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Kamay Ferry Wharves Seagrass Pre-construction Monitoring Report: Baseline 2 (Summer 2022)

Prepared for Transport for NSW | 5 July 2022

Document control

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Glossary and list of abbreviations

Term or abbreviation	Definition
BOM	Bureau of Meteorology
CHIRP	Compressed High-Intensity Radiated Pulse
CPCe	Coral Point Count with Excel extensions
DoD	Depth of Disturbance
DPI	The NSW Department of Primary Industries
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EIS	Environmental Impact Statement
FM Act	*Fisheries Management Act 1994* (NSW)
Shoot (seagrass)	A shoot is considered the section of seagrass from the sheaf up and may consist of one or various leaves.
TBC	To be completed
TfNSW	Transport for New South Wales

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1. Introduction

1.1 Project Background

Transport for New South Wales (TfNSW) is proposing to reinstate the ferry wharves at La Perouse and Kurnell in Botany Bay (Figure 1 and Figure 2 respectively). The Project was classified State Significant Infrastructure (SSI) under the NSW Planning Framework and is a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (EPBC Act referral 2020/8825).

The Project would allow for an alternative to the road connection between La Perouse and Kurnell. Its main purpose would be to operate a public ferry service for visitors and the community. In addition, the Project would provide supplementary temporary moorings for tourism-related commercial vessels and recreational boating.

A Marine Biodiversity Assessment Report was prepared as part of the Environmental Impact Statement (EIS) (TfNSW 2021a). This report identified that the project would result in impact to seagrasses, including the endangered *Posidonia australis* ecological community and population in Botany Bay. Impacts on seagrasses will include some losses of seagrass within the Construction Footprint and associated 15 m buffer from shading, disturbances during construction works and ongoing operation of the wharves and ferries (TfNSW 2021a). In addition, a large and significant bed of *P. australis* seagrass occurring adjacent to and beyond the Project Boundary at Kurnell is considered of ecological significance and an important conservation requirement. *P. australis* within Botany Bay is listed as an Endangered Population under the *Fisheries Management Act* 1994 (FM Act).

Investigations of seagrass in or nearby the Project Boundaries at La Perouse and Kurnell have found seagrass bed distribution and morphology (i.e. shoot density, leaf length) to be highly temporally and spatially variable, especially off Silver Beach at Kurnell. In some places, distribution was wider than previously mapped (Larkum and West 1990, Otway and Macbeth 1999, NSW DPI 2021). At both La Perouse and Kurnell, several vessel moorings within or adjacent to the Project Boundaries are likely to be having, and may have ongoing, impacts on seagrass distribution in these areas. At Kurnell in particular, exposure to large easterly swells is considered a major driver of temporal changes in seagrasses within the Project Boundary and expansion of the adjacent large *P. australis* bed to the east.

1.2 Project Description

The Project includes the construction of two new wharves, one at La Perouse and one at Kurnell. The wharves would be designed to accommodate ferries up to 40 m length, along with recreational and commercial vessels up to 20 m in length.

The total construction period is anticipated to take up to 13 months and will require the following:

- Use of a temporary crane and rig platform (onshore) to install nearshore piles and piers at La Perouse.
- Construction of a causeway to provide piling shoot access to install nearshore piles and piers at Kurnell.
- Repositioning and anchoring of a jack-up barge to provide a platform for construction works for the wharfs.

1.3 Monitoring Purpose

The EIS has identified the need for the establishment of a seagrass monitoring program that includes pre-construction (baseline) surveys and designed to determine construction and operation impacts. It is anticipated that pre-construction surveys will include up to four surveys and two years of data to obtain a sufficient baseline. Furthermore, pre-construction monitoring will be required to determine baseline distribution and condition of seagrasses both within and adjacent to the Project Boundary to determine final offset requirements and provide adequate long-term protection of the adjacent large *P. australis* bed.

The purpose of the monitoring program is to identify any large-scale changes in seagrass composition and distribution within the Project Boundary and monitor for any changes in the adjacent large bed of *P. australis* at Kurnell during construction and operation that may be attributable to the Project.

1.4 Monitoring to date

This report details the methods and findings of the second baseline seagrass monitoring surveys completed in the summer of 2022. This is the second pre-construction monitoring survey completed as part of the ongoing monitoring program, with the first baseline survey being completed in winter 2021 (Niche 2021a). While focussing on the outcomes of the second baseline survey, this report also incorporates key results from the first baseline survey to develop an understanding of overall baseline conditions and change amongst seagrass communities within the Project Boundary. Monitoring surveys that have been completed as part of the monitoring program to date are identified in Table 1.

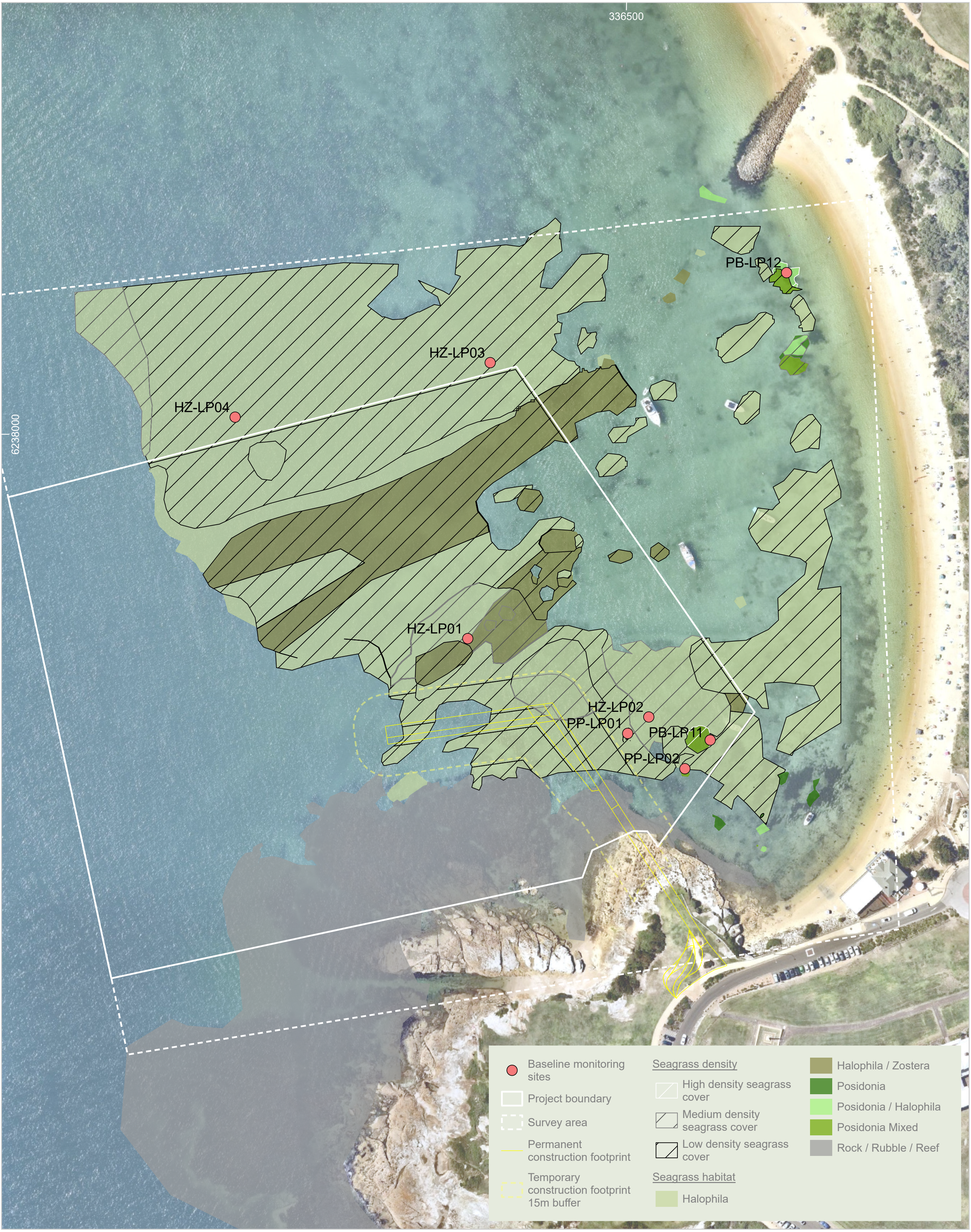
Table 1: Seagrass monitoring surveys completed to date

Survey	Season	Survey date	Period	Reference
Baseline 1	Winter 2021	July – September 2021	Pre-construction	Niche (2021a)
Baseline 2	Summer 2022	February – April 2022	Pre-construction	Current Report

1.5 Baseline 1 Findings

The first pre-construction baseline monitoring survey was completed between July and September, 2021. This first survey (Niche 2021a) included the establishment of the monitoring sites. As part of this process, two additional sites (HZ-K-09 & HZ-K-10) were established at Kurnell to account for areas of higher density *Zostera*-dominated seagrass beds that had established near the shore and in close proximity to the Construction Footprint. During establishment of each *Posidonia* bed monitoring site at Kurnell three Depth of Disturbance (DoD) rods were installed with height above the seabed of 400 mm (Plate 1).

Seagrass mapping during the first baseline survey in winter 2021 (Niche 2021a) identified an area of 9,717 m^2 of seagrasses within the buffer and/or Construction Footprint of the project. This area was dominated by very variable *Zostera* and *Halophila* beds ranging from <1 to 43% cover, while *P. australis* seagrass accounted for only 248 m^2 of the seagrass. Based on distribution mapping, measures of densities within beds and patches, and field observations of smaller patches collected during the winter 2021 survey, it is estimated that there are approximately 10,000 *P. australis* shoots inside the buffer area (including construction footprint) with potential to be impacted, however, there are only approximately 850 *P. australis* shoots within the construction footprint observed at Kurnell only.



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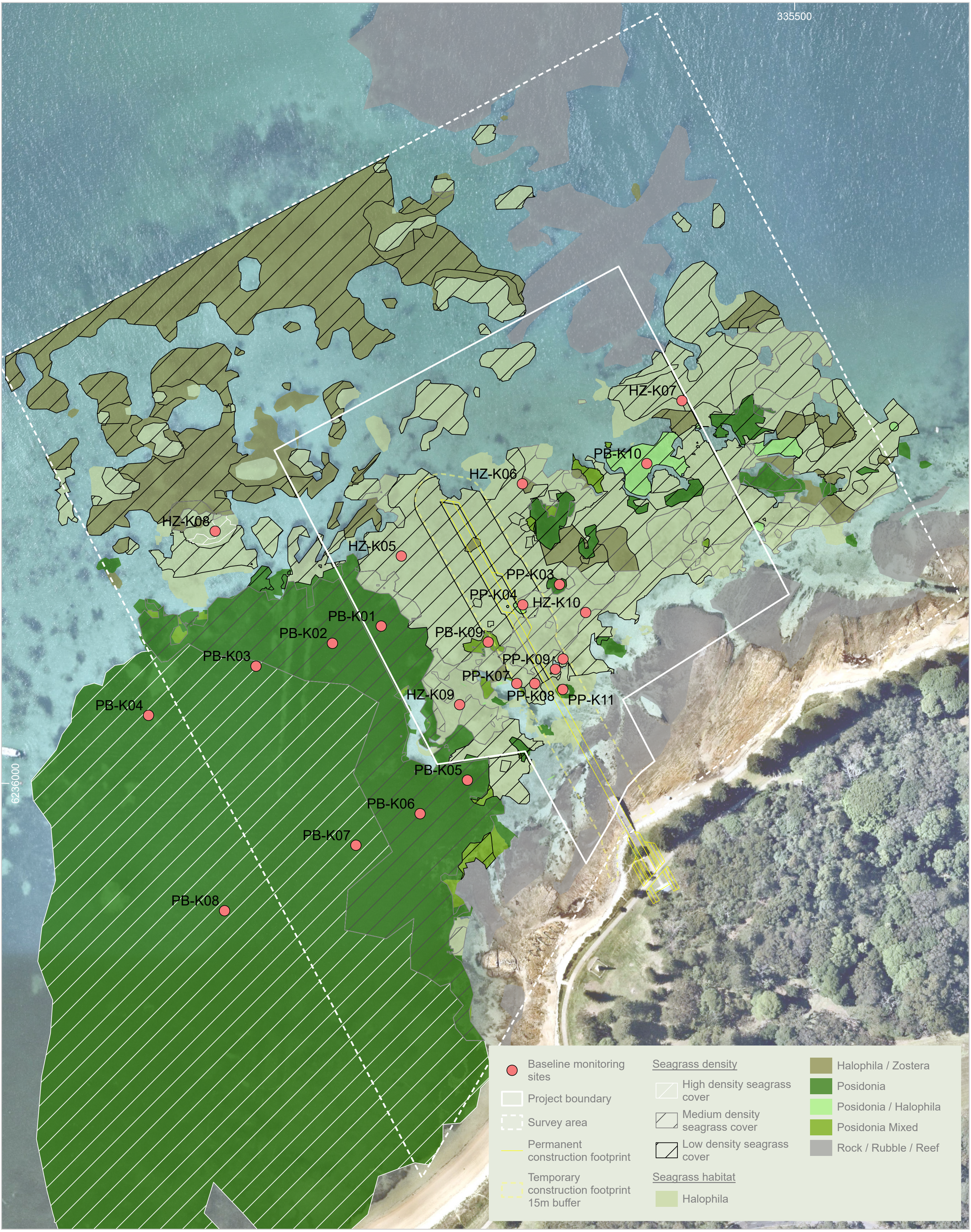
Survey Sites and Habitat Mapping: La Perouse Summer 2022

Kamay Ferry

Niche PM: Matthew Russell
Niche Proj. #: 6649
Client: Arup Pty Ltd

Figure 1

World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community/Terrain: Multi-Directional Hillshade: Airbus,USGS,NGA,NASA,CGIAR,NCEAS,NLS,OS,NMA,Geodatastyrelsen,GSA,GSI and the GIS User Community | Watercourses, Waterbodies, Road and Rail alignments, Protected areas of NSW © Spatial Services 2021. | Niche uses GDA2020 as standard for all project-related data. In order to ensure that data from numerous sources and coordinate systems is aligned, on-the-fly transformation to WGS1984 Web Mercator Auxilliary Sphere is used in the map above. For ease of reference, the grid tick marks and labels shown around the border of the map are presented in GDA2020, using the relevant MGA zone.



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Survey Sites and Habitat Mapping: Kurnell Summer 2022

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Figure 2

v2.0

2. Methods

2.1 Overview

The seagrass monitoring program has been developed to align with the requirements identified within the Marine Biodiversity Offset Strategy (TfNSW 2021b). The program includes four survey approaches:

- Seagrass Mapping: Seagrass distribution mapping of the Project Boundaries;
- Drop Camera Surveys: Drop-camera-based surveys of *Halophila* and *Zostera* seagrass beds;
- *Posidonia* Bed Monitoring: Seagrass morphology surveys of *P. australis* beds (>100 m^2); and
- *Posidonia* Patch Monitoring: Seagrass morphology surveys of smaller *P. australis* patches (<100 m^2).

Specific monitoring sites are shown for La Perouse in Figure 1, and for Kurnell in Figure 2. A full list of site codes and GPS coordinates can be found in Appendix 1.

2.2 Survey Frequency and Timing

Surveys are programmed to be undertaken twice per year (biannually) – with consideration of winter and summer seasons. The pre-construction baseline survey program, including previous surveys completed to date, is summarised in Table 2. A total of four programmed baseline surveys are recommended , with the first baseline survey (Baseline 1) having been completed in winter 2021 (Niche 2021a) and the second baseline survey (Baseline 2) completed in summer 2022. This report addresses the findings of the second baseline survey.

Table 2: Pre-construction survey program

Survey	Status	Season	Survey dates	Reference
EIS survey surveys				
EIS survey	Complete	Winter 2020	June 2020	(Niche 2020a)
EIS survey	Complete	Winter	August – September 2020	(Niche 2020b)
EIS survey	Complete	Summer 2022	December 2020	(Niche 2021b)
Pre-construction baseline monitoring surveys				
Baseline 1	Complete	Winter 2021	July – September 2021	Niche (2021a)
Baseline 2	Complete	Summer 2022	February – April 2022	Current Report
Baseline 3	TBC	Winter	July -August2022	TBC
Baseline 4	TBC	Summer 2022	December 2022	TBC

The second baseline surveys (Summer 2022) were completed over February – April 2022. Dates for each survey method undertaken for the second baseline monitoring set of surveys are identified in Table 3. The significant weather events and associated rainfall presented a limitation to the program by disrupting the ability to survey on consecutive days and under similar conditions within the season. This resulted in some survey methods being completed at different times across the season due to the limited survey windows. Importantly, the seagrass mapping was completed prior to the drop camera surveys, resulting in some somewhat contradictory results where seagrass mapped was no longer present or highly diminished (due to the significant weather events) at the time of the drop camera surveys. Seagrass mapping at La Perouse was also impacted by adverse weather resulting in the collection of some data following the frequent weather events that occurred during the season. Seagrass distributions mapped during these two separate days are likely to have been different because of the high rainfall events and storms that occurred between these two days.

Table 3: Baseline 2 seagrass monitoring survey dates

Methodology	Survey date Kurnell	Survey date La Perouse	Comment
Seagrass mapping	9 – 10 February 2022	10 February and 3 April 2022	Partly delayed by poor weather, swell and water clarity.
Drop camera surveys	25 April 2022	25 April 2022	Delayed by poor weather, swell and water clarity.
Posidonia Bed Monitoring	15 and 18 Feb 2022	15 and 18 Feb 2022	-
Posidonia Patch Monitoring	15 and 18 Feb 2022	15 and 18 Feb 2022	-
DoD rods	15 and 18 Feb 2022	N/A	No depth of disturbance rods were installed at La Perouse.

The unprecedented storm events described above occurred throughout summer 2022. Meaning that the second baseline survey results collected in summer 2022 are representative of impacts associated with the significant storms. For this reason, and due to the ongoing nature of the storms into March and April 2022, a supplementary survey was not required. The impact of the extensive storm events on the pre-construction baseline monitoring surveys are further described and discussed in sections 3.1 and 4.1.

2.3 Seagrass Mapping

2.3.1 Objective

To determine a baseline measure of seagrass composition and distribution within the Survey Area.

2.3.2 Survey Areas

La Perouse

Subtidal areas of seagrass habitat within 50-100m of the Project Boundary (Figure 1).

Kurnell

Subtidal areas of seagrass habitat within 50-100m of the Project Boundary (Figure 2).

2.3.3 Methodology

Preliminary desktop works included review of Nearmap imagery (captured: 21/12/2021) and previously prepared polygons of seagrass distribution developed as part of the Baseline 1 Report (Niche 2021a).

Previously developed layers and associated Nearmap imagery were loaded onto a GIS based field collection device with GPS accuracy of approx. +/-3m. Verification of habitat was recorded on the device as point data using Field Maps Software.

Visual observations to verify the seabed habitat were made using a combination of towed camera (Plate 1) transects through the Survey Area and spot observations using a bathoscope, drop camera or, in the cases of shallow areas and during periods of clear water, observation from the side of the boat. The towed camera was towed within 1 m of the seabed and positioned so imagery was being provided from directly under the survey vessel where seagrass boundaries occurred or within 2 m of the stern of the survey vessel when verifying larger uniform areas. The towed and drop cameras allowed for in situ field verification of mapping by providing video imagery live to the topside monitor on the survey vessel. The vessel sonar, which included CHIRP ClearVu and SideVu sonar that incorporates a thin, wide beam to provide clear images of structure and any larger seagrasses (with lengths of approximately 10cm or greater) below the vessel, was also used to aid mapping and target seabed areas with structure.

Field verification survey effort within seagrass habitat inside the Survey Area consisted of collection of 3,422 points at La Perouse and Kurnell during the Baseline 2 survey, with no greater than 30 m between two verification points.

Post-collection analysis of field verification points was undertaken using GIS software to construct an updated set of habitat polygons. The dataset depicting the distribution and extent of seagrass and non-seagrass habitats was created from interpolated point observations collected on site. Each point was assigned a value for the habitat type (seagrass or non-seagrass) and seagrass habitats were assigned a density value (Low, Medium, High). Polygon data was interpolated by distance, with spatially associated points forming distinct patches of habitat and density. The data was then cleaned to remove errors, and a manual verification and editing pass was conducted by the Niche GIS team to better align boundaries to those observed in recent, high-resolution Nearmap imagery. Finally, the data was verified for accuracy by the Ecology team and edited where required.

2.3.4 Data Analysis

The following calculations were made using GIS Software for La Perouse and Kurnell:

- Seagrass area within the Project Boundary
- Seagrass area within the Construction Footprint
- Seagrass area within the 15 m buffer zone around the construction footprint.

2.4 Drop Camera Surveys

2.4.1 Objective

To determine the baseline community composition and density of *Zostera*- and *Halophila*-dominated seagrass beds in the Project Boundary.

2.4.2 Survey Area

Each baseline monitoring site was a circular area with a radius of 10 m from a central point, amounting to a total area of 314 m^2.

La Perouse

Four drop camera monitoring sites were re-surveyed at La Perouse (Figure 1):

- Two (2) potential 'impact' sites (HZ-LP-01 & HZ-LP-02) within the Project Boundary, that were established during the Baseline 1 survey.
- Two (2) 'control' sites (HZ-LP-03 & HZ-LP-04) outside the Project Boundary, that were established during the Baseline 1 survey.

Kurnell

Six drop camera monitoring sites were re-surveyed at Kurnell (Figure 2):

- Four (4) potential impact sites, two in deeper areas near the seaward end of the wharf (HZ-K-05 & HZ-K-06) and two nearer to the shore in shallower water (HZ-K-09 & HZ-K-10) that were established during the Baseline 1 survey.
- Two (2) control sites (HZ-K-07 & HZ-K-08) outside the Project Boundary that were established during the Baseline 1 survey.

2.4.3 Methodology

The centre point of each monitoring site was located using handheld GPS. Once located, a temporary float was positioned at the centre of the site. Each photo quadrat was haphazardly collected within 10 m of the centre of the site.

Photoquadrats were collected with a drop camera custom designed for seagrass surveys (Plate 1), which can obtain a high-resolution image of a known area of the seabed while providing real time imagery. Care was taken to avoid collecting photographs of the seabed that overlapped during the field survey.

Photos that were of poor quality, taken when the frame was not stationary on the seabed or duplicates were removed from the dataset. A total of 30 photos were then randomly selected from the dataset and uploaded into CPCe Software for analysis. Within the CPCe software a digital photoquadrat was created to form an area of 0.25 m^2 (0.5 x 0.5 m) and 30 points were randomly assigned to the image. Under each point a habitat category was assigned (Table 1).

Table 4: Major and sub-categories used with the CPCe Software.

Major category	Sub-categories
SEAGRASS (S)	Halophila, Zostera, Posidonia
ALGAE (A)	Macroalgae, Turfing Algae, Epiphytic Algae (when identified to be attached to the seagrass)
CORAL (C)	Hard Coral, Soft Coral
SUBSTRATE (SU)	Gravel & Shell, Rock & Rubble, Sand & Silt
OTHER BIOTA (OB)	Sessile Invertebrate
TAPE WAND SHADOW (TWS)	Tape, Wand (frame), Shadow (insufficient resolution), Macroalgae Wrack, Seagrass Wrack, Other Debris.

2.4.4 Data Analysis

Within the CPCe software percent cover for each of the categories (except Tape, Wand and Shadow) and sub-categories were calculated for each photoquadrat (Plate 1), while Tape, Wand and Shadow were excluded from the percent cover calculations. Summaries for each site including means and standard errors were then calculated for:

- Seagrass cover by type
- Sediment/silt cover
- Turfing algae cover
- Epiphytic algae cover.

2.5 Posidonia Bed Monitoring

2.5.1 Objective

To determine the baseline community composition and biomass (density and leaf lengths) of *P. australis* seagrass beds (>100 m^2) with potential to be impacted during construction and operation.

2.5.2 Survey Area

Each monitoring site was a circular area with a radius of 5 m from a central point, amounting to a total area of 79 m^2.

La Perouse

Two *P. australis* bed monitoring sites were re-surveyed at La Perouse (Figure 1):

- One (1) potential impact site (PB-LP11) within the Project Boundary that was established during the Baseline 1 survey.
- One (1) control site (PB-LP12) outside the Project Boundary that was established during the Baseline 1 survey.

Kurnell

Ten *P. australis* bed monitoring sites were re-surveyed at Kurnell (Figure 2):

- Eight (8) potential impact sites within the large extensive bed of *P. australis* to the west of the Project Boundary (PB-K01 to PB-K08) that was established during the Baseline 1 survey. These sites are positioned within the main western bed to allow for a gradient-based approach to monitoring for impacts to the large bed of *P. australis* to the west of the Project Boundary. Sites are located along two longshore transects (one near shore and one offshore) at a range of distances from the Construction Footprint (Approx. 75 m, 100 m, 150 m and 230 m).
- Two (2) additional potential impact sites within much smaller beds of *P. australis* inside the Project Boundary (PB-K09 and PB-K10) that was established during the Baseline 1 survey.
- Control sites will be determined at the completion of the baseline monitoring. It is envisaged they will be selected from monitoring sites in the main western bed outside the Project Boundary (e.g. PB-K03, -K04, -K07 and -K08). There is also potential to include the most easterly site in the Project Boundary as a control site, where impact from the proposal is considered unlikely.

2.5.3 Methodology

The centre point of each monitoring site was located using handheld GPS and is marked by the centre DoD rods (Kurnell Only). Once located a temporary float was positioned at the centre of the site. Seagrass was haphazardly surveyed via five 0.25 m^2 (0.5 x 0.5 m) quadrats within 5 m of the centre of the site.

Within each quadrat the following data were recorded by ADAS scientific divers:

- Shoot density (counted from the sheaf) for each seagrass species present (Note *Halophila* counted as shoots).
- Percent of shoots with visible sheafs for 10 randomly selected *P. australis* shoots.
- Visible sheaf Length for 10 randomly selected *P. australis* shoots.
- Epiphyte Load (scored 1-5, see Appendix 2) for 10 randomly selected leaves for each seagrass species present.

In addition to the above measurements a photograph was taken above each quadrat for archiving purposes.

DoD rods were installed in the Baseline 1 survey (Niche 2021a). Where relocated without disturbance, the measurement of sediment accretion and erosion were collected using the DoD rods. A measurement was recorded between the sediment and the bottom of the cork and the steel washer and the top of the sediment where sediment accretion had occurred. The DoD rods were then reset with the washers on the seabed and 40 cm distance between the washer and bottom of the cork.

2.5.4 Data Analysis

Data calculations and summaries included means and standard errors for the following:

- Shoot (Shoot *Halophila*) count per 0.25 m^2
- Leaf length (cm)
- Epiphyte load score.

In the first and second baseline surveys, many seagrass sheafs for *P. australis* shoots were found to be covered by sediment and sheaf measurements could not be obtained. For the purposes of the program it was deemed more appropriate to present sheaf data as percent of shoots with visible sheafs rather than as measurements of sheaf length (which are no longer recorded).

2.6 Posidonia Patch Monitoring

2.6.1 Objective

To determine the baseline community composition and biomass (shoot density and leaf lengths) of *P. australis* seagrass patches (<100 m^2) in close proximity to the Construction Footprint.

2.6.2 Survey Area

Patches (<100 m^2) of *P. australis* seagrass that met the following criteria were surveyed:

- Inside or within 15 m of the construction footprint
- Shoot density of at least five shoots per 1 m^2
- Has a size of at least 10 m^2 and minimum average width/radius of 2 m.

La Perouse

Two *P. australis* patches were re-surveyed at La Perouse that were established during the Baseline 1 survey (Figure 1):

- PP-LP-01: Approximately 10 m east of the 15 m buffer
- PP-LP-02: Approximately 15 m east of the 15 m buffer

Kurnell

Ten *P. australis* patches were re-surveyed at Kurnell that were established during the Baseline 1 survey. (Figure 2):

- PP-K-03: Approximately 15 m east of the 15 m buffer.
- PP-K-04: Inside the Construction Footprint and 15 m buffer.
- PP-K-07: Approximately 3 m west of the 15 m buffer.
- PP-K-08: On the western edge of the 15 m buffer.
- PP-K-09: On the eastern edge of the 15 m buffer.
- PP-K-11: On the eastern edge of the 15 m buffer. Note that this site has a *Zostera* patch in the middle that was not sampled.
- PP-K-12: On the eastern edge of the 15 m buffer.

2.6.3 Methodology

The centre point of each monitoring site was located using handheld GPS and is marked by a Depth of Disturbance (DoD) rod (Kurnell Only). Once located a temporary float was positioned at the centre of the site. Seagrass was haphazardly surveyed via up to five 0.25 m^2 (0.5 x 0.5 m) quadrats within 5 m of the centre of the site.

Within each quadrat the following data were recorded by ADAS scientific divers:

- Shoot density (counted from the sheaf) for each seagrass species present (Note *Halophila* counted as shoots).
- Leaf Length of 10 randomly selected leaves for both *Zostera* and *P. australis*.

- Percent of shoots with visible sheafs for 10 randomly selected *P. australis* shoots.
- Epiphyte Load (scored 1-5, see Appendix 2) for 10 randomly selected leaves for each seagrass species present.

In addition to the above measurements a photograph was taken above each quadrat for archiving purposes.

2.6.4 Data Analysis

Data calculations and summaries included means and standard errors for the following:

- Shoot (Shoot *Halophila*) count per 0.25 m^2
- Leaf length (cm)
- Percent of shoots with visible sheafs
- Epiphyte load score.

3. Results

3.1 Survey conditions

A combined total of 577 millimetres of rain fell over the summer months (December 2021, January 2022 and February 2022), which is over half of the average annual rainfall recorded at Sydney Airport (Bureau of Meteorology (BOM) station number 66037). Rainfall was above average in each of these months (Table 5), with particularly high falls in the month of February. As shown in Figure 3, several peaks in daily rainfall exceeding 50 millimetres of rainfall over 24 hours were recorded during the summer period, with the highest (145.8 millimetres) recorded on 23 February 2022. These conditions continued into the early autumn months of March and April 2022.

Table 5: Monthly rainfall summaries from BOM station number 66037 (BOM 2022)

Summary data (mm)	December 2021	January 2022	February 2022	March 2022	April 2022
Mean (1929-2022)	72.9	93.9	117.2	124.7	106.5
Total (2021-22)	83.0	110.2	383.8	489.4	247.2

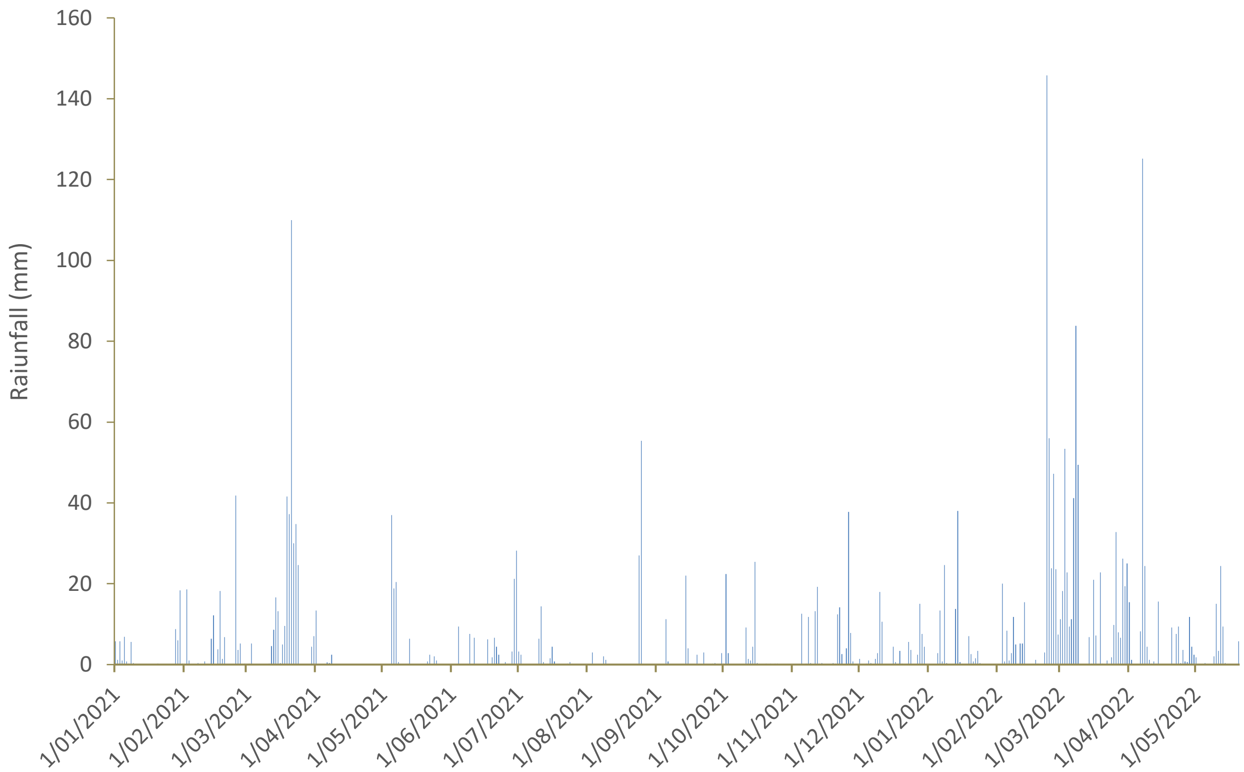

Figure 3: Rainfall 2021 – 2022 from station no. 66037 (Bureau of Meteorology 2022)

Wave height data (IMOS 2022) recorded by Waverider buoys Observations offshore of Sydney provides an indication of relative wave heights experienced throughout summer 2022 and the second baseline monitoring season (Figure 4). Figure 4 indicates a general increase in maximum wave heights during January – May 2022, with the incidence of higher maximum wave heights also appearing to increase during this period. A review of wind data also recorded by Waverider buoys Observations offshore of Sydney (IMOS 2022) identifies that south-easterly winds were dominant during this period.

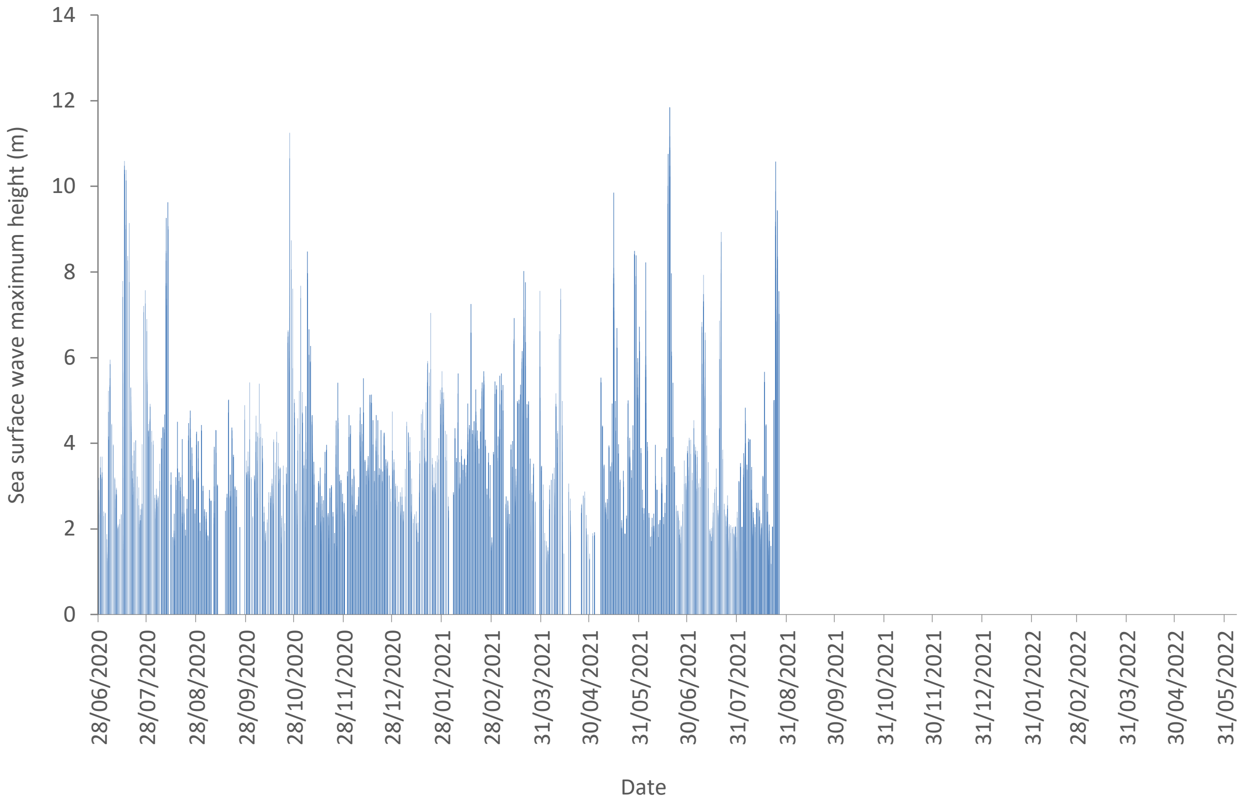

Figure 4: Sea surface wave maximum height records, Waverider buoys Observations: Sydney (IMOS 2022)

The high rainfall events and east coast weather events that occurred throughout the summer season impacted on water quality /visibility which delayed the surveys, as described in section 2.2. These events also resulted in floods and easterly swells that impacted upon seagrass communities. Extensive shoreline erosion because of the swell and wave refraction was observed at La Perouse during February and March 2022, with these effects also impacting upon seagrass distributions and densities (addressed in section 3.2).

3.2 Seagrass Distribution

As part of the second baseline monitoring survey in summer 2022, 60,272 m^2 (6.027 ha) of seagrasses were mapped within the entire Project Boundary at La Perouse and Kurnell. This included 1,042 m^2 (0.104 ha) of seagrasses within the Construction Footprint and an additional 4,585 m^2 (0.459 ha) within the 15 m buffer area at Kurnell. At La Perouse, 676 m^2 (0.068 ha) of seagrasses within the Construction Footprint and an additional 2,499 m^2 (0.250 ha) within the 15 m buffer area. The vast majority of seagrass mapped in the second baseline survey was comprised of *Halophila* beds (Table 6).

Table 6: Seagrass area mapped during the second baseline monitoring survey within the Project Boundary, Construction Footprint and associated buffer zone.

Area	Baseline 2 (summer 2022)			Baseline 1 (winter 2021)		
	Kurnell (m^2)	La Perouse (m^2)	Total (m^2)	Kurnell (m^2)	La Perouse (m^2)	Total (m^2)
Project boundary						
Posidonia	3555	0	3555	2864	0	2864
Posidonia / Halophila	838	0	838	843	170	1013
Posidonia / Zostera	0	0	0	0	0	0
Posidonia Mixed	484	132	616	772	0	772
Zostera	0	0	0	199	0	199

Area	Baseline 2 (summer 2022)			Baseline 1 (winter 2021)		
	Kurnell (m^2)	La Perouse (m^2)	Total (m^2)	Kurnell (m^2)	La Perouse (m^2)	Total (m^2)
Zostera / Halophila	2246	7704	9951	27243	6417	33660
Halophila	19258	17252	36510	1874	25340	27214
Total	*26381*	*25089*	*51469*	*33795*	*31927*	*65722*
Construction footprint						
Posidonia	0	0	0	4	0	4
Posidonia / Halophila	14	0	14	16	0	16
Posidonia / Zostera	0	0	0	0	0	0
Posidonia Mixed	0	0	0	0	0	0
Zostera	0	0	0	52	0	52
Zostera / Halophila	42	0	42	867	0	867
Halophila	985	676	1661	57	991	1048
Total	*1042*	*676*	*1718*	*996*	*991*	*1987*
Buffer area						
Posidonia	106	0	106	70	0	70
Posidonia / Halophila	23	0	23	22	0	22
Posidonia / Zostera	0	0	0	0	0	0
Posidonia Mixed	91	0	91	136	0	136
Zostera	0	0	0	146	0	146
Zostera / Halophila	7	0	7	3745	52	3797
Halophila	4358	2499	6858	84	3474	3558
Total	*4585*	*2499*	*7085*	*4203*	*3526*	*7729*

The combined total of *Posidonia australis* seagrass (including *Posidonia*, *Posidonia / Halophila*, *Posidonia / Zostera* and *Posidonia* mixed beds) mapped in both baseline surveys are presented in Table 7. During the Baseline 2 survey (summer 2022) a total of 234 m^2 of *Posidonia australis* seagrass was mapped within the construction footprint and buffer area at Kurnell (Figure 2). This equates to a 30% reduction in the area of *Posidonia australis* within the Construction Footprint and a 3.51% reduction within the buffer area at Kurnell (Table 8) between the first and second baseline surveys. No *Posidonia australis* seagrass was mapped within the construction footprint or buffer area at La Perouse (Figure 1).

Table 7: *Posidonia australis* seagrass (including *Posidonia, Posidonia / Halophila, Posidonia / Zostera* and *Posidonia* Mixed beds) areas mapped during baseline surveys to date.

Area	Baseline 2 (summer 2022)			Baseline 1 (winter 2021)		
	Kurnell (m^2)	La Perouse (m^2)	Total (m^2)	Kurnell (m^2)	La Perouse (m^2)	Total (m^2)
Project boundary	4876	132	5008	4479	170	4649
Construction footprint	14	0	14	20	0	20
Buffer area	220	0	220	228	0	228

Table 8: Percentage change in *Posidonia australis* seagrass (including *Posidonia, Posidonia / Halophila, Posidonia / Zostera* and *Posidonia* Mixed beds) areas mapped between baseline surveys 1 and baseline survey 2.

Area	Kurnell	La Perouse	Total
Project boundary	8.86%	-22.35%	7.72%
Construction footprint	-30.00%	N/A	-30.00%
Buffer area	-3.51%	N/A	-3.51%

An overall reduction in the total amount of seagrass within the entire Project boundary at La Perouse and Kurnell was identified between the first two baseline surveys (Appendix 3). Comparisons of seagrass distributions between the two baseline surveys are displayed in Figure 5, Figure 6 and Figure 7. These figures identify that changes in seagrass distributions between the seasons have been predominantly driven by a declines in areas of *Zostera* and *Zostera/Halophila* seagrass, while areas of *Halophila* increased.

These findings align with an examination of spatial seagrass distributions (Figure 1 and Figure 2), when compared to that completed in winter 2021 (Niche 2021a). During the Baseline 2 (summer 2022) survey at Kurnell, the change in distribution of *Posidonia* was found to be very minimal, with mapped densities similar to the Baseline 1 survey (winter 2021). Mapping found *Halophila* replaced the *Halophila/Zostera* beds previously mapped closer to the shore. At La Perouse, areas of *Halophila*/*Zostera* have reduced in extent in the second baseline survey (summer 2022) in the near shore (shallower) zones. As was also the case at Kurnell, areas of *Halophila*/*Zostera* seagrass in the near shore zone were found to contain *Halophila* only in baseline 2, although bands of *Zostera* were recorded in deeper areas within the large *Halophila* bed. Many areas of seagrass have also been described to be of low density in this survey, in comparison with the previous survey where many of these areas were described as medium density.

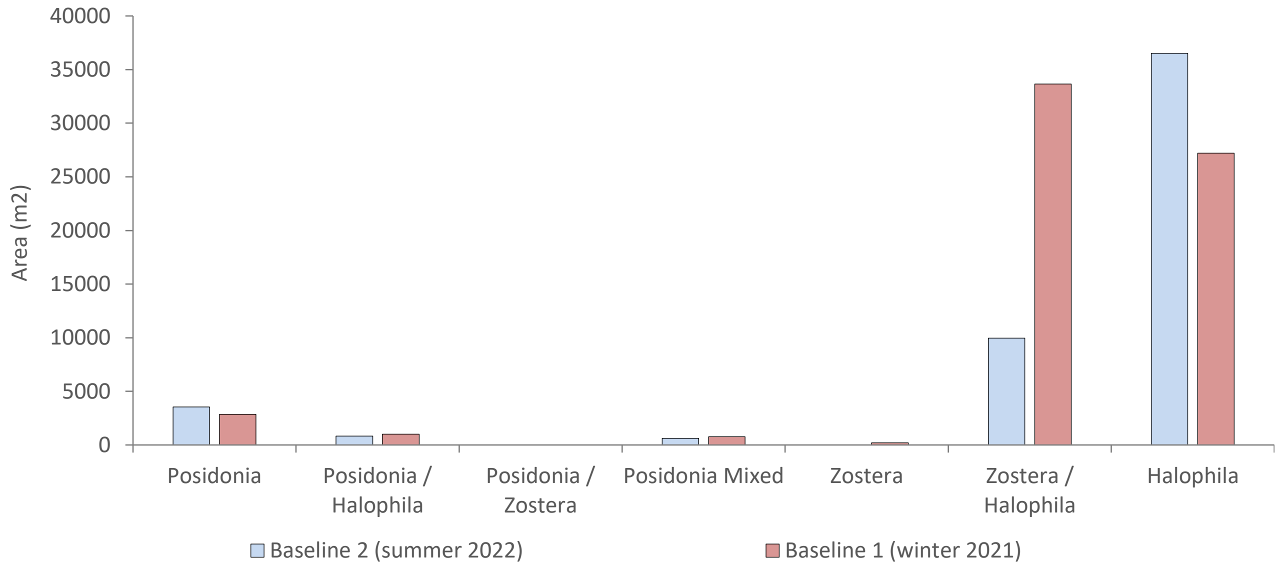

Figure 5: Seagrass distributions within the Project boundary in Baseline 2 (summer 2022) and Baseline 1 (winter 2021).

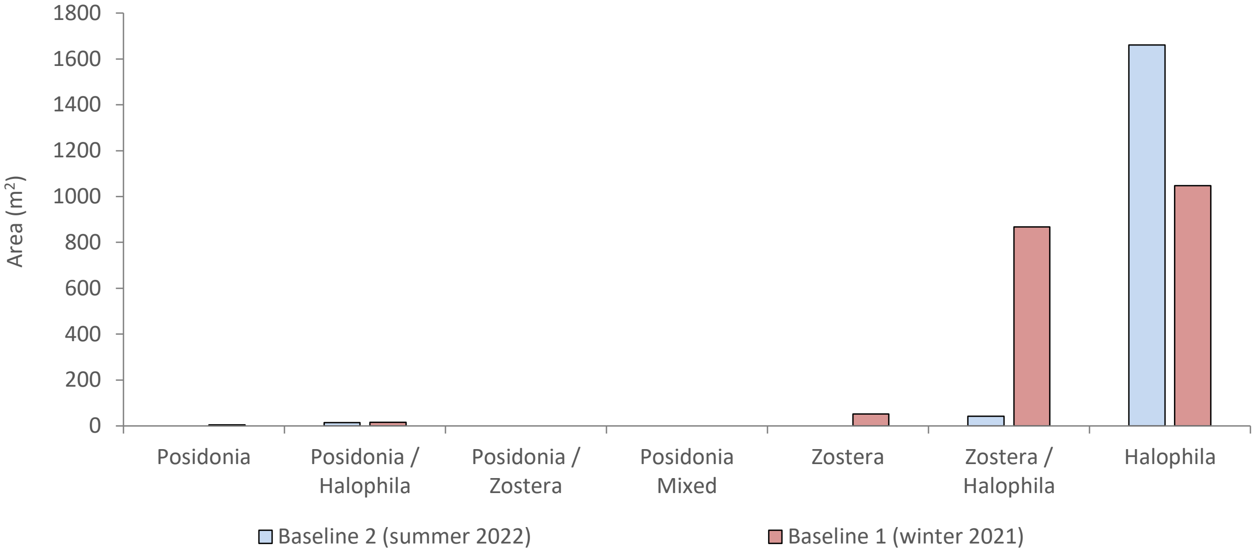

Figure 6: Seagrass distributions within the Construction footprint in Baseline 2 (summer 2022) and Baseline 1 (winter 2021).

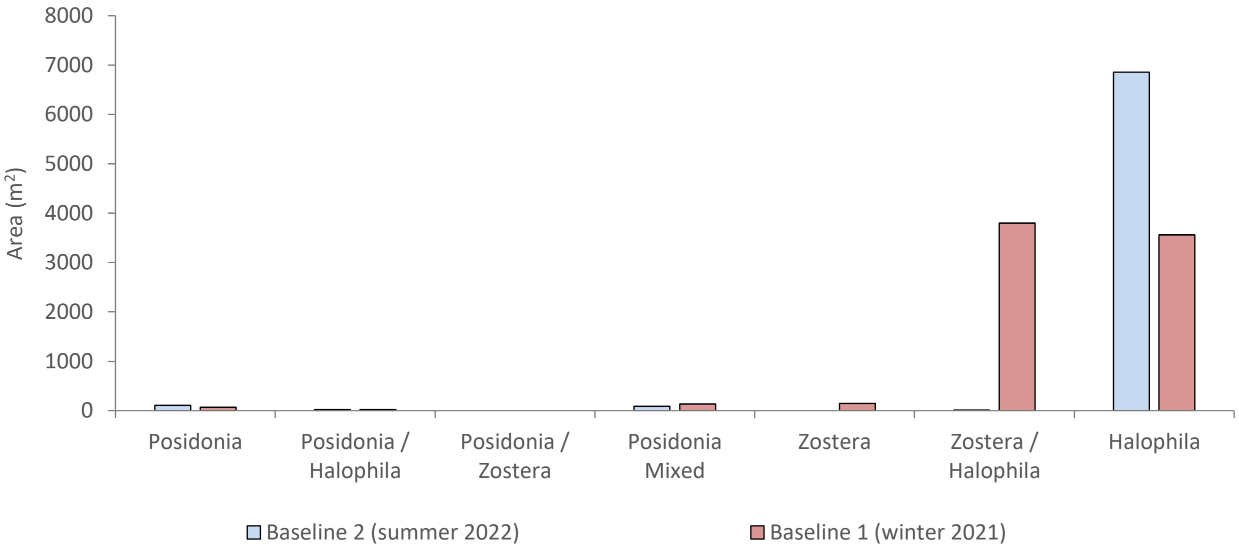

Figure 7: Seagrass distributions within the Buffer area in Baseline 2 (summer 2022) and Baseline 1 (winter 2021).

3.3 *Zostera* and *Halophila* seagrasses

The key results for cover of *Zostera*- and *Halophila*-dominated beds (Figure 8) in the second baseline survey (summer 2022) are summarised below, with further data provided in Appendix 2:

- A substantial reduction in seagrass cover across the monitoring sites was observed in the second baseline survey in summer 2022 (Figure 8) when compared to the first baseline survey in winter 2021 (Figure 9), with no seagrass of any species detected at HZ-LP02 during the drop camera survey.
- At La Perouse, seagrass cover ranged between 0-7% total cover, comprised entirely of *Halophila* sp. with no *Zostera* detected during this drop camera survey.
- At La Perouse the sites inside the Project Boundary (HZ-LP-01 and HZ-LP-02) showed a trend of lower total seagrass cover than at the control sites outside the Project Boundary (HZ-LP-03 and HZ-LP-04). Notably, no seagrass of any species was detected at HZ-LP02 during this drop-camera survey.
- At Kurnell, seagrass cover was very variable (0.22-20.88% total cover), dominated by *Halophila* sp., with *Zostera* very minimal and restricted to sites HZ-K09 and HZ-K10.

- At Kurnell, seagrass cover and composition at the four beds further from shore (HZ-K-05 to HZ-K-08) were noticeably different from those for the two sites closer to shore and adjacent to the Construction Footprint (HZ-K-09 and HZ-K-10), this included:
  - At Kurnell the seagrass beds further from shore (HZ-K-05 to HZ-K-08) had very low seagrass cover (<1.5%) with only *Halophila* seagrass present.
  - At Kurnell, seagrass beds at the sites close to shore and adjacent to the Construction Footprint (HZ-K-09 and HZ-K-10) had substantially higher cover of seagrass than at other sites (12.7-20.5%), with *Zostera* also present in limited amounts.
  - Substantial decreases in the cover of *Zostera* at the two sites closer to shore and adjacent to the Construction Footprint (HZ-K-09 and HZ-K-10) were observed in this survey.

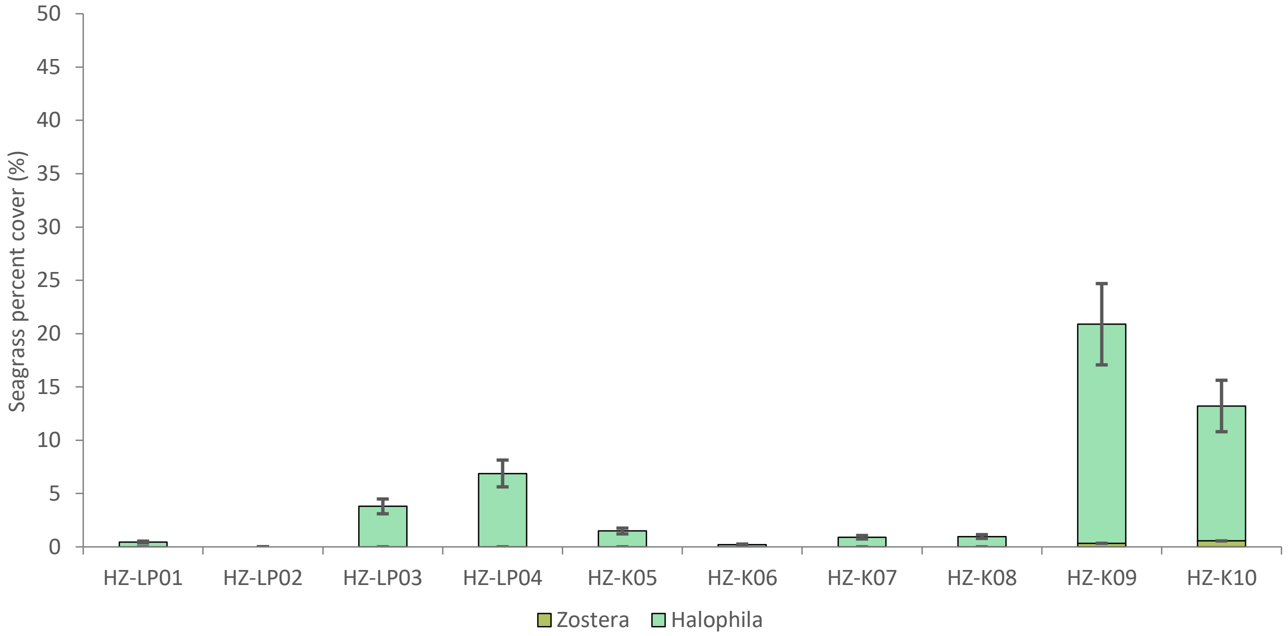

Figure 8: Baseline 2 (summer 2022), mean Halophila and Zostera seagrasses cover (+/- SE total seagrass cover).

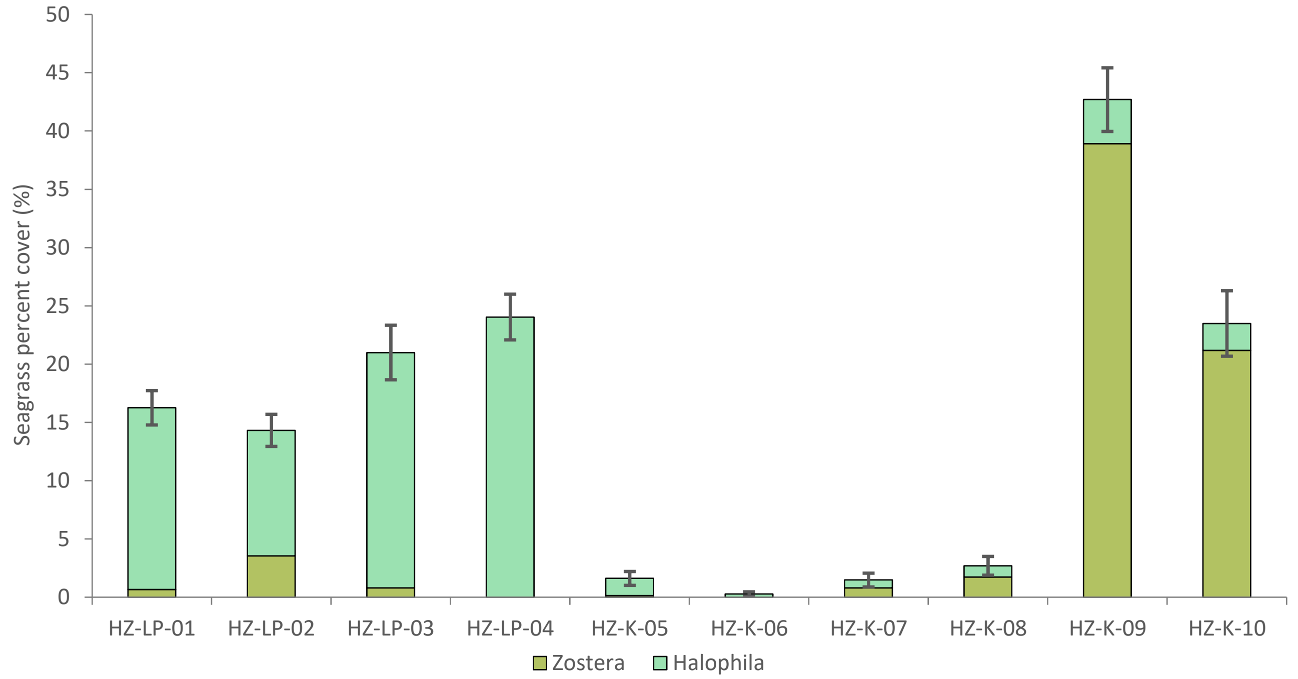

Figure 9: Baseline 1 (winter 2021), mean Halophila and Zostera seagrasses cover (+/- SE total seagrass cover).

At La Perouse, sediment cover was greater in this survey, contributing to 52-91% cover (Table 9). Turfing algae was present at sites HZ-LP-01 and HZ-LP-02 during this survey where it was previously absent, and absent from sites HZ-LP-03 and HZ-LP-04 where it was previously present. Notably, the cover of turfing algae at HZ-LP-02 was higher (4%) than previously recorded at any site (<0.6%).

Similar to La Perouse, sediment cover at Kurnell was greater in this survey (Table 9). As in the first baseline survey (winter 2021), in the second baseline survey (summer 2022) the four sites further from shore (HZ-K-05 to HZ-K-08) recorded the most sediment (98-99.6%), while the two sites closer to shore (HZ-K-09 and HZ-K-10) had the least (79-87%).

In this survey no epiphytic algae were recorded at any monitoring site during Baseline 2 (summer 2022). This is in contrast to Baseline 1 (winter 2022), where epiphytic algae were present at the majority of locations (Table 9).

Table 9: Mean covers of sediment, turfing algae and epiphytic algae at each site over winter 2021 and summer 2022.

Site	Sediment		Turfing algae		Epiphytic algae	
Season	Baseline 2 (summer 2022)	Baseline 1 (winter 2021)	Baseline 2 (summer 2022)	Baseline 1 (winter 2021)	Baseline 2 (summer 2022)	Baseline 1 (winter 2021)
HZ-LP-01	51.77	67.77	0.23	0.00	0.000	0.00
HZ-LP-02	82.94	83.16	4.11	0.00	0.00	0.48
HZ-LP-03	91.40	75.45	0.00	0.03	0.00	0.00
HZ-LP-04	74.27	46.92	0.00	0.07	0.00	0.03
HZ-K-05	98.40	94.90	0.12	0.33	0.00	0.50
HZ-K-06	99.55	95.06	0.00	0.07	0.00	0.90
HZ-K-07	98.42	96.64	0.00	0.00	0.00	0.43
HZ-K-08	99.03	92.35	0.00	0.57	0.00	0.57
HZ-K-09	78.78	57.00	0.34	0.00	0.00	0.03
HZ-K-10	86.79	76.22	0.00	0.00	0.00	0.07

3.4 *Posidonia* Seagrasses

3.4.1 Shoot density

The key results from the shoot density surveys at *Posidonia* bed monitoring sites (PB-) and *Posidonia* patch monitoring sites (PP-) in the second baseline survey (Summer 2022) (Figure 10, Table 10) were:

- All *Posidonia* monitoring sites were found to include all three seagrass species, except sites PB-K02 and PB-LP11, where *Zostera* was absent. Similarly, all *Posidonia* patches were found to include all three seagrass species, except patches PP-LP01 and PP-LP02, where *Zostera* was absent. This is in contrast with the previous survey (Figure 11), where all three seagrass species were found at every site and patch.
- Average *P. australis* shoot density at *Posidonia* bed monitoring sites ranged between 12.2 shoots per 0.25 m^2 (PB-K10) and 50.4 shoots per 0.25 m^2 (PB-K07). The highest *P. australis* densities were recorded at sites towards the centre of the main bed (southwest of the project boundary) at Kurnell (PB-K07 and PB-K08). Although lower relative densities were also recorded elsewhere within this main bed (PB-K02, PB-K01, PB-K03, PB-K05, PB-K04), at sites that were typically closer to the margins of the extent of the bed.
- The lowest densities were recorded at monitoring sites within the smaller beds at Kurnell (PB-K10, PB-K09) (Figure 10).

- Average *P. australis* shoot density in *Posidonia* patches at La Perouse and Kurnell ranged between 12.4 shoots per 0.25 m^2 (PP-K03) and 24.7 shoots per 0.25 m^2 (PP-LP02).
- The presence of *Zostera* and *Halophila* amongst *P. australis* at Kurnell sites was recorded in higher densities in comparison to at the La Perouse sites (Table 10, Figure 10).
- The La Perouse impact site (PB-LP-11) and control site (PB-LP-12) were similar in *P. australis* shoot densities, however no *Zostera* seagrass was recorded at the PB-LP-11 impact site in this survey.

The key differences between the Baseline 1 (summer 2022) and Baseline 2 (winter 2021) surveys (Figure 10 and Figure 11) are identified as:

- The overall shoot density (of combined seagrass species) was greater at all sites in the second baseline survey.
- The relative density of *Halophila* was observed to increase at all sites in the second baseline survey. This increase appears to have been the dominant contributor to the overall increase in shoot density across the sites, which has occurred despite the relative decrease of *Zostera* at some locations.
- A decrease in the relative density of *Zostera* was observed at the majority of sites including PB-K01, PB-K02, PB-K08, PB-K09, PB-K10, PB-LP11, PP-LP01, PP-LP02, PP-K03, PP-K04, PP-K07, PP-K08, PP-K09 PP-K11. With no *Zostera* recorded at four of these sites (PB-K02, PB-LP11, PP-LP01, PP-LP02) in summer 2022.
- While the relative density of *Posidonia* was generally observed to increase, a decrease was identified at six of the locations (PB-K03, PB-K05, PB-K06, PB-K10, PP-K03, PP-K04) in the second baseline survey.

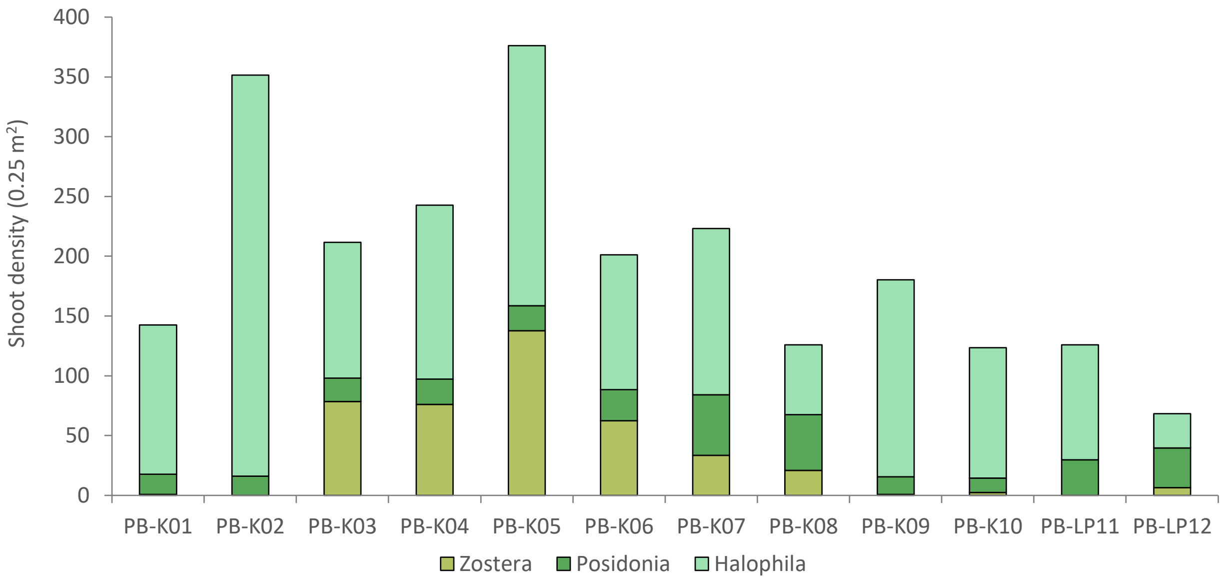

Figure 10: Mean shoot density of each seagrass species within the *Posidonia* bed monitoring sites in Baseline 2 (summer 2022).

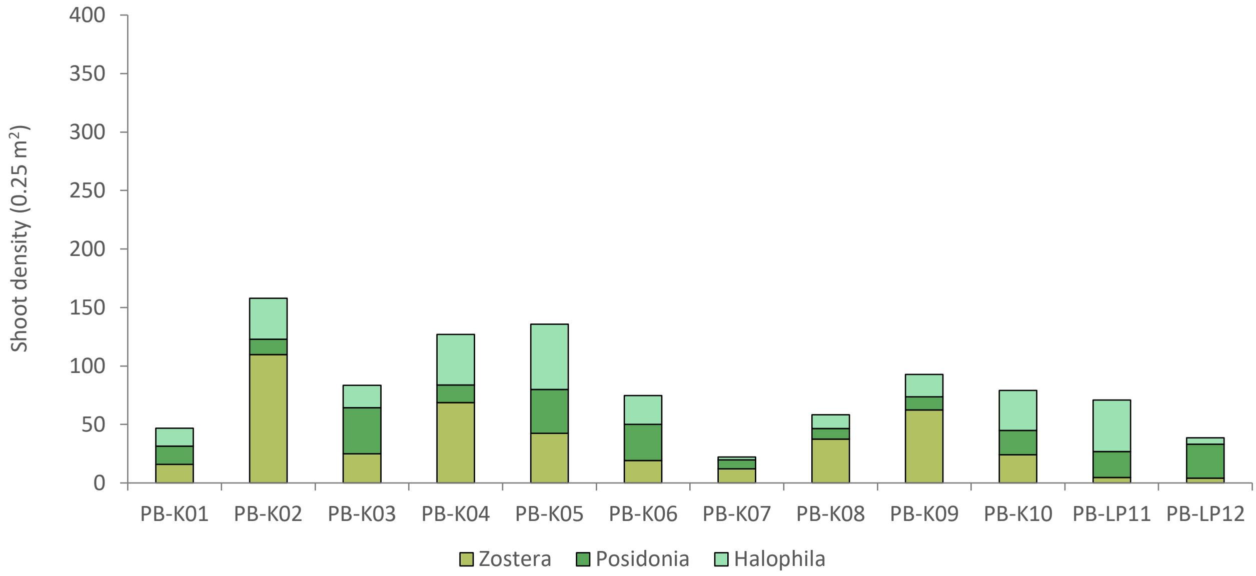

Figure 11: Mean shoot density of each seagrass species within the *Posidonia* bed monitoring sites in Baseline 1 (winter 2021).

Table 10: Average shoot density recorded at *Posidonia* bed monitoring sites and patches.

Average shoot density (O.25 m²)						
Season	**Baseline 2 (summer 2022)**			**Baseline 1 (winter 2021)**		
Species	***Halophila***	***Zostera***	***Posidonia***	***Halophila***	***Zostera***	***Posidonia***
PB-K01	124.8	0.8	16.8	15.2	15.8	15.8
PB-K02	335.2	0.0	16.2	35.2	109.6	13.2
PB-K03	113.6	78.4	19.6	19.2	24.8	39.6
PB-K04	145.6	76.0	21.2	43.2	68.8	15.0
PB-K05	217.6	137.6	21.0	56.0	42.4	37.4
PB-K06	112.8	62.4	26.0	24.8	19.2	30.8
PB-K07	139.2	33.6	50.4	2.4	12.0	7.8
PB-K08	58.4	20.8	46.8	12.0	37.6	8.8
PB-K09	164.8	0.8	14.8	19.2	62.4	11.2
PB-K10	108.8	2.4	12.2	34.4	24.0	20.8
PB-LP11	96.0	0.0	29.8	44.0	4.8	22.0
PB-LP12	28.8	6.4	33.2	5.6	4.0	29.0
PP-LP01	152.0	0.0	13.0	140.0	4.0	12.0
PP-LP02	128.0	0.0	24.7	97.3	13.3	15.3
PP-K03	428.0	4.8	12.4	32.8	32.8	17.4
PP-K04	230.4	4.0	12.8	83.2	62.4	13.0
PP-K07	322.0	7.0	16.0	155.0	146.0	6.5
PP-K08	220.0	12.0	14.3	50.7	104.0	13.0
PP-K09	110.0	52.0	15.3	24.0	71.0	13.0
PP-K11	184.0	22.0	20.0	42.0	76.0	17.3

Figure 12 illustrates patterns in *Posidonia* shoot density in the outer transect of the main *Posidonia* bed (Figure 2) along sites PB-K01, PB-K02, PB-K03, PB-K04, which increase in distance from the Construction Footprint. Similar overall patterns of increases in *Posidonia* shoot density with distance from the Construction Footprint are observed between the two baseline surveys. Key differences between the seasons includes the substantial increase relative in density at PB-K03 in this survey, while minor decreases are detected at the other monitoring sites in this survey relative to the previous survey.

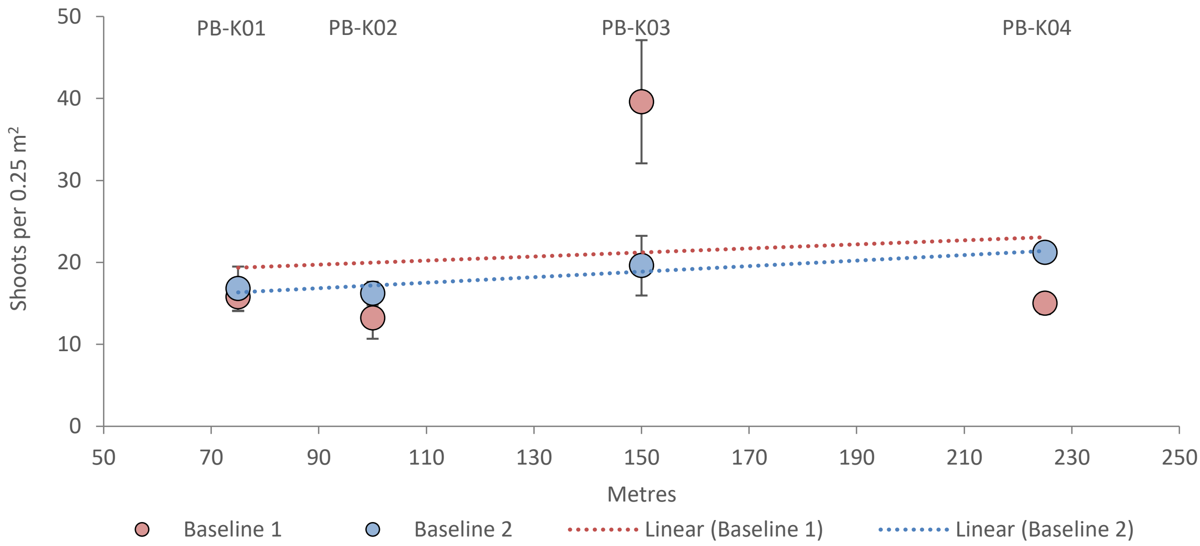

Figure 12: Mean *Posidonia* shoot density at Posidonia bed monitoring sites (+/-SE), positioned at different distances from the Construction Footprint along the outer transect (PB-K01, PB-K02, PB-K03, PB-K04), in Baseline 1 (winter 2021) and Baseline 2 (summer 2022).

Figure 13 illustrates patterns in *Posidonia* shoot density in the inner transect of the main *Posidonia* bed (Figure 2) along sites PB-K05, PB-K06, PB-K07, PB-K08, which increase in distance from the Construction Footprint. Differing overall patterns in *Posidonia* shoot density with distance from the Construction Footprint are observed between the surveys, with overall increases with distance occurring this survey and decreases in the previous survey.

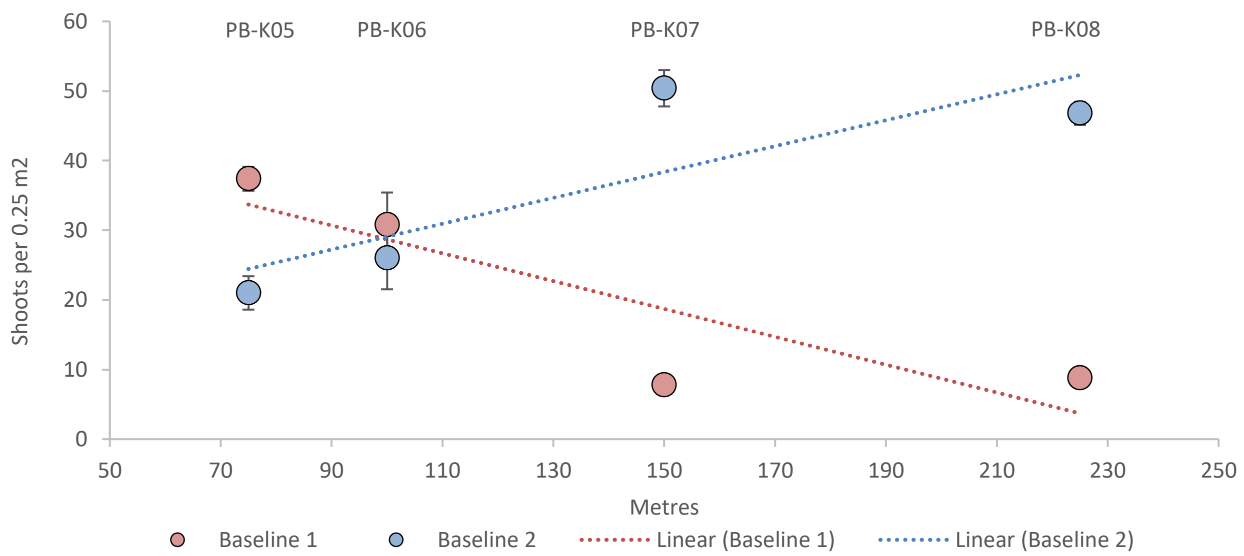

Figure 13: Mean *Posidonia* shoot density at Posidonia bed monitoring sites (+/-SE), positioned at different distances from the Construction Footprint along the inner transect (PB-K05, PB-K06, PB-K07, PB-K08).

Further data are provided in Appendix 3.

3.4.2 Leaf Length

The results for assessment of leaf lengths at *Posidonia* bed monitoring sites (PB-) and *Posidonia* patch monitoring sites (PP-) for both pre-construction monitoring seasons are presented in Table 11 below. Further data are provided in Appendix 3.

P. australis leaf lengths

The key results for leaf lengths at *Posidonia* bed monitoring sites and patches in the Baseline 2 survey are summarised below:

- Mean leaf lengths for *P. australis* ranged between 28.5 (PB-K02) and 46.2 cm (PB-LP11) across all monitoring sites within *Posidonia* beds.
- Mean leaf length for *P. australis* within the smaller *Posidonia* patch monitoring sites ranged between 27.8 cm (PP-K03) and 42 cm (PP-K11). While the range of mean leaf lengths was lower than that at *Posidonia* beds, leaf lengths were typically slightly longer at these patches.
- Where present, the mean leaf length for *Zostera* was variable across *P. australis* bed monitoring sites, ranging between 7.5 cm (PB-K06) and 16.1 cm (PB-K08).

When compared to the first baseline survey, the average leaf lengths for *P. australis* across the *Posidonia* monitoring beds were typically longer in the second monitoring survey (Figure 14), with PB-K05 and PB-K09 being the exception to this. The greatest increase between surveys in average *P. australis* leaf length occurred at sites PB-K03 and PB-K04.

