

Transport
for NSW

Kamay Ferry Wharves project

Seagrass Translocation, Rehabilitation
and Monitoring

Baseline Report

October 2023



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Acknowledgement of Country

Transport for NSW acknowledges the Bidjigal and Gweagal clans who traditionally occupied Kamay (Botany Bay).

We pay our respects to Elders past and present and celebrate the diversity of Aboriginal peoples and their ongoing cultures and connections to the lands and waters of NSW.

Many of the transport routes we use today – from rail lines, to roads, to water crossings – follow the traditional Songlines, trade routes and ceremonial paths in Country that our nation's First Peoples followed for tens of thousands of years.

Transport for NSW is committed to honouring Aboriginal peoples' cultural and spiritual connections to the land, waters and seas and their rich contribution to society.

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- A Survey data for rehabilitation and reference sites
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1. Introduction

1.1 Overview of the project

The NSW Government is reinstating the wharves at La Perouse and Kurnell to provide a valuable recreational resource for the community, and to allow for future ferry access between both sides of Kamay Botany Bay National Park. The wharves will improve access for locals and visitors in small commercial and recreational boats and for people to swim, dive, fish, walk and enjoy the local sights. Importantly, through the incorporation of stories of Country into the design of the wharves and shelter structures, the project recognises the rich culture and ongoing importance of the area to Aboriginal people.

The project forms part of the NSW Government's Kamay Botany Bay National Park, Kurnell Master Plan, which aims to improve visitor experience and access to the park. The plan is being delivered by Transport for NSW and the NSW National Parks and Wildlife Service.

The project was classified State Significant Infrastructure under the NSW Planning Framework and a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act). Accordingly, bilateral approval was sought from the NSW State Government, under the *Environmental Planning and Assessment Act 1979* (EP&A Act), and the Australian Government, under the EPBC Act.

An environmental impact statement (EIS) was placed on public exhibition from July to August 2021. A response to submissions report was prepared in October 2021 to address issues raised during public exhibition of the EIS. The project was determined under the EP&A Act by the NSW Minister for Planning in July 2022 and under the EPBC Act by the Australian Government in March 2023.

Construction of the wharves commenced in July 2023 and is expected to be completed by late 2024.

1.2 The Marine Biodiversity Offset Strategy

The Kamay Ferry Wharves EIS assessed how likely the project is to impact on the area's marine ecology and biodiversity values. The EIS determined that some impacts to marine ecology and biodiversity due to the project could not be fully avoided. The EIS identified the project was likely to result in residual impacts to Key Fish Habitat, including direct and indirect impacts to *Posidonia australis* Threatened Ecological Community (TEC).

Posidonia australis TEC is protected under both the EPBC Act and *Fisheries Management Act 1994* (FM Act, NSW). In order to mitigate these unavoidable impacts, a process known as 'ecological offsetting' is implemented under State and Commonwealth legislation.

The Marine Biodiversity Offset Strategy (MBOS) provides a strategy for managing and mitigating the residual impacts on marine ecology and biodiversity identified in the EIS. The MBOS identifies appropriate offset requirements under the EPBC Act and FM Act and documents how Transport for NSW will meet its marine offset obligations. It also describes how these actions will be implemented in consultation with NSW Department of Primary Industries Fisheries (DPI Fisheries), Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) and other stakeholders to result in a net gain in environmental outcomes for Botany Bay as a priority and the Sydney Bioregion more broadly where suitable offset sites are not available in Botany Bay.

The MBOS has an operational life of no less than ten years from the date of the commencement of the MBOS activities, and therefore is an adaptive document that will be reviewed and updated as required by Transport for NSW. Revisions to the MBOS will be implemented in consultation with the MBOS Implementation Reference Panel, which was established in early 2023 and comprises representatives from Transport for NSW, DPI Fisheries Coastal Systems and Threatened Species Division, an independent scientist and observers from the NSW Department of Planning and Environment. The MBOS will be reviewed and updated during its operational life as required and as recommended by the MBOS Implementation Reference Panel.

1.3 *Posidonia australis* offset requirements

The MBOS identifies the offsets required under State and Commonwealth policies to mitigate direct and indirect impacts to *Posidonia australis* resulting from the project. Direct impacts account for the construction activities carried out in the project boundary and the predicted scour likely to occur by operational ferries, while indirect impacts account for incidental

construction mooring and limited sediment disturbances across the construction boundary. The *Posidonia australis* offset requirements were determined in response to baseline monitoring data, consultation with the MBOS Implementation Reference Panel and other project stakeholders and the conditions of approval for the project. Based on the expected maximum direct impact to *Posidonia australis* (268 m²) and using the EPBC offset calculator, the total offset area required to mitigate impacts to *Posidonia australis* was determined to be 770 m².

The MBOS identifies two key direct offset actions that aim to rehabilitate and improve existing *Posidonia australis* habitat:

- a) Translocating *Posidonia australis* from the area expected to be impacted during construction of the project at Kurnell to nearby degraded habitats (detailed in Implementation Plan 1 (UNSW, 2023a) at Appendix 4 of the MBOS Rev4)
- b) Rehabilitating seagrass meadows by replanting naturally detached beach-cast *Posidonia australis* fragments (detailed in Implementation Plan 2 (UNSW, 2023b) at Appendix 5 of the MBOS Rev4).

These direct offset actions involve harvesting and replanting all the *Posidonia australis* within the Kurnell wharf footprint plus 15 metre buffer area and improving existing *Posidonia australis* habitat in Botany Bay by collecting and planting naturally detached *Posidonia australis* fragments in unvegetated patches. These direct offset actions aim to rehabilitate and improve at least 536 m² of *Posidonia australis* habitat over the ten-year life of the MBOS. This approach aims to satisfy the environmental compensation requirements of the FM Act which mandates a minimum 2:1 ratio of offsetting area to account for direct and indirect impacts to threatened and key fish habitat such as *Posidonia australis*. Monitoring will be carried out over the life of the MBOS to determine the success or otherwise of the *Posidonia australis* offset strategy.

The offset strategy to achieve the remaining offset obligations for *Posidonia australis* may include additional direct offset actions such as installing environmentally friendly moorings and artificial habitats for Syngnathids. Transport for NSW is developing implementation plans for these offset actions in consultation with the MBOS Implementation Reference Panel and other key stakeholders.

1.4 Implementing the *Posidonia australis* offset strategy

Posidonia australis rehabilitation efforts for the project will be carried out in stages. Stage one involving translocating harvested *Posidonia australis* fragments from the project impact area at Kurnell to nearby rehabilitation sites commenced in mid-June and was completed in early July.

This process involved Scientific Divers removing by hand, quantifying and recording all of the *Posidonia australis* shoots located within the project impact area at Kurnell. Harvesting involved carefully digging by hand and removing the *Posidonia australis* from the sediment while avoiding as much as possible damaging the rhizome. Great care was taken during the harvesting process to minimise damaging the *Posidonia australis* plants and this was achieved for about 98% of all harvested material.

The harvested *Posidonia australis* shoots were immediately replanted by hand at six nearby rehabilitation sites using two methods: (a) transplanting shoots into biodegradable jute mats deployed to the seabed and securing the rhizomes with metal pins; and (b) transplanting shoots directly into bare sediment and securing the rhizomes with metal pins. The two planting methods were used interchangeably at the rehabilitation sites: a single planting method was used at three sites (either jute mats only or directly into sediment only) and three sites contained both planting methods. Long-term monitoring of the density, condition and growth of *Posidonia australis* shoots transplanted at the three sites where both planting methods occurred will provide valuable data to help inform future restoration strategies.

