	Sites
Unvegetated areas			
A	Sandy beach	4.17	
B	Lithified shore	0.93	
0	Naturally bare patches	0.14	
Shorelines, beaches and sand spits			
1a	Sparse to open grassland/herbland dominated by stalky grass (*Lepturus repens)* &/or white flowered tar vine (*Boerhavia albiflora* var. *albiflora)*	0.05	1, 5
6	*White flowered tar vine (Boerhavia albiflora* var*. albiflora)* open herbland	0.92	3, 4, 7, 8, 13, 15
Interior grasslands and herblands			
3a	Stalky grass *(Lepturus repens)* closed grassland to grassland with white flowered tar vine (*Boerhavia albiflora* var. *albiflora)*	0.67	0, 2, 6, 9, 14, 18
3b	Stalky grass *(Lepturus repens)* closed grassland to grassland with chaff flower (*Achyranthes aspera)* and white flowered tar vine (*Boerhavia albiflora* var. *al*biflora)	0.44	10, 12, 16, M22
3c	Stalky grass *(Lepturus repens)*/white flowered tar vine (*Boerhavia albiflora* var *albiflora)* open grassland/herbland	0.40	no sites
3d	Interior stalky grass (*Lepturus repens*) and white flowered tar vine (*Boerhavia albiflora var. albiflora)* grassland/herbland with occasional chaff flower (*Achyranthes aspera)* (vegetation is sparse and low in areas with high density of nesting birds)	0.83	17
8e	Chaff flower *(Achyranthes aspera)* herbland with white flowered tar vine (*Boerhavia albiflora* var. *albiflora)* and stalky grass (*Lepturus repens)*	0.3	11
	Total area	8.86	
	Total vegetated area	3.75	

Note: Areas of sandy 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.

Photographs and descriptions of vegetation communities

Shorelines, beaches and sand spits

Unit 1a Sparse to open grassland/herbland dominated by stalky grass (*Lepturus repens)* &/or white flowered tar vine (*Boerhavia albiflora* var. *albiflora)*

Vegetation community 1a consists of very sparse vegetation establishing on the seaward margins of sand spits and existing shoreline vegetation (Figure 36 and 37). Sites 1 and 5 consist entirely of isolated plants of white flowered tar vine (*Boerhavia albiflora* var. *albiflora*). This community is very dynamic, expanding during suitable conditions and then disappearing as a result of beach erosion or unfavourable climatic conditions.

Ground truthing sites: 1 and 5

Figure 36. Vegetation map unit 1a, Site 1 Herald Beacon Islet. Credit: Joy Brushe ©

Figure 37. Vegetation map unit 1a, Site 5, Herald Beacon Islet. Credit: Joy Brushe ©

Unit 6 White flowered tar vine (*Boerhavia albiflora* var*. albiflora)* open herbland

Vegetation community 6 forms an almost continuous zone around the entire perimeter of the cay adjacent to the shoreline (Figure 38 and 39). The vegetation in this unit typically consists entirely of white flowered tar vine. Stalky grass is also present at some sites in low abundance. Large numbers of seabirds were nesting in this vegetation community.

Ground truthing sites: 3, 4, 7, 8, 13, 15

Figure 38. Vegetation map unit 6, site 3 Herald Beacon Islet. Credit: Joy Brushe ©

Figure 39. Vegetation map unit 6, site 7 Herald Beacon Islet. Credit: Joy Brushe ©

Interior grasslands and herblands

Unit 3a Stalky grass (*Lepturus repens)* closed grassland to grassland with white flowered tar vine (*Boerhavia albiflora* var. *albiflora)*

Vegetation communities 3a and 3c formed a zone around the landward edge of unit 6 (white flowered tar vine (*Boerhavia albiflora var. albiflora*) open herbland). The vegetation in 3a (Figure 40 and 41) was dominated by stalky grass (*Lepturus repens*) and also contained white flowered tar vine. Occasional chaff flower (*Achyranthes aspera*) was present in two of the six sites.

Ground truthing sites: 0, 2, 6, 9, 14, 18

Figure 40. Vegetation map unit 3a, site 14 Herald Beacon Islet. Credit: Joy Brushe ©

Figure 41. Vegetation map unit 3a, site 18, Herald Beacon Islet. Credit: Joy Brushe ©

Unit 3c Stalky grass (*Lepturus repens)/*white flower tar vine *(Boerhavia albiflora* var *albiflora*) open grassland/herbland

No photos or site data were obtained for this unit.

Unit 3b Stalky grass (*Lepturus repens)* closed grassland to grassland with chaff flower (*Achyranthes aspera)* and white flowered tar vine (*Boerhavia albiflora* var. *albiflora)*

Vegetation community 3b was dominated by stalky grass (Figure 42 and 43).

Ground truthing sites: 10,12,16, BioCondition monitoring site M22

Figure 42. Vegetation map unit 3b, site 10, Herald Beacon Islet. Credit: Joy Brushe ©.

Figure 43. Vegetation map unit 3b, site 16, Herald Beacon Islet. Credit: Joy Brushe ©.

Unit 3d Stalky grass (*Lepturus repens)* and white flower tar vine (*Boerhavia albiflora* var. *albiflora)* grassland/herbland with occasional chaff flower (*Achyranthes aspera).*

Community 3d was co-dominated by stalky grass (*Lepturus repens)* and white flower tar vine (*Boerhavia albiflora* var. *albiflora)* (Figure 44).

Ground truthing site: 17

Figure 44. Vegetation map unit 3d, Site 17, Herald Beacon Islet. Credit: Joy Brushe ©.

Unit 8e Chaff flower (*Achyranthes aspera)* herbland with white flower tar vine (*Boerhavia albiflora* var. *albiflor*a) and stalky grass (*Lepturus repens).*

Community 8e was dominated by chaff flower (Figure 45).

Ground truthing site: 11

Figure 45. Vegetation map unit 8e, Site 11, Herald Beacon Islet. Credit: Joy Brushe ©.

Vegetation communities 3b, 3d and 8e were characterised by their location in the central interior of the cay and the presence of chaff flower. All three communities contained stalky grass, white flowered tar vine and chaff flower. Large numbers of seabirds were nesting in these communities.

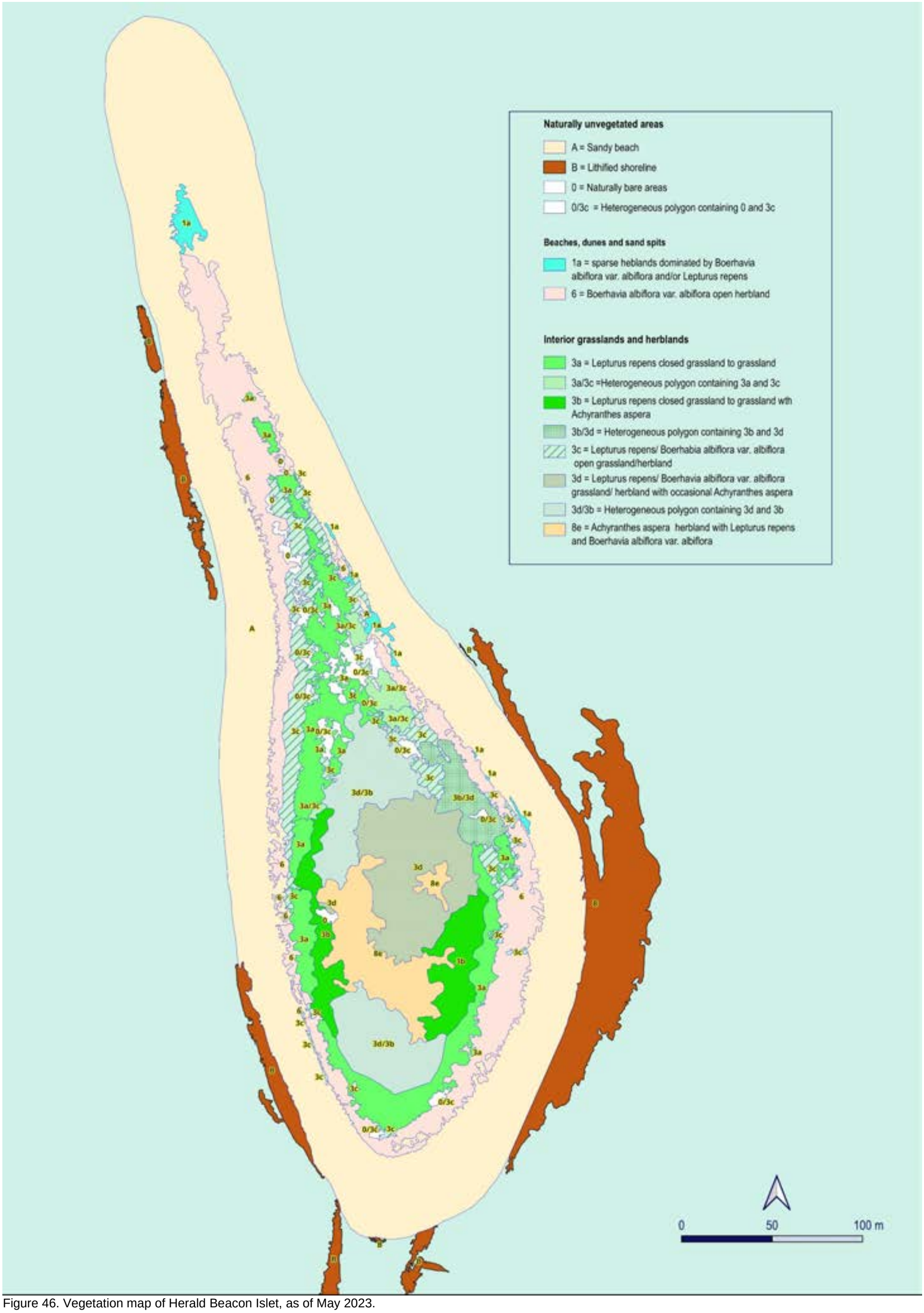

Figure 46. Vegetation map of Herald Beacon Islet, as of May 2023.

Table 15. Site data recorded at Herald Beacon Islet.
Datum = WGS 84 green shading = site dominants

Site	Number of Photos	Latitude	Longitude	Landform	Aspect	Soil description	Rock outcrop	Notes	Estimated altitude	Ground layer height	Dominant growth form	Ground FPC	Total weed cover %	Vegetation community description	Veg map unit	*Achyranthes aspera* G	*Boerhavia albiflora* var. *albiflora*	*Lepturus repens* G	Litter	Birds
001	3	-	155.86959	flat		white coarse sand, abundant fine coral rubble fragments and coral rubble surface fragments			2	10 cm	herb	very sparse (<10%)	0	*Boerhavia albiflora* var. *albiflora* sparse herbland	1a		5-25%		trace-5%	abundant sooty terns, some masked boobies
002	4	-	155.869	slope	NE	light grey-brown coarse sand with some organic content abundant fine coral rubble fragments and fine coral rubble surface fragments			2	15 to 25	grass	mid-dense (>30-70%)	0	*Lepturus repens* grassland	3a		5-25%	25-50%	5-25%	some brown noddies, some sooty terns, some brown boobies, some masked boobies
003	2	-	155.8694	flat		light grey-brown coarse sand with some organic content occasional fine coral rubble fragments and coral rubble and pumice surface fragments			3	10 to 15cm	herb	mid-dense (>30-70%)	0	*Boerhavia albiflora* var. *albiflora* herbland	6		25-50%	trace-5%	25-50%	abundant sooty terns, some brown boobies, occasional masked boobies
004	3	-	155.8692	sight	NE	light grey-brown coarse sand with some organic content occasional fine coral rubble fragments and medium coral rubble surface fragments, abundant pumice & shells			2	10cm	herb	sparse (10-30%)	0	*Boerhavia albiflora* var. *albiflora* open herbland	6		5-25%		5-25%	large numbers brown boobies, occasional masked boobies
005	2	-	155.86910	slope	NE	white coarse sand, fine coral rubble fragments and medium coral rubble surface fragments and abundant pumice & shells			2	10cm	herb	very sparse (<10%)	0	*Boerhavia albiflora* var. *albiflora* open herbland	1a		5-25%		trace-5%	large numbers masked boobies
006	3	-	155.8698	slope	NE	grey-brown coarse sand with some organic content fine coral rubble fragments and occasional fine coral rubble surface fragments			3	30 cm	grass	dense (>70)	0	*Lepturus repens* closed grassland	3a		trace-5%	50-75%	5-25%	abundant sooty terns, some brown noddies, occasional brown boobies
007	2	-	155.86966	flat		grey-brown coarse sand with some organic content and abundant medium coral rubble, pumice and shells surface fragments			3	10 cm	herb	sparse (10-30%)	0	*Boerhavia albiflora* var. *albiflora* open herbland	6		5-25%	trace-5%	trace-5%	abundant sooty terns, occasional masked boobies
008	2	-17.402246	155.869577	dune		light coloured coarse sand, and fine coral rubble, shells and pumice surface fragments			3	0 cm	herb	sparse (10-30%)	0	*Boerhavia albiflora* var. *albiflora* open herbland	6		5-25%		trace-5%	some masked boobies, occasional brown boobies
009	3	-	155.86974	flat		dark brown loamy sand with high organic content and fine coral rubble surface fragments		grass chewed by grass hoppers	3	25 cm	grass	dense (>70)	0	*Lepturus repens* closed grassland with *Boerhavia albiflora* var. *albiflora*	3a		5-25%	50-75%	5-25%	large numbers sooty terns, some brown noddies, some brown boobies, occasional masked boobies
010	4	-	155.87004	depressio		dark brown organic soil with high organic content and medium coral rubble surface fragments		grass chewed by grass hoppers	2		grass	dense (>70)	0	*Lepturus repens* closed grassland with *Achyranthes aspera*	3b	5-25%	trace-5%	50-75%	5-25%	abundant sooty terns, some brown boobies, some brown boobies
0		-17.402921	155.86975			coarse sand etc. Organic in some places				30-40cm	grass	dense (>70)	0	*Lepturus repens* closed grassland with *Boerhavia albiflora* var. *albiflora* and occasional *Achyranthes aspera*	3a	trace-5%	5-25%	75-95		sooty terns, Brown noddies, masked boobies

Site	Number of Photos	Latitude	Longitude	Landform	Aspect	Soil description	Rock outcrop	Notes	Estimated altitude	Ground layer height	Dominant growth form	Ground FPC	Total weed cover %	Vegetation community description	Veg map unit	*Achyranthes aspera* G	*Boerhavia albiflora* var. *albiflora*	*Lepturus repens* G	Litter	Birds
011	4	-	155.87012	depressio		dark brown organic soil with high organic content and medium coral rubble surface fragments		Lepturus eaten by grasshoppers	3	A. aspera 30cm	herb	mid-dense (>30-70%)	0	*Achyranthes aspera* herbland with *Lepturus repens* and *Boerhavia albiflora* var. *albiflora*	8e	25-50%	5-25%	5-25%	25-50%	abundant sooty terns, some brown noddies, occasional brown boobies
012	4	-	155.8699	slope	NNE	light brown coarse sand with some organic content and medium coral rubble surface fragments		*Achyranthes aspera* die back, grass hoppers		15 to 40 cm	grass	mid-dense (>30-70%)	0	*Lepturus repens* grassland with *Achyranthes aspera*	3b	5-25%	trace-5%	25-50%	5-25%	abundant sooty terns, large numbers brown noddies, some brown boobies
013	2	-	155.87014			light coloured coarse sand, fine coral rubble fragments and medium coral rubble surface fragments				10cm	herb	sparse (10-30%)	0	*Boerhavia albiflora* var. *albiflora* open herbland	6		5-25%	trace-5%	trace-5%	some brown boobies, some masked boobies
014	3	-	155.8701	flat		brown coarse sand with some organic content fine coral rubble fragments and medium coral rubble and pumice surface fragments			2	30cm	grass	mid-dense (>30-70%)	0	*Lepturus repens* grassland with *Boerhavia albiflora* var. *albiflora*	3a		5-25%	25-50%	5-25%	large numbers brown boobies, some brown noddies, some sooty terns
015	4	-	155.87081	flat		light brown coarse sand with some organic content fine coral rubble fragments and abundant medium coral rubble and pumice surface fragments		extends along coastline	2	10cm	herb	sparse (10-30%)	0	*Boerhavia albiflora* var. *albiflora* open herbland	6		5-25%	trace-5%	5-25%	abundant sooty terns, some brown noddies
016	3	-	155.87058	flat		brown coarse sand with some organic content and medium coral rubble and pumice surface fragments			2	30cm	grass	dense (>70)	0	*Lepturus repens* closed grassland with *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*	3b	5-25%	5-25%	50-75%	5-25%	large numbers brown noddies, some brown boobies
017	2	-	155.870	flat		brown coarse sand with high organic content fine coral rubble fragments and fine coral rubble surface fragments		grass hoppers	2	15-30cm	grass	mid-dense (>30-70%)	0	*Lepturus repens* and Boerhavia *albiflora* var. *albiflora* grassland/herbland	3d		25-50%	25-50%	5-25%	abundant sooty terns, large numbers brown noddies, some brown boobies
018	3	-	155.87017	flat		light brown coarse sand with some organic content	low		3	20cm	grass	dense (>70)	0	*Lepturus repens* closed grassland	3a	trace-5%	trace-5%	50-75%	5-25%	large numbers brown noddies, some brown boobies, some sooty terns
M22	10	-	155.870	flat		light brown coarse sand with some organic content. Refer to soil analysis data.		Grass chewed by grasshoppers, strong wind exposure, old wooden post at 17.403370 155.870401	3	15-30 cm	grass	dense (>70)	0	Closed grassland dominated by *Lepturus repens*	3b	trace-5%	5-25%	75-95%	trace-5%	large numbers of brown noddies and occasional brown boobies nesting in site,

Comparison with previous surveys

Chaff flower (*Achyranthes aspera*) was not recorded as present on the Herald Beacon Islet at the time of the 1961 visit (Hindwood et al. 1963) and there were no herbarium records of this species from Mellish Reef prior to the 2023 collection.

There is a single Queensland Herbarium record of beach peppercress (*Lepidium englerianum* - named *Coronopus integrifolius* at the time) from Mellish Reef, collected by Keith in 1961. This species was not present at the time of the 2023 survey.

According to Sayer (2019), 100 coconuts were planted on Herald Beacon Islet in 1911 and vegetables were also planted in 1859 for sustenance of shipwrecked sailors. There is currently no evidence of persistence or successful re-establishment of these. No introduced vegetable plants were present and despite numerous coconut drift seeds along the shoreline, only one germinated seedling was present along the shoreline. While it is not unusual to see one or 2 germinated coconut seedlings originating from drift seeds along the shoreline of CSMP cays, these are short lived and have not been observed to grow larger than seedling size.

Permanent BioCondition monitoring site

One permanently marked BioCondition monitoring site (M22) was established and surveyed on Herald Beacon Islet in a stalky grass (*Lepturus repens*) closed grassland. The location of the centre transect of this site is shown as the red line in Figure 35. Table 16 contains the BioCondition attribute data recorded at this site. The BioCondition site photographs (Figure 47) are taken from the centre point of the centre transect, the first facing along the transect bearing and then consecutively facing 90^{o}, 180^{0} and 270^{0} from the direction of the centre transect bearing.

Table 16. BioCondition attribute data recorded in monitoring site M22, Herald Beacon Islet on 29 May 2023.

Site	M22
Cay	Herald Beacon Islet
Landform	Flat
Soil	Light brown coarse sand with some organic content. Refer to soil analysis data.
Vegetation community description	Closed grassland dominated by *Lepturus repens*
Transect start (WGS 84)	-17.40301200 155.87056500
Transect centre (WGS84)	-17.40322000 155.87049000
Transect end (WGS 84)	-17.40343000 155.87041700
Transect bearing (degrees)	190
Median canopy height/range (metres)	0.25 (0.15 to 0.3)
Tree canopy cover %	NA
Shrub canopy cover %	NA
Basal area m^2/ha	NA
Total number of large trees/ha	NA
Total no of trees per ha	NA
Total number of tree stems/ha	NA
Total no. shrubs/ha	NA
Recruitment of ecologically dominant layer (%)	NA
Tree species richness	0
Tree species present	NA
Shrub species richness	0
Shrub species present (layer in brackets)	NA
Median ground layer height/range (metres)	0.25 (0.15 to 0.3)
Total ground layer cover of native cay species (%)	94.0%
Grass species richness	1
Grass cover (%)	81.2%
Grass species present in order of decreasing cover - most abundant first (cover in brackets)	*Lepturus repens* (81.2%)
Forb (including vines) species richness	2
Forb species cover (%)	12.8%
Forb species present in order of decreasing cover - most abundant first (cover in brackets)	*Boerhavia albiflora* var. *albiflora* (12.8%), *Achyranthes aspera* (<1%)
Native shrub ground cover (%)	NA
Introduced plant (weed) cover (all strata) (%)	0.0%
Litter cover (%)	4.2%
Bare ground (%)	21.8%
Woody debris (m/ha of logs >0.5m long and >10cm wide)	0
Soil pH	8.01 (0-10cm), 8.32 (10-20cm), 8.67 (20-30cm), 8.88 (30-40cm)
Notes	Strong wind exposure, grass was chewed by grasshoppers, large numbers of brown noddies and occasional brown boobies (*Sula leucogaster*) nesting in site, old wooden post at 17.403370 155.870401.

BioCondition monitoring site photographs

A.

B.

C.

D.

Figure 47. BioCondition monitoring site M22, Herald Beacon Islet.
A. Facing South, B. Facing West, C. Facing North, D. Facing East.
Credit: Joy Brushe ©.

2.2.4 Soil

Soil samples were collected from BioCondition monitoring site M22 on Herald Beacon Islet. These samples had higher nitrogen levels than all other CSMP soil samples collected in the recent (2021 to 2023) surveys. Aluminium and iron levels at M22 on Herald Beacon Islet were also higher than other CSMP samples collected from 2021 to 2023 except for samples collected from Site M02 adjacent to the grey water outlet on South Islet which had considerably higher levels of aluminium and iron than all other samples. The octopus bush (*Argusia argentea*) shrubland site on South Islet also had much higher iron levels than the Herald Beacon Islet samples.

Total sulphur levels were high in all CSMP samples collected during the 2022 and 2023 voyages (including the M22 sample) compared with previous samples.

Refer to Appendix 9. 2023 Soil analysis results for all results of the soil analyses for samples collected at site M22. For comparison of M22 soil analysis data with data from those for other CSMP and Southern GBR cays, refer to Appendix 8. Comparison of soils data.

2.2.5 Birds

Herald Beacon Islet

Three sooty terns (*Onychoprion fuscatus)* nests per square metre were observed in some areas suggesting it may be the densest breeding colony in the CSMP (Figure 48). Further, breeding numbers of sooty tern were comparable to that of North Cay (Willis Island). A number of sooty terns chicks/young had perished, probably due to exposure to adverse weather. The far south-west beach was used as a roost site for red-footed boobies (*Sula sula).* Two species of overwintering shorebirds were observed: Pacific golden plover (*Pluvialis fulva)* and ruddy turnstone (*Arenaria interpres).* Table 17 contained the bird data or Heral Beacon Islet.

Figure 48. Sooty tern nesting, Herald Beacon Islet.
Credit: Andrew McDougall ©, Queensland Government.

Table 17. Bird species and breeding effort on Herald beacon Islet.
Key: P= Present, U= Unknown, NR= Not recorded

Herald Beacon Islet, Mellish Reef 29/05/2023		Breeding status				
Common name	Scientific name	Nests	Chicks	Young	Breeding pairs	Adolescents and adults
red-tailed tropicbird	*Phaethon rubricauda roseotinctus*	0	0	0	0	0
Herald petrel	*Pterodroma heraldica*	0	0	0	0	0
wedge-tailed shearwater	*Ardenna pacifica*	0	0	0	0	0
great frigatebird	*Fregata minor*	0	0	0	0	1
lesser frigatebird	*Fregata ariel*	0	0	0	0	0
masked booby	*Sula dactylatra dactylatra*	225	3	0	228	257
brown booby	*Sula leucogaster*	129			P	136
red-footed booby	*Sula sula*	0	0	0	0	145
sooty tern	*Onychoprion fuscatus*	P	P		39-40,000	>40,000
bridled tern	*Onychoprion anaethetus*	0	0	0	0	0
crested tern	*Thalasseus bergii*	0	0	0	0	0
roseate tern	*Sterna dougallii*	0	0	0	0	0
black-naped tern	*Sterna sumatrana*	0	0	0	0	0
New Caledonian fairy tern	*Sternula nereis exsul*	0	0	0	0	0
black noddy	*Anous minutus*	0	0	0	0	0
brown noddy	*Anous stolidus*	P	P	P	P	870
buff-banded rail	*Gallirallus philippensis tounelieri*	0	0	0	0	0
purple swamphen	*Porphyrio melanotus*	0	0	0	0	0
sacred kingfisher	*Todiramphus sanctus*	0	0	0	0	0
masked lapwing	*Vanellus miles novaehollandiae*	0	0	0	0	1
white-faced heron	*Egretta novaehollandiae*	0	0	0	0	0
eastern reef egret	*Egretta sacra*	0	0	0	0	0
Pacific golden plover	*Pluvialis fulva*	0	0	0	0	1
ruddy turnstone	*Arenaria interpres*	0	0	0	0	1
wandering tattler	*Tringa incana*	0	0	0	0	0
grey-tailed tattler	*Tringa brevipes*	0	0	0	0	0
lesser sand plover	*Charadrius mongolus*	0	0	0	0	0
welcome swallow	*Hirundo neoxena*	0	0	0	0	0
tree martin	*Petrochelidon nigricans*	0	0	0	0	0
magpie-lark	*Grallina cyanoleuca*	0	0	0	0	0
hardhead	*Aythya australis*	0	0	0	0	0
eastern great egret	*Ardea alba*	0	0	0	0	0
little pied cormorant	*Microcarbo melanoleucos*	0	0	0	0	0

North Cay

North Cay is unvegetated cay and was observed as a roosting site at low and mid tides. At high tide the cay was inundated. Table 18 contained the bird data or Heral Beacon Islet.

Table 18. Bird species and breeding effort on North Cay (Mellish Reef).
Key: P= Present, U= Unknown, NR= Not recorded

Noth Cay, Mellish Reef 29/05/2023		Breeding status				
Common name	Scientific name	Nests	Chicks	Young	Breeding pairs	Adolescents and adults
red-tailed tropicbird	*Phaethon rubricauda roseotinctus*	0	0	0	0	0
Herald petrel	*Pterodroma heraldica*	0	0	0	0	0
wedge-tailed shearwater	*Ardenna pacifica*	0	0	0	0	0
great frigatebird	*Fregata minor*	0	0	0	0	0
lesser frigatebird	*Fregata ariel*	0	0	0	0	0
masked booby	*Sula dactylatra dactylatra*	0	0	0	0	0
brown booby	*Sula leucogaster*	0	0	0	0	2
red-footed booby	*Sula sula*	0	0	0	0	0
sooty tern	*Onychoprion fuscatus*	0	0	0	0	4
bridled tern	*Onychoprion anaethetus*	0	0	0	0	0
crested tern	*Thalasseus bergii*	0	0	0	0	0
roseate tern	*Sterna dougallii*	0	0	0	0	0
black-naped tern	*Sterna sumatrana*	0	0	0	0	1
New Caledonian fairy tern	*Sternula nereis exsul*	0	0	0	0	0
black noddy	*Anous minutus*	0	0	0	0	0
brown noddy	*Anous stolidus*	0	0	0	0	23
buff-banded rail	*Gallirallus philippensis tounelieri*	0	0	0	0	0
purple swamphen	*Porphyrio melanotus*	0	0	0	0	0
sacred kingfisher	*Todiramphus sanctus*	0	0	0	0	0
masked lapwing	*Vanellus miles novaehollandiae*	0	0	0	0	0
white-faced heron	*Egretta novaehollandiae*	0	0	0	0	0
eastern reef egret	*Egretta sacra*	0	0	0	0	0
Pacific golden plover	*Pluvialis fulva*	0	0	0	0	0
ruddy turnstone	*Arenaria interpres*	0	0	0	0	0
wandering tattler	*Tringa incana*	0	0	0	0	0
grey-tailed tattler	*Tringa brevipes*	0	0	0	0	0
lesser sand plover	*Charadrius mongolus*	0	0	0	0	0
welcome swallow	*Hirundo neoxena*	0	0	0	0	0
tree martin	*Petrochelidon nigricans*	0	0	0	0	0
magpie-lark	*Grallina cyanoleuca*	0	0	0	0	0
hardhead	*Aythya australis*	0	0	0	0	0
eastern great egret	*Ardea alba*	0	0	0	0	0
little pied cormorant	*Microcarbo melanoleucos*	0	0	0	0	0

2.2.6 Invertebrates and rodents

Rodents

In the morning 8 rodent tracking tunnels were placed in strategic positions around the cay. That afternoon the traps were retrieved, however showed no sign of rodent activity. Thorough searches of the cay were conducted, and evidence of rodents was not detected (Table 19).

Table 19. Rodent survey results from Herald Beacon Islet.

Location: Mellish Reef – Herald Beacon Islet **Sampler:** Chad Hoult QPWS **Date Collected:** 29/05/2023				
Rodent Stations	**GPS**	**Tracks**	**scat**	**Trail camera**
1	17.40263-155.86964	no	no	-
2	17.40318-155.86975	no	no	-
3	17.40364-155.86993	no	no	-
4	17.40393-155.87024	no	no	-
5	17.40343-155.87057	no	no	-
6	17,40295-155.87064	no	no	-
7	17.40096-155.86972	no	no	-
8	17.40274-155.86986	no	no	-

Ants

There was no sign of ants at any of the 8 stations (Table 20).

Table 20. Ant survey results from Herald Beacon Islet.

Location: Mellish Reef – Herald Beacon Islet **Sampler:** Chad Hoult QPWS **Date Collected:** 29/05/2023				
Ant Stations	**GPS**	**Specimen number**	**Species**	**Amount**
1	17.40263-155.86964	nil	nil	0
2	17.40318-155.86975	nil	nil	0
3	17.40364-155.86993	nil	Nil	0
4	17.40393-155.87024	nil	Nil	0
5	17.40343-155.87057	nil	Nil	0
6	17,40295-155.87064	nil	Nil	0
7	17.40096-155.86972	nil	Nil	0
8	17.40274-155.86986	nil	nil	0

Insects

A total of 391 Insects were counted (Table 21), 12 of which were collected for identification. No introduced species were identified.

Table 21. Insect survey results from Herlad Beacon Islet.

Location: Mellish Reef – Herald Beacon Islet
Sampler: Chad Hoult QPWS
Date Collected: 29/05/2023

specimen number	Class	Order	Family	Species	Introduced	Count	Amount collected	GPS
1	Insecta	Orthoptera	Acrididae	*Aiolopus thalassinus*		100	3	S17.40263-E155.86964
2	Insecta	Lepidoptera				5	1	S17.40014-E155.86937
3	Insecta	Hemiptera	Cicadellidae	*Chiasmus varicolor?*		50	3	S17.40364-E155.86993
4	Arachnida	Acari	Argasidae			100	1	S17.40270-E155.86977
5	Insecta	Hemiptera	Cicadellidae			8	1	S17.40370-E155.86966
6	Malacostraca	Isopoda				15	1	S17.40370 -E155.86986
7	Chilopoda	Scolopendromorpha	Scolopendridae			5	1	S17.40381-E155.86998
8	Arachnida	Araneae	Lycosidae			30	4	S17.40389-E155.87003
9	Insecta	Lepidoptera				15	1	S17.40331-E155.87085
10	Insecta	Diptera	Chloropidae	indet. species		12	2	S17.40331-E155.87085
11	Insecta	Dermaptera	Anisolabididae	indet. species		50	1	S17.40370 -E155.86986
12	Insecta	Lepidoptera				1	1	S17.40370-E155.86966

2.2.7 Health Checks

Herald Beacon Islet

Table 22. Health Check results – Unvegetated (Seabird, shorebird and marine turtle habitat) on Herald Beacon Islet.

Key: **G = good**; **GC = good with some concerns**; **SC = significant concern**; **C = critical**; **NA** = not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G	G			G
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	G	G	G			G
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	GC	G			G
7. Trampling, digging or rooting or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	G	G			G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	G			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	G	G	G			G
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	G	G	G			G
Overall Condition Class						G

Significant graving from grasshoppers was observed at Site 2, however overall, the Health Check results indicate a ‘good’ rating for Unvegetated (Seabird, shorebird and marine turtle habitat) on Herald Beacon Islet (Table 22).

North Cay

Table 23. Health Check results – unvegetated (Seabird, shorebird and marine turtle habitat) on North Cay (Mellish Reef).

Key: **G = good; GC = good with some concerns; SC = significant concern; C = critical; NA** = not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G					G
2. Infestations of pest plants other than ecosystem-changers	G					G
3. Risk of future invasion by significant pest plants not already present	G					G
4. Rainforest invasion	G					G
5. Woody thickening (other than by rainforest species)	G					G
6. Overgrazing/browsing by feral animals, stray stock or natives	G					G
7. Trampling, digging or rooting or trampling by visitors	G					G
8. Impacts on wetlands	NA					NA
9. Vehicle impacts	G					G
10. Dumping	G					G
11. Ground cover	G					G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G					G
13. Fire damage to peat-based ecosystems	NA					NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA					NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA					NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G					G
17. Overtopping, erosion and associated impacts	G					G
18. Tree/shrub health and dieback	G					G
19. Key features for faunal biodiversity in terrestrial ecosystems	G					G
20. Recruitment of canopy species	G					G
Overall Condition Class						G

Overall, the Health Check results indicate a ‘good’ rating for unvegetated (Seabird, shorebird and marine turtle habitat) on North Cay (Mellish Reef) (Table 23).

2.3 Tregrosse Reefs – East Diamond Islet

2.3.1 Drone imagery

Drone work was not conducted on East Diamond Islet.

2.3.2 Physical description

A vegetated cay with a low tide extent of 988m x 262m. Located 536km east of Innisfail, Queensland.

2.3.3 Vegetation

Survey intensity

On May 31, 2023, two people spent 5.5 hours on East Diamond Islet, traversing the cay, establishing a new permanent BioCondition monitoring site, photographing an existing BioCondition monitoring site and undertaking targeted weed searching.

Vegetation Condition

There was some wind damage to the exposed upper canopy of the sea trumpet (*Cordia subcordata*) shrubs (Figure 50.C). Egging scale tended by ants was also observed on some of the sea trumpet plants at BioCondition monitoring site M23. There were no parasitoid emergent holes in the eggs and no lady beetle larvae present on the leaves examined.

The remainder of the vegetation was in good condition at the time of the 2023 visit.

Information from previous surveys

The vegetation of East Diamond Islet was thoroughly surveyed and mapped during the 2021 voyage and briefly assessed again during the 2022 voyage. In addition to results of the vegetation surveys and mapping, the 2021 and 2022 voyage reports (Chapman et al. 2022 and McDougall and Brushe 2023) contain information on birds, soils, location and physical description, drone imagery, health checks, insects and Island Watch data as well as comparisons with earlier Parks Australia voyage reports.

Observations and collections

Not all parts of the cay could be searched in the time available. Targeted searching was undertaken in the most likely site for weed incursions. No weeds were observed.

There was an increase in abundance of lantern bush (*Abutilon albescens*) in the interior of the cay between 2021 and 2023. The vegetation of the interior of the cay was dominated by herbaceous vegetation in the 2021 survey, predominantly stalky grass (*Lepturus repens*), the herb*,* chaff flower (*Achyranthes aspera*) and the vines, moonflower (*Ipomoea violacea)* and coastal jack bean (*Canavalia rosea*). The herbaceous species which previously dominated the vegetation in the interior of the cay, were still present at the time of the 2023 visit, but the vegetation had changed from a grassland/herbland to a lantern bush shrubland*.* Images taken at the centre transect in BioCondition monitoring site M08, show the changes in vegetation between 2021 and 2023 (Figures 51-54). The location of BioCondition monitoring site M08 is shown in Figure 49.

Similar transitions from grassland/herbland vegetation to lantern bush shrublands were also observed on Chilcott Islet, North East Cay (Herald Cays) and Magdelaine Cay South during the 2023 visits. These observations suggest that the grassland, herbland and ephemeral shrubland vegetation on these cays is dynamic with transitions in floristic dominance and structure between these communities, in response to different climatic regimes.

No plant specimens were collected on East Diamond Islet as comprehensive collections were made during the 2021 survey.

Permanent BioCondition monitoring sites

During the 2021 voyage, 3 permanent BioCondition monitoring sites were established on East Diamond Islet. Although these were not resurveyed during the 2023 voyage, photographs were taken at Site M08 to illustrate the transition between grassland/herbland and lantern bush (*Abutilon albescens)* shrubland which appears to be part of the natural dynamics of these communities on

the CSMP cays. An additional BioCondition monitoring site, M23, was established in a sea trumpet (*Cordia subcordata*) shrubland during the 2023 voyage. The location of the centre transect at BioCondition monitoring site M23 on East Diamond Islet is shown in Figure 49.

Figure 49. Location of BioCondition sites M08 and M23 on East Diamond Islet relative to the 2021 vegetation mapping. Credit: Joy Brushe ©.

Table 24 contains the BioCondition attribute data recorded at site M23 during the 2023 voyage. The BioCondition site photographs are some of the site photographs taken at site M23 in 2023 (Figure 51) and at site M08 in 2021 and 2023 (Figure 51-54). Photographs are all taken from close to the centre point of the centre transects, the first facing along the transect bearing and then consecutively facing 90^{o}, 180^{0} and 270^{0} from the direction of the centre transect bearing.

Table 24. BioCondition attribute data recorded in monitoring site M23, East Diamond Islet on 31 May 2023.

Site	M23
Cay	East Diamond Islet
Landform	Crest – highest point on cay
Soil	light coloured coarse sandy soil with organic bands, organic surface soil. Refer to soil analysis data
Vegetation community description	patches of *Cordia subcordata* closed scrub with a mid-dense ground layer of *Lepturus repens* and *Tribulus cistoides* between patches, very little ground cover under *Cordia* patches
Transect start (WGS 84)	-17.44129700 151.07442700
Transect centre (WGS84)	-17.44142500 151.07423100
Transect end (WGS 84)	-17.44153900 151.07406000
Transect bearing (degrees)	225
Median canopy height/range (metres)	2.5 (1.5 to 3.0)
Tree canopy cover %	NA
Shrub canopy cover %	65
Basal area m^2/ha	0.68
Total number of large trees/ha	NA
Total no of trees per ha	NA
Total number of tree stems/ha	NA
Total no. shrubs/ha	1860 (high error – shrubs were multi-stemmed with horizontal and buried stems), difficult to distinguish which stems were from same plant
Recruitment of ecologically dominant layer (%)	-
Tree species richness	0
Tree species present	NA
Shrub species richness	1
Shrub species present (layer in brackets)	*Cordia subcordata* (S1)
Median ground layer height/range (metres)	0.5 (0.1-0.6)
Total ground layer cover of native cay species (%)	14%
Grass species richness	2
Grass cover (%)	8.0%
Grass species present in order of decreasing cover – most abundant first (cover in brackets)	*Lepturus repens* (8%), *Stenotaphrum micranthum* (<1%)
Forb (including vines) species richness	4
Forb species cover (%)	6.0%
Forb species present in order of decreasing cover – most abundant first (cover in brackets)	*Tribulus cistoides* (6%), *Achyranthes aspera* (<1%), *Boerhavia albiflora* var. *albiflora* (<1%), *Canavalia rosea* (<1%)
Native shrub ground cover (%)	0.0%
Introduced plant (weed) cover (all strata) (%)	0.0%
Litter cover (%)	80.8% (77.8% fine litter, 3% coarse litter)
Bare ground (%)	0.6%
Woody debris (m/ha of logs >0.5m long and >10cm wide)	54m
Soil pH	7.38 (0-10cm). 8.6 (10-20cm), 8.47 (30-40 cm)
Notes	Wind sheared canopy with severe wind damage to upper canopy, black noddies and red-footed boobies nesting in *Cordia* shrubs, occasional shearwater burrows.

BioCondition monitoring site photographs

A.

B.

C.

D.

Figure 50. BioCondition monitoring site M23, East Diamond Islet.
A. Facing South West, B. Facing North West, C. Facing North East, D. Facing South East.
Credit: Joy Brushe ©.

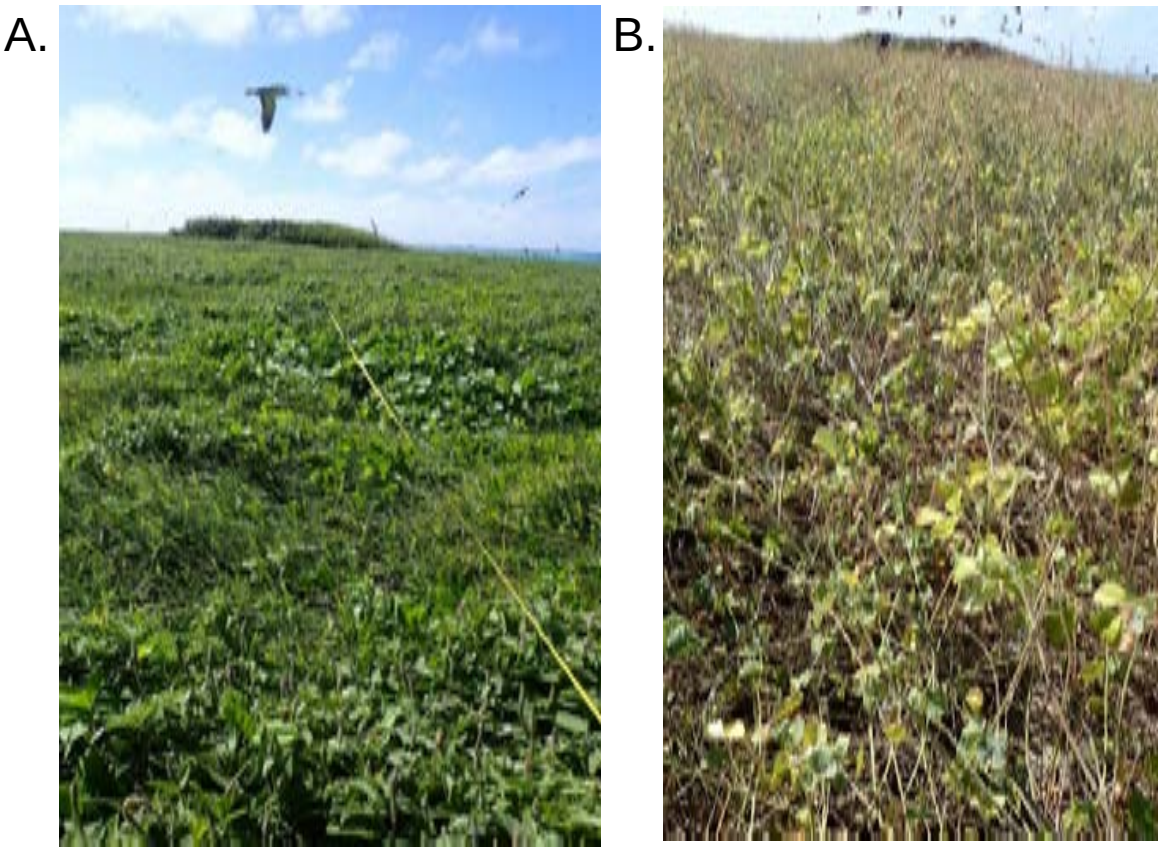

Figure 51. Facing North changes in vegetation at site M08 between 2021 and 2023, East Diamond Islet. A. 2021, B. 2023. Credit: Joy Brushe ©.

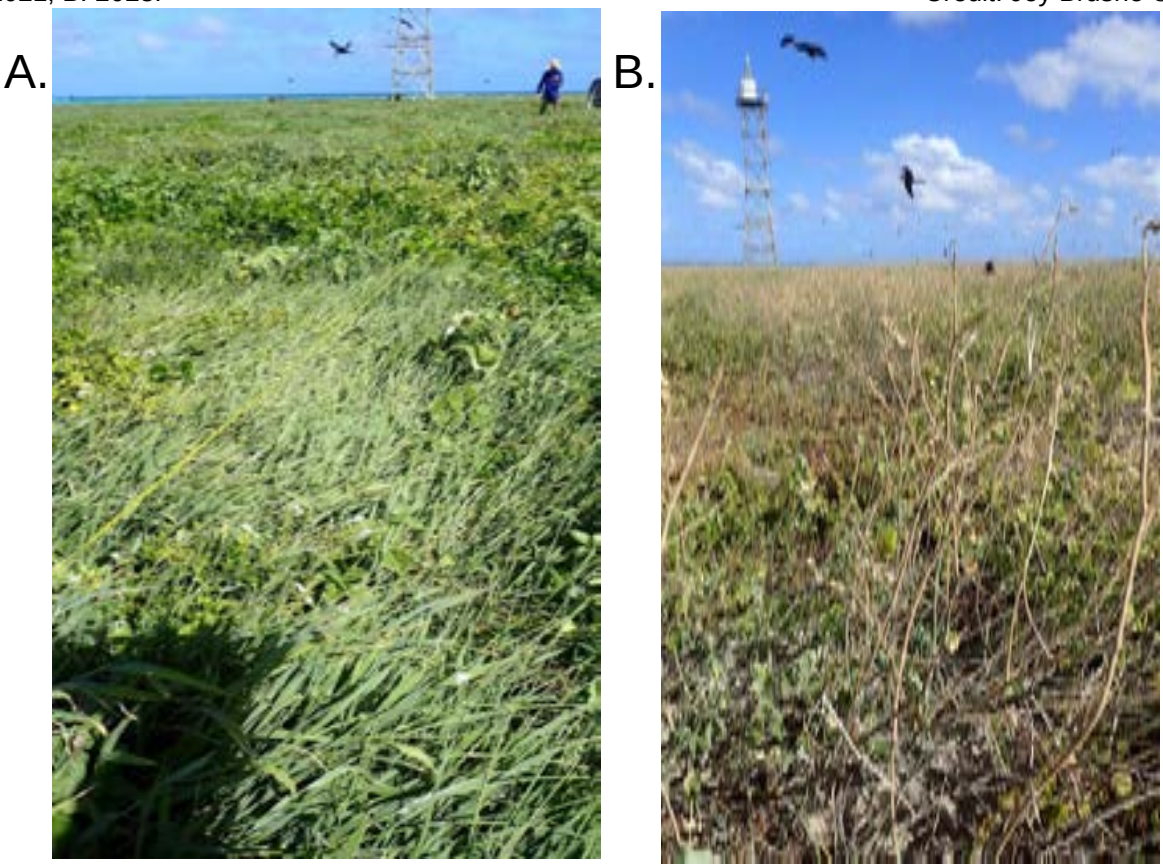

Figure 52. Facing South changes in vegetation at site M08 between 2021 and 2023, East Diamond Islet. A. 2021, B. 2023. Credit: Joy Brushe ©.

A. B.

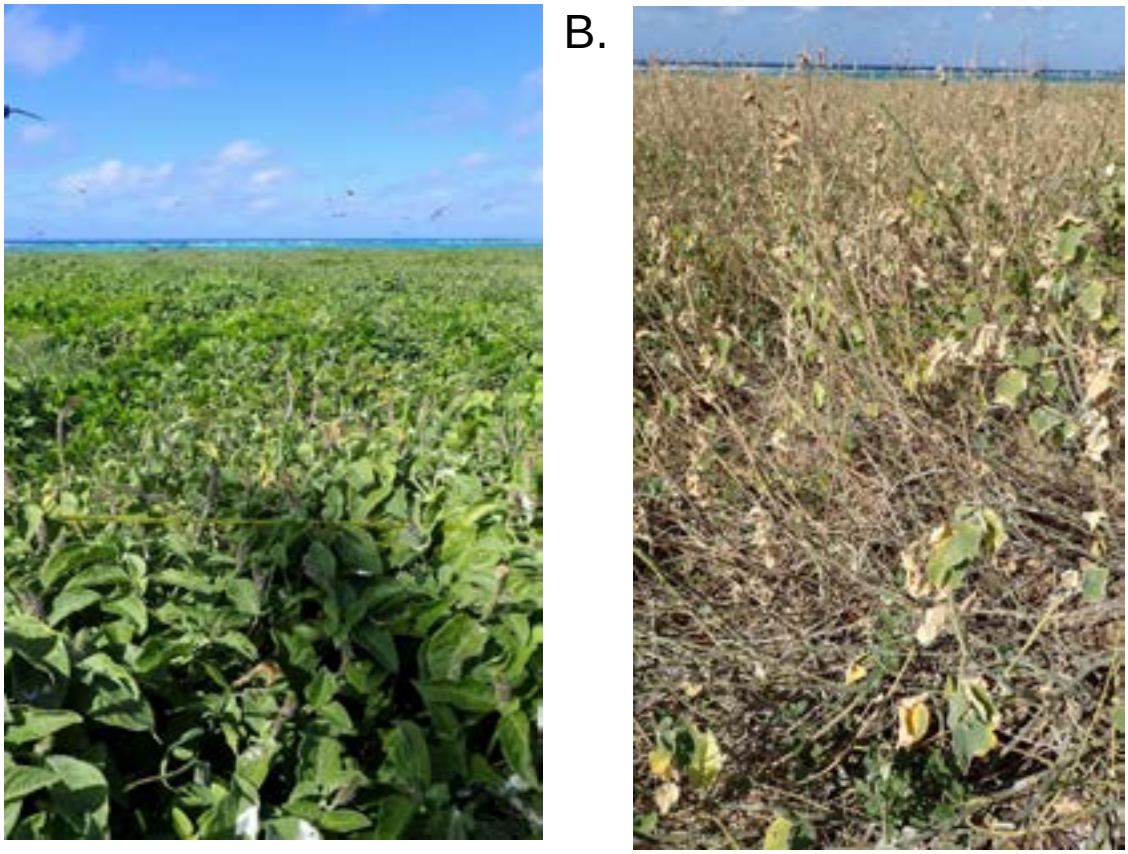

Figure 53. Facing East changes in vegetation at site M08 between 2021 and 2023, East Diamond Islet. A. 2021, B. 2023. Credit: Jov Brushe ©.

A. B.

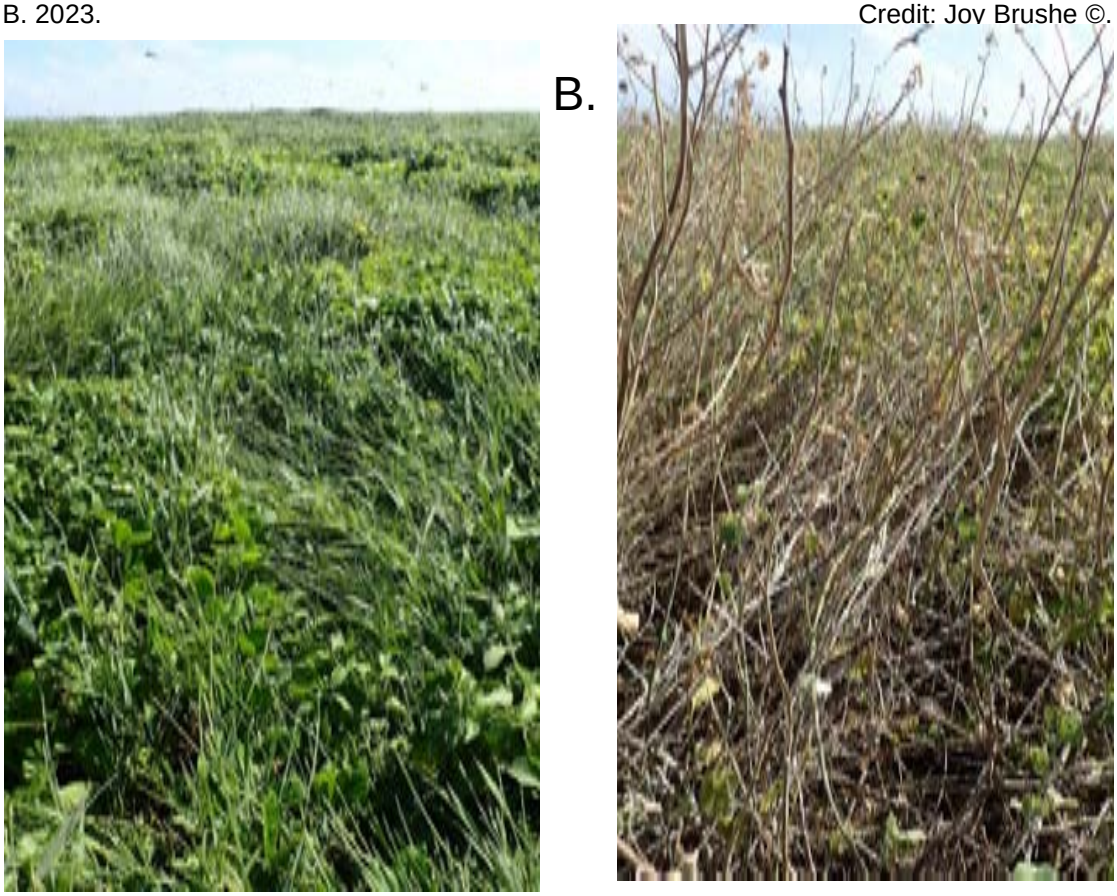

Figure 54. Facing West changes in vegetation at site M08 between 2021 and 2023, East Diamond Islet. A. 2021, B. 2023. Credit: Joy Brushe ©.

2.3.4 Soil

Soil samples were collected from BioCondition monitoring site M23 on East Diamond Islet.

Results of soil analyses from site M23 samples were similar to those of other samples collected in interior shrublands during the 2021 to 2023 voyages.

Total sulphur levels were high in all CSMP samples collected during the 2022 and 2023 voyages (including the M23 sample) compared with previous samples.

Refer to Appendix 9. 2023 Soil analysis results for all results of the soil analyses for samples from M23. For comparison of M23 soil analysis data with data from those for other CSMP and Capricorn Bunker cays in the southern GBR, refer to Appendix 8. Comparison of soils data.

2.3.5 Birds

Species nesting along the beach fringe were targeted for monitoring given the time available to survey (apart from the lesser frigatebird (*Fregata ariel)* count on the eastern end and internal counts of red-footed booby (*Sula sula)* nests). The vegetation experts observed two small colonies of crested terns (*Thalasseus bergii)*. Table 25 contains the bird data for East Diamond Islet. Photographs (Figure 55-59) are some of the bird photographs taken at East Diamond Islet.

Other observations:

- Two dead red-tailed tropicbird chicks were seen (not included in Table 25).
- 27 breeding pairs of red-tailed tropicbirds were observed during the 2022 survey, compared to the 20 observed in 2023. Birds may have been missed this survey or have been part of the breeding event on North East Cay (Herald Cays).
- Lesser frigatebird count was observed over 5.4ha at the eastern end of the Islet.
- The Pacific golden plovers had unusually blue legs.

Table 25. Species and breeding effort at East Diamond Islet.
Key: P= Present, U= Unknown, NR= Not recorded

East Diamond Islet, Tregrosse Reefs 31/05/2023		Breeding status				
Common name	Scientific name	Nests	Chicks	Young	Breeding pairs	Adolescents and adults
red-tailed tropicbird	*Phaethon rubricauda roseotinctus*	19	1	0	20	22
Herald petrel	*Pterodroma heraldica*	0	0	0	0	0
wedge-tailed shearwater	*Ardenna pacifica*	0	0	0	0	0
great frigatebird	*Fregata minor*	U	U	U	U	P
lesser frigatebird	*Fregata ariel*	1140	P		1140	1220
masked booby	*Sula dactylatra dactylatra*	26	0	0	26	37
brown booby	*Sula leucogaster*	P	0	0	P	56
red-footed booby	*Sula sula*	422	0	0	422	459
sooty tern	*Onychoprion fuscatus*	P	P		P	P
bridled tern	*Onychoprion anaethetus*	0	0	0	0	0
crested tern	*Thalasseus bergii*	50	0	0	50	58
roseate tern	*Sterna dougallii*	0	0	0	0	0
black-naped tern	*Sterna sumatrana*	0	0	0	0	0
New Caledonian fairy tern	*Sternula nereis exsul*	0	0	0	0	0

black noddy	*Anous minutus*	228			228	255
brown noddy	*Anous stolidus*	NR	NR	NR	NR	P
buff-banded rail	*Gallirallus philippensis tounelieri*	0	0	0	0	P
purple swamphen	*Porphyrio melanotus*	0	0	0	0	0
sacred kingfisher	*Todiramphus sanctus*	0	0	0	0	0
masked lapwing	*Vanellus miles novaehollandiae*	0	0	0	0	0
white-faced heron	*Egretta novaehollandiae*	0	0	0	0	0
eastern reef egret	*Egretta sacra*	0	0	0	0	0
Pacific golden plover	*Pluvialis fulva*	0	0	0	0	3
ruddy turnstone	*Arenaria interpres*	0	0	0	0	0
wandering tattler	*Tringa incana*	0	0	0	0	0
grey-tailed tattler	*Tringa brevipes*	0	0	0	0	0
lesser sand plover	*Charadrius mongolus*	0	0	0	0	0
welcome swallow	*Hirundo neoxena*	0	0	0	0	2
tree martin	*Petrochelidon nigricans*	0	0	0	0	0
magpie-lark	*Grallina cyanoleuca*	0	0	0	0	0
hardhead	*Aythya australis*	0	0	0	0	0
eastern great egret	*Ardea alba*	0	0	0	0	0
little pied cormorant	*Microcarbo melanoleucos*	0	0	0	0	0

Figure 55. Red-footed booby on East Diamond Islet.
Credit: Andrew McDougall ©, Queensland Government.

Figure 56. Black noddy at nest with chick on East Diamond Islet.
Credit: Andrew McDougall ©, Queensland Government.

Figure 57. A red-tailed tropicbird on East Diamond Islet.
Credit: Andrew McDougall ©, Queensland Government.

Figure 58. Great frigatebird (female) at nest with chick on East Diamond Islet.
Credit: Andrew McDougall ©, Queensland Government.

Figure 59. Lesser frigatebird (female) at nest on East Diamond Islet.
Credit: Andrew McDougall ©, Queensland Government.

2.3.6 Invertebrates and rodents

Rodents

In the morning 8 rodent tracking tunnels and 3 trail cameras were placed in strategic positions around the cay. That afternoon the traps were retrieved, however showed no sign of rodent activity. Thorough searches of the cay were conducted however, no trace of rodents was evident (Table 26).

Table 26. Rodent survey results from East Diamond Islet.

Location: Tregrosse Reef East Diamond Islet **Sampler:** Chad Hoult QPWS **Date Collected:** 31/05/2023				
Rodent Stations	**GPS**	**Tracks**	**scat**	**Trail camera**
9	17,44080-151.07549	no	no	-
10	17,44101-151.07634	no	no	-
11	17.44186-151.07527	no	no	yes
12	17.44403-151.07114	no	no	-
13	17.44316-151.07196	no	no	-
14	17.43991-151.07486	no	no	yes
15	17.43991-151.07483	no	no	yes
16	17.43856-151.07642	no	no	-

Ants

Between 2300-2550 ants were recorded across 11 ant stations (Table 27). Three samples were taken for identification.

Table 27. Ant survey results from East Diamond Islet.

Location: Tregrosse Reef – East Diamond Islet **Sampler:** Chad Hoult QPWS **Date Collected:** 31/05/2023				
Ant Stations	**GPS**	**Specimen number**	**Species**	**Amount**
9	17.44080-151.07549		unknown	50-100
10	17.44101-151.07634		unknown	250
11	17.44186-151.07527		unknown	250
12	17.44403-151.07114		unknown	50-100
13	17.44316-151.07196		unknown	500
14	17.43991-151.07486		unknown	500
15	17.43991-151.07483		unknown	500
16	17.43856-151.07642		unknown	50 -100
17	17.44104 -151.07457	31	*Nylanderia obscura*	50-100
18	17.44077-151.07545	21	*Tetramorium simillimum?*	50-100
19	17.44003-151.07639	22	*Tetramorium simillimum?*	50

Insects

A total of 545 insects were counted, and 21 insect samples were collected for identification (Table 28). Two introduced species were identified, the German Cockroach (*Blattella germanica*) and an ant species known as *Tetramorium simillimum.*

Table 28. Insect survey results from East Diamond Islet.

Location: Tregrosse Reef East Diamond Islet
Sampler: Chad Hoult QPWS
Date Collected: 31/05/2023

Specimen number	Class	Order	Family	Species	Introduced	Count	Amount collected	GPS
13	Arachnida	Araneae	?			3	1	S17.44316- E151.07196
14	Arachnida	Araneae	?Araneidae			15	1	S17.43991-E151.07486
15	Insecta	Diptera	Sarcophagidae	indet. species		12	1	S17.43991-E151.07483
16	Arachnida	Araneae	?Araneidae			23	1	S17.43856-E151.07642
17	Chilopoda	Scolopendromorpha	Scolopendridae			9	1	S17.44003-E151.07639
18	Insecta	Orthoptera	Acrididae	*Aiolopus thalassinus*		100	1	S17.43930-E151.07520
19	Malcostraca	Isopoda				100	1	S17.44281-E151.07327
20	Insecta	Blattodea	Ectobiidae	*Blattella germanica*	yes	34	1	S17.43839-E151.07596
21	Insecta	Hymenoptera	Formicidae	*Tetramorium ?simillimum*	yes	50	6	S17.44077-E151.07545
22	Insecta	Hymenoptera	Formicidae	*Tetramorium ?simillimum*	yes	10	5	S17.44003-E151.07639
23	Insecta	Hemiptera	Cicadellidae	indet. species		4	1	S17.44086-E151.07632
24	Arachnida	Araneae	?Araneidae			5	1	S17.44127-E151,97561
25	Insecta	Lepidoptera	Erebidae	*Utetheisa* sp.		23	1	S17.44162-E151.07538
26	Insecta	Blattodea				5	1	S17.44162-E151.07474
27	Insecta	Lepidoptera				4	1	S17.44202-E151.97437
28	Chilopoda	Scolopendromorpha	Scolopendridae	*Scolopendra morsitans*		6	1	S17.44220-E151.07396
29	Insecta	Orthoptera	Acrididae	*Aiolopus thalassinus*		50	1	S17.44268-E151.07365
30	Insecta	Blattodea	Ectobiidae	*Blattella germanica*	yes	50	1	S17.44268-E151.07301
31	Insecta	Hymenoptera	Formicidae	*Nylanderia 'obscura'*		5	1	S17.44113-E151.07370
32	Insecta	Hemiptera	Coccoidea			34	6	S17.44982-E151.07423
33	Arachnida	Ixodida	Ixodidae	*Amblyomma loculosum*		3	1	S17.44060-E151.07423

2.3.7 Health Checks

Table 29. Health Check results – Octopus Bush (*Argusia argentea*) shrublands on East Diamond Islet.
Key: **G = good**; **GC = good with some concerns**; **SC = significant concern**; **C = critical**; **NA** = not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G	G			G
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	G	G	G			G
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G	G			G
7. Trampling, digging or rooting or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	G	G			G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	G			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	G	G	G			G
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	G	G	G			G
Overall Condition Class						G

Overall, the Health Check results indicate a 'good' rating for octopus bush shrublands on East Diamond Islet (Table 29).

Table 30. Health Check results – Sea Trumpet (*Cordia subcordata*) shrublands on East Diamond Islet.
Key: **G = good**; **GC = good with some concerns**; **SC = significant concern**; **C = critical**; **NA =** not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G	G			G
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	G	G	G			G
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G	G			G
7. Trampling, digging or rooting or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	G	G			G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	G			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	SC	SC	SC			SC
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	GC	GC	GC			GC
Overall Condition Class						SC

Extensive dieback across most sea trumpet shrub was observed. Overall, the Health Check results indicate a 'significant concern' rating for sea trumpet shrublands on East Diamond Islet (Table 30).

2.4 Willis Islets – South Islet

South Islet is the only cay in the CSMP which is inhabited. At any given time, four Bureau of Meteorology staff are on the cay working in the 'Willis Island' weather station.

Figure 60: Voyegers arriving at the Bureau of Meteorology weather station on South Islet.
Credit: Andrew McDougall ©, QWPS.

2.4.1 Drone imagery

A total of 927 nadir images were acquired with the Zenmuse P1 35mm camera, at a target height of 80m above take-off (concrete pad on the north-east of the station facilities). These images were initially processed in ESRI SiteScan with Pix4DengineSDK version 5.0.45, however as the orthomosaic quality was poor, the imagery was reprocessed in Drone Deploy (Figure 62).

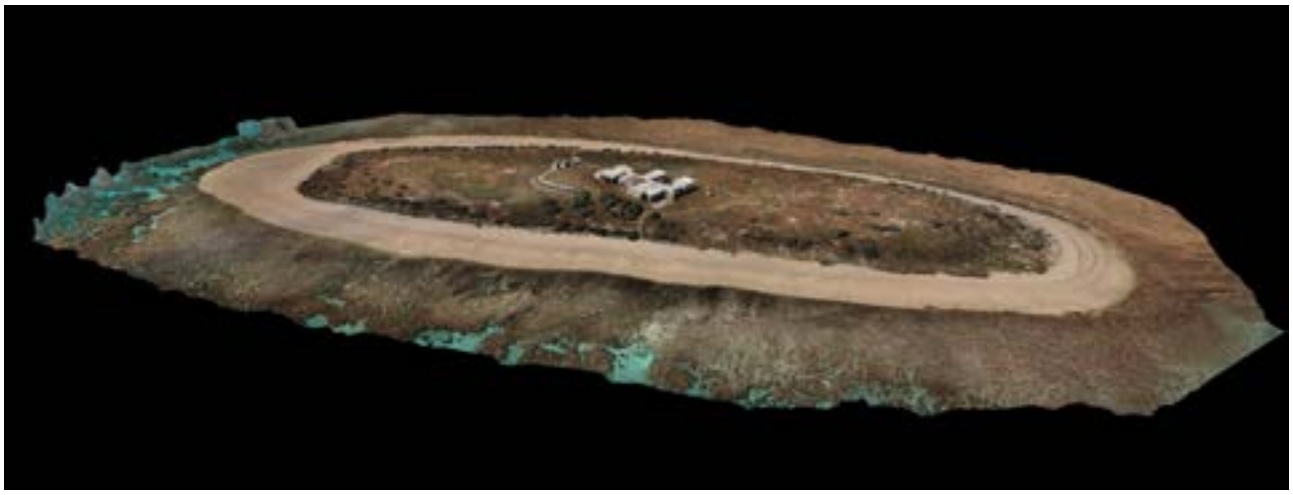

Figure 61: 3D Model (mesh) of South Islet from Drone Deploy.
Credit: Dan Wilkins ©, Parks Australia.

Figure 62. South Islet orthomosaic preview (Pix4DengineSDK version 5.0.45), showing the entire island (coral sand beaches, vegetation and station infrastructure), as well as a portion of the exposed reef (low tide). Credit: Dan Wilkins ©, Parks Australia.

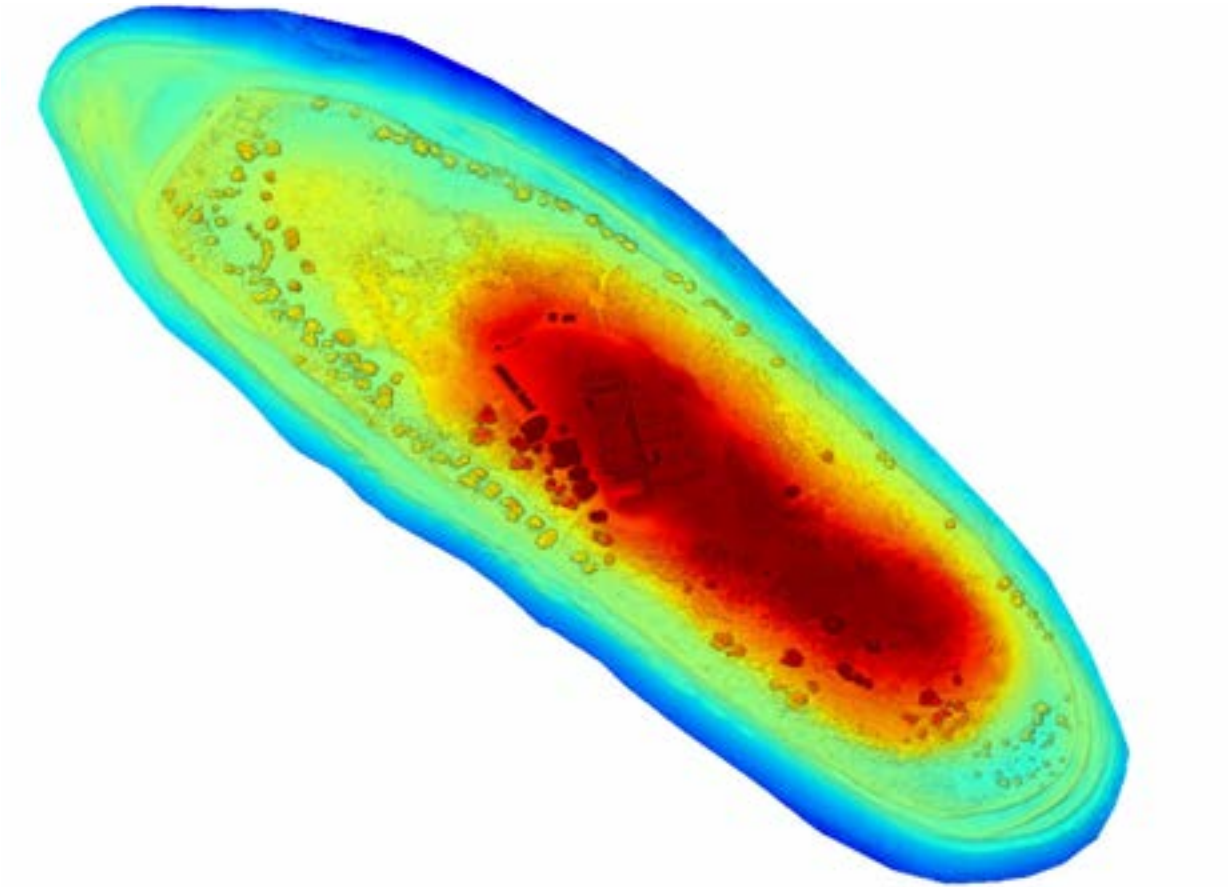

Figure 63: Digital Elevation Model of South Islet (Drone Deploy model) (3.6cm resolution). Credit: Dan Wilkins ©, Parks Australia.

Figure 64. South Islet Normalised Difference Vegetation Index (NDVI), cropped to the shoreline.
Credit: Dan Wilkins ©, Parks Australia.

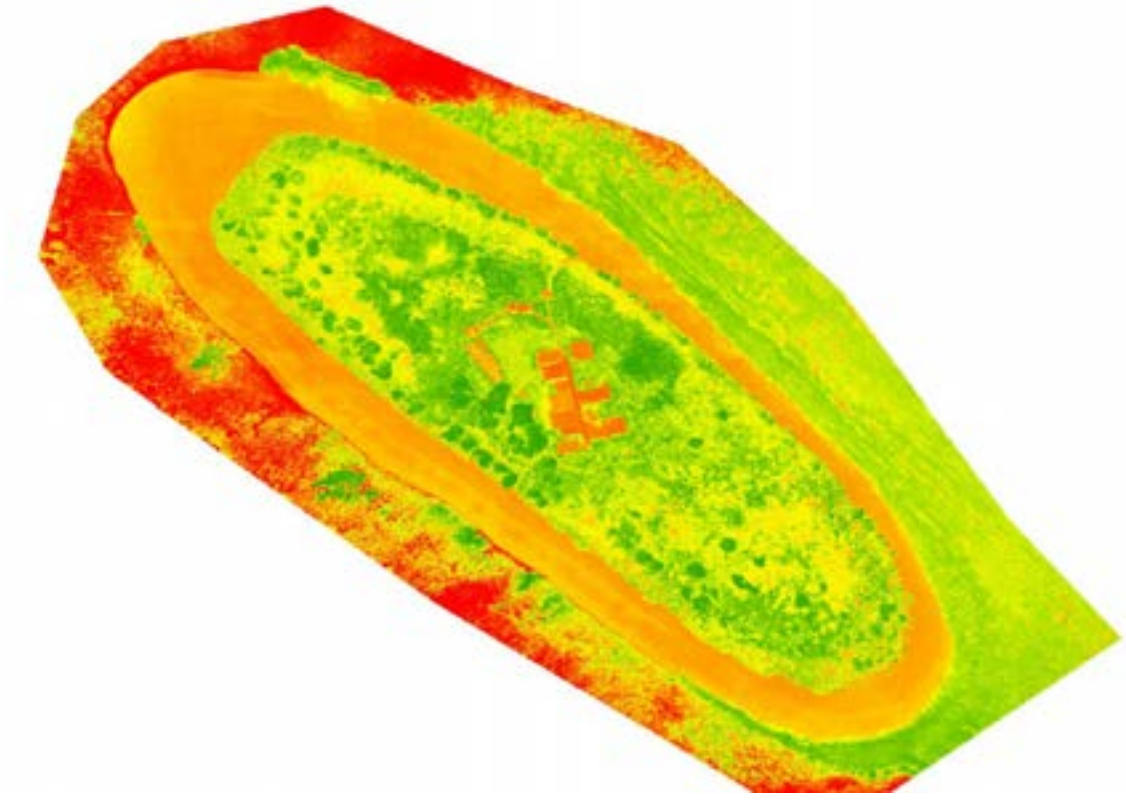

Figure 65. South Islet Soil Adjusted Vegetation Index (SAVI) (L value of 0.5).
Credit: Dan Wilkins ©, Parks Australia.

2.4.2 Physical description

South Islet is a vegetated cay located approximately 470 km ENE of Cairns and 480 km northeast of Townsville at -16.2873 degrees latitude and 149.9645 degrees longitude. The beaches are approximately 30m wide with a 75m wide sand spit at the northwestern end. Low dunes are present around the outside perimeter of the vegetation adjoining the beach and landward of the dunes is a narrow swale. The interior is a central plateau with steep slopes rising from a narrow terrace adjacent to the dunal swale in most places. Adjacent to the North West spit is a flat area approximately 100m wide.

Figure 66 and 67 shows surface elevation profiles of South Islet prepared by Dan Wilkins. As no survey marks exist, raw elevation was adjusted by adding 62 metres to bring all values into an approximate sea level metric (dubbed ‘above low tide’). Note that this is not “mean sea level”. This digital elevation model is based off the surface, as reconstructed by photogrammetry. Buildings, structures, and trees/bushes are featured in the elevation model and subsequent transect outputs.

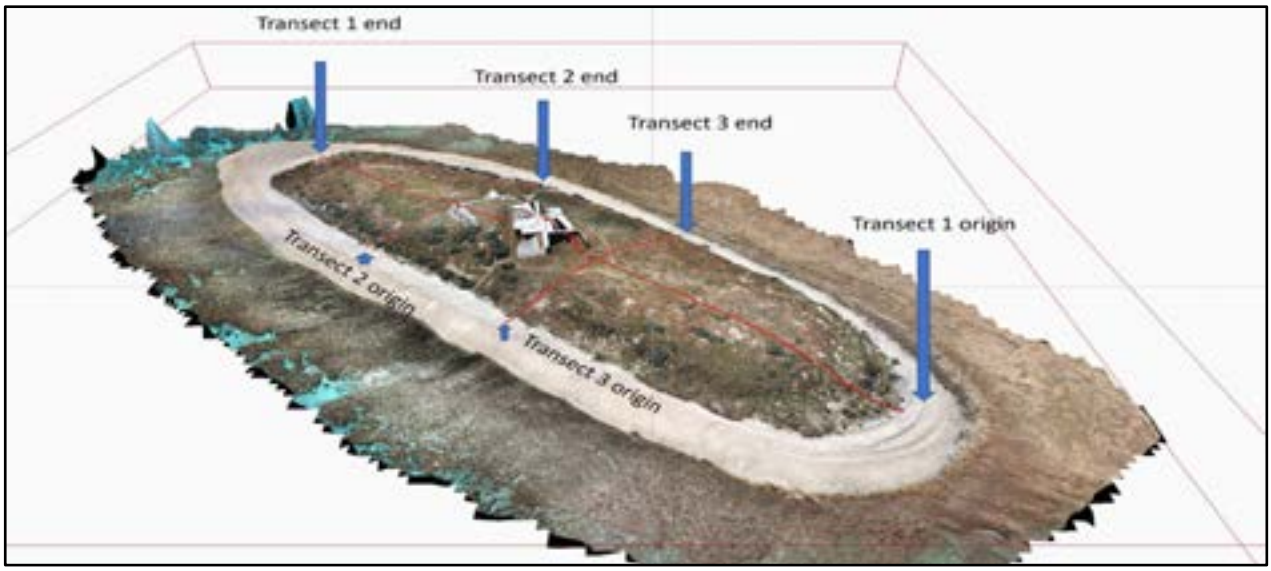

Figure 66. Surface elevation profiles of South Islet. Credit: Dan Wilkins ©, Parks Australia.

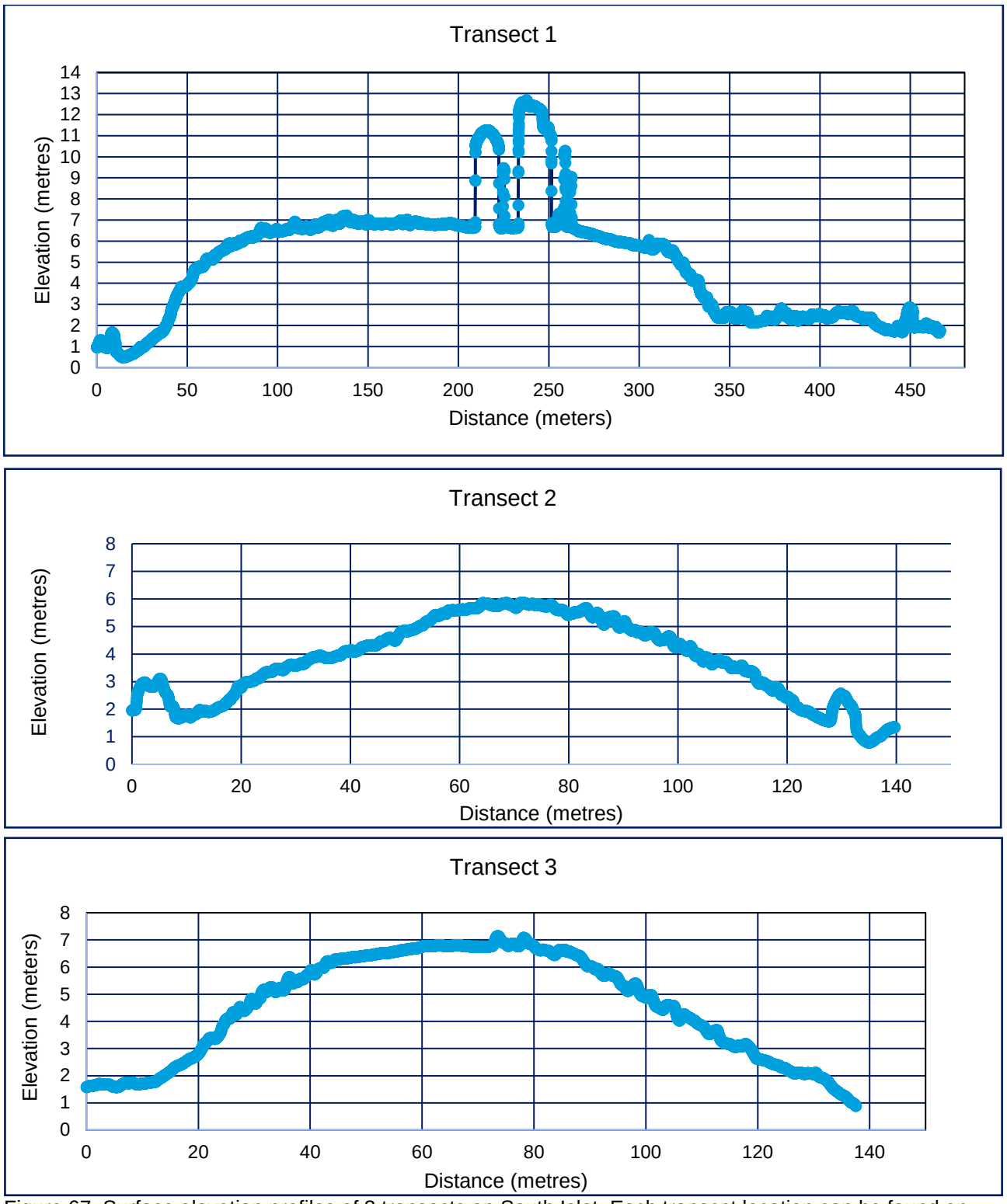

Figure 67. Surface elevation profiles of 3 transects on South Islet. Each transect location can be found on Figure 66.

2.4.3 Vegetation

Survey intensity

On 1-2 June 2023, two people each spent approximately 8.6 hours surveying the vegetation of South Islet. Vegetation data was recorded at 30 ground-truthing sites in the natural areas. The locations of these sites are shown in Figure 68. The yellow lines are the boundaries of the vegetation communities shown on the vegetation map in Figure 107.

The mown Operational Area was also systematically surveyed and a comprehensive species list compiled for this area.

Specimens of 20 species (11 native species and nine weed species) were collected for incorporation into national and state herbaria.

Figure 68. South Islet showing the number and location of ground-truthing vegetation survey sites relative to the vegetation map unit boundaries.

Vegetation condition

At the time of the June 2023 survey, just under 1 ha (17% of the vegetated area of the cay) was dominated by weeds (Figure 69).

The presence of weeds in the natural areas reduces the area of available bird nesting habitat. Whilst brown noddies (*Anous stolidus)* will nest on top of dwarf poinsettia *(Euphorbia cyathophora)* albeit in lower numbers and wedge tailed shearwaters (*Ardenna pacifica)* will burrow under it, sooty terns (*Onychoprion fuscatus*) and brown boobies (*Sula leucogaster*) are unlikely to nest in it. If control measures for this weed are not implemented, it is likely that it will continue to spread, further reducing the available nesting habitat for these and possibly other bird species.

The weed species, Mossman River grass (*Cenchrus echinatus*) is an annual which dies back in winter (Figure 70). The fuel load resulting from large quantities of standing dead Mossman River grass is increasing the fire risk.

At the time of the survey the natural vegetation was in good condition in areas where weeds were absent.

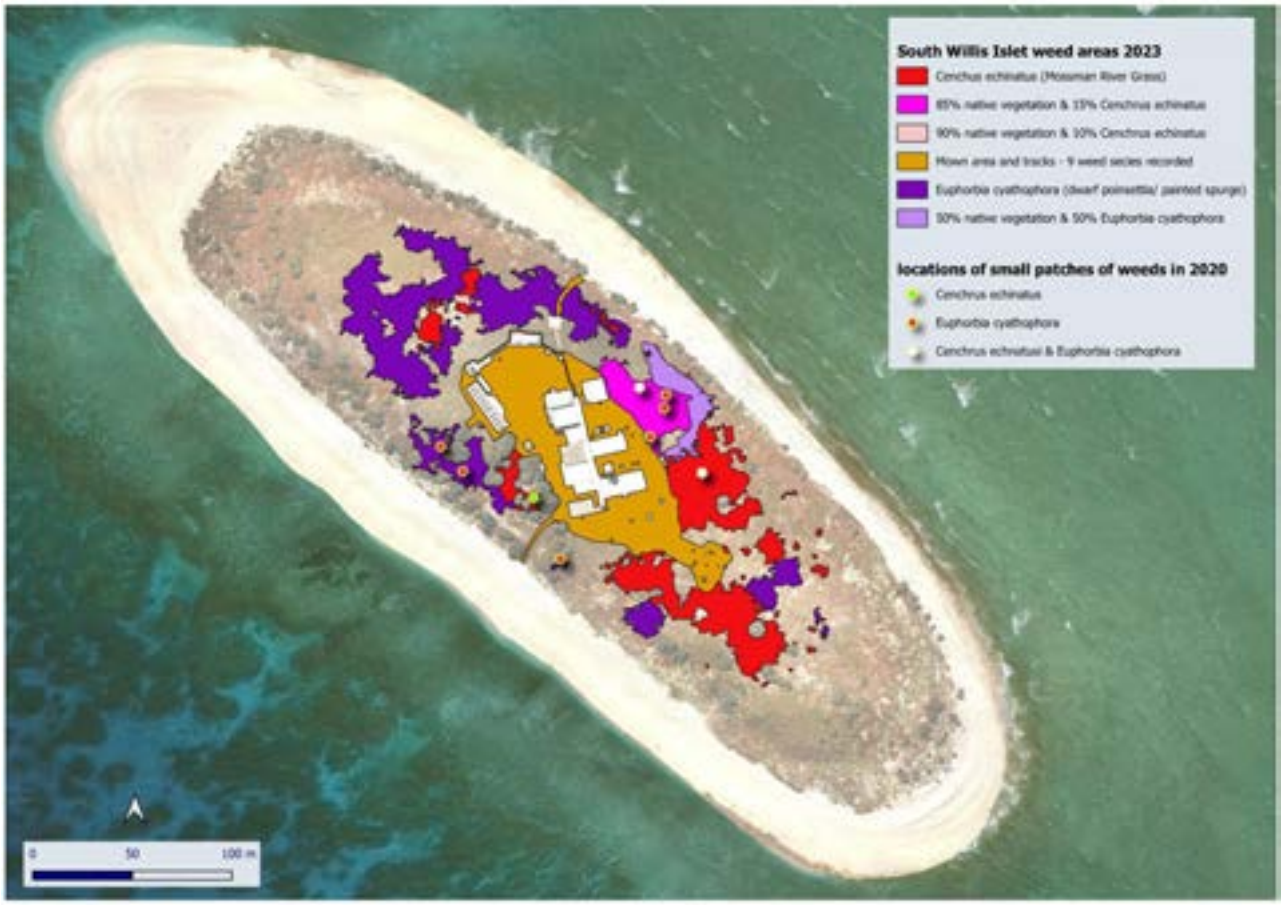

Figure 69. Distribution of weeds on South Islet, June 2023.


Figure 70. Dead Mossman River grass (*Cenchrus echinatus*) plants, a weed species, increase the fire risk in the natural areas. The green grass is native cay grass, South Islet. Credit: Joy Brushe ©.

Floristic data

All 20 plant species currently present on South Islet were collected for incorporation into state and national herbaria.

Native cay species

Eleven native cay plant species were recorded in the natural areas. White flowered tar vine (*Boerhavia albiflora* var. *albiflora*) was the most widespread species in the natural area, present in 83% of the sites. Other widespread species were stalky grass (*Lepturus repens*), pig weed (*Portulaca oleracea*), marine couch (*Sporobolus virginicus*) and bulls head burr (*Tribulus cistoides*). The species marine couch had the highest overall cover of 12.3%.

The native shrub, octopus bush (*Argusia argentea*) formed shrubland communities around the perimeter of the shoreline as is typical for this species. It was also present in parts of the interior, either as small patches of shrubland or isolated plants. The presence of this species in the interior may represent locations of former shoreline or locations where blown octopus bush seeds established on bare ground following cyclone impacts.

There are no previous herbarium or confirmed report records of beach buffalo grass (*Stenotaphrum micranthum*) on South Islet prior to the 2020 survey, although this species is quite common on other CSMP cays.

Lantern bush (*Abutilon albescens*) has been recorded as present on the cay in the past. This species was not seen during the 2020 survey and only one plant was seen during the 2023 survey. This was a mature seeding plant.

A single juvenile plant of sea trumpet (*Cordia subcordata*) was growing adjacent to the lantern bush shrubland on the dunes on the northeastern coastline. This species has not been recorded previously on South Islet.

Table 31 contains the frequency in sites, the averaged cover for each species for sites in which the species was present and their averaged cover over the entire cay for each of the plant species present in the natural areas on the cay. Data for occurrence and cover of each species in the natural areas in relation to vegetation community and landform are contained in Table 33.

Introduced plant species (weeds)

Although native grasses and other herbs were present in the human-use areas, these were present in very low abundance. Nine weed species were present in the mown area, tracks and edges of the mown area (Table 32). The mown area was dominated by coast button grass (*Dactyloctenium aegypticum*), a species not native to Australia or the CSMP cays.

Seven of the 9 weed species in the Operational Area do not currently occur in the natural areas.

Two weed species, dwarf poinsettia (*Euphorbia cyathophora*) and Mossman River grass (*Cenchrus echinatus*) were present in the natural areas. These weeds cover approximately 5500$m^{2,}$ and 4200 m^2 respectively in the natural area, reducing the area of already restricted CSMP native cay communities. They would both have originally established as a result of human activity but are now also being spread around by birds. Both are significant problem weeds in the southern GBR. If these weeds continue to spread on the cay, habitat of sooty terns (and possibly other bird species) will be lost.

Dwarf poinsettia (*Euphorbia cyathophora)* forms a dense ground cover to about 0.7 metre high (Figure 71 and 72). Although brown noddies and shearwaters will probably continue to nest in areas infested with this species, sooty terns will not nest in dense infestations.

Mossman River grass (Cenchrus echinatus) has prickly seeds that easily adhere to clothing, footwear and feathers (Figure 73 and 74). It is an annual and dies back in the winter dry season.

Summer grass *(Digitaria ciliaris),* an exotic annual weed grass was recorded during the 2023 survey. This species has not been recorded previously on South Islet or any other location in the CSMP.

Khaki weed (*Alternanthera pungens*) and tridax daisy (*Tridax procumbens*), both previously recorded on South Islet (Willis Islets) in 1995 and 2007 respectively, were not seen during the 2020 or 2023 surveys. Mexican poppy (*Argemone ochroleuca*), a species documented as present on the cay in the Willis Island Building Rectification Plan for contractors (Bureau of Meteorology, 2013), was not seen during the 2020 or the 2023 surveys. There are no herbarium records for this species confirming its presence on any CSMP cay and its presence on South Islet has not been documented in any available previous reports.

Figure 71. Dwarf poinsettia (*Euphorbia cyathophora*) a weed species on South Islet.
Credit: Joy Brushe ©.

Figure 72. Dwarf poinsettia (*Euphorbia cyathophora*) growing at site 36 on South Islet.
Credit: Joy Brushe ©.

Figure 73. Various images of Mossman River grass (*Cenchrus echinatus*).
Credit: Joy Brushe ©.

Figure 74. Mossman River grass (*Cenchrus echinatus*) growing at site 39 on South Islet.
Credit: Joy Brushe ©.

Table 31. Plant species recorded in the natural areas on South Islet.
Layer: (G) = ground
Lifeform: G = grass, Ga = annual or short-lived grass, Gp = perennial grass, H = herb, Ha = annual or short-lived herb, Hp = perennial herb, S = shrub, ST = large shrub/small tree, V = vine
Data for naturalized exotic species not native to Australia (weeds) are shown in red

Scientific name	Common name	Family	Life form	Presence in sites (% of sites)	Average % cover for each layer (averaged cover only for sites in which species was present)	Overall average % cover for each layer (averaged cover over all sites including 0% covers at sites where species was absent)
Argusia argentea	octopus bush	Boraginaceae	ST	13%	30.0% (S1), 2.5% (G)	3.0% (S1), 0.1% (G)
Abutilon albescens	lantern bush	Malvaceae	S	One plant only, not recorded in any site		
Achyranthes aspera	chaff flower	Amaranthaceae	Ha	33%	5.0%	1.7%
Boerhavia albiflora var. *albiflora*	white flowered tar vine	Nyctaginaceae	Hp	83%	7.5%	6.3%
Cenchrus echinatus	Mossman River grass	Poaceae	Ga	17%	38.0%	6.3%
Cordia subcordata	sea trumpet	Boraginaceae	ST	3%	2.5%	0.15%
Euphorbia cyathophora	dwarf poinsettia	Euphorbiaceae	Ha	20%	47.9%	9.6
Ipomoea pes-caprae subsp. *brasiliensis*	goats foot convolvulus	Convolvulaceae	V	7%	15.0%	1.0%
Lepturus repens	stalky grass	Poaceae	Gp	50%	15.2%	7.6%
Portulaca oleracea	pig weed	Portulaceae	H	47%	5.2%	2.4%
Sporobolus virginicus	marine couch	Poaceae	Gp	43%	28.3%	12.3%
Stenotaphrum micranthum	beach buffalo grass	Poaceae	G	3%	15.0%	0.5%
Tribulus cistoides	bulls head burr	Zygophyllaceae	Ha	37%	3.6%	1.3%
Total no of species in natural areas = 13 (11 native species, 2 weed species)						

Table 32. Lists all introduced plant (weed) species recorded in the mown Operational Area on South Islet.
Lifeform: Ga = annual or short- lived grass, Gp = perennial grass, Ha = annual or short lived herb, Hp = perennial herb

Scientific name	**Common name**	**Family**	**Life form**
Amaranthus viridis	green amaranth	Amaranthaceae	Ha
Cenchrus echinatus	Mossman River grass	Poaceae	Ga
Dactyloctenium aegyptium	coast button grass	Poaceae	Ga
Digitaria ciliaris	summer grass	Poaceae	Ga
Eleusine indica	crows foot grass	Poaceae	Ga
Euphorbia cyathophora	dwarf poinsettia	Euphorbiaceae	Ha
Euphorbia prostrata	red caustic creeper	Euphorbiaceae	Ha
Trianthema portulacastrum	black pigweed	Aizoaceae	Hp
Gynandropsis gynandra	cat's whiskers	Cleomaceae	Ha

Planted species

Trees and shrubs not native to the CSMP cays (coconuts and *Casuarina*) that were planted on the cay prior to Cyclone Yasi, have not been replanted and have not re-established naturally. During the 2023 visit, planted species consisted only of food plants. The hanging garden arrangement used during the 2020 visit (Brushe 2021) was no longer in use. Most food plants were growing hydroponically in a purpose-built enclosure inside the enclosed deck area within the building (Figure 77-80). There were also a few potted food plants enclosed in the deck area (Figures 75 and 76).

These food plants should not be a biosecurity risk if:

- Potting mixes are made from materials sourced only from the South Islet or have been obtained from reputable suppliers and guaranteed to be suitably sterilized (weed, pest and pathogen free) and sealed in suitable packaging before leaving the mainland.
- Dead plants, prunings and or spent potting material are placed in sealed packaging for incineration or removal from South Islet.
- Food plants do not include invasive weeds likely to self-establish in the cay environment.

Figure 75. Potted food plants in indoor deck area on South Islet. Credit: Joy Brushe ©.

Figure 76. Planting mix and potted food plants on South Islet. Credit: Joy Brushe ©.

Figure 77. Indoor hydroponics setup for food plants. Credit: Joy Brushe ©.

Figure 78. Indoor hydroponics set up, outside perspective. Credit: Joy Brushe ©.

Figure 79. Indoor hydroponics setup, seedlings. Credit: Joy Brushe ©.

Figure 80. Indoor hydroponics setup. Credit: Joy Brushe ©.

Vegetation communities

No pisonia (*Pisonia grandis*) communities were present on South Islet. Table 33 lists the vegetation communities present on South Islet in 2023, the total area and representative survey sites for each. Appendix 6. Extent and distribution of CSMP cay vegetation communities 2019 to 2023 contains comparisons with equivalent and similar communities on other CSMP cays.

Table 33. Vegetation communities on South Islet (Willis Islets).

Vegetation Map Unit Description		Total area (m^2)	Sites
Naturally unvegetated areas			
A	Sandy shores	3.26	No sites
B	Lithified shores	3.81	No sites
C	Rubble banks	0.16	No sites
0	Naturally bare	0.01	No sites
Shorelines beaches and sand spits			
1a	Littoral sparse to open grassland/herbland dominated by *Lepturus repens* and/or *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea* on sandy shorelines and sand spits	0.09	20, 24
2a	*Argusia argentea* open shrubland/isolated shrubs on shorelines and sand spits	0.01	No sites
2bi	Coastline *Argusia argentea* shrubland with a mid-dense ground layer dominated by *Lepturus repens*	0.34	33
2bii	Coastline *Argusia argentea* shrubland with a sparse ground layer dominated by *Sporobolus virginicus* and *Tribulus cistoides*	0.000	43
Grasslands			
3a	*Lepturus repens* grassland to closed grassland with *Boerhavia albiflora* var. *al*biflora	0.22	32
3b	*Lepturus repens*/*Boerhavia albiflora* var. *albiflora* grassland/herbland with occasional *Portulaca oleracea* and *Tribulus cistoides*	0.18	22, 25, 31
5	*Stenotaphrum micranthum* grassland to closed grassland with *Boerhavia albiflora* var *albiflora* and occasional *Portulaca oleracea*, *Sporobolus virginicus* +/-*Tribulus cistoides*	0.03	42, 45
17	*Sporobolus virginicus* grassland to closed grassland with occasional *Boerhavia albiflora* var. *albiflora*, *Tribulus cistoides* and *Achyranthes aspera*	0.21	29
17a	*Sporobolus virginicus*/*Boerhavia albiflora* var. *albiflora*/*Tribulus cistoides* open grassland/open herbland	0.11	No sites
17c	*Sporobolus virginicus*/*Ipomoea pes-caprae* subsp. *brasiliensis* closed grassland with occasional *Achyranthes aspera*	0.16	37
17d	*Sporobolus virginicus*/*Ipomoea pes-caprae* subsp. *brasiliensis* grassland / herbland with *Boerhavia albiflora* var. *albiflora* and occasional *Euphorbia cyathophora*, *Achyranthes aspera*, *Portulaca oleracea* and *Tribulus cistoides*	0.01	48
17e	*Sporobolus virginicus*/*Achyranthes aspera*/*Tribulus cistoides* closed grassland with occasional *Boerhavia albiflora* var. *albiflora* (+/- *Cenchrus echinatus*)	0.83	41
19	*Cenchrus echinatus* closed grassland +/- *Euphorbia cyathophora* +/- *Lepturus repens* +/- occasional *Achyranthes aspera*, *Boerhavia albiflora* var. *albiflora* and *Tribulus cistoides*	0.42	35, 38, 39
Herblands			
6	*Boerhavia albiflora* var. *albiflora* open herbland	0.32	No sites
6a	*Boerhavia albiflora* var. *albiflora*/*Portulaca oleracea*/ *Tribulus cistoides* herbland	0.04	44
6b	*Boerhavia albiflora* var. *albiflora*/*Portulaca oleracea*/ *Stenotaphrum micranthum* open herbland with occasional *Lepturus repens*	0.03	46
6f	*Boerhavia albiflora* var. *albiflora*/*Sporobolus virginicus open herbland*	0.06	No sites
21	*Tribulus cistoides* open herbland to herbland with *Boerhavia albiflora* var. *albiflora* +/- *Lepturus repens* +/- *Sporobolus virginicus*	1.08	19, 21, 26, 27, 30, 34, 40
22	*Euphorbia cyathophora* naturalised closed herbland +/-*Lepturus repens* +/- occasional *Achyranthes aspera* +/- occasional *Cenchrus echinatus, Boerhavia albiflora* var. *albiflora* and *Tribulus cistoides*	0.55	23, 28, 36
Interior shrublands			
2c	Interior *Argusia argentea* shrubland with a mid-dense ground layer dominated by *Sporobolus virginicus* +/- *Cenchrus e*chinatus	0.22	47
15	*Abutilon albescens* dwarf shrub	0.0001	No sites
Human use areas			
20	Mown areas and tracks	0.50	no sites (species list only)
I	Infrastructure	0.21	no sites
	Total area (ha)	12.85	
	Total vegetated natural area (ha)	4.91	
	Total area dominated by weeds (ha)	1.47	
	% of total vegetated area dominated by weeds	0.27	

Note: Areas of sandy 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.

Photographs and descriptions of vegetation communities

Shorelines beaches and sand spits

Unit 1a Littoral sparse to open grassland/herbland dominated by stalky grass (*Lepturus repens)* and/or white flowered tar vine (*Boerhavia albiflora* var. *albiflora)* +/- pig weed *(Portulaca oleracea)*

Vegetation community 1a consists of isolated plants establishing outside the seaward edge of the existing vegetation (Figure 81 and 82). Vegetation in this unit is dynamic establishing when conditions are suitable and then disappearing again as a result of coastal erosion, turtle nesting activity or unfavourable. climatic conditions.

Ground truthing sites: 20, 24

Figure 81. Vegetation map unit 1a, Site 20 South Islet. Credit: Joy Brushe ©.

Figure 82. Vegetation map unit 1a, Site 24 South Islet. Credit: Joy Brushe ©.

Unit 2a Coastline octopus bush (*Argusia argentea*) open shrubland/isolated shrubs on shorelines and sand spits

No sites or photographs for this community

Unit 2bi Coastline octopus bush (*Argusia argentea*) shrubland with a mid-dense ground layer dominated by stalky grass (*Lepturus repens)*

Ground truthing site: 33

Unit 2bii Coastline octopus bush (*Argusia argentea)* shrubland with a sparse ground layer dominated by marine couch (*Sporobolus virginicus)* and bulls head burr (*Tribulus cistoides)*

Ground truthing site: 43

2a, 2bi (Figure 83) and 2bii (Figure 84) are octopus bush shrubland communities located on the low coastal dunes and sand spits adjacent to the beach. They form a discontinuous zone around the entire perimeter of the cay and provide important nesting habitat for red-footed boobies, noddies and frigatebirds.

Figure 83. Vegetation map unit 2bi, Site 33 Soth Islet. Credit: Joy Brushe ©.

Figure 84. Vegetation map unit 2bii, Site 43 South Islet. Credit: Joy Brushe ©.

Grasslands

Unit 3a Stalky grass (*Lepturus repens)* grassland to closed grassland with white flowered tar vine (*Boerhavia albiflora* var. *albiflora)*

Ground truthing site: 32

Unit 3b Stalky grass (*Lepturus repens)/white flowered tar vine (Boerhavia albiflora* var. *albiflora)* grassland/herbland with occasional pigweed (*Portulaca oleracea)* and bulls head burr *(Tribulus cistoides)*

Ground truthing sites: 22, 25, 31

Vegetation communities 3a (figure 85) and 3b (Figure 86 and 87) together with the coastal octopus bush (*Argusia argentea*) communities, are present on low coastal dunes around the outer perimeter of the vegetated area. Unit 3a is dominated by stalky grass and unit 3b is co-dominated by stalky grass and herbaceous species, predominantly white flowered tar vine. Other species present include pigweed and bulls head burr. Chaff flower (*Achyranthes aspera*) is present in one site in unit 3b.

Figure 85. Vegetation map unit 3a, Site 32, South Islet. Credit: Joy Brushe ©.

Figure 86. Vegetation map unit 3b, Site 22, South Islet. Credit: Joy Brushe ©.

Figure 87. Vegetation map unit 3b, Site 31, South Islet Credit: Joy Brushe ©.

Unit 5 Beach buffalo grass (*Stenotaphrum micranthum)* grassland to closed grassland with white flowered tar vine (*Boerhavia albiflora* var *albiflora)* and occasional pigweed (*Portulaca oleracea)*, marine couch (*Sporobolus virginicus)* +/- bulls head burr *(Tribulus cistoides)*

Vegetation community 5 is relatively infrequent, occurring in only two locations on the cay both located on lower slopes in the southeast of the cay (Figure 88 and 89).

Ground truthing sites: 42, 45

Figure 88. Vegetation map unit 5, Site 42, South Islet. Credit: Joy Brushe ©.

Figure 89. Vegetation map unit 5, Site 45, South Islet. Credit: Joy Brushe ©.

Sporobolus virginicus grassland communities 17, 17a, 17c, 17d and 17e

These vegetation communities are all dominated by marine couch (*Sporobolus virginicus*) and consist of closed grasslands which cover much of the vegetation on the slopes of the cay.

Communities 17c and 17d contain goats foot convolvulus (*Ipomoea pes-caprae* subsp. *brasiliensis*) and in some areas this species is co-dominant with marine couch. South Islet is the only CSMP cay with goats foot convolvulus communities, although this species is more common on GBR cays.

Areas of marine couch grassland containing the weeds, dwarf poinsettia (*Euphorbia cyathophora*) and Mossman River grass (*Cenchrus echinatus*) have been mapped separately to obtain accurate distribution maps to assist with weed management.

Community 17e contains chaff flower (*Achyranthes aspera*) and is located on the upper slopes.

Unit 17 Marine couch (*Sporobolus virginicus)* grassland to closed grassland with occasional white flowered tar vine (*Boerhavia albiflora var. albiflora),* bulls head burr *(Tribulus cistoides)* and chaff flower *(Achyranthes aspera)* (Figure 90).

Ground truthing site: 29

Figure 90. Vegetation map unit 17, Site 29, South Islet. Credit: Joy Brushe ©.

Unit 17a Marine couch (*Sporobolus virginicus)/*white flowered tar vine *(Boerhavia albiflora* var. *albiflora)/*pigweed *(Tribulus cistoides)* open grassland/open herbland

No sites or photographs for this community

Unit 17c Marine couch (*Sporobolus virginicus)/*goats foot convolvulus (*Ipomoea pes-caprae* subsp. *brasiliensis)* closed grassland with occasional chaff flower (*Achyranthes aspera)* (Figure 91 and 92).

Ground truthing site: 37

Figure 91. Vegetation map unit 17c, Site 37 South Islet. Credit: Joy Brushe ©.

Figure 92. *Ipomoea pes-caprae* subsp*. brasiliensis* growing with *Sporobolus virginicus* in vegetation map unit 17c, Site 37 South Islet. Credit: Joy Brushe ©.

Unit 17d Marine couch (*Sporobolus virginicus)/*goats foot convolvulus (*Ipomoea pes-caprae* subsp*. brasiliensis)* grassland/herbland with white flowered tar vine (*Boerhavia albiflora* var*. albiflora*) and occasional dwarf poinsettia (*Euphorbia cyathophora),* chaff flower *(Achyranthes aspera),* pigweed *(Portulaca oleracea)* and bulls head burr (*Tribulus cistoides)* (Figure 93 and 94).

Ground truthing site: 48

Figure 93. Vegetation map unit 17d, Site 48 South Islet. Credit: Joy Brushe ©.

Figure 94. Vegetation map unit 17d, Site 48 South Islet. Credit: Joy Brushe ©.

Unit 17e Marine couch (*Sporobolus virginicus)/*chaff flower *(Achyranthes aspera)/* bulls head burr *(Tribulus cistoides)* closed grassland with occasional white flowered tar vine (*Boerhavia albiflora* var*. albiflora)* +/- Mossman River grass *(Cenchrus echinatus)* (Figure 95).

Ground truthing site: 41

Figure 95. Vegetation map unit 17e, Site 41 South Islet. Credit: Joy Brushe ©.

Unit 19 Mossman River grass *(Cenchrus echinatus)* naturalised closed grassland +/- dwarf poinsettia *(Euphorbia cyathophora)* +/- stalky grass (*Lepturus repens)* +/- occasional chaff flower (*Achyranthes aspera),* white flowered tarn vine (*Boerhavia albiflora var. albiflora)* and bulls head burr *(Tribulus cistoides)*

Ground truthing sites: 35, 38, 39

Vegetation community 19 is dominated by the naturalised exotic grass, Mossman River grass (*Cenchrus echinatus*) which has replaced former native cay communities (predominantly marine couch (*Sporobolus virginicus)* grasslands) (Figure 96 and 97). Mossman River grass is an annual which dies off in winter increasing the fire risk in this vegetation community. Prickly seeds of this species readily attach to feathers and birds are now spreading it around the cay.

Figure 96. Vegetation map unit 19, Site 35 South Islet. Credit: Joy Brushe ©.

Figure 97. Vegetation map unit 19, Site 39 South Islet. Credit: Joy Brushe ©.

Herblands

Vegetation communities 6, 6a, 6b and 6f are dominated by white flowered tar vine *(Boerhavia albiflora* var. *albiflora*).

6a is co-dominated by pigweed (*Portulaca oleracea*) and bulls head burr (*Tribulus cistoides*) (Figure 98).

6b is co-dominated by pigweed (*Portulaca oleracea*) and contains beach buffalo grass (*Stenotaphrum micranthum*) (Figure 99).

Unit 6 White flowered tar vine (*Boerhavia albiflora* var. *albiflora)* open herbland

No sites or photographs for this community

Unit 6a White flowered tar vine (*Boerhavia albiflora* var*. albiflora)/*pigweed *(Portulaca oleracea)/*bulls head burr *(Tribulus cistoides)* herbland

Ground truthing site: 44

Figure 98. Vegetation map unit 6a Site 44, South Islet. Credit: Joy Brushe ©.

Unit 6b White flowered tar vine (*Boerhavia albiflora* var. *albiflora)/* pigweed *(Portulaca oleracea)/*beach buffalo grass *(Stenotaphrum micranthum)* open herbland with occasional stalky grass (*Lepturus repens)*

Ground truthing site: 46

Figure 99. Vegetation map unit 6b Site 46, South Islet. Credit: Joy Brushe ©.

Unit 6f White flowered tar vine (*Boerhavia albiflora* var*. albiflora)*/marine couch *(Sporobolus virginicus)* open herbland

No sites or photographs for this community

Unit 21 Bulls head burr (*Tribulus cistoides)* open herbland to herbland with white flowered tar vine (*Boerhavia albiflora* var. *albiflora) +/-* stalky grass *(Lepturus repens) +/-* marine couch *(Sporobolus virginicus)*

Ground truthing sites: 19, 21, 26, 27, 30, 34, 40

Vegetation community 21 was one of the most abundant vegetation communities in the interior of the cay at the time of the 2023 survey. Large numbers of seabirds were nesting in this vegetation community (Figure 100 and 101).

Figure 100. Vegetation map unit 21 in foreground, Site 19, South Islet. Credit: Joy Brushe ©.

Figure 101. Vegetation map unit 21 Site 30, South Islet. Credit: Joy Brushe ©.

Unit 22 Dwarf poinsettia *(Euphorbia cyathophora)* naturalized closed herbland +/- stalky grass (*Lepturus repens)* +/- occasional chaff flower (*Achyranthes aspera),* Mossman River grass *(Cenchrus echinatus),* white flowered tar vine *(Boerhavia albiflora var. albiflora)* and bulls head burr (Tribulus cistoides)

Ground truthing sites: 23, 28, 36

Vegetation community 22 is dominated by the naturalized exotic herb, dwarf poinsettia (*Euphorbia cyathophora*) (Figure 102 and 103). This highly invasive species is difficult to control and is a major problem on Lady Elliot Island, Heron Island and other cays in the southern GBR.

Figure 102. Vegetation map unit 22 Site 28, South Islet. Credit: Joy Brushe ©.

Figure 103. Vegetation map unit 22 Site 36, South Islet. Credit: Joy Brushe ©.

Interior shrublands

Unit 2c Interior octopus bush (*Argusia argentea)* shrubland with a mid-dense ground layer dominated by marine couch (*Sporobolus virginicus)* +/- Mossman River grass (*Cenchrus echinatus)*

Ground truthing site: 47

Octopus bush (*Argusia argentea*) shrublands (Figure 104 and 105) are typically found around the seaward perimeter of cay vegetation where the plants establish from ocean dispersed seed. The presence of this community in the elevated areas in the interior of the cay could be the result of colonization of bare areas by windblown seed during/following cyclone disturbance or result from seeds distributed to areas of higher elevation by cyclonic wave surges. The presence of octopus bush in interior areas with lower elevation may indicate previous shoreline locations.

Figure 104. Vegetation map unit 2c Site 47, South Islet. Credit: Joy Brushe ©.

Figure 105. Vegetation map unit 2c Site 47, South Islet. Credit: Joy Brushe ©.

Unit 15 Lantern bush (*Abutilon albescens*) dwarf shrub

No sites or photographs for this community. Only one plant of lantern bush was seen on the cay during the 2023 visit. The plant was mature and fertile.

Mown areas (including beach access tracks)

No sites (species list only) (Figure 106).

Figure 106. Mown lawn in the Bureau's Operational Area dominated by coast button grass (*Dactyloctenium aegyticum*), South Islet. Credit: Joy Brushe ©.

The area surrounding infrastructure in the Operational Area is regularly mown. This area is dominated by the exotic naturalised coast button grass (*Dactyloctenium aegypticum*).

Eight other weeds were also recorded during a thorough traverse of this area (Table 32).

Abundance of native cay species was quite low in the mown area, indicating that exotic naturalised species are outcompeting native species under current management regimes.

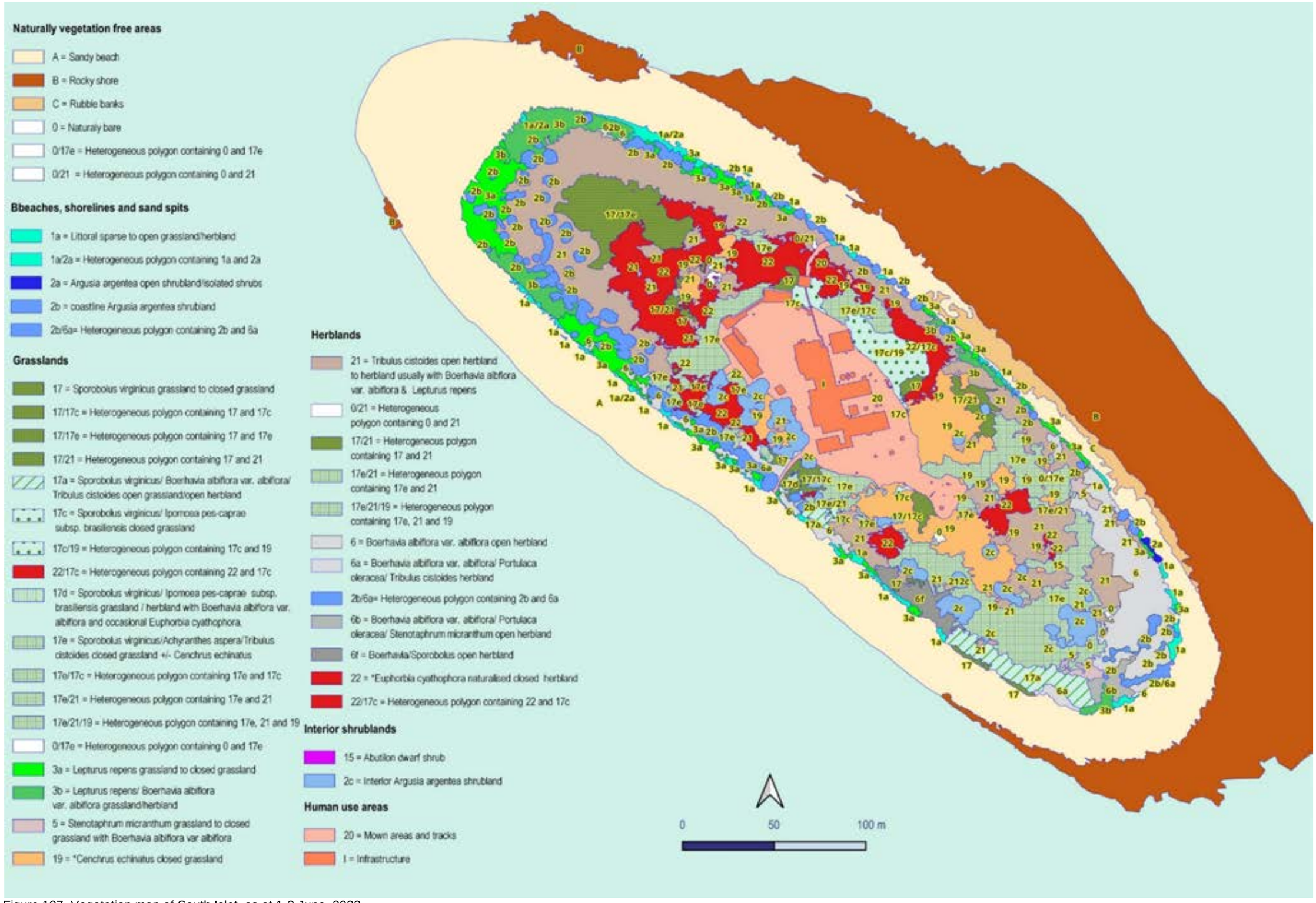

Figure 107. Vegetation map of South Islet, as at 1-2 June, 2023

Table 34. Site data recorded on South Islet.
Datum = WGS 84 green shading = site dominants Layers (after species name): S1 = Shrub, G = ground

Site	Number of Photos	Latitude	Longitude	Landform	Aspect	Soil description	Rock outcrop	Notes	Estimated altitude	Ground layer height	Shrub layer height	T/S canopy crown cover	U/S shrub crown cover	Dominant growth form	Ground FPC	Total weed cover %	Vegetation community description	Veg map unit	*Argusia argentea* S1	*Achyranthes aspera* G	*Argusia argentea* G	*Boerhavia albiflora* var. *albiflora* G	*Cenchrus echinatus* G	*Cordia subcordata* G	*Euphorbia cyathophora* G	*Ipomoea pes-caprae* subsp. *brasiliensis*- G	*Lepturus repens* G	*Portulaca oleracea* G	*Sporobolus virginicus* G	*Stenotaphrum micranthum* G	*Tribulus cistoides* G	Litter	Birds	Turtle activity
019	3	-16.286259	149.963963	slope (lower)	N	light grey-brown coarse sand with some organic content and fine coral rubble surface fragments		adjacent Argusia has dense Lepturus ground cover	2	10cm				herb	sparse (10-30%)	0	*Tribulus cistoides* open herbland with *Boerhavia albiflora* var. *albiflora*	21				trace-5%					trace-5%				5-25%	5-25%	large numbers sooty terns, some brown boobies, some brown noddies	
020	2	-16.286036	149.963742	beach	NNE	white coarse sand, abundant fine coral rubble fragments and abundant medium coral rubble surface fragments		from the edge of the octopus bush to the shoreline one polygon, frontal dune slope and adjacent beach	1					grass	very sparse (<10%)	0	*Lepturus repens*, *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea* open herbland	1a				trace-5%					5-25%	trace-5%				trace-5%	some brown noddies	
021	2	-16.286034	149.963320	slope (lower)	NW	light grey-brown coarse sand with some organic content and medium coral rubble surface fragments		some bare patches in this unit continuation of the same unit	2					herb	mid-dense (>30-70%)	0	*Tribulus cistoides* herbland with *Sporobolus virginicus*, *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea*	21				trace-5%						trace-5%	trace-5%		5-25%	5-25%	abundant sooty terns, some brown boobies, some brown noddies	
022	3	-16.285928	149.963183	dune		light grey-brown coarse sand with some organic content abundant fine coral rubble fragments and abundant coral rubble surface fragments			3					grass	mid-dense (>30-70%)	0	*Lepturus repens*, *Boerhavia albiflora* var. *albiflora* grassland/ herbland with *Portulaca oleracea* and *Tribulus cistoides*	3b				5-25%					5-25%	trace-5%			trace-5%	5-25%	abundant brown boobies	
023	11	-16.287396	149.964041	slope	SW	light coloured sand			4	60 cm				forb	dense (>70)	50-75%	*Euphorbia cyathophora*/ *Lepturus repens* closed herbland with *Cenchrus echinatus*, *Boerhavia albiflora* var. *albiflora* and *Tribulus cistoides*	22				trace-5%	trace-5%		50-75%		25-50%				trace-5%	5-25%	abundant brown noddies (nesting in grassy patches and on top of weeds), large numbers wedgetail shearwater burrows on upper but not lower slope, occasional brown boobies,	
024	4	-	149.9631	dune	SW	light coloured coarse sand, and coral rubble surface fragments		only occasional Argusia	1					herb	very sparse (<10%)	0	*Boerhavia albiflora* var. *albiflora*, *Lepturus repens* sparse herbland	1a				trace-5%	trace-5%				trace-5%	trace-5%				trace-5%	some sooty terns, some brown noddies	
025	3	-16.286737	149.963035	dune		light coloured coarse sand, and abundant coral rubble surface fragments			2					grass	mid-dense (>30-70%)	0	*Lepturus repens*, *Boerhavia albiflora* var. *albiflora* grassland/herbland with *Portulaca oleracea* and *Tribulus cistoides*	3b				5-25%					25-50%	trace-5%			trace-5%	trace-5%	abundant sooty terns, occasional brown noddies	
026	3	-16.286546	149.963016	slope (lower)	W	light grey-brown coarse sand with some organic content occasional fine coral rubble fragments and abundant coral rubble surface fragments		some bare patches	2					herb	mid-dense (>30-70%)	0	*Tribulus cistoides* herbland	21				trace-5%					trace-5%				5-25%	5-25%	abundant sooty terns, large numbers brown boobies	

Site	Number of Photos	Latitude	Longitude	Landform	Aspect	Soil description	Rock outcrop	Notes	Estimated altitude	Ground layer height	Shrub layer height	T/S canopy crown cover	U/S shrub crown cover	Dominant growth form	Ground FPC	Total weed cover %	Vegetation community description	Veg map unit	*Argusia argentea* S1	*Achyranthes aspera* G	*Argusia argentea* G	*Boerhavia albiflora* var. *albiflora* G	*Cenchrus echinatus* G	*Cordia subcordata* G	*Euphorbia cyathophora* G	*Ipomoea pes-caprae* subsp. *brasiliensis*- G	*Lepturus repens* G	*Portulaca oleracea* G	*Sporobolus virginicus* G	*Stenotaphrum micranthum* G	*Tribulus cistoides* G	Litter	Birds	Turtle activity
027	0	-	149.963					equals Site 026									*Tribulus cistoides* herbland	21																
028	3	-16.286758	149.963576	terrace		light coloured coarse sand with some organic content fine coral rubble fragments and occasional fine coral rubble surface fragments	low	100% litter cover under	5	70cm				forb	dense (>70)	75-95%	*Euphorbia cyathophora* closed herbland	22								75-95%							5-25%	some brown noddies	
029	4	-	149.963	terrace		light coloured sand		patches of chaff flower, high litter under	5					grass	dense (>70)	0	*Sporobolus virginicus* closed grassland	17		trace-5%		trace-5%							95-100%		trace-5%	trace-5%	abundant brown noddies, occasional brown boobies	
030	3	-	149.9633	slope	NW	light coloured sand, and coral rubble surface fragments		some bare patches	3	15cm				forb	mid-dense (>30-70%)	0	*Tribulus cistoides* herbland	21				trace-5%					trace-5%		trace-5%		25-50%	5-25%	abundant sooty terns, some brown noddies, some brown boobies	
031	3	-16.285906	149.963195	dune		light grey-brown coarse sand with some organic content fine coral rubble fragments and occasional medium coral rubble surface fragments		no marine couch	2					herb	mid-dense (>30-70%)	0	*Lepturus repens*, *Boerhavia albiflora* var. *albiflora*, *Portulaca oleracea* grassland/herbland with Achyranthes aspera and *Tribulus cistoides*	3b		trace-5%		5-25%					5-25%	5-25%			trace-5%	5-25%	abundant brown noddies, occasional sooty terns, some brown boobies	
032	3	-16.286101	149.962969	dune		light coloured coarse sand, and coral rubble surface fragments			2	70cm				grass	mid-dense (>30-70%)	0	*Lepturus repens*, *Boerhavia albiflora* var. *albiflora* grassland with *Portulaca oleracea* and *Tribulus cistoides*	3a				5-25%					25-50%	5-25%			trace-5%	5-25%	large numbers brown noddies, some brown boobies	high
033	4	-16.286185	149.963985	dune		light coloured coarse sand, occasional fine coral rubble fragments and coral rubble surface fragments		one only small struggling *Cordia* (collected small sample)	2		2	sparse (20-50%)	mid-dense (>50-80%)	shrub 1-2m	mid-dense (>30-70%)	0	*Argusia argentea* shrubland with a mi-dense ground layer dominated by *Lepturus repens*	2bi	25-50%	trace-5%		trace-5%		trace-5%			25-50%	5-25%			trace-5%	5-25%	large numbers red-footed boobies, some brown boobies, some brown noddies	
034	3	-16.286267	149.964000	slope (lower)	NNW	light grey-brown coarse sand with some organic content fine coral rubble fragments and medium coral rubble surface fragments			2					herb	sparse (10-30%)	0	*Tribulus cistoides* open herbland	21				trace-5%					trace-5%				5-25%	5-25%	abundant sooty terns, large numbers brown boobies	
035	4	-	149.9640	slope	NW			GPS taken at NE edge of MRG	6					grass	dense (>70)	75-95%	*Cenchrus echinatus* closed grassland with *Euphorbia cyathophora* and *Lepturus repens*	19					50-75%		5-25%		5-25%					occasional brown noddies	
036	3	-16.286650	149.964202	slope	W	light coloured coarse sand, and occasional medium coral rubble surface fragments			8					forb	dense (>70)	95-100%	*Euphorbia cyathophora* closed herbland	22		trace-5%					75-95%							trace-5%	some brown noddies, wedgetail shearwater burrows	

Site	Number of Photos	Latitude	Longitude	Landform	Aspect	Soil description	Rock outcrop	Notes	Estimated altitude	Ground layer height	Shrub layer height	T/S canopy crown cover	U/S shrub crown cover	Dominant growth form	Ground FPC	Total weed cover %	Vegetation community description	Veg map unit	*Argusia argentea* S1	*Achyranthes aspera* G	*Argusia argentea* G	*Boerhavia albiflora* var. *albiflora* G	*Cenchrus echinatus* G	*Cordia subcordata* G	*Euphorbia cyathophora* G	*Ipomoea pes-caprae* subsp. *brasiliensis*- G	*Lepturus repens* G	*Portulaca oleracea* G	*Sporobolus virginicus* G	*Stenotaphrum micranthum* G	*Tribulus cistoides* G	Litter	Birds	Turtle activity
037	4	-	149.9647	10%	NE	grey-brown coarse sand with some organic content	low		8					grass	dense (>70)	0	*Sporobolus virginicus*/ *Ipomoea pes-caprae* subsp. *brasiliensis* closed grassland	17c		trace-5%							5-25%			75-95%				large numbers brown noddies	
038	5	-	149.96465	slope	NNE	light coloured coarse sand			5					herb	dense (>70)	50-75%	*Cenchrus echinatus*/ Euphorbia cyathopora closed grassland/herbland with Sporobolus virginicus	19					25-50%		25-50%				5-25%		trace-5%	trace-5%	some brown noddies	
039	4	-16.287398	149.965199	slope	NE	light coloured coarse sand			7					grass	dense (>70)	75-95%	*Cenchrus echinatus*/ *Sporobolus virginicus* closed grassland with *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*	19		trace-5%		trace-5%	75-95%							5-25%		trace-5%	trace-5%	occasional brown boobies, occasional brown noddies, some wedgetail shearwater burrows	
040	3	-16.287296	149.965320	terrace		light grey-brown coarse sand with some organic content fine coral rubble fragments and medium coral rubble surface fragments			2					herb	mid-dense (>30-70%)	0	*Sporobolus virginicus*/ *Boerhavia albiflora* var. *albiflora*/ *Tribulus cistoides* grassland/herbland	21				5-25%							5-25%		5-25%	5-25%	large numbers brown noddies, large numbers brown boobies	
041	2	-	149.9654	slope	NE	light coloured coarse sand			6					grass	dense (>70)	trace-5%	*Sporobolus virginicus*/ *Achyranthes aspera*/ *Tribulus cistoides* closed grassland	17e			5-25%		trace-5%	trace-5%					25-50%		5-25%	5-25%	some wedgetail shearwater burrows, large numbers brown boobies, some brown noddies	
042	4	-16.287747	149.965734	slope	NE	light brown coarse sand with some organic content and fine coral rubble surface fragments			3	25cm				grass	mid-dense (>30-70%)	0	*Stenotaphrum micranthum* grassland with *Boerhavia albiflora* var. *albiflora* and *Tribulus cistoides*	5				5-25%						trace-5%	trace-5%	25-50%	5-25%	5-25%	large numbers brown boobies, large numbers brown noddies	
043	2	-16.287950	149.965992	dune		light coloured coarse sand, coral rubble fragments and abundant medium coral rubble surface fragments			2		2	sparse (20-50%)		shrub 1-2m	sparse (10-30%)	0	*Argusia argentea* shrubland with a sparse ground layer dominated by *Sporobolus virginicus* and *Tribulus cistoides*	2bii	5-25%			trace-5%						trace-5%	5-25%		5-25%	5-25%	some red-footed boobies, some brown noddies, large numbers black noddies	
044	3	-16.288349	149.966064	slope	E	light brown coarse sand with some organic content fine coral rubble fragments and medium coral rubble surface fragments			2					forb	mid-dense (>30-70%)	0	herbland dominated by Boerhavia *albiflora*, *Portulaca oleracea* and *Tribulus cistoides*	6a				5-25%						trace-5%	5-25%		5-25%	5-25%	large numbers brown noddies, some brown boobies	
045	4	-	149.9658	20%	SSE	light coloured coarse sand			5					grass	dense (>70)	0	*Stenotaphrum micranthum* closed grassland with Boerhavia *albiflora* var. *albiflora*	5			trace-5%	5-25%						trace-5%	5-25%	trace-5%	50-75%		5-25%	large numbers brown noddies	low
046	3	-16.288775	149.965829	terrace		light coloured coarse sand with some organic content occasional fine coral rubble fragments and medium coral rubble surface fragments			2					herb	sparse (10-30%)	0	open herbland dominated by *Boerhavia albiflora* var. *albiflora* and *Portulaca oleracea* with *Lepturus repens* and *Stenotaphrum micranthum*	6b				5-25%					trace-5%	5-25%	5-25%		5-25%	trace-5%	abundant sooty terns, some brown noddies, some brown boobies	low

Site	Number of Photos	Latitude	Longitude	Landform	Aspect	Soil description	Rock outcrop	Notes	Estimated altitude	Ground layer height	Shrub layer height	T/S canopy crown cover	U/S shrub crown cover	Dominant growth form	Ground FPC	Total weed cover %	Vegetation community description	Veg map unit	*Argusia argentea* S1	*Achyranthes aspera* G	*Argusia argentea* G	*Boerhavia albiflora* var. *albiflora* G	*Cenchrus echinatus* G	*Cordia subcordata* G	*Euphorbia cyathophora* G	*Ipomoea pes-caprae* subsp. *brasiliensis*- G	*Lepturus repens* G	*Portulaca oleracea* G	*Sporobolus virginicus* G	*Stenotaphrum micranthum* G	*Tribulus cistoides* G	Litter	Birds	Turtle activity
047	3	-16.288488	149.965695	slope	SSE	light grey-brown sand with some organic content			8		2	sparse (20-50%)		shrub 1-2m	mid-dense (>30-70%)	0	*Argusia argentea* interior shrubland with a mid-dense ground layer dominated by *Sporobolus virginicus*	2c	25-50%	5-25%		trace-5%							50-75%		5-25%	5-25%	large numbers red-footed boobies, large numbers brown noddies, some wedgetail shearwater burrows	
048	4	-	149.96430					adjacent to access track							mid-dense (>30-70%)	trace-5%	*Sporobolus virginicus*/*Ipomoea pes-caprae* subsp. *brasiliensis* grassland/ herbland with *Euphorbia cyathophora*	17d		trace-5%		5-25%		trace-5%	5-25%			trace-5%	5-25%			trace-5%	5-25%	large numbers sooty terns, large numbers brown noddies, occasional brown boobies	

Comparison with previous surveys

The vegetation of South Islet (Willis Islets) was previously surveyed and mapped in October 2020 (Brushe 2021). Due to the very dry conditions at that time, much of the vegetation had died back and not all species were evident. In 2020 there was no high-resolution aerial image to prepare a vegetation map, as a result the 2023 mapping is more detailed and accurate.

Although the 2020 and 2023 mapping were undertaken during different seasons and under different prevailing climatic conditions, comparison of the two vegetation maps show the distribution of the native cay vegetation communities to be similar. Much of the interior natural vegetation is now, however, dominated by the weeds dwarf poinsettia (*Euphorbia cyathophora*) and Mossman River grass (*Cenchrus echinatus*). Dwarf poinsettia was only present as occasional plants in a few locations during the 2019 survey and the only plants of Mossman River grass reported in October 2020 were a few standing dead plants.

The relative absence of weed plants growing in the natural areas at the time of the 2020 survey could have been due to the dry conditions at the time, with weeds present as a viable soil seed bank rather than living above ground plants.

The two weed species in the natural areas were both recorded prior to the 2020 visit (herbarium data and recorded in Batianoff et al, 2008). Mossman River grass was listed as infrequent and dwarf poinsettia as frequent in 2007 (Batianoff et al, 2008). The earliest records of dwarf poinsettia and Mossman River grass were 1981 and 1995 respectively.

Donaldson (1994) listed Mossman River grass as frequent at the collection locality recorded in his 1996 specimen record. This however may only describe abundance at the collection site, not necessarily the extent over the entire cay.

Large areas of herbland in the interior of the cay were dominated by bulls head burr (*Tribulus cistoides*) at the time of the 2023 survey. Although this species was present at the time of the October 2020 survey, it did not dominate any of the herbland communities at that time. It is an annual plant and therefore its abundance will naturally vary between seasons. Its cover may also have been reduced by the prevailing dry conditions during the 2020 survey. Wilgar (1994) reported bulls head burr as “prolific across the island”.

There were no previously confirmed records of beach buffalo grass (*Stenotaphrum micranthum*) prior to the 2020 survey. Although this species was recorded in October 2020, no collection was made due to the expense and logistical difficulty of import restrictions and import permit conditions. Samples were collected during the 2023 survey as part of a comprehensive collection of all species present on South Islet at the time of survey.

Wilgar (1994) described the distribution of octopus bush (*Argusia argentea*) as “scattered along the foreshore” in 1993-1994. He did not mention its presence in the interior of the cay.

Batianoff (2008) listed lantern bush (*Abutilon albescens*) as “Infrequent”. Wilgar (1994) reported lantern bush (referred to as *Abutilon indicum (asiaticum*) in his report) as “small colonies spread across the island). Only one plant of this species was recorded during the 2023 survey.

The weed summer grass (*Digitaria ciliaris*), recorded in the 2023 survey, was not recorded in previous surveys.

All other weeds recorded in the Operational Area in 2023 have been recorded previously.

Cat’s whiskers (*Gynandropsis gynandra*) was listed as present in the Willis Island Building Rectification Plan for Contractors (Bureau of Meteorology, 2013) together with the following comments:

“A few plants were seen early Sept-Nov 2011 project near the sewage tank and were removed as soon as they were identified. They re-grew after the irrigation sprinklers were installed and started appearing all around the operational area. It will take several seasons of targeted removal to eradicate”.

The species was referred to by a previous name, *Cleome gynandra* in the Bureau's document. No specimens or specimen records of this species were held by any of the national or state herbaria prior to the 2023 survey. Specimens have now been sent for incorporation into the National Herbarium in Canberra, the Queensland Herbarium in Brisbane and the Australian Tropical Herbarium in Cairns.

Common couch *(Cynodon dactylon* var*. dactylon)* was recorded on South Islet by Batianoff et al in 2007, but was not recorded during the 2020 or 2023 surveys.

Two weeds, previously recorded in the operational area, but not seen during either the 2020 or the 2023 survey or by Batianoff and Halford in their 2007 visit were:

- Khaki weed (*Alternanthera pungens*) recorded as a common weed on South Islet by Donaldson in 1994. This weed is quite invasive, so, if previously present, is likely to still be present on the cay. It has prickly seeds that easily attach to footwear, wheels etc., can spread quickly and is difficult to eradicate.
- Mexican poppy (*Argemone ochroleuca*) listed as present in the Building Rectification Plan for Contractors (Bureau of Meteorology, 2013). This species has not been recorded in any other reports and there are currently no herbarium records of this species for any CSMP cays.

Permanent BioCondition monitoring sites

Four permanent BioCondition monitoring were established and surveyed on South Islet in October 2020. BioCondition monitoring surveys were not repeated and no new permanent BioCondition monitoring sites were established on South Islet during the 2023 visit.

2.4.4 Soil

Previous analyses of South Islet soil samples from BioCondition monitoring site M02 in the vicinity of the grey water outlet had very high levels of some nutrients compared to other cays, particularly aluminium, iron, copper, manganese and zinc. Soil samples were collected again from this site during the 2023 visit for repeat analysis.

Levels of copper and iron were also high in the surface soil sample collected (single sample, 0-20cm depth) at the octopus bush (Argusia argentea) BioCondition monitoring site M04 in 2020. It was intended to collect more samples at a range of depths at this site during the 2023 survey however there was insufficient time.

Iron and alumnium levels in the 2023 sample from M02 were even greater than the extremely high levels in the 2020 samples from this site.

Copper, manganese, levels in both the 2020 and 2023 samples were considerably higher at site M02 than all other samples analysed.

Both 2020 and 2023 samples had higher electrical conductivity than all other samples except the 2006/2007 CHNNR samples.

Exchangeable calcium, potassium, magnesium and sodium were relatively high resulting in a high cation exchange capacity in the M02 soil samples in both the 2020 and 2023 South Islet samples.

The pH of the 2023 samples were lower than those in the 2020 samples. The pH of the 2023 samples at site M02 was the lowest pH of all the available data sets.

Total sulphur levels were high in all CSMP samples collected during the 2022 and 2023 voyages (including the 2023 M02 sample) compared with previous samples.

Refer to Appendix 9. 2023 Soil analysis results for results of all the 2023 soil analyses for samples from site M02. For comparison of the 2023 data with M02 2020 soil analysis and soil analyses from other CSMP and Southern GBR soil surveys, refer to Appendix 8. Comparison of soils data.

2.4.5 Birds

Table 35 contains the bird data from South Islet. An unusual concentration of otherwise terrestrial (Australian mainland) species were observed, including eastern great egret (*Ardea alba*) (deceased), hardhead (*Aythya australis*) (deceased), magpie-lark (*Grallina cyanoleuca*) (female, alive), masked lapwing (*Vanellus miles novaehollandiae*) (alive) and white-faced heron (*Egretta novaehollandiae*) (alive).

Four red-tailed tropicbirds (*Phaethon rubricauda roseotinctus*) appeared to be prospecting nesting sites (Figure 109). Birds would perform aerial displays and land occasionally inspecting the area under octopus bushes (*Argusia argentea*).

A welcome swallow (*Hirundo neoxena*) was seen hawking across open areas. This species was seen on several cays during the 2023 voyage and is probably a seasonal migrant

Figure 108. Brown noddy pair at nest on South Islet.
Credit: Andrew McDougall ©, Queensland Government.

Table 35. Species and breeding effort of birds at South Islet.
Key: P= Present, U= Unknown, NR= Not recorded

South Islet, Willis Islet 02/06/2023		Breeding status				
Common name	Scientific name	Nests	Chicks	Young	Breeding pairs	Adolescents and adults
red-tailed tropicbird	*Phaethon rubricauda roseotinctus*	0	0	0	0	4
Herald petrel	*Pterodroma heraldica*	0	0	0	0	0
wedge-tailed shearwater	*Ardenna pacifica*	0	0	0	0	0
great frigatebird	*Fregata minor*	0	0	0	0	1
lesser frigatebird	*Fregata ariel*	0	0	0	0	1
masked booby	*Sula dactylatra dactylatra*	0	0	0	0	2
brown booby	*Sula leucogaster*	94	0	0	94	400-500
red-footed booby	*Sula sula*	183	P	0	183	>200
sooty tern	*Onychoprion fuscatus*	13,205			13,205	13,800
bridled tern	*Onychoprion anaethetus*	0	0	0	0	0
crested tern	*Thalasseus bergii*	0	0	0	0	12
roseate tern	*Sterna dougallii*	0	0	0	0	0
black-naped tern	*Sterna sumatrana*	0	0	0	0	7
New Caledonian fairy tern	*Sternula nereisexsul*	0	0	0	0	0
black noddy	*Anous minutus*	P/U			P/U	P
brown noddy	*Anous stolidus*	7,840			7,840	8,400
buff-banded rail	*Gallirallus philippensis tounelieri*	0	0	0	0	P
purple swamphen	*Porphyrio melanotus*	0	0	0	0	0
sacred kingfisher	*Todiramphus sanctus*	0	0	0	0	0
masked lapwing	*Vanellus miles novaehollandiae*	0	0	0	0	3
white-faced heron	*Egretta novaehollandiae*	0	0	0	0	2
eastern reef egret	*Egretta sacra*	0	0	0	0	0
Pacific golden plover	*Pluvialis fulva*	0	0	0	0	1
Ruddy turnstone	*Arenaria interpres*	0	0	0	0	0
wandering tattler	*Tringa incana*	0	0	0	0	0
grey-tailed tattler	*Tringa brevipes*	0	0	0	0	0
Lesser sand plover	*Charadruis mongolus*	0	0	0	0	0
welcome swallow	*Hirundo neoxena*	0	0	0	0	1
tree martin	*Petrochelidon nigricians*	0	0	0	0	0
magpie-lark	*Grallina cyanoleuca*	0	0	0	0	1
hardhead	*Aythya australis*	0	0	0	0	1
eastern great egret	*Ardea alba*	0	0	0	0	1
little pied cormorant	*Microcarbo melanoleucos*	0	0	0	0	0

Figure 109. One of four red-tailed tropicbirds prospecting (possibly nest sites) at South Islet.
Credit: Andrew McDougall ©, Queensland Government.

2.4.6 Invertebrates and rodents

Rodents

In the afternoon, 10 rodent tracking tunnels and trail cameras were placed in strategic positions around the cay and left overnight. The equipment was collected the following day, however showed no sign of rodent activity. During a thorough searches of the cay, an animal looking similar to that of an introduced skink was sighted. Photos were taken for identification. However, no trace of rodents was evident (Table 36).

Table 36. Rodent survey results on South Islet.

Location: Willis Islet - South Islet **Sampler:** Chad Hoult QPWS **Date Collected:** 2/06/2023				
Rodent stations	**GPS**	**Tracks**	**scat**	**Trail camera**
17	S16.28842-E149.96512	no	no	-
18	s16.28879-e149.96599	no	no	-
19	S16.28793-E149.96599	no	no	-
20	S16.28671-E149.96477	no	no	-
21	S16.28616-E149.96387	no	no	-
22	S16.28632-E149.96277	no	no	-
23	S16.28746-E149.96391	no	no	-
24	S16.28736-E149.96442	no	no	-
25	S16.28719-E149.96442	no	no	-
26	S16.28714-E149.96457	no	no	-
27	S16.28690-E149.96457	no	no	-

Ants

South Islet had the greatest number of ants recorded, with an approximation of 1100-5500 ants recorded across 11 ant stations (Table 37). A sample specimen was identified to be the introduced Arican big-headed ant (*Pheidole megacephala).*

Table 37. Ant survey results on South Islet.

Location: Willis Islets - South Islet **Sampler:** Chad Hoult QPWS **Date Collected:** 2/06/2023				
Ant stations	**GPS**	**Specimen number**	**Species**	**Amount**
20	S16.28842-E149.96512		Unknown	100-500
21	s16.28879-e149.96599		Unknown	100-500
22	S16.28793-E149.96599	36	*Pheidole megacephala*	100-500
23	S16.28671-E149.96477		Unknown	100-500
24	S16.28616-E149.96387		Unknown	100-500
25	S16.28632-E149.96277		Unknown	100-500
26	S16.28746-E149.96391		Unknown	100-500
27	S16.28736-E149.96442		Unknown	100-500
28	S16.28719-E149.96442		Unknown	100-500
29	S16.28714-E149.96457		Unknown	100-500
30	S16.28690-E149.96457		Unknown	100-500

Insects

A total of 1648 insects were counted, and 24 insect samples were collected for identification (Table 38). In addition to the African big-headed ant (*Pheidole megacephala),* an introduced cockroach, likely *Pycnoscelis surinamensis,* was identified.

Table 38. Insect survey results on South Islet.

Location: Willis Islets - South Islet
Sampler: Chad Hoult QPWS
Date Collected: 2/06/2023

Specimen number	Class	Order	Family	Species	Introduced	Count	Amount collected	GPS
34	Arachnida	Araneae	Oonopidae	*Xestaspis* sp.		4	1	S16.28574-E149.96310
35	Arachnida	Araneae	?Araneidae			7	1	S16.28588-E149.96339
36	Insecta	Hymenoptera	Formicidae	*Pheidole megacephala*	yes	500	5	S16.28793-E149.96599
37	Insecta	Orthoptera	Acrididae			100	1	S16.28618-E149.96408
38	Arachnida	Araneae	?Pholcidae			2	1	S16.28624-E149.96422
39	Insecta	Coleoptera	Coccinellidae	*Harmonia octomaculata*		16	1	S16.28633-E149.96434
40	Insecta	Hemiptera	Pentatomidae	*Plautia affinis*		23	1	S16.28668-E149.96494
41	Insecta	Hymenoptera	Formicidae	*Pheidole megacephala*	yes	300	5	S16.28616-E149.96387
42	Insecta	Coleoptera	Anthribidae			12	1	S16.28703-E149.96535
43	Insecta	Coleoptera	Coccinellidae	*Harmonia octomaculata*		11	1	S16.28754-E149.96585
44	Insecta	Hemiptera	Cicadellidae	indet. species		9	1	S16.28798-E149.96617
45	Insecta	Coleoptera	Tenebrionidae	*Gonocephalum* sp.		5	1	S16.28822-E149.96617
46	Insecta	Hymenoptera	Formicidae	*Pheidole megacephala*	yes	200	5	S16.28690-E149.96457
47	Arachnida	Araneae	Lycosidae			7	1	S16.28866-E149.96635
48	Insecta	Orthoptera	Acrididae	*Aiolopus thalassinus*		100	1	S16.28869-E149.96635
49	Insecta	Hemiptera	Cicadellidae	indet. species		9	1	S16.28881-E149.96576
50	Malacostraca	Isopoda				200	1	S16.28875-E149.96558
51	Arachnida	Araneae	Salticidae			1	1	S16.28845-E149.96535
52	Insecta	Coleoptera	Coccinellidae	*Coelophora inaequalis*		4	1	S16.28822-E149.96494
53	Insecta	Diptera	Sarcophagidae	indet. species		7	1	S16.28798-E149.96494
54	Arachnida	Araneae	Salticidae			6	1	S16.28798-E149.96461
55	Insecta	Blattodea	Blaberidae	*Pycnoscelis ?surinamensis*	yes	50	1	S16.28795-E149.96461
56	Insecta	Hymenoptera	Formicidae	*Pheidole megacephala*	yes	50	5	S16.28786-E149.96443
56	Insecta	Hemiptera	Coccoidea					S16.28786-E149.96443
57	Insecta	Lepidoptera	Lycaenidae	? Zizeeria karsandra		25	1	S16.28780-E149.96487

2.4.7 Health Checks

Table 39. Health Check results – octopus bush (*Argusia argentea*) shrublands on South Islet.
Key: **G = good**, **GC = good with some concerns**, **SC = significant concern**, **C = critical**, **NA =** not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G	G			G
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	GC	GC	GC			GC
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G	G			G
7. Trampling, digging or rooting or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	G	G			G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	G			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	G	GC	G			G
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	G	G	G			G
Overall Condition Class						G

Mossman River grass (*Cenchrus echinatus*) and crow's foot grass (*Eleusine indica*) were present adjacent to the octopus bush communities. These weed species growing in close proximation to the shrubland community indicates there is risk these weed species may invade the shrubland community. Overall, the Health Check results indicate a 'good' rating for octopus bush (*Argusia argentea*) shrublands on South Islet (Table 39).

Table 40. Health Check results – grasslands (mixed *Lepturus repens* and *Sporobolus virginicus*) on South Islet.

Key: **G = good**, **GC = good with some concerns**, **SC = significant concern**, **C = critical**, **NA** = not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	GC	G			GC
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	SC	SC	SC			SC
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G	G			G
7. Trampling, digging or rooting or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	G	G			G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	G			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	G	G	G			G
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	G	G	G			G
Overall Condition Class						GC

Mossman River grass (*Cenchrus echinatus*) and crow's foot grass (*Eleusine indica*) were present on the cay and are likely to invade the grassland community in future. Overall, the Health Check results for indicate a 'good with some concern' rating for grasslands on South Islet (Table 40).

Table 41. Health Check results – *ipomoea* Vineland on South Islet.
Key: **G = good**; **GC = good with some concerns**; **SC = significant concern**; **C = critical**; **NA =** not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	SC					SC
2. Infestations of pest plants other than ecosystem-changers	G					G
3. Risk of future invasion by significant pest plants not already present	G					G
4. Rainforest invasion	G					G
5. Woody thickening (other than by rainforest species)	G					G
6. Overgrazing/browsing by feral animals, stray stock or natives	G					G
7. Trampling, digging or rooting or trampling by visitors	G					G
8. Impacts on wetlands	NA					NA
9. Vehicle impacts	G					G
10. Dumping	G					G
11. Ground cover	G					G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G					G
13. Fire damage to peat-based ecosystems	NA					NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA					NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA					NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G					G
17. Overtopping, erosion and associated impacts	G					G
18. Tree/shrub health and dieback	G					G
19. Key features for faunal biodiversity in terrestrial ecosystems	G					G
20. Recruitment of canopy species	G					G
Overall Condition Class						GC

Mossman River grass (*Cenchrus echinatus*) and crow's foot grass (*Eleusine indica*) were present on the cay and are likely to invade the vineland community in future. Overall, the Health Check results indicate a 'good with some concern' rating for *Ipomoea* Vineland on South Islet (Table 41).

2.5 Herald Cays - North East Cay

2.5.1 Drone imagery

A total of 1,214 nadir photographs were acquired, over two mapping mission flights with the M300 RTK drone. A single orthomosaic was processed in ESRI SiteScan (Figure 110). Two separate orthomosiacs were produced with DroneDeploy – one swath following the western (leeward) side of the island, on a north-south axis (NNE to SSW), and another swath across the middle of the island, on an east-west axis. Mapping of the island was not completed due to strong winds.

Figure 110. North East Cay (Herald Cays) orthomosaic from June 2023 (bright green) overlaid over an orthomosaic acquired from a previous voyage. DEA Coastlines are shown as yellow, white and orange outlines. Credit: Dan Wilkins ©, Parks Australia.

2.5.2 Vegetation

Survey intensity

On 3 June 2023, two people spent 5.8 hours traversing North East Cay (Heralds Cays), establishing and surveying a new permanent BioCondition monitoring site and undertaking targeted searching for weeds.

Vegetation condition

With the exception of sea trumpet (*Cordia subcordata*) communities the vegetation was in good condition at the time of the 2023 visit.

Information from previous surveys

The vegetation of North East Cay (Herald Cays) was thoroughly surveyed and mapped during the 2019 voyage (Hemson et al 2020). Vegetation was briefly assessed during the 2022 voyage with particular attention given to the condition of the sea trumpet patches and ensuring that there have been no weed invasions since the 2019 visit (McDougall and Brushe 2023).

Previous observations (Hicks 1983, Hicks 1984, Donaldson 1994, Freebairn 2006 and 2007, Smith and Papacek 2001, Batianoff et al. 2010) indicate that sea trumpet dieback is caused by a combination of leaf eating insects and drought. Insects that may be responsible include noctuid

moth (*Armatica columbina*), grasshoppers including the giant grasshopper (*Valanga irregularis*) and the larvae of hawk moth (*Hippotion velox*).

Observations and collections

The sea trumpet (*Cordia subcordata*) plants that appeared dead in 2019 are now reshooting from the base and roots in some of the patches. Some patches did not reshoot and are now dead. There was evidence of heavy chewing of the sea trumpet leaves by flying insects in some places during the 2023 visit, but no insects were observed.

There appeared to be an increase in the cover of lantern bush (*Abutilon albescens*) since the 2019 survey. The dense presence of this species covered with moonflower (*Ipomoea violacea)* vine, and the presence of nesting frigate birds made it impossible to traverse parts of the interior of the cay.

Not all parts of the cay could be searched in the time available. Targeted searching was undertaken in the most likely sites for weed incursions. No weeds were observed.

Specimens of 10 plant species that were unable to be collected in the prevailing dry conditions during the 2019 voyage, were collected during the 2023 voyage for incorporation into state and national herbaria. Due to limited time available for traversing and collecting, on North East Cay (Herald Cay), not all species could be collected to complete the 2019 to 2023 collection.

Permanent BioCondition monitoring site

A new permanent BioCondition monitoring site (M24) was established and surveyed in a patch of lantern bush (*Abutilon albescens*)/sea trumpet (*Cordia subcordata*) shrubland where above ground *Cordia* had completely died back in 2019 but is now reshooting from the base and roots. The location of the centre transect of this site is shown as the red line in Figure 111.

Table 42 contains the BioCondition attribute data recorded at this site. The photographs included with the BioCondition attribute data are four of the 10 site photographs taken at the site. The BioCondition site photographs (Figure 112) are all taken from the centre point of the centre transect, the first facing along the transect bearing and then consecutively facing 90^{o}, 180^{0} and 270^{0} from the direction of the center transect bearing.

Figure 111. North East Cay (Herald Cays) showing BioCondition monitoring site M24 relative to the 2019 vegetation map unit boundaries.

Table 42. BioCondition attribute data recorded in monitoring site M24, North East Cay (Herald Cays), on 3 June 2023.

Site	M24
Cay	NE Herald Cay
Landform	flat
Soil	Refer to soil analysis data
Vegetation community description	*Abutilon albescens/ Cordia subcordata* closed shrubland with a very sparse ground cover dominated by *Ipomoea violacea* and *Boerhavia mutabilis*
Transect start (WGS 84)	-16.94402200 149.20102800
Transect centre (WGS84)	16.9438372 149.2011496
Transect end (WGS 84)	-16.943655 149.20127100
Transect bearing (degrees)	25
Median canopy height/range (metres)	2.0 (1.5 to 2.5)
Tree canopy cover %	NA
Shrub canopy cover %	90% (estimated)
Basal area m^2/ha	too difficult to traverse and measure
Total number of large trees/ha	NA
Total no of trees per ha	NA
Total number of tree stems/ha	NA
Total no. shrubs/ha	too difficult to traverse and count
Recruitment of ecologically dominant layer (%)	*Cordia* re-shooting from base and rooted stems on ground
Tree species richness	0
Tree species present	NA
Shrub species richness	2
Shrub species present (layer in brackets)	*Abutilon albescens* (S1), *Cordia subcordata* (S1)
Median ground layer height/range (metres)	1.0 (0.1 to 1.6) m
Total ground layer cover of native cay species (%)	10%
Grass species richness	0
Grass cover (%)	0.0%
Grass species present in order of decreasing cover – most abundant first (cover in brackets)	NA
Forb (including vines) species richness	4
Forb species cover (%)	10.0%
Forb species present in order of decreasing cover – most abundant first (cover in brackets)	*Ipomoea violacea* (5%), *Boerhavia mutabilis* (3%), *Boerhavia albiflora* var. *albiflora* (1%), *Portulaca oleracea* (1%) – estimated
Native shrub ground cover (%)	0.0%
Introduced plant (weed) cover (all strata) (%)	0.0%
Litter cover (%)	70.0%
Bare ground (%)	5.0%
Woody debris (m/ha of logs >0.5m long and >10cm wide)	impossible to measure – lots of dead *Cordia* logs on ground (Figure 101)
Soil pH	8.64 (0-10cm), 8.69 (10-20cm), 8.71 (20-30cm), 8.79 (30-40cm)

BioCondition monitoring site photographs

A.

B.

C.

D.

Figure 112. BioCondition monitoring site M24, North East Cay (Herald Cays).
A. Facing NNE, B. Facing ESE, C. Facing SSW, D. Facing WNW. Credit: Joy Brushe ©.

2.5.3 Soil

Soil samples were collected from the sea trumpet (*Cordia subcordata*)/lantern bush (*Abutilon albescens*) BioCondition monitoring site M24 on North East Cay (Herald Cays). Site M24 soils had lower electrical conductivity, total nitrogen, organic carbon, and phosphorus levels compared to the East Diamond M23 sea trumpet site and pH was higher. Total sulphur levels were high in all CSMP samples collected during the 2022 and 2023 voyages (including the M24 sample) compared with previous samples.

Refer to Appendix 9. 2023 Soil analysis results for all results of soil analyses for samples collected at site M24. For comparison of M24 soil analysis data with data from those for other CSMP and Capricorn Bunker cays in the southern GBR, refer to Appendix 8. Comparison of soils data.

2.5.4 Birds

Table 43 contains the bird data from North East Cay (Heralds Cays).The limited survey time was dedicated to red-tailed tropicbird (*Phaethon rubricauda roseotinctus*) breeding effort. The lower and upper red-tailed breeding effort confidence interval is between 860 pairs (actual count) to 946 pairs (given a one in ten undercount). This total is another nationally significant record, exceeding the 2022 voyage records. Unfortunately, South West Cay could not be surveyed on this voyage to complete an overall breeding effort summary for the Herald Cays. Considering the 2022 count, around 1000 pairs of red-tailed tropicbirds would be expected for the Herald Cays. The storm-washed beach rock (broken rock) provides protected nesting habitat for red-tailed tropicbirds (Figure 113). The numerous rock cavities make it difficult to locate all the breeding pairs.

Table 43. Bird species and breeding effort on North East Cay, Herald Cays.
Key: P= Present, U= Unknown, NR= Not recorded

North East Cay, Herald Cays 04/06/2023		Breeding status				
Common name	Scientific name	Nests	Chicks	Young	Breeding pairs	Adolescents and adults
red-tailed tropicbird	*Phaethon rubricauda roseotinctus*	688	30	142	860	910
Herald petrel	*Pterodroma heraldica*	0	0	0	0	0
wedge-tailed shearwater	*Ardenna pacifica*	0	0	0	0	0
great frigatebird	*Fregata minor*	U			P	P
lesser frigatebird	*Fregata ariel*	U			P	P
masked booby	*Sula dactylatra dactylatra*	U			P	P
brown booby	*Sula leucogaster*	U			P	P
red-footed booby	*Sula sula*	U			P	P
sooty tern	*Onychoprion fuscatus*	0	0	0	0	P
bridled tern	*Onychoprion anaethetus*	0	0	0	0	0
Crested tern	*Thalasseus bergii*	0	0	0	0	0
Roseate tern	*Sterna dougallii*	0	0	0	0	0
Black-naped tern	*Sterna Sumatrana*	0	0	0	0	0
New Caledonian fairy tern	*Sternula nereisexsul*	0	0	0	0	0
black noddy	*Anous minutus*	U			P	P
brown noddy	*Anous stolidus*	U			P	P
buff-banded rail	*Gallirallus philippensis tounelieri*	0	0	0	0	P
purple swamphen	*Porphyrio melanotus*	0	0	0	0	2
sacred kingfisher	*Todiramphus sanctus*	0	0	0	0	1
welcome swallow	*Hirundo neoxena*	0	0	0	0	2
masked lapwing	*Vanellus miles novaehollandiae*	0	0	0	0	0
white-faced heron	*Egretta novaehollandiae*	0	0	0	0	0
eastern reef egret	*Egretta sacra*	0	0	0	0	0
pacific golden plover	*Pluvialis fluva*	0	0	0	0	0
ruddy turnstone	*Arenaria interpres*	0	0	0	0	0

wandering tattler	*Tringa incana*	0	0	0	0	0
grey-tailed tattler	*Tringa brevipes*	0	0	0	0	0
lesser sand plover	*Charadruis mongolus*	0	0	0	0	0
tree martin	*Petrochelidon nigricians*	0	0	0	0	0
magpie-lark	*Grallina cyanoleuca*	0	0	0	0	0
hardhead	*Aythya australis*	0	0	0	0	0
eastern great egret	*Ardea alba*	0	0	0	0	0
little pied cormorant	*Microcarbo melanoleucos*	0	0	0	0	0

Figure 113. Approximately 80m of lithified shoreline on the southern and windward side of North East Cay. Credit: Graham Hemson ©, Queensland Government

2.5.5 Invertebrates and rodents

Rodents

Due to time limitation, ink tunnels were not placed around the cay. Despite thorough searches of the cay, no trace of rodents was evident**.**

Ants

A total of 1212 ants were recorded detected across 10 ant stations (Table 44). All specimens were identified as an introduced ant species called bicoloured pennant ant (*Tetramorium bicarinatum*).

Table 44. Ant survey results on North East Cay, Herald Cays.

Location: Herald Cays - North East Cay
Sampler: Chad Hoult QPWS
Date Collected: 3/06/2023

Ant stations	GPS	Specimen number	Species	Amount
31	S16.94188-E149.19720	69	*Tetramorium bicarinatum*	500
32	S16.94257-E149.19630	70	*Tetramorium bicarinatum*	300
33	S16.94267-E149.19621	75	*Tetramorium bicarinatum*	100
34	S16.90453-E149.19878	85	*Tetramorium bicarinatum*	300
35	S16.90453-E149.20041	86	*Tetramorium bicarinatum*	12
36	S16.94039-E149.20232	-	-	0
37	S16.93971-E149.20232	-	-	0
38	S16.93960-E149.20232	-	-	0
39	S16.93825-E149.20232	-	-	0
40	S16.94188-E149.19729	-	-	0

Insects

A total of 1851 insects were counted and 30 insect samples were collected for identification (Table 45). In addition to the introduced bicoloured pennant ant, an introduced Saunders' Webspinner (*Oligotoma saudersii)* was also identified.

Table 45. Insect survey results on North East Cay, Herald Cays.

Location: Herald Cays – North East Cay
Sampler: Chad Hoult QPWS
Date Collected: 3/06/2023

Specimen number	Class	Order	Family	Species	Introduced	Count	Amount collected	GPS
58	Insecta	Embioptera	?Oligotomidae	?*Oligotoma saudersii*		12	1	S16.94242-E149.20091
59	Insecta	Hemiptera	Miridae			23	1	S16.94377-E149.20091
60	Insecta	Blattodea	Ectobiidae	Ectobiidae sp. A		15	1	S16.94546-E149.19765
61	Insecta	Coleoptera	Dermestidae	*Dermestes ater*		50	1	S16.94242-E149.20116
62	Insecta	Orthoptera	Acrididae	?*Valanga sp.*		21	1	S16.94185-E149.20116
63	Insecta	Orthoptera	Acrididae	*Aiolopus thalassinus*		100	1	S16.94185-E149.20139
64	Arachnida	Araneae	Lycosidae			7	1	S16.94185-E149.20232
65	Insecta	Zygentoma	Lepismatidae			54	1	S16.94039-E149.20232
66	Arachnida	Araneae	?Araneidae			1	1	S16.93971-E149.20232
67	Insecta	Hemiptera	Rhyparochromidae	*Eudeocoris* sp.		2	1	S16.93960-E149.20232
68	Insecta	Orthoptera	Gryllidae			12	1	S16.93825-E149.20232
69	Insecta	Hymenoptera	Formicidae	*Tetramorium bicarinatum*	yes	500	10	S16.94188-E149.19720
70	Insecta	Hymenoptera	Formicidae	*Tetramorium bicarinatum*	yes	300	10	S16.94257-E149.19630
71	Insecta	Coleoptera	Tenebrioidae	*Gonocephalum* sp.		2	1	S16.93836-E149.20116
72	Insecta	Diptera	Sarcophagidae	Sarcophagidae indet. sp. B		39	1	S16.93937-E149.20021
73	Insecta	Diptera	Lonchaeidae	indet. species		36	1	S16.94039-E149.19905
74	Insecta	Hemiptera	Coccoidea			40	4	S16.94545-E149.19423
75	Insecta	Hymenoptera	Formicidae	*Tetramorium bicarinatum*	yes	100	5	S16.94267-E149.19621
76	Insecta	Embioptera	?Oligotomidae	?*Oligotoma saudersii*	?	15	1	S16.94501-E149.19373
77	Arachnida	Araneae				1	1	S16.94488-E149.19373
78	Insecta	Embioptera	Oligotomidae	*Oligotoma saudersii*	yes	11	1	S16.94439-E149.19363
79	Insecta	Orthoptera	Gryllidae			21	1	S16.94403-E149.19427
80	Insecta	Diptera	Milichiidae	indet. species		11	1	S16.94368-E149.19464

81	Insecta	Hymenoptera	Crabronidae	*Liris* sp. A		3	1	S16.94333-E149.19514
82	Insecta	Lepidoptera	Crambidae	*Spoladea recurvalis*		24	1	S16.94333-E149.19600
83	Insecta	Diptera	Sarcophagidae	Sarcophagidae indet. sp.		34	1	S16.94311-E149.19600
84	Arachnida	Araneae	Lycosidae			5	1	S16.94302-E149.19609
85	Insecta	Hymenoptera	Formicidae	*Tetramorium bicarinatum*	yes	300	10	S16.90453-E149.19878
86	Insecta	Hymenoptera	Formicidae	*Tetramorium bicarinatum*	yes	12	2	S16.94053-E149.20041
87	Malcostraca	Isopoda				100	1	S16.94007-E149.20018
88	Insecta	Hymenoptera	Megachilidae	*Lithurgus (Lithurgus)* sp.		4	1	S16.94030-E149.20018

2.5.6 Health Checks

Table 46. Health Check results – Octopus bush (*Argusia argentea*) shrublands on North East Cay, Herald Cays.
Key: **G = good**, **GC = good with some concerns**, **SC = significant concern**, **C = critical**, **NA =** not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G	G			G
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	G	G	G			G
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G	G			G
7. Trampling, digging or rooting or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	G	G			G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	GC			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	G	G	GC			G
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	G	G	G			G
Overall Condition Class						G

Minor impacts to foliage was observed on some octopus bushes, potentially from storms/windshear. Octopus bush plants typically adapt to such conditions, so it is unlikely to significantly impact the shrubland community. Overall, the Health Check results indicate a ‘good’ rating for octopus bush shrublands on North East Cay (Herald Cays) (Table 46).

Table 47. Health Check results – Sea trumpet (*Cordia subcordata*) shrublands on North East Cay, Herald Cay. Key: **G = good**; **GC = good with some concerns**; **SC = significant concern**; **C = critical**; **NA =** not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G				G
2. Infestations of pest plants other than ecosystem-changers	G	G				G
3. Risk of future invasion by significant pest plants not already present	G	G				G
4. Rainforest invasion	G	G				G
5. Woody thickening (other than by rainforest species)	G	G				G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G				G
7. Trampling, digging or rooting or trampling by visitors	G	G				G
8. Impacts on wetlands	NA	NA				NA
9. Vehicle impacts	G	G				G
10. Dumping	G	G				G
11. Ground cover	SC	GC				GC
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G				G
13. Fire damage to peat-based ecosystems	NA	NA				NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA				NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA				NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G				G
17. Overtopping, erosion and associated impacts	G	G				G
18. Tree/shrub health and dieback	C	SC				C
19. Key features for faunal biodiversity in terrestrial ecosystems	SC	GC				GC
20. Recruitment of canopy species	C	C				C
Overall Condition Class						C

Almost complete die back across all sea trumpet (*Cordia subcordata)* plants was observed. Sea trumpet plants are becoming smothered by moon flower (*Ipomoea violacea)* vineland, diminishing its habitat value for roosting birds. There was no recruitment of canopy species observed. Overall, the Health Check results indicate a 'critical' rating for sea trumpet shrublands on North East Cay (Herald Cays) (Table 47).

Table 48. Health Check results – Pisonia (*Pisonia grandis*) forest on North East Cay, Herald Cays.
Key: **G = good**, **GC = good with some concerns**, **SC = significant concern**, **C = critical**, **NA =** not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G	G			G
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	G	G	G			G
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G	G			G
7. Trampling, digging or rooting or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	G	G			G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	G			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	G	G	G			G
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	G	G	G			G
Overall Condition Class						G

Overall, the Health Check results indicate a ‘good’ rating for Pisonia forest on North East Cay (Herald Cays) (Table 48).

Table 49. Health Check results – Mixed Shrublands (*Plumbago zeylanica, Abutilon albescens* shrublands ± *Ipomoea*) on North East Cay, Heralds Cay.
Key: **G = good**, **GC = good with some concerns**, **SC = significant concern**, **C = critical**, **NA =** not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G				G
2. Infestations of pest plants other than ecosystem-changers	G	G				G
3. Risk of future invasion by significant pest plants not already present	G	G				G
4. Rainforest invasion	G	G				G
5. Woody thickening (other than by rainforest species)	G	G				G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G				G
7. Trampling, digging or rooting …. . or trampling by visitors	G	G				G
8. Impacts on wetlands	NA	NA				NA
9. Vehicle impacts	G	G				G
10. Dumping	G	G				G
11. Ground cover	G	GC				G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G				G
13. Fire damage to peat-based ecosystems	NA	NA				NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA				NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA				NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G				G
17. Overtopping, erosion and associated impacts	G	G				G
18. Tree/shrub health and dieback	GC	GC				GC
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G				G
20. Recruitment of canopy species	G	G				G
Overall Condition Class						G

Some dead stags were observed, possibly dead sea trumpet (*Cordia subcordata)* which has since been invaded by lantern bush (*Abutilon albescens).* Overall, the Health Check results indicate a 'good' rating for mixed shrublands on North East Cay (Heralds Cays) (Table 49).

2.6 Coringa Islets - Chilcott Islet

Figure 114. Martin Russell and John Prichard installing Chilcott Islet Coral Sea Marine Park sign. Credit: Martin Russell ©, Parks Australia.

2.6.1 Drone imagery

Drone work was not conducted Chilcott Islet.

2.6.2 Physical description

Chilcott Islet is a vegetated cay located 250km east of Cairns, Queensland. At low tide the cay extends approximately 805m x 264m.

2.6.3 Vegetation

Survey intensity

On June 4, 2023, two people spent 4.3 hours traversing Chilcott Islet, undertaking weed surveys and collecting plant specimens.

Vegetation condition

Vegetation was in good condition in all areas visited at the time of the 2023 visit.

Comparison with previous surveys

Marine couch (*Sporobolus virginicus*), a perennial native grass that was recorded during the 2006/2007 survey (Batianoff et al. 2008), was not observed during the 2023 visit. As the entirety of the cay was not traversed due to time restrictions, this species may be present in areas not visited.

As on other cays visited during the 2023 voyage, there appeared to be an increase in extent of lantern bush (*Abutilon albescens*) shrubland since the 2019 visit, in areas previously dominated by grasses or other herbaceous species.

Observations and collections

No weed species were observed during the 2023 voyage.

Specimens of 13 plant species were collected for incorporation into state and national herbaria including a specimen of pink flowered tar vine (*Boerhavia mutabilis*), a species that has not previously been recorded on Chilcot Islet.

Figure 115. Octopus bush (*Argusia argentea)* seedlings establishing along shoreline on Chilcott Islet. Credit: Joy Brushe ©

BioCondition Sites

No BioCondition sites were established or surveyed on Chilcott Islet.

2.6.4 Soil

Soil samples were not taken at Chilcott Islet.

2.6.5 Birds

Tree martins (*Petrochelidon nigricans)* and welcome swallows (*Hirundo neoxena)* appear to be seasonal migrants. There have been sporadic records of tree martins in the past, but enough to indicate they are not windswept vagrants.

Due to time limitations, the interior of the island was not surveyed, observations were made on the beach and strand vegetation zones.

A little pied cormorant (*Microcarbo melanoleucos*) was observed. As there are no records on Birdlife Australia's "Birdata" or on Cornel lab's "Ebird", this may be the first record for this species in the Coral Sea Islands Territory. Table 50 contains the bird data from Chilcott Islet.

Table 50. Bird species and breeding effort on Chilcott Islet.
Key: P= Present, U= Unknown, NR= Not recorded

Chilcott Islet, Coringa Islets 04/06/2023		**Breeding status**				
Common name	**Scientific name**	**Nests**	**Chicks**	**Young**	**Breeding pairs**	**Adolescents and adults**
red-tailed tropicbird	*Phaethon rubricauda roseotinctus*	17	0	0	17	22
Herald petrel	*Pterodroma heraldica*	0	0	0	0	0
wedge-tailed shearwater	*Ardenna pacifica*	0	0	0	0	0
great frigatebird	*Fregata minor*	0	0	0	0	0
lesser frigatebird	*Fregata ariel*	0	0	0	0	0
masked booby	*Sula dactylatra dactylatra*	56	1	0	57	74
brown booby	*Sula leucogaster*	4			4	5
red-footed booby	*Sula sula*	NR				P

sooty tern	*Onychoprion fuscatus*	3873	U	U	3873	
bridled tern	*Onychoprion anaethetus*	0	0	0	0	0
crested tern	*Thalasseus bergii*	0	0	0	0	17
roseate tern	*Sterna dougallii*	0	0	0	0	0
black-naped tern	*Sterna sumatrana*	0	0	0	0	24
New Caledonian fairy tern	*Sternula nereis exsul*	0	0	0	0	0
black noddy	*Anous minutus*	P			P	P
brown noddy	*Anous stolidus*	NR				P
buff-banded rail	*Gallirallus philippensis tounelieri*	0	0	0	0	P
purple swamphen	*Porphyrio melanotus*	0	0	0	0	0
sacred kingfisher	*Todiramphus sanctus*	0	0	0	0	0
masked lapwing	*Vanellus miles novaehollandiae*	0	0	0	0	0
white-faced heron	*Egretta novaehollandiae*	0	0	0	0	0
eastern reef egret	*Egretta sacra*	0	0	0	0	0
Pacific golden plover	*Pluvialis fulva*	0	0	0	0	0
ruddy turnstone	*Arenaria interpres*	0	0	0	0	1
wandering tattler	*Tringa incana*	0	0	0	0	0
grey-tailed tattler	*Tringa brevipes*	0	0	0	0	0
lesser sand plover	*Charadrius mongolus*	0	0	0	0	0
welcome swallow	*Hirundo neoxena*	0	0	0	0	4
tree martin	*Petrochelidon nigricans*	0	0	0	0	4
magpie-lark	*Grallina cyanoleuca*	0	0	0	0	0
hardhead	*Aythya australis*	0	0	0	0	0
eastern great egret	*Ardea alba*	0	0	0	0	0
little pied cormorant	*Microcarbo melanoleucos*	0	0	0	0	1

Figure 116. Brown boobies are often seen roosting on beach rock on the windward side of cays. Credit: Andrew McDougall ©, Queensland Government.

2.6.6 Invertebrates and rodents

Rodents

No ink tunnels were placed around the cay as time was limited. Despite thorough searches of the cay, no trace of rodents was evident**.**

Ants

Between 440-990 ants were recorded across 10 ant stations (Table 51). Several samples were taken for identification. Specimen number 108 was identified to be an introduced Pharaoh ant *(Monomorium pharaonis)*.

Table 51. Ant survey results from Chilcott Islet, Coringa Islet.

Location: Coringa Islets - Chilcott Islet
Sampler: Chad Hoult QPWS
Date Collected: 4/06/2023

Ant Stations	GPS	Specimen number	Species	Amount
41	S16.93678-E150.00258	96	*Teleogryllus oceanicus*	50
42	S16.93723-E150.00514	102	*Sarcophagidae indet. sp. A*	50
43	S16.93622-E150.00562	107	Unknown	50
44	S16.93645-E150.00562	108	*Monomorium pharaonis*	20
45	S16.93847-E150.00072		Unknown	50-100
46	S16.93690-E150.00549		Unknown	10
47	S16.93678-E150.00562		Unknown	50-100
48	S16.93587-E150.00562		Unknown	50-100
49	S16.93767-E150.00230		Unknown	100-500
50	S16.93566-E150.00562		Unknown	10

Insects

A total of 584 Insects were counted, including ants, and 23 insect samples were collected for identification (Table 52). No additional introduced species were identified other than the Pharaoh ant *(Monomorium pharaonis)*.

Table 52. Insect survey results from Chilcott Islet, Coringa Islets.

Location: Coringa Islets - Chilcott Islet
Sampler: Chad Hoult QPWS
Date Collected: 4/06/2023

Specimen number	Class	Order	Family	Species	Introduced	Count	Amount collected	GPS
89	Insecta	Diptera	Lonchaeidae	indet. species		3	1	S16.93824-E150.00150
90	Insecta	Orthoptera	Trigonidiidae	Trigonidiinae sp.		12	1	S16.93746-E150.00150
91	Arachnida	Araneae	Lycosidae			50	1	S16.93779-E150.00136
92	Arachnida	Pseudoscorpiones				32	1	S16.93847-E150.00072
93	Insecta	Coleoptera	Tenebrionidae	*Gonocephalum* sp.		100	1	S16.93871-E150.00130
94	Arachnida	Araneae	?Araneidae			45	1	S16.93882-E150.00188
95	Malcostraca	Isopoda				3	1	S16.93882-E150.00188
96	Insecta	Orthoptera	Gryllidae	*Teleogryllus oceanicus*		50	3	S16.93678-E150.00258
87	Insecta	Zygentoma	Lepismatidae			23	1	S16.93802-E150.00398
98	Insecta	Hymenoptera	Formicidae	*Monomorium pharaonis*	yes	4	1	S16.93802-E150.00409
99	Arachnida	Acari	Ixodidae	*Amblyomma loculosum*		2	1	S16.93768-E150.00468
100	Arachnida	Araneae	Lycosidae			12	1	S16.93757-E150.00479
101	Arachnida	Araneae	?Araneidae			5	1	S16.93746-E150.00490
102	Insecta	Diptera	Sarcophagidae	Sarcophagidae indet. sp. A		20	3	S16.93723E-150.00514
103	Insecta	Hymenoptera	Formicidae	*Monomorium pharaonis*	yes	100	1	S16.93712-E150.00537
104	Insecta	Orthoptera	Acrididae	*Aiolopus thalassinus*		3	1	S16.93690-E150.00549
105	Insecta	Hymenoptera	Ichneumonidae	*Temelucha* sp.		12	1	S16.93678-E150.00562
106	Insecta	Hemiptera	Cicadellidae	indet. species		2	1	S16.93667-E150.00562
107	Insecta	Blattodea				50	2	S16.93645-E150.00562
108	Insecta	Hymenoptera	Formicidae	*Monomorium pharaonis*	yes	20	2	S16.93622-E150.00562
109	Insecta	Hymenoptera	Formicidae	*Monomorium pharaonis*	yes	24	1	S16.93587-E150.00562
110	Arachnida	Araneae	Lycosidae			11	1	S16.93566-E150.00562
111	Insecta	Diptera	Hippoboscidae	*Olfersia* sp.		1	1	S16.93767-E150.00230
88	Arachnida	Araneae	Salticidae			12	1	S16.93600-E150.00562

2.6.7 Health Checks

Table 53. Health Check Results – octopus bush (*Argusia argentea*) shrublands, on Chilcott Islet.
Key: **G = good**; **GC = good with some concerns**; **SC = significant concern**; **C = critical**; **NA** = not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G	G			G
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	G	G	G			G
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G	G			G
7. Trampling, digging or rooting or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	GC	GC			GC
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	G			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	G	G	G			G
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	G	G	G			G
Overall Condition Class						G

The Health Check results for octopus bush ground cover at site 2 and 3 was recorded as ‘Good with some concern’ however this is to be expected for this shrublands community. Overall, the results indicate a ‘good’ rating for octopus shrub on Chilcott Islet (Table 53).

Table 54. Health Check Results – sea trumpet (*Cordia subcordata*) shrublands, on Chilcott Islet.
Key: **G = good**; **GC = good with some concerns**; **SC = significant concern**; **C = critical**; **NA** = not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G	G			G
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	G	G	G			G
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G	G			G
7. Trampling, digging or rooting …. . or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	G	G			G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	G			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	C	C	C			C
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	SC	C	C			C
Overall Condition Class						C

Almost complete dieback across almost all sea trumpet shrublands was observed and no evidence of recruitment (Figure 117 and 118). Overall, the Health Check results indicate a ‘critical’ rating for sea trumpet shrublands, on Chilcott Islet (Table 54).

Figure 117: Die back observed at sea trumpet (*Cordia subcordata*) Health Check Site 1 on Chilcott Islet. Credit: Andrew Meiklejohn ©, Queensland Government.

Figure 118: Die back observed at sea trumpet (*Cordia subcordata*) Health Check Site 1 on Chilcott Islet. Credit: Andrew Meiklejohn ©, Queensland Government.

Table 55. Health Chek Results – grassland (*Lepturus repens* and *Sporobolus virgnicus*) on Chilcott Islet.
Key: **G = good**; **GC = good with some concerns**; **SC = significant concern**; **C = critical**; **NA =** not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G	G			G
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	G	G	G			G
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G	G			G
7. Trampling, digging or rooting or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	GC	GC			GC
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	G			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	G	G	G			G
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	G	G	GC			G
Overall Condition Class						G

The Health Check results for grassland ground cover at site 2 and 3 was recorded as ‘Good with some concern’ however this is to be expected on sand cays (Table 55). Overall, the results indicate a ‘good’ rating for grassland vegetation community on Chilcott Islet.

Table 56. Health Check Results – mixed shrublands (*Plumbago zeylanica*, *Abutilon albescens* shrublands ± *Ipomoea*) on Chilcott Islet.

Key: **G = good**; **GC = good with some concerns**; **SC = significant concern**; **C = critical**; **NA =** not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G	G			G
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	G	G	G			G
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G	G			G
7. Trampling, digging or rooting or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	G	G			G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	G			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	G	G	G			G
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	G	G	G			G
Overall Condition Class						G

Overall, the Health Check results indicate a ‘good’ rating for mixed shrublands community on Chilcott Islet (Table 56).

2.7 Magdelaine Cays - Magdelaine Cay South

Figure 119: John Prichard and Martin Russell installing the Magdelaine Cay South Coral Sea Marine Park sign.

2.7.1 Drone imagery

Drone work was not conducted on Magdelaine Cay South.

2.7.2 Physical description

Magdelaine Cay South is a vegetated cay located 487km East- north-east of Cairns, Australian. At low tide the cay extends approximately 890x525m.

2.7.3 Vegetation

Survey intensity

On May 5, 2023, two people each spent approximately 4.4 hours traversing Magdelaine Cay South, establishing and surveying a new permanent BioCondition monitoring site, undertaking targeted weed searching and collecting plant specimens.

Vegetation condition

With the exception of sea trumpet (Cordia subcordata) communities, the vegetation was in good condition in all areas visited at the time of the 2023 visit.

Comparison with previous surveys

As on other cays visited during the 2023 voyage, there appeared to be an increase in extent of lantern bush (*Abutilon albescens*) shrubland since the 2019 visit, in areas previously dominated by grasses or other herbaceous species.

Observations and collections

No weed species were observed during the 2023 voyage. Specimens of seven plant species were collected for incorporation into state and national herbaria.

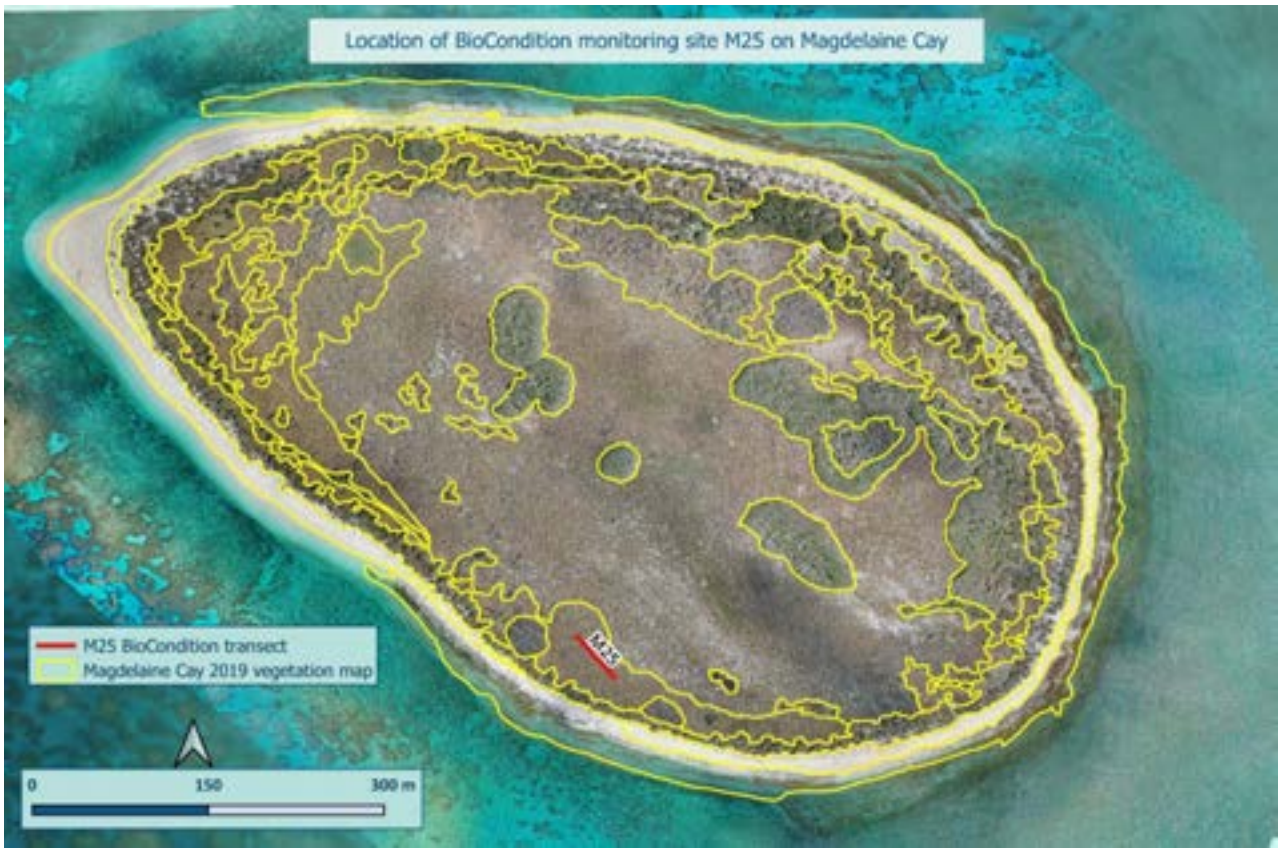

Figure 120. Magdelaine Cay South showing the location of BioCondition monitoring site M25 relative to the 2019 vegetation map unit boundaries Credit: Graham Hemson ©, Queensland Government.

Permanent BioCondition monitoring sites

A BioCondition monitoring site, M25, was established in a lantern bush (*Abutilon albescens*) shrubland during the 2023 voyage.

The location of the centre transect of the site is shown as the red line in Figure 120.

Table 57 contains the BioCondition attribute data recorded at site M25 during the 2023 voyage. The BioCondition site photographs (Figure 121) are four of the 10 site photographs taken at site M27 in 2023. Photographs are all taken from the centre point of the centre transect, the first facing along the transect bearing and then consecutively facing 90^{o}, 180^{0} and 270^{0} from the direction of the centre transect bearing.

Table 57. BioCondition attribute data recorded in monitoring site M25, Magdelaine Cay South on 2 June 2023.

Site	M25
Cay	Magdelaine Cay South
Landform	flat
Soil	light brown coarse sand. Refer to soil analysis data
Vegetation community description	*Abutilon albescens* shrubland with a mid-dense ground layer dominated by *Lepturus repens*
Transect start (WGS 84)	-16.60378900 150.33594600
Transect centre (WGS84)	-16.60363100 150.33581200
Transect end (WGS 84)	-16.60347800 150.33566400
Transect bearing (degrees)	313
Median canopy height/range (metres)	1.5 (0.8 to 1.8) m
Tree canopy cover %	NA
Shrub canopy cover %	59.0%
Basal area m^2/ha	NA
Total number of large trees/ha	NA
Total no of trees per ha	NA
Total number of tree stems/ha	NA
Total no. shrubs/ha	8,700
Recruitment of ecologically dominant layer (%)	-
Tree species richness	0
Tree species present	NA
Shrub species richness	1
Shrub species present (layer in brackets)	*Abutilon albescens* (S1)
Median ground layer height/range (metres)	0.6 (0.4 to 0.8)
Total ground layer cover of native cay species (%)	50.2%
Grass species richness	1
Grass cover (%)	34.6%
Grass species present in order of decreasing cover - most abundant first (cover in brackets)	*Lepturus repens* (34.6%)
Forb (including vines) species richness	3
Forb species cover (%)	8.2%
Forb species present in order of decreasing cover - most abundant first (cover in brackets)	*Achyranthes aspera (5.4%), Abutilon albiflora* var. *albiflora (2.8%), Boerhavia mutabilis (<1%)*
Native shrub ground cover (%)	7.4%
Introduced plant (weed) cover (all strata) (%)	0.0%
Litter cover (%)	47.4%
Bare ground (%)	2.4%
Woody debris (m/ha of logs >0.5m long and >10cm wide)	0
Soil pH	8.45 (0-10cm), 8.59 (10-20cm), 8.74 (20-30cm), 9.09 (30-40cm)

BioCondition monitoring site photographs

A.

B.

C.

D.

Figure 121. BioCondition monitoring site M25, Magdelaine Cay South
A. Facing NW, B. Facing NE, C. Facing SE, D. Facing SW. Credit: Joy Brushe ©

2.7.4 Soil

Soil samples were collected from the lantern bush (*Abutilon albescens*) shrubland BioCondition monitoring site M25 on Magdelaine Cay South.

Site M25 soils had a higher pH and lower electrical conductivity, total nitrogen and organic carbon than other lantern bush shrubland samples.

Total sulphur levels were high in all CSMP samples collected during the 2022 and 2023 voyages (including the M25 sample) compared with previous samples.

Refer to Appendix 9. 2023 Soil analysis results for all results of the soil analyses for samples collected from M25. For comparison of M25 soil analysis data with data from those for other CSMP and the Capricorn Bunker cays in the southern GBR, refer to Appendix 8. Comparison of soils data.

2.7.5 Birds

Due to the limited time available, surveys focused on the beach and strand vegetation zones. Table 58 contains the bird data from Magdelaine Cay South.

Observations notes:

- The eastern reef egret (*Egretta sacra)* was a pale phase bird with greenish legs and contrasting yellow feet.
- Some brown noddies (*Anous stolidus)* had constructed grass-lined nests in abutilon shrubs.
- The Pacific golden plover (*Pluvialis fulva)* was in partial breeding plumage.
- Welcome swallows (*Hirundo neoxena*) were seen hawking through the middle of the cay.
- Tree martins (*Petrochelidon nigricans*) were seen flying back and forth through the strand vegetation on the windward side of the cay.
- The wandering tattler (*Tringa incana*) was feeding in rockpools on the northern shoreline.

Table 58. Bird species and breeding effort on Magdelaine Cay South.
(P – Present, U – Unknown, NR – Not recorded)

Magdelaine Cay South, Magdelaine Cays 05/06/2023		Breeding status				
Common name	Scientific name	Nests	Chicks	Young	Breeding pairs	Adolescents and adults
red-tailed tropicbird	*Phaethon rubricauda roseotinctus*	0	0	0	0	0
Herald petrel	*Pterodroma heraldica*	0	0	0	0	0
wedge-tailed shearwater	*Ardenna pacifica*	0	0	0	0	0
great frigatebird	*Fregata minor*	P	U	U	P	P
lesser frigatebird	*Fregata ariel*	0	0	0	0	0
masked booby	*Sula dactylatra dactylatra*	40	U	U	40	66
brown booby	*Sula leucogaster*	18	U	U	18	47
red-footed booby	*Sula sula*	P	U	U	P	P
sooty tern	*Onychoprion fuscatus*	0	0	0	0	0
bridled tern	*Onychoprion anaethetus*	0	0	0	0	0
crested tern	*Thalasseus bergii*	0	0	0	0	11
roseate tern	*Sterna dougallii*	0	0	0	0	0
black-naped tern	*Sterna sumatrana*	0	0	0	0	0
New Caledonian fairy tern	*Sternula nereis exsul*	0	0	0	0	0

black noddy	*Anous minutus*	P	P	U	P	P
brown noddy	*Anous stolidus*	P	P	P	P	P
buff-banded rail	*Gallirallus philippensis tounelieri*	0	0	0	0	1
purple swamphen	*Porphyrio melanotus*	0	0	0	0	0
sacred kingfisher	*Todiramphus sanctus*	0	0	0	0	0
masked lapwing	*Vanellus miles novaehollandiae*	0	0	0	0	0
white-faced heron	*Egretta novaehollandiae*	0	0	0	0	0
eastern reef egret	*Egretta sacra*	0	0	0	0	1
Pacific golden plover	*Pluvialis fulva*	0	0	0	0	1
ruddy turnstone	*Arenaria interpres*	0	0	0	0	0
wandering tattler	*Tringa incana*	0	0	0	0	1
grey-tailed tattler	*Tringa brevipes*	0	0	0	0	0
lesser sand plover	*Charadrius mongolus*	0	0	0	0	0
welcome swallow	*Hirundo neoxena*	0	0	0	0	4
tree martin	*Petrochelidon nigricans*	0	0	0	0	2
magpie-lark	*Grallina cyanoleuca*	0	0	0	0	0
hardhead	*Aythya australis*	0	0	0	0	0
eastern great egret	*Ardea alba*	0	0	0	0	0
little pied cormorant	*Microcarbo melanoleucos*	0	0	0	0	0

2.7.6 Invertebrates and rodents

Rodents

No ink tunnels were placed around the cay as time was limited. Despite thorough searches of the cay, no trace of rodents was evident**.**

Ants

Between 70-350 ants were recorded across 6 ant stations (Table 59). Several samples were taken for identification. As it was raining, it is likely majority of the ants were underground. Several specimen samples were identified to be the introduced pharaoh ant *(Monomorium pharaonis).* Additionally, there is speculation whether the wooly ant *(Tetramorium lanuginosum)* is native or introduced.

Table 59. Ant survey results from Madelaine Cay South.

Location: Magdelaine Cays - Magdelaine Cay South
Sampler: Chad Hoult QPWS
Date Collected: 5/06/2023

Ant Stations	GPS	Specimen number	Species	Amount
51	S16.60088-E150.33632	115	*Cicadellidae* indet. sp. A	10-50
52	S16.60126-E150.34123	121	*Tetramorium lanuginosum*	10-50
53	S16.60202-E150.34123	122	unknown	10-50
53	S16.60435-E150.33359	123	*Ectobiidae* sp. A	10-50
54	S16.60680-E150.34044	133	*Monomorium pharaonis*	10-50
55	S16.60680-E15034161	134	*Monomorium pharaonis*	10-50
56	S16.60463-E150.33740	136	*Monomorium pharaonis*	10-50

Insect

A total of 820 insects were counted and 26 insect samples were collected for identification (Table 60). No additional introduced species were identified other than the pharaoh ant *(Monomorium pharaonis)* and the speculated wooly ant *(Tetramorium lanuginosum).*

Table 60. Insect survey results from Madelaine Cay South.

Location: Magdelaine Cay
Sampler: Chad Hoult QPWS
Date Collected: 5/06/2023

Specimen number	Class	Order	Family	Species	Introduced	Count	Amount collected	GPS
111	Insecta	Diptera	Ephydridae			100	1	S16.60202-E150.33437
112	Insecta	Hemiptera	Cicadellidae			23	1	S16.59957-E150.33475
113	Insecta	Coleoptera	Coccinellidae	*Microcaria mulsanti*		2	1	S16.59938-E150.33475
114	Insecta	Dermaptera	Anisolabididae			5	1	S16.59938-E150.33574
115	Insecta	Hymenoptera	Formicidae	*Monomorium pharaonis*	yes	30	4	S16.60088-E150.33632
116	Insecta	Hemiptera	Cicadellidae	Cicadellidae indet. sp. A		34	1	S16.60088-E150.33788
117	Arachnida	Araneae	?Araneidae			11	1	S16.60088-E150.33809
118	Arachnida	Araneae	?Araneidae			56	1	S16.60088-E150.33966
119	Insecta	Hymenoptera	Crabronidae	*Liris* sp. A		3	1	S16.60088-E150.34004
120	Insecta	Diptera	Sarcophagidae	Sarcophagidae indet. sp. C		13	1	S16.60126-E150.34024
121	Insecta	Hymenoptera	Formicidae	*Tetramorium lanuginosum*	?	10	1	S16.60126-E150.34123
122	Malacostraca	Isopoda				100	5	S16.60202-E150.34123
123	Insecta	Blattodea	Ectobiidae	Ectobiidae sp. A		50	5	S16.60435-E150.33359
124	Arachnida	Araneae	Scytodidae			2	1	S16.60474-E150.33397
125	Insecta	Coleoptera	Tenebrionidae	*Gonocephalum* sp.		12	1	S16.60511-E150.33496
126	Arachnida	Araneae	?Araneidae			4	1	S16.60511-E150.33496
127	Insecta	Lepidoptera				20	1	S16.60548-E150.33496
128	Insecta	Lepidoptera	Crambidae	*Spoladea recurvalis*		12	1	S16.60586-E150.33496
129	Arachnida	Acari				1	1	S16.60699-E150.33496
130	Arachnida	Araneae	Lycosidae			9	1	S16.60699-E150.33653
131	Insecta	Hemiptera	Lygaeoidea	*Oxycarenus* sp.		4	2	S16.60699-E150.33788
132	Insecta	Orthoptera	Tettogoniidae			2	1	S16.60699-E150.33945
133	Insecta	Hymenoptera	Formicidae	*Monomorium pharaonis*	yes	5	1	S16.60680-E150.34044
134	Insecta	Hymenoptera	Formicidae	*Monomorium pharaonis*	yes	100	5	S16.60680-E15034161
135	Insecta	Orthoptera	Acrididae			200	1	S16.60463-E150.33585
136	Insecta	Hymenoptera	Formicidae	*Monomorium pharaonis*	yes	12	1	S16.60463-E150.33740

2.7.7 Health Checks

Table 61. Health Chek Results – octopus bush (*Argusia argentea*) shrublands on Magdelaine Cay South.
Key: **G = good**; **GC = good with some concerns**; **SC = significant concern**; **C = critical**; **NA** = not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G	G			G
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	G	G	G			G
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G	G			G
7. Trampling, digging or rooting or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	GC	GC			GC
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	G			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	G	G	G			G
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	G	G	G			G
Overall Condition Class						G

The Health Check results for octopus bush ground cover at site 2 and 3 was recorded as ‘good with some concern’, however this is to be expected for this vegetation community (Table 61). Overall, the results indicate a ‘good’ rating for octopus shrub on Magdelaine Cay South.

Table 62. Health Chek Results – sea trumpet (*Cordia Subcordata*) shrublands on Magdelaine Cay South.
Key: **G = good**;**GC = good with some concerns**; **SC = significant concern**; **C = critical**; **NA =** not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G	G			G
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	G	G	G			G
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G	G			G
7. Trampling, digging or rooting or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	G	G			G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	G			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	C	C	C			C
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	SC	C	C			C
Overall Condition Class						C

Almost complete dieback across almost all sea trumpet shrublands observed and there was no evidence of recruitment. Overall, the results indicate a ‘critical’ rating for Sea trumpet shrublands, on Magdelaine Cay South (Table 62).

Table 63: Health Chek Results – pisonia (Pisonia grandis) forest on Magdelaine Cay South.
Key: **G = good**; **GC = good with some concerns**; **SC = significant concern**; **C = critical**; **NA =** not applicable.

Health Check Indicator	Condition Class					General impression
	Site 1	Site 2	Site 3	Site 4	Site 5	
1. Infestations of ecosystem-changing pest plants	G	G	G			G
2. Infestations of pest plants other than ecosystem-changers	G	G	G			G
3. Risk of future invasion by significant pest plants not already present	G	G	G			G
4. Rainforest invasion	G	G	G			G
5. Woody thickening (other than by rainforest species)	G	G	G			G
6. Overgrazing/browsing by feral animals, stray stock or natives	G	G	G			G
7. Trampling, digging or rooting or trampling by visitors	G	G	G			G
8. Impacts on wetlands	NA	NA	NA			NA
9. Vehicle impacts	G	G	G			G
10. Dumping	G	G	G			G
11. Ground cover	G	G	G			G
12. Fire damage to fire-sensitive and non fire-dependent ecosystems	G	G	G			G
13. Fire damage to peat-based ecosystems	NA	NA	NA			NA
14. Age class distribution in fire-adapted ecosystems in conservation….	NA	NA	NA			NA
15. Severe wildfire in fire-adapted wooded ecosystems	NA	NA	NA			NA
16. Severe storm, cyclone or tornado in wooded ecosystems	G	G	G			G
17. Overtopping, erosion and associated impacts	G	G	G			G
18. Tree/shrub health and dieback	G	G	G			G
19. Key features for faunal biodiversity in terrestrial ecosystems	G	G	G			G
20. Recruitment of canopy species	G	G	G			G
Overall Condition Class						G

Overall, the results indicate a ‘good’ rating for Pisonia forest on Magdelaine Cay South (Table 63).

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Appendices

Appendix 1. Plot orientation and data recorded at permanent monitoring sites

Plots are located in representative areas within a vegetation community.

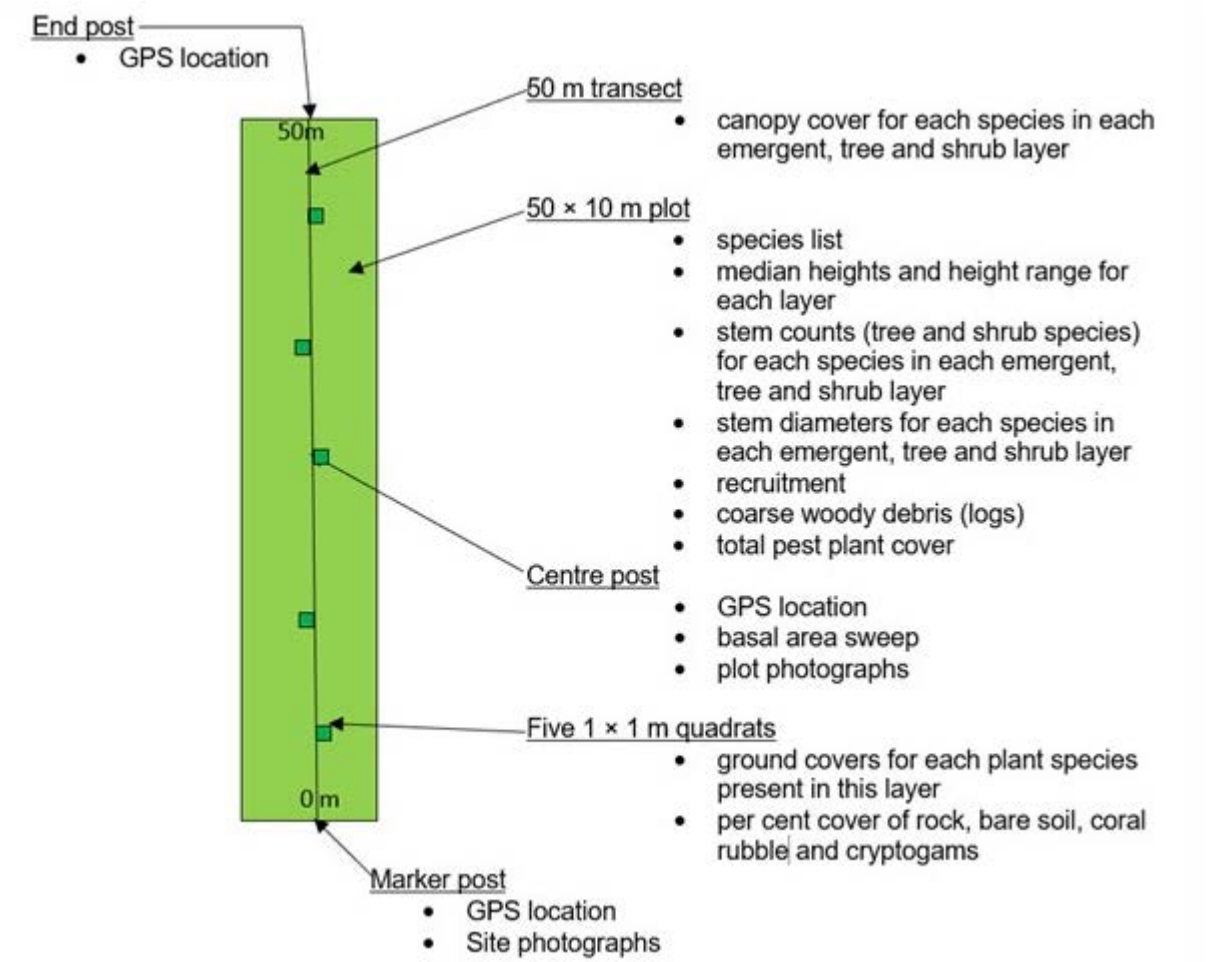

Figure A.1. Plot orientation and data recorded at each permanent vegetation monitoring site.

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
    - introduced plant (weed) cover in each layer
    - species richness – total and differentiated by growth form
    - native species richness – total and differentiated by growth form
    - introduced plant (weed) 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
    - introduced plant (weed) species richness in each layer present – total and differentiated by growth form
    - estimate of overall introduced plant (weed) 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 A.1 (Neldner et al., 2019b).

Table A.1. 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 2. Photographs of drift seeds collected during 2023 voyage

A.

B.

C.

D.

Figure A.2. Photographs of drift seeds collected during the 2023 voyage. A. Herald Beacon Islet, B. East Diamond Islet, C. Chilcott Islet, D. Magdelaine Cay South.

Credit: Joy Brushe ©

Appendix 3. Comparisons of vegetation survey intensity

Table A.2. Comparisons of vegetation survey intensity at each cay on the 2023 voyage.

Cay	Number of ground-truthing sites	Number of BioCondition monitoring sites	Other	Hours spent surveying cay (excluding meal breaks)
Herald Beacon Islet (Mellish Reef)	20	1 (M22)	Additional traverse, weed survey, plant collection	6.75
East Diamond Islet (Tregrosse Reef)	0	1 (M23) Plus photographs taken at M08	Traverse and weed survey	5.5
Willis South Islet (Willis Islets)	30	0	Additional traverse, weed survey, plant collection, labelling monitoring sites	8.5
NE Herald Cay (Herald Cays)	0	1 (M24)	Traverse, weed survey, plant collection	5.75
Chilcott Islet (Coringa Islet)	0	0	Traverse. Weed survey, plant collection	4.25
Magdelaine Cay South (Magdelaine Cays)	0	1 (M25)	Traverse, weed survey	4
Total	50	4		35

Table A.3. Average time surveying each type of site.

Average time per site	
Ground-truthing sites	BioCondition monitoring sites
Average of 8 minutes per site (14.5 minutes including traversing time)	Range (excluding M08) = 30 minutes to 3.75 hours)

Appendix 4. Plant species recorded on all Coral Sea cays

Native cay plant species.

✓	Recently recorded – 2019 to 2023 Parks Australia ecological assessment voyages and /or the 2016 Bush Blitz voyage)
✓	Latest record was 2007 or earlier
Dates in blue	The latest date recorded for species not recorded during 2016 to 2022 voyages. Dates are from herbarium records and the following reports: Hindwood, Keith & Serventy 1963, Heatwole 1967, Heatwole 1969, Stokes 1979, Stokes and McNamara 1979, Stokes and Skeat 1980, Skeat 1981, Skeat and Henry 1981, Shaughnessy and Hill 1983, Hicks 1983, Telford, 1991, Donaldson 1994, Batianoff 1997, Batianoff et al. 2008, Wilgar 93
	Species recorded on the cay prior to the 2016 and 2019 to 2023 voyages
	No record for the cay prior to 2019 to 2023 voyages
Life form:	G = grass, Ga = annual/short lived grass, Gp = perennial grass, Ha = annual/short-lived herb; Hp = perennial herb; V = vine; S = shrub, ST = tall shrub/small tree (2-5m); T = tree (>2m).
Dispersal mechanism:	B = Birds, O = Ocean Currents, W = Wind, H = Human activity,

Scientific name	Common name	Family	Life form	Dispersal mechanism	Reef or island group	Magdelaine Cays	Herald Cays		Coringa Islets		Tregrosse Reef				Willis Islets			Cato Reef	Lihou Reef					Wreck Reef		Mellish Reef	Total number of cays on which each species is currently established
					Cay	South Cay	North East Cay	South West Cay	Chilcott Islet	South West Islet	East Diamond Islet	West Diamond Islet	Central Diamond Islet	South Diamond Islet	South Islet	Mid Islet	North Cay	Cato Island	South West Cay	Hermit Crab Islet	Turtle Islet	Lorna Cay	Georgina Cay	Bird Islet	Porpoise Cay	Herald Beacon Cay	
					Vegetated area (ha)	32	42.7	14.7	13	10	10.4	9.8	10.9	4.2	6	3.4	18.9	14.8	5.7	8.1	2.5	6.4	2.8	8.4	0.2	3.8	
					Max elevation (m)	12	5	7	8	13.5	8	6	8	12	?6?9	7.5	?3	6	5	5	6	?3	6	3.5	3	2	
Achyranthes aspera	chaff flower	Amaranthaceae	Ha	B		✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓	✓	✓ ✓	✓ ✓	✓ ✓	✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓	✓ ✓	✓ ✓	✓	✓	20
Boerhavia albiflora var. *albiflora*	white flowered tar vine	Nyctaginaceae	Hp	B		✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓	✓	✓	✓ ✓	✓ ✓	✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓	✓ ✓	✓ ✓	✓	✓ ✓	20
Portulaca oleracea	pig weed	Portulaceae	Hap	O,B		✓ ✓	✓ ✓	✓	✓ ✓	✓ ✓	✓	✓	✓	✓ ✓	✓ ✓	✓ ✓	✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓	✓	✓ ✓	✓		20
Lepturus repens	stalky grass	Poaceae	Gp	O,B		✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓	✓	✓ ✓	✓ ✓	✓	✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓	1984	✓ ✓	✓	✓ ✓	19
Stenotaphrum micranthum	beach buffalo grass	Poaceae	G	O		✓ ✓	2006	2006	✓ ✓		✓ ✓	✓	✓	✓	✓	✓	✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓	✓ ✓	✓ ✓			18
Tribulus cistoides	bulls head burr	Zygophyllaceae	Ha	B, O		✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓	✓	✓ ✓	✓ ✓	✓ ✓	✓	✓ ✓	✓	✓ ✓	✓ ✓	✓		✓			18
Abutilon albescens	lantern bush	Malvaceae	S	B, W		✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓	✓	✓	✓ one well established mature plant ✓	✓ ✓			✓ ✓	✓ ✓	✓ ✓		✓ ✓				14
Argusia argentea	octopus bush	Boraginaceae	ST	O		✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓	✓	✓ ✓	✓ ✓	✓ ✓		✓ ✓				✓ one well established plant					13
Ipomoea violacea	moon flower	Convolvulaceae	V	O, B		✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓	✓								1983						8
Plumbago zeylanica	native plumbago	Plumbaginaceae	Hp	B		✓ ✓		✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓	✓	✓ ✓							1980						8
Sporobolus virginicus	marine couch	Poaceae	Gp	O, B		✓ ✓	✓ ✓	✓ ✓	2007						✓ ✓	✓ ✓	✓										7
Cordia subcordata	sea trumpet	Boraginaceae	ST	O		✓ ✓	✓ ✓		✓ ✓	✓ ✓	✓ ✓	✓			✓ one small plant												6
Lepidium englerianum	beach peppercress	Brassicaceae	Ha	O		✓ ✓	✓ ✓	1983	✓ ✓	2007	✓ ✓						✓									1961	6
Boerhavia mutabilis	pink flowered tar vine	Nyctaginaceae	Hp	B		✓ ✓	✓ ✓	✓	✓	✓ ✓																	4
Canavalia rosea	beach bean	Leguminosae	V	O		✓ ✓					✓ ✓	1961	✓														3
Digitaria bicornis	crabgrass	Poaceae	Ga	?B, ?W		✓				✓																	2
Ipomoea pes-caprae subsp. *brasiliensis*	goats foot convolvulus	Convolvulaceae	V	O							✓				✓ ✓						1984						2
Pisonia grandis	bird lime tree	Nyctaginaceae	T	B		✓ ✓	✓ ✓			1991																	2
Ximenia americana	yellow plum	Olacaceae	ST	?O			1997					✓ ✓															1
Colubrina asiatica	Asian naked wood	Rhamnaceae	S	O		2007																					?0
Calophyllum inophyllum	Alexandrian laurel	Clusiaceae	ST	O			1996 - transient																				?0
Cocos nucifera	coconut	Arecaceae	T	H, O			1997- transient								✓ transient - single juvenile plant ✓ planted							✓ transient - single seedling				✓ transient - single juvenile plant	?0
Digitaria ctenantha	comb finger grass	Poaceae	Ga	?B, ?W		1987	1997			1984																	?0
Guilandina bonduc	knicker nuts	Leguminosae	V	O			✓ transient - single seedling																				?0
Scaevola taccada	Cardwell cabbage	Goodeniaceae	S	O							2021 transient- one juvenile; not present in 2022																0
Current total no of native-cay species = 19						17	13	11	13	12	14	12	11	9	11	9	8	7	7	7	7	7	5	6	4	3	Total number of cays = 21

Table A.4. Native cay species recorded on all Coral Sea Cays.

Weeds (introduced plant species)

✓	Recorded during 2019 to 2023 Parks Australia voyages
✓	Species was recorded prior to 2019
dates in red	The latest date recorded for species not recorded during 2019 to 2023 voyages (dates are from herbarium records and reports - Donaldson 1994, Batianoff et al. 2008)
	Species recorded prior to the 2019 to 2023 voyages
	No record for this cay prior to 2019 to 2023 voyages
Life form	Ga = annual grass, Ha = annual/short-lived herb; H = perennial herb
Dispersal mechanism	According to Batianoff et al 2012, weeds are introduced and spread by human activity

Table A.5. Weed (introduced plant species) recorded on all CSMP Cays.

Scientific name	Common name	Family	Life form	Dispersal mechanisms	Willis Islets	Wreck Reef	Total number of cays with each species
					South Islet	Bird Islet	
Alternanthera pungens	kahki weed	Amaranthaceae	Ha	H	1995		1
Amaranthus viridis	green amaranth	Amaranthaceae	Ha	H	✓ ✓	✓	2
Cenchrus echinatus	Mossman River grass	Poaceae	Ha	H	✓ ✓		1
Cynodon dactylon var. *dactylon*	common couch	Poaceae	Hp	H	2007	✓ ✓	2
Dactyloctenium egypticum	coast button grass	Poaceae	Ha	H	✓ ✓		1
Digitaria ciliaris	summer grass	Poaceae	H	H	✓		
Eleusine indica	crows foot grass	Poaceae	Ha	H	✓ ✓		1
Euphorbia cyathophora	dwarf poinsettia	Euphorbiaceae	Ha	H	✓ ✓		1
Euphorbia prostrata	red caustic creeper	Euphorbiaceae	Ha	H	✓ ✓		1
Solanum americanum	nightshade	Solanaceae	Ha	H		✓	1
Trianthema portulacastrum	black pigweed	Aizoaceae	Hp	H	✓ ✓		1
Tridax procumbens	tridax daisy	Asteraceae	Ha	H	2007		1
Gynandropsis gynandra	cat's whiskers	Cleomaceae	Ha	H	✓ ✓		1

Appendix 5. Plant species collected on all CSMP cays

currently present and previously collected prior to 2019.

Currently present, latest collection is 2007 or earlier (to be collected at next opportunity).

First collected during 2019 to 2023 voyages.

Dates are the years of collection

Dates in cells with no shading are the latest dates that species not currently present were collected.

Introduced plant species (weeds) are shown in red.

Table A.6. Plant species collected from CSMP Cays

Scientific name	Common name	Family	Magdelaine Cays	Herald Cays		Coringa Islets		Tregrosse Reef				Willis Islets			Cato Reef	Lihou Reef					Wreck Reef		Mellish Reef	Total no of cays on which each species was collected 2019 to 2023
			South Cay	North East Cay	South West Cay	Chilcott Islet	South West Islet	East Diamond Islet	West Diamond Islet	Central Diamond Islet	South Diamond Islet	South Islet	Mid Islet	North Cay	Cato Island	South West Cay	Hermit Crab Islet	Turtle Islet	Lorna Cay	Georgina Cay	Bird Islet	Porpoise Cay	Herald Beacon Cay	
Abutilon albescens	lantern bush	Malvaceae	2023	2023	2019	2023	2016	2021	2021	2021	2021	2023	2022			2021	2021	2021		2021				14
Achyranthes aspera	chaff flower	Amaranthaceae	2023	1997	2006	2023	2016	2021	2021	2021	2021	2023	2022	2022	2022	2021	2021	2021	2021	2021	2022	2022	2023	18
Alternanthera pungens	kahki weed	Amaranthaceae										1995												0
Amaranthus viridis	green amaranth	Amaranthaceae										2023									2022			2
Argusia argentea	octopus bush	Boraginaceae	2019	2023	2006	2023	2007	2021, 2022	2021	2021	2021	2023	2022		2022				2021					11
Boerhavia albiflora var. *albiflora*	tar vine	Nyctaginaceae	2023	2022	2019	2023	2019	2021	2021	2021	2021	2023	2022	2022	2022	2021	2021	2021	2021	2021	2022	2022	2023	21
Boerhavia mutabilis	pink flower tar vine	Nyctaginaceae	2023	2023	recorded 2019; not collected	2023	2019																	4
Calophyllum inophyllum	Alexandrian laurel	Clusiaceae		1996 - transient																				0
Canavalia rosea	beach bean	Fabaceae	2019					2021	1961	2021														3
Cenchrus echinatus	Mossman River grass	Poaceae										2023												1
Colubrina asiatica	Asian naked wood	Rhamnaceae	2007																					0
Cordia subcordata	sea trumpet	Boraginaceae	2019	2022, 2023		2023	2016	2021, 2022	2021			2023												7
Cynodon dactylon var. dactylon	common couch	Poaceae										2007									2022			1
Dactyloctenium aegyptium	coast button grass	Poaceae										2023												1
Digitaria ciliaris	summer grass	Poaceae										2023												1
Digitaria bicornis	crabgrass	Poaceae	recorded 2019 not collected				2019																	1
Digitaria ctenantha	comb finger grass	Poaceae	1987	1997			1984																	0
Eleusine indica	crows foot grass	Poaceae										2023												1
Euphorbia cyathophora	dwarf poincettia	Euphorbiaceae										2023												1
Euphorbia prostrata	red caustic creeper	Euphorbiaceae										2023												1
Guilandina bonduc	knicker nuts	Caelalpiniaceae		transient - single seedling																				0
Gynandropsis gynandra	cat's whiskers	Capparaceae										2023												1
Ipomoea pes-caprae subsp. *brasiliensis*	goats foot convolvulus	Fabaceae						2021				2023						1984						2
Ipomoea violacea	moon flower	Convolvulaceae	2007	2023	2006	2023	2019	2021	2021	2021								1983						6
Lepidium englerianum	beach peppercress	Brassicaceae	2023	2022, 2023		2023	1983	2021, 2022						2022									1961	5
Lepturus repens	stalky grass	*Poaceae*	2019, 2023	2007	1983	2019, 2023	2016	2021	2021	2021	2021	2023	2022	2022	2022	2021	2021	2021	2021		2022	2022	2023	17
Pisonia grandis	pisonia	Nyctaginaceae	2007	2023			1991 (no longer present																	1
Plumbago zeylanica	native plumbago	Plumbaginaceae	2007		2006	2023	2019	2021	2021	2021	2021							1980						6
Portulaca oleracea	pig weed	Portulaceae	2007	2023	2006	2023	2016	2021	2021	2021	2021	2023	2022	2022	2022	2021	2021	2021	2021	2021	2022	2022		18
Scaevola taccada	Cardwell cabbage	Goodeniaceae						2021 (transient)																1
Solanum americanum	nightshade	Solanaceae																			2022			1
Sporobolus virginicus	marine couch	Poaceae	2007	2023	2019							2023	2022	2022										5
Stenotaphrum micranthum	beach buffalo grass	Poaceae	2023	2006	2006	2019, 2023		2021	2021	2021	2021	2023	2022	2022	2022	2021	2021	2021	2021	2021	2022			16
Trianthema portulacastrum	black pigweed	Aizoaceae										2023												1
Tribulus cistoides	bulls head burr	Zygophyllaceae	2007	2023	2019	2023	2007	2021	2021	2021	2021	2023	2022	2022	2022	2021	2021	2021	2021		2022			16
Tridax procumbens	tridax daisy	Asteraceae										2007												0
Ximenia americana	yellow plum	Olacaceae		1997					2021															1
Total number of species recorded on each cay 2019 to 2023			17	13	11	13	12	15	12	11	9	20	9	8	7	7	7	7	7	5	9	4	3	
Total number of species collected on each cay 2019 to 2023			10	11	4	13	6	15	12	11	9	20	9	8	7	7	7	7	7	5	9	4	3	

Notes: Some species recorded on Magdelaine, Coringa and Herald cays during 2006/2007 but not recorded on later trips may still be present (due to dry conditions in Dec 2019 and limited time for searching on later voyages).
Three specimens of *Boerhavia* (two from SW Coringa, one from SW Herald) collected in 2019 and kept by Qld Herbarium could not be identified as they were infertile.
There are 20 specimens not collected since before 2008 that still need to be collected – 7 from Magdelaine Cay South, 3 from NE Herald Cay, 8 from SW Herald Cay, 2 from SW Coringa Islet.

Appendix 6. Extent and distribution of CSMP cay vegetation communities 2019 to 2023

Table A.7. Extent and distribution of CSMP cay vegetation communities 2019 to 2023.

Area (ha) - top value in black
% of total vegetated area - bottom value in blue (this does not include the human use (operational) areas and infrastructure)

		Islet/cay group	Coringa Herald 2007						Coringa Herald 2019						Willis Islets (2020, 2022, 2023)						Diamond Islets (2021)					Lihou Reef (2021)						Cato (2022)	Wreck Reefs (2022)				Mellish Reef (2023)
		Islet /cay	NE Herald	SW Herald	SW Coringa	Chilcott	SE Magdelaine	Total Area Coringa Herald group	NE Herald	SW Herald	SW Coringa	Chilcott	SE Magdelaine	Total Area Coringa Herald group	Mid Islet	North Cay	South Islet 2020	South Islet 2023	Total area Willis Islets 2020-2022	Total area Willis Islets 2022-2023	Central Diamond	East Diamond	South Diamond	West Diamond	Total area Diamond Islets	Georgina Cay	Hermit Crab Islet	Lorna Cay	SW Cay	Turtle Islet	Total area Lihou reef cays	Cato Island	Bird Islet	Porpoise Cay	Total area Wreck Reefs cays	Herald Beacon Cay
Total vegetated area (incl. naturally bare)			51.16	14.75	9.99	13.75	34.85	124.50	41.5	14.5	12.1	12.0	30.9	111.4	3.4	18.9	4.7	4.9	27.0	27.2	10.9	10.4	4.2	9.8	35.2	2.8	8.1	6.4	5.7	2.5	25.5	14.8	8.4	0.2	8.5	3.8
Unvegetated areas		Sandy shores	4.11	3.02	2.13	2.03	2.52	13.81	5.42	3.35	2.76	3.37	2.72	17.63	2.60	7.47	3.22	3.26	13.29	13.33	2.69	4.84	1.97	2.69	12.19	3.70	3.59	10.16	3.33	2.39	23.16	4.63	2.787	0.53	3.32	4.17
		Lithified shores	5.07	1.34	1.33	1.04	3.9	12.68	6.32	1.59	1.47	3.75	4.23	17.35	1.81	6.17	0.33	3.81	8.31	11.79	5.12	2.54	1.76	2.62	12.04	2.17	1.50	4.03	1.89	1.39	10.98	4.19	2.943	0.89	3.83	0.94
		Rubble banks													0.26			0.16	0.26	0.42	0.41	0.34	0.40	0.62	1.78	0.10	0.10		0.30		0.50	0.31	0.024		0.02	
		bare/ dead vegetation							0.17 0.41					0.17 0.15				0.01 0.26		0.01 0.05																0.14 3.59
Human use and infrastructure																	0.75	0.71	0.75	0.71		0.006			0.01							0.006				
Vegetation communities	shoreline sparse grassland/ herbland	sparse to open grassland or herbland on sandy shores	8.48 16.58	0.09 0.61	0.64 6.41	0.12 0.87	0.36 1.03	9.69 7.78		0.01 0.06	0.31 2.56	0.28 2.33	0.14 0.45	0.74 0.66	0.36 10.49	0.63 3.34	0.06 1.27	0.09 1.85	1.05 3.89	1.08 3.97	0.54 5.01	0.30 2.86	0.28 6.67	0.19 1.93	1.31 3.72	0.55 19.52	0.15 1.83	0.35 5.48	0.14 2.55	0.05 2.14	1.25 4.89	0.17 1.15	0.31 3.73	0.05 25.02	0.36 4.18	0.05 1.44
		sparse herbland on shoreline rubble banks																			0.01 0.05			0.07 0.69	0.07 0.20				0.16 2.79		0.16 0.62	0.02 0.11	0.002 0.024			
	coastal *Argusia argentea* shrublands	*Argusia argentea* open shrubland to isolated shrubs on shorelines and sand spits													0.05 1.46			0.01 0.13	0.05 0.18	0.06 0.21	0.05 0.41	0.22 2.09	0.05 1.15	0.36 3.69	0.67 1.90							0.12 0.79				
		Coastline Argusia argentea dwarf open shrubland/ dwarf shrubland/ open shrubland/shrubland/ open scrub	4.5 8.80	1.99 13.49	2.45 24.52	1.51 10.98	4.77 13.69	15.22 12.22	4.50 10.84	3.27 22.45	2.61 21.54	1.36 11.34	4.46 14.45	16.48 14.80	0.34 10.06		0.68 14.41	0.34 6.88	1.02 3.79	0.68 2.51	2.03 18.71	0.94 8.97	0.08 1.84	2.40 24.61	5.44 15.45							0.53 3.60				
	shrublands	Interior and subcoastal *Argusia argenea* dwarf shrubland/ shrubland/ tall open shrubland/ tall shrubland/closed scrub							0.69 1.66		0.39 3.22	0.25 2.08	0.83 2.69	2.16 1.94	0.40 11.56		0.39 8.26	0.22 4.43	0.79 2.91	0.61 2.26	0.34 3.14	0.14 1.34	0.61 14.58	2.04 20.89	3.13 8.88											
		Cordia subcordata open to closed shrublands/closed scrub	2.35 4.59		0.02 0.20	0.01 0.07	0.37 1.06	2.75 2.21			0.05 0.41	0.02 0.17	1.46 4.75	1.53 1.38								0.20 1.91		0.00 0.02	0.20 0.57											
		Argusia argentea shrubland with occasional *Cordia subcordata* and a ground layer dominated by *Lepturus repens*																						0.00 0.03	0.00 0.01										
		Abutilon albescens open shrubland to shrubland with emergent dead *Cordia subcordata*							1.52 3.66					1.52 1.36																						
		Abutilon albescens open shrubland/ shrubland	5.74 11.22	11.35 76.95	3.29 32.93	8.46 61.53	14.53 41.69	43.37 34.84	4.39 10.57	5.73 39.40	0.24 1.98	1.29 10.73	9.10 29.49	20.75 18.64				0.0001 0.0012		0.0001 0.0002			0.26 6.28		0.26 0.75	0.01 0.35			1.04 18.32		1.05 4.10					
		Abutilon albescens open heath with emergent *Pisonia grandis*	1.05 2.05					1.05 0.84																												
		Ximenia americana shrublands																						0.05 0.50	0.05 0.14										
	grasslands	*Stenotaphrum micranthum* open to closed grassland - coastal/ subcoastal														5.53 29.31	0.04 0.85	0.03 0.57	5.57 20.62	5.56 20.43			0.08 1.89		0.08 0.22	0.80 28.40	0.00 0.01	0.50 7.74	0.26 4.67	0.69 27.69	2.25 8.82	0.02 0.16	0.76 9.08		0.76 8.89	
		Lepturus repens/ Stenotaphrum micranthum grassland														2.33 12.35			2.33 8.63	2.33 8.57		0.20 1.87			0.20 0.55		0.10 1.28		0.23 4.03	0.26 10.50	0.59 2.32		0.52 6.23		0.52 6.10	
		Lepturus repens open to closed grassland			0.21 2.10	0.39 2.84	8.24 23.64	8.84 7.10			1.06 8.75	0.41 3.41	2.10 6.80	3.57 3.20		1.73 9.17	0.25 5.30	0.39 8.04	1.98 7.33	2.12 7.81	3.54 32.60	6.83 65.45	1.96 46.91	4.64 47.57	16.97 48.17		1.60 19.71	1.67 25.82	2.57 45.44	1.35 54.34	7.18 28.15	0.07 0.51	0.12 1.43	0.14 74.98	0.26 3.00	2.34 62.35
		Sporobolus virginicus open to closed grassland	0.60 1.17	0.24 1.63			0.66 1.89	1.50 1.20	0.31 0.75	0.33 2.26			1.52 4.93	2.16 1.94	0.15 4.50	0.09 0.46	1.93 40.89	1.16 23.60	2.17 8.03	1.40 5.14														
		Sporobolus virginicus closed grassland with emergent *Argusia argentea*															0.16 3.39		0.16 0.59																
		**Cynodon dactylon* var. *dactylon* naturalised closed grassland																													0.67 8.06		0.67 7.89		
		**Cenchrus echinatus* naturalised closed grassland																0.42 8.65		0.42 1.56															
	herblands	*Boerhavia albiflora var. albiflora* sparse herbland to closed herbland			0.04 0.40	0.64 4.65		0.68 0.55			0.50 4.15	0.80 6.65		1.30 1.17	0.61 17.81	4.16 22.03	0.97 20.55	0.44 9.00	5.74 21.24	5.21 19.15		0.79 7.54	0.03 0.76	0.01 0.08	0.83 2.34	0.27 9.62	0.22 2.66	2.85 44.17	0.49 8.68	0.13 5.33	3.96 15.52	0.18 1.24	1.35 16.17		1.35 15.83	0.92 24.55
		Achyranthes aspera herbland to closed herbland		0.52 3.53	2.1 21.02			2.62 2.10		2.02 13.90	1.96 16.20	2.90 24.12	5.46 17.69	12.35 11.09	1.51 44.12		0.08 1.69		1.59 5.89	1.51 5.55	2.30 21.18	0.11 1.01	0.57 13.64		2.98 8.45	1.19 42.10	6.04 74.51	1.08 16.79	0.77 13.53		9.08 35.58	9.05 61.12	3.88 46.38		3.88 45.40	0.30 8.06
		Portulaca oleracea herbland to closed herbland														4.41 23.34			4.41 16.30	4.41 16.19												4.64 31.31	0.74 8.89		0.74 8.70	
		Plumbago zeylanica herbland/ shrubland/ closed shrubland		0.51 3.46		0.24 1.75		0.75 0.60		2.58 17.73	1.02 8.42	3.45 28.69	0.70 2.27	7.75 6.96							1.80 16.62		0.26 6.28		2.07 5.87											
		Tribulus cistoides open herbland to herbland																1.08 22.01		1.08 3.97															
		**Euphorbia cyathophora* naturalised closed herbland																0.55 11.12		0.55 2.01															
	Vinelands	*Ipomoea violacea* vineland		0.06 0.41	1.23 12.31	2.37 17.24		3.66 2.94		0.61 4.20	3.97 32.76	1.26 10.48		5.84 5.25							0.25 2.28	0.72 6.88			0.97 2.74											
		Ipomoea pes-caprae subsp. *brasiliensis/ Sporobolus virginicus* vineland/ herbland															0.16 3.39	0.17 3.44	0.16 0.59	0.17 0.62		0.01 0.10			0.01 0.03											
	Pisonia grandis communities	Windsheared *Pisonia grandis* closed scrub	3.29 6.43				0.69 1.98	3.98 3.20	3.72 8.96				0.15 0.47	3.87 3.47																						
		Pisonia grandis open shrubland/ tall shrubland											1.17 3.79	1.17 1.05																						
		Pisonia grandis closed scrub/ low closed forest	25.15 49.16				5.23 15.01	30.38 24.40	26.40 63.57				3.77 12.23	30.17 27.10																						

Appendix 7. CSMP BioCondition monitoring sites established and monitored 2019-2023

Table A.8. Coral Sea Marine Park BioCondition monitoring sites established and monitored 2019 to 2023.

Community		Sites	Location	Site community description
Forests	*Pisonia grandis* forest	NEH01	North East Cay (Herald Cays)	*Pisonia grandis* closed scrub to low closed forest
		NEH02	North East Cay (Herlad Cays)	*Pisonia grandis* closed scrub to low closed forest
		SEM01	Magdelaine Cay South (Magdelaine Cays)	*Pisonia grandis* closed scrub to low closed forest
Shrublands	Coastal *Argusia argentea* shrubland	M04	South Islet (Willis Islets)	A*rgusia argentea* dwarf shrubland
		M06	East Diamond Islet (Tregrosse Reefs)	*Argusia argentea* shrubland with a mid dense ground layer dominated by *Achyranthes aspera, Boerhavia albiflora* var. *albiflora, Stenotaphrum micranthum* and *Lepturus repens*
		M07	East Diamond Islet (Tregrosse Reefs)	*Argusia argentea* closed scrub with a mid-dense ground layer dominated by *Lepturus repens, Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*
	Interior *Argusia argentea* shrubland	M21	Mid Islet (Willis Islets)	*Argusia argentea* shrubland with a dense ground layer dominated by *Sporobolus virginicus*
	Cordia subcordata shrubland	M23	East Diamond Islet (Tregrosse Reefs)	*Cordia subcordata* patchy open scrub with a sparse ground layer of Lepturus *repens* and *Tribulus cistoides* between patches, very little ground cover under *Cordia* patches
		M24	NE Cay (Herald Cays)	*Abutilon albescens/Cordia subcordata* closed shrubland with a very sparse ground cover dominated by *Ipomoea violacea* and *Boerhavia mutabilis*
	Abutilon albescens shrubland (dynamic communities transitioning between grassland, herbland and shrubland)	M09	South Diamond Islet (Tregrosse Reefs)	*Abutilon albescens* shrubland with a dense ground layer dominated by *Plumbago zeylanica* and *Achyranthes aspera*
		M25	Magdelaine Cay South (Magdelaine Cays)	*Abutilon albescens* shrubland with a mid-dense ground layer dominated by *Lepturus repens*
Grassland and grassland/herbland	*Lepturus repens* grassland	M12	Turtle Cay (Lihou Reef)	Closed grassland dominated by *Lepturus repens*
		M22	Herald Beacon Islet (Mellish Reef)	Closed grassland dominated by *Lepturus repens*
	Lepturus repens grassland/herbland	M11	Hermit Crab Islet (Lihou Reef)	Closed grassland dominated by *Lepturus repens* and *Achyranthes aspera*
		M15	Lorna Cay (Lihou Reef)	Grassland/herbland dominated by *Lepturus repens* and *Achyranthes aspera*
		M05	West Diamond Islet (Tregrosse Reefs)	Closed grassland dominated by *Lepturus repens, Boerhavia albiflora* var. *albiflora* and *Ipomoea violacea*
	Sporobolus virginicus grassland	M01	South Islet (Willis Islets)	*Sporobolus virginicus* grassland
		M03	South Islet (Willis Islets)	*Sporobolus virginicus* grassland
	Stenotaphrum micranthum grassland/ herbland	M18	Bird Islet (Wreck Reefs)	Closed grassland/herbland dominated by *Stenotaphrum micranthum* and *Achyranthes aspera*
		M13	Turtle Cay (Lihou Reef)	Grassland dominated by *Stenotaphrum micranthum* and *Portulaca oleracea*
Herblands	*Achyranthes aspera* herbland	M10	Hermit Crab Islet (Lihou Reef)	Closed herbland dominated by *Achyranthes aspera*
		M19	Bird Islet (Wreck Reefs)	Closed forbland dominated by *Achyranthes aspera* and *Boerhavia albiflora* var. *albiflora*
		M17	Cato Island (Cato Reef)	Closed herbland dominated by *Achyranthes aspera, Portulaca oleracea* and *Boerhavia albiflora* var. *albiflora*
	Achyranthes aspera herbland/ grassland	M08	East Diamond Islet (Tregrosse Reefs)	Closed herbland dominated by *Achyranthes aspera, Canavalia rosea, Lepturus repens* and *Boerhavia albiflora* var. *albiflora*
	Boerhavia albiflora var. *albiflora* herbland	M14	Lorna Cay (Lihou Reef)	Open herbland dominated by *Boerhavia albiflora* var. *albiflora*
		M20	North Cay (Willis Islets)	Closed herbland dominated by *Boerhavia albiflora* var. *albiflora, Stenotaphrum micranthum* and *Portulaca oleracea*
	Portulaca oleracea herbland	M16	Cato Island (Cato Reefs)	*Portulaca oleracea* herbland
Vinelands	*Ipomoea pes-caprae* vineland/herbland	M02	South Islet (Willis Islets)	*Ipomoea pes-caprae* subsp. *brasiliensis/ Sporobolus virginicus* herbland
	Total number of BioCondition monitoring site	28		

Appendix 8. Comparison of soils data

Data for comparison presented in this appendix are from soil samples collected and reported during the following surveys:

- Coringa, Herald and Magdelaine cays 2006 and 2007 survey (Batianoff et al. 2008 and Batianoff et al. 2010). This island group was then identified as the Coringa Herald National Nature Reserve (CHNNR). It is now part of the Coral Sea Marine Park.
- Capricorn Bunker cays 2007/2008 survey in the Southern GBR (Batianoff et al. 2012).
- South Islet (Willis Islets) survey (Sites M01 to M04) in October 2020 survey (Brushe 2021).
- Diamond Islets, Tregrosse Reef (sites M05 to M09) and Lihou Reef Cay (site M10 to M15) surveys in July 2021 (Chapman et al. 2022).
- Cato Island (sites M16 and M17), Bird Islet (sites M18 and M19), site M20 North Cay (Willis Islets) and site M21 Mid Islet (Willis Islets) surveyed in May/June 2022 (McDougall and Brushe 2023)
- Herald Beacon Islet site M22, South Islet (Willis Islets) site M02, East Diamond Islet site M23, NE Herald Cay site M24 and Magdelaine Cay South site M25 surveyed in May/June 2023 (this report).

The graphed data (Figure A.3-13) are averages of soil samples collected to 30 to 40 cm depths grouped into vegetation types; octopus bush (*Argusia argentea*) shrublands, interior grasslands, interior herblands, interior lantern bush (*Abutilon albescens*) shrublands, sea trumpet (*Cordia subcordata*) shrublands and pisonia (*Pisonia* grandis) communities.

Although no soils were sampled from pisonia communities during the 2019 to 2023 voyages, soil data for this tree community was taken in 2006/2007 (CHNNR cays) and 2007/2008 (Capricorn Bunker cays) and has been included for comparison.

Values obtained from multiple cays were averaged for each vegetation type in the 2006/2007 CHNNR samples, the 2007/2008 Capricorn Bunker sites, the Diamond Islets 2021 sites and the Lihou Reef 2021 sites. Two South Islet (Willis Islets) grassland sites were also averaged. Therefore, variation between cays in the same vegetation type within each of these island groups for these years are not shown in the graphs.

The 2020 soil samples from site M02 (South Islet) had very high levels of phosphorus, aluminium, iron and other trace elements. Samples from this site were collected and analysed again in 2023 for comparison.

The following colour coding has been used to distinguish the results of samples collected from different cays or groups of cays. Results of the 2023 samples are distinguished by the hashed pattern.

South Islet (Willis Islets) sites sampled in October 2020.

South Islet (Willis Islets) site M02 sampled in June 2023.

North Cay (Willis Islets) site M20 and Mid Willis site M21 sampled in June 2022.

Averages (all cays) for all sites in each vegetation type sampled in the Diamond Islets (Tregrosse Reef) sites during the July 2021 voyage.

Site M23 East Diamond Islet (Tregrosse Reef) sampled in June 2023.

Averages (all cays) for all sites in each vegetation type sampled in Lihou Reef cay sites during the July 2021 voyage.

Cato Island sites M16 and M17 sampled in May 2022.

Bird Island (Wreck Reefs) sites M18 and M19 sampled in May 2022.

Site M22 sampled at Herald Beacon Cay (Mellish Reef) in May 2023.

NE Herald Cay site M24 and Magdelaine Cay South site M25 sampled in June 2023.

Averages (all cays) of all sites in each vegetation type sampled during the CHNNR 2006-2008 survey.

Averages (all cays) in each similar vegetation type sampled during the Capricornia Cays 2007/2008 survey (excluding Lady Elliot Island which was a highly disturbed weed dominated cay).

no data available

Cay soils are derived solely from coral and other organisms growing on the reefs. The calcareous sand substate is very low in nutrient and contains no clay. Cay soils usually have little to no profile development beyond some accumulation of organic matter in the A-horizon. The absence of a B-horizon indicates recent development and/or a lack of weathering from the original marine deposits (Batianoff et al. 2012). Organic input from seabird guano, turtle nesting and decaying vegetation provides soil nutrient and enhances nutrient availability to plants. Rainfall and oceanic aerosols also contribute to soil development.

Batianoff et al. (2012) demonstrated that soil nutrient concentrations were higher and pH lower in the surface soils than in deeper horizons. Soil pH is lower in surface soils than at depth due to leaching of the carbonate by rainfall. Although no samples were collected deeper than 30cm to 40 cm during the 2020 to 2023 voyages, with some exceptions, levels of total nitrogen, organic carbon, Colwell phosphorus, total and exchangeable potassium, exchangeable sodium, exchangeable calcium, exchangeable Mg and CEC generally decreased with sample depth and pH increased with depth.

Collectively, the soil analysis data demonstrated that there is a relationship between soil properties, associated vegetation community, distance from the shoreline and increasing elevation of the cay interior. Soil generally varies 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 on plateaus and higher elevation sites in cay interiors where vegetation is denser and soils have had a longer time to develop. Soil nutrient levels are lowest on beaches/shorelines and highest in the interior soils, while pH is highest in the beach/shoreline soils and lowest in the higher elevation interior organic soils with long established vegetation.

The lower elevation interior herbland on North Cay (Willis Islets) and the interior octopus bush (*Argusia argentea*) community on Mid Islet (Willis Islets) had less developed, lower nutrient soils with higher pH than on those cays with higher elevation interior sites.

Batianoff et al. (2012) previously noted that soil nutrient levels in the CHNNR cays were considerably higher than those in samples from the Capricorn Bunker Cays in the southern GBR. The higher nutrient status of the CSMP Cays compared to the southern GBR cays is evident in the graphs on the following pages.

Chemical composition of soil varies with recent climatic conditions which affect nutrient input from decaying vegetation and guano and rate of nutrient leaching from surface soils. Nutrient levels will also vary with time of the year in which the samples were collected due to both variation in climatic conditions and intensity of seasonal bird nesting. These factors must be considered when interpreting comparative data and may explain some of the variations between samples evident in the graphs below. Additionally, while the samples collected during the 2020 to 2023 surveys provide good data for individual sites, the small number of samples collected nay not be sufficient to provide representative data in each vegetation type for accurate comparison.

pH

Soil pH on cays is typically alkaline due to the high carbonate content. Alkaline pH can make several of the trace elements, particularly iron, manganese and zinc, unavailable to plants.

The interior octopus bush (*Argusia argentea*) shrubland on Mid Islet (Willis Islets) and the interior herbland on North Cay (Willis Islets) had higher average and median pH values than soil samples from all other locations.

Site M02 (grey water outlet site) had a much lower pH in 2023 samples than the 2020 samples.

Excluding the 2023 samples from M02, which had the lowest pH of all the samples, the vegetation type with the lowest pH soils were the CHNNR interior mature pisonia (*Pisonia grandis)* forests. Averaged CHNNR pisonia soils have lower average pH than average pH from the same community on the Capricorn Bunker, although the soils in the largest, most well-developed forests on the Capricorn Bunker cays (Masthead and North West Island) have the lowest pH (7.08 and 7.33 respectively) within the available data sets.

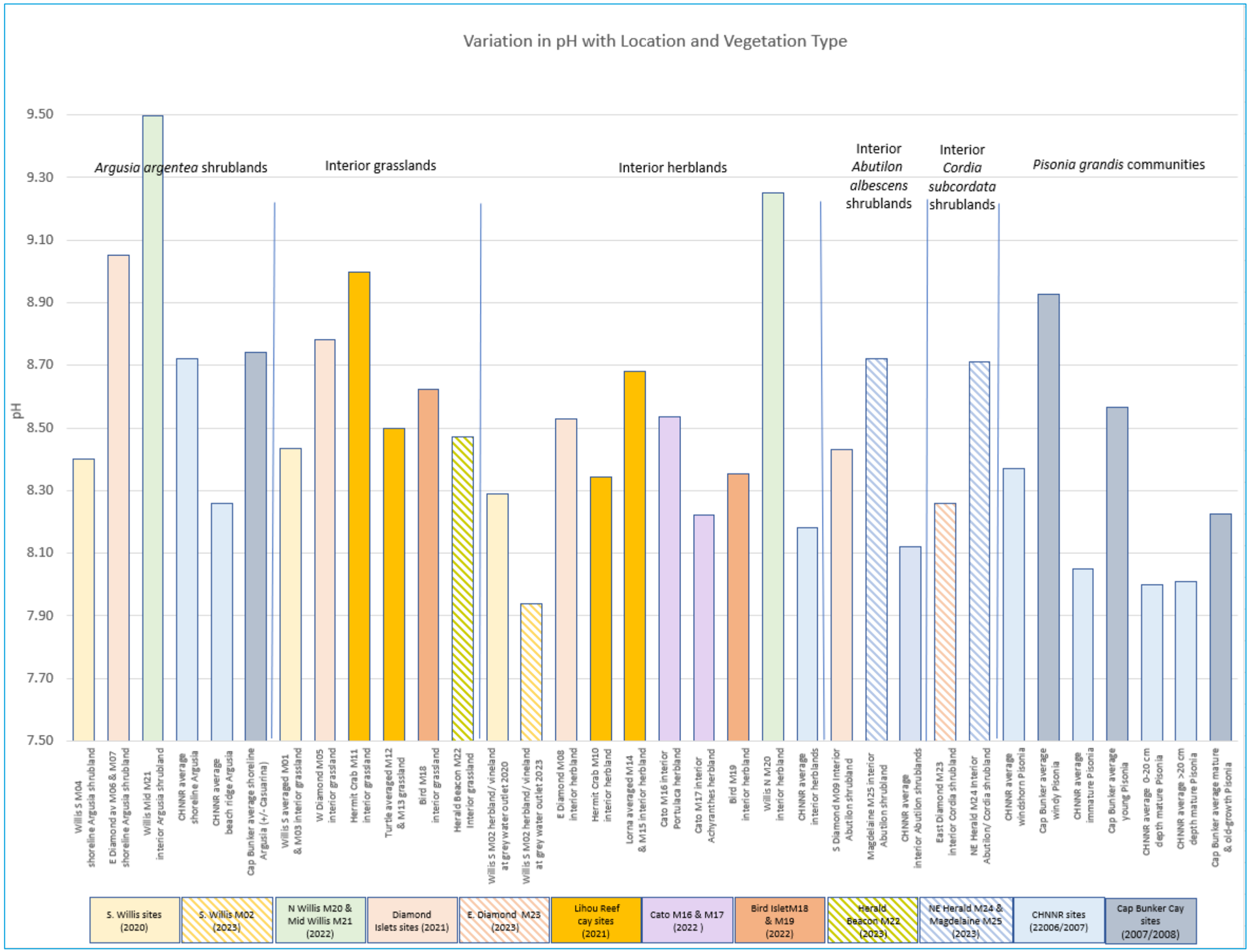

Figure A.3. Variation in soil pH with location and vegetation type across CSMP and southern GBR cays.

Electrical conductivity (EC)

EC is an indication of the availability of nutrients in the soil. Beach sand has low EC and EC increases with increasing organic content. The octopus bush (*Argusia argentea*) and other coastline communities typically have lower EC than interior communities. Soils from South Islet (Willis Islets) had relatively high EC. Interior pisonia (*Pisonia grandis*) communities in the CHNNR cays have the highest EC values within the available datasets.

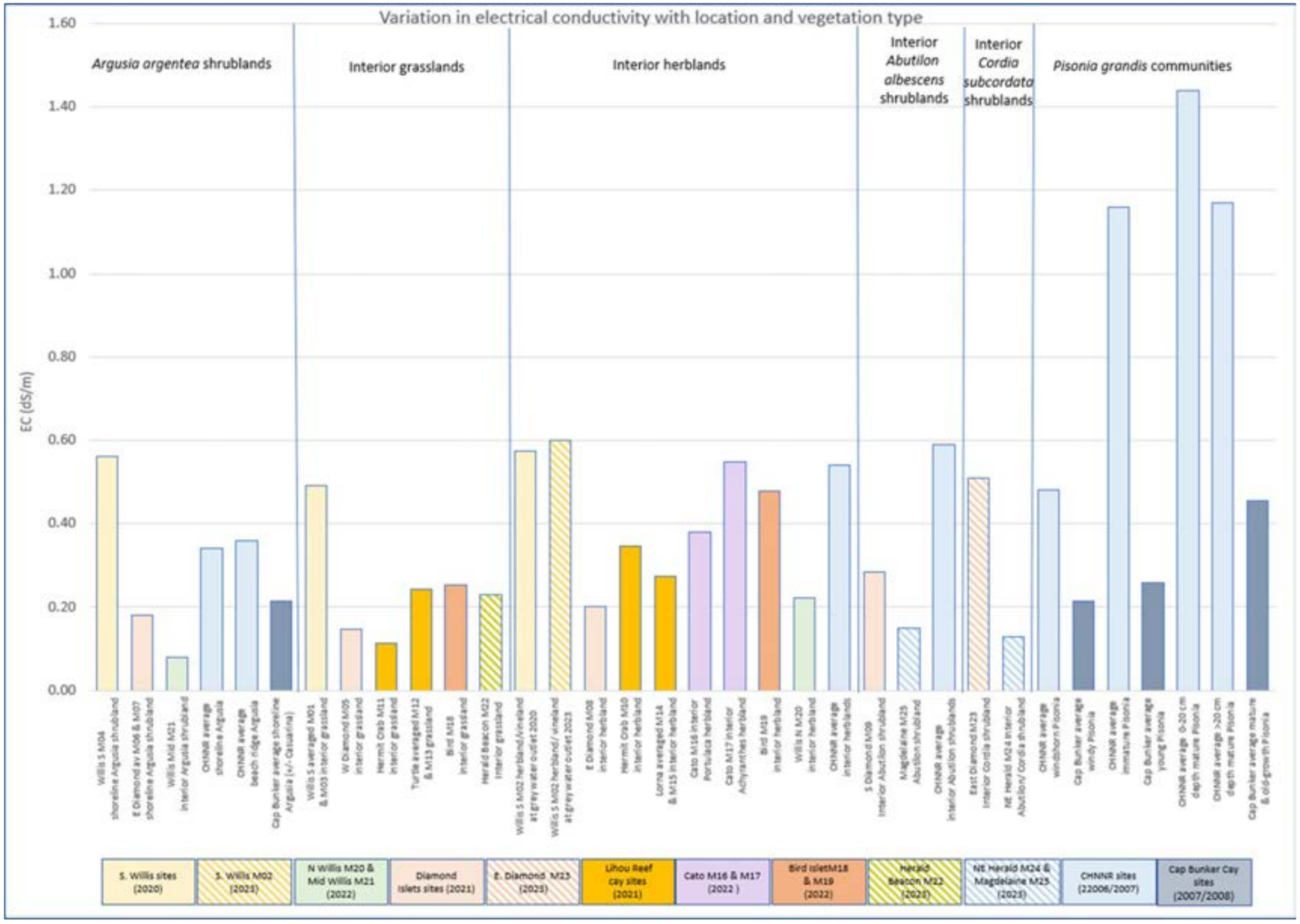

Figure A.4. Variation in soil electrical conductivity with location and vegetation type across CSMP and southern GBR cays.

Total nitrogen (N)

Cay soils are low in nutrient and typically have low total nitrogen levels. Levels of N are related to organic content.. Levels of N were very variable. Within the available datasets, the North Cay and Mid Islet (Willis Islets) have the lowest N levels compared to similar vegetation in other locations. The averaged samples from the 2006/2007 CHNNR sites and from Site M22, the grassland site on Herald Beacon Islet had higher N levels than similar communities in other locations.

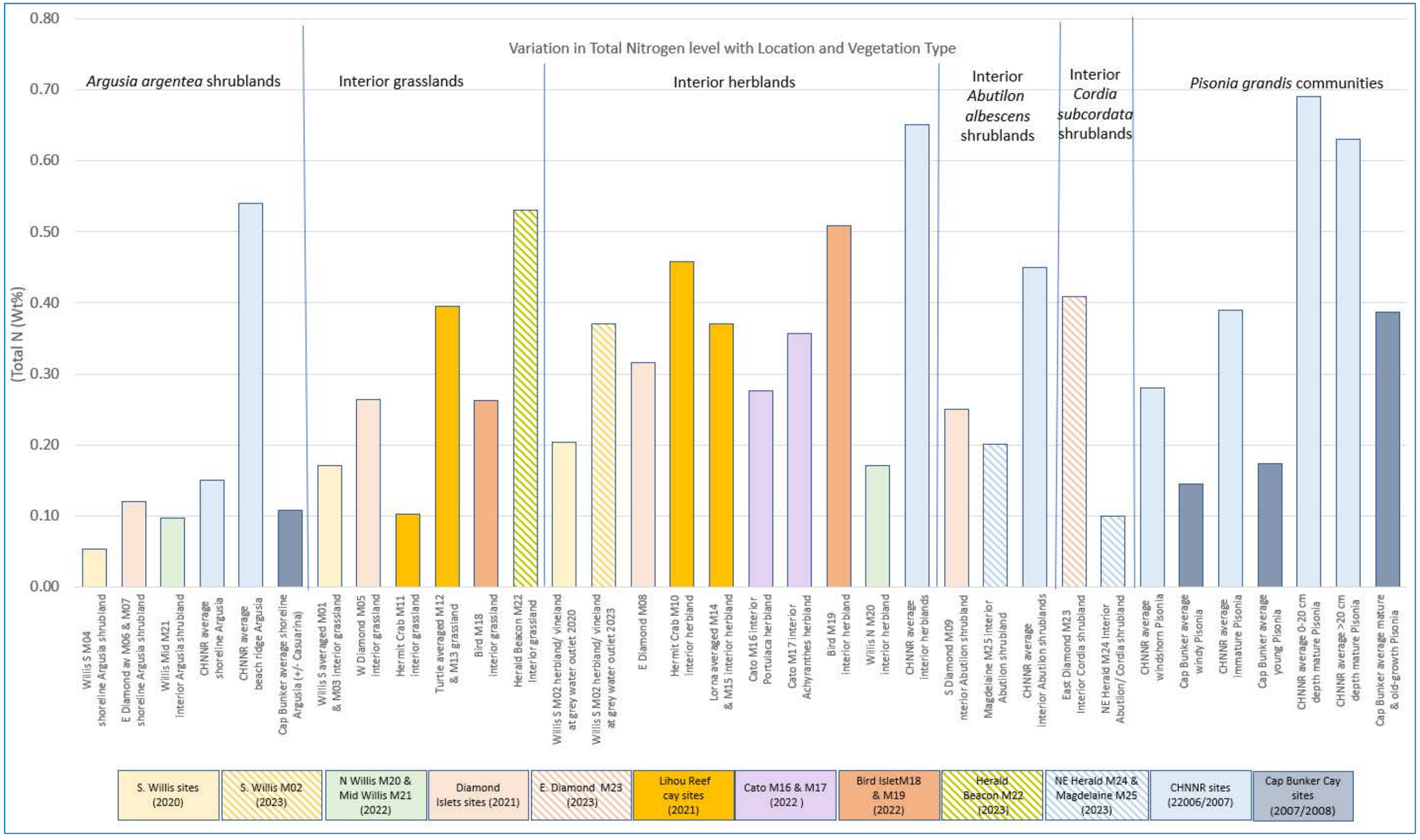

Figure A.5. Variation in soil total Nitrogen with location and vegetation type across CSMP and southern GBR cays.

Total carbon (TC) and organic carbon (OC)

TC levels were high in all data sets as would be expected with the calcium carbonate mineralogy of the calcareous sand.
The soils in the earlier samples from both the Capricorn Bunker and the CHNNR cays generally have lower TC levels than the more recent CSMP samples.

Within the 2020 to 2023 datasets, octopus bush (*Argusia argentea)* coastal shrublands have the lowest OC levels. although the TC levels at these cays were comparable with levels from all the recent CSMP samples. Site M02 (greywater outlet site on South Islet) had low organic carbon in the 2020 sample compared to other samples but levels in the 2023 sample were comparable to those at other sites.
The interior herbland soils on Cato Island and Bird Islet (Wreck Reefs) had relatively high OC levels.

Figure A.6. Variation in soil total and organic carbon with location and vegetation type across CSMP and southern GBR cays.

Phosphorus (P) and Colwell phosphorus (Col P)

Levels of P were high at all sites, as would be expected with deposition of guano by large populations of nesting seabirds.

Col P is a measure of the phosphorus in the soil that is available to plants. Cato Island and Bird Islet (Wreck Reefs) had higher Col P levels than other sites. Soil Col P levels were considerably lower in the 2007/2008 Capricorn Bunker cay samples than in CSMP cay samples.

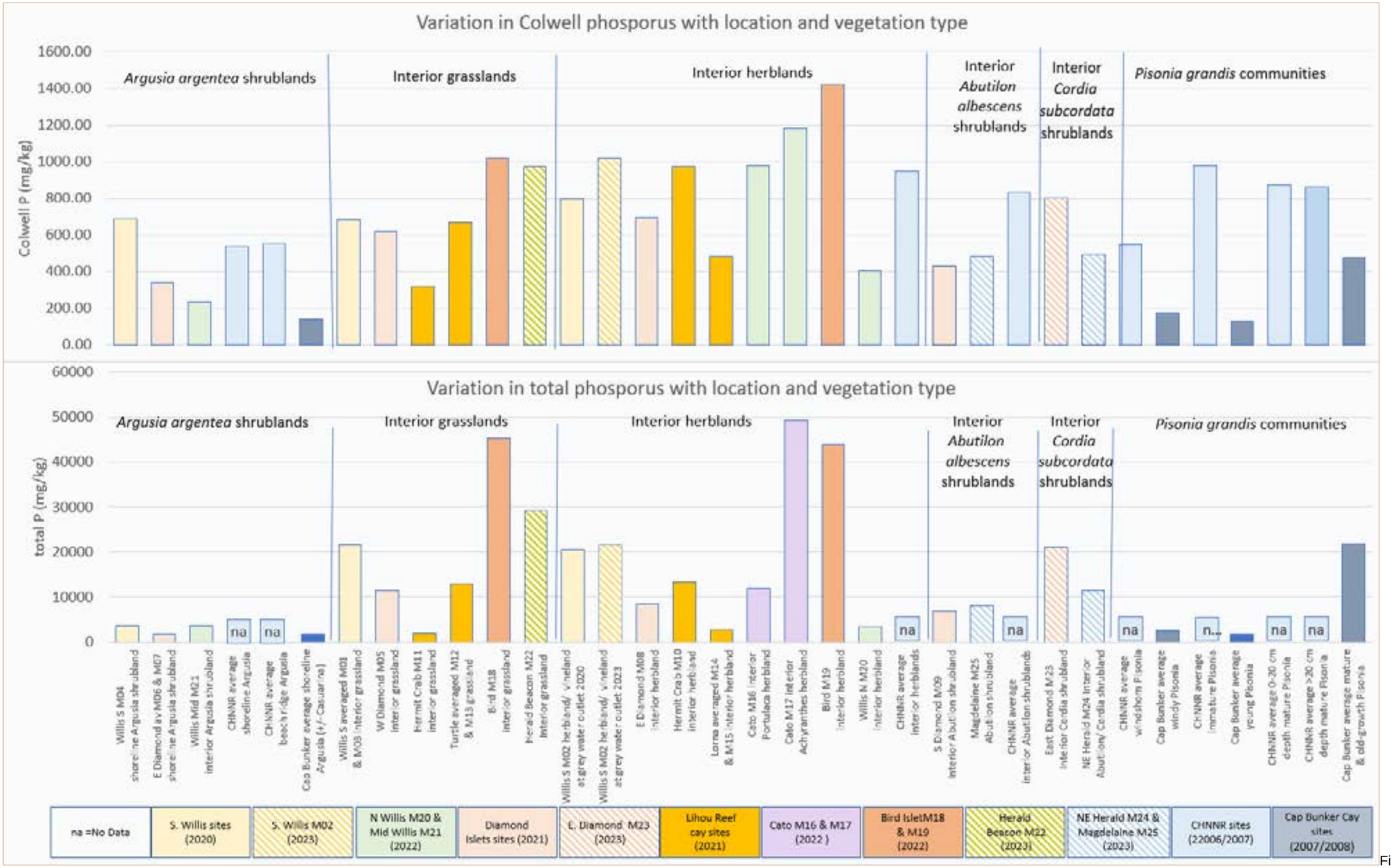

Figure A.7. Variation in soil total and Colwell phosphorus levels with location and vegetation type across CSMP and southern GBR cay.

Cation exchange capacity (CEC), total and exchangeable calcium (Ca), potassium (K), magnesium (Mg) and sodium (Na)

Comparative total element data was not available for all locations.

Cation exchangeable capacity CEC

CEC is a summation of the levels of exchangeable Ca, exchangeable K, exchangeable Mg and exchangeable Na and is a measure of the total negative charges within the soil that adsorb plant nutrient cations. CEC describes the soils capacity to supply nutrient cations to the soil solution for plant uptake. According to Morrison (1990) CEC is closely related to organic content.

CEC was higher in the South Islet (Willis Islets) sites than at all other sites in similar vegetation types.

CEC levels in 2007/2008 Capricorn Bunker cay samples were lower than all other sites in all vegetation types.

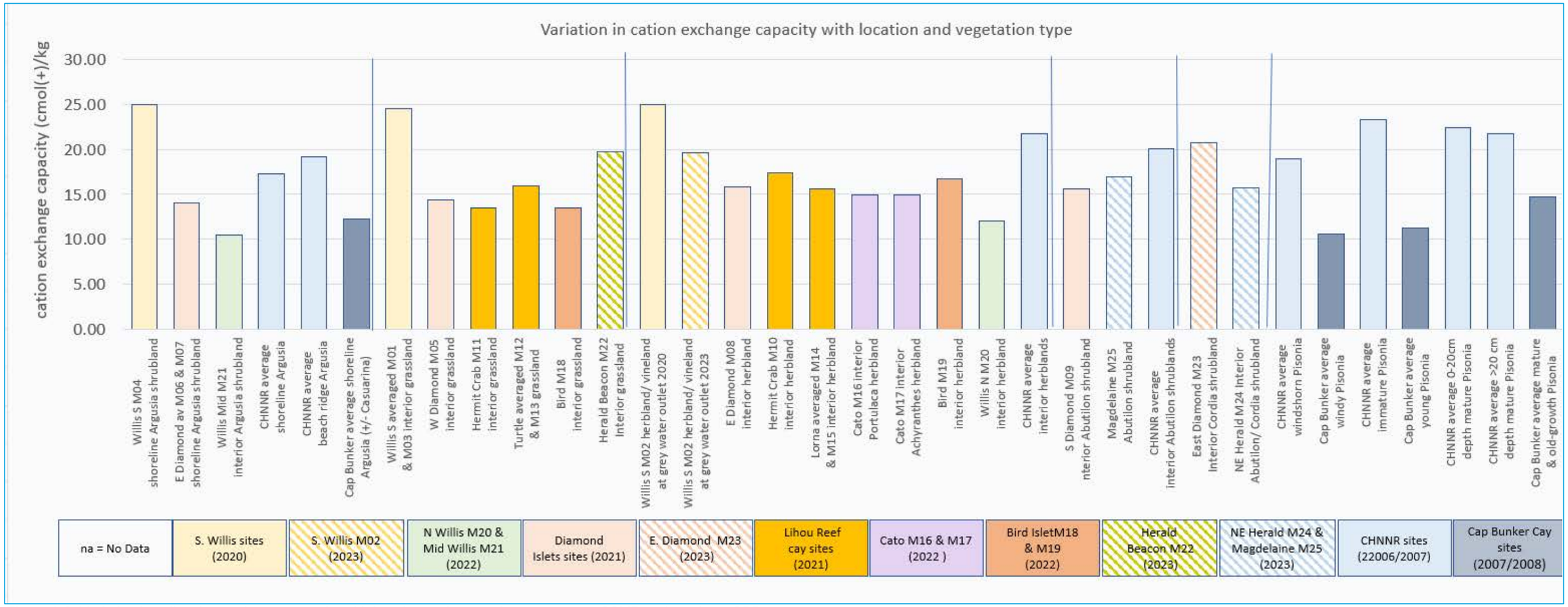

Figure A.8. Variation in soil cation exchange capacity with location and vegetation type across CSMP and southern GBR cays

Total calcium (Ca) and exchangeable calcium (exchangeable Ca)

Levels of Ca in cay soils are high due to the calcareous mineralogy of the cay sands.

Exchangeable Ca levels were higher in all the South Islet (Willis Islets sites) than in other location sampled. The Herald Beacon Islet grassland samples also had relatively high exchangeable Ca levels.

Exchangeable Ca levels were lower in the Capricorn Bunker soil samples than the CSMP samples in similar vegetation types.

Total potassium (K) and exchangeable potassium (exchangeable K)

Exchangeable K was higher in the 2006/2007 CHNNR samples than all the 2007/2008 Capricorn Bunker samples and all 2020 to 2023 samples.

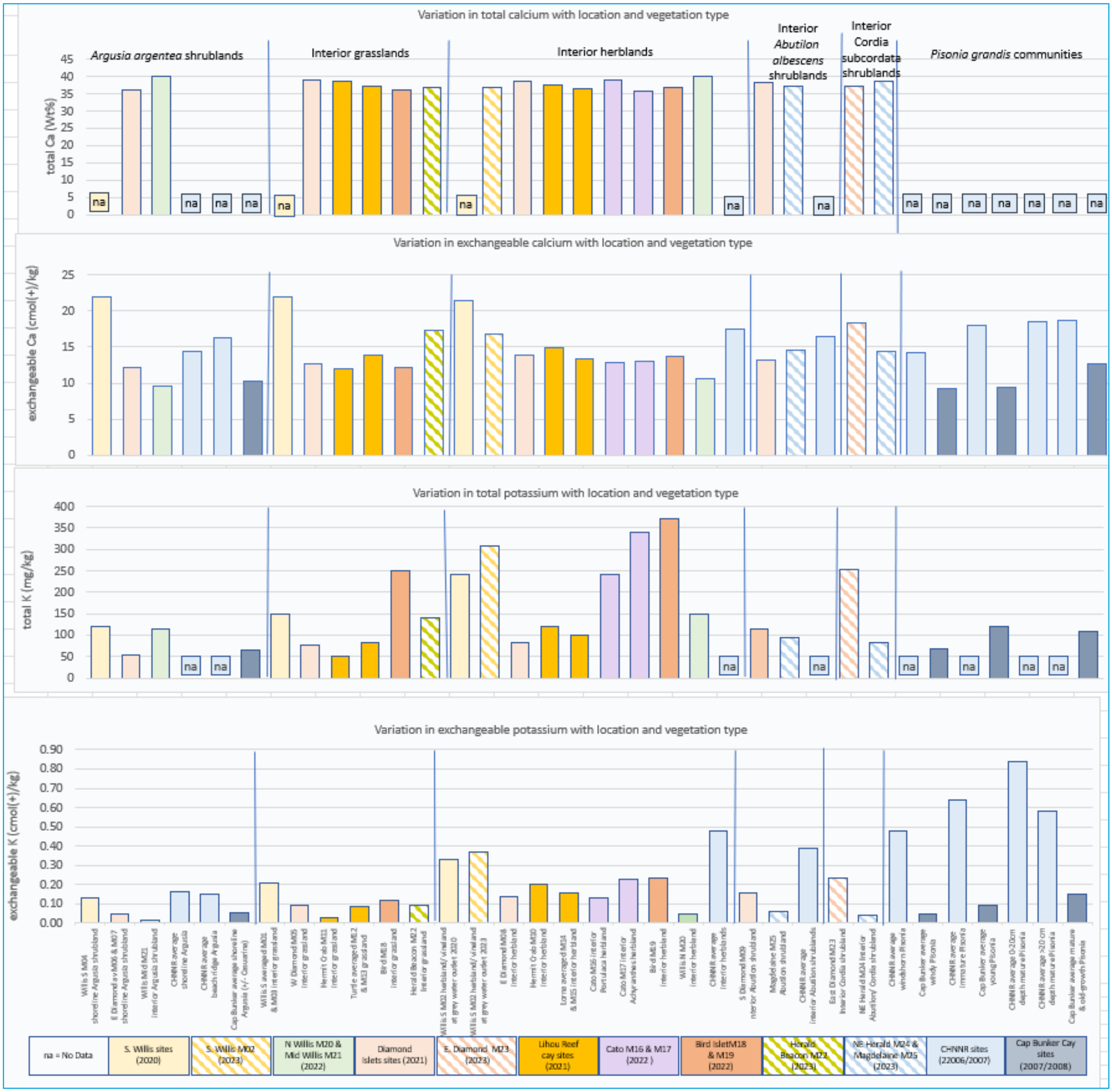

Figure A.9 . Variation in soil calcium and potassium levels with location and vegetation type across CSMP and southern GBR cays.

Total magnesium (Mg) and exchangeable magnesium (exchangeable Mg)

Total Mg was higher in the Lihou Reef cay samples and the North Islet (Willis Islets) samples than other samples.

Exchangeable Mg was higher in the 2006/2007 CHNNR samples than the 2020 to 2023 samples and the 2007/2008 Capricorn Bunker cay samples in similar vegetation types.

Total sodium (Na) and exchangeable sodium (exchangeable Na)

Exchangeable Na levels were higher in the South Islet (Willis Islets) sites than in recent samples from all other locations in similar vegetation types.

Exchangeable Na was higher in the 2006/2007 CHNNR samples than samples from other locations and higher in the CSMP cay samples than the 2007/2008 Capricorn Bunker cay samples in similar vegetation types.

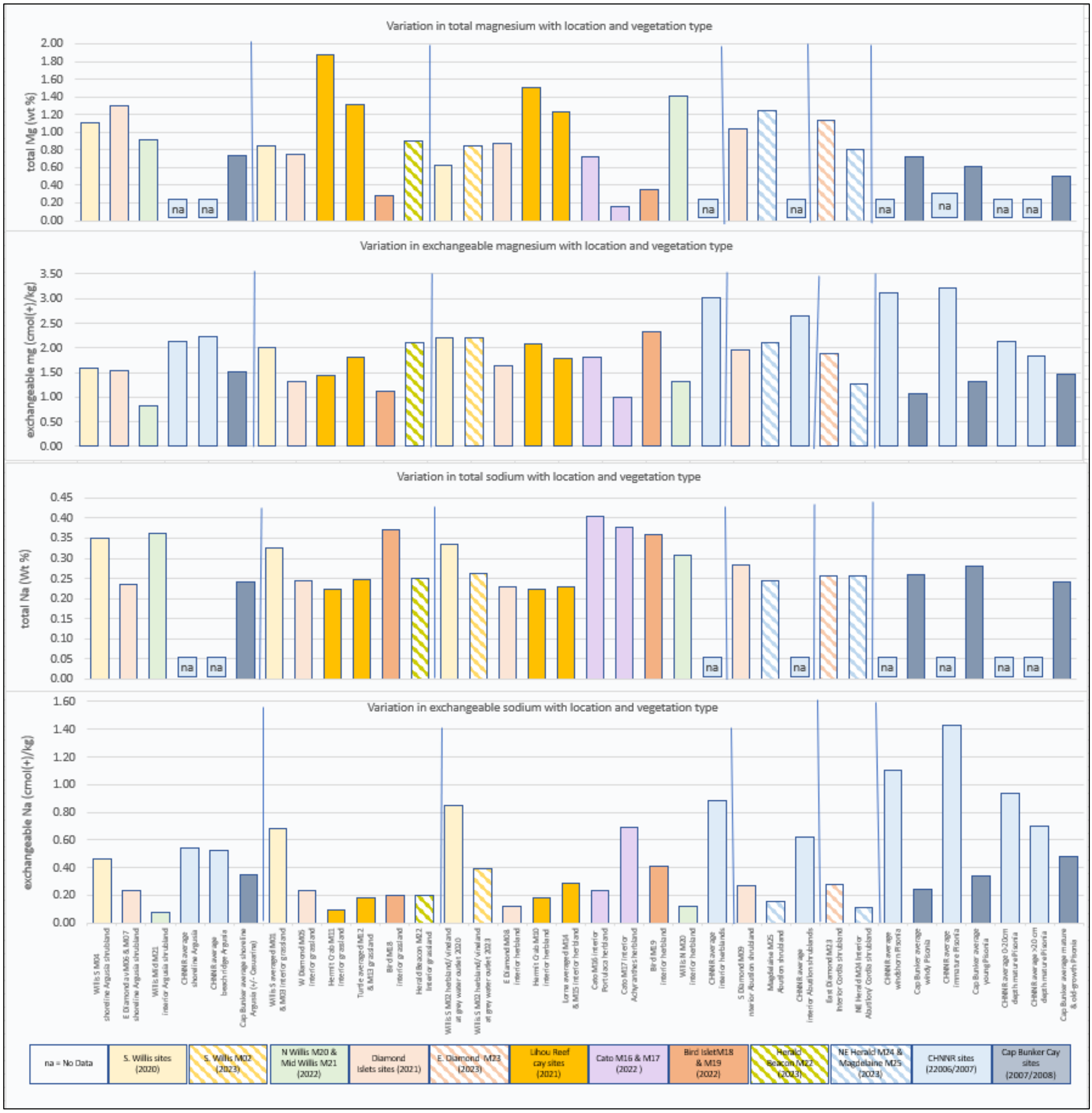

Figure A.10. Variation in soil magnesium and sodium levels with location and vegetation type across CSMP and southern GBR cays.

Aluminium (Al)

Levels of Al were variable. Soil samples from site M02 (grey water outlet) on South Islet had very high levels of Al compared to other locations. Levels were much higher in the 2023 samples from this site than 2020 levels. Herald Beacon Islet and the grassland sites on South Islet had relatively high levels of Al in subsurface soil layers compared to other grassland sites.

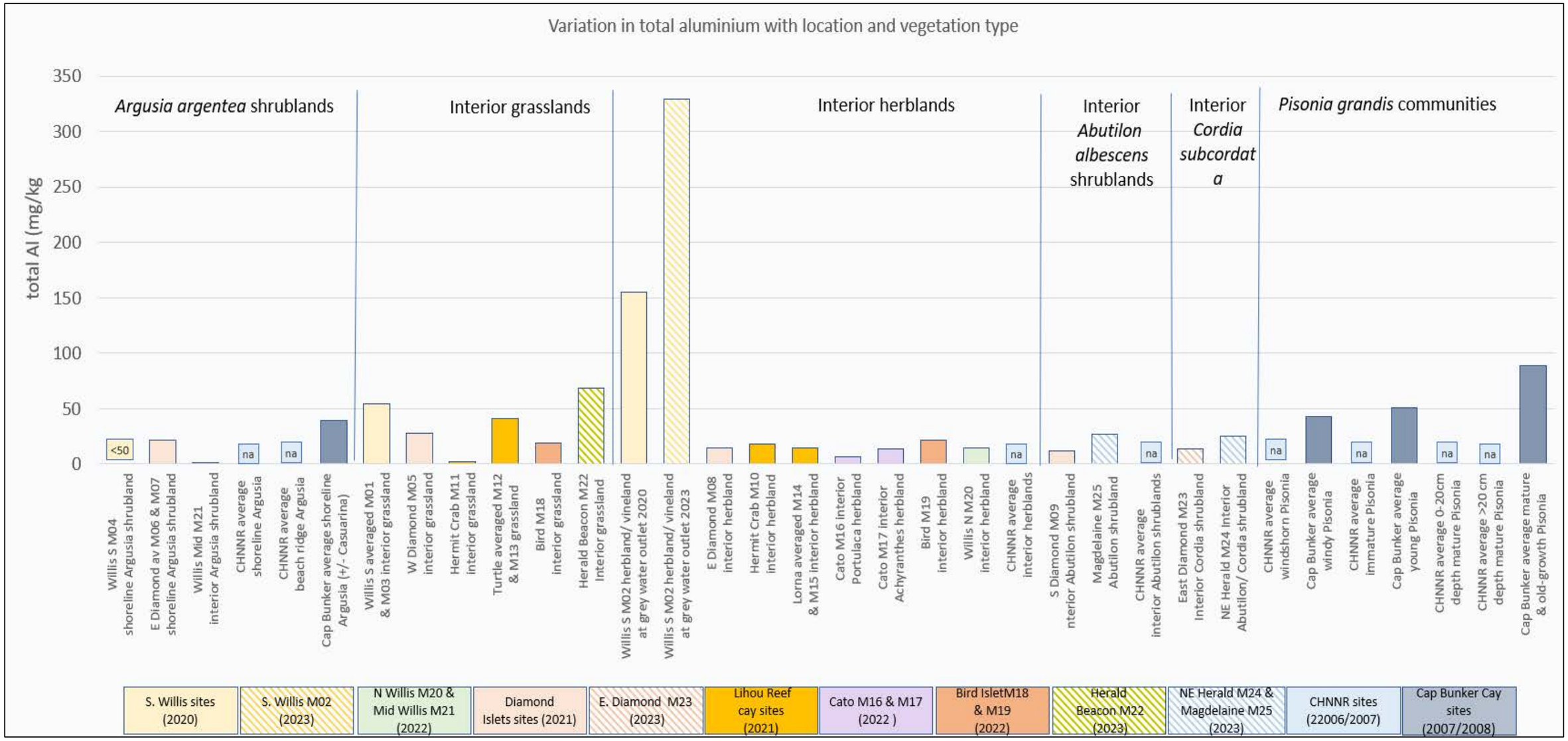

Figure A.11. Variation in soil aluminium levels with location and vegetation type across CSMP and southern GBR cays.

Sulphur (S)

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

S level levels at all sites sampled in 2022 and 2023 were considerably higher than levels from all samples previously obtained at all other cays. It is not known why S levels at all these sites should be so high, particularly when the sites were spread over such a large geographic area and were from differing vegetation and soil types. A possible source of the S may be acid rain produced in the sulphur dioxide plume that was reported over northern Australia and the SW Pacific Ocean following the volcanic eruption of the Hunga Tonga-Hunga Ha'apai volcano in January 2022 (AIRS 2022 and ESA 2022).

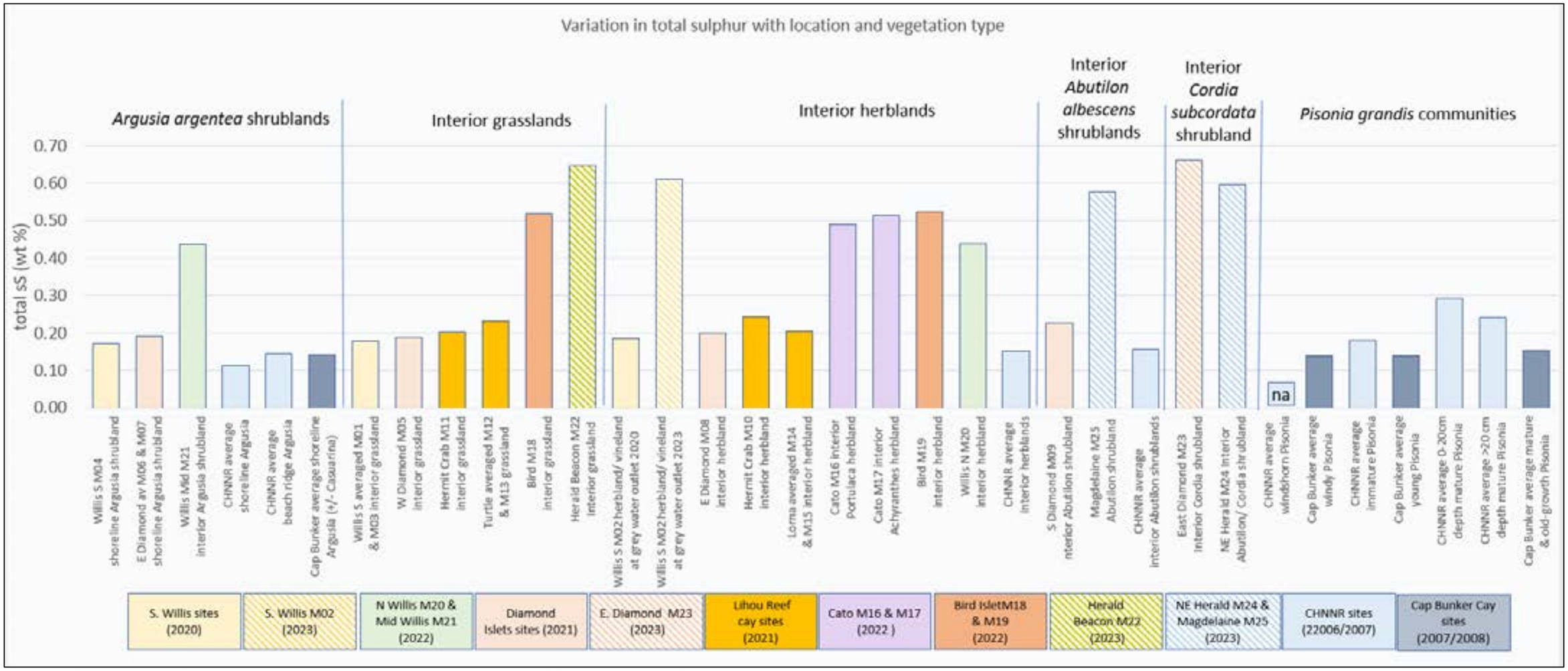

Figure A.12. Variation in soil sulphur levels with location and vegetation type across CSMP and southern GBR cays.

Trace elements: copper (Cu), iron (Fe), manganese (Mn), zinc (Zn)

Levels of each of the trace elements (particularly Fe) in the soil samples collected at site M02 (grey water outlet) on South Islet in both the 2020 and 2023 samples were all considerably higher than those in all other datasets. Cu and Fe levels were also higher in the coastal octopus bush (*Argusia argentea*) site samples on South Islet than in Coastline octopus bush shrubland soils sampled in other locations.

The soil samples from the Herald Beacon Islet grassland also had a relatively high Fe level compared to other 2019 to 2023 samples.

Levels of Cu, Zn and Fe in the 2007/2008 Capricorn Bunker soil samples were generally lower than those in the 2006/2007 CHNNR samples.

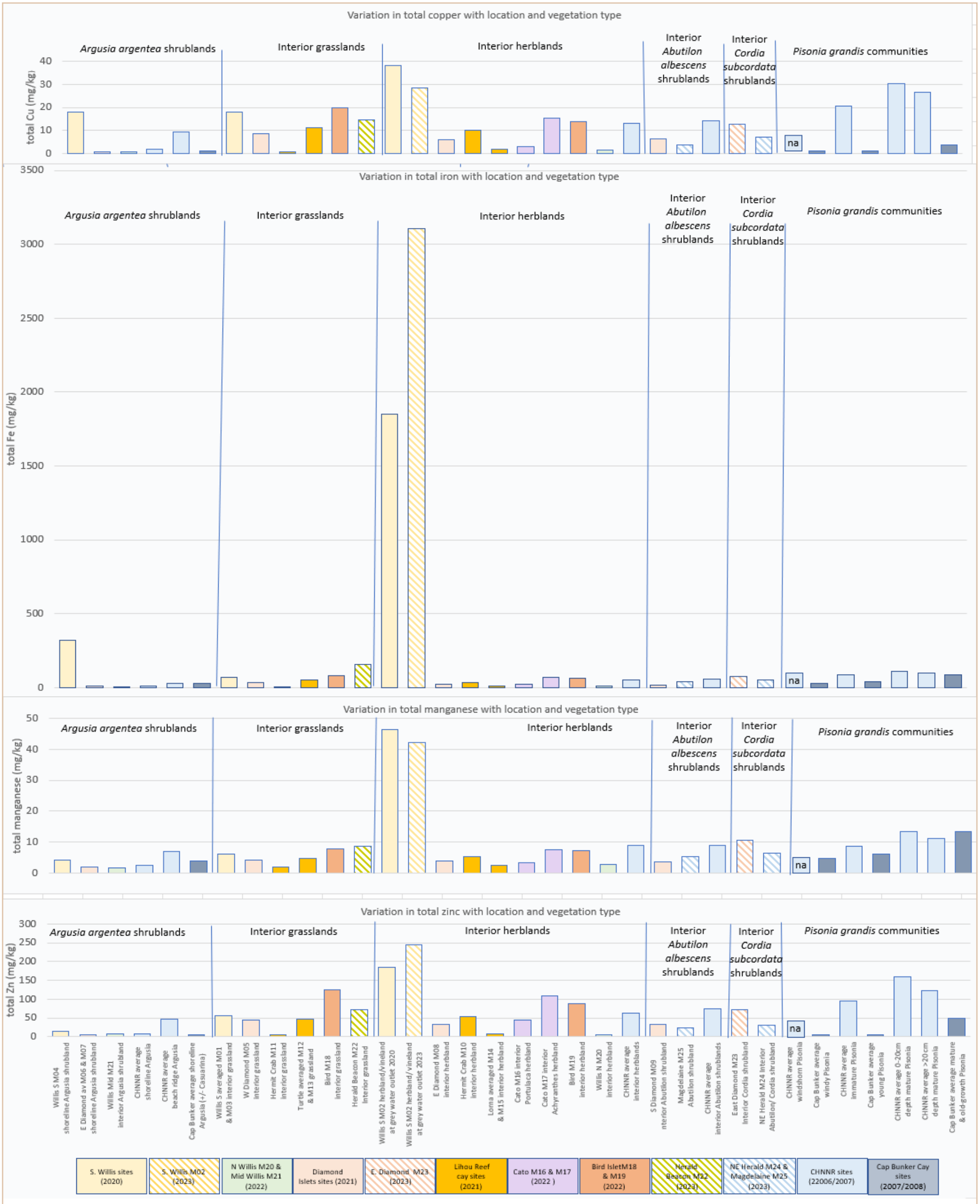

Figure A.13.Variation in soil trace element (copper, iron, manganese, zinc) levels with location and vegetation type across CSMP and southern GBR cays.

Appendix 9. 2023 Soil analysis results

Table A.9. Soil analysis results from the soil samples taken during the 2023 voyage.

	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
					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
South Islet (Willis Islets)	1	MO2	0-10	7.48	1.251	0.529	13.96	4.97	1177	20.82	0.82	3.38	0.63	25.65	1.69	401	34.8	23.7	1968	479	0.840	29	0.251	0.590	190
	2	MO2	10-20	8.00	0.431	0.311	11.77	1.85	893	15.54	0.26	1.88	0.37	18.04	2.21	501	37.8	34.1	2475	301	0.780	38	0.270	0.630	234
	3	MO2	20-30	8.04	0.406	0.316	12.77	2.16	992	15.80	0.23	1.90	0.30	18.23	2.50	283	37.6	31.4	3360	270	0.872	51	0.268	0.627	279
	4	MO2	30-40	8.23	0.324	0.326	11.57	1.40	1017	14.72	0.16	1.62	0.26	16.77	2.27	131	37.1	25.2	4620	185	0.910	50	0.259	0.598	271
Herald Beacon Islet (Mellish Reef)	5	M22	0-10	8.01	0.325	0.992	16.09	4.21	1195	20.52	0.18	2.72	0.27	23.68	3.95	34	32.5	19.6	197	199	0.793	14	0.235	0.676	117
	6	M22	10-20	8.32	0.246	0.494	12.47	1.84	1273	18.16	0.09	2.31	0.18	20.75	4.47	126	37.1	19.8	196	144	0.759	10	0.251	0.659	96
	7	M22	20-30	8.67	0.186	0.358	11.42	1.68	895	16.32	0.07	1.81	0.18	18.38	1.72	68	38.8	9.5	143	111	1.101	6	0.262	0.640	40
	8	M22	30-40	8.88	0.169	0.280	11.73	1.66	539	14.48	0.05	1.54	0.16	16.23	1.54	44	38.4	8.9	101	108	0.958	5	0.252	0.613	34
East Diamond Islet (Tregrosse Reefs)	9	M23	0-10	7.38	1.226	1.369	17.26	7.82	1658	29.33	0.69	3.68	0.72	34.42	6.42	38	31.2	41.2	228	625	0.679	28	0.254	0.786	248
	10	M23	10-20	8.60	0.281	0.069	9.98	0.72	611	14.69	0.08	1.39	0.13	16.29	0.58	2	40.8	3.0	18	131	1.378	4	0.267	0.637	9
	11	M23	20-30	8.60	0.258	0.088	9.64	0.65	417	14.48	0.09	1.19	0.13	15.89	0.66	5	38.7	2.6	18	122	1.296	5	0.248	0.608	15
	12	M23	30-40	8.47	0.284	0.109	10.18	0.64	531	15.06	0.09	1.24	0.14	16.53	0.78	10	38.6	3.5	28	136	1.197	6	0.258	0.612	18
North East Cay (Herald Cays)	13	M24	0-10	8.64	0.141	0.149	11.13	1.20	507	14.86	0.05	1.45	0.12	16.48	1.32	32	37.9	8.7	57	99	0.683	7	0.257	0.598	37
	14	M24	10-20	8.69	0.126	0.120	10.23	1.06	536	14.51	0.04	1.23	0.10	15.87	1.03	22	39.2	6.2	41	85	0.781	6	0.256	0.594	27
	15	M24	20-30	8.71	0.118	0.075	10.14	1.06	483	14.05	0.03	1.21	0.11	15.40	1.16	25	39.1	7.2	45	76	0.856	6	0.256	0.598	31
	16	M24	30-40	8.79	0.117	0.055	9.82	0.98	451	13.83	0.02	1.16	0.12	15.13	1.09	23	38.3	7.0	55	74	0.902	6	0.256	0.595	29
Magdelaine Cay South (Magdelaine cays)	17	M25	0-10	8.45	0.203	0.315	12.52	3.12	612	16.69	0.09	2.89	0.18	19.84	0.94	29	37.0	4.3	43	123	1.340	7	0.246	0.587	31
	18	M25	10-20	8.59	0.149	0.303	12.92	1.87	586	14.84	0.07	2.29	0.16	17.36	0.80	30	35.0	4.2	42	96	1.242	6	0.238	0.561	26
	19	M25	20-30	8.74	0.130	0.167	10.52	0.84	445	13.78	0.05	1.77	0.15	15.74	0.73	27	37.9	3.3	39	81	1.295	5	0.241	0.579	21
	20	M25	30-40	9.09	0.100	0.019	8.44	0.82	295	12.99	0.03	1.50	0.12	14.64	0.74	21	38.6	3.3	42	75	1.087	4	0.255	0.583	18

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 AQ400 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 1hr, 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 Organic Carbon

0.25 g of sample weighed out and reacted with 0.167 M potassium dichromate and conc sulphuric acid then heated for half an hour at 135°C. Samples diluted then analysed colorimetrically at 600 nm on a UV-vis spectrophotometer and calibrated with sucrose standards. Handbook section: 6B1, 71.

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 mL 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 10. Bird species Summary

Table A.10. Bird species and common name summary
(blue highlight indicates breeding effort observed during the 2023 voyage).

Cay seabirds	
black noddy	*Anous minutus*
black-naped tern	*Sterna sumatrana*
brown booby	*Sula leucogaster*
brown noddy	*Anous stolidus*
crested tern	*Thallaseus bergii*
great frigatebird	*Fregata minor*
lesser frigatebird	*Fregata ariel*
masked booby	*Sula dactylatra dactylatra*
red-footed booby	*Sula sula*
red-tailed tropicbird	*Phaethon rubricauda roseotinctus*
sooty tern	*Onychoprion fuscatus*
Other seabirds only recorded at sea	
black-bellied storm-petrel	*Fregetta tropica*
bridled tern	*Onychoprion anaethetus*
providence petrel	*Pterodroma solandri*
Tahiti petrel	*Pseudobulweria rostrata*
wedge-tailed shearwater	*Ardenna pacifica*
white-faced storm-petrel	*Pelagodroma marina*
white-tailed tropicbird	*Phaethon lepturus*
Cay shorebirds	
Pacific golden plover	*Pluvialus fulva*
ruddy turnstone	*Arenaria interpres*
wandering tattler	*Tringa incana*
Resident or often seen island based birds	
buff-banded rail	*Gallirallus philippensis tounelieri*
purple swamphen	*Porphyrio melanotus*
sacred kingfisher	*Todiramphus sanctus*
white-faced heron	*Egretta novaehollandiae*
Uncommon visitors, vagrants or migrants	
eastern great egret (deceased)	*Ardea alba*
eastern reef egret	*Egretta sacra*
hardhead (deceased)	*Aythya australis*
little pied cormorant	*Microcarbo melanoleucos*
magpie-lark	*Grallina cyanoleuca*
masked lapwing	*Vanellus miles novaehollandiae*
tree martin	*Petrochelidon nigricans*
welcome swallow	*Hirundo neoxena*

Appendix 11. Pelagic Bird Records

The following data represent bird observations made at sea during the voyage.

Figure A.14. Sighting locations (white circles) of pelagic bird sightings in the southern CSMP reef systems. Credit: Andrew McDougall ©, Queensland Government.

Figure A.15. Sighting locations (white circles) of pelagic bird sightings in the central CSMP reef systems. Credit: Andrew McDougall ©, Queensland Government.

Figure A.16. Black-bellied storm-petrel (*Fregetta tropica*).
Credit: Andrew McDougall ©, Queensland Government.

Table A.11. Pelagic bird sightings observed between Saumarez Reefs and Frederick Reefs (Figure A.14).

Southern Coral Sea reef systems Between Saumarez Reefs and Frederick Reefs					
Date	**Latitude**	**Longitude**	**species**	**number**	**Notes**
27/05/2023	-21.714	153.675	wedge-tailed shearwater	1	
27/05/2023	-21.714	153.675	brown noddy	1	
27/05/2023	-21.6873	153.711	masked booby	1	
27/05/2023	-21.6873	153.711	crested tern	1	
27/05/2023	-21.5888	153.7891	sooty tern	26	
27/05/2023	-21.5888	153.7891	brown booby	1	
27/05/2023	-21.5888	153.7891	masked booby	1	Adolescent
27/05/2023	-21.5554	153.8064	red-footed booby	5	4 dark, 1 light morphology
27/05/2023	-21.5554	153.8064	sooty tern	1	
27/05/2023	-21.5348	153.8169	wedge-tailed shearwater	1	
27/05/2023	-21.5348	153.8169	brown booby	3	
27/05/2023	-21.5348	153.8169	masked booby	1	Adolescent
27/05/2023	-21.4953	153.8371	red-footed booby	1	
27/05/2023	-21.4585	153.8562	masked booby	1	
27/05/2023	-21.4481	153.8652	brown booby	1	
27/05/2023	-21.3788	153.8942	Tahiti petrel	1	
27/05/2023	-21.2768	153.9453	black-bellied storm-petrel	1	
27/05/2023	-21.2681	153.949	white-faced storm-petrel	2	
27/05/2023	-21.2181	153.9738	black-bellied storm-petrel	1	
27/05/2023	-21.1894	153.989	white-faced storm-petrel	1	

Table A.12. Pelagic bird sightings observed between south west of Mellish Reef 181km to 36km from Herald Beacon Islet (Figure A.15).

Central Coral Sea reef systems South west of Mellish Reef 181km to 36km from Herald Beacon Islet					
Date	**Latitude**	**Longitude**	**species**	**number**	**Notes**
28/05/2023	-18.8642	155.1399	red-footed booby	1	Adolescent
28/05/2023	-18.8289	155.1598	white-tailed tropicbird	1	
28/05/2023	-18.8156	155.1667	brown booby	1	
28/05/2023	-18.8025	155.1727	sooty tern	2	
28/05/2023	-18.5296	155.3026	wedge-tailed shearwater	2	
28/05/2023	-18.5296	155.3026	sooty tern	1	
28/05/2023	-18.3746	155.3795	black-bellied storm-petrel	1	
28/05/2023	-18.3426	155.3952	white-faced storm-petrel	1	
28/05/2023	-18.3072	155.413	sooty tern	2	
28/05/2023	-18.3072	155.413	masked booby	1	
28/05/2023	-18.2478	155.4421	white-tailed tropicbird	1	
28/05/2023	-18.2333	155.4494	red-footed booby	1	
28/05/2023	-18.2027	155.4637	red-footed booby	5	
28/05/2023	-18.2027	155.4637	brown noddy	1	
28/05/2023	-18.1381	155.4953	sooty tern	3	
28/05/2023	-18.1145	155.5069	sooty tern	6	
28/05/2023	-18.0067	155.5594	red-footed booby	2	
28/05/2023	-17.9019	155.6115	red-footed booby	6	
28/05/2023	-17.9019	155.6115	masked booby	1	
28/05/2023	-17.9019	155.6115	sooty tern	7	
28/05/2023	-17.7989	155.657	sooty tern	1	

Table A.13. Pelagic bird sightings observed between Mellish Reef to Lihou Atoll (Figure A.15).

Central Coral Sea reef systems Mellish Reef to Lihou Atoll					
Date	**Latitude**	**Longitude**	**species**	**number**	**Notes**
30/05/2023	-17.1997	153.6277	wedge-tailed shearwater	1	
30/05/2023	-17.1889	153.4848	sooty tern	44	
30/05/2023	-17.1889	153.4848	great frigatebird	2	
30/05/2023	-17.1871	153.46	wedge-tailed shearwater	2	
30/05/2023	-17.1871	153.46	sooty tern	7	
30/05/2023	-17.1838	153.3858	great frigatebird	1	Female
30/05/2023	-17.1838	153.3858	sooty tern	3	
30/05/2023	-17.1754	153.2905	lesser frigatebird	1	Female
30/05/2023	-17.1712	153.2387	sooty tern	1	
30/05/2023	-17.1667	153.145	sooty tern	4	
30/05/2023	-17.1637	153.1144	sooty tern	3	
30/05/2023	-17.1613	153.097	sooty tern	125	Feeding
30/05/2023	-17.1613	153.097	black-bellied storm-petrel	1	
30/05/2023	-17.1613	153.097	red-tailed tropicbird	1	With sooty terns
30/05/2023	-17.1568	153.0642	sooty tern	2	
30/05/2023	-17.1509	153.0233	providence petrel	1	

30/05/2023	-17.1489	153.0097	sooty tern	62	
30/05/2023	-17.1489	153.0097	lesser frigatebird	2	
30/05/2023	-17.1476	153.0011	sooty tern	130	
30/05/2023	-17.1476	153.0011	wedge-tailed shearwater	2	
30/05/2023	-17.1437	152.9752	wedge-tailed shearwater	2	
30/05/2023	-17.1374	152.9336	wedge-tailed shearwater	1	
30/05/2023	-17.1341	152.9098	sooty tern	3	
30/05/2023	-17.1323	152.898	wedge-tailed shearwater	3	
30/05/2023	-17.1154	152.6345	wedge-tailed shearwater	1	
30/05/2023	-17.1154	152.6345	sooty tern	2	
30/05/2023	-17.1137	152.616	black-bellied storm-petrel	1	
30/05/2023	-17.1137	152.616	sooty tern	2	
30/05/2023	-17.1072	152.5498	sooty tern	2	
30/05/2023	-17.104	152.5165	sooty tern	4	
30/05/2023	-17.1005	152.4817	brown booby	1	
30/05/2023	-17.0986	152.4598	black-bellied storm-petrel	1	
30/05/2023	-17.0986	152.4598	sooty tern	1	
30/05/2023	-17.0963	152.4356	white-faced storm-petrel	2	
30/05/2023	-17.0944	152.4159	white-faced storm-petrel	1	
30/05/2023	-17.0944	152.4159	black-bellied storm-petrel	1	
30/05/2023	-17.0921	152.3877	bridled tern	1	
30/05/2023	-17.0897	152.3592	sooty tern	61	Feeding
30/05/2023	-17.0897	152.3592	masked booby	1	Feeding
30/05/2023	-17.0897	152.3592	white-faced storm-petrel	1	
30/05/2023	-17.0891	152.3518	white-faced storm-petrel	1	
30/05/2023	-17.0879	152.3397	white-faced storm-petrel	3	
30/05/2023	-17.0879	152.3397	black-bellied storm-petrel	2	
30/05/2023	-17.0879	152.3397	red-tailed tropicbird	2	
30/05/2023	-17.0879	152.3397	sooty tern	9	
30/05/2023	-17.0879	152.3397	brown noddy	2	
30/05/2023	-17.0847	152.3024	sooty tern	4	
30/05/2023	-17.0838	152.2945	masked booby	1	
30/05/2023	-17.0759	152.2072	wedge-tailed shearwater	1	
30/05/2023	-17.0724	152.1705	red-footed booby	1	
30/05/2023	-17.0724	152.1705	sooty tern	8	
30/05/2023	-17.0724	152.1705	brown noddy	2	
30/05/2023	-17.0704	152.1481	red-footed booby	1	
30/05/2023	-17.0696	152.1397	brown noddy	1	
30/05/2023	-17.0696	152.1397	masked booby	5	
30/05/2023	-17.0696	152.1397	sooty tern	3	

Table A.14. Pelagic bird sightings observed between Coringa Islets and Willis Islets (Figure A.15).

Central Coral Sea reef systems Coringa Islets to Willis Islets					
Date	**Latitude**	**Longitude**	**species**	**number**	**Notes**
1/06/2023	-16.8085	149.9903	red-footed booby	2	Feeding on flying fish
1/06/2023	-16.7545	149.9812	sooty tern	4	
1/06/2023	-16.7545	149.9812	red-footed booby	1	
1/06/2023	-16.7545	149.9812	brown booby	1	
1/06/2023	-16.7545	149.9812	brown noddy	1	
1/06/2023	-16.7144	149.9814	great frigatebird	1	Female
1/06/2023	-16.7144	149.9814	sooty tern	2	
1/06/2023	-16.6523	149.9756	lesser frigatebird	1	Female
1/06/2023	-16.6237	149.9713	lesser frigatebird	1	
1/06/2023	-16.6237	149.9713	great frigatebird	1	
1/06/2023	-16.6237	149.9713	brown booby	1	
1/06/2023	-16.6237	149.9713	sooty tern	7	
1/06/2023	-16.503	149.9724	brown booby	2	
1/06/2023	-16.503	149.9724	sooty tern	3	

Table A.15. Pelagic bird sightings observed between 100km and 76km north of Hydrographer's passage (Figure A.15).

Central Coral Sea reef systems 100km to 76km north of Hydrographer's passage					
Date	**Latitude**	**Longitude**	**species**	**number**	**Notes**
6/06/2023	-19.0252	150.3192	sooty tern	5	
6/06/2023	-19.0424	150.3195	sooty tern	6	
6/06/2023	-19.1272	150.3217	sooty tern	2	
6/06/2023	-19.1406	150.3212	Tahiti petrel	1	
6/06/2023	-19.1406	150.3212	sooty tern	2	
6/06/2023	-19.1679	150.3205	Tahiti petrel	1	
6/06/2023	-19.1679	150.3205	black-bellied storm-petrel	1	
6/06/2023	-19.2338	150.3211	brown booby	2	Feeding, 1 Adult and 1 Adolescent
6/06/2023	-19.2338	150.3211	sooty tern	6	Feeding

Appendix 12. Health Check Site Photographs

A.

B.

C.

D.

Figure A.17: Health Check, Site 2, Herald Beacon Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.18: Health Check, Site 3, Herald Beacon Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.19: Health Check, Site 4, Herald Beacon Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.20: Health Check, Site 1, North Cay (Mellish Reef).
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.21: Octopus Bush (*Argusia argentea*) shrublands Health Check, Site 1, East Diamond Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.22: Octopus Bush (*Argusia argentea*) shrublands Health Check, Site 2, East Diamond Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.23: Octopus Bush (*Argusia argentea*) shrublands Health Check, Site 2, East Diamond Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.24: Sea trumpet (*Cordia subcordata*) shrublands Health Check, Site 1, East Diamond Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

Figure A.25: Sea trumpet (*Cordia subcordata*) shrublands Health Check, Site 2, East Diamond Islet.
A. E-W, B. N-S, C. S-N.
Credit: Andrew Meiklejohn ©, Queensland Government

A.

B.

C.

Figure A.26: Sea trumpet (*Cordia subcordata*) shrublands Health Check, Site 3, East Diamond Islet.
A. W-E, B. N-S, C. N-S.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.27: Grasslands (mixed *Lepturus repens* and *Sporobolus virginicus*) on Health Check, Site 1, East Diamond Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn, Queensland Government.

A.

B.

C.

D.

Figure A.28: Octopus bush (*Argusia argentea*) shrublands Health Check, Site 1, South Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.29: Octopus bush (*Argusia argentea*) shrublands Health Check, Site 2, South Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.30: Octopus bush (*Argusia argentea*) shrublands Health Check, Site 3, South Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.31: Grasslands (mixed *Lepturus repens* and *Sporobolus virginicus*) Health Check, Site 1, South Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.32: Grasslands (mixed *Lepturus repens* and *Sporobolus virginicus*) Health Check, Site 2, South Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.33: Grasslands (mixed *Lepturus repens* and *Sporobolus virginicus*) Health Check, Site 3, South Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.34: *Ipomoea* Vineland Health Check, Site 1, South Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.35: Octopus bush (*Argusia argentea*) shrublands Health Check, Site 1, Chilcott Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.36: Octopus bush (*Argusia argentea*) shrublands Health Check, Site 2, Chilcott Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.37: Octopus bush (*Argusia argentea*) shrublands Health Check, Site 3, Chilcott Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.38: Sea trumpet (*Cordia subcordata*) shrublands Health Check, Site 1, Chilcott Islet.
A. S-N, B. E-W, C. N-S, D. W-E.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.39: Grassland (*Lepturus repens* and *Sporobolus virgnicus*) Health Check, Site 1, Chilcott Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.40: Grassland (*Lepturus repens* and *Sporobolus virgnicus*) Health Check, Site 2, Chilcott Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.41: Grassland (*Lepturus repens* and *Sporobolus virgnicus*) Health Check, Site 3, Chilcott Islet.
A. North, B. East, C. South, D. West
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.42: Mixed shrublands (*Plumbago zeylanica, Abutilon albescens shrublands* ± *Ipomoea*) Health Check, Site 1, Chilcott Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.43: Mixed shrublands (*Plumbago zeylanica, Abutilon albescens shrublands* ± *Ipomoea*) Health Check, Site 2, Chilcott Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.44: Mixed shrublands (*Plumbago zeylanica, Abutilon albescens shrublands* ± *Ipomoea*) Health Check, Site 3, Chilcott Islet.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.45: Octopus bush (*Argusia argentea*) shrublands Health Check, Site 1, Magdelaine Cay South.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.46: Octopus bush (*Argusia argentea*) shrublands Health Check, Site 2, Magdelaine Cay South.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.47: Octopus bush (*Argusia argentea*) shrublands Health Check, Site 3, Magdelaine Cay South.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.48: Sea trumpet (*Cordia subcordata*) shrublands Health Check, Site 1, Magdelaine Cay South.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.49: Sea trumpet (*Cordia subcordata*) shrublands Health Check, Site 2, Magdelaine Cay South.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.50: Sea trumpet (*Cordia subcordata*) shrublands Health Check, Site 3, Magdelaine Cay South.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.51: Pisonia (*Pisonia grandis*) forest Health Check, Site 1, Magdelaine Cay South.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.52: Pisonia (*Pisonia grandis*) forest Health Check, Site 2, Magdelaine Cay South.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.

A.

B.

C.

D.

Figure A.53: Pisonia (*Pisonia grandis*) forest Health Check, Site 3, Magdelaine Cay South.
A. North, B. East, C. South, D. West.
Credit: Andrew Meiklejohn ©, Queensland Government.