Coastal Processes and Marine Ecology Impact Assessment

Point Nepean Research and Education Field Station

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1 Introduction

The University of Melbourne (UoM) and Monash University are collaboratively working to the Point Nepean Research and Education Field Station (PNREFS). The facility is to be situated within and adjacent to Badcoe Hall at the Point Nepean Quarantine Station precinct in the Point Nepean National Park, Victoria.

As part of this project, UoM and Monash University have contracted BMT to design the seawater intake and outfall system which will feed the external tanks, laboratory and aquaria at the proposed facility. BMT has also been tasked with supporting the applications for approvals associated with marine aspects of the project. The proposed concept design of the seawater intake and outfall system is outlined in the following section of this report. Based on the proposed concept and regulating agencies advice (DELWP, Parks Victoria, EPA), the marine approvals required for the project are:

- Consent under the *Marine and Coastal Act 2018* ('MaCA Consent').
- Development Licence for prescribed development activity B03 – Fish farms under the *Environment Protection Act 2017* (EP Act) and regulations ('EPA Development Licence') OR a licence exemption.
- Operating Licence for prescribed development activity under the EP Act and regulations ('EPA Operating Licence') OR a licence exemption.
- Works Permit in a Waterway / Marine Area – to be sought before construction from the Local Port Authority (Parks Victoria for the location of this project).

Each of these approvals require information regarding the potential impacts of the coastal and marine construction works and the facility while in operation on the marine environment.

In line with the above, and in support of applications for all approvals, this assessment will consider the impacts of the proposed works on the marine and coastal environment, with focus on following:

- Coastal processes (including waves, tides and sediment movement)
- Marine ecology in the study area
- Water quality

The objectives of this report are to support applications for the various consents and licenses mentioned above. Initially, this report will also support the submission of an Environmental Effects Statement (EES) referral to the Department of Land Water and Planning (DELWP) by the project team.

1.1 Study Area

The Point Nepean Quarantine Station Precinct (see Figure 1.1) is located on the northern coast (Port Phillip Bay side) of the Mornington Peninsula approximately 4km east of the tip of Point Nepean. The precinct and the broader Point Nepean National Park area are culturally important locations for peoples of both indigenous and European descent. Pre-colonisation, it is reported the area was predominantly utilised by women with areas for birthing, women's ceremony, and initiation rituals (Bunurong Land Council Aboriginal Coorporation, n/d).

After colonisation, the area became the 'Quarantine Station' where boats travelling to Melbourne would anchor offshore and be quarantined for a time to ensure no viruses or sicknesses would be transmitted to local Melbournians when passengers disembarked. In some cases, many people died while in quarantine and were buried in cemeteries within what is now Point Nepean National Park. The army assumed control of the facilities from 1950-1998 and introduced the Officer Cadet School. After this, the area became the Point Nepean National Park (Nepean Historical Society, n/d).

Offshore, the study area is predominantly characterised by strong tidal currents which run through Port Phillip Heads. Ocean swells propagate through the Heads in some instances and impact beaches at the Quarantine Station, however the area is largely protected. There is a seawall at the back of the beach infront of the Parade Ground and more naturalised dune systems west of this. During summer months, the Point Nepean National Park is popular predominantly for swimmers and bushwalkers.

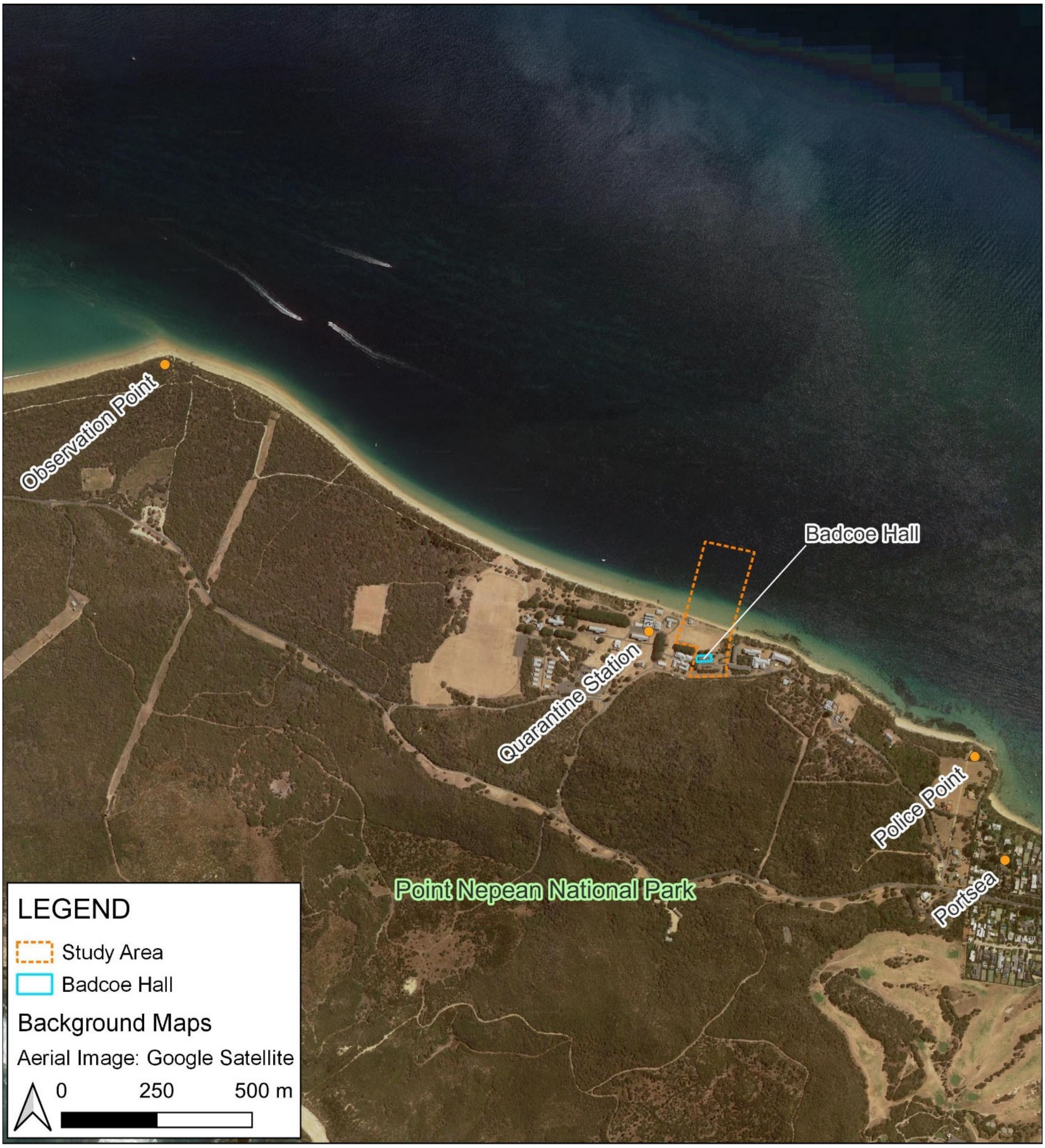

Figure 1.1 Study Area Map – PNREFS

2 Planned Works

Designs for the marine components of the proposed seawater system for the PNREFS have been developed by BMT (up to Concept Design level). The design includes the following:

- Horizontal directional drilling (HDD) of the seawater intake and outfall pipes from the PNREFS building next to Badcoe Hall to a location approximately 170m offshore (as indicatively shown on Figure 2.1.
- A seawater intake valve inside a precast concrete end-structure protected from entrainment and intake of biota by a mesh screen. This will be sitting on a concrete mattress to protect from scour.
- A seawater outfall system with a diffuser nozzle outlet to be protected by a concrete structure to shield from falling objects (e.g., anchors). This will be sitting on a concrete mattress to protect form scour.

Installation works will include:

- Excavating a pit inland from which to begin the HDD operations (which will follow the technical guide attached in Annex B).
- Drilling the pipelines from the landside and pushing the pipelines through. This step will use natural drilling lubrication fluids such as a bentonite (clay) slurry.
- Small scale excavation of the seabed (using air lifting of materials) to reach the seaward end of the HDD pipe.
- Concrete encasing structures around both the intake and outfall will be pre-cast and lowered into place during construction.

Once installed, effluent emitted from the outfall is modelled to disperse fully, to background seawater concentration levels, within 25m from the outlet diffuser.

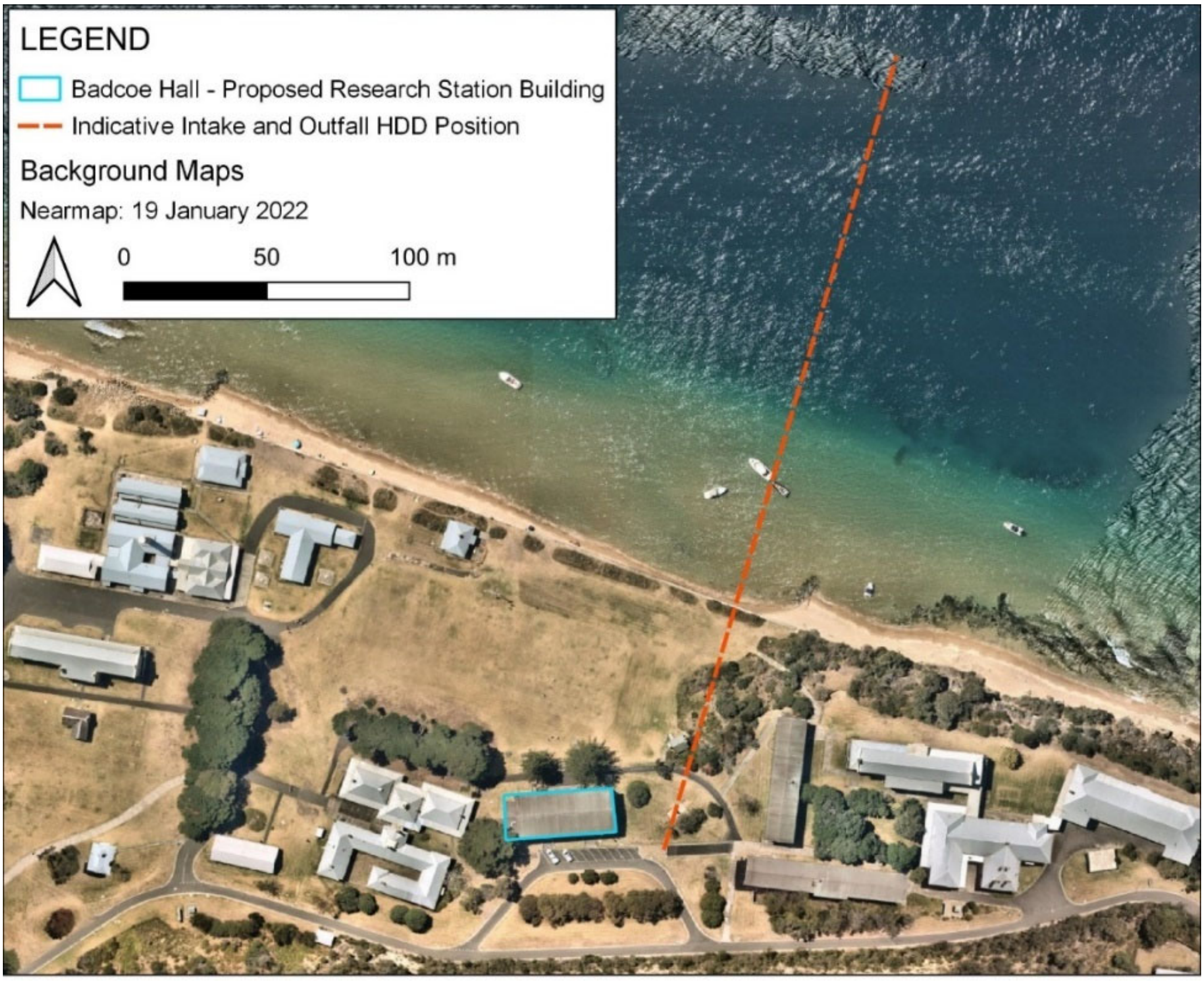

Figure 2.1 Proposed marine components of the Seawater System for the PNREFS

2.2 Policy Context

The project team, including Urbis as planning consultants, have previously completed an in-depth review of all potentially relevant legislation to identify all approvals that UoM and Monash University will require for the development of the PNREFS. Key approvals/studies required include an EPBC Self-Assessment, Heritage Permit, Cultural Heritage Management Plan, Planning Permit/Approval, MACA Consent, EPA Development License, EPA Operating License, Works Permits.

BMT are currently supporting UoM and Monash University to prepare the MACA Consent application, as well as the EPA approvals, which pending on feedback from the EPA may take the form of either licenses or license exemptions. The policy context for each of these approvals are outlined below. We note that additional approvals to these are also required, however the focus of this report is on the marine components, as outlined above.

Marine and Coastal Act (2018) Consent

For consent to be granted under the MACA the proposed works must meet certain criteria as follows.

The proposed works must be in line with:

- The objectives and guiding principles set out in Part 2 of the MACA.

- The Victorian Marine and Coastal Strategy 2014
- Any plans prepared under a regional and strategic partnership which may apply to the land.
- Any applicable environmental management plan
- Any applicable coastal or marine management plan
- Any relevant coastal recommendation

More specifically, the MACA consent assesses the long- and short-term Environmental, Social and Economic impacts of the proposed works. This includes impacts to coastal processes and the marine and terrestrial coastal environments, including impacts to individual at-risk species and coastal communities.

EPA Development License

For a development license to be granted by the EPA, the proposed works must meet the provisions set out under s69(3) of the *Environment Protection Act* (2017) as follows.

The proposed works must:

- Comply with the general environmental duty
- Have acceptably low potential impacts to human health, and the environment, including the impact on any environmental values identified in any relevant environment reference standard
- Comply with the principles of environment protection
- Utilise the best available techniques or technologies
- Comply with the EP Act and relevant regulations
- Also be assessed favourably by any other required regulatory agency

Specifically, the EPA Development approval will assess the potential impacts of the proposed works on human health and the environment regarding contamination and/or pollution of air, noise, water land and groundwater, odour and waste. For the PNREFS, impacts such as these may stem from the ocean outfall and the laboratory solid waste stream.

EPA Operating License

For an operating license to be granted by the EPA, the proposed works must meet the provisions set out under s74(3) of the *Environment Protection Act* (2017). These provisions are the same as those listed above required for the Development License. The Operating License is the mechanism whereby the EPA prescribes any required conditions which must be met during operation of the facility. These conditions will likely include limits to concentrations of certain potential pollutants in the effluent water to ensure minimal impact to water quality in the local area from the facility.

EPA License Exemption

For an exemption for either a development license or an operating license to be granted by the EPA, the proposed works must meet the provisions set out under r24 of the *Environment Protection Regulations* (2021) as follows.

The proposed works must:

- Comply with the purposes of the EP Act
- Comply with the Objective of the Authority

- minimise litter and waste disposal by encouraging the management of waste in accordance with the EPA waste management hierarchy
- promote waste reduction, resource recovery and resource efficiency
- minimise the impact on human health and the environment from waste generation and waste disposal
- Comply with the principles of environmental protection
- Not adversely affect human health or the environment
- Not adversely affect the interests of any person other than the applicant
- Not adversely affect any environmental values identified in any relevant environment reference standard
- Utilise the best available techniques or technologies for engaging in the prescribed activity
- Have previously adequately engaged with any person whose interests may be affected by the proposed exemption

Further to this, the applicant must:

- be a fit and proper person
- have supplied sufficient further information to the Authority within a reasonable time if requested by the Authority.

The EPA must also consider whether it is in the public interest to grant a license exemption.

The application for a license exemption if appropriate, still requires the applicant to supply an acceptable level of information to the Authority concerning the potential impacts of the proposed works on human health and the environment from contamination and/or pollution of air, noise, water land and groundwater, odour and waste, with a focus on the ocean outfall and the laboratory waste streams.

3 Methods

3.1 Coastal Process Impact Assessment

The Coastal Process Impact Assessment consists of two key assessments:

1. Desktop analysis of previous studies

Previous studies relating to the Point Nepean Quarantine Station area supplied by UoM were reviewed. Some of these papers related to the Portsea front beach erosion and channel deepening project, by Port of Melbourne. We also reviewed publicly available online resources relating to coastal processes. These included:

- The Coast of Victoria: The Shaping of Scenery – (Bird, The Coast of Victoria, 1993)
- Report 04 Port Phillip Bay Wave Climate – (Cardno, 2017)
- Changes on the Coastline of Port Phillip Bay – (Bird, 2011)
- Hydrodynamics: Infrastructure Victoria Second Container Port Advice – (Cardno, 2017)
- Beach Report and Yarra Watch Results 2020-2021 – (EPA Victoria, 2021)
- Review of OEM assessment of potential causes of beach erosion at Portsea – CSIRO 2013 (Symonds & McInnes, 2013)
- Portsea Front Beach: Wave Modelling and Monitoring Investigation – (Advisian, 2016)
- Vic Tides 2022 – (Ports Victoria, 2022)
- Hydrodynamic Climate of Port Phillip Bay - (Tran, Provis, & Babanin, 2021)

Information contained in these reports allowed us to identify coastal process presently occurring at the Point Nepean Quarantine Station study site.

2. Historical Aerial Imagery and Bathymetry Survey Analysis

Bathymetric survey data collected in approximately 2010 was initially compared to historic aerial photography to determine the general form of the offshore bathymetry and to identify the location of the crest of an offshore sand slope. After this, twenty-eight historical aerial photographs were analysed for years between 1950 – 2022 to map the approximate location of the top of this sand slope. This allowed us to identify the likely zone of natural horizontal (toward and away from the shoreline) movement for the offshore sand slope.