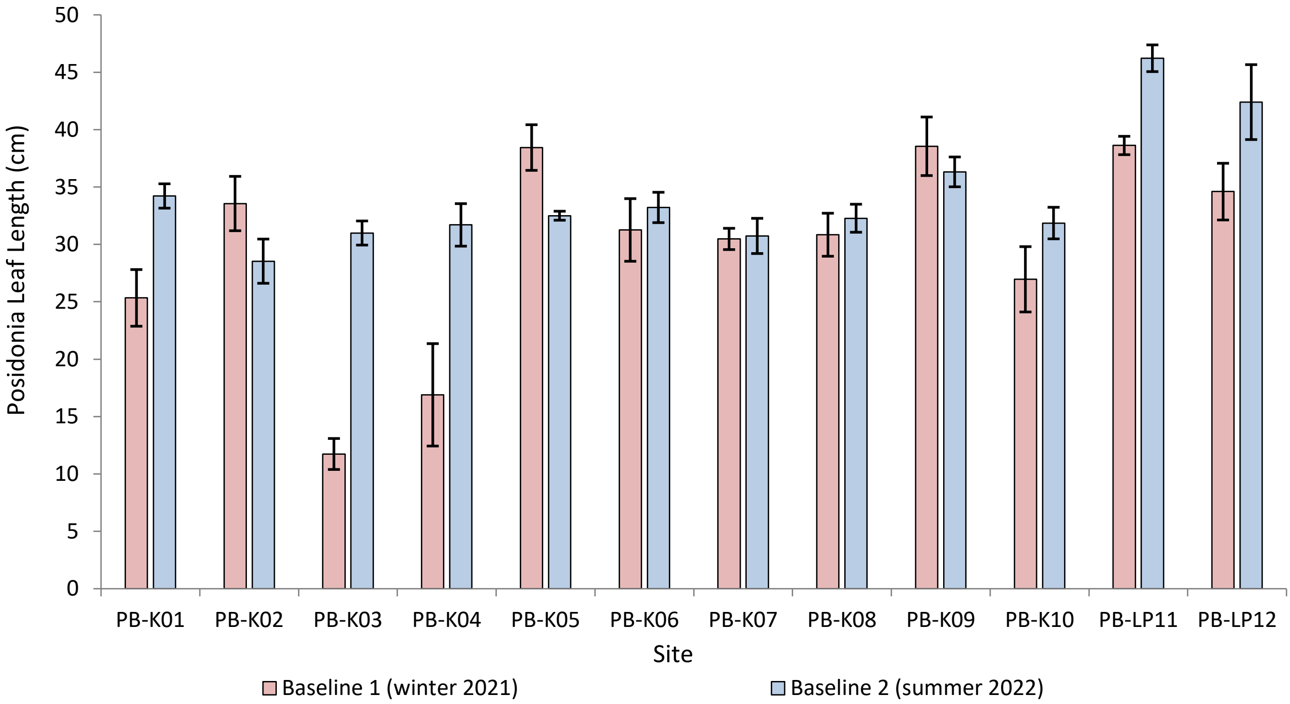

Figure 14: Mean *Posidonia* leaf length at the *Posidonia* bed monitoring sites (+/-SE) in the Baseline 1 and Baseline 2 surveys.

Table 11: Mean values for leaf length measurements, visible seagrass sheafs (*Posidonia* only) and epiphyte cover score.

Season	Baseline 2 (summer 2022)						Baseline 1 (winter 2021)					
Average	Leaf length (cm)		Epiphytic cover score			Sheaf visible (%)	Leaf length (cm)		Epiphytic cover score			Sheaf visible (%)
Species	*Posidonia*	*Zostera*	*Halophila*	*Zostera*	*Posidonia*	*Posidonia*	*Posidonia*	*Zostera*	*Halophila*	*Zostera*	*Posidonia*	*Posidonia*
PB-K01	34.2	16.0	2.8	4.0	4.1	34	25.3	5.3	2.2	2.7	2.0	46
PB-K02	28.5	N.D.	2.2	N.D.	3.3	12	33.6	8.7	2.6	1.7	3.0	43
PB-K03	31.0	11.3	2.7	3.0	4.3	28	11.7	30.6	2.5	3.3	2.0	42
PB-K04	31.7	13.6	2.3	2.5	3.8	12	16.9	29.1	3.0	3.0	3.3	0
PB-K05	32.5	9.1	2.7	2.6	3.9	18	38.4	5.5	2.6	1.3	3.0	68
PB-K06	33.2	7.5	3.2	2.6	4.4	34	31.3	9.2	3.1	1.5	3.7	44
PB-K07	30.7	10.4	2.8	2.1	4.2	30	30.5	10.5	4.0	1.7	3.6	41
PB-K08	32.3	16.1	2.5	3.6	4.4	88	30.8	10.4	3.6	1.9	3.8	47
PB-K09	36.3	12.6	2.6	2.4	4.1	24	38.6	15.2	2.5	2.1	3.8	4
PB-K10	31.9	14.7	2.6	2.1	4.4	6	27.0	4.2	3.9	2.9	3.8	55
PB-LP11	46.2	N.D.	3.3	N.D.	3.0	50	38.6	4.4	2.3	1.7	2.2	6
PB-LP12	42.4	12.2	1.9	1.7	2.9	28	34.6	4.6	2.9	2.8	3.9	50
PP-LP01	35.8	N.D.	3.1	N.D.	3.5	75	32.7	13.9	1.7	2.0	2.3	31
PP-LP02	39.0	0.0	3.4	0.0	3.0	40	27.2	2.1	1.8	N.D.	1.9	3
PP-K03	27.8	N.D.	2.3	N.D.	3.7	10	36.9	6.2	4.1	N.D.	4.2	46
PP-K04	38.4	N.D.	2.9	N.D.	4.2	32	27.7	8.7	3.4	N.D.	4.1	N.D.
PP-K07	30.6	N.D.	2.4	N.D.	3.6	35	34.8	9.9	2.1	N.D.	2.2	15
PP-K08	37.0	N.D.	2.6	N.D.	4.2	46	37.0	11.9	3.0	N.D.	4.1	0
PP-K09	33.0	N.D.	2.3	N.D.	3.7	73	37.1	11.7	3.7	N.D.	4.0	68
PP-K11	42.0	N.D.	2.3	N.D.	4.3	15	58.5	10.1	2.6	N.D.	3.0	25

ND = No data,

Figure 15 illustrates patterns in average *Posidonia* leaf length in the outer transect of the main *Posidonia* bed (Figure 2) along sites PB-K01, PB-K02, PB-K03, PB-K04, which increases in distance from the Construction Footprint. A very minor trend of decreasing leaf length with distance from the construction footprint is observed in the summer season, with each site essentially fluctuating around 30 cm. This is opposed to the winter survey, where an overall trend of decreasing leaf length with distance is observed. However, this is not a consistently linear pattern with average leaf length at each site varying substantially.

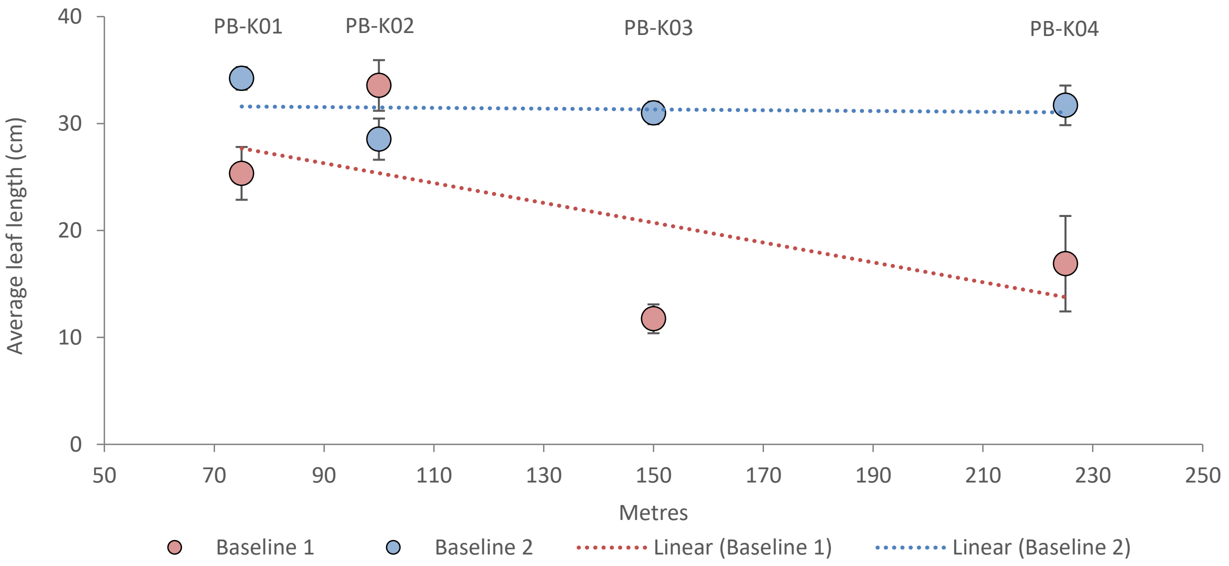

Figure 15: Mean Posidonia shoot density at Posidonia bed monitoring sites (+/-SE), positioned at different distances from the Construction Footprint along the in outer transect (PB-K01, PB-K02, PB-K03, PB-K04), in Baseline 1 (winter 2021) and Baseline 2 (summer 2022).

Figure 16 illustrates patterns in average *Posidonia* leaf length in the inner transect of the main *Posidonia* bed (Figure 2) along sites PB-K05, PB-K06, PB-K07, PB-K08, which increase in distance from the Construction Footprint. A very minor trend of decreasing leaf length with distance from the construction footprint is observed in both seasons, with a high degree of similarity between the seasons observed.

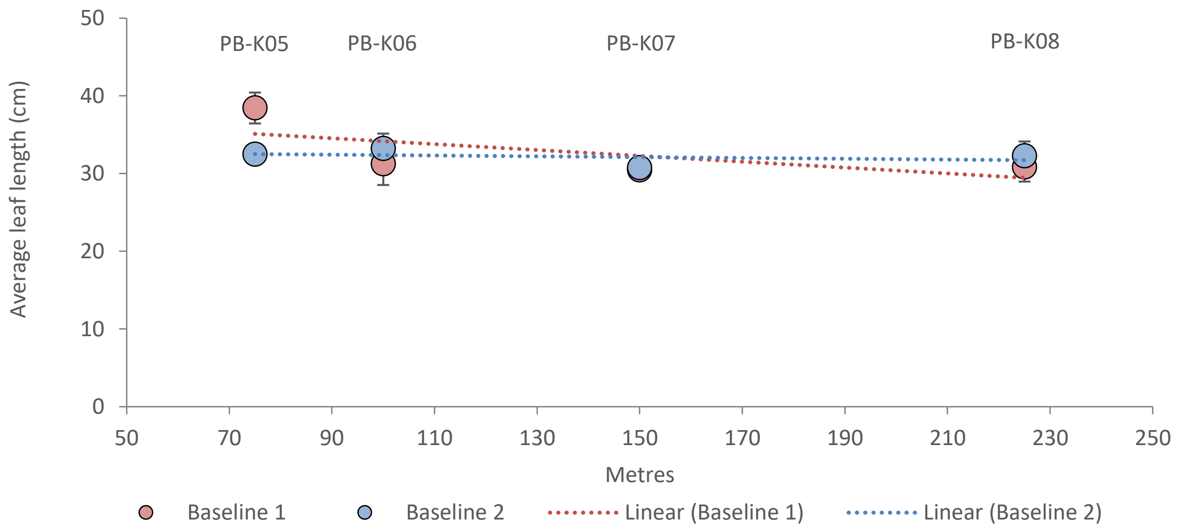

Figure 16: Mean *Posidonia* shoot density at *Posidonia* bed monitoring sites (+/-SE), positioned at different distances from the Construction Footprint along the inner transect (PB-K05, PB-K06, PB-K07, PB-K08) , in Baseline 1 (winter 2021) and Baseline 2 (summer 2022).

Seagrass Sheafs

The average percentage of visible sheafs was found to be highly variable across the sites in this survey (Table 11). Within the *Posidonia* beds, results ranged from 6% (PB-K10) to 88% (PB-K8). Within the smaller *Posidonia* patches, results ranged from 10% (PP-K03) to 75% (PP-LP01). Further data are provided in Appendix 3.

There was also a high degree of variability in the average percentage of visible sheafs between the surveys at the individual monitoring sites. On average, a greater percentage of visible sheaths were present at the *Posidonia* beds in the previous survey, conversely at the *Posidonia* patches a greater percentage of visible sheaths were present in this survey.

Epiphyte Cover

The epiphyte cover results (Table 11) show that epiphytic growth was found to typically be higher on *P. australis* shoots.

The epiphyte cover scores across the *P. australis* monitoring sites and patches ranged between 2.9 (PB-LP12) and 4.4 (PB-K10, PB-K06, PB-K08) for *P. australis* in this survey. For *Zostera* the range was between 0.0 (PP-LP02 and PP-K04) and 4.0 (PB-LP12). The range for *Halophila* seagrasses was between 1.9 (PB-LP12) and 3.4 (PB-K07).

Epiphytic growth was found to be, on average, higher in this survey for *P. australis* and *Zostera,* but lower for *Halophila* seagrasses.

Further data are provided in Appendix 3.

3.5 Depth of disturbance

DoD rods were only recovered in a reliable state from two sites. At site PBK02 there was an average change of -18 cm indicating erosional processes. A similar, albeit greater, average change of -32 cm was measured at PBK08 (Table 12).

Table 12: Depth of disturbance data recorded during baseline survey 2

Site	Rod	Measurement (cm)	Change (cm)	Indication	Comment
PBK01	1	N/A	-	-	Missing
	2	N/A	-	-	Missing
	3	N/A	-	-	Missing
PBK02	1	63	-23	Erosion	-
	2	43	-3	Erosion	-
	3	67	-27	Erosion	-
PBK03	1	N/A	-	-	Missing
	2	N/A	-	-	Missing
	3	N/A	-	-	Missing
PBK04	1	N/A	-	-	Missing
	2	N/A	-	-	Disturbed

Site	Rod	Measurement (cm)	Change (cm)	Indication	Comment
	3	N/A	-	-	Missing
PBK05	1	N/A	-	-	Missing
	2	N/A	-	-	Missing
	3	N/A	-	-	Missing
PBK06	1	N/A	-	-	Missing
	2	N/A	-	-	Disturbed
	3	N/A	-	-	Missing
PBK07	1	N/A	-	-	Missing
	2	N/A	-	-	Missing
	3	N/A	-	-	Missing
PBK08	1	64	-24	Erosion	-
	2	81	-41	Erosion	-
	3	71	-31	Erosion	-
PBK09	1	N/A	-	-	Missing
	2	N/A	-	-	Missing
	3	N/A	-	-	Missing
PBK10	1	N/A	-	-	Missing
	2	N/A	-	-	Missing
	3	N/A	-	-	Missing
PBK11	1	N/A	-	-	Missing
	2	N/A	-	-	Missing
	3	N/A	-	-	Missing
PBK12	1	N/A	-	-	Missing
	2	N/A	-	-	Missing
	3	N/A	-	-	Missing

4. Discussion

4.1 Significant weather conditions

Significant above average rainfall and swell conditions in each of the summer months, especially February, impacted upon seagrass condition at both La Perouse and Kurnell. This series of significant weather events has impacted upon seagrass beds through increased wave action, in addition to flooding outflows from the Georges River. This has resulted in erosion and loss of individual seagrasses, along with increases in suspended sediment (reducing water quality and light availability) as well as sediment erosion/deposition (removing/covering seagrass). Extensive shoreline erosion was observed at La Perouse due to the significant the swell and refraction, resulting in a decrease in seagrass distribution, density and potential loss of *Zostera* in these shallow zones.

The impact of the significant weather events is reflected in the monitoring data (collected in April). With increases in sediment cover across all *Zostera*- and *Halophila*-dominated beds, along with substantial reductions in overall seagrass cover and density at these sites. The greatest observed reductions were for *Zostera*. Due the timing of the significant weather events occurring mid survey, this resulted in significant changes in relation to the cover and extent recorded in the mapping and in the drop camera surveys. This resulted in contradictory observations where seagrass that was initially mapped was no longer present or was highly diminished during the drop camera surveys.

The second baseline monitoring results must be considered in context of significant environmental perturbations during summer 2022 baseline monitoring (i.e. the seagrass cover and density results are likely to be lower than a more typical summer season). This will need to be considered when comparing future monitoring results to this baseline survey. Additionally, consideration of responses (e.g. changes in seagrass density or distribution) and overall recovery following the summer 2022 weather events at the control and impact monitoring sites should be considered in future monitoring surveys.

In consideration that 80% of the DoD rods were missing or disturbed during the second baseline survey, the results should be interpreted with care as reliability in the data and potential disturbance of the rods that were found cannot be assumed. Given the flooding events since monitoring of the rods in February 2022 and lack of reliability in the data, it appears that this methodology is unlikely to be suitable for this location without much more regular monitoring. Considering this, it is recommended that the use of DoD rods be discontinued as part of the baseline monitoring program.

4.2 Seasonal changes in seagrass growth and distribution

The key changes in seagrass growth and distribution identified during the second baseline monitoring survey (summer 2022) are summarised below:

- At Kurnell, a total of 14 m^2 of *Posidonia australis* seagrass was mapped within the Construction Footprint, with 220 m^2 mapped within the Buffer Area. No *Posidonia australis* seagrass was mapped within the Construction Footprint or Buffer Area at La Perouse.
- A substantial reduction in seagrass cover across the monitoring sites was observed in the *Zostera*- and *Halophila*-dominated beds. This decrease in cover was particularly acute for *Zostera*.
- Sediment cover at both Kurnell and La Perouse was higher when compared to baseline survey 1 (winter 2021).
- Epiphytic algae was found to be absent from all drop camera survey locations.

- The overall shoot density (of combined seagrass species) was greater than in baseline survey 1 (winter 2021).
- The relative density of *Halophila* was observed to increase at all sites.
- While the relative density of *Posidonia* was generally observed to increase, this was not observed at all locations.
- When comparing summer 2022 to winter 2021, epiphytic growth was found to be, on average, higher in summer for *P. australis* and *Zostera*, but lower for *Halophila* seagrasses.

The most significant changes in seagrass distributions detected between the first and second baseline surveys have been the decline in areas of *Zostera* and *Zostera/Halophila* seagrass. Areas of *Halophila* were found to increase, which may to some extent replaced the declines in extent of *Zostera* seagrass that has experienced the most acute level of reduction. The findings from February 2022 suggest that the *Zostera* communities experienced some degree of change in distribution and density from the first baseline survey prior to the most intense weather events in March and April 2022. The overall reduction in *Zostera* detected is likely to reflect the rapid growth of this seagrass from the seed bank followed by reseeding around the time of the significant weather events, with the juvenile *Zostera* shoots susceptible to disturbance and therefore the *Zostera* community reducing in distribution and density during the second baseline surveys. *Halophila*, which appears to be less susceptible to these effects has replaced the *Zostera* in areas where it had not successfully re-established after seeding during the second baseline survey.

It is recommended that the suitability of control sites be examined in depth following the collection of the full baseline dataset, which is recommended to be four baseline monitoring surveys. Following the collection of the complete baseline dataset, statistical analyses will be performed to establish whether any differences between the seasonal (winter and summer) datasets are statistically significant and therefore whether the whole baseline dataset should be combined or analysed on the basis of season. At this time, the suitability of the experimental design should be reviewed to identify the best statistical approach to detect impacts during the construction phase of the Project.

4.3 Development of the Success Criteria

Comparison with success criteria will be an essential component of monitoring during the construction and operation phases. As part of the baseline monitoring the following outcomes will be required:

- Seagrass distribution changes will need to be reviewed at the completion of baseline monitoring to determine acceptable decreases or rates off change in seagrass distribution.
- Data from the *Zostera/ Halophila* and *Posidonia australis* seagrass bed control sites will need to be reviewed to determine their suitability as control/reference sites in the statistical analysis. The outcomes of the statistical analysis will need to be considered in finalizing the success criteria.

It is recommended that the setting of success criteria be reassessed following the collection of the complete baseline dataset.

4.4 Conclusions and recommendations

This report concerns the findings of the second baseline monitoring survey undertaken in summer 2022. Notably, the surveys and seagrass communities were impacted by significant rainfall during this period. Seagrass mapping during summer 2022 identified an area of 8,802 m^2 of seagrasses within the combined buffer and Construction Footprint of the project. This area was dominated by variable *Halophila* beds (previously *Zostera/Halophila* beds) with minor areas of *Zostera* remaining, while *P. australis* seagrass accounted for only 234 m^2 of seagrass in this area.

Considering the significant weather events during the second baseline survey in summer 2022 and the associated impacts to seagrass communities, it is recommended that four baseline surveys be completed, in line with the programmed baseline surveys identified in Table 2 (Section 2.2). This is to build on the existing baseline dataset under more nominal conditions than was observed during summer 2022. Additionally further surveys are required to investigate any ongoing impacts associated with the significant weather events of summer 2022, prior to works commencing, in order that these may be differentiated from any potential impacts associated with the project. It is recommended that the third baseline survey (winter 2022) is undertaken between July and August 2022, and fourth baseline survey (summer 2023) to commence in December 2022, prior to the commencement of construction works.

In consideration of the limited data provided by the DoD rods and apparent limitations in terms of suitability to the location, it is recommended that this methodology be discontinued.

It is recommended that the suitability of control sites and success criteria by established following the collection of the full baseline dataset (four baseline monitoring surveys). At this time, the suitability of the experimental design should also be reviewed to identify the best statistical approach to detect impacts during the construction phase of the Project.

A summary of the recommendations made in this report, following the completion of the Baseline 2 survey, are provided in Table 13.

Table 13: Recommendations summary.

Survey method	Recommendation
Baseline surveys	A total of four programmed baseline surveys should be completed prior to construction commencing.
	The third (winter 2022) baseline survey should be undertaken between July and August 2022, with the fourth (summer 2023) baseline survey commencing in December 2022.
DoD rods	The DoD monitoring methodology should be discontinued from the program.
Control sites	The suitability of control sites and success criteria should be established following the collection of the full baseline dataset (four baseline monitoring surveys).
Statistical analysis	The suitability of the experimental design and most appropriate statistical approach to detect impacts during the construction phase should be defined following the collection of the full baseline dataset (four baseline monitoring surveys).

5. References

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6. Plates

Plate 1: Survey equipment and methodologies a) Towed camera used to map seagrasses, b) Drop camera used to collect photoquadrats, c) CPCe digital photoquadrat analysis screen, d) DoD rod installed within the main *P. australis* seagrass bed at Kurnell, e) dive survey, f) 0.25 m^2 quadrat.

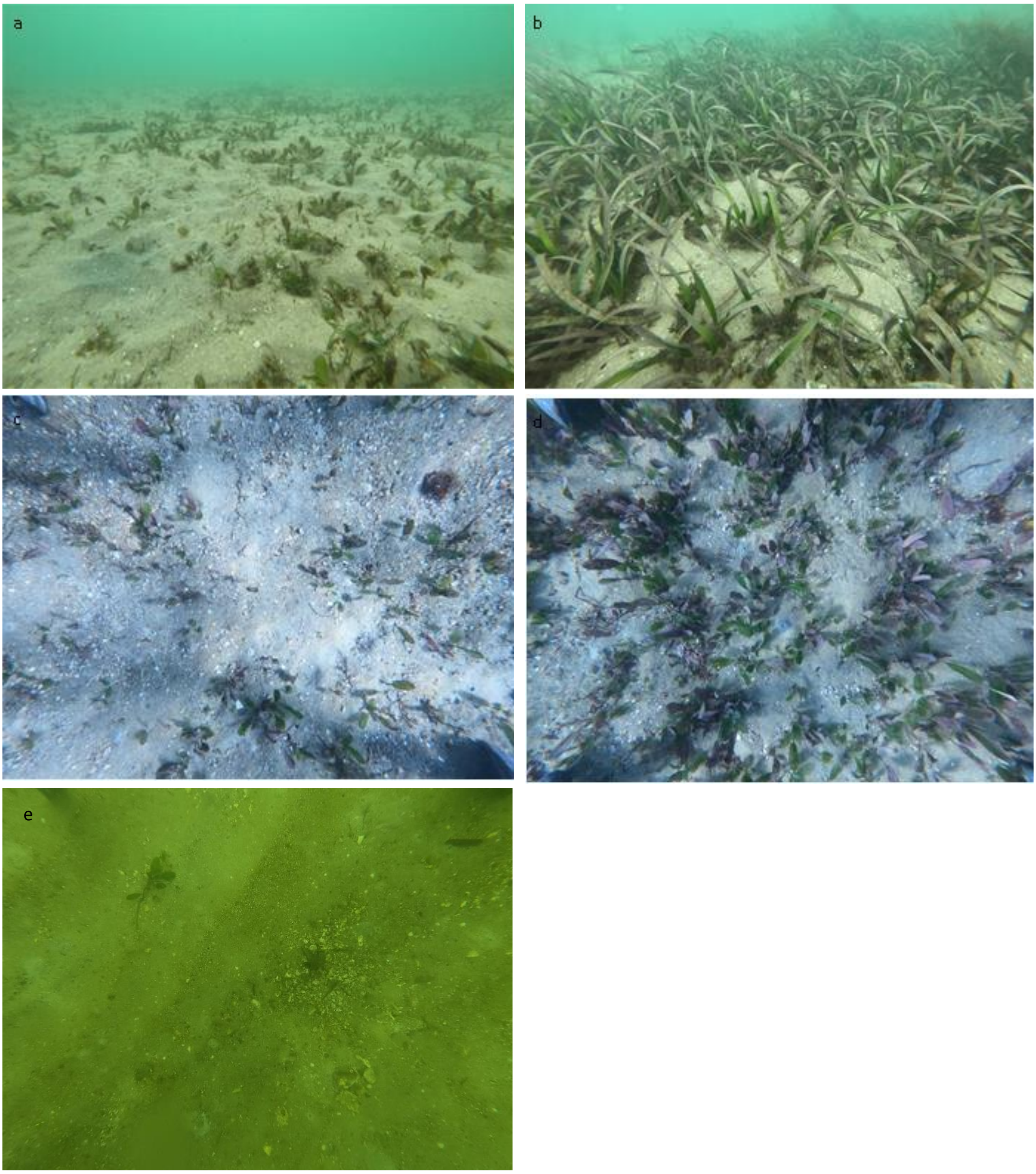


Plate 2: Seagrasses in the Project Area at La Perouse, a) Low density *Halophila* dominated seagrass within *Zostera / Halophila* beds, b) *Posidonia australis*, c) low density *Halophila*, d) medium density *Halophila*, e) reduced *Halophila* density in summer 2022 (HZ-LP02), previously *Zostera / Halophila* in winter 2021 (Niche 2021a).

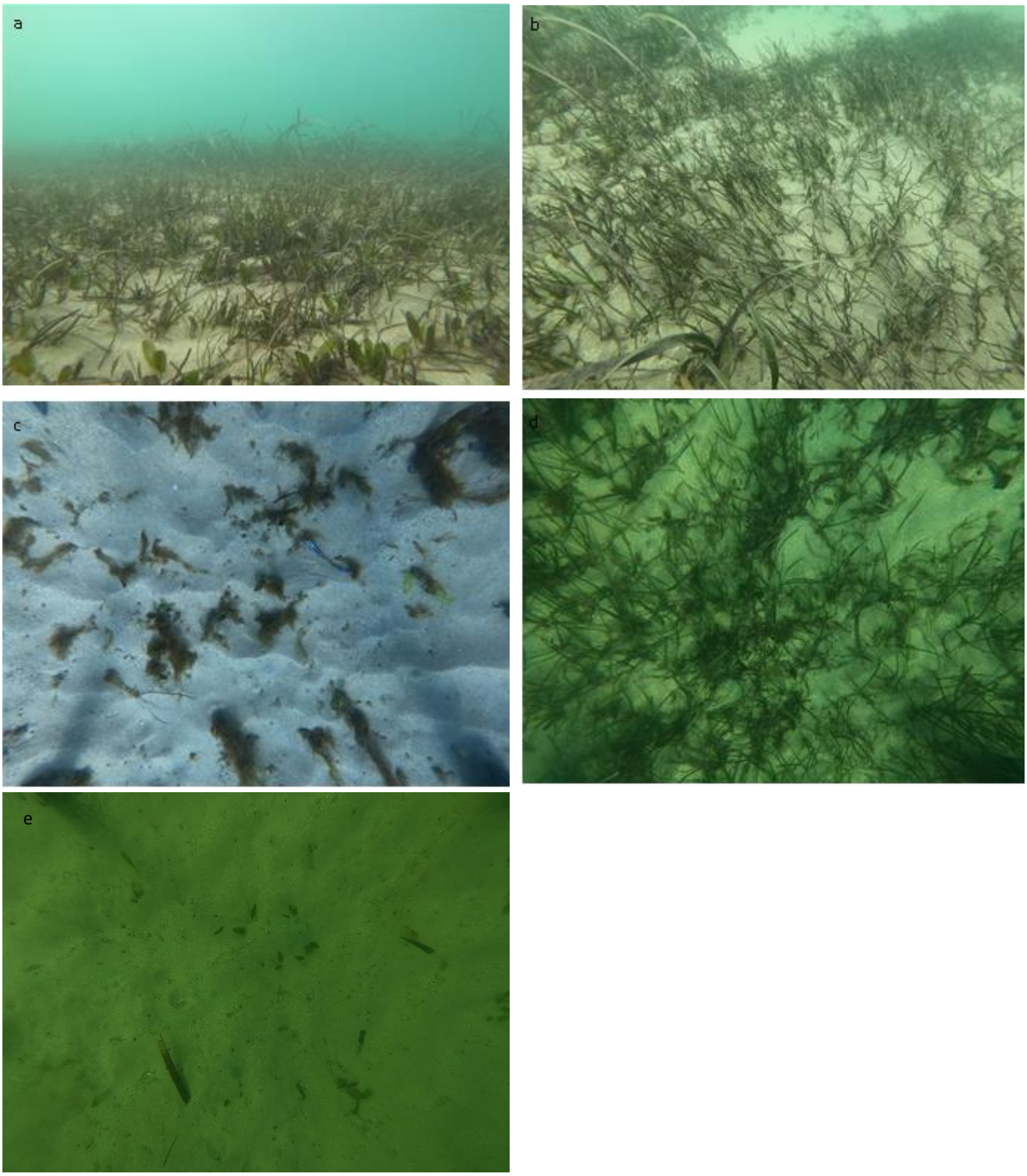
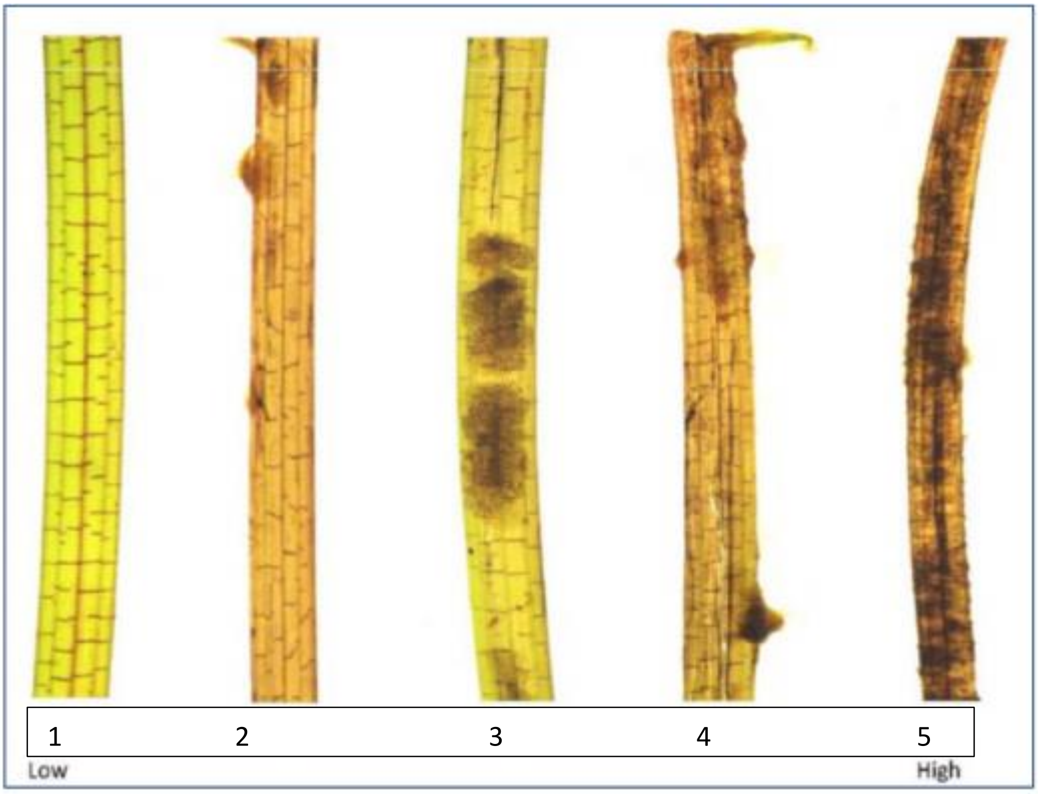


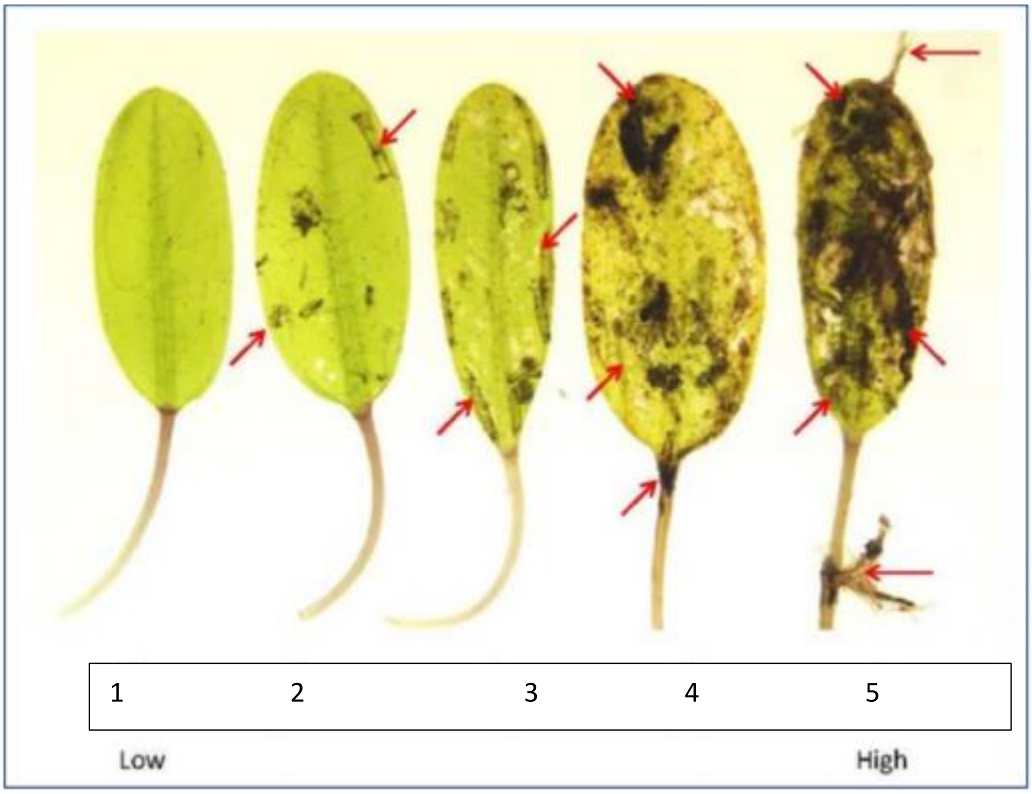
Plate 3: Seagrasses in the Project Area at Kurnell, a) Medium density *Zostera* dominated seagrass within *Zostera* / *Halophila* beds with *P. australis* in the background, b) Medium density *Zostera* dominated seagrass within *Zostera* / *Halophila* beds adjoining a low density patch of *P. australis*, c) low density *Halophila* with heavy epiphytic fouling and d) Medium density *Zostera* dominated seagrass within *Zostera / Halophila* bed in shallow areas close to the proposal footprint, e) reduced *Halophila* density in summer 2022 (HZ-K07).

Appendix 1: Monitoring site locations

Site	Location	Purpose	Easting (GDA94 MGA56)	Northing (GDA94 MGA56)
***Halophila / Zostera* monitoring (drop camera)**				
HZ-LP01	La Perouse	Potential impact	336429.98	6237907.4
HZ-LP02	La Perouse	Potential impact	336516.36	6237871.92
HZ-LP03	La Perouse	Control	336438.35	6238037.7
HZ-LP04	La Perouse	Control	336317.97	6238009.92
HZ-K05	Kurnell	Potential impact	335274.25	6236137.09
HZ-K06	Kurnell	Potential impact	335344.73	6236180.62
HZ-K07	Kurnell	Control	335437.75	6236230.96
HZ-K08	Kurnell	Control	335164.51	6236149.72
HZ-K09	Kurnell	Potential impact	335310.06	6236050.64
HZ-K10	Kurnell	Potential impact	335383.27	6236105.94
***Posidonia* bed monitoring (ADAS scientific divers)**				
PB-K01	Kurnell	Potential impact	335263.13	6236095.86
PB-K02	Kurnell	Potential impact	335234.62	6236085.28
PB-K03	Kurnell	Potential impact, possible control	335189.91	6236071.11
PB-K04	Kurnell	Potential impact, possible control	335127.2	6236041.22
PB-K05	Kurnell	Potential impact	335315.43	6236006.55
PB-K06	Kurnell	Potential impact	335287.92	6235986.41
PB-K07	Kurnell	Potential impact, possible control	335250.49	6235967.27
PB-K08	Kurnell	Potential impact, possible control	335173.89	6235927.58
PB-K09	Kurnell	Potential impact	335326.24	6236087.61
PB-K10	Kurnell	Potential impact, possible control	335417.71	6236193.76
PB-LP11	La Perouse	Potential impact	336545.65	6237861.53
PB-LP12	La Perouse	Control	336578.02	6238082.55
***Posidonia* patch monitoring (ADAS scientific divers)**				
PP-LP01	La Perouse	Potential impact	336506.15	6237863.79
PP-LP02	La Perouse	Potential impact	336533.9	6237847.83
PP-K03	Kurnell	Potential impact	335367.57	6236122.05
PP-K04	Kurnell	Potential impact	335346.18	6236109.77
PP-K07	Kurnell	Potential impact	335340.22	6236069.58
PP-K08	Kurnell	Potential impact	335355.6	6236062.17
PP-K09	Kurnell	Potential impact	335366.1	6236071.99
PP-K11	Kurnell	Potential impact	335370.57	6236060.62

Appendix 2: Epiphyte Loading Scale





Appendix 3: Summary data collected during baseline 2 (summer 2022)

Baseline 2: drop camera survey results from Baseline 2 (summer 2022)

Site	MACROALGAE (MA)		SEAGRASS (S)		SUBSTRATE (SU)		*Posidonia australis* (PA)		*Zostera capricorni* (ZC)		*Halophila* sp. (HS)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
HZ-LP01	0.00	0.00	0.46	0.08	99.3	18.13	0.00	0.00	0.00	0.00	0.46	0.08
HZ-LP02	0.00	0.00	0.00	0.00	95.9	17.51	0.00	0.00	0.00	0.00	0.00	0.00
HZ-LP03	0.78	0.14	3.80	0.69	95.4	17.42	0.00	0.00	0.00	0.00	3.80	0.69
HZ-LP04	0.00	0.00	6.88	1.26	92.7	16.92	0.00	0.00	0.00	0.00	6.88	1.26
HZ-K05	0.00	0.00	1.49	0.27	98.4	17.96	0.00	0.00	0.00	0.00	1.49	0.27
HZ-K06	0.22	0.04	0.22	0.04	99.6	18.18	0.00	0.00	0.00	0.00	0.22	0.04
HZ-K07	0.68	0.12	0.90	0.17	98.4	17.97	0.00	0.00	0.00	0.00	0.90	0.17
HZ-K08	0.00	0.00	0.97	0.18	99.0	18.08	0.00	0.00	0.00	0.00	0.97	0.18
HZ-K09	0.00	0.00	20.88	3.81	78.8	14.38	0.00	0.00	0.34	0.06	20.54	3.75
HZ-K10	0.00	0.00	13.21	2.41	86.8	15.84	0.00	0.00	0.56	0.10	12.65	2.31

Site	Sediment (Sand Silt (SS))		Turfing Algae (TA)		Epiphytic Algae	
	Mean	SE	Mean	SE	Mean	SE
HZ-LP-01	51.77	9.45	0.228	0.04	0.00	-
HZ-LP-02	82.94	15.14	4.110	0.75	0.00	-
HZ-LP-03	91.40	16.69	0.000	0.00	0.00	-
HZ-LP-04	74.27	13.56	0.000	0.00	0.00	-
HZ-K-05	98.40	17.96	0.115	0.02	0.00	-
HZ-K-06	99.55	18.18	0.000	0.00	0.00	-
HZ-K-07	98.42	17.97	0.000	0.00	0.00	-
HZ-K-08	99.03	18.08	0.000	0.00	0.00	-
HZ-K-09	78.78	14.38	0.339	0.06	0.00	-
HZ-K-10	86.79	15.84	0.000	0.00	0.00	-

Posidonia monitoring sites and patches

Baseline 2 (summer 2022): shoot density results

Seagrass	*Halophila* density (0.25 m²)		*Zostera* density (0.25 m²)		*Posidonia* density (0.25 m²)	
	Mean	SE	Mean	SE	Mean	SE
PB-K01	124.8	18.0	0.8	0.8	16.8	2.7
PB-K02	335.2	32.9	0.0	0.0	16.2	1.4
PB-K03	113.6	9.0	78.4	20.4	19.6	3.6
PB-K04	145.6	22.7	76.0	13.1	21.2	0.9
PB-K05	217.6	29.7	137.6	35.5	21.0	2.4
PB-K06	112.8	12.2	62.4	12.4	26.0	4.5
PB-K07	139.2	18.9	33.6	14.4	50.4	2.6
PB-K08	58.4	27.4	20.8	11.0	46.8	1.7
PB-K09	164.8	32.1	0.8	0.8	14.8	1.0
PB-K10	108.8	13.9	2.4	1.6	12.2	2.1
PB-LP11	96.0	4.0	0.0	0.0	29.8	3.0
PB-LP12	28.8	17.7	6.4	3.9	33.2	8.1
PP-LP01	152.0	36.7	0.0	0.0	13.0	2.0
PP-LP02	128.0	6.9	0.0	0.0	24.7	1.9
PP-K03	428.0	69.4	4.8	3.2	12.4	1.3
PP-K04	230.4	12.8	4.0	2.8	12.8	2.6
PP-K07	322.0	110.2	7.0	3.4	16.0	5.0
PP-K08	220.0	21.2	12.0	4.6	14.3	2.7
PP-K09	110.0	55.1	52.0	18.5	15.3	2.0
PP-K11	184.0	41.4	22.0	11.6	20.0	3.2

Baseline 2 (summer 2022): epiphyte score results

Site	*Halophila*		*Zostera*		*Posidonia*	
	Mean	SE	Mean	SE	Mean	SE
PB-K01	2.76	0.34	4.00	0.00	4.05	0.14
PB-K02	2.22	0.09	0.00	0.00	3.26	0.13
PB-K03	2.66	0.22	2.98	0.44	4.27	0.13
PB-K04	2.30	0.25	2.54	0.23	3.76	0.09
PB-K05	2.68	0.33	2.62	0.14	3.90	0.06
PB-K06	3.22	0.19	2.64	0.32	4.40	0.08
PB-K07	2.78	0.39	2.10	0.13	4.16	0.17
PB-K08	2.47	0.21	3.57	0.54	4.42	0.07
PB-K09	2.64	0.21	2.38	0.18	4.08	0.29
PB-K10	2.56	0.17	2.13	0.08	4.37	0.39
PB-LP11	3.28	0.29	N.D.	N.D.	3.04	0.05
PB-LP12	1.90	0.38	1.68	0.30	2.94	0.11
PP-LP01	3.07	0.61	N.D.	N.D.	3.48	0.27
PP-LP02	3.40	0.06	0.00	0.00	2.97	0.41
PP-K03	2.32	0.20	N.D.	N.D.	3.68	0.19
PP-K04	2.88	0.31	N.D.	N.D.	4.17	0.30
PP-K07	2.35	0.42	N.D.	N.D.	3.55	0.16
PP-K08	2.60	0.25	N.D.	N.D.	4.20	0.20
PP-K09	2.28	0.14	N.D.	N.D.	3.68	0.15
PP-K11	2.28	0.11	N.D.	N.D.	4.28	0.15

Baseline 2 (summer 2022): depth of disturbance (DoD) rod data

Site	Rod	Measurement	Change	Indication
PBK01	1	N/A	-	-
	2	N/A	-	-
	3	N/A	-	-
PBK02	1	63	-23	Erosion
	2	43	-3	Erosion
	3	67	-27	Erosion
PBK03	1	N/A	-	-
	2	N/A	-	-
	3	N/A	-	-
PBK04	1	N/A	-	-
	2	N/A	-	-
	3	N/A	-	-
PBK05	1	N/A	-	-
	2	N/A	-	-
	3	N/A	-	-
PBK06	1	N/A	-	-
	2	N/A	-	-
	3	N/A	-	-
PBK07	1	N/A	-	-
	2	N/A	-	-
	3	N/A	-	-
PBK08	1	64	-24	Erosion
	2	81	-41	Erosion
	3	71	-31	Erosion
PBK09	1	N/A	-	-
	2	N/A	-	-
	3	N/A	-	-
PBK10	1	N/A	-	-
	2	N/A	-	-
	3	N/A	-	-
PBK11	1	N/A	-	-
	2	N/A	-	-
	3	N/A	-	-
PBK12	1	N/A	-	-
	2	N/A	-	-
	3	N/A	-	-

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Archaeological, built and landscape values

Environmental management and approvals
Impact assessments
Development and activity approvals
Rehabilitation
Stakeholder consultation and facilitation
Project management

Environmental offsetting
Offset strategy and assessment (NSW, QLD, Commonwealth)
Accredited BAM assessors (NSW)
Biodiversity Stewardship Site Agreements (NSW)
Offset site establishment and management
Offset brokerage
Advanced Offset establishment (QLD)