Posidonia australis was replanted at rehabilitation sites to maintain the overall mean shoot density of the *Posidonia australis* patches that were harvested and relocated (about 42 shoots per m²). Planting was done in rows with about 20cm of space between *Posidonia australis* rhizomes to allow for growth, adjusted for the length of individual rhizomes which ranged from <5 to about 25cm. Most of the harvested *Posidonia australis* had a plagiotropic (horizontal) growth form. Natural expansion of translocated *Posidonia australis* in the rehabilitated areas was encouraged by positioning plagiotropic rhizomes oriented out from the centre of planted plots and jute mats.

The translocation process involved the relocation of about 13,000 *Posidonia australis* shoots from the project impact area to six rehabilitation sites and resulted in a total rehabilitated area of about 302 m². This work was carried out in accordance with the methods detailed in the MBOS (refer to Implementation Plan 1 (UNSW, 2023a) at Appendix 4 of the MBOS) and a permit under section 37 of the *Fisheries Management Act 1994* obtained from DPI Fisheries.

Stage two of the rehabilitation efforts involves collecting naturally detached *Posidonia australis* fragments from shorelines in Botany Bay and transplanting them in rehabilitation sites at Kurnell. This stage commenced in mid-July and will continue at

regular intervals for about eight years until about mid-2031 (subject to any increase in effort being identified through review of monitoring results).

The monitoring program will commence in October 2023 and continue for ten years. Monitoring of rehabilitation sites with restored *Posidonia australis* and reference sites will occur four times per year for the first year following translocation and twice per year for the next four years. Monitoring will occur annually after five years with the program completing by about the end of 2033. Monitoring reports will document the outcomes of the offset strategy for *Posidonia australis* by assessing against success criteria (section 4).

1.5 Purpose of the Seagrass Baseline Report

An initial round of in-situ mapping and surveys was carried out in late July-early August 2023 following completion of translocation of *Posidonia australis* at Kurnell. Surveys were carried out at six rehabilitation sites that received translocated *Posidonia australis* and six reference sites located within the natural meadow at Kurnell. The purpose of the initial surveys was to provide baseline data about the density and condition of translocated and natural meadows of *Posidonia australis*.

The purpose of this report is to document the results of the in-situ surveys and mapping that were carried out to:

- Survey the density and condition of translocated *Posidonia australis* in rehabilitation sites
- Survey the density and condition of *Posidonia australis* in reference sites
- Survey and confirm the area of rehabilitation sites restored with translocated *Posidonia australis* shoots.

An assessment of the results of the initial survey against the success criteria for the *Posidonia australis* offset strategy was carried out.

This report will be reviewed by the MBOS Implementation Reference Panel.

2. Methods

2.1 Location and timing of initial survey

Surveys were carried out at six rehabilitation sites that were restored using *Posidonia australis* shoots harvested from the project impact area at Kurnell during the translocation process. The rehabilitation sites are located within the main *Posidonia australis* meadow to the west of the project boundary at Kurnell at depths of about 2.5-4.0 metres (Figure 2-1). Previous surveys and assessment of the rehabilitation sites (UNSW, 2023c) identified the sites as high priority (Trench east, Trench west and Scar F) and medium priority (Scar B, Scar C and Scar E) for rehabilitation.

Surveys were also carried out at six reference sites to enable comparisons between the density and condition of natural *Posidonia australis* meadows and translocated *Posidonia australis* in rehabilitation sites. The reference sites were established as part of the long-term monitoring program for the project. These sites are located at least 130 metres from the project boundary at Kurnell and impacts from the Kamay Ferry Wharves project on the reference sites are expected to be negligible. The reference sites are distributed to ensure they represent healthy natural *Posidonia australis* meadows with similar exposure, tidal range, depth and physical characteristics to the rehabilitation sites.

A detailed description and assessment of the rehabilitation and reference sites is provided in the Site Selection and Validation Report (UNSW, 2023c) in the MBOS.

The initial surveys were carried out over four days in late July-early August 2023 by experienced marine ecologists from the University of New South Wales (UNSW) using SCUBA.

Table 2-1: Details of the rehabilitation and reference sites surveyed at Kurnell

Site ID	Site type	Coordinates
Scar B	Rehabilitation	-34.003730, 151.214583
Scar C	Rehabilitation	-34.004288, 151.214468
Scar E	Rehabilitation	-34.004739, 151.213979
Scar F	Rehabilitation	-34.004842, 151.214691
Trench east	Rehabilitation	-34.002933, 151.215704
Trench west	Rehabilitation	-34.002979, 151.215608
PBK03	Reference	-34.003308, 151.215431
PBK04	Reference	-34.003443, 151.215073
PBK07	Reference	-34.0039644, 151.2157027
PBK08	Reference	-34.004118, 151.215373
PBR01	Reference	-34.0046782, 151.2144946
PBR02	Reference	-34.0045811, 151.2149550