3.2 Marine Ecology Impact Assessment

The marine ecology impact assessment included a desktop analysis of the following relevant databases to identify the key marine environmental values for the area (e.g., threatened, migratory or otherwise protected flora and fauna) and determine the likelihood of these values occurring in the study area:

- *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) Protected Matters Search Tool
- *Flora and Fauna Guarantee Act 1988* (Vic) (FFG Act) Threatened List (DELWP, 2021)
- *Fisheries Act 1995* (Vic) Protected Aquatic Biota List (Fisheries Victoria, 2021)
- Victorian Biodiversity Atlas (VBA) Survey Records (DELWP, 2022)

- Seamap Australia - Port Phillip Bay Marine Biotopes Dataset (Seamap Australia, 2019),
- Ramsar wetland Ecological Character Description for the 'Port Phillip Bay (Western Shorelines) and Bellarine Peninsula' Ramsar site (Hale, 2020).

The key marine environmental values likely to occur were then each considered in the context of potential impacts resulting from the construction and operation of the proposed PNREFS.

4 Coastal Process Impact Assessment

4.1 Geomorphology

The geomorphology of Point Nepean is defined by the presence (or absence) of dune calcarenite at the shoreline. This rock is formed as rain percolates through calcareous relic sand dunes over thousands of years, washing calcium from the upper, more recently deposited sand into horizons of cemented calcrete (or calcarenite) at depth beneath the dunes. When rising sea levels act to erode these relic dune systems, the hard calcarenite layers inhibit erosion of the otherwise sandy vegetated dunes.

This calcarenite can be seen prolifically in cliffs along much of the ocean coast of Point Nepean, as well as in headlands and reef platforms on the northern Port Phillip Bay coast such as at Fort Pearce and Police Point (Figure 4.1). Erosion of areas where the erosion resistant calcarenite is present tends to form cliffs and bluffs (Bird, The Coast of Victoria, 1993).

Where this calcarenite is not present at the shoreline, the backshore area is mostly flat and has little relief from the beach level. An example area with this geomorphology is the quarantine station and surrounding lawns (Figure 4.1). These regions are described as prograded Holocene dunes which formed at times of lower sea level shoreward of a former sea cliff in the calcarenite dunes. The extent of this former sea cliff can be seen clearly by comparing the landform elevation of different section of Point Nepean (Figure 4.1) (Bird, 1993).

Erosion in these areas has historically been an issue which has led to the construction of various coastal protection structures such as seawalls and groynes.

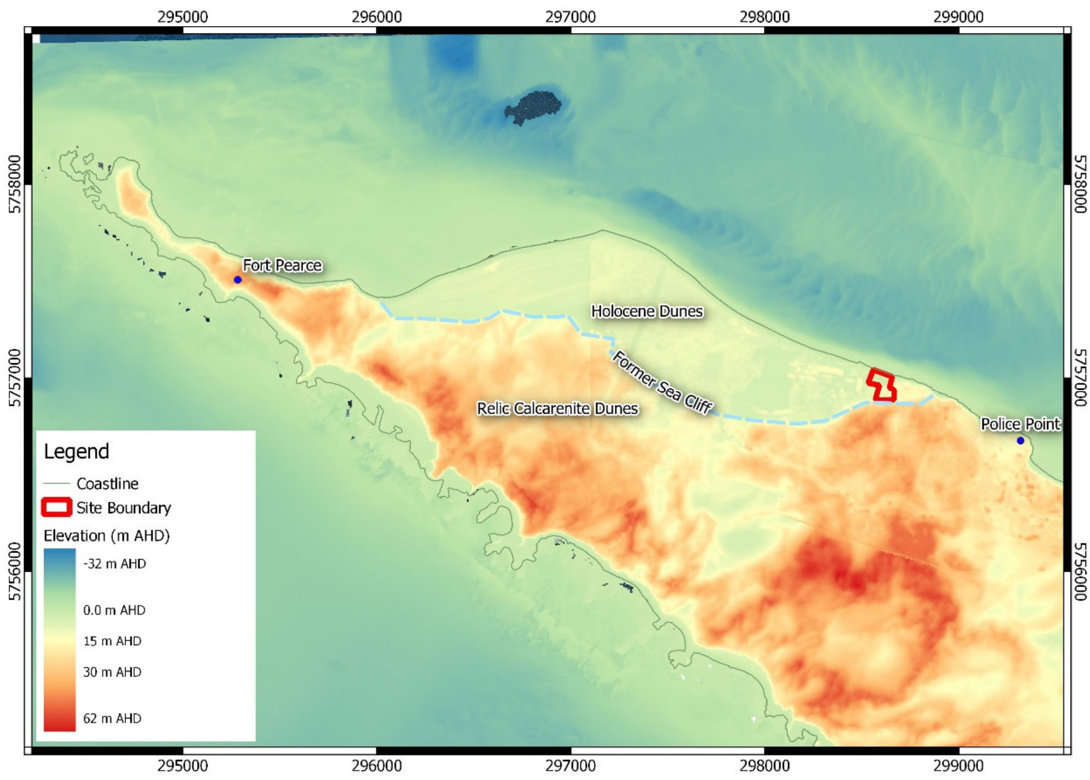

Figure 4.1 Point Nepean Geomorphology Map

4.2 Wind

Predominant winds at the site vary seasonally with predominant southerly – southwesterly winds in summer and predominant northerly – northwesterly winds in winter (Tran, Provis, & Babanin, 2021).

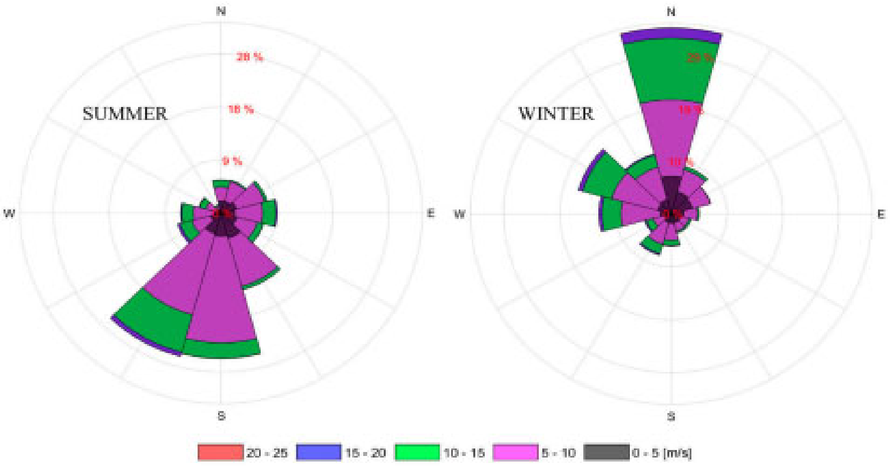

Figure 4.2 Wind rose 1998-2013 from South Channel Island station during summer and winter months (Tran, Provis, & Babanin, 2021).

4.3 Waves

Both long period swell waves and short period wind waves impact the site with varying magnitudes. These different wave sources are addressed individually below.

Swell Waves

Swell waves at the study site have the following characteristics:

- Waves propagate through Port Phillip Heads and refract around Point Nepean
- Due to local bathymetry, swell waves would be of minimal wave height by the time they refract to the shores immediately shoreward of the study site (Figure 4.3).
- Waves propagate differently through the heads under different tidal flows. Greatest propagation occurs at peak flood tide, moderate propagation at slack tide, low propagation at ebb tide (Cardno, 2017)

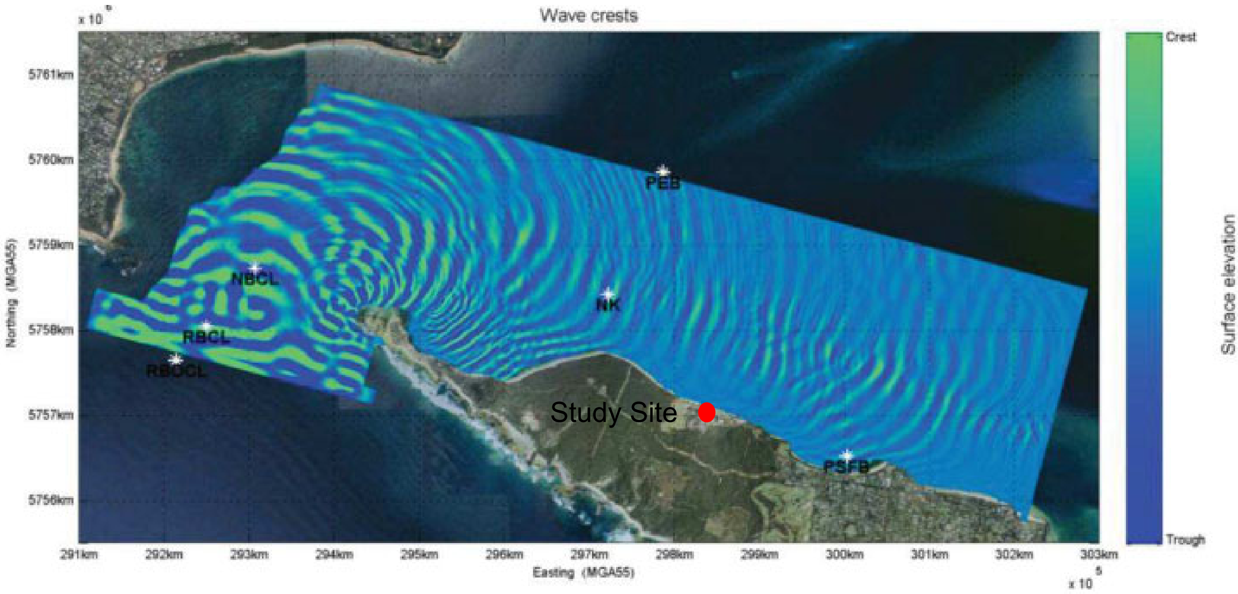

Figure 4.3 Modelled wave propagation and refraction into Port Phillip Bay (T = 20 swell waves) (Advisian, 2016).

Wind Waves

Wind waves impact the site when winds blow from the north through northwest (Figure 4.4), the prevailing condition during winter (Figure 4.2). The Point Nepean bay side shoreline (i.e, Ticonderoga Bay) is shielded from most of this wave energy by the Great Sands and Mud Island which sit immediately north of the study site (Bird, The Coast of Victoria, 1993). Despite this sheltering, wave heights can reach up to approximately 2 m at the study site under 1% AEP northerly winds (Cardno, 2017) (Figure 4.5).

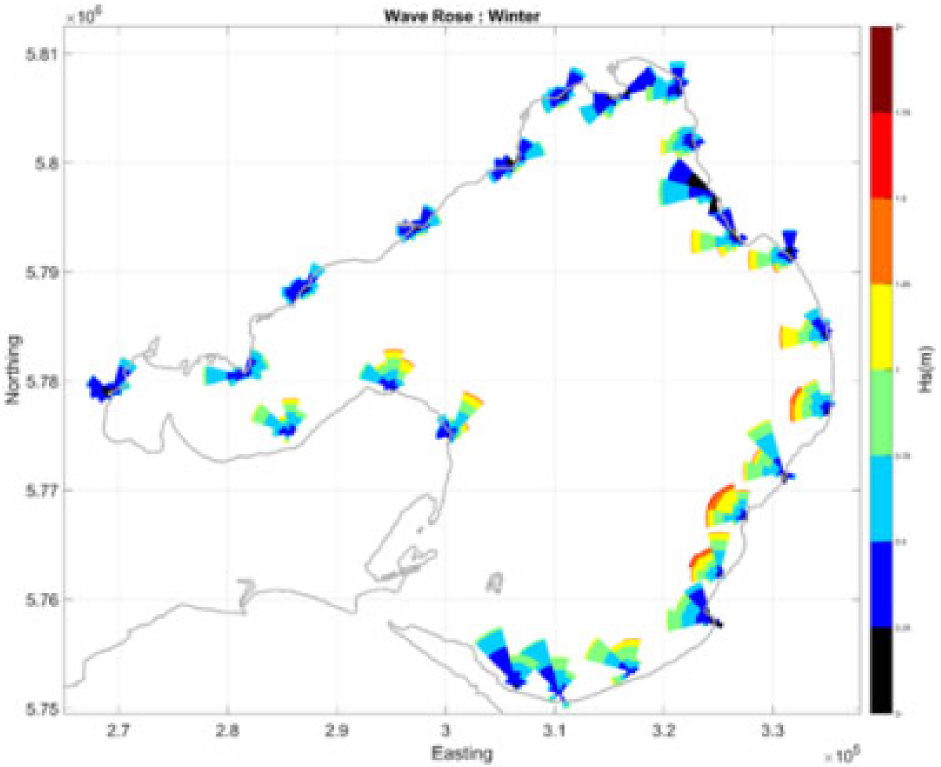

Figure 4.4 Winter wave roses for various locations around Port Phillip Bay including Blairgowrie (fair representation of Poinjt Nepean) (Cardno, 2017)

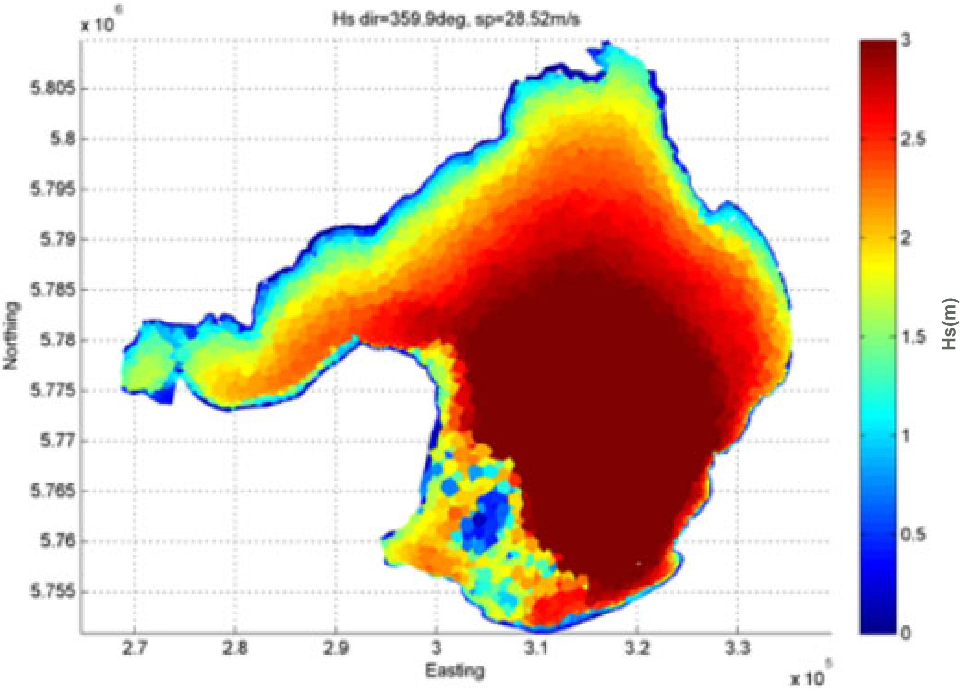

Figure 4.5 Wave heights associated with a 1% AEP northerly wind event (Cardno, 2017).

4.4 Tides/Currents

The tides at Port Phillip Heads are predominantly semidiurnal. The tidal planes for Point Lonsdale published by the Victorian Regional Channels Authority (VRCA) are provided in Table 4.1. Due to the attenuation of the tide within Port Phillip Bay, the tidal planes at the study site will vary to those presented in Table 4.1. VRCA (2021) suggest a 40% reduction in peak tidal water levels between Point Lonsdale and Portsea Pier. Prolonged data collection and analysis would be required to determine the actual reduction in peak tidal water levels from the Point Lonsdale tidal plane at the study Site.

Table 4.1 Point Lonsdale Tidal Planes (Ports Victoria, 2022)

AHD metres	Predominantly semidiurnal tides	Point Lonsdale Chart Datum metres
1.21	Highest recorded tide 12/07/1964	2.16
0.95	Highest Astronomical Tide (HAT)	1.90
0.62	Mean High Water Springs (MHWS)	1.57
0.36	Mean High Water Neaps (MHWN)	1.31
0.00	Australian Height Datum	0.95
-0.27	Mean Low Water Neaps (MLWN)	0.68
-0.53	Mean Low Water Springs (MLWS)	0.42
-0.95	Chart & Prediction Datum	0.00
-1.35	Lowest recorded tide 27/10/1972	-0.4

Current and future climate extreme water levels have been modelled along the Victorian coastline by McInnes et al. (2008). Storm tide values for Sorrento have been adopted for Point Nepean in this study (Table 4.2).

Table 4.2 Adopted current and future climate storm tide levels for Point Nepean (McInnes, Macadam, & O'Grady, 2008).

Annual Recurrence Interval (ARI)	Storm Tide Water Level Elevation (m AHD)		
	Current Climate	2030	2070
10	0.91	1.12	1.54
20	0.97	1.17	1.60
50	1.03	1.24	1.67
100	1.07	1.28	1.70

As tides fluctuate in Bass Strait, water moves in and out of Port Phillip Heads at varying flow rates. This occurs in the following way:

- Low tide in Bass Strait causes the greatest flow velocity from Port Phillip Bay out into Bass Strait. This can be up to 2 m/s at the heads and up to approximately 0.7 m/s in a North westerly direction at the study site (Figure 4.6).
- High Tide in Bass Strait causes the greatest flow velocity from Bass Strait to Port Phillip Bay. This can be up to 1.5 m/s in the heads and up to approximately 0.5 m/s in a south easterly direction at the study site.
- Approximately mid-tide causes what is known as 'slack water' in the heads where very little to no tidal current is evident.

