REGIA
Marine Seismic Survey

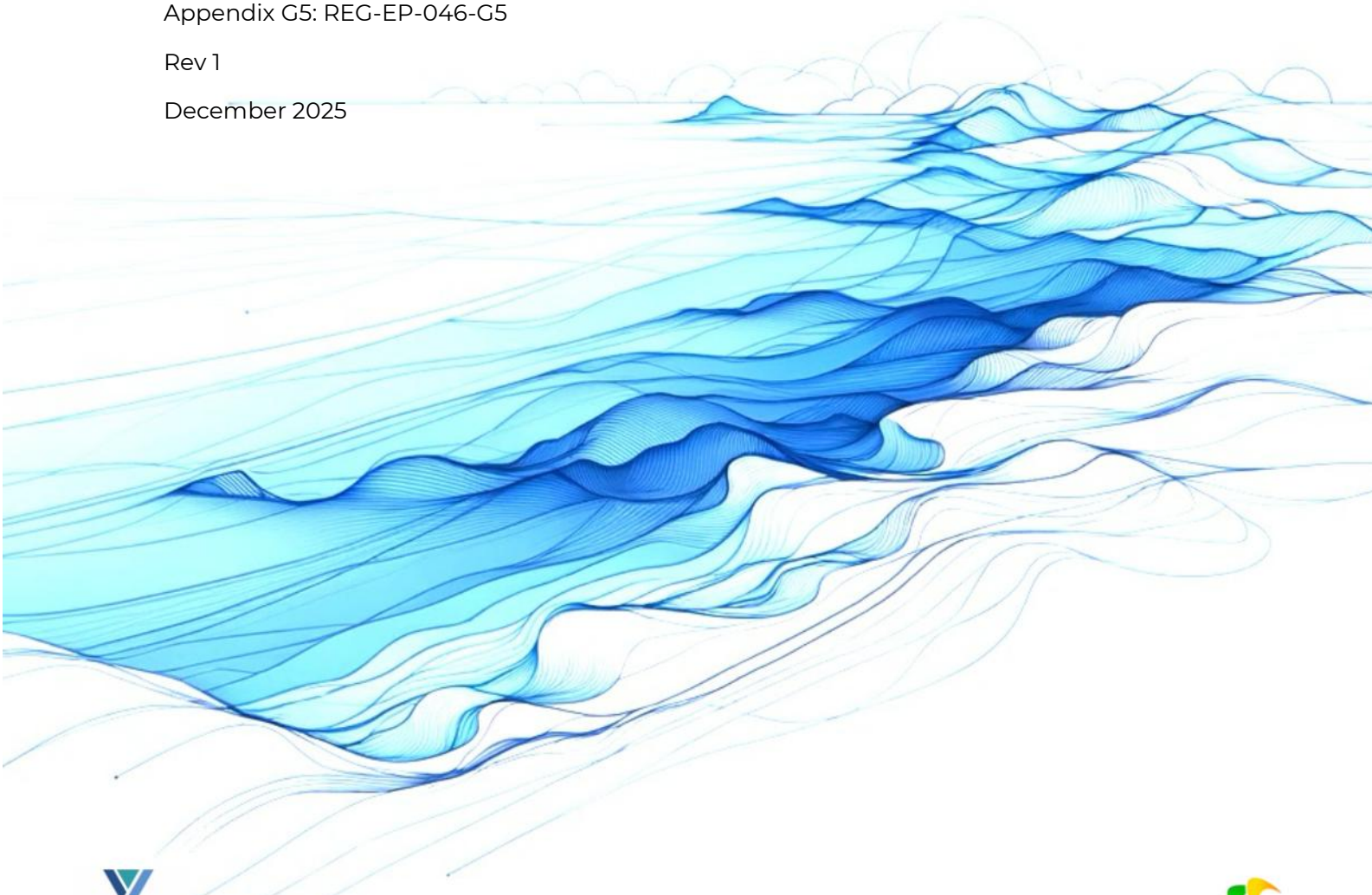
Coastal Monitoring Programme for Southern Right Whales and Pygmy Blue Whales

Implementation Plan

Appendix G5: REG-EP-046-G5

Rev 1

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Klarite

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1 Introduction

This document describes a monitoring programme required because of the outcomes of an environmental impact assessment conducted by CGG for the Regia Marine Seismic Survey (**Regia MSS**). Context for this document can be found in the Regia MSS Environment Plan (**EP**) and users unfamiliar with the Regia MSS EP should read, in the following order:

- Impact Assessment – Underwater Sound: Marine Mammals (Appendix E7)
- Further Assessment – Southern Right Whales (Appendix F3, Section 3.1.1)
- Implementation Strategy (Appendix B3)
- Fauna Management Plan (Appendix G2)

Section 0 of this document presents the implementation plan for Southern Right Whales (**SRW**). This coastal monitoring program is designed to ensure the requirements of the National Recovery Plan for SRW are met and impacts from the activity are kept below an acceptable level.

Section 3 of this document presents the implementation plan for Blue Whales (Antarctic and Pygmy) (**BW**s). This pre-season coastal aerial surveillance plan is designed to detect BWs as they arrive at the Otway region ahead of their foraging season, with the aim to provide an early signal for scaling protection measures before their arrival near the survey.

2 Monitoring Framework – Southern Right Whale

Herein we outline the framework for a dedicated SRW monitoring program along the south-west Victorian coastline to monitor the presence and movements of SRW in the lead-up to and during the Regia MSS.

2.1 Monitoring Objective

The key objective of this program is to provide real-time visual assessment of SRW whale presence within the greater Otway offshore region encompassing waters exposed to elevated levels of sound from the Regia MSS.

The program forms part of a multiple lines-of-evidence approach to SRW detection that will work in parallel with in-water ambient sound monitoring, citizen science data, social media monitoring, and offshore detection methods (Passive Acoustic Monitoring (PAM) systems and vessel-based Marine Fauna Observers (MFO's)) to provide a continual scanning system for whale presence to inform management and mitigation decisions.

2.2 Coastal Activities within the Monitoring Framework

2.2.1 Detection Methods Selection

CGG has evaluated various visual (coastal and aerial) surveillance methods. A full evaluation of these methods is presented in Appendix F2. In short, Unmanned Aerial Vehicles (UAVs)[1], otherwise known as drones, allied with qualified Marine Fauna Observers (MFOs) have been selected as the preferred coastal detection method with the largest geographical coverage due to their lower cost, lower safety risk, higher uptime, and operational flexibility.

2.2.2 Coastal Monitoring Area

The primary study area is a strip extending 5 km from the shore and running continuously between Cape Bridgewater and Cape Otway. This strip encompasses the SRW Biologically Important Area (BIA) (extending 5 km from shore) and covers the portion of the Victorian coastline with possible sound exposure exceedances above ambient levels from the Regia MSS (Figure G5-1).

[1] The terms Remotely Piloted Aircraft System (RPAS), Drones, Unmanned Aerial Vehicle (UAV), and Remotely Piloted Aircraft (RPA) are used interchangeable across industries and refer to the same generalised technology. For this framework, these systems are collectively referred to as "drones."