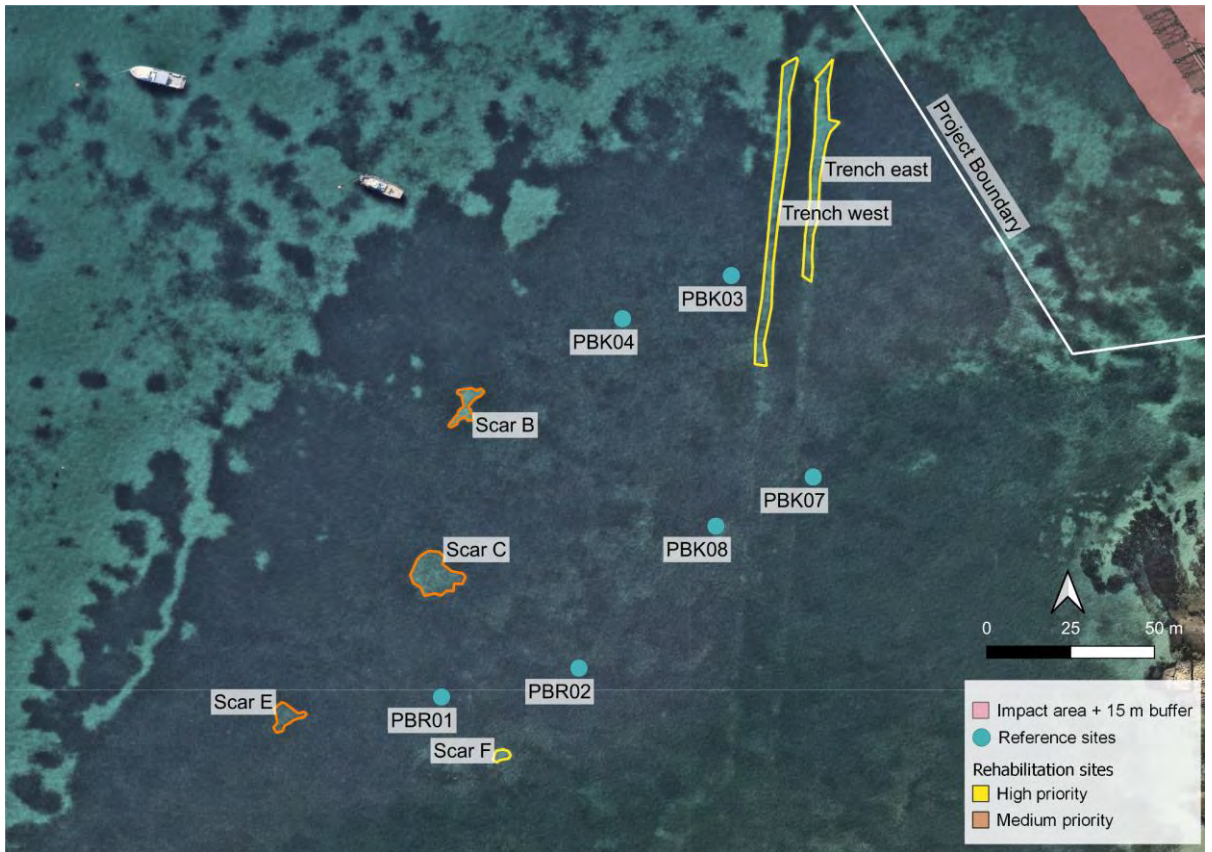


Figure 2-1: Overview of the survey area at Kurnell (Gamay, Botany Bay)

2.2 *Posidonia australis* surveys

2.2.1 Surveys of translocated *Posidonia australis* in rehabilitation sites

Monitoring of *Posidonia australis* density and condition (leaf length and epiphyte cover) was carried out at the six rehabilitation sites where translocation of *Posidonia australis* occurred. Each site was located in the field using a GPS and a temporary float was deployed in the centre of the site.

Posidonia australis was surveyed within randomly placed 0.25 m² quadrats (0.5 metre x 0.5 metre). The number of quadrats surveyed in rehabilitation sites was based on the size of the area transplanted within the site and ranged from five (Scar F) to fifteen (Scar C) with ten quadrats surveyed in all other sites. In each quadrat, the number of *Posidonia australis* shoots was quantified, and maximum leaf length and estimate of epiphyte cover (using a one to five scale, where one indicated minimal and five indicated heavy epiphyte cover) was recorded for three shoots per quadrat. Photos and general observations of the sites were also recorded.

2.2.2 Surveys of *Posidonia australis* reference sites

The six reference sites were surveyed using the same methods described above. Once located, a temporary float was deployed in the centre of the site. *Posidonia australis* shoot density, maximum leaf length and estimated epiphyte cover were quantified in ten randomly placed 0.25 m² quadrats within about a five-metre radius of the centre of the site. Photos and general observations of the sites were also recorded.

2.3 Mapping rehabilitation sites

2.3.1 Desktop review

A desktop review of existing mapping data was carried out to produce updated maps of the rehabilitation sites pre-translocation. High resolution aerial imagery of Botany Bay captured by Nearmap on 1 May 2023 was displayed in GIS software (QGIS). Analysis of the areal extent of each rehabilitation site was performed by overlaying polygons. The calculated areas available for rehabilitation in the sites were compared to those provided in the MBOS (refer to Site Selection and Validation Report (UNSW, 2023c) at Appendix 6 of the MBOS).

Data recorded during the translocation stage were reviewed and the area in each rehabilitation site that had been restored with translocated *Posidonia australis* was calculated based on the recorded number of 1m x 2m plots planted.

2.3.2 Field-based mapping of translocated *Posidonia australis* in rehabilitation sites

In-situ mapping was carried out to record the extent of the area within rehabilitation sites that had been restored using translocated *Posidonia australis* shoots. At each site, metal reinforcing bars were installed around the perimeter of the planted area. Transect tapes were temporarily placed around the marked-out perimeter to aid the visibility of a snorkeler at the surface. The snorkeler, using the transect tapes as a guide, swam the perimeter of the planted area while towing by hand a dive float with a handheld GPS attached that was set in tracking mode.

2.4 Analysis

2.4.1 *Posidonia australis* characteristics

Data on *Posidonia australis* shoot density, leaf length and epiphyte cover recorded during the surveys of *Posidonia australis* in the rehabilitation and reference sites were analysed to obtain summary descriptive statistics. The mean (\pm standard error) of these variables were calculated for each site and plotted for visual interpretation of the results. Analyses and plots were prepared using the R programming language version 4.3.1 (R Core Team, 2023).

2.4.2 Extent of *Posidonia australis* restored area in rehabilitation sites

The GPS data collected during the in-situ mapping was reviewed in GIS software. Polygons were produced to depict the approximate area within rehabilitation sites restored using translocated *Posidonia australis* shoots. Polygons were produced for four of the six rehabilitation sites: Scar F, Scar B, Scar E, and Scar C. Mapping was not carried out for Trench east and Trench west sites because the area planted with translocated *Posidonia australis* in these sites is discontinuous. These sites are characterised by unvegetated areas interspersed with patches of dense, mixed-species seagrasses.

3. Results

3.1 *Posidonia australis* density and condition at rehabilitation and reference sites at Kurnell

A summary of the overall mean values for *Posidonia australis* shoot density, leaf length and epiphyte cover for the six rehabilitation and six reference sites is provided in Table 3-1. Site-level data is provided in Appendix A.

The density of translocated *Posidonia australis* shoots in rehabilitation sites was on average about 53% lower overall than reference site shoot densities (Table 3-1). This result was to be expected because the approach to planting *Posidonia australis* during the translocation stage aimed to maintain the original overall mean shoot density of the harvested impact area patches of about 42 shoots per m². The overall mean shoot density of translocated *Posidonia australis* in the rehabilitation sites quantified by the initial survey was 53 shoots per m² (Table 3-1). Mean shoot densities ranged from about 38-69 shoots per m² and exceeded the target planting density at all but one site (Trench east) (Figure 3-1a, Figure 3-2a).

When compared to *Posidonia australis* shoot densities in individual reference sites, rehabilitation site shoot densities were generally lower, except when comparing scars B and E (about 68 shoots per m²) to reference site PBK03 (about 62 shoots per m²) (Figure 3-2b-c). Shoot densities in reference sites tended to decrease across the depth gradient (range 62-152 shoots per m²) and *Posidonia australis* meadows were exceptionally dense at the two shallow reference sites (PR01 and PR02) (Figure 3-1a, Figure 3-2d).

Leaf lengths of translocated *Posidonia australis* in rehabilitation sites were about 10% shorter on average than leaf lengths of *Posidonia australis* in reference sites (Table 3-1). Leaf lengths of translocated *Posidonia australis* in rehabilitation sites ranged on average from about 23-38 cm and in reference sites ranged from about 31-36 cm (Figure 3-1b).

Overall there was no difference in mean epiphyte cover of translocated *Posidonia australis* in rehabilitation sites and *Posidonia australis* in reference sites (Table 3-1). Epiphyte cover of translocated *Posidonia australis* in rehabilitation sites ranged on average from 1.2-3.0 and in reference sites ranged from 1.6-3.1 (Figure 3-1c). Epiphyte cover could generally be described as low (<3), but in the natural meadow tended to be higher in the shallower reference sites (Figure 3-2e).

Table 3-1: Summary of *Posidonia australis* characteristics quantified in rehabilitation and reference sites at Kurnell.