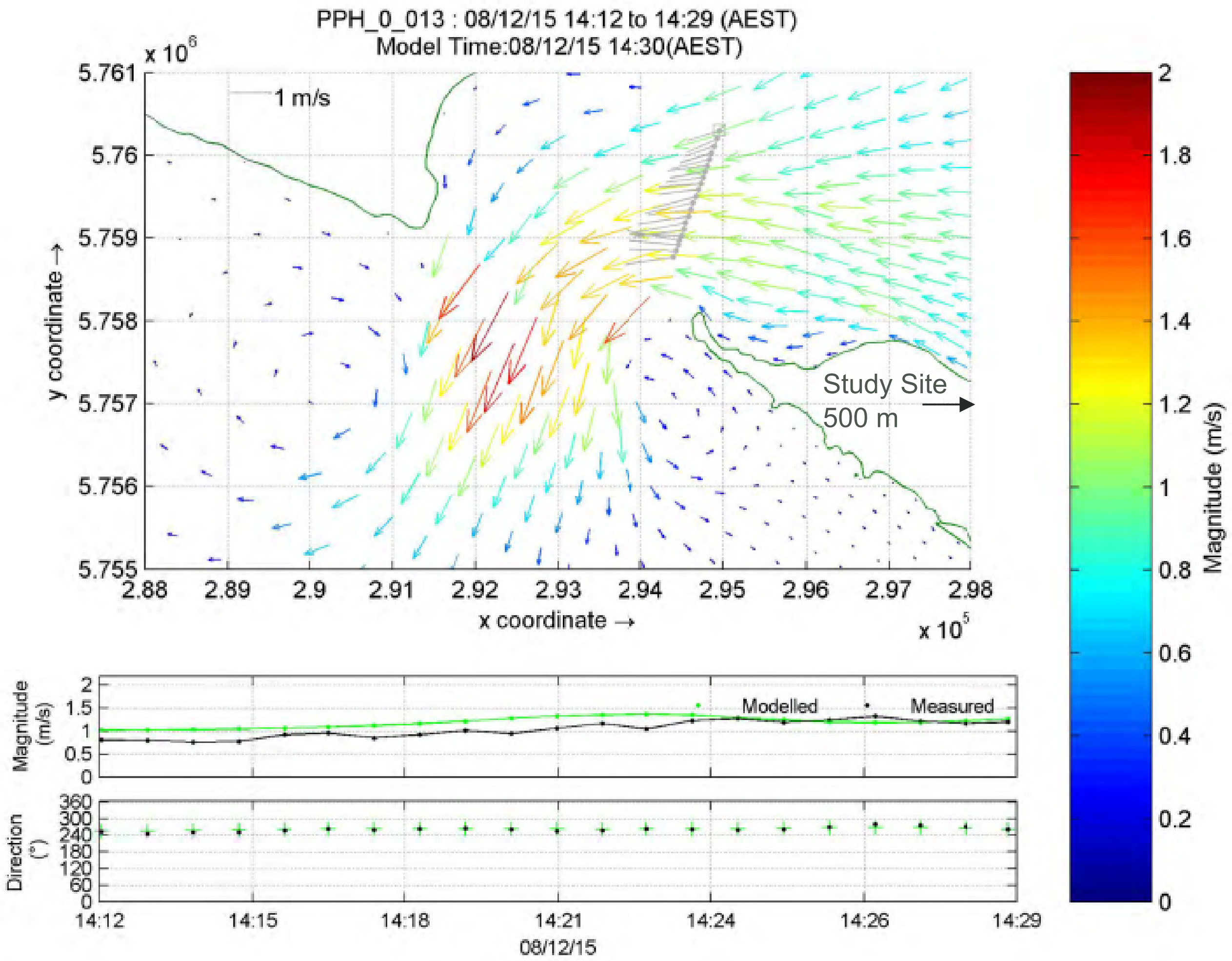

Figure 4.6 Ebb tide current velocities at Port Phillip heads (Cardno, 2017).

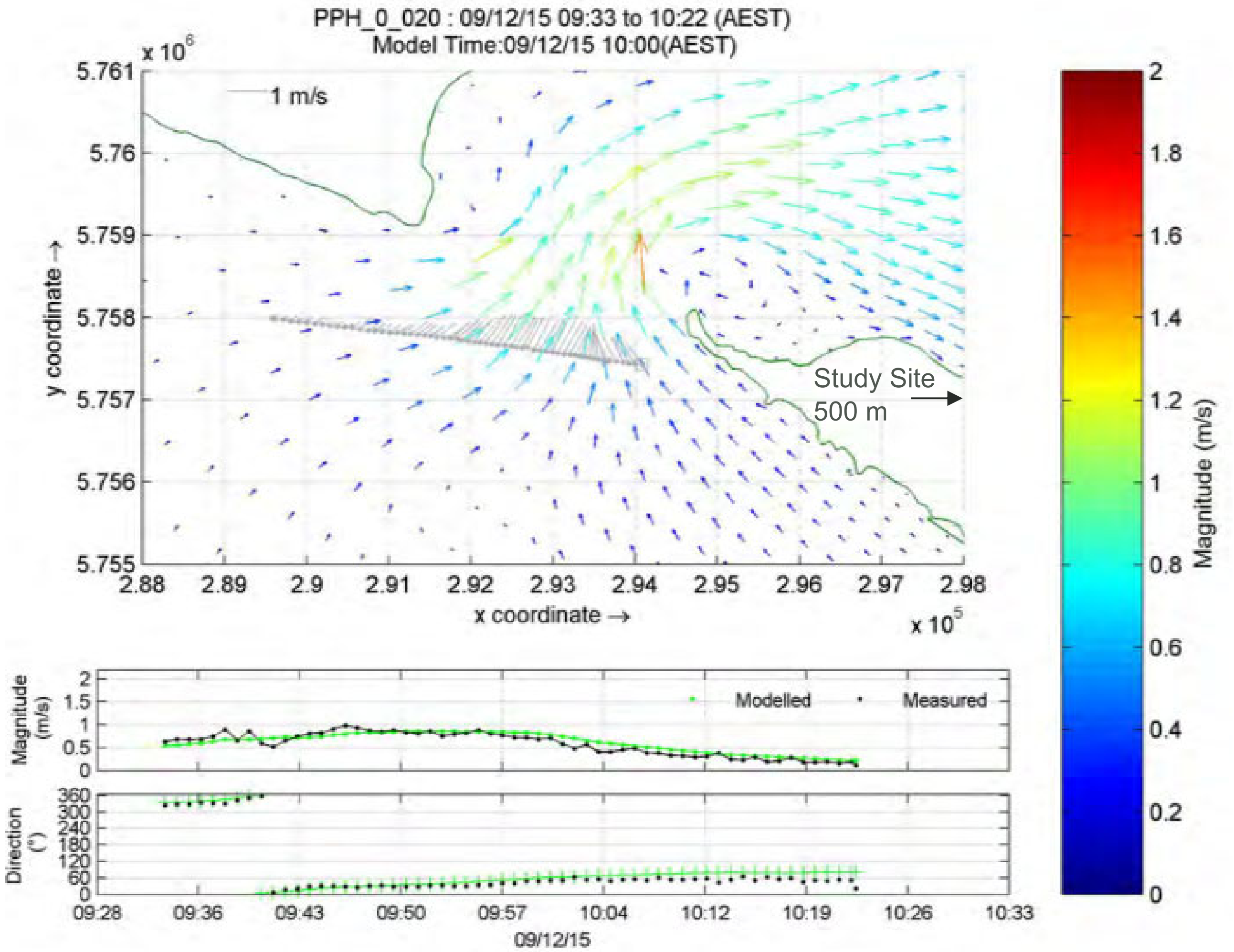

Figure 4.7 Ebb tide current velocities at Port Phillip heads (Cardno, 2017).

4.5 Sea Level Rise

The Intergovernmental Panel on Climate Change (IPCC) is the most widely recognised body that disseminates objective science on climate change and its associated impacts. The IPCC has released several broad documents that detail the state of the current science and prediction, the latest (finalised release) of which is the Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) (IPCC, 2019). The SROCC details the following conclusions:

- Mean sea level has risen globally throughout the 20th century and has accelerated in recent decades.
- The global mean sea level rise from 1902 to 2015 is 0.16m (likely range of 0.12-0.21m).
- The rate of sea level rise over 2006-2015 is 3.6mm/year (very likely range of 3.1-4.1mm/year).
- The Greenland and Antarctic ice sheets are predicted to lose mass at an increasing rate throughout the 21st century.
- Strong reductions in greenhouse gas emissions in the coming decades are required to reduce further changes after 2050.

These projected changes (last two points above) are based on a range of different global climate models that simulate several potential future scenarios of carbon emissions. These different scenarios are known as Representative Concentration Pathways (RCPs). While it is currently difficult to predict the pathway that the global society will 'adopt' over the longer-term, these different RCPs provide suitable pathways to quantify potential impacts that would result for each one.

The most conservative 'RCP8.5' is typically adopted for coastal management planning in Australia. This represents a 'business as usual' pathway where limited success is achieved in reducing global carbon emissions. The projected rate of sea level rise for the Mornington Peninsula under the RCP8.5 scenario is illustrated in Figure 4.8.

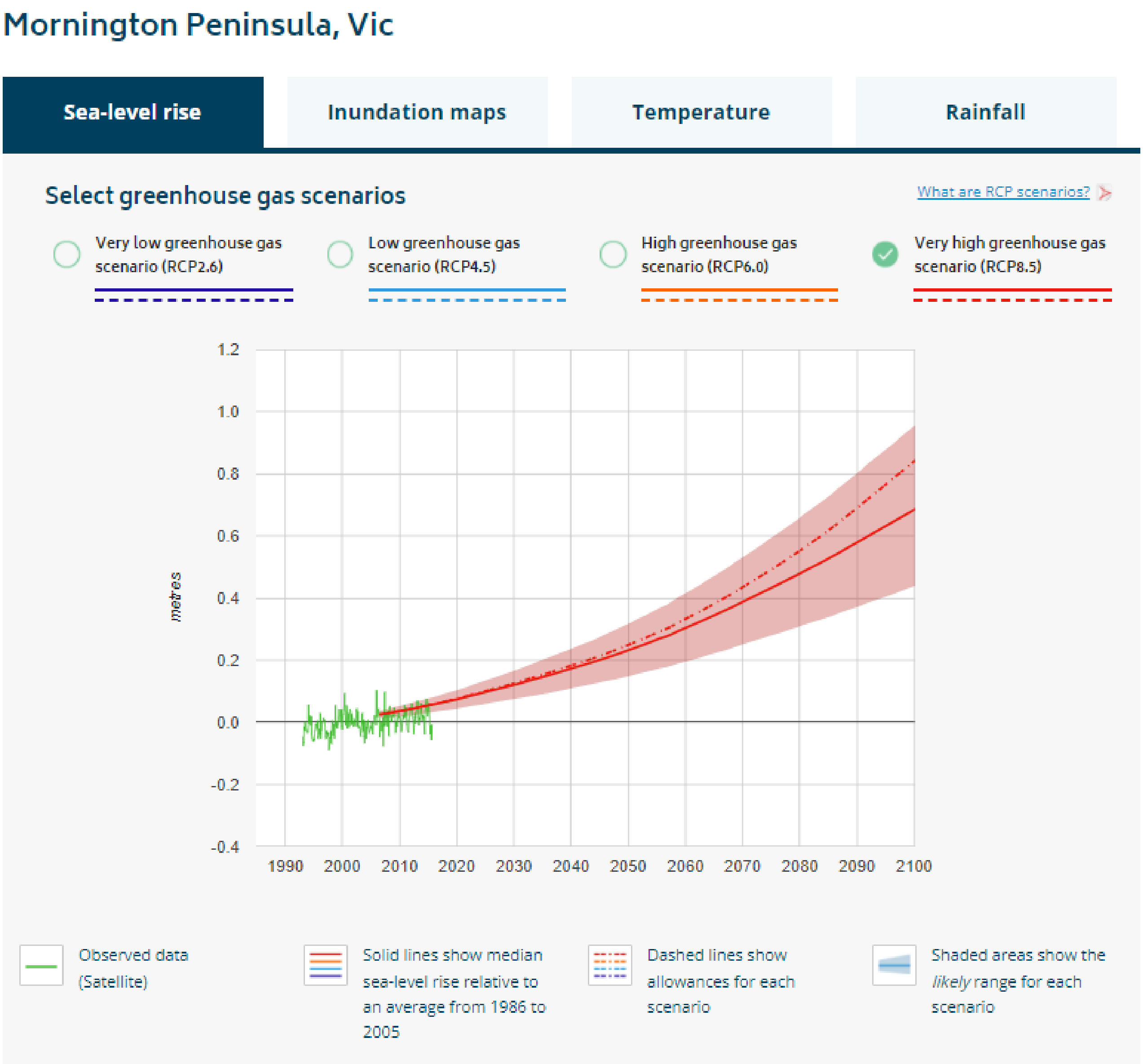

Figure 4.8 Sea Level Rise prediction, Mornington Peninsula (NCCARF, 2021)

The Victorian Marine and Coastal Policy (DELWP, 2020) requires coastal adaptation works to plan for "not less than 0.8 m" of sea level rise by 2100 relative to 2020 mean sea levels, which is within the likely range of the RCP8.5 scenario. Considering the sea level rise projection shown in Figure 4.8 and the Victorian Government policy, Table 4.3 presented the sea level rise allowances adopted for this study.

Table 4.3 Sea Level Rise under RCP8.5 emissions scenario scaled up to match the requirements of the VMACP (0.8 m by 2100).

Year	Sea Level Rise Allowances (m)
2030	0.2
2050	0.4
2070	0.5
2090	0.7
2100	0.8

4.6 Sediment Transport/Sand Movement

Sediment transport along the bay side coast of Point Nepean is driven by a combination of tidal currents through Port Phillip Heads, swell waves refracting around Point Nepean and breaking on beaches, and wind waves from the north breaking on beaches (Bird, Changes on the Coastline of Port Phillip Bay, 2011). These processes yield sediment transport with the following characteristics:

- West-east net sediment transport
- A fluctuating wide to narrow beach at the study area between approximately 12 – 0 m wide.

Figure 4.9 Panel A: Wide beach at old storm water outlet pipe 1973. Panel B: No hightide beach shoreward of seawall 1957. Images: (Bird, 2011)

Recent studies into the erosion of Portsea front beach have focussed on sediment transport processes in the area. Modelling of the sediment driving processes described above resulted in an estimate of net sediment transport at Police Point (900m east of the current study area) of 2,000 m^3/year in an easterly direction toward Portsea (Figure 4.10) (Advisian, 2016). This estimation is based on an aerial imagery analysis of changes in beach alignment within Weeroona Bay (Portsea) over one decade of available imagery from 2005-2015. It is intended to be indicative only. Further investigation is required to confirm the applicability of this estimation to the current study area.

We also note that gross sediment transport is likely of much greater magnitude than net sediment transport due to the relatively high velocity tidal currents along the Ticonderoga Bay coastline which may mobilise sand along the coast on ebb and flood tides.

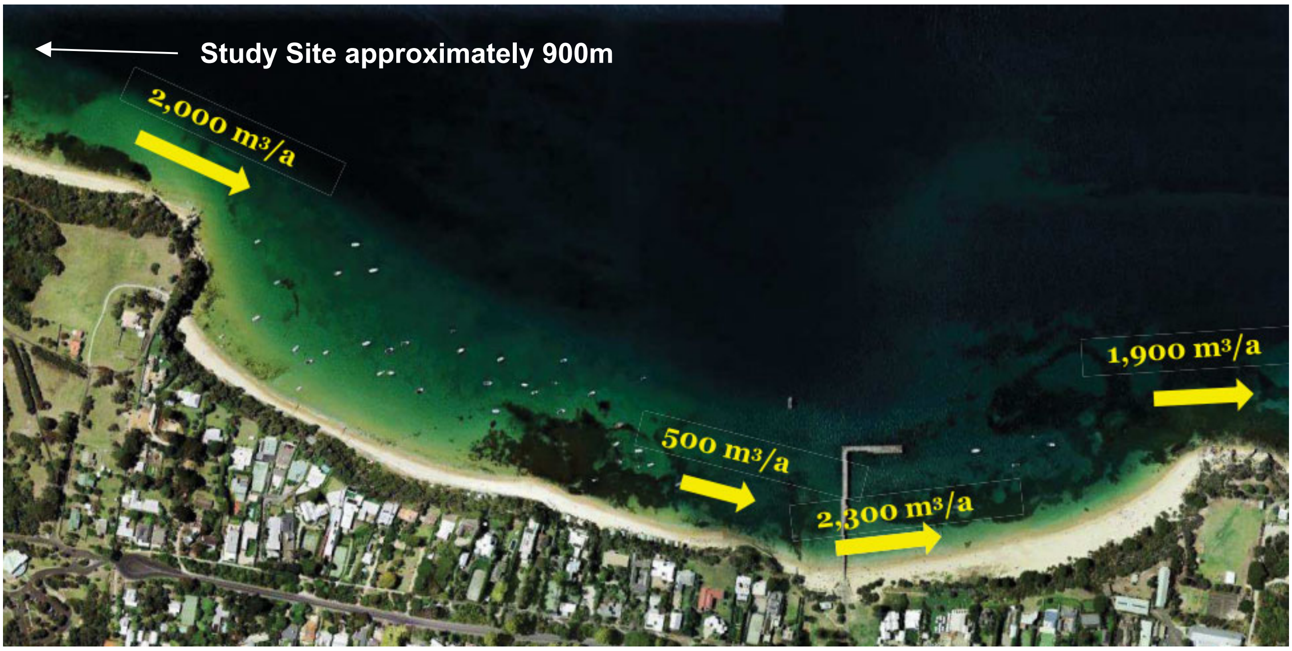

Figure 4.10 Net Sediment transport estimation based on aerial imagery analysis of images taken 2005-2015 in Weeroona bay Portsea (Advisian, 2016).