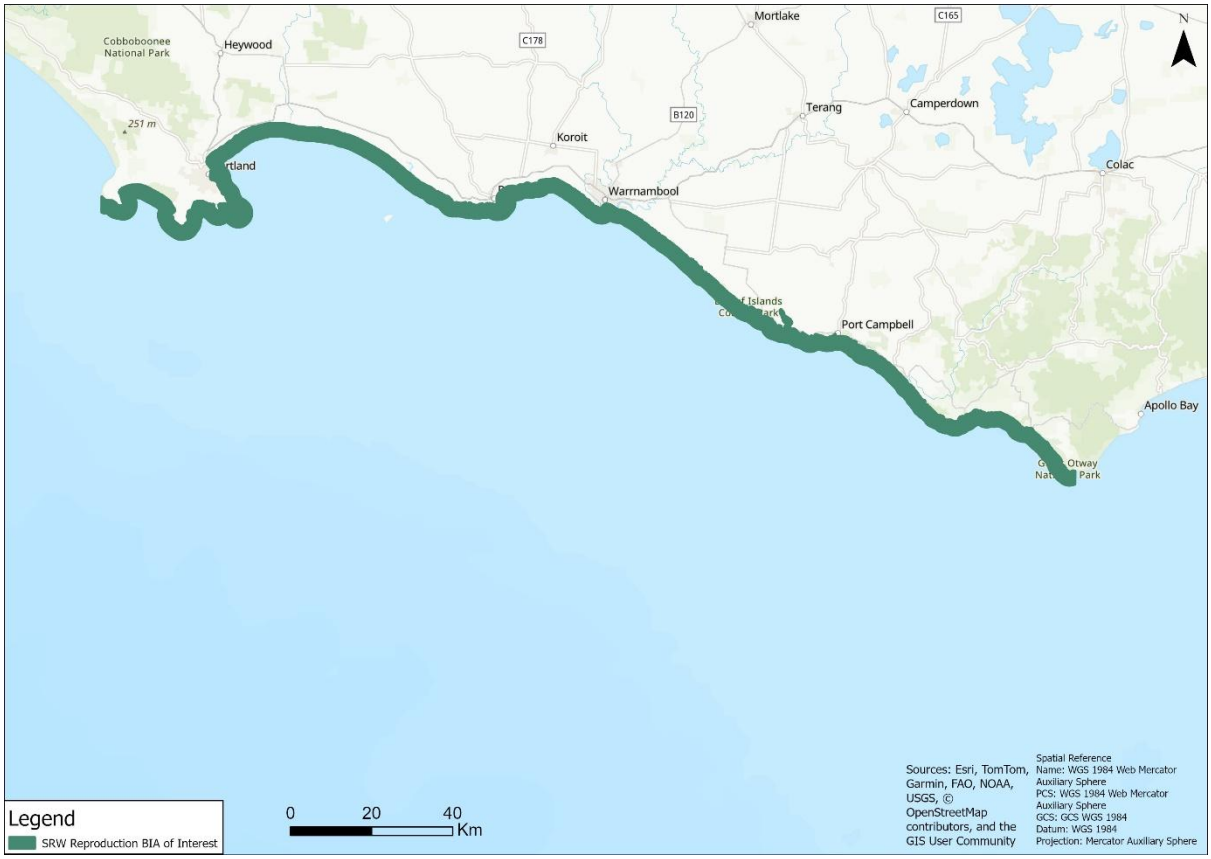


Figure G5-1 – Primary Study Area - SRW Reproduction BIA from Cape Bridgewater to Cape Otway

2.2.3 Resources

The monitoring will be undertaken with two "Whale Monitoring Teams" (WMTs) - each comprising one trained MFO and one Drone Pilot-in-Command (PIC) – who will be responsible for conducting flights west (Zone 1) and east (Zone 2) of Logans Beach respectively (See Figure 2 for flight area delineations). A third team will serve as a backup should extra observation capability be needed.

Using MFOs and drones together provides a more comprehensive approach to coastal marine fauna monitoring. WMT's will move between coastal vantage points each day. Drone PICs will operate their UAVs to extend effective observation ranges, enhance spatial coverage, increase detection probability, and allow for dynamic monitoring of whale movements. MFOs will conduct systematic visual watches and provide taxonomic identification through firsthand observations and through reviewing drone footage. Behavioural observations may also be recorded. Together, these coordinated efforts are expected to support near real-time mitigation enforcement and ensure continued compliance with all relevant regulatory (NOPSEMA and CASA) requirements.

This strategy provides a flexible and operationally efficient approach to whale monitoring, enabling rapid mobilisation across an array of coastal locations. This adaptability is particularly valuable given the variable and often unpredictable weather conditions characteristic of the Otway Coast, ensuring that monitoring efforts remain effective throughout the season.

2.2.4 Program Duration

The program will run for the entirety of the SRW season in Southern Australia which is nominally from May until November.

2.2.5 Program Tasking

Three operational plans have been developed, based around daily weather conditions:

1 Optimal Weather Deployment Plan
2 Sub-Optimal Weather Deployment Plan, and
3 No-Fly Plan

Analysis of long-term weather records for the area indicates there will be optimal conditions up to 15 % of the time, and sub-optimal conditions for up to 60 % of the time (See analysis of weather records in Appendix 2).

The Drone PIC holds ultimate authority and the responsibility for the planning and safe conduct of all flight operations lies with them. Therefore, the daily operational plan will be selected by the Drone PIC, and signed off by the Environment Officer, after assessing forecast weather conditions. While operational weather thresholds and procedural guidelines provide a framework for decision-making, the PICs assessment of real-time conditions always takes precedence. Factors such as visibility, wind strength, cloud ceiling, sea state, and crew readiness must all be evaluated on-site, and the PIC may modify, delay, or cancel a flight at any time if safety could be compromised.

All nominated flight locations identified in this document are publicly accessible areas that have been visually assessed as the most suitable sites for drone deployment based on current information. However, access to these sites may become temporarily restricted due to factors such as high visitor activity, local events, or other unforeseen circumstances. As such, the locations outlined should be considered indicative only. If a preferred site is inaccessible, a nearby alternative location offering comparable vantage and operational safety will be identified and utilised. Final deployment sites will be confirmed and adjusted as required on the day of operations, in accordance with access conditions and safety considerations.

2.3 Coastal Deployment Plans

2.3.1 Optimal Weather Deployment Plan

Optimal weather days represent conditions that are highly suitable for drone operations, characterised by low wind speeds, good visibility, and minimal precipitation. Under these conditions, drone endurance and stability are maximised, allowing for extended flight durations and broader spatial coverage. The weather conditions are expected to permit each WMT to operate efficiently across larger zones, enabling comprehensive monitoring with reduced operational overlap across the survey region.

This monitoring design has four central locations with two to the west and two to the east of Warrnambool (Figure G5-2), with the aim to provide visual coverage of up to 100% of the defined scope area each day during daylight hours. One WMT will monitor the eastern locations and another WMT will do the western locations. A summary of the meteorological parameters that will typically define this plan are presented in Table G5-1. These conditions are predicted to occur on approximately 10-15 % of days in September and October (Refer to Appendix 2 for analysis of climate data).

The primary monitoring sites (PMSs) were identified based on elevated vantage and visual arc, drone deployment feasibility, and accessibility. At each PMS, WMTs will undertake shore-based visual monitoring and at least one drone flight. Drone transects will be defined for each plan in the lead-up to the activity and will be designed to optimise battery efficiency and spatial coverage.

The primary monitoring sites to the west of Warrnambool have a visual range encompassing the Reproduction BIA offshore of Cape Bridgewater, Cape Nelson, Portland, The Craggs, Port Fairy, and Warrnambool. The PMSs within Zone 1 are:

(i) Cape Nelson Lighthouse
(ii) The Craggs.

The primary monitoring sites to the east of Warrnambool have a visual range encompassing the Reproduction BIA offshore of Warrnambool, Logan's Beach Whale Nursey, Mathiesons Road, the Gables, and Cape Otway Light Station. The PMSs within Zone 2 include

(i) Mathiesons Road
(ii) The Gables.

A third WMT will be stationed at a central base located at Logan's Beach, Warrnambool near the midpoint of the scope area between Cape Bridgewater and Cape Otway on days when this plan is active. This WMT will serve as a contingency resource, ready to be deployed at short notice in the event of an unforeseen situation, or if additional monitoring effort is required.

Table G5-1 - Optimal Deployment Plan – Meteorological Parameters

Parameter	Optimal Conditions Threshold	Description
Wind	≤ 10 kt sustained (gusts ≤ 15 kt)	Stable hover, no gimbal shake
Beaufort Sea State	≤ Bft 3 (wave height < 0.5 m)	Minimal whitecaps; stable horizon
Visibility	≥ 10 km	Full horizon clarity for long-range optical ID
Precipitation	Nil	Keep airframe and optics dry
Cloud ceiling	≥ 300 m	Ample vertical separation
Glare / Sun angle	Low or manageable	Smooth horizon contrast
Temperature	5–35 °C	Normal battery operating range

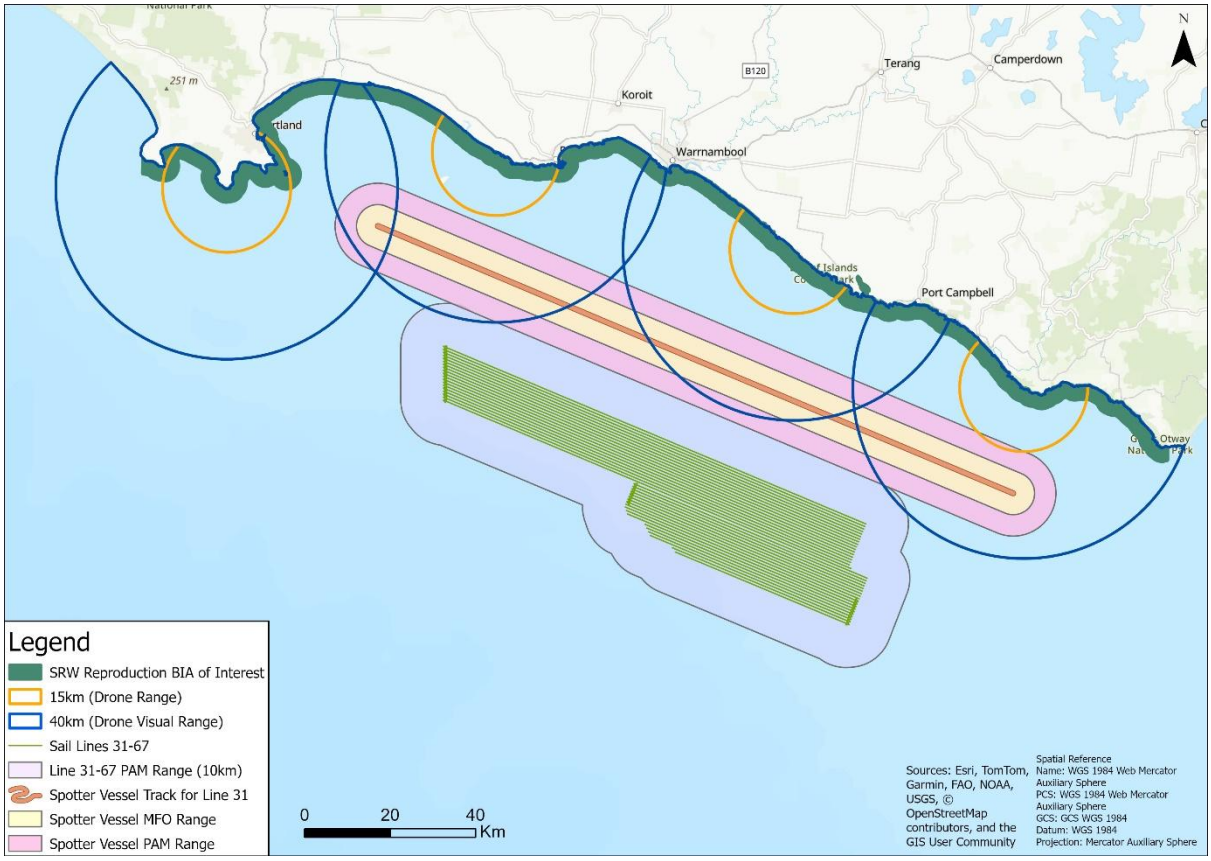


Figure G5-2 - Optimal Weather Deployment Plan Coverage – Figure also shows the Regia MSS survey lines for September & October (lines 31-67) and indicative location of the spotter vessel that has PAM and MFO capacity.

2.3.2 Sub-Optimal Weather Deployment Plan

Sub-optimal weather days are characterised by conditions that may not be ideal for drone operations but are still considered suitable for deployment. On these days, while drone flights are likely to remain feasible, operational efficiency and endurance may be affected. Stronger winds, increased cloud cover, or intermittent light rain can reduce visibility, shorten safe flight windows, and accelerate battery depletion, limiting the duration or range of individual flights.

To maintain effective monitoring coverage under these conditions, three WMTs will be deployed in accordance with the weather-dependent deployment plan. By reducing the spatial extent each team is responsible for, operational demands can be balanced against weather constraints, allowing teams to focus on shorter missions within safer operating limits. This adaptive approach permits monitoring even under less favourable meteorological conditions and remains consistent with the required performance standards.

Under this monitoring design, six primary monitoring sites will be utilised, with WMTs allocated across these sites each day to support broad visual coverage of the defined scope area during daylight hours (See Figure G5-3). Team distribution will remain flexible and may vary according to weather, access, and operational considerations, enabling the intent of achieving up to 100% daily coverage while adhering to all applicable SRW coastal monitoring requirements.

A summary of the meteorological parameters that will typically define this plan, are presented in Table G5-2 below. Long term averages suggest these conditions will prevail on approximately 55-60 % of days in September and October.

At each PMS, WMTs will undertake coastal visual monitoring effort combined with the aim of at least one drone flight at each PMS. Drone transects will be defined for each plan in the lead-up to the activity and will be designed with the intention to optimise battery efficiency and spatial coverage to search for SRWs.

The western third of the scope area, has a visual range encompassing the Reproduction BIA offshore of Cape Bridgewater Cape Nelson, and Portland. The central area encompasses The Craggs and Warrnambool while the eastern third encompasses London Bridge and Johanna Beach (Figure G5-3).

Table G5-2 - Sub-Optimal Deployment Plan – Meteorological Parameters

Parameter	Sub-Optimal Conditions Threshold	Description
Wind	11–21.5 kt sustained (gusts ≤ 23 kt)	Fly only ≤ 5 km; limit altitude 90 m
Beaufort	Bft 4–5 (0.5–2.0 m waves)	Whitecaps frequent; avoid long-range optical ID
Visibility	5–10 km	Thermal useful
Precipitation	Light intermittent drizzle only	Abort on sustained rain
Cloud ceiling	≥ 150 m	Maintain visual horizon
Glare / Sun angle	Moderate; sun on water	Adjust gimbal tilt ≥ 25°
Temperature	0–5 °C or 35–40 °C	Monitor battery performance