Site type (number of sites)	Shoot density (m ⁻²) (mean ±SE)	Leaf length (cm) (mean ±SE)	Epiphyte cover (1-5 scale) (mean ±SE)
Rehabilitation (6)	53 (±2.3)	31 (±0.7)	2.2 (±0.1)
Reference (6)	114 (±5.6)	35 (±0.7)	2.2 (±0.1)

Note: SE=standard error

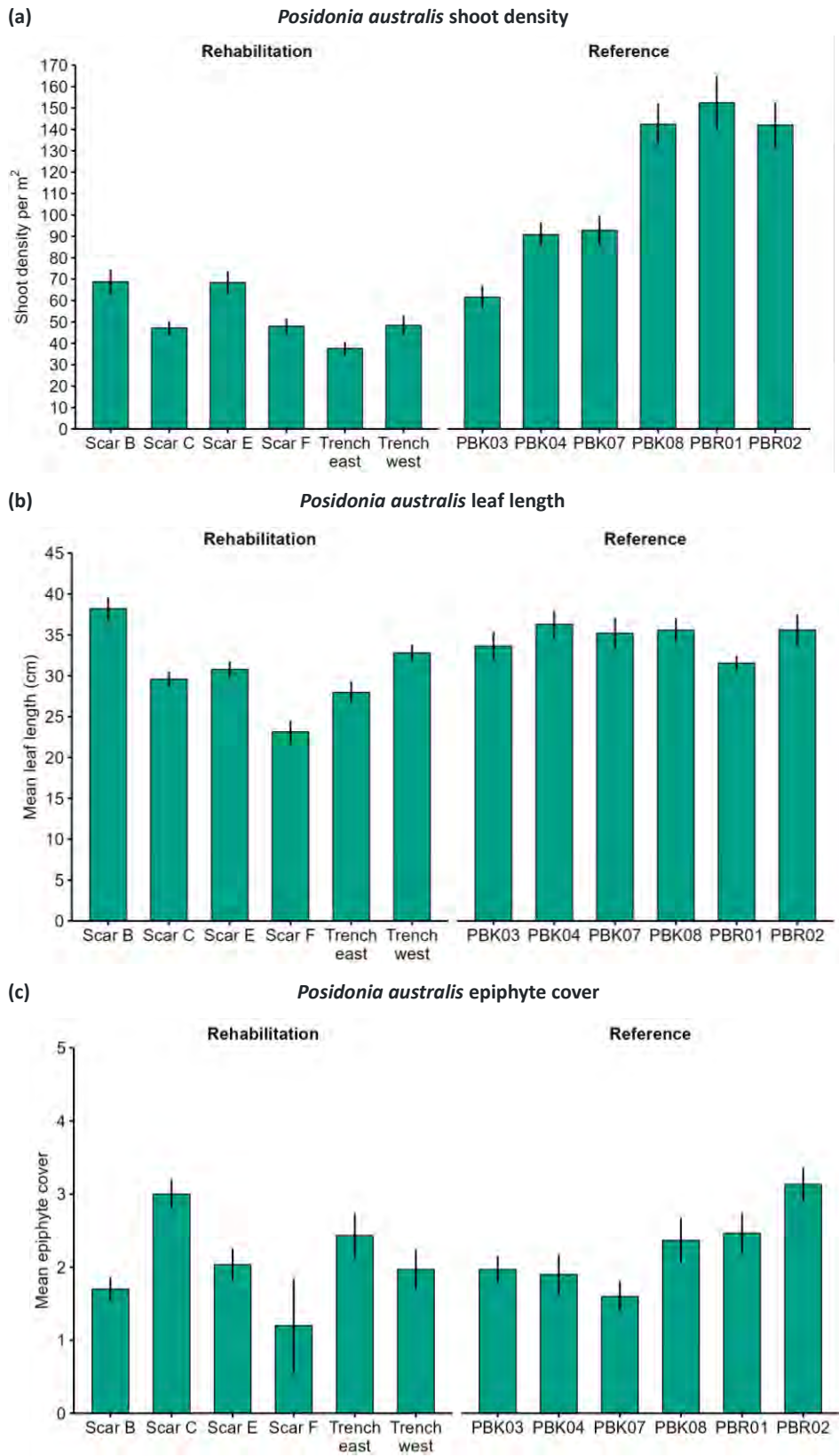


Figure 3-1: *Posidonia australis* characteristics at six rehabilitation and six reference sites at Kurnell: (a) shoot density, (b) leaf length and (c) epiphyte cover. Error bars indicate standard error of the mean.