We analysed the bathymetry in the nearshore area adjacent to the proposed location for the PNREFS using a 2.5m bathymetry DEM (DELWP, 2022). A cross section of this coastal DEM through the approximate location of the HDD shown in Figure 4.11 shows a narrow area of shallow water immediately offshore from the beach (approximately 45 m wide). This shallow area has a steep drop-off on the seaward side with depth increasing to approximately 20m over a horizontal distance of 50m.

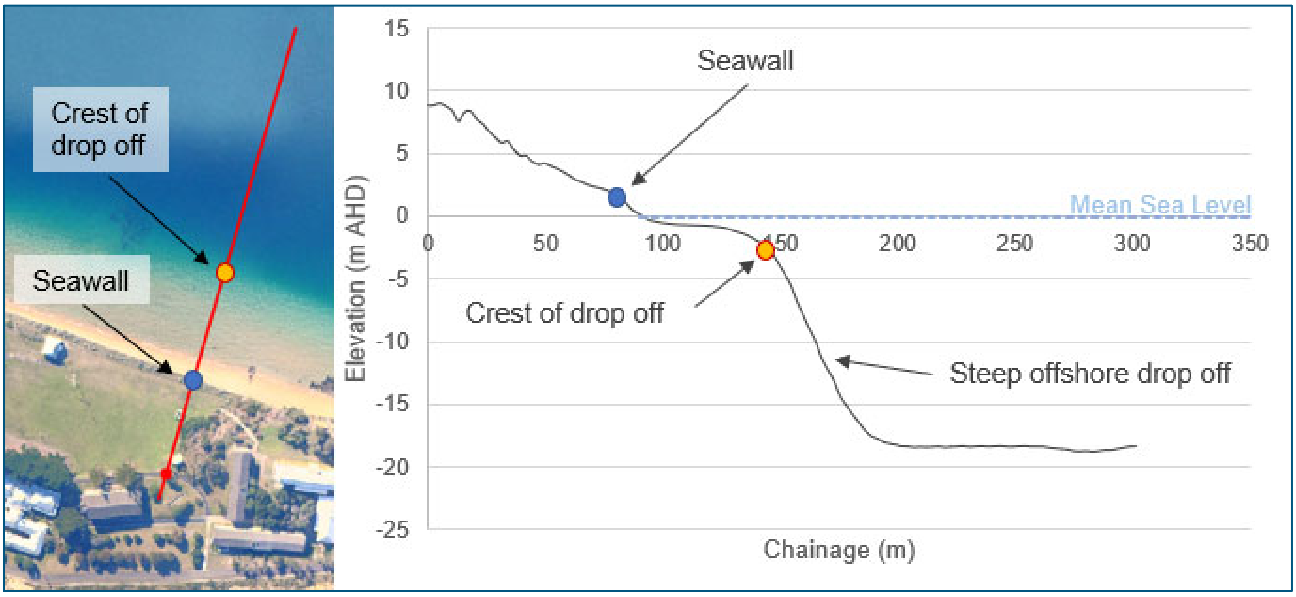

Figure 4.11 Topographic and bathymetric cross section of approximate HDD location on 2010 aerial Image.

The bathymetry data also allowed us to identify that the change in colour seen in the aerial images between light green (shallow water) and darker blue (deeper water) represents the crest of the steep offshore drop off. Using this information, we assessed how the position of the offshore drop off relative to the shoreline has changed over time by mapping the location of the drop off crest from 28 aerial images spanning 72 years (1950-2022). Results of this analysis demonstrate that the crest of the drop off has migrated landward and seaward approximately 15 m during the 72 years assessed. The current position of the crest is almost exactly in the middle of this zone of migration. There was no clear pattern between the year an image was taken and the position of the drop off crest relative to the shoreline.

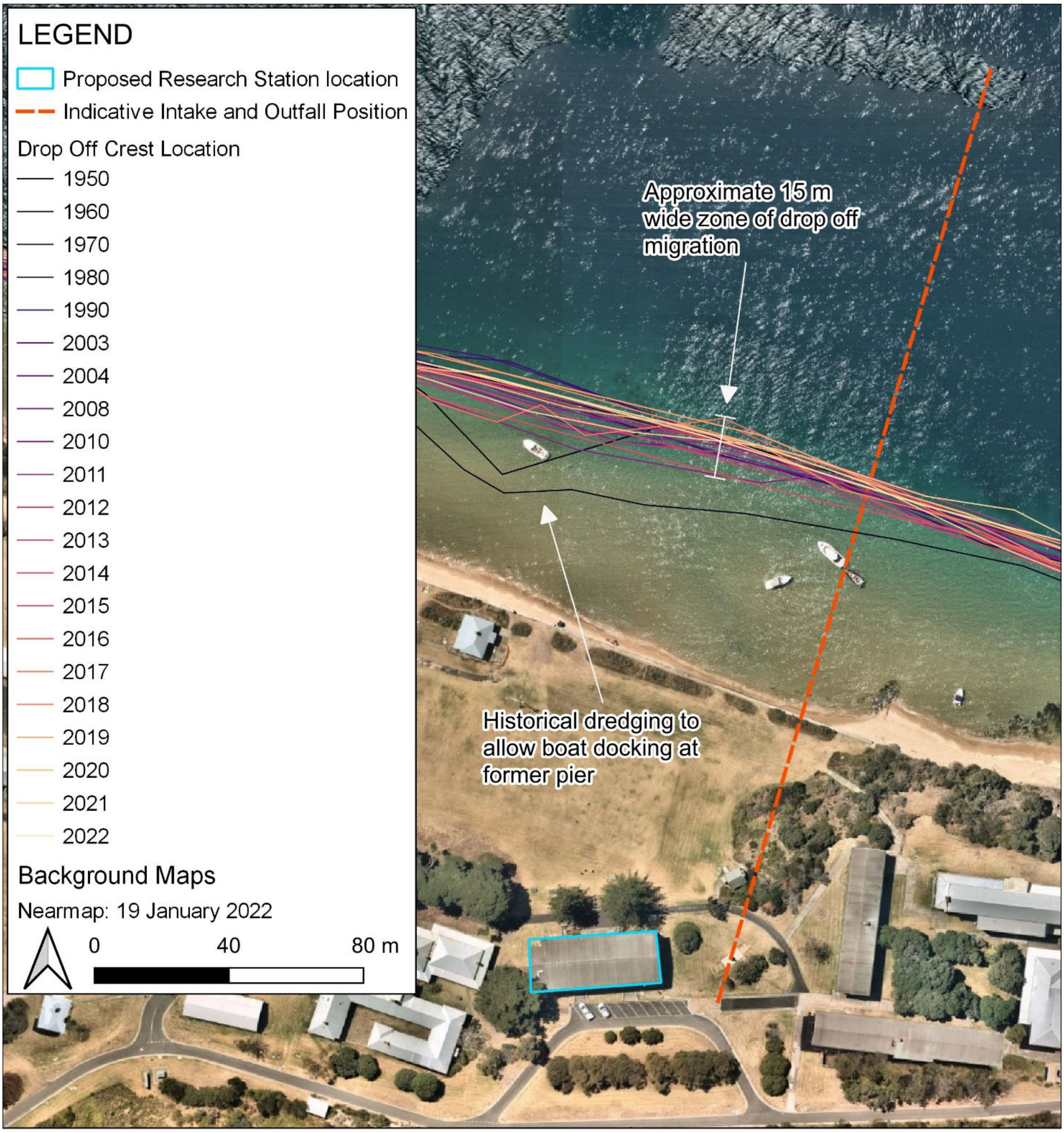

Figure 4.12 Offshore drop off zone of migration.

4.7 Predicted Impact of proposed works on coastal processes

Offshore works relating to the PNREFS which may have an impact on coastal processes are as follows:

- HDD of both the intake and outfall pipelines beneath the land and seabed surfaces
- Small scale excavation of the seabed using air lifting techniques to uncover the seaward end of the intake and outfall pipelines.
- Placement of pre-cast concrete structures on the seabed to encase the intake and outfall pipelines
- Placement of concrete scour protection mattresses around the intake and outfall to minimise scour around the pipes

None of these works or structures are considered likely to impact on coastal processes in the area. We note that the location of the outfall has been designed to avoid the drop off zone of migration and will sit on the relatively flat seabed at approximately 18-20m AHD.

5 Marine Ecology Impact Assessment

5.1 Description of Marine Environment

Overview and Protected Areas

The coastal area of the site is largely exposed, characterised by large windswept areas and steep coastal headlands. The site figures within larger ecologies and wildlife corridors—the entrance of Port Phillip Bay forms the eastern distribution limit for cold water species from Western Victoria and the western limit for warm water species from Eastern Victoria.

The sites' adjacent waters have been protected since 1975 and were proclaimed part of Port Phillip Heads Marine National Park (PPHMNP) in 2002 under the *National Parks Act 1975*. The two key parts of the PPHMNP include Point Nepean (waters adjacent to the headland) and the Portsea Hole (rectangular feature 600m offshore from the Portsea Pier) (Figure 5.1). Parks Victoria's *Port Phillip Heads Marine National Park Management Plan 2006* outlines conservation objectives, regulation of the park's recreational use, and the role of Parks Victoria in collaboratively managing the park. It is noted that the current project site is not within the extent of either marine national park. Each marine National Park is located approximately 1km from the project site.

The significant natural value of the PPHMNP at Point Nepean include (Parks Victoria, 2006):

- dynamic sedimentation regime related to the tidal and wave movement of sand through Port Phillip Heads, with sustained sandy accretion at Observatory Point
- an unusual example of a shore platform that has developed in contrasting wave environments, highlighting the processes that have shaped the opening to Port Phillip
- intertidal reef platforms that contain a high invertebrate diversity similar to Point Lonsdale which have been protected due to long-standing park regulations that prohibit access
- subtidal reefs with diverse fish and invertebrate assemblages with extensive encrusting communities such as ascidians, bryozoans and sponges
- frequent sightings of dolphin pods
- shorebird habitat along the reef platforms and sandy beaches.

The significant natural value of the PPHMNP at Portsea Hole include (Parks Victoria, 2006):

- unusual geomorphology consisting of a remnant section of the Yarra River, with a sharp gradient between the depths of 12 and 32m exposing strata changes over depth, descending from a limestone structure to a sandy base
- abundant and diverse fish assemblages and a rich benthic community of encrusting algae, sedentary organisms, sponges and soft corals.

The site is also adjacent the Ticonderoga Bay Sanctuary Zone (Figure 5.1), with frequent sighting of dolphins. This may include a unique species known as the Burrunan dolphin (*Tursiops australis*) as listed under the FFG Act. The Ticonderoga Bay Sanctuary Zone is protected under Section 16(1) of the *Wildlife (Marine Mammals) Regulations 2019* as a whale sanctuary zone (Victoran State Government , 2019). This regulation provides measures for exclusion zones and vessel restrictions in these sanctuary zones and near whales and dolphins.

The terrestrial area is classified as Point Nepean National Park, highlighting the site's archaeological, ecological, architectural, historical, scientific and social significance.

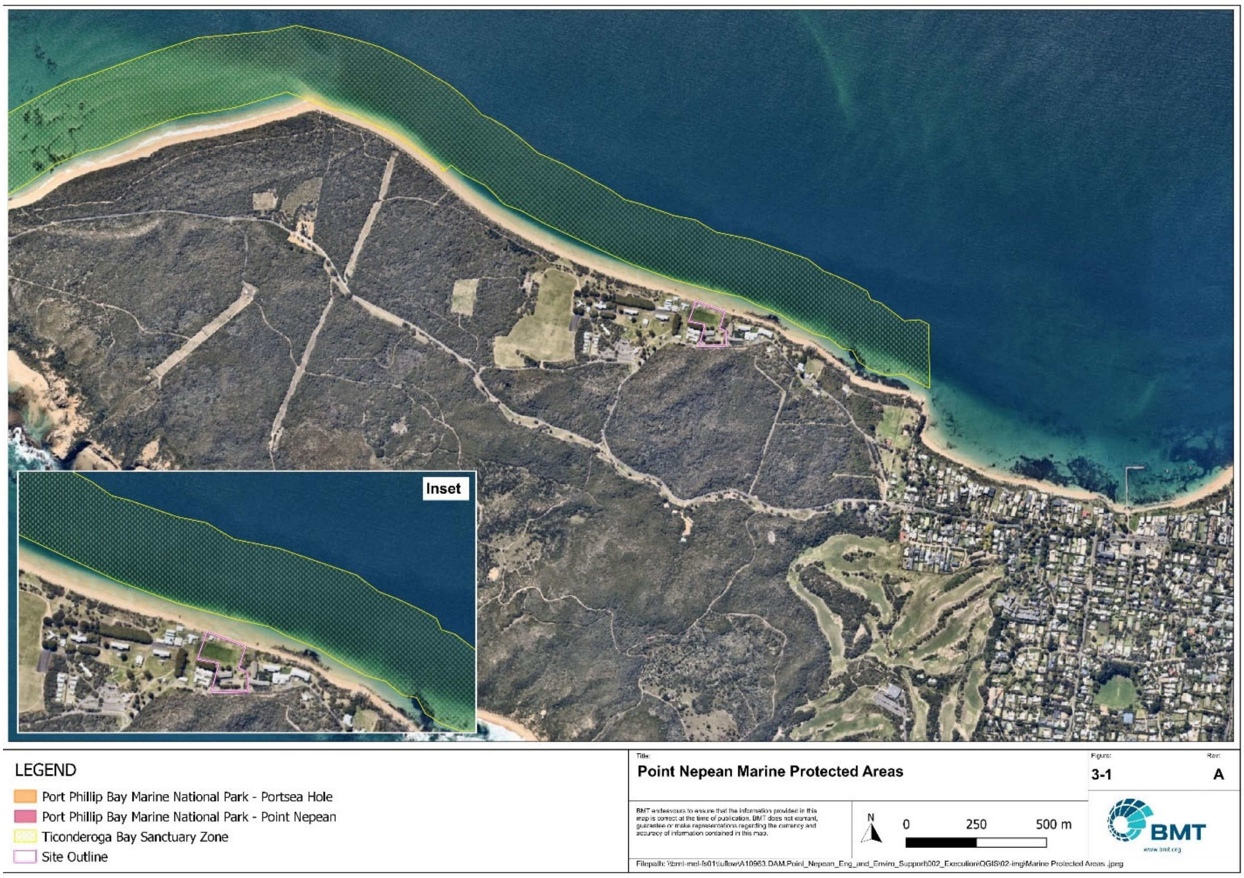

Figure 5.1 Point Nepean Marine Protected Areas

Benthic Habitats

A review of publicly available benthic habitat mapping indicates that there are potentially sensitive habitats directly to the east of the project site including seagrass and rocky reef and infralittoral rock (Figure 5.2). This mapping suggests the majority of benthic habitat is sand directly adjacent to the project site. The Portsea Hole is also classified as an area of course sediment. The data shown in Figure 5.2 is sourced from satellite imagery and field survey data.

This suggests that sensitive habitats including seagrass and hard substrate/corals may exist scattered around the project area. However, the information available indicates that it is unlikely that any of these sensitive habitats occurs neither at the specific site for the proposed intake and outfall nor in its direct proximity. The extent of seagrass will likely be limited to depths of less the 7m, which is where the majority of seagrass, predominantly *Zostera* spp. is located in the southern regions of Port Phillip Bay (Ball, Soto-Berelov, & Young, 2014).

Nevertheless, site-specific benthic habitat information is being gathered by Marine Ecology Australia for the purpose of this project, to better inform the final design and construction. In terms of impact assessment, it is expected that the site-specific information will not result in identification of higher environmental risk, but potentially lower, and importantly, the information will help informing and preparation of the environmental management plan for the construction stage.