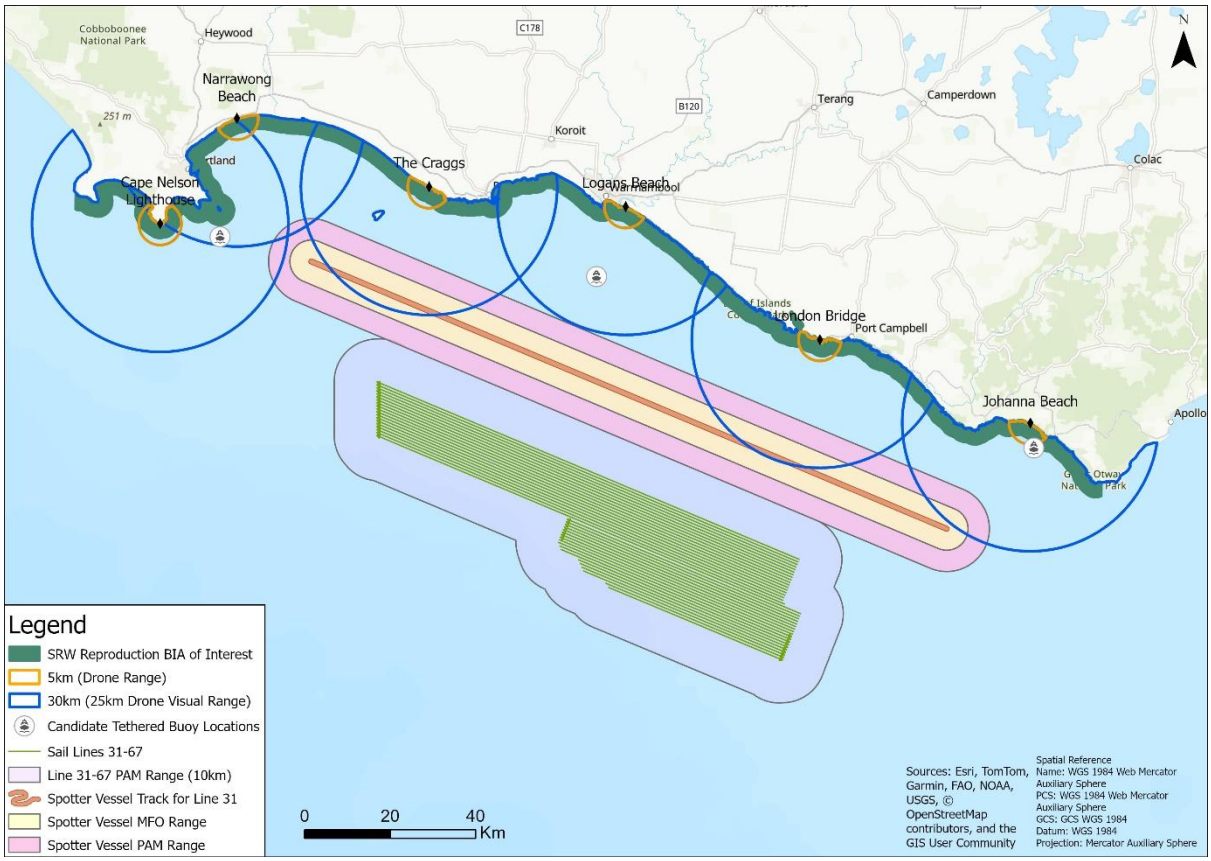


Figure G5-3 - Sub-Optimal Deployment Plan Coverage - Figure also shows the Regia MSS survey lines for September & October (lines 31-67) and indicative location of the spotter vessel that has PAM and MFO capacity.

2.3.3 No-Fly Plan

No-Fly weather days are characterised by adverse meteorological conditions that render drone operations unsafe or impractical. These conditions typically include high or gusting winds, heavy or persistent rainfall, low cloud cover, or reduced visibility, any of which can compromise flight stability, sensor performance, or personal safety. On these days, drone deployment will be suspended, and the focus of monitoring will shift entirely to shore-based visual observation.

Under this monitoring design, multiple PMSs are established along the coast wherever safe access can be gained, with the intent to provide broad visual coverage of the defined scope area during daylight hours. WMTs will be distributed across the broader region in a manner that supports this coverage objective (Figure G5-4).

A summary of the meteorological parameters that will typically define this plan is presented in Figure G5-4. These conditions are predicted to occur on approximately 25-30 % of days in September and October (see Appendix 2).

Under No-Fly conditions there will be no predefined PMSs due to the variable and unpredictable nature of adverse weather conditions. Instead, each WMT will identify and select the most suitable vantage points available on the day to maintain safe and effective visual coverage of their respective portion of the coast.

Given that heavy rain, strong winds, or rough coastal conditions may render certain locations unsafe or inaccessible, site selection on these days will remain highly adaptive. Teams will assess local

conditions in real time and make informed decisions regarding the safest and most practical observation points. In some cases, no coastal observations may be possible if weather or safety conditions prevent effective or safe deployment.

This approach is designed to maintain the maximum monitoring effort across the scope area that weather, and visibility allow. Even when drone deployment is not possible, WMTs will remain active and adaptive throughout the survey period.

Table G5-3 - No Fly Plan – Meteorological Parameters

Parameter	Threshold / Description
Wind	≥ 21.5 kt sustained or gusts > 23 kt
Beaufort Sea State	≥ Bft 6 (waves > 2 m, heavy whitecaps, spindrift)
Visibility	< 5 km or heavy haze / rain curtain
Precipitation	Rain, squalls, hail, or low cloud over site
Thunderstorms	Any convective activity within 10 NM
Temperature	< 0 °C or > 40 °C
Equipment / telemetry	GPS lock < 10 satellites, link instability, compass/IMU warning
Glare	Extreme surface reflection making horizon unreadable
Sea spray / salt fog	Persistent aerosol reducing visibility and risking corrosion

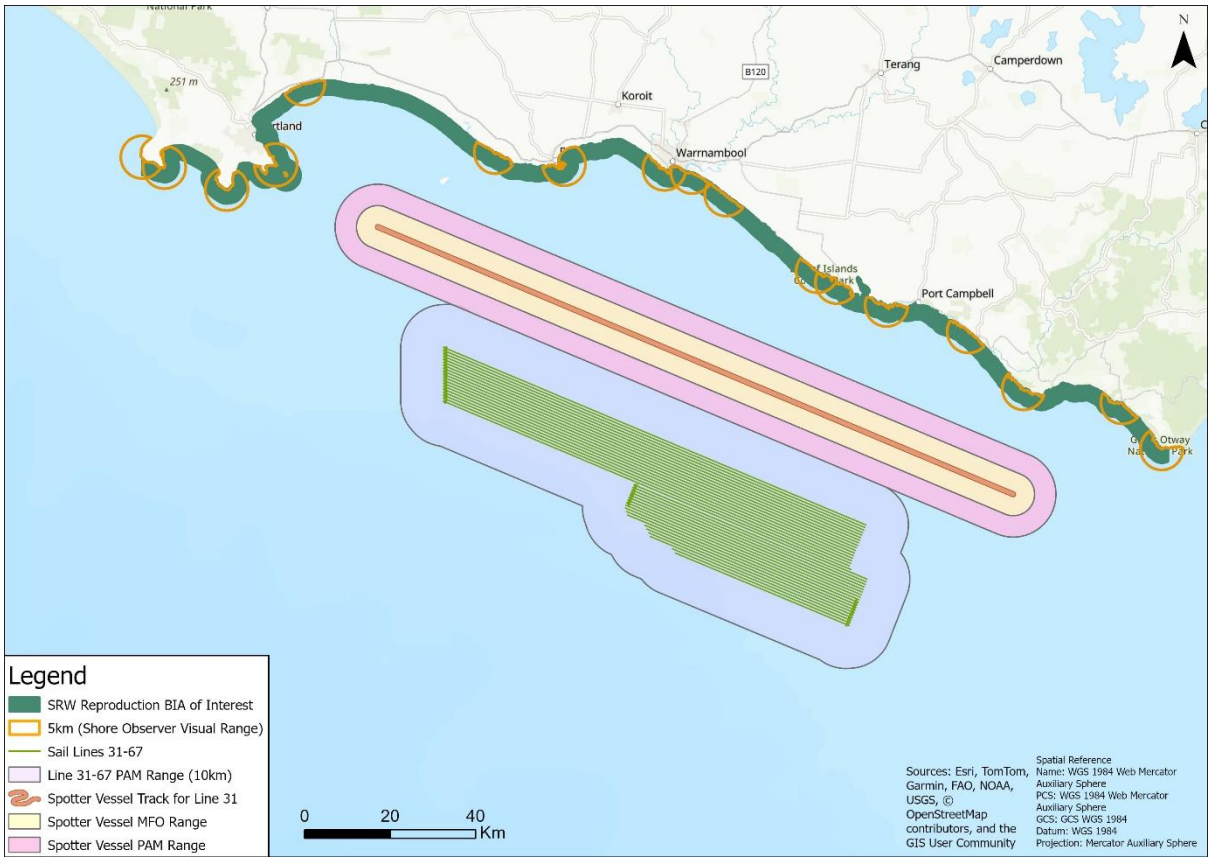


Figure G5-4 - No-Fly Plan Coverage - Figure also shows the Regia MSS survey lines for September & October (lines 31-67) and indicative location of the spotter vessel that has PAM and MFO capacity.

2.4 SRW Detection and Escalation Procedure

2.4.1.1 Confirmed Detection

A confirmed detection is a SRW sighting that has been verified by:

- a qualified MFO or an expert scientist in the field, and
- photographic/video evidence showing a visible time/date stamp and a geographically traceable location.

Only detections meeting this standard are treated as confirmed for shutdown and restart decisions. All confirmed and unconfirmed detections must be reported immediately to the Survey Environment Adviser (SEA) and the CGG Environment Officer.

2.4.2 SEA Decision Pathway

Upon receiving a detection, the SEA determines which pathway applies:

A. Confirmed Detection (from any platform)

1) If the survey is acquiring, the sound source must be shut down immediately.
2) The SEA records time and location and provides instructions to the Party Chief consistent with Appendix G2.
3) Restart may only occur after 24 hours with no confirmed detections from any platform.

B. Unconfirmed Detection

1) The SEA refers the sighting to the Whale Expert Panel (WEP) for advice within 2 hours of receiving the report.
2) The WEP provides advice on whether the sighting is likely to represent a SRW in or near the BIA.
3) If the WEP advises that the sighting is credible, the SEA must treat it as requiring precautionary action. If the survey is acquiring, the SEA will direct an immediate shutdown.
4) The SEA must also direct the nearest WMT to mobilise within 12 hours, where conditions allow, to investigate and attempt to verify the sighting.
5) If the WEP advises that the sighting is unlikely to be a SRW, the SEA may choose not to shut down but must still direct WMT verification.

This approach ensures potential SRW presence is taken seriously while maintaining evidence-based decision-making.

2.4.3 Daytime Procedure (Post-Confirmation)

If a WMT confirms a SRW inside the BIA after shutdown, the team will continue monitoring for as long as daylight and visibility allow or until visual contact is lost. The 24-hour restart clock begins from the last daylight confirmed observation of the SRW within the BIA.

2.4.4 Night-Time Procedure

If a WMT has confirmed SRW presence during daylight and daylight ends:

- Night-time monitoring is not feasible due to safety and visibility constraints.
- The WMT must return to the last confirmed location at first light.
- If the SRW is not observed, the 24-hour restart clock begins from the time absence is confirmed.

The survey remains shut down overnight.

2.4.5 External Sightings and Citizen Science Information

WMTs may use external information (citizen science programs, whale-watching platforms, or social-media reports) to support situational awareness and detection confirmation.

Only reports with verifiable photographic/video evidence (time/date-stamped, traceable location) may be treated as confirmed detections unless verified independently by a WMT or expert.

All other external reports are treated as unconfirmed detections and escalated through the SEA and WEP as per Section 2.2.2(B).

3 Monitoring Framework – Blue Whale

3.1 Purpose and Objectives

The proposed timing of the Regia MSS sits between the end of the SRW season and the beginning of the BW season. Managing the interaction of these two groups with the MSS requires a real-time understanding of their numbers in time and space. Shore or boat based visual surveillance is a traditional method for visual detection of whales, but the spatial coverage is limited due to vessel speeds and viewing height above water. Drones, however, now provide a relatively low-cost method for drastically increasing visual coverage at higher speeds and vantage points.

Drones will be used to detect BW as they arrive at the Otway region ahead of their foraging season, which typically occurs between November and March each year.

BW arrive in the Otway region following historical marine highways, which lead them down the West Coast, around the SW Cape and directly across the Great Australian Bight to feed on krill associated with the upwelling systems off the Otway coast. Because of this consistent west to east path, flights launched from Cape Nelson could improve early detectability through more extensive searching of offshore waters than is otherwise possible.

3.2 Site Rationale

Cape Nelson is one of the few vantage points along the southwest Victorian coast where BW can, at times, be observed from shore. Located west of the Operational Area, it is likely to be the first location through which BW pass as they arrive at the region. Its elevation above sea level and orientation toward the offshore feeding zone reduce curvature limitations, maximise sensor line-of-sight, and minimise transit time to areas of interest. The lighthouse precinct offers secure ground infrastructure suitable for controlled Beyond Visual Line of Sight (**BVLOS**) operations. Taken together, these characteristics make Cape Nelson the most suitable site for launching long-range surveillance intended to detect early BW presence.

3.3 Operational Context

Flights will focus on monitoring near-shore to mid-shelf sectors, up to approximately 40 km offshore of Cape Nelson, aligned with recent historical observations (Figure G5-5 and Figure G5-6) and expected prey distribution, using established altitudes, ranges, and sensor configurations appropriate to BVLOS over-water operations. Weather-responsive scheduling will be used to capitalise on short windows of suitable conditions. Outputs will include time-stamped georeferenced imagery and observation notes sufficient to confirm presence/absence, general distribution, and indicative movement, providing an early signal for subsequent survey scaling.

3.4 Summary

Pre-season aerial surveillance from Cape Nelson Lighthouse has the potential to provide a practical and strategically positioned means to confirm early blue whale arrival using an already trialled drone platform and procedures. The activity supports timely decision-making for the duration of the Regia MSS and offers a low-impact, cost-effective approach to initiating broader monitoring efforts once presence is confirmed.



Figure G5-5 - Sub-optimal Drone Range and Historical Blue Whale Sightings in November (OBIS-SEAMAP)



Figure G5-6 - Optimal Drone Range and Historical Blue Whale Sightings in November (OBIS-SEAMAP)

4 Document Control

Version	Date of Revision	Author/Reviewer	Summary of Changes
0.1	1 December 2025	RH, EO	Document Created

Appendix 1 - Cape Nelson Lighthouse - September-October Operational Weather Analysis (1995 - 2025 Analysis)

4.1 Executive Summary

This report provides an analysis of a 30-year (1995–2025) climatological dataset that considers wind, rainfall, and associated environmental factors that have the potential to affect drone operations at Cape Nelson Lighthouse, Victoria. Cape Nelson was chosen as the sole analysis site because it is the most exposed headland on the regional coastline, directly influenced by the Southern Ocean.

Of the total feasible fly-time, optimal conditions are projected to occur based on historical averages, between 10 and 15 percent of the time, while sub-optimal but flyable conditions are anticipated for approximately 55 to 60 percent of the period.

Taken together, these results indicate that drone deployment is feasible for an estimated 70 to 75 percent of the September–October period, with the remaining 25 to 30 percent classified as no-fly conditions due to wind or rainfall exceeding operational thresholds.

The weather analysis conducted was used to develop threshold-based definitions for three categories of drone operations: Optimal, Sub-optimal, and No-Fly conditions. These definitions are presented below:

Condition Level	Wind Speed (km/h)	Rainfall (mm/day)	Environmental Description	Operational Guidance
Optimal	≤ 20	≤ 1	Calm to light winds and dry or near-dry conditions. Excellent visibility and platform stability.	Safe for full-scale drone operations. Ideal for mapping, whale observation, and precision video capture.
Sub-optimal	21–40	>1 to ≤10	Moderate winds or intermittent light rain. Some turbulence and minor visibility reduction expected.	Proceed with caution. Experienced pilots only. Reduce altitude, range, and payload weight. Monitor gusts.
No-fly	>40	>10	Strong winds or moderate to heavy rain associated with frontal systems. High turbulence and low visibility.	Suspend all drone operations. Unsafe for launch, flight, or recovery. Resume only when conditions improve.

4.2 Introduction

This report presents a climatological assessment of environmental conditions relevant to drone deployment at Cape Nelson Lighthouse, Victoria. Using 30 years of Bureau of Meteorology (BOM) data (1995–2025), the analysis evaluates wind speed, direction, and rainfall to determine operational feasibility for over-water drone surveys during the Austral spring months of September and October. This assessment draws on daily climate observations obtained from the Bureau of Meteorology's Climate Data Online database (Station ID: 090184) for the full 1995–2025 period.

The findings provide a data-driven foundation for defining optimal, sub-optimal, and no-fly thresholds, enabling informed scheduling, risk management, and field safety planning for marine monitoring activities.

Overall, the results show Cape Nelson experiences drone-deployable conditions approximately 70% of the time, when wind and rainfall are within acceptable operational limits.

Fully optimal conditions are defined as wind speeds below 20 km/h and rainfall less than 1 mm per day - occur on average 10-15% of the time, primarily during calm morning windows associated with high-pressure systems. Sub-optimal conditions, where operations remain viable but require pilot discretion, represent on average 55-60% of the period, while no-fly conditions (winds >40 km/h or rainfall >10 mm) occur on average 30% of the time, generally aligned with frontal weather systems. This report combines these meteorological patterns to provide practical guidance for deployment planning, ensuring that operations can be conducted safely, efficiently, and with minimal disruption due to environmental constraints.

4.3 Site Selection Rationale – Cape Nelson Lighthouse

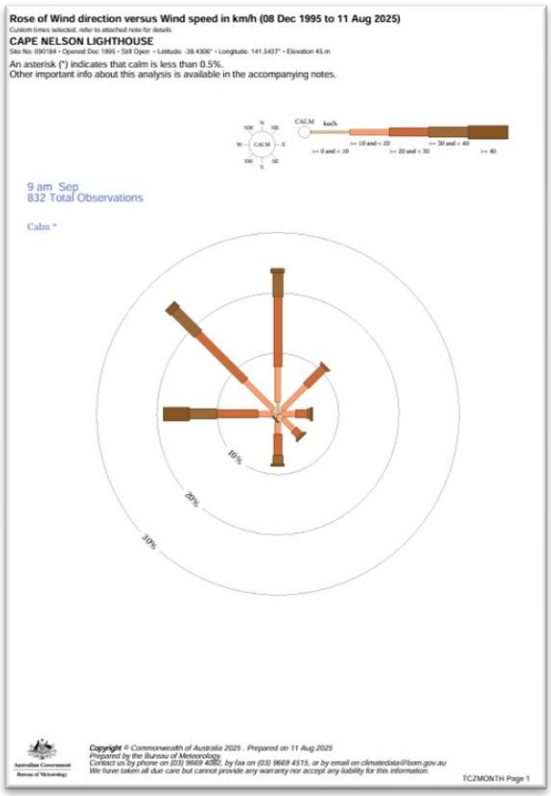
Cape Nelson Lighthouse was selected as the single reference location for this weather analysis because it represents the most exposed and meteorologically demanding site along the regional coastline. Positioned on a prominent headland facing the Southern Ocean, Cape Nelson experiences the full impact of prevailing westerly and south-westerly systems, including the strongest winds, highest rainfall totals, and most rapid weather changes. These conditions consistently exceed those recorded at more sheltered inland or coastal stations. As a result, using Cape Nelson as the baseline ensures that the operational thresholds and risk assessments presented in this report are based on worst-case environmental conditions. If drone deployment is feasible under Cape Nelson parameters, it is expected to remain safe and viable at any nearby site with more moderate exposure, providing a conservative and reliable foundation for regional flight planning.

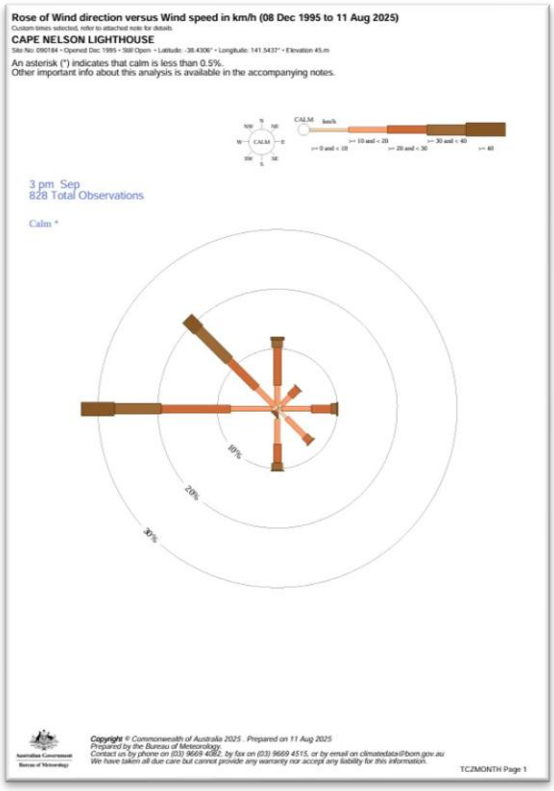
4.4 Wind

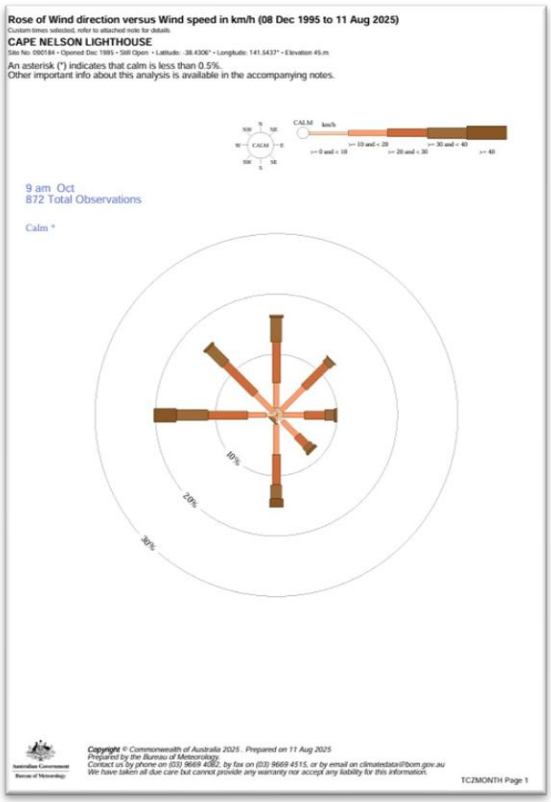
Wind conditions at Cape Nelson Lighthouse were observed to be consistently strong throughout September and October, reflecting the region's exposure to prevailing westerlies from the Southern Ocean. Long-term BOM data show mean wind speeds of approximately 24 km/h at both 9 AM and 3 PM, with stronger afternoon winds being common, especially in October. Wind rose analysis confirms that winds exceeding 20 km/h occur over 80% of the time, while calm conditions (<10 km/h) are rare (<5%). The dominant wind directions are from the west to northwest, occasionally shifting southerly in the afternoon.

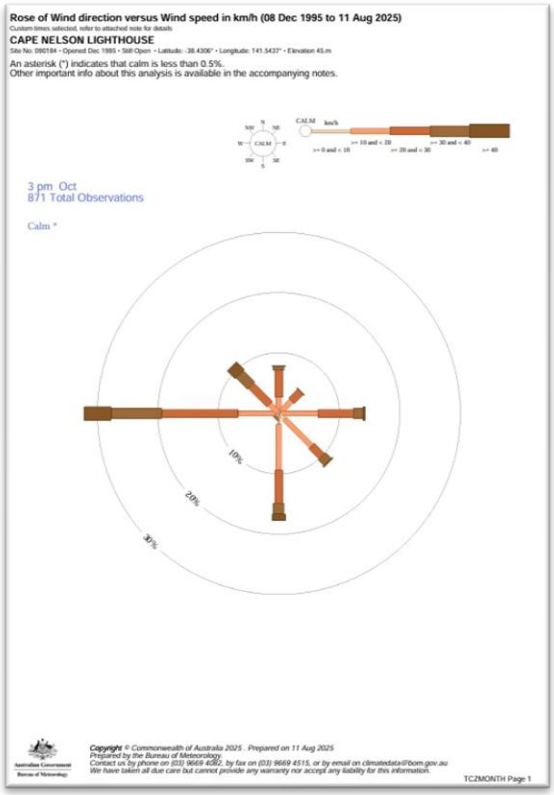
For drone operations, these conditions indicate that moderate to strong winds (20–40 km/h) should be expected during most daylight hours. Optimal flight windows are likely to occur during brief calm periods in the early morning, especially under wind speeds below 20 km/h, which represent only 15–20% of observations. Pilot discretion should remain critical due to the expected rapid onset of gusts exceeding 40 km/h.

Time / Month	<10 km/h	10–20 km/h	20–30 km/h	30–40 km/h	>40 km/h	Most Prevalent Wind Directions	Additional Information
9 AM Sep	~5 %	~10 %	~25 %	~40 %	~20 %	W, NW, N	Strong morning westerlies
3 PM Sep	~5 %	~10 %	~25 %	~40 %	~20 %	W, NW, S	Afternoon pattern mirrors morning but slightly more southerly winds
9 AM Oct	~5 %	~10 %	~30 %	~35 %	~20 %	W, NW, N	Persistent westerlies with slightly higher moderate winds
3 PM Oct	~5 %	~10 %	~25 %	~35 %	~25 %	W, NW, S	Strongest winds overall; higher incidence >40 km/h


Rose of Wind direction versus Wind speed in km/h (08 Dec 1995 to 11 Aug 2025)
CAPE NELSON LIGHTHOUSE
An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.
9 am Sep
832 Total Observations
Calm *
10%
20%
30%
TCZMONTH Page 1


Rose of Wind direction versus Wind speed in km/h (08 Dec 1995 to 11 Aug 2025)
CAPE NELSON LIGHTHOUSE
An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.
3 pm Sep
828 Total Observations
Calm *
10%
20%
30%
TCZMONTH Page 1


Rose of Wind direction versus Wind speed in km/h (08 Dec 1995 to 11 Aug 2025)
CAPE NELSON LIGHTHOUSE
An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.
9 am Oct
872 Total Observations
Calm *
10%
20%
30%
TCZMONTH Page 1


Rose of Wind direction versus Wind speed in km/h (08 Dec 1995 to 11 Aug 2025)
CAPE NELSON LIGHTHOUSE
An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.
3 pm Oct
871 Total Observations
Calm *
10%
20%
30%
TCZMONTH Page 1

4.5 Defined Operational Conditions – Wind

September

Condition Level	Wind Speed (km/h)	Approx. Frequency (% of time)	Operational Guidance	Key Points for Planning
Optimal	0–20	15%	Safe for full-scale drone operations. Ideal for long-range surveys, whale detection, or detailed mapping.	Calm morning windows before strengthening westerlies. Occurs mainly around sunrise to mid-morning.
Sub-optimal	21–40	65%	Suitable for experienced pilots only. Maintain shorter flight durations and reduced altitudes.	Moderate to strong westerlies dominate most of the day. Maintain visual line-of-sight over water.
No-fly	>40	20%	Suspend all drone operations. Winds and gusts exceed safe control limits.	Frequent strong westerly gusts; ensure all equipment secured. Pilot discretion required to resume.

October

Condition Level	Wind Speed (km/h)	Approx. Frequency (% of time)	Operational Guidance	Key Points for Planning
Optimal	0–20	15%	Proceed with operations during calm early-morning periods. Excellent visibility and platform stability.	Calm periods shorter than September; prioritise early flights.
Sub-optimal	21–40	63%	Continue operations with caution. Reduce flight range and duration. Maintain awareness of shifting wind direction.	Afternoon conditions stronger and more variable (W–S sector). Maintain buffer for gusts.
No-fly	>40	22%	Suspend operations. Turbulent airflow and high gusts exceed control tolerances.	October prone to stronger spring winds; monitor gust forecasts.

Combined Averages

Condition Level	Wind Speed (km/h)	Approx. Frequency (% of time)	Operational Guidance	Key Points for Planning
Optimal	0–20	15%	Fully suitable for over-water flights, high-resolution observation, and extended coverage.	Short, reliable windows—mostly in early morning under stable westerlies.
Sub-optimal	21–40	64%	Viable for limited operations under pilot discretion. Shorter flights and reduced payloads recommended.	Most common condition; use this band for regular flight planning.
No-fly	>40	21%	Ground all operations; unsafe for drone control or recovery over water.	Expect multiple high-wind days per week; plan standby or alternate tasks.

4.6 Rain

Rainfall during this period averages 18.7 days in September and 15.8 days in October, though most events are light (<10 mm).

	September	October
Mean number of days of rain >= 1 mm for years 1995 to 2025	12.8	9.1
Mean number of days of rain >= 10 mm for years 1995 to 2025	2.1	1.2

4.7 Defined Operational Conditions – Rainfall

September

Condition Level	Rainfall (mm/day)	Approx. Frequency (% of time)	Operational Guidance	Key Points for Planning
Optimal	≤ 1	~58%	Safe for full-scale drone operations. Light or no precipitation allows clear visibility and stable flight.	Most days are light or dry. September still experiences regular light rain but short-lived.
Sub-optimal	>1–10	~38%	Fly with caution. Reduced visibility and light moisture can affect sensors and optics. Limit flight duration.	Typical during frontal passages. Allow drying time for equipment after light showers.
No-fly	>10–25	~4%	Suspend all drone operations. Moderate to heavy rainfall creates unsafe conditions for takeoff, flight, and recovery.	Occasional heavier rain days; usually associated with passing cold fronts.

October

Condition Level	Rainfall (mm/day)	Approx. Frequency (% of time)	Operational Guidance	Key Points for Planning
Optimal	≤ 1	~70%	Fully suitable for flight operations. Minimal rainfall supports longer flight windows and safe equipment handling.	October is drier and more stable than September. Ideal for extended operations.
Sub-optimal	>1–10	~27%	Operate with caution during light showers. Maintain visual contact and assess water exposure on equipment.	Occasional light rain; often short-lived. Avoid over-water recovery during precipitation.
No-fly	>10–25	~3%	Ground all operations. Heavy rain severely limits visibility and can damage electronics.	Heavy rain days are rare; monitor forecasts to plan around them.

Combined Averages

Condition Level	Rainfall (mm/day)	Approx. Frequency (% of time)	Operational Guidance	Key Points for Planning
Optimal	≤ 1	~64%	Ideal for consistent flight scheduling with minimal precipitation interference.	Majority of operational days are dry or lightly damp; early-morning dew possible.
Sub-optimal	>1–10	~33%	Proceed cautiously; intermittent light rain may disrupt data capture.	Use water-resistant drones or delay until rainfall ceases.
No-fly	>10–25	~3%	Suspend all flights. Heavy rain significantly increases operational risk.	Rare but impactful; align operations around dry periods.

4.8 Wind-Rain Relationship at Cape Nelson

At Cape Nelson (and most exposed southern coastal sites in Victoria), windy days and rainy days are highly correlated because both are typically driven by passing low-pressure systems and cold fronts.

Key Points:

- Strong westerlies and heavy rain are part of the same synoptic event — frontal systems from the Southern Ocean.
- Calm, dry periods occur under high-pressure ridges between fronts.
- So, the same weather system that brings >40 km/h winds also produce most of the rainfall >10 mm.

4.9 Adjusted Interpretation of Deployment Opportunity

Given the correlation between wind and rain, the restrictions shouldn't be double counted. Instead, most "rain-restricted" days overlap with "wind-restricted" days.

Adjusted Combined Estimate (Factoring Overlap):

Condition	Combined (Wind + Rain)	Adjusted Occurrence	Operational Meaning
Optimal	Calm (<20 km/h) and Dry (≤1 mm)	**10-15%**	Excellent windows — clear, dry, and stable. Usually early morning under high pressure.
Sub-optimal	Moderate wind (20–40 km/h) and/or light showers (≤10 mm)	**55-60%**	Most common. Light drizzle or gusty periods, but often flyable. Pilot experience essential.
No-fly	High wind (>40 km/h) and/or moderate-heavy rain (>10 mm)	**25-30%**	Typically, the same frontal events. High turbulence, rain, and low visibility.

4.10 Summary

Analysis of long-term data from Cape Nelson Lighthouse (1995–2025) indicates that wind and rainfall restrictions are strongly interrelated. The site is highly exposed to Southern Ocean weather systems, where the passage of low-pressure troughs and cold fronts produces both elevated wind speeds and rainfall events. These systems typically generate westerly or north-westerly winds exceeding 40 km/h, coinciding with the majority of rainfall days (>1 mm). Consequently, days restricted by rainfall are usually the same days restricted by wind, rather than separate occurrences. In contrast, calm and dry periods occur under high-pressure ridges that follow frontal passage, resulting in stable, dry conditions with wind speeds typically below 20 km/h. These periods provide the most favourable conditions for drone deployment, offering clearer visibility, minimal turbulence, and reliable flight control.

When this overlap is accounted for, the combined analysis shows that approximately 70% of the September–October period is potentially usable for some level of drone operation. Within this window, 10-15% of days present fully optimal conditions - light winds (<20 km/h), dry weather (≤1 mm rainfall), and stable air - ideal for full-scale drone operations. The remaining 55-60% of the time falls into a sub-optimal but manageable category, characterised by moderate winds (20-40 km/h) or light showers. No-fly conditions (>40 km/h winds or >10 mm rainfall) are limited to approximately 25-30% of the time, typically concentrated around cold-front events.

Operational planning should therefore emphasise flexibility, with teams ready to mobilise rapidly during calm high-pressure intervals, which often persist for two to three consecutive days. Scheduling should avoid the days immediately surrounding frontal activity, when gusts and residual instability remain high despite clearing rainfall.

4.11 Full Operational Conditions Parameters

Optimal Conditions

Parameter	Optimal Conditions Threshold	Notes
Wind	≤ 10 kt (≤ 20 km/h) sustained, gusts ≤ 15 kt (28 km/h)	Stable hover and control; minimal gimbal movement.
Beaufort Sea State	≤ Bft 3 (wave height < 0.5 m)	Calm to slight seas; stable horizon reference for optical tracking.
Visibility	≥ 10 km	Full horizon clarity for long-range optical identification.
Precipitation	Nil	Dry airframe and optics; optimal camera performance.
Cloud Ceiling	≥ 300 m	Safe vertical separation and strong line-of-sight.
Glare / Sun Angle	Low or manageable	Good contrast for tracking and horizon definition.
Temperature	5–35 °C	Normal operational range for batteries and sensors.

Sub-Optimal Conditions

Parameter	Sub-Optimal Conditions Threshold	Notes
Wind	11–21.5 kt (21–40 km/h) sustained, gusts ≤ 23 kt (43 km/h)	Moderate turbulence; requires skilled pilot control.
Beaufort Sea State	Bft 4–5 (0.5–2.0 m waves)	Noticeable whitecaps; minor horizon instability.
Visibility	5–10 km	Haze or marine layer; maintain conservative range.
Precipitation	Light drizzle or 1-10 mm/day	Limit flight duration; monitor sensor moisture.
Cloud Ceiling	150–300 m	Lower clearance; operate at reduced altitude.
Glare / Sun Angle	Moderate glare	Use filters or adjust angle of approach.
Temperature	0–5 °C or 35–40 °C	Battery and sensor efficiency reduced; shorten flights.

No-Fly Conditions

Parameter	No-Fly Threshold	Notes
Wind	> 21.5 kt (> 40 km/h) sustained or gusts > 23 kt (> 43 km/h)	Unsafe for control; excessive drift and instability.
Beaufort Sea State	≥ Bft 6 (wave height > 2.0 m)	High seas; severe horizon instability and spray risk.
Visibility	< 5 km	Unsafe for navigation or VLOS/BVLOS flight.
Precipitation	> 10 mm/day (moderate to heavy rain)	Electronics and optics at risk; terminate flight.
Cloud Ceiling	< 150 m	Insufficient clearance for safe operation.
Glare / Sun Angle	Severe glare or low sun directly on horizon	Loss of horizon contrast; risk of sensor blinding.
Temperature	< 0 °C or > 40 °C	Exceeds manufacturer safety range; hardware failure likely.

4.12 Justification of Flight Environment Parameters

There are currently no legislated environmental parameters specific to Remotely Piloted Aircraft System (RPAS) operations in Australia beyond the overarching requirement under the Civil Aviation Safety Regulations (CASR) for operators to maintain safe control and operate within aircraft limitations. Accordingly, the environmental parameters defined in this report have been established using a combination of manufacturer specifications, aeronautical best practice, and empirical field experience obtained through extensive on-site observation and trial operations conducted by the project team at Cape Nelson during the current season, in preparation for next year's deployment.

The wind parameters are derived conservatively from the DJI Matrice 350 RTK / H30T system's manufacturer-rated maximum wind resistance of approximately 43 km/h (23 kt). Operating at or near this upper limit presents an unacceptable risk margin for coastal BVLOS operations, where mechanical turbulence, terrain-induced shear, and abrupt gusting are common. To ensure stable flight control, accurate telemetry, and reliable gimbal performance, the Sub-optimal category is limited to 40 km/h (21.5 kt) sustained wind, with any sustained or gust conditions above this level classified as No-Fly. This approach provides a buffer below the manufacturer limit, consistent with aviation risk-management principles that require operational ceilings below technical maxima.

Other environmental parameters, including Beaufort Sea State, visibility, cloud ceiling, precipitation, and temperature, have been benchmarked against CASA Beyond Visual Line of Sight (BVLOS) operational guidance under CASR Part 101 and associated Advisory Circulars, together with established industry best practice for over-water RPAS operations. These frameworks collectively require operators to define environmental limits that preserve safe control, telemetry integrity, and situational awareness equivalent to or better than Visual Line of Sight (VLOS) operations.

A minimum visibility of 5 km has therefore been adopted to ensure reliable sensor-based situational awareness and effective use of electro-optical and thermal payloads for target detection and tracking. The cloud-ceiling thresholds maintain adequate vertical separation from coastal terrain while preserving uninterrupted command-and-control links. Precipitation limits are based on payload manufacturer guidance and field observations demonstrating that even light moisture, glare, and refraction significantly reduce optical and thermal imaging performance and can impact electrical components.

Collectively, these parameters represent accurate, fair, and conservative operating envelopes for BVLOS marine drone operations at Cape Nelson and similar exposed coastal environments. They ensure flight safety, maintain data quality, and provide a transparent, defensible framework suitable for regulatory review and inclusion within the operator's Safety Management System and Operations Manual in the absence of formal legislative limits.

Appendix 2 – Technology Specifications – Drone and Camera

This section presents examples of proposed technology-types that may be used to support long-range aerial whale monitoring, including examples of commercially available drones and associated high-performance optical sensors/cameras for attachment to a drone, expected to be capable of meeting the operational requirements. While the exact makes and models have not yet been selected, the examples have been provided to demonstrate the general capabilities of systems currently available on the market. Sections 4.13 and 4.14 present indicative drone platforms and camera specifications (with links to publicly available technical data), while Section 4.15 illustrates how the proposed camera technology is technically capable of detecting and observing whales at distances of up to 25 km under suitable conditions.

4.13 Example of Drone Specifications -DJI Matrice 400

https://enterprise.dji.com/matrice-400/specs

4.14 Example of Camera Specifications - Zenmuse H30 Specs:

https://enterprise.dji.com/zenmuse-h30-series/specs

4.15 Demonstration that the H30T Tele Camera Can Visually Detect a Whale at 25 km

Demonstrate, on an optics-only basis (independent of radio link or endurance), that the Zenmuse H30T telephoto camera provides sufficient angular resolution to resolve a whale at a slant range of 25 km under clear atmospheric conditions and low sea state.

Basis and Parameters:

- Camera geometry: Zenmuse H30T tele module, horizontal field of view (HFOV) 15° with 8192 effective horizontal pixels.

  Per-pixel angular subtense $\alpha = \frac{15^\circ \times \pi/180}{8192} \approx 3.20 \times 10^{-5}$ rad/px.

- Target: Southern right whale; adult body length typically 14–18 m. To account for foreshortening, partial emergence, and non-broadsides presentation, adopt a conservative apparent dimension of 10 m.

- Range of interest: $R = 25{,}000$m.

- Identification criterion: Johnson/NATO electro-optical standards (50 % probability) require approximately 12–13 pixels across the critical dimension to achieve identification (recognition is ≈8 px; detection ≈2 px).

- Line-of-sight geometry: Operation at or below 120 m AGL (Above Ground Level).

Optical Resolving Power at 25 km

The target's angular extent at 25 km with a 10 m apparent dimension is

$$\theta = \frac{10}{25{,}000} = 4.0 \times 10^{-4} \text{ rad.}$$

Pixels across the target are:

$$N = \frac{\theta}{\alpha} = \frac{4.0 \times 10^{-4}}{3.20 \times 10^{-5}} \approx 12.5 \text{ px.}$$

Interpretation: Even under the conservative 10 m apparent size, the body spans ~12.5 px, which meets the Johnson identification threshold. Using the typical adult length (14-18 m) would yield ≈17.5–22.5 px at the same range, providing additional margin.

Line-of-Sight Constraint:

From 120 m AGL, the geometric horizon to sea surface is ~39 km (to the top of a 5 m blow ~47 km). A 25 km slant range is therefore well within the curvature-limited line of sight and does not constrain the optical result.

4.16 Conclusion

On an optics-only basis, the Zenmuse H30T tele camera provides ≥12 pixels across a conservatively modelled 10 m whale body at a slant range of 25 km, satisfying the Johnson identification criterion. Line-of-sight at ≤120 m AGL does not limit this range. Accordingly, a 25 km visual observation claim is conservative and technically supported by the camera's angular sampling.