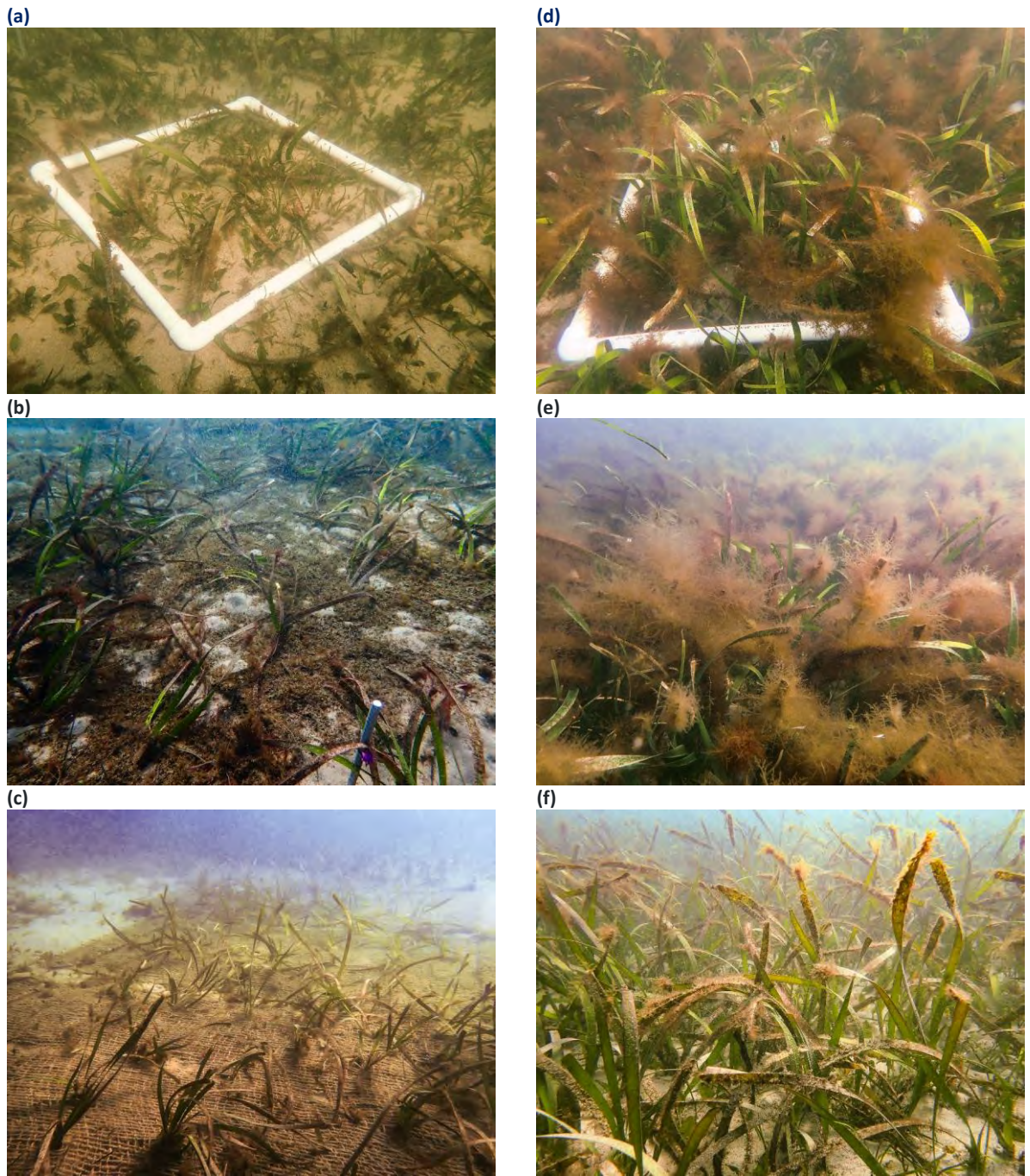


Figure 3-2: Photos of *Posidonia australis* at rehabilitation and reference sites at Kurnell. Photos showing (a) survey quadrat of translocated *Posidonia australis* planted directly into sediment at Trench east, (b and c) jute mats planted with *Posidonia australis* at Scar B and Scar E, (d and e) survey quadrat and view of shallow depth reference site PBR02 showing dense meadow and heavy epiphyte cover, and (f) view of deeper reference site PBK04 with little epiphyte cover.

3.2 Areal extent of translocated *Posidonia australis* in rehabilitation sites

The rehabilitation area available prior to translocation of *Posidonia australis* in the six high and medium priority rehabilitation sites that was estimated from polygon data obtained using recent Nearmap imagery is provided in Table 3-2. The estimated extents of the sites available for rehabilitation ranged from 14-203 m² and provided a total available area of 607 m². In general, the estimated areal extents of the sites had decreased compared to previous estimates (UNSW, 2023c). This variation could be attributed to changes in the distribution of seasonal seagrass species *Zostera sp.* and *Halophila sp.* during the preceding summer-autumn months.

The area of the six sites rehabilitated with *Posidonia australis* translocated from the impact area at Kurnell is provided in Table 3-2. The area of the sites rehabilitated with translocated *Posidonia australis* ranged from 10-152 m². With the exception of the two largest rehabilitation sites, Trench east and Trench west, most of the area available in the sites was planted with *Posidonia australis* during the translocation stage.

Polygons representing the approximate areas of the six sites rehabilitated with translocated *Posidonia australis* obtained from data collected during the field-based mapping are displayed on Figure 3-3. Note that the polygons for sites Trench east and Trench west were not prepared using field-based mapping data and provide an estimated representation of the location and area rehabilitated in these sites. The polygons will be continuously updated and refined as part of the reporting for the long-term monitoring program for the *Posidonia australis* rehabilitation efforts.

Table 3-2: Estimated rehabilitation area available in sites prior to translocation and the area rehabilitated with translocated *Posidonia australis*

Site ID	Rehabilitation area available (m ²)	Rehabilitated area (m ²)
Scar B	52	48
Scar C	158	152
Scar E	46	38
Scar F	14	10
Trench east	134	26
Trench west	203	28
Total	607	302

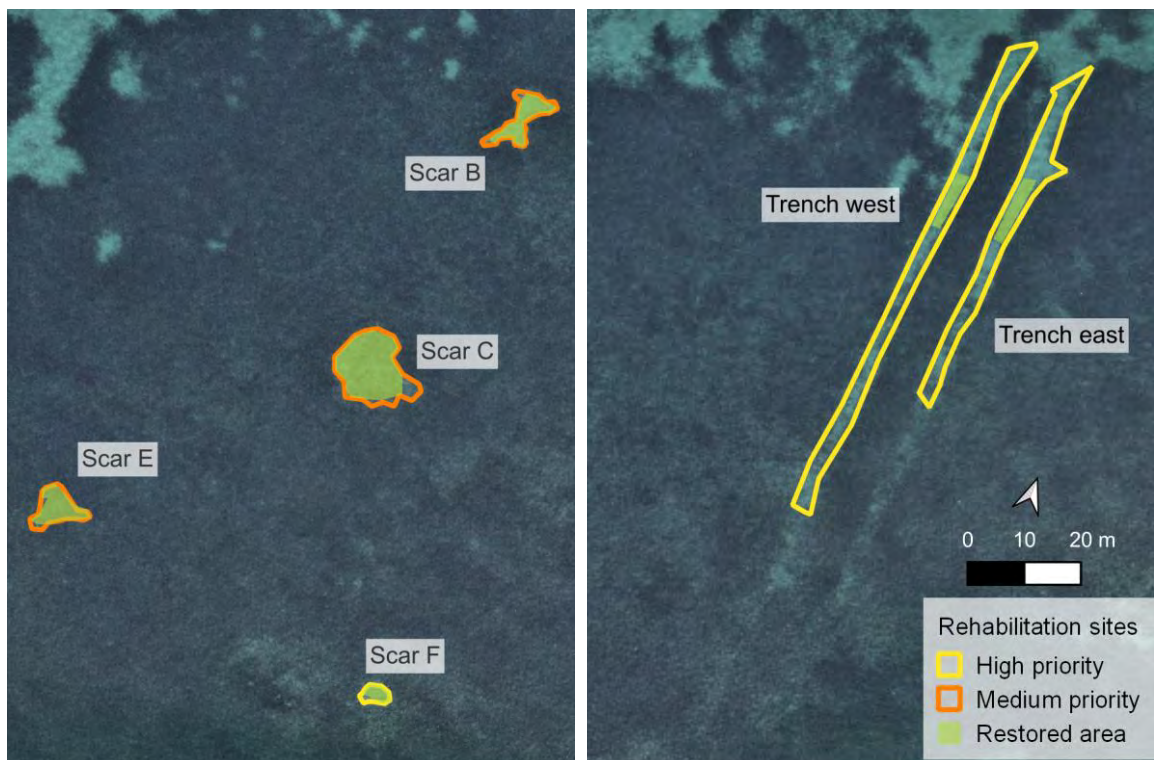


Figure 3-3: Map of Kurnell showing the approximate areas within each of the six medium and high priority rehabilitation sites that were rehabilitated with *Posidonia australis* during the translocation stage.

3.3 Botany Bay climate patterns

Monthly rainfall and air temperature data for the Sydney Airport AMO weather station (66037) obtained from the Bureau of Meteorology (BOM, 2023a; BOM 2023b) indicated that weather conditions were drier and warmer than the long-term mean

during the period (June-July) when *Posidonia australis* translocation and the initial surveys were carried out (Figure 3-4a,b). June 2023 was particularly dry with <15 mm of rain falling during the month, well below the long-term monthly mean of 122 mm. Maximum air temperatures in June and July were about 2°C warmer than the long-term mean.

Global solar exposure is the total amount of solar energy falling on a horizontal surface (BOM, 2020). The daily global solar exposure is the total solar energy for a day, and in Australia generally range from 9-24 MJm⁻² annually. Solar exposure is influenced by the position of the sun in the sky and level of cloud cover, and in the Sydney region is typically related to the seasons, being lowest in winter and highest in summer. At a local level, it can be used as a proxy for the amount of light reaching seagrasses. Daily global solar exposure data recorded at the Kurnell automatic weather station (AWS) (66043) indicated that levels were slightly above the long-term mean in June and July 2023 (Figure 3-4c). The above-average solar exposure could be attributed to lower than average rainfall and cloud cover during this period.

Wind data recorded at Kurnell AWS indicated that conditions were generally calm during June and July 2023 (Figure 3-4d). Mean wind speeds were 18 km/h and 16km/h in June and July respectively. This followed two months in which maximum wind speeds were >10 km/h higher than in June and July 2023.

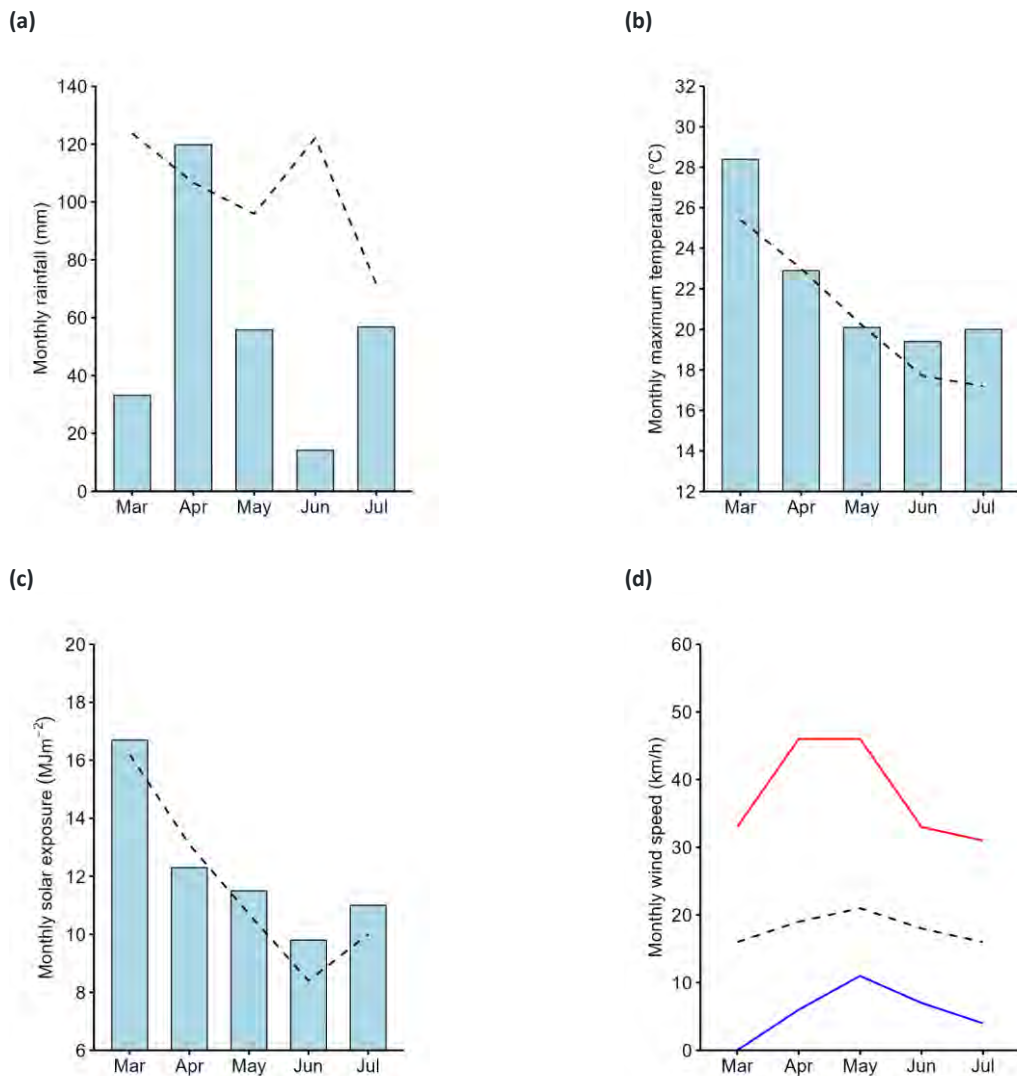


Figure 3-4: Monthly climate data for Botany Bay (a) total rainfall, (b) maximum air temperature, (c) mean solar exposure and (d) mean, minimum and maximum wind speed. Dashed line in a, b and c indicates the long-term mean. Rainfall and air temperature records at Sydney Airport AMO commenced in 1929 and 1939 respectively. Solar exposure monitoring at Kurnell AWS commenced in 2007.

4. Discussion

The initial survey used a combination of desktop-based data review and mapping, and field-based underwater surveys and mapping to obtain baseline data following completion of translocation of *Posidonia australis* at Kurnell. Specifically, the initial survey obtained baseline data on:

- The density and condition of *Posidonia australis* translocated to six rehabilitation sites at Kurnell
- The density and condition of *Posidonia australis* in six reference sites representative of natural meadows at Kurnell
- The area within rehabilitation sites that was rehabilitated with *Posidonia australis* during the translocation stage.

The following is a discussion of the initial survey findings and general observations recorded during the surveys.

4.1 Assessment against success criteria

Success criteria for monitoring the performance of the *Posidonia australis* restoration efforts were established in consultation with the MBOS Implementation Reference Panel and other key project stakeholders. Success criteria were developed for pre-construction, short, mid and long-term periods of monitoring. Success criteria relevant to pre-construction and the short-term (two year) period of the offsetting strategy are outlined in Table 4-1. The success criteria are detailed in full in the MBOS.

The success criteria provide readily measurable structural attributes that will indicate changes in the status of transplanted and nearby naturally occurring *Posidonia australis* meadows through time: *Posidonia australis* areal extent and shoot density. The performance of the offsetting strategy will be evaluated by comparing the monitoring data with these targets. An evaluation of the initial survey monitoring results against the pre-construction and short-term success criteria is summarised in Table 4-1.

Table 4-1: *Posidonia australis* offsetting success criteria and measures for pre-construction and the short-term period of the restoration program (MBOS rev4)

Criteria	Measure	Timing and description of success	Outcome of translocation work
Removal of all <i>Posidonia australis</i> to be impacted	All <i>Posidonia australis</i> successfully transplanted from the impact area to offset sites.	Pre-construction Removal and recording of all <i>Posidonia australis</i> shoots from impact area prior to construction (Kurnell). Storage of shoots for no longer than 72 hours until transplanting is complete.	Survey of the impact area at Kurnell confirmed that all <i>Posidonia australis</i> , totalling 12,946 shoots, was relocated from the impact area prior to construction at Kurnell. All <i>Posidonia australis</i> shoots removed from the impact area were transplanted on the same day; no storage was required. Meets target
Increase in area of <i>Posidonia</i> .	Areal extent of restored <i>Posidonia australis</i> meets EPBC offset requirements.	Short-term success (2-years) Areal extent of restored <i>Posidonia australis</i> is to a 1:1 ratio of area removed from the impact area.	Total area rehabilitated with translocated <i>Posidonia australis</i> is greater than the target at this stage.
Long term (10-year) goal: 536m ²	Minimum value:	268m ²	302m ² Exceeds target

Criteria	Measure	Timing and description of success	Outcome of translocation work
Maintain <i>Posidonia australis</i> density.	Shoot density of restored <i>Posidonia australis</i> (based on 0.25m ² quadrats).	Short-term success (2-years) Increase in shoot density in the offset sites from bare to vegetated at a minimum density of 25 shoots per square meter (>50% of the impact area density).	Densities of translocated <i>Posidonia australis</i> shoots in six rehabilitation sites closely match or exceed the natural density of the impact area patches of 42 shoots/m ² .
Long term (10-year) goal: 42 shoots/m ²	Minimum value:	25 shoots/m ²	53 shoots/m ² (range 38-69) Exceeds target

Surveys and data collected during the translocation stage confirmed that the success criteria for the pre-construction period detailed in Table 4-1 were met. A survey of the entire impact area at Kurnell by Scientific Divers immediately following completion of translocation identified that all *Posidonia australis* had been removed from the area. Records maintained by Scientific Divers throughout the translocation process confirmed that 12,946 shoots were relocated from the impact area. No storage of shoots was necessary as shoots were harvested and transplanted on the same day.

Baseline data collected during surveys carried out immediately following translocation of *Posidonia australis* from the project impact area to rehabilitation sites at Kurnell indicates that the short-term offset strategy targets for restored area and shoot density detailed in Table 4-1 were exceeded. Substantial areas of bare substrate in the six rehabilitation sites have been restored with translocated *Posidonia australis*. Ongoing restoration over the following months will use naturally detached *Posidonia australis* fragments collected from shorelines around Botany Bay to target planting the remaining bare areas within these six rehabilitation sites, following which restoration of new sites will commence. Naturally detached *Posidonia australis* fragments may be transplanted in the six initial rehabilitation sites to supplement the translocated shoots in response to declines in densities, should this occur.

Shoot densities of translocated *Posidonia australis* in rehabilitation sites immediately following translocation exceed on average the long-term success criteria goal of 42 shoots/m², which is equivalent to the estimated overall mean shoot density of *Posidonia australis* translocated from the impact area at Kurnell. To maintain this outcome, ongoing restoration using naturally detached *Posidonia australis* shoots will continue at a minimum target density of 42 shoots/m². Mortality of *Posidonia australis* shoots is expected to be highest during the initial 9-12 months following translocation. Changes in shoot densities during this period of potentially higher mortality will be captured during four monitoring events over 12 months commencing in October 2023.

The baseline data collected during the initial surveys suggests that *Posidonia australis* naturally forms dense meadows in areas free from human-caused physical disturbance (e.g. scour from boat moorings) and fragmentation at Kurnell. Shoot densities in the survey sites in the main meadow at Kurnell reach up to 152 shoots/m² and are substantially higher than the baseline shoot densities in the rehabilitation sites. Nevertheless, monitoring of reference sites is important for detecting broader scale impacts on seagrass habitat at Kurnell resulting from naturally occurring or project-related disturbances during construction or operation.

Although not directly related to the success criteria, monitoring of leaf length and epiphyte cover provide an indication of the condition of translocated *Posidonia australis*. Using measurements of these two attributes, the baseline data collected immediately following the translocation stage indicates that there is little difference in condition between *Posidonia australis* translocated to rehabilitation sites and *Posidonia australis* in the main meadow; values of these attributes for translocated and reference site *Posidonia australis* shoots generally differed by less than ten percent.

4.2 Environmental conditions and general observations during the initial survey

A substantial bloom of filamentous algae that was initially observed during surveys of seagrass meadows at Kurnell carried out in early November 2023 remains present throughout the area. The algae was observed attached to *Posidonia australis* shoots at the surveyed reference sites and in natural meadows surrounding the rehabilitation sites (refer to photographs in Appendix B). The influence of the algae appears greatest at shallow depths and may be due to higher light penetration and less tidal flushing at these inshore locations. Typically a seasonal occurrence at Kurnell, the persistence and increasing density of the algal bloom could be attributed to local weather patterns including lower than average rainfall, warmer than average temperatures and greater than average solar exposure. Visual monitoring and documenting of the algal bloom will continue.

A variety of marine biota was observed during the surveys inhabiting the restored and natural *Posidonia australis* sites, including various species of cuttlefish, octopus, squid, sea hares, invertebrates, rays and fishes. Flowers were observed beginning to form on some shoots within the main *Posidonia australis* meadow. Some examples of these observations are included in photographs at Appendix B.

5. Terms and acronyms

Term /acronym	Description
AWS	Automatic weather station
BOM	Bureau of Meteorology
DCCEEW	Department of Climate Change, Energy, the Environment and Water
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i> (NSW). Provides the legislative framework for land use planning and development assessment in NSW
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Commonwealth). Provides for the protection of the environment, especially matters of national environmental significance, and provides a national assessment and approvals process.
EIS	Environmental impact statement
FM Act	<i>Fisheries Management Act 1994</i> (NSW)
MBOS	Marine Biodiversity Offset Strategy
DPI Fisheries	NSW Department of Primary Industries Fisheries
TEC	Threatened Ecological Community
Transport for NSW	Transport for New South Wales
UNSW	University of New South Wales

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Appendix A

Survey data for rehabilitation and reference sites

Table A-1: Mean *Posidonia australis* shoot density, leaf length and epiphyte cover at rehabilitation and reference sites from the initial surveys

Site ID	Site type	Shoot density (m ⁻²) (mean ±SE)	Leaf length (cm) (mean ±SE)	Epiphyte cover (1-5 scale) (mean ±SE)
Scar B	Rehabilitation	68.8 (± 5.8)	38.2 (± 1.4)	1.7 (± 0.2)
Scar E	Rehabilitation	68.4 (± 5.2)	30.8 (± 1.0)	2.0 (± 0.2)
Scar C	Rehabilitation	47.2 (± 3.2)	29.6 (± 0.9)	3.0 (± 0.2)
Scar F	Rehabilitation	48.0 (± 3.6)	23.1 (± 1.4)	1.2 (± 0.6)
Trench west	Rehabilitation	48.4 (± 4.6)	32.8 (± 1.0)	2.0 (± 0.3)
Trench east	Rehabilitation	37.6 (± 3.0)	28.0 (± 1.3)	2.4 (± 0.3)
PBK07	Reference	92.8 (± 6.8)	35.2 (± 2.0)	1.6 (± 0.2)
PBK08	Reference	142.4 (± 9.7)	35.6 (± 1.5)	2.4 (± 0.3)
PBK03	Reference	61.6 (± 5.4)	33.6 (± 1.8)	2.0 (± 0.2)
PBK04	Reference	90.8 (± 5.8)	36.3 (± 1.7)	1.9 (± 0.3)
PBR01	Reference	152.4 (± 12.6)	31.5 (± 0.9)	2.5 (± 0.3)
PBR02	Reference	142.0 (± 10.7)	38.2 (± 1.4)	3.1 (± 0.2)

Note: SE = standard error

Appendix B

Site photographs

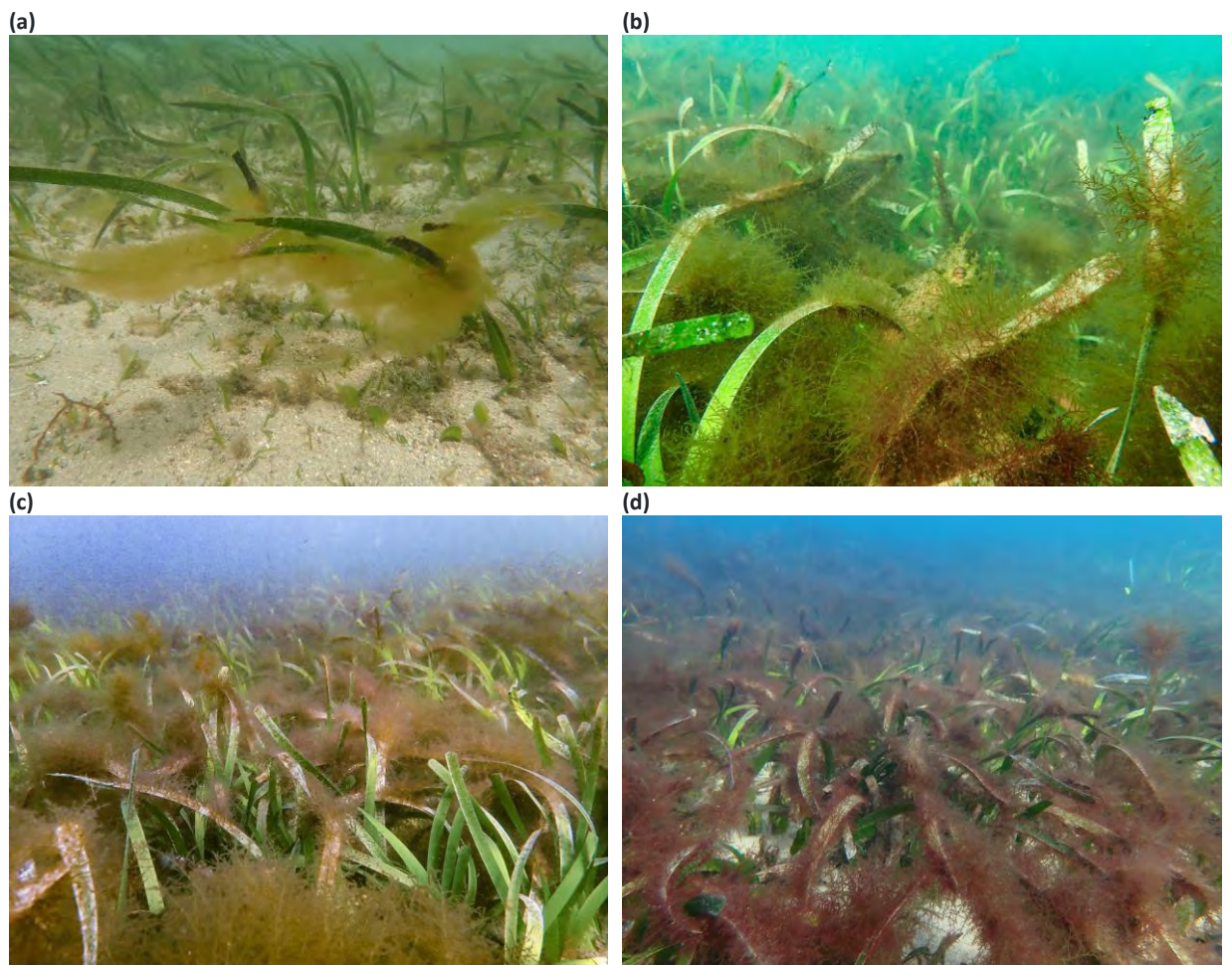


Figure B-1: Photographs captured by Scientific Divers during the initial survey (July-August 2023) of the filamentous algae bloom in *Posidonia australis* at Kurnell: (a) A *Posidonia australis* patch in November 2022 before it was translocated, (b) Reference site PBK08 in August 2023 (c) Reference site PBR02 in August 2023 and (d) Meadow surrounding Scar E in July 2023.

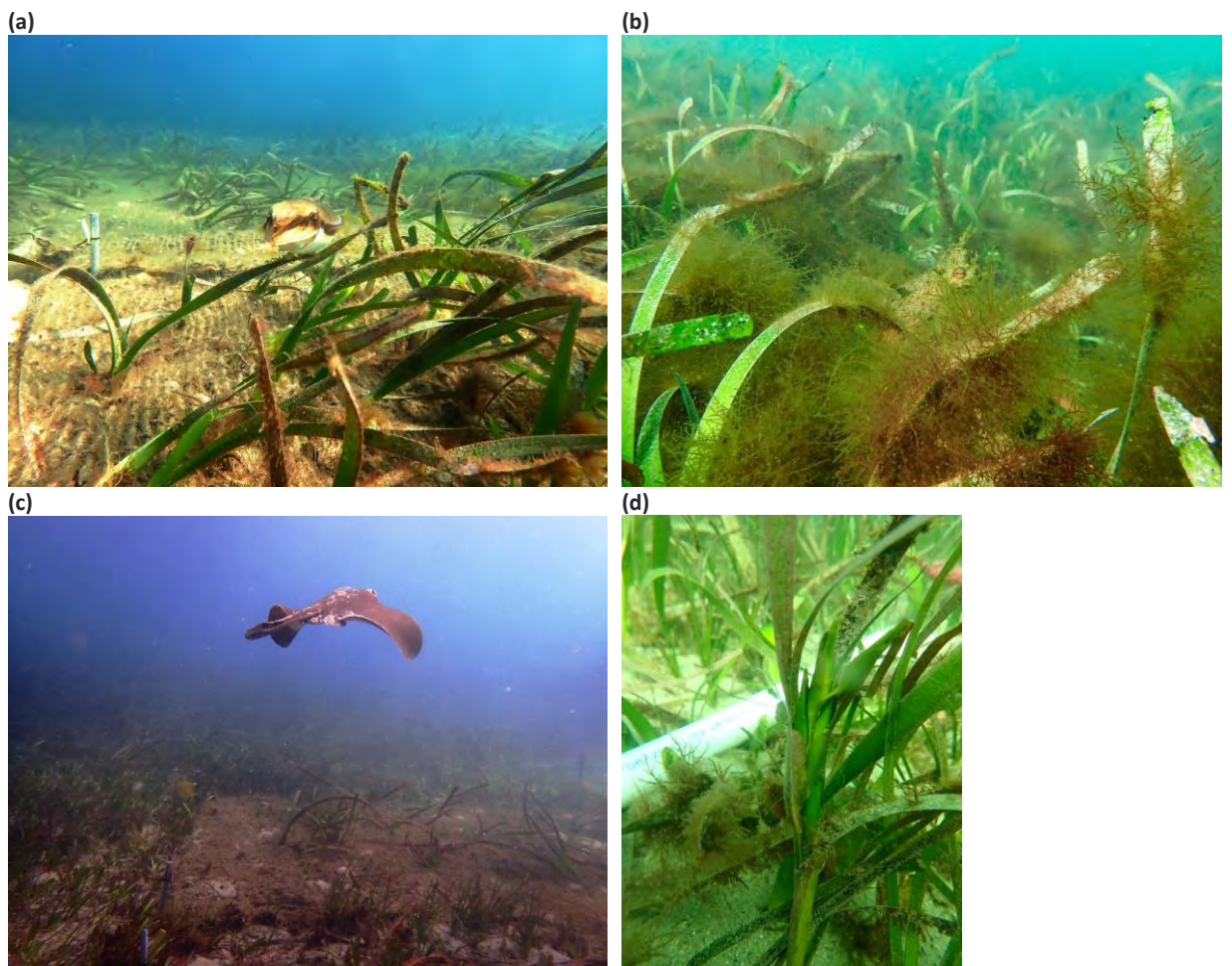


Figure B-2: Photographs captured by Scientific Divers during the initial survey showing examples of rehabilitation sites at Kurnell: (a) A cuttlefish at Scar E, (b) An octopus creeping through the seagrass in a reference site, (c) A ray swims over the restored area at Scar B and (d) A flower beginning to form on a shoot in a reference site.