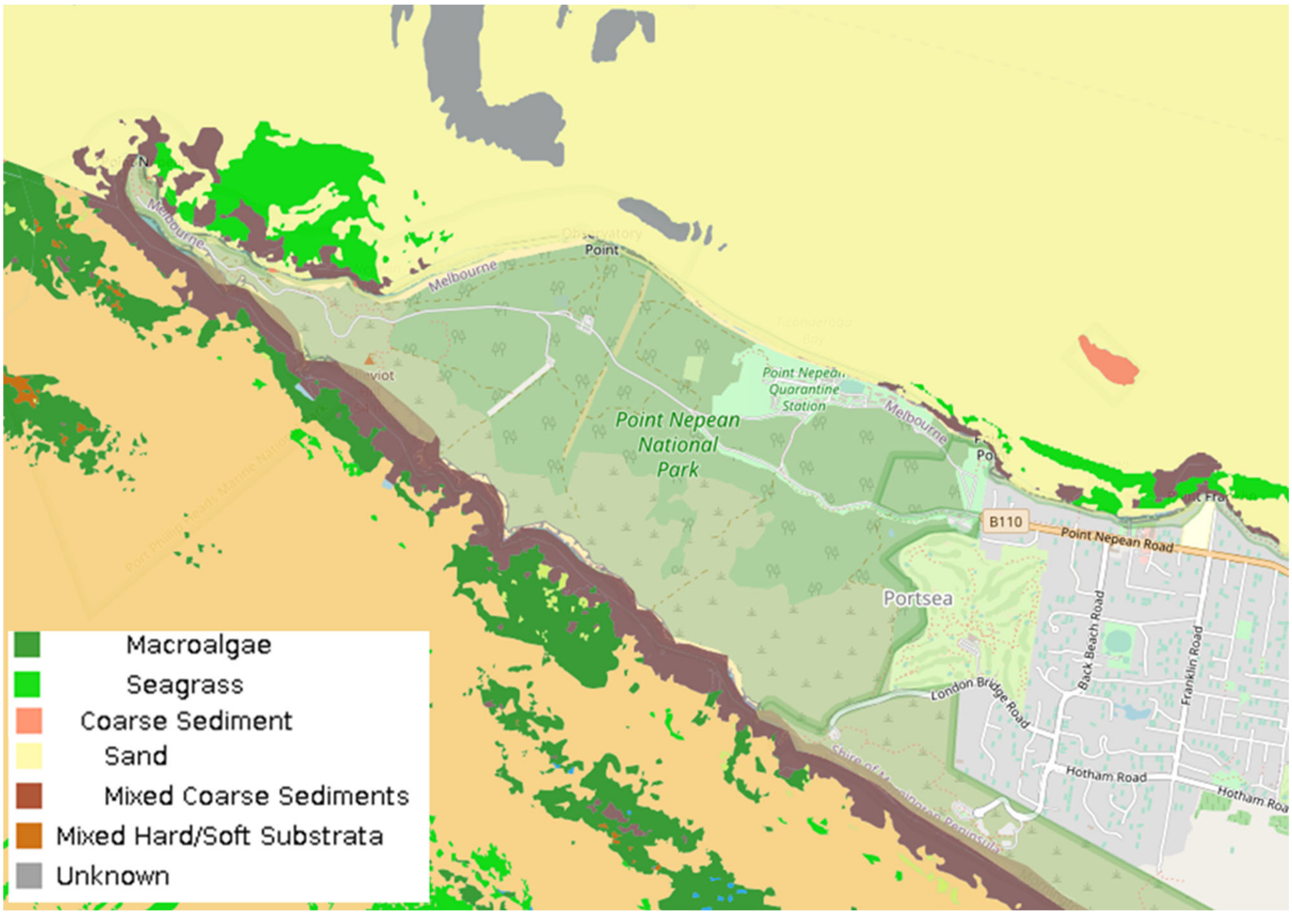

Figure 5.2 Benthic Habitats Source: (Seamap, 2021)

Threatened Species

Species lists from the FFG Act and EPBC Act threatened species list for the area were compared against observation and potential occurrence databases from the Atlas of Living Australia (Atlas of Living Australia , 2021) for the offshore area of the project site. Table 5.1 displays these species including conservation status for each legislative instrument. Atlas of Living Australia Records are shown in Annex A.

Table 5.1 Threatened Species

Common Name	Scientific Name	Atlas of Living Australia Record	FFG Act Status	EPBC Act Status	Likelihood of Presence in Study Area
Bird					
Fork- Tailed Swift	*Apus pacificus*	Potential	-	Marine/Migratory	**Unlikely** – mostly flies, unlikely to be present on sea surface or land
Marine Mammal					
Leopard Seal	*Hydrurga leptonyx*	Observed	-	Marine	**Unlikely –** predominately

Common Name	Scientific Name	Atlas of Living Australia Record	FFG Act Status	EPBC Act Status	Likelihood of Presence in Study Area
					Antarctic species. Seen in Victoria 3-5 times a year.
Burrunan Dolphin	*Tursiops australis*	Observed	Critically Endangered	-	**Possible –** these dolphins are regularly seen in the T. Bay dolphin sanctuary.
Southern Right Whale	*Eubalaena australis*	Potential	Endangered	Endangered	**Unlikely –** predominantly pelagic species
Turtle					
Loggerhead Turtle	*Caretta caretta*	Potential	-	Endangered (Marine/Migratory)	**Unlikely** - predominantly tropical and subtropical species
Green Turtle	*Chelonia mydas*	Potential	-	Vulnerable (Marine/Migratory)	**Unlikely** - predominantly tropical and subtropical species
Leatherback Turtle, Leathery Turtle	*Dermochelys coriacea*	Potential	Critically Endangered	Endangered (Marine/Migratory)	**Unlikely** - predominantly tropical and subtropical species
Shark					
Great White Shark	*Carcharodon carcharias*	Potential	Endangered	Vulnerable (Migratory)	**Possible –** have been seen in Port Phillip Bay
Bony Fish					
Southern Bluefin Tuna	*Thunnus maccoyii*	Potential	Conservation Dependent	Conservation Dependent	**Unlikely** - predominantly pelagic species
Blue Warehou	*Seriolella brama*	Potential	Conservation Dependent	Conservation Dependent	**Unlikely** - predominantly pelagic species

Common Name	Scientific Name	Atlas of Living Australia Record	FFG Act Status	EPBC Act Status	Likelihood of Presence in Study Area
Southern Dogfish, Endeavour Dogfish, Little Gulper Shark	*Centrophorus zeehaani*	Potential	-	Conservation Dependent	**Unlikely –** predominantly deep-water species (i.e., >200m depth)

Marine Water Quality

The protection and management of surface and groundwaters is implemented under the *State Environmental Protection Policy (Waters)* 2018 (SEPP Waters). Table 3.2 shows the quality indicators and objectives for Port Phillip Bay within the 'Exchange', as per the SEPP (Waters).

Table 5.2 Environmental Quality Indicators and Objectives for Port Phillip Bay – Exchange

Indicators	Percentile	Value
Surface/Bottom	-	Surface
Total phosphorus (µg/L)	75^{th}	50
Total nitrogen (µg/L)	75^{th}	150
Dissolved Oxygen (% saturation)	25^{th} - Max	N/A
Chlorophyll-a (µg/L)	75^{th}	1
Dissolved Inorganic Phosphorus (µg/L)	75^{th}	30
Dissolved Inorganic Nitrogen (µg/L)	75^{th}	10
Total Suspended Solids (mg/L)	75^{th}	2
Salinity (PSU)	25^{th} to 75^{th}	35-36
Light Attenuation (m-1)	75^{th}	0.3
pH	25^{th} to 75^{th}	7.5-8.5
Toxicants Water	-	99% Protection
Toxicants Sediment	-	Low

Available Marine Water Quality Information

Few water quality testing results are available for seawater at or near Point Nepean. The most relevant available data is from EPA testing of water quality at popular beaches through each summer period (EPA Victoria, 2021). This testing regime focused on the presence of microbial pathogens in sea water and found the following:

- During 2020-21 summer at Portsea front beach (closest testing location to current study site) there were 0 tested days with short-term objective levels over the SEPP (waters) standard of 200 orgs per 100mL.

There are no other water quality data available and further water quality measurements may need to be taken to determine baseline water quality characteristics for the current study.

5.2 Predicted Impact of Proposed Works on Marine Environment

Marine Ecology and Environment

Port Phillip Heads Marine National Park
The proposed locations of the intake and outfall are approximately 1km from both the main body of the PPHMNP and thew Portsea Hole section of the park. Given effluent from the outfall is modelled to disperse fully within 25m of the outfall, the effluent is very unlikely to have any effect on the Marine National Park.

Similarly, any direct impacts of the outfall and intake structures on the marine environment will be localised to each location and will not have any impact on the Marine National Park.

Seagrass and Hard Substrate/Corals – Sensitive Benthic Habitats
Analysis of benthic habitat mapping showed small areas of seagrass and hard substrate (likely sub-tidal reef) present to the east of the study area, and that the seabed immediately offshore of the study area was predominantly sandy. This was confirmed via aerial image analysis which showed large areas of bare sand offshore of the offshore drop off.

The intake and outfall are situated to be on bare sandy flats with no sensitive benthic habitats with 25m of the outfall. As such, the construction and placement of the intake and outfall will have no direct impact on any sensitive areas, nor will the effluent from the outfall impact any sensitive habitats.

Threatened Species
All threatened species mapped as possibly being within the study area were identified as unlikely to be present except for the following:

- Burunan dolphin (*Tursiops australis)* – These dolphins are regularly observed in the Ticonderoga Bay Dolphin Sanctuary. They are highly mobile mammals and if present within the study area during the commencement of construction, would be expected to be naturally inclined to move away from the works area to avoid disturbance. Operation of the intake and outfall system is not expected to have any potential negative impacts to these animals.

- Great white shark (*Carcharodon carcharias)* – Great white sharks have been observed in Port Phillip Bay previously and may be in the vicinity of the study area at the commencement of construction. They are similarly highly mobile and would be expected to be naturally inclined to move away from the works area to avoid disturbance.

As such, the proposed works are not likely to pose any risk to threatened species possibly present within the study area.

Water Quality

HDD Drilling of intake and outfall
There are a variety of potential risks predominantly to water quality from HDD drilling as follows:

- **Frac Outs of Drilling Fluid** – When HDD drilling occurs, a lubricating fluid is used which is usually either a saltwater polymer fluid, or a natural bentonite clay slurry. Neither of these fluids are toxic and bentonite clay is a naturally and commonly occurring substance. HDD drilling is performed under pressure which can cause some of the drilling fluid to escape the borehole (either through loose soil in a shallow bore or through a fracture or fault in the geology) and reach the surface – termed a Frac Out. These fluids are non-toxic, however, if frac outs occur beneath the sea surface and a clay slurry is used, a sediment plume may occur which may cause concerns amongst the community. The marine environment within the study area is naturally very dispersive which means that any fluid escaping the bore would be dispersed below background levels very quickly and would not likely settle to the sea floor. As such, there is a low risk that frac outs will cause negative impacts to water quality or the marine environment if they occur. Measures to avoid Frac Outs where possible during the construction process will be utilised as outlined in Section 6 and Annex B below.

- **Loss of drilling fluids and bore cuttings from the offshore end of the bore** – Some HDD methods can cause loss of the drilling fluid and borehole cuttings from the offshore end of the bore. As above, this may cause a sediment plume beneath the sea surface from the escaping drilling fluid (if a clay slurry is used) and may cause concerns within the community. Any plume will likely disperse very quickly in the high energy marine environment and will not likely have any negative impacts on water quality or the marine environment. Bore hole cuttings are waste material (coarse rock cuttings/shavings from the drilling process). At the end of the borehole drilling process, the hole is cleaned of these cuttings. If the hole is drilled completely through to the ocean, these cuttings will be flushed out the ocean end of the pipe and settle on the seafloor. The benthic environment surrounding the proposed bore hole end is a sandy plain and rock cuttings falling to the sea floor here will not likely pose a risk to benthic flora or fauna. Different HDD methods can be used to prevent the escape of both drilling fluid and bore cuttings from the end of the pipe to further reduce/mitigate any potential impacts as described in Section 6 and Annex B below.

Outfall Effluent

The effluent emitted from the outfall will be seawater with elevated nutrient concentrations from excess feedstock and dissolved fauna excrement. Near field modelling of effluent dispersal demonstrates that even during slack tides (the time period with the lowest hydrodynamic energy at this site), effluent will likely disperse fully within 25m of the outfall. As such, the effluent is predicted to have minimal impact on water quality in the area.

6 Potential Impact Summary and Recommendations

The possible impacts of the proposed outfall and intake pipe works are summarised in Table 6.1 below. Key risks for consideration by University of Melbourne and Monash University are the potential for frac-outs of HDD drilling fluid within the Ticonderoga Bay Dolphin Sanctuary, and the loss of drilling fluids and bore cuttings from the end of the pipe during pipe reaming and flushing. Recommendations to control and mitigate these risks are outlined in Table 6.1 below.

Table 6.1 Risk Summary

Category / Activity	Potential Impact	Risk Rating	Mitigation Recommendations
Horizontal Directional Drilling (HDD) of intake and outfall	Frac-out of drilling fluid potentially producing sediment plume (if using natural clay slurry fluid)	Low Risk	Report any frac-out occurrence to relevant regulator within 2 hours of occurrence. Perform any required geotechnical investigations prior to HDD as guided by technical specialist contractor. Use the most appropriate drilling fluid as recommended by technical specialists. Monitor drilling fluid properties during drilling process. Monitor pressure of the HDD bore hole during drilling.
Horizontal Directional Drilling (HDD) of intake and outfall	Discharge of drilling fluid and bore cuttings from the offshore end of the bore	Low Risk	Leave the bore closed just prior to exit from seabed while hole is successively reamed and flushed of cuttings (back to the landside). Thrust the pipe into the bore from the landside to the still closed offshore end of the bore. Shallow seabed excavation down to the inserted pipe using air lifting of seabed sediment material.
Outfall effluent discharge - Water Quality	Potential impact of seawater system outfall effluent discharge on water quality in the receiving marine environment of Port Phillip Bay	Low Risk	Regular monitoring and reporting to EPA) of effluent stream characteristics according to conditions to be set out in future EPA Operating License or License Exemption.

All potential impacts on coastal processes and to the marine environment from the proposed Point Nepean Research and Education Field Station seawater intake and outfall system have low (or very low) risk of potential impact. Measures for further risk mitigation regarding the HDD process for the intake and outfall pipes are described in Table 6.1 and these should be used as guided by HDD specialist contactors.

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Annex A Atlas of Living Australia Survey Records

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	Balaenopteridae	30424			urn:lsid:biodi	7043921	FALSE	Balaenoptera			Balaenoptera edeni		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Bryde's Whale		100035		31946			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30424
(Gvºnther, 18	BERYCIDAE	34176	TRUE	redfishes	urn:lsid:biodi	7047673	TRUE	Centroberyx	FALSE	FALSE	Centroberyx gerrardi	gerrardi	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	11	2.8817E-05	E	Bight Redfish	37 258	37258004	260	1155	37 258004	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34176
(Cuvier, 1829	BERYCIDAE	34177	TRUE	redfishes	urn:lsid:biodi	7047674	FALSE	Centroberyx	FALSE	FALSE	Centroberyx lineatus	lineatus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	12	2.8817E-05	E	Swallowtail	37 258	37258005	157	1156	37 258005	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34177
(Klunzinger, 1	BOTHIDAE	34022	TRUE	flatfishes	urn:lsid:biodi	7047519	TRUE	Arnoglossus	FALSE	TRUE	Arnoglossus muelleri	muelleri	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	5	2.8817E-05	G	Mueller's Flounder	37 460	37460030	200	1004	37 460030	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34022
Gvºnther, 18	BOTHIDAE	34890	TRUE	flatfishes	urn:lsid:biodi	7048387	FALSE	Lophonectes	FALSE	TRUE	Lophonectes gallus	gallus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	11	2.8817E-05	G	Crested Flounder	37 460	37460001	640	1869	37 460001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34890
(McCulloch &	BRACHIONICHTHYIDAE	33165	TRUE		urn:lsid:biodi	7046662	TRUE	Thymichthys	FALSE	TRUE	Thymichthys verrucosus	verrucosus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	5	2.8817E-05	G	Warty Handfish	37 209	37209001	230	143	37 209001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33165
Schwarzhans	BYTHITIDAE	33312	FALSE		urn:lsid:biodi	7046809	TRUE	Dactylosurculus	FALSE	TRUE	Dactylosurculus gomoni	gomoni	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	southern pigmy blindfish	37 228	37228046	25	289	37 228046	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33312
Gvºnther, 18	CALLANTHIIDAE	36136	TRUE	rockcods	urn:lsid:biodi	7049633	TRUE	Callanthias	FALSE	TRUE	Callanthias allporti	allporti	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	15	2.8817E-05	G	Rosy Perch	37 311	37311004	365	3117	37 311004	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36136
(Richardson,	CALLIONYMIDAE	37235	TRUE		urn:lsid:biodi	7050732	FALSE	Foetorepus	FALSE	FALSE	Foetorepus calauropomus	calauropomus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	15	2.8817E-05	G	Common Stinkfish	37 427	37427001	183	4217	37 427001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:37235
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Cuvier, 1833	CARANGIDAE	36620	TRUE		urn:lsid:biodi	7050117	FALSE	Pseudocaranx	FALSE	FALSE	Caranx georgianus	georgianus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	11	2.8817E-05	G	[a trevally]	37 337	37337004	124	3617	37 337004	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36620
Cuvier, 1833	CARANGIDAE	36716	TRUE	trevallies	urn:lsid:biodi	7050213	FALSE	Pseudocaranx	FALSE	TRUE	Pseudocaranx georgianus	georgianus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Silver Trevally	37 337	37337062	200	3698	37 337062	1	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36716
(Jenyns, 1841	CARANGIDAE	36632	FALSE	trevallies	urn:lsid:biodi	7050129	FALSE	Trachurus	FALSE	TRUE	Trachurus declivis	declivis	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Common Jack Mackerel	37 337	37337002	500	3613	37 337002	2	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36632
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	CHARADRIIDAE	4945			urn:lsid:biodi	7041992	FALSE	Charadrius			Charadrius (Charadrius) mongolus	mongolus	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		1.5972E-06		Lesser Sand Plover		24721		24721			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:4945
	CHARADRIIDAE	6696				7043742	FALSE	Thinornis			Thinornis rubricollis	rubricollis	https://spatial.ala.org.au/v	ALA_Thinornis_rubricollis			e	Expert distrib	dr804		1.5866E-06		Hooded Plover		26472		26472			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6696
	Charadriidae	32691				7046188	FALSE	Thinornis			Thinornis rubricollis rubricollis		https://spatial.ala.org.au/v	ALA_Thinorn		http://www.	e	Expert distrib	dr2099		2.8817E-05		Hooded Plover (eastern)		266726		33777			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32691
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(Hutton, 187	CHEILODACTYLIDAE	33588	TRUE	morwongs	urn:lsid:biodi	7047085	FALSE	Cheilodactylus	FALSE	TRUE	Cheilodactylus spectabilis	spectabilis	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Banded Morwong	37 377	37377006	50	570	37 377006	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33588
(Whitley, 193	CHEILODACTYLIDAE	33572	TRUE	morwongs	urn:lsid:biodi	7047069	TRUE	Nemadactylus	FALSE	TRUE	Nemadactylus valenciennesi	valenciennesi	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	5	2.8817E-05	E	Blue Morwong	37 377	37377004	240	555	37 377004	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33572
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(Saville-Kent,	CLINIDAE	34327	TRUE		urn:lsid:biodi	7047824	TRUE	Heteroclinus	FALSE	TRUE	Heteroclinus johnstoni	johnstoni	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	E	Johnston's Weedfish	37 416	37416011	50	1309	37 416011	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34327
(Lucas, 1891)	CLINIDAE	37405	FALSE		urn:lsid:biodi	7050902	TRUE	Heteroclinus	FALSE	TRUE	Heteroclinus wilsoni	wilsoni	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	E	Wilson's Weedfish	37 416	37416016	25	4377	37 416016	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:37405
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(Whitley, 194	CONGRIDAE	35008	TRUE	eels	urn:lsid:biodi	7048505	FALSE	Gnathophis	FALSE	FALSE	Gnathophis umbrellabius	umbrellabius	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	12	2.8817E-05	G	Umbrella Conger	37 067	37067016	200	1987	37 067016	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:35008
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Ogilby, 1899	DASYATIDAE	34732	TRUE	rays	urn:lsid:biodi	7048229	FALSE	Dasyatis	FALSE	TRUE	Dasyatis thetidis	thetidis	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Black Stingray	37 035	37035002	360	1700	37 035002	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34732
	DASYORNITHIDAE	6474			urn:lsid:biodi	7043520	FALSE	Pycnoptilus			Pycnoptilus floccosus	floccosus	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Pilotbird		26250		26250			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6474
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	Dicruridae	31372			urn:lsid:biodi	7044869	FALSE	Monarcha			Monarcha melanopsis		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Black-faced Monarch		200609		33866			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31372
	Dicruridae	31374			urn:lsid:biodi	7044871	FALSE	Myiagra			Myiagra cyanoleuca		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Satin Flycatcher		200612		33868			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31374
	Dicruridae	31369			urn:lsid:biodi	7044866	FALSE	Rhipidura			Rhipidura rufifrons		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		5.4441E-06		Rufous Fantail		200592		33864			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31369
(Griffith, 183	DINOLESTIDAE	36499	TRUE		urn:lsid:biodi	7049996	TRUE	Dinolestes	FALSE	TRUE	Dinolestes lewini	lewini	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	1	2.8817E-05	G	Longfin Pike	37 327	37327002	64	3480	37 327002	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36499
Whitley, 193	DIODONTIDAE	33677	TRUE		urn:lsid:biodi	7047174	FALSE	Allomycterus	TRUE	TRUE	Allomycterus pilatus	pilatus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	5	2.8817E-05	G	Australian Burrfish	37 469	37469002	320	662	37 469002	1	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33677
	Diomedeidae	5226			urn:lsid:biodi	7042273	FALSE				Diomedea antipodensis	antipodensis	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Antipodean Albatross		25002		25002			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5226
	Diomedeidae	32443			urn:lsid:biodi	7045940	FALSE	Diomedea			Diomedea antipodensis		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Antipodean Albatross		264458		33885			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32443
	Diomedeidae	31088			urn:lsid:biodi	7044585	FALSE	Diomedea			Diomedea dabbenena		https://spati	urn:lsid:biodi	40040019	http://www.	e	Expert distrib	dr2099		2.8817E-05		Tristan Albatross		166471		32134			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31088
	DIOMEDEIDAE	5227			urn:lsid:biodi	7042274	FALSE	Diomedea			Diomedea epomophora	epomophora	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Royal Albatross		25003		25003			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5227
	Diomedeidae	32174			urn:lsid:biodi	7045671	FALSE	Diomedea			Diomedea epomophora epomophora		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Southern Royal Albatross		225996		33881			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32174
	Diomedeidae	32864			urn:lsid:biodi	7046361	FALSE	Diomedea			Diomedea epomophora sanfordi		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Northern Royal Albatross		282331		33899			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32864
	Diomedeidae	31439			urn:lsid:biodi	7044936	FALSE	Diomedea			Diomedea epomophora (sensu stricto)		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Southern Royal Albatross		201072		33877			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31439
	DIOMEDEIDAE	5229			urn:lsid:biodi	7042276	FALSE	Diomedea			Diomedea epomophora sanfordi	sanfordi	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Northern Royal Albatross		25005		25005			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5229
	DIOMEDEIDAE	5228			urn:lsid:biodi	7042275	FALSE	Diomedea			Diomedea exulans	exulans	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Wandering Albatross		25004		25004			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5228
	Diomedeidae	32859			urn:lsid:biodi	7046356	FALSE	Diomedea			Diomedea exulans antipodensis		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Antipodean Albatross		282269		33896			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32859
	Diomedeidae	31225			urn:lsid:biodi	7044722	FALSE	Diomedea			Diomedea exulans exulans		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Tristan Albatross		182337		32141			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31225
	Diomedeidae	31440			urn:lsid:biodi	7044937	FALSE	Diomedea			Diomedea exulans (sensu lato)		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Wandering Albatross		201073		33878			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31440
	Diomedeidae	32441			urn:lsid:biodi	7045938	FALSE	Diomedea			Diomedea sanfordi		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Northern Royal Albatross		264456		33883			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32441
	Diomedeidae	31441			urn:lsid:biodi	7044938	FALSE	Phoebetria			Phoebetria fusca		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Sooty Albatross		201075		33879			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31441
	Diomedeidae	30993			urn:lsid:biodi	7044490	FALSE	Thalassarche			Thalassarche bulleri		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Buller's Albatross, Pacific Albatross		164460		32128			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30993
	Diomedeidae	32448			urn:lsid:biodi	7045945	FALSE	Thalassarche			Thalassarche carteri		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Indian Yellow-nosed Albatross		264464		33890			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32448
	Diomedeidae	6686			urn:lsid:biodi	7043732	FALSE	Thalassarche			Thalassarche carteri	carteri	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Indian Yellow-nosed Albatross		26462		26462			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6686
	DIOMEDEIDAE	6687			urn:lsid:biodi	7043733	FALSE	Thalassarche			Thalassarche cauta	cauta	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Shy Albatross		26463		26463			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6687
	Diomedeidae	32868			urn:lsid:biodi	7046365	FALSE	Thalassarche			Thalassarche cauta cauta		https://spati	urn:lsid:biodi	NZOR-6-7328	http://www.	e	Expert distrib	dr2099		2.8817E-05		Shy Albatross, Tasmanian Shy Albatross		282345		33903			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32868
	Diomedeidae	32866			urn:lsid:biodi	7046363	FALSE	Thalassarche			Thalassarche cauta salvini		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Salvin's Albatross		282343		33901			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32866
	Diomedeidae	32867			urn:lsid:biodi	7046364	FALSE	Thalassarche			Thalassarche cauta steadi		https://spati	urn:lsid:biodi	NZOR-6-6319	http://www.	e	Expert distrib	dr2099		2.8817E-05		White-capped Albatross		282344		33902			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32867
	Diomedeidae	32520			urn:lsid:biodi	7046017	FALSE	Thalassarche			Thalassarche cauta (sensu stricto)		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Shy Albatross, Tasmanian Shy Albatross		264697		33892			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32520
	Diomedeidae	31090			urn:lsid:biodi	7044587	FALSE	Thalassarche			Thalassarche chrysostoma		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Grey-headed Albatross		166491		32136			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31090
	DIOMEDEIDAE	6688			urn:lsid:biodi	7043734	FALSE	Thalassarche			Thalassarche chrysostoma	chrysostoma	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Grey-headed Albatross		26464		26464			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6688
	Diomedeidae	32444			urn:lsid:biodi	7045941	FALSE	Thalassarche			Thalassarche impavida		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Campbell Albatross		264459		33886			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32444
	Diomedeidae	6690			urn:lsid:biodi	7043736	FALSE				Thalassarche impavida	impavida	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Campbell Albatross		26466		26466			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6690
	Diomedeidae	31089			urn:lsid:biodi	7044586	FALSE	Thalassarche			Thalassarche melanophris		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Black-browed Albatross		166472		32135			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31089
	Diomedeidae	32873			urn:lsid:biodi	7046370	FALSE	Thalassarche			Thalassarche melanophris impavida		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Campbell Albatross		282449		33904			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32873
	Diomedeidae	32447			urn:lsid:biodi	7045944	FALSE	Thalassarche			Thalassarche salvini		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Salvin's Albatross		264463		33889			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32447
	Diomedeidae	6692			urn:lsid:biodi	7043738	FALSE				Thalassarche salvini	salvini	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Salvin's Albatross		26468		26468			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6692
	Diomedeidae	6693			urn:lsid:biodi	7043739	FALSE				Thalassarche steadi	steadi	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		White-capped Albatross		26469		26469			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6693
	Diomedeidae	32446			urn:lsid:biodi	7045943	FALSE	Thalassarche			Thalassarche steadi		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		White-capped Albatross		264462		33888			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32446
(Lowe, 1839)	ECHENEIDAE	36629	FALSE		urn:lsid:biodi	7050126	FALSE	Remora	FALSE	FALSE	Remora brachyptera	brachyptera	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Spearfish Remora	37 336	37336005	200	3610	37 336005	2	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36629
Pietschmann	ECHINORHINIDAE	34677	TRUE	sharks	urn:lsid:biodi	7048174	FALSE	Echinorhinus	FALSE	TRUE	Echinorhinus cookei	cookei	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	11	2.8817E-05	G	Prickly Shark	37 022	37022002	1100	1654	37 022002	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34677
Hoese & Lars	ELEOTRIDAE	34522	FALSE		urn:lsid:biodi	7048019	TRUE	Thalasseleotris	FALSE	TRUE	Thalasseleotris adela	adela	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05		Cryptic Sea Gudgeon	37 429	37429042	24	1497	37 429042	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34522
Richardson, 1	EMMELICHTHYIDAE	35378	TRUE		urn:lsid:biodi	7048875	FALSE	Emmelichthys	FALSE	TRUE	Emmelichthys nitidus	nitidus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	11	2.8817E-05	G	Redbait	37 345	37345001	600	2362	37 345001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:35378
(Valencienne	EXOCOETIDAE	33586	FALSE		urn:lsid:biodi	7047083	FALSE	Hirundichthys	FALSE	FALSE	Hirundichthys rufipinnis	rufipinnis	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Rondelet's Flyingfish	37 233	37233002	200	568	37 233002	2	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33586
	Fabaceae	31852			https://id.bio	7045349	FALSE	Glycine			Glycine latrobeana		https://spati	https://id.bic	https://id.bic	http://www.	e	Expert distrib	dr2099		2.8817E-05		Clover Glycine, Purple Clover		213910		34032			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31852
	Galaxiidae	30953			urn:lsid:biodi	7044450	FALSE	Galaxiella			Galaxiella pusilla		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.3372E-05		Eastern Dwarf Galaxias, Dwarf Galaxias		156790		32366			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30953
	Galaxiidae	32385			urn:lsid:biodi	7045882	FALSE	Galaxiella			Galaxiella pusilla		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		5.4441E-06		Eastern Dwarf Galaxias, Dwarf Galaxias		256790		34125			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32385
Gray, 1851	GEOTRIIDAE	33955	FALSE	lampreys	urn:lsid:biodi	7047452	FALSE	Geotria	TRUE	TRUE	Geotria australis	australis	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Pouch Lamprey	37 003	37003001	50	1070	37 003001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33955
(Richardson,	GOBIESOCIDAE	33027	FALSE		urn:lsid:biodi	7046524	TRUE	Alabes	FALSE	TRUE	Alabes dorsalis	dorsalis	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	E	Common Shore Eel	37 206	37206008	30	13	37 206008	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33027
Hutchins, 198	GOBIESOCIDAE	33022	FALSE		urn:lsid:biodi	7046519	TRUE	Cochleoceps	FALSE	TRUE	Cochleoceps bassensis	bassensis	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05		Broadhead Clingfish	37 206	37206002	40	8	37 206002	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33022
Hutchins, 199	GOBIESOCIDAE	33093	FALSE		urn:lsid:biodi	7046590	TRUE	Cochleoceps	FALSE	TRUE	Cochleoceps bicolor	bicolor	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Western Cleaner Clingfish	37 206	37206011	40	77	37 206011	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33093
(Ramsay & O.	GOBIIDAE	37272	FALSE		urn:lsid:biodi	7050769	TRUE	Callogobius	FALSE	TRUE	Callogobius depressus	depressus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Flathead Goby	37 428	37428087	30	4253	37 428087	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:37272
(Gvºnther, 18	GOBIIDAE	37256	FALSE		urn:lsid:biodi	7050753	TRUE	Callogobius	FALSE	TRUE	Callogobius mucosus	mucosus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Sculptured Goby	37 428	37428003	30	4239	37 428003	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:37256
(Meyer, 1793	HETERODONTIDAE	34118	TRUE	sharks	urn:lsid:biodi	7047615	FALSE	Heterodontus	FALSE	TRUE	Heterodontus portusjacksoni	portusjacksoni	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	A	Port Jackson Shark	37 007	37007001	275	1102	37 007001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34118
(PV©ron, 180	HEXANCHIDAE	34121	TRUE	sharks	urn:lsid:biodi	7047618	FALSE	Notorynchus	FALSE	TRUE	Notorynchus cepedianus	cepedianus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	E	Broadnose Shark	37 005	37005002	136	1105	37 005002	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34121
	Hydrobatidae	32427			urn:lsid:biodi	7045924	FALSE	Fregetta			Fregetta grallaria grallaria		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian)		264438		34195			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32427
	Hylidae	31474			urn:lsid:biodi	7044971	FALSE	Litoria			Litoria raniformis		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog		201828		34203			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31474
(Richardson,	LABRIDAE	37423	FALSE		urn:lsid:biodi	7050920	TRUE	Heteroscarus	FALSE	TRUE	Heteroscarus acroptilus	acroptilus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	1	2.8817E-05		Rainbow Cale	37 385	37385010	25	4409	37 385010	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:37423
(Valencienne	LABRIDAE	37389	FALSE		urn:lsid:biodi	7050886	TRUE	Neoodax	TRUE	TRUE	Neoodax balteatus	balteatus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	1	2.8817E-05	E	Little Weed Whiting	37 385	37385005	22	4388	37 385005	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:37389
Richardson, 1	LABRIDAE	35906	FALSE		urn:lsid:biodi	7049403	TRUE	Odax	FALSE	TRUE	Olisthops cyanomelas	cyanomelas	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	1	2.8817E-05	E	Herring Cale	37 385	37385001	30	2880	37 385001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:35906
Richardson, 1	LABRIDAE	37413	FALSE		urn:lsid:biodi	7050910	TRUE	Siphonognathus	FALSE	TRUE	Siphonognathus argyrophanes	argyrophanes	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	1	2.8817E-05	E	Tubemouth	37 385	37385008	40	4399	37 385008	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:37413
(Ogilby, 1897	LABRIDAE	37390	FALSE		urn:lsid:biodi	7050887	TRUE	Siphonognathus	FALSE	TRUE	Siphonognathus attenuatus	attenuatus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	1	2.8817E-05	G	Slender Weed Whiting	37 385	37385004	40	4389	37 385004	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:37390
	Lamnidae	32451			urn:lsid:biodi	7045948	FALSE	Carcharodon			Carcharodon carcharias		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Great White Shark		264470		34255			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32451
Rafinesque, 1	LAMNIDAE	34161	FALSE	sharks	urn:lsid:biodi	7047658	FALSE	Isurus	FALSE	FALSE	Isurus oxyrinchus	oxyrinchus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Shortfin Mako	37 010	37010001	650	1141	37 010001	2	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34161
	Lamnidae	32937			urn:lsid:biodi	7046434	FALSE	Lamna			Lamna nasus		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Porbeagle, Mackerel Shark		283288		34258			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32937
(Bonnaterre,	LAMNIDAE	34164	FALSE	sharks	urn:lsid:biodi	7047661	FALSE	Lamna	FALSE	FALSE	Lamna nasus	nasus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Porbeagle	37 010	37010004	370	1144	37 010004	2	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34164
	LARIDAE	4973			urn:lsid:biodi	7042020	FALSE	Chlidonias			Chlidonias (Chlidonias) leucopterus	leucopterus	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		8.953E-06		White-winged Black Tern		24749		24749			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:4973
	LARIDAE	5574			urn:lsid:biodi	7042620	FALSE	Chroicocephalus			Chroicocephalus novaehollandiae novaehollandiae	novaehollandiae	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Silver Gull		25350		25350			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5574
	LARIDAE	6619			urn:lsid:biodi	7043665	FALSE	Sterna			Sterna (Sterna) hirundo	hirundo	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Common Tern		26395		26395			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6619
	Laridae	30485			urn:lsid:biodi	7043982	FALSE	Sterna			Sterna albifrons		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Little Tern		100813		32501			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30485
	LARIDAE	6621			urn:lsid:biodi	7043667	FALSE	Sterna			Sterna nereis	nereis	https://spati	urn:lsid:biodi	NZOR-6-111356		e	Expert distrib	dr804		2.8817E-05		Fairy Tern		26397		26397			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6621
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	Laridae	32916			urn:lsid:biodi	7046413	FALSE	Sternula			Sternula nereis nereis		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Australian Fairy Tern		282950		34269			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32916
	LARIDAE	6616			urn:lsid:biodi	7043662	FALSE	Thalasseus			Thalasseus bergii	bergii	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Crested Tern		26392		26392			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6616
(Castelnau, 1	LATRIDAE	33621	TRUE	trumpeters	urn:lsid:biodi	7047118	FALSE	Latridopsis	FALSE	TRUE	Latridopsis forsteri	forsteri	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	2	2.8817E-05	G	Bastard Trumpeter	37 378	37378002	60	606	37 378002	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33621
(Schneider, 1	LATRIDAE	33620	TRUE	trumpeters	urn:lsid:biodi	7047117	FALSE	Latris	FALSE	TRUE	Latris lineata	lineata	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	3	2.8817E-05	E	Striped Trumpeter	37 378	37378001	300	605	37 378001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33620
	Meliphagidae	32865			urn:lsid:biodi	7046362	FALSE	Anthochaera			Anthochaera phrygia		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Regent Honeyeater		282338		34346			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32865
	MELIPHAGIDAE	5284			urn:lsid:biodi	7042331	FALSE	Entomyzon			Entomyzon cyanotis	cyanotis	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.3661E-05		Blue-faced Honeyeater		25060		25060			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5284
	MELIPHAGIDAE	5597			urn:lsid:biodi	7042643	FALSE	Lichenostomus			Lichenostomus (Lichenostomus) melanops	melanops	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Yellow-tufted Honeyeater		25373		25373			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5597
	Meropidae	30477			urn:lsid:biodi	7043974	FALSE	Merops			Merops ornatus		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr2099		2.8817E-05		Rainbow Bee-eater		100670		32590			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30477
(Gvºnther, 18	MICROCANTHIDAE	36997	FALSE		urn:lsid:biodi	7050494	FALSE	Atypichthys	FALSE	TRUE	Atypichthys strigatus	strigatus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	E	Mado	37 361	37361010	30	3975	37 361010	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36997
(Cuvier, 1831	MICROCANTHIDAE	36971	TRUE		urn:lsid:biodi	7050468	FALSE	Microcanthus	FALSE	TRUE	Microcanthus strigatus	strigatus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Stripey	37 361	37361005	50	3948	37 361005	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36971
(Richardson,	MICROCANTHIDAE	36960	FALSE		urn:lsid:biodi	7050457	TRUE	Tilodon	FALSE	TRUE	Tilodon sexfasciatus	sexfasciatus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	1	2.8817E-05	E	Moonlighter	37 361	37361003	30	3937	37 361003	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36960
(Castelnau, 1	MONACANTHIDAE	33707	FALSE	leatherjacket	urn:lsid:biodi	7047204	TRUE	Acanthaluteres	FALSE	TRUE	Acanthaluteres vittiger	vittiger	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	1	2.8817E-05	E	Toothbrush Leatherjacket	37 465	37465002	40	689	37 465002	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33707
(Quoy & Gair	MONACANTHIDAE	33776	FALSE	leatherjacket	urn:lsid:biodi	7047273	TRUE	Brachaluteres	TRUE	TRUE	Brachaluteres jacksonianus	jacksonianus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	G	Southern Pygmy Leatherjacket	37 465	37465025	40	758	37 465025	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33776
(Whitley, 193	MONACANTHIDAE	33818	TRUE	leatherjacket	urn:lsid:biodi	7047315	TRUE	Eubalichthys	FALSE	TRUE	Eubalichthys bucephalus	bucephalus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	5	2.8817E-05	G	Black Reef Leatherjacket	37 465	37465039	250	801	37 465039	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33818
(Ramsay & O.	MONACANTHIDAE	33708	TRUE	leatherjacket	urn:lsid:biodi	7047205	TRUE	Eubalichthys	FALSE	TRUE	Eubalichthys mosaicus	mosaicus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	6	2.8817E-05	G	Mosaic Leatherjacket	37 465	37465003	150	690	37 465003	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33708
Hutchins, 197	MONACANTHIDAE	33820	FALSE	leatherjacket	urn:lsid:biodi	7047317	TRUE	Meuschenia	FALSE	TRUE	Meuschenia flavolineata	flavolineata	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	1	2.8817E-05	G	Yellowstriped Leatherjacket	37 465	37465035	30	803	37 465035	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33820
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Hutchins, 197	MONACANTHIDAE	33743	TRUE	leatherjacket	urn:lsid:biodi	7047240	TRUE	Meuschenia	FALSE	TRUE	Meuschenia venusta	venusta	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	5	2.8817E-05	G	Stars-and-stripes Leatherjacket	37 465	37465060	100	727	37 465060	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33743
(Richardson,	MORDACIIDAE	33956	FALSE	lampreys	urn:lsid:biodi	7047453	TRUE	Mordacia	TRUE	TRUE	Mordacia mordax	mordax	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	A	Shorthead Lamprey	37 003	37003002	50	1071	37 003002	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33956
Paulin, 1986	MORIDAE	33265	FALSE		urn:lsid:biodi	7046762	TRUE	Eeyorius	FALSE	TRUE	Eeyorius hutchinsi	hutchinsi	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	0	2.8817E-05	E	Finetooth Beardie	37 224	37224019	25	246	37 224019	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33265
(Forster, 180	MORIDAE	33212	TRUE		urn:lsid:biodi	7046709	FALSE	Lotella	FALSE	TRUE	Lotella rhacina	rhacina	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	10	2.8817E-05	G	Largetooth Beardie	37 224	37224005	90	189	37 224005	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33212
(Forster, 180	MORIDAE	33208	TRUE		urn:lsid:biodi	7046705	FALSE	Pseudophycis	FALSE	FALSE	Pseudophycis bachus	bachus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	10	2.8817E-05	G	Red Cod	37 224	37224006	375	185	37 224006	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33208
Gvºnther, 18	MORIDAE	33206	TRUE		urn:lsid:biodi	7046703	FALSE	Pseudophycis	FALSE	FALSE	Pseudophycis barbata	barbata	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	1	2.8817E-05	E	Bearded Rock Cod	37 224	37224003	275	183	37 224003	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33206
(Richardson,	MORIDAE	33214	TRUE		urn:lsid:biodi	7046711	FALSE	Pseudophycis	FALSE	FALSE	Pseudophycis breviuscula	breviuscula	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.	e	Expert distrib	dr803	4	2.8817E-05	E	Bastard Red Cod	37 224	37224011	200	191	37 224011	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33214

(Richardson,	MURAENIDAE	34973	FALSE	eels	urn:lsid:biodi	7048470	FALSE	Gymnothorax	FALSE	TRUE	Gymnothorax prasinus	prasinus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	E	Green Moray	37 060	37060006	40	1955	37 060006	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34973
	Muridae	31331			urn:lsid:biodi	7044828	FALSE	Pseudomys			Pseudomys novaehollandiae		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		New Holland Mouse, Pookila		200096		34358			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31331
Hector, 1877	MYLIOBATIDAE	34757	TRUE	rays	urn:lsid:biodi	7048254	FALSE	Myliobatis	FALSE	TRUE	Myliobatis tenuicaudatus	tenuicaudatus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	E	Southern Eagle Ray	37 039	37039001	130	1732	37 039001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34757
	Neobalaenidae	30428			urn:lsid:biodi	7043925	FALSE	Caperea			Caperea marginata		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Pygmy Right Whale		100039		32802			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30428
Whitley, 193	NEOSEBASTIDAE	35650	TRUE		urn:lsid:biodi	7049147	FALSE	Maxillicosta	FALSE	TRUE	Maxillicosta scabriceps	scabriceps	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	2	2.8817E-05	G	Little Gurnard Perch	37 287	37287007	46	2630	37 287007	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:35650
Guichenot, 1	NEOSEBASTIDAE	35648	TRUE		urn:lsid:biodi	7049145	FALSE	Neosebastes	FALSE	TRUE	Neosebastes scorpaenoides	scorpaenoides	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	1	2.8817E-05	G	Common Gurnard Perch	37 287	37287005	181	2628	37 287005	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:35648
	OCEANITIDAE	5378			urn:lsid:biodi	7042424	FALSE	Fregetta			Fregetta tropica	tropica	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Black-bellied Storm-petrel		25154		25154			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5378
	OCEANITIDAE	6018			urn:lsid:biodi	7043064	FALSE	Oceanites			Oceanites oceanicus	oceanicus	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Wilson's Storm-petrel		25794		25794			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6018
	OCEANITIDAE	6128			urn:lsid:biodi	7043174	FALSE	Pelagodroma			Pelagodroma marina	marina	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		White-faced Storm-petrel		25904		25904			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6128
(Macleay, 18	OPHICHTHIDAE	34897	TRUE	eels	urn:lsid:biodi	7048394	FALSE	Scolecenchelys	FALSE	TRUE	Scolecenchelys australis	australis	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	2	2.8817E-05	G	Shortfin Worm Eel	37 068	37068003	50	1876	37 068003	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34897
(GVºnther, 1	OPHICHTHIDAE	34898	TRUE	eels	urn:lsid:biodi	7048395	FALSE	Scolecenchelys	TRUE	TRUE	Scolecenchelys breviceps	breviceps	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	2	2.8817E-05	G	Shorthead Worm Eel	37 068	37068004	156	1877	37 068004	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34898
(McCulloch,	OPHICHTHIDAE	34899	FALSE	eels	urn:lsid:biodi	7048396	TRUE	Scolecenchelys	FALSE	TRUE	Scolecenchelys tasmaniensis	tasmaniensis	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	A	Tasmanian Worm Eel	37 068	37068008	50	1878	37 068008	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34899
(Forster, 180	OPHIDIIDAE	33255	TRUE		urn:lsid:biodi	7046752	FALSE	Genypterus	FALSE	FALSE	Genypterus blacodes	blacodes	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	10	2.8817E-05	G	Pink Ling	37 228	37228002	989	231	37 228002	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33255
Klunzinger, 1	OPHIDIIDAE	33166	TRUE		urn:lsid:biodi	7046663	TRUE	Genypterus	FALSE	TRUE	Genypterus tigerinus	tigerinus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	1	2.8817E-05	E	Rock Ling	37 228	37228008	60	235	37 228008	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33166
	Orchidaceae	31728			https://id.bic	7045225	FALSE	Prasophyllum			Prasophyllum frenchii		https://spati	https://id.bic	https://id.bic	http://www.e	Expert distrib	dr2099		2.8817E-05		Maroon Leek-orchid, Slaty Leek-orchid, Stout Leek-orchid, French's Leek-orchid, Swamp Leek-orchid		209704		34609			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31728
	Orchidaceae	31892			https://id.bic	7045389	FALSE	Pterostylis			Pterostylis cucullata		https://spati	https://id.bic	https://id.bic	http://www.e	Expert distrib	dr2099		5.4441E-06		Leafy Greenhood		215455		34629			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31892
(Shaw, 1798)	OSTRACIIDAE	33698	TRUE		urn:lsid:biodi	7047195	TRUE	Aracana	FALSE	TRUE	Aracana aurita	aurita	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	10	2.8817E-05	G	Shaw's Cowfish	37 466	37466003	160	680	37 466003	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33698
McCulloch, 1	PARASCYLLIIDAE	34188	TRUE	sharks	urn:lsid:biodi	7047685	TRUE	Parascyllium	FALSE	TRUE	Parascyllium ferrugineum	ferrugineum	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	5	2.8817E-05	G	Rusty Carpetshark	37 013	37013005	150	1167	37 013005	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34188
(GVºnther, 1	PATAECIDAE	36121	TRUE		urn:lsid:biodi	7049618	TRUE	Aetapcus	FALSE	TRUE	Aetapcus maculatus	maculatus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	1	2.8817E-05	G	Warty Prowfish	37 292	37292004	45	3102	37 292004	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36121
(Castelnau, 1	PATAECIDAE	36122	FALSE		urn:lsid:biodi	7049619	TRUE	Neopataecus	FALSE	TRUE	Neopataecus waterhousii	waterhousii	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	G	Whiskered Prowfish	37 292	37292005	40	3103	37 292005	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36122
Kaup, 1861	PEGASIDAE	36276	TRUE		urn:lsid:biodi	7049773	TRUE	Pegasus	FALSE	TRUE	Pegasus lancifer	lancifer	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	G	Sculptured Seamoth	37 309	37309003	55	3250	37 309003	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36276
(McCulloch,	PEMPHERIDAE	36885	TRUE		urn:lsid:biodi	7050382	TRUE	Parapriacanthus	FALSE	FALSE	Parapriacanthus elongatus	elongatus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	1	2.8817E-05	G	Elongate Bullseye	37 357	37357002	70	3869	37 357002	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36885
Klunzinger, 1	PEMPHERIDAE	36875	TRUE		urn:lsid:biodi	7050372	TRUE	Pempheris	FALSE	TRUE	Pempheris multiradiata	multiradiata	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	2	2.8817E-05	G	Bigscale Bullseye	37 357	37357001	70	3859	37 357001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36875
	Peramelidae	32740			urn:lsid:biodi	7046237	FALSE	Isoodon			Isoodon obesulus obesulus		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Southern Brown Bandicoot (Eastern)		268050		34823			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32740
Whitley, 193	PERCOPHIDAE	37377	TRUE		urn:lsid:biodi	7050874	TRUE	Enigmapercis	FALSE	TRUE	Enigmapercis reducta	reducta	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	1	2.8817E-05	A	Broad Duckbill	37 393	37393008	60	4354	37 393008	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:37377
Knapp, 1987	PLATYCEPHALIDAE	36240	TRUE	flatheads	urn:lsid:biodi	7049737	TRUE	Platycephalus	FALSE	TRUE	Platycephalus aurimaculatus	aurimaculatus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	10	2.8817E-05	E	Toothy Flathead	37 296	37296035	160	3220	37 296035	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36240
(Richardson,	PLATYCEPHALIDAE	36098	TRUE	flatheads	urn:lsid:biodi	7049595	TRUE	Thysanophrys	TRUE	TRUE	Thysanophrys cirronasa	cirronasa	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	G	Tasselsnout Flathead	37 296	37296045	35	3077	37 296045	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36098
McCoy, 1890	PLESIOPIDAE	36332	FALSE		urn:lsid:biodi	7049829	TRUE	Trachinops	TRUE	TRUE	Trachinops caudimaculatus	caudimaculatus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	2	2.8817E-05	G	Southern Hulafish	37 316	37316001	35	3305	37 316001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36332
(Richardson,	PLEURONECTIDAE	34009	TRUE	flatfishes	urn:lsid:biodi	7047506	TRUE	Ammotretis	FALSE	TRUE	Ammotretis lituratus	lituratus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	1	2.8817E-05	G	Spotted Flounder	37 461	37461004	80	987	37 461004	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34009
GVºnther, 18	POMACENTRIDAE	35339	FALSE		urn:lsid:biodi	7048836	TRUE	Parma	FALSE	TRUE	Parma microlepis	microlepis	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	G	White-ear	37 372	37372005	30	2322	37 372005	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:35339
(Linnaeus, 17	POMATOMIDAE	36813	FALSE		urn:lsid:biodi	7050310	FALSE	Pomatomus	TRUE	TRUE	Pomatomus saltatrix	saltatrix	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	G	Tailor	37 334	37334002	15	3793	37 334002	1	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36813
GVºnther, 18	PRISTIOPHORIDAE	34678	TRUE	sharks	urn:lsid:biodi	7048175	TRUE	Pristiophorus	FALSE	TRUE	Pristiophorus nudipinnis	nudipinnis	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	5	2.8817E-05	G	Southern Sawshark	37 023	37023001	110	1655	37 023001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34678
	PROCELLARIIDAE	6448			urn:lsid:biodi	7043494	FALSE	Ardenna			Ardenna carneipes	carneipes	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Flesh-footed Shearwater		26224		26224			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6448
	PROCELLARIIDAE	5172			urn:lsid:biodi	7042219	FALSE	Daption			Daption capense	capense	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Cape Petrel		24948		24948			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5172
	PROCELLARIIDAE	5381			urn:lsid:biodi	7042427	FALSE	Fulmarus			Fulmarus glacialoides	glacialoides	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Southern Fulmar		25157		25157			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5381
	Procellariidae	30499			urn:lsid:biodi	7043996	FALSE	Halobaena			Halobaena caerulea		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Blue Petrel		101059		33145			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30499
	PROCELLARIIDAE	5486			urn:lsid:biodi	7042532	FALSE	Halobaena			Halobaena caerulea	caerulea	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Blue Petrel		25262		25262			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5486
	PROCELLARIIDAE	5684			urn:lsid:biodi	7042730	FALSE	Lugensa			Lugensa brevirostris	brevirostris	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Kerguelen Petrel		25460		25460			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5684
	Procellariidae	30500			urn:lsid:biodi	7043997	FALSE	Macronectes			Macronectes giganteus		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Southern Giant-Petrel		101060		33146			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30500
	PROCELLARIIDAE	5692			urn:lsid:biodi	7042738	FALSE	Macronectes			Macronectes giganteus	giganteus	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Southern Giant-petrel		25468		25468			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5692
	Procellariidae	30501			urn:lsid:biodi	7043998	FALSE	Macronectes			Macronectes halli		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Northern Giant-Petrel		101061		33147			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30501
	PROCELLARIIDAE	5693			urn:lsid:biodi	7042739	FALSE	Macronectes			Macronectes halli	halli	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Northern Giant-petrel		25469		25469			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5693
	PROCELLARIIDAE	6096			urn:lsid:biodi	7043142	FALSE	Pachyptila			Pachyptila belcheri	belcheri	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Slender-billed Prion		25872		25872			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6096
	PROCELLARIIDAE	6098			urn:lsid:biodi	7043144	FALSE	Pachyptila			Pachyptila desolata	desolata	https://spati	urn:lsid:biodi	NZOR-6-39520	e	Expert distrib	dr804		2.8817E-05		Antarctic Prion		25874		25874			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6098
	PROCELLARIIDAE	6099			urn:lsid:biodi	7043145	FALSE	Pachyptila			Pachyptila salvini	salvini	https://spati	urn:lsid:biodi	NZOR-6-29884	e	Expert distrib	dr804		2.8817E-05		Salvin's Prion		25875		25875			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6099
	PROCELLARIIDAE	6336			urn:lsid:biodi	7043382	FALSE	Procellaria			Procellaria (Procellaria) aequinoctialis	aequinoctialis	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		White-chinned Petrel		26112		26112			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6336
	PROCELLARIIDAE	6388			urn:lsid:biodi	7043434	FALSE	Pterodroma			Pterodroma (Cookilaria) leucoptera	leucoptera	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Gould's Petrel		26164		26164			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6388
	PROCELLARIIDAE	6387			urn:lsid:biodi	7043433	FALSE	Pterodroma			Pterodroma (Pterodroma) lessonii	lessonii	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		White-headed Petrel		26163		26163			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6387
	PROCELLARIIDAE	6389			urn:lsid:biodi	7043435	FALSE	Pterodroma			Pterodroma (Pterodroma) macroptera	macroptera	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Great-winged Petrel		26165		26165			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6389
	PROCELLARIIDAE	6386			urn:lsid:biodi	7043432	FALSE	Pterodroma			Pterodroma (Unplaced) inexpectata	inexpectata	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Mottled Petrel		26162		26162			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6386
	Procellariidae	30861			urn:lsid:biodi	7044358	FALSE	Pterodroma			Pterodroma leucoptera leucoptera		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Gould's Petrel		126033		33149			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30861
	Procellariidae	30497			urn:lsid:biodi	7043994	FALSE	Pterodroma			Pterodroma mollis		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Soft-plumaged Petrel		101036		33141			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30497
	PROCELLARIIDAE	6446			urn:lsid:biodi	7043492	FALSE	Puffinus			Puffinus (Puffinus) assimilis	assimilis	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Little Shearwater		26222		26222			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6446
	PROCELLARIIDAE	6449			urn:lsid:biodi	7043495	FALSE	Puffinus			Puffinus (Puffinus) gavia	gavia	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Fluttering Shearwater		26225		26225			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6449
	PROCELLARIIDAE	6452			urn:lsid:biodi	7043498	FALSE	Puffinus			Puffinus (Puffinus) huttoni	huttoni	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Hutton's Shearwater		26228		26228			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6452
	Procellariidae	31434			urn:lsid:biodi	7044931	FALSE	Puffinus			Puffinus carneipes		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Flesh-footed Shearwater, Fleshy-footed Shearwater		201043		34902			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31434
	PROCELLARIIDAE	6450			urn:lsid:biodi	7043496	FALSE	Puffinus			Puffinus griseus	griseus	https://spati	urn:lsid:biodi	NZOR-6-8862	e	Expert distrib	dr804		2.8817E-05		Sooty Shearwater		26226		26226			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6450
MVºller & Tro	PSEUDOCHROMIDAE	36314	FALSE		urn:lsid:biodi	7049811	FALSE	Pseudochromis	FALSE	TRUE	Pseudochromis fuscus	fuscus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	G	Dusky Dottyback	37 313	37313006	30	3289	37 313006	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36314
	Psittacidae	30481			urn:lsid:biodi	7043978	FALSE	Lathamus			Lathamus discolor		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Swift Parrot		100744		33273			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30481
	Psittacidae	31382			urn:lsid:biodi	7044879	FALSE	Neophema			Neophema chrysogaster		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Orange-bellied Parrot		200747		35033			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31382
	PSITTACIDAE	6364			urn:lsid:biodi	7043410	FALSE	Psittacula			Psittacula krameri	krameri	https://spatial.ala.org.au	urn:lsid:biodiversity.org.au		e	Expert distrib	dr804		2.8817E-05		Ring-necked Parakeet		26140		26140			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6364
	Pteropodidae	31340			urn:lsid:biodi	7044837	FALSE	Pteropus			Pteropus poliocephalus		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Grey-headed Flying-fox		200186		35043			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31340
(Linnaeus, 17	RACHYCENTRIDAE	36814	FALSE		urn:lsid:biodi	7050311	FALSE	Rachycentron	FALSE	TRUE	Rachycentron canadum	canadum	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	G	Cobia	37 335	37335001	200	3794	37 335001	2	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36814
(Richardson,	RAJIDAE	34792	TRUE	rays	urn:lsid:biodi	7048289	TRUE	Dentiraja	FALSE	TRUE	Dentiraja lemprieri	lemprieri	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	G	Thornback Skate	37 031	37031007	170	1766	37 031007	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34792
(Iredale, 193	RAJIDAE	34791	TRUE	rays	urn:lsid:biodi	7048288	TRUE	Spiniraja	FALSE	TRUE	Spiniraja whitleyi	whitleyi	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	1	2.8817E-05	E	Melbourne Skate	37 031	37031006	345	1765	37 031006	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34791
	Retropinnidae	32197			urn:lsid:biodi	7045694	FALSE	Prototroctes			Prototroctes maraena		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Australian Grayling		226179		35061			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32197
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	Rostratulidae	31170			urn:lsid:biodi	7044667	FALSE	Rostratula			Rostratula australis		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Australian Painted Snipe		177037		33326			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31170
	Rostratulidae	30490			urn:lsid:biodi	7043987	FALSE	Rostratula			Rostratula benghalensis (sensu lato)		https://spati	urn:lsid:biodi	NZOR-6-6375	http://www.e	Expert distrib	dr2099		2.8817E-05		Painted Snipe		100889		33325			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30490
(Temminck &	SCIAENIDAE	36898	TRUE	jewfishes	urn:lsid:biodi	7050395	FALSE	Argyrosomus	FALSE	TRUE	Argyrosomus japonicus	japonicus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	G	Mulloway	37 354	37354001	150	3881	37 354001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36898
	SCOLOPACIDAE	4861			urn:lsid:biodi	7041908	FALSE	Calidris			Calidris (Erolia) ferruginea	ferruginea	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Curlew Sandpiper		24637		24637			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:4861
	Scolopacidae	30488			urn:lsid:biodi	7043985	FALSE	Gallinago			Gallinago hardwickii		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Latham's Snipe, Japanese Snipe		100863		33462			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:30488
	SCOLOPACIDAE	5620			urn:lsid:biodi	7042666	FALSE	Limosa			Limosa haemastica	haemastica	https://spati	urn:lsid:biodi	NZOR-6-23572	e	Expert distrib	dr804		2.8817E-05		Hudsonian Godwit		25396		25396			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:5620
	SCOLOPACIDAE	6190			urn:lsid:biodi	7043236	FALSE	Phalaropus			Phalaropus lobatus	lobatus	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Red-necked Phalarope		25966		25966			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6190
	SCOLOPACIDAE	6214			urn:lsid:biodi	7043260	FALSE	Philomachus			Philomachus pugnax	pugnax	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.8817E-05		Ruff		25990		25990			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6214
	SCOLOPACIDAE	6752			urn:lsid:biodi	7043798	FALSE	Tringa			Tringa (Rhyacophilus) stagnatilis	stagnatilis	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		2.7808E-05		Marsh Sandpiper		26528		26528			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6752
	SCOLOPACIDAE	6799			urn:lsid:biodi	7043845	FALSE	Xenus			Xenus cinereus	cinereus	https://spati	urn:lsid:biodi	urn:lsid:biodiversity.org.au	e	Expert distrib	dr804		1.5966E-06		Terek Sandpiper		26575		26575			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:6799
(Linnaeus, 17	SCOMBRIDAE	33715	FALSE	tunas & macl	urn:lsid:biodi	7047212	FALSE	Katsuwonus	FALSE	FALSE	Katsuwonus pelamis	pelamis	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	G	Skipjack Tuna	37 441	37441003	200	904	37 441003	2	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33715
Cuvier, 1832	SCOMBRIDAE	33926	FALSE	tunas & macl	urn:lsid:biodi	7047423	FALSE	Scomber	FALSE	FALSE	Scomber australasicus	australasicus	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	5	2.8817E-05	G	Blue Mackerel	37 441	37441001	200	902	37 441001	2	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:33926
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	Scombridae	32763			urn:lsid:biodi	7046260	FALSE	Thunnus			Thunnus maccoyii		https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr2099		2.8817E-05		Southern Bluefin Tuna		269402		35228			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:32763
Richardson, 1	SCORPIDIDAE	36961	FALSE		urn:lsid:biodi	7050458	TRUE	Scorpis	FALSE	TRUE	Scorpis aequipinnis	aequipinnis	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	1	2.8817E-05	G	Sea Sweep	37 361	37361004	25	3938	37 361004	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36961
Kner, 1865	SCORPIDIDAE	36985	FALSE		urn:lsid:biodi	7050482	FALSE	Scorpis	FALSE	TRUE	Scorpis lineolata	lineolata	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	1	2.8817E-05	G	Silver Sweep	37 361	37361009	30	3963	37 361009	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36985
	Scrophulariaceae	31908			https://id.bic	7045405	FALSE	Euphrasia			Euphrasia collina subsp. muelleri		https://spati	https://id.bic	ALA_Euphras	http://www.e	Expert distrib	dr2099		5.4441E-06		Purple Eyebright, Mueller's Eyebright		216151		35237			https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:31908
(DumV©ril, 1	SCYLIORHINIDAE	34100	TRUE	sharks	urn:lsid:biodi	7047597	TRUE	Cephaloscyllium	FALSE	TRUE	Cephaloscyllium laticeps	laticeps	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	0	2.8817E-05	G	Draughtboard Shark	37 015	37015001	60	1078	37 015001	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:34100
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(Forster, 180	SERRANIDAE	36134	TRUE	rockcods	urn:lsid:biodi	7049631	FALSE	Caesioperca	FALSE	TRUE	Caesioperca lepidoptera	lepidoptera	https://spati	urn:lsid:biodi	urn:lsid:biodi	http://www.e	Expert distrib	dr803	10	2.8817E-05	G	Butterfly Perch	37 311	37311002	100	3115	37 311002	0	https://spatial.ala.org.au/geoserver/wms?service=WMS&version=1.1.0&request=GetMap&layers=ALA:Distributions&format=image/png&viewparams=s:36134
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Species	Species Na	Scientific N	Taxon Ranl	Kingdom	Phylum	Class	Order	Family	Genus	Vernacular	Conservati	Invasive
urn:lsid:bic	Tursiops tr	(Montagu,	species	Animalia	Chordata	Mammalia	Cetacea	Delphinida	Tursiops	bottle-nos	Queensland : Conservation Status | Northern Territory : Conservation Status	
35032041	Pyura prae	Heller, 187	species	Animalia	Chordata	Ascidiacea	Stolidobrar	Pyuridae	Pyura	cunjevoi		
https://prc	(Miq.) Tieg	species	Plantae	Charophyt	Equisetops	Santalales	Loranthace	Amyema		Queensland : Conservation Status | Northern Territory : Conservation Status		
urn:lsid:bic	Hydrurga l	(Blainville,	species	Animalia	Chordata	Mammalia	Carnivora	Phocidae	Hydrurga	leopard se	South Australia : Conservation Status | Queensland : Conservation Status	
urn:lsid:bic	Tursiops au	Charlton-R	species	Animalia	Chordata	Mammalia	Cetacea	Delphinida	Tursiops	burrunan dolphin		
urn:lsid:bic	Scutiphora	(Kirby, 182	species	Animalia	Arthropod	Insecta	Hemiptera	Scutellerid	Scutiphora	Metallic Shield Bug		

Annex B HDD Technical Guide

Technical guide:

information and advice for the successful planning and execution of horizontal directional drilling works

by Charles Stockton

Director and Senior Consultant

Stockton Drilling Services

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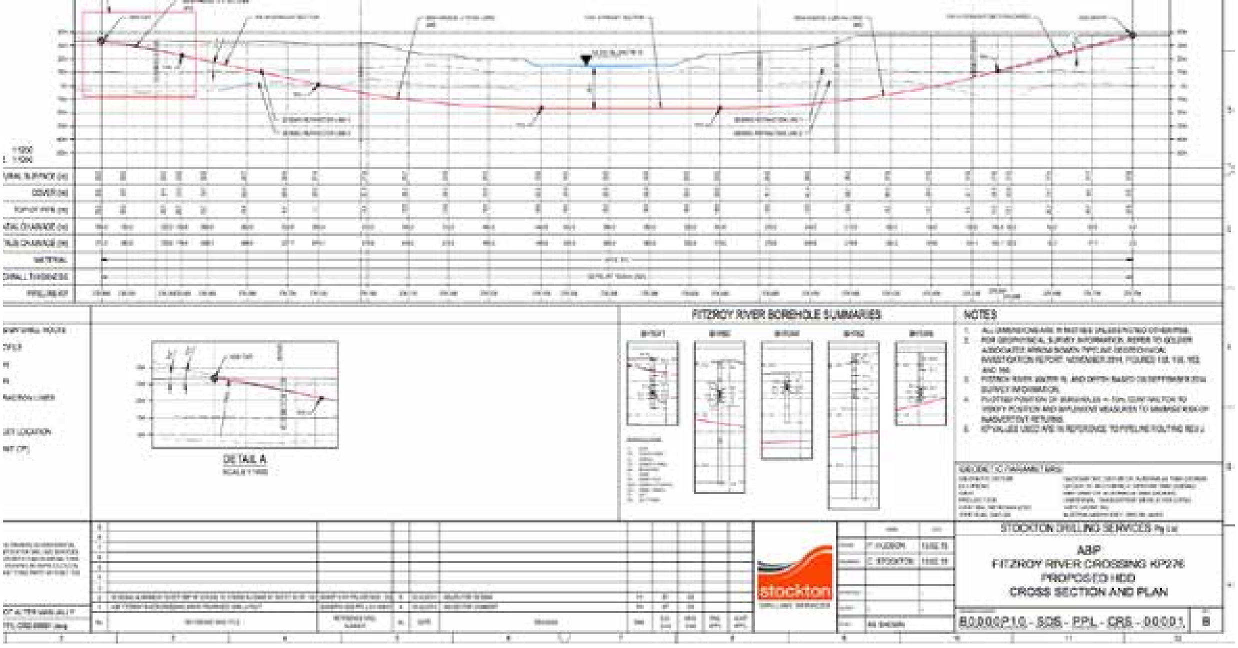

SO...WHAT EXACTLY IS HDD?

Horizontal Directional Drilling (HDD) is a trenchless method of installing pipeline or conduit and cables underground , along a predetermined path, by the use of specialised drilling equipment. This approach provides a flexible way of installing pipes and cables where conventional open cut methods are not permitted, practical, or environmentally or economically viable.

HDD is very useful in built up urban areas or where various obstacles or terrain, such as shore approaches, swamps and river crossings lie along the proposed route. By using HDD, the pipeline or cable land disturbance is only required at the entry and exit point and the pipeline or conduit is installed underneath the obstacle.

> Trenchless technology allows for the installation or rehabilitation of a pipeline, conduit or casing between a given entry and exit point without any disturbance to the natural surface between those points. When new assets are installed using trenchless technologies, a tunnel is installed by directional drilling, microtunnelling, auger boring or impact moling. These different techniques allow for a great variety of distances, depths and diameters to be installed whilst minimising social and environmental impacts. HDD is usually employed when the required installation depth and length exceeds the boundaries of the other trenchless installation methods. HDD is most commonly used for road, river and shore crossings.

In order to take full advantage of the benefits offered by HDD and produce designs that can be efficiently executed in the field, design engineers should have demonstrated working knowledge of the process, including both industry capabilities and limitations.

The HDD process is usually undertaken in three distinct stages:

- Pilot hole drilling
- Reaming or hole opening
- Pipe installation

The first stage consists of directionally drilling a small diameter pilot hole along the pre-determined pathway. In the second stage, the pilot hole is enlarged by successive reaming and cleaning passes. When the hole is of the suitable diameter and condition, the pipe is pulled back or thrust into the fluid filled bore.

KEY BENEFITS OF HDD

HDD has become increasingly versatile in its application and progressively more reliable in its execution. Today, the question is not "Why use HDD?" but rather "Why not use HDD?".

The key benefits of employing HDD include:

- Access for construction equipment is only required at either end of the crossing
- Disturbance is only required at the entry and exit points and not for the entire crossing length
- The limited work footprint required at either side of an installation allows it that it can cater for all weather working conditions
- Due to a constrained work site, it can be easily adapted to a 24-hour program to safeguard the works schedule
- Due to the static position of major plant, safe access and egress, the site can be developed for worker safety – no deep pits or shafts are required and all work is performed above ground
- Alternative tooling and mud formulations allow for all soil conditions to be drilled
- Unforeseen ground conditions can be quickly addressed by changing the tooling and drilling fluid formula with limited cost and schedule impact
- HDD can be used along with other technologies such as retractable tunnelling and direct pipe to overcome instability problems, such as cobbles and cohesiveless soils
- Flexibility in the profile design allows for engineers to develop creative solutions to difficult geometries, including compound bends and steep entry and exit angles, with the only limit being the minimum radius of the installed pipeline material

In order to take full advantage of the benefits offered and use HDD for increasingly difficult crossings, HDDs should be designed and planned by experienced personnel who have proven working knowledge of the process, including both industry capabilities and limitations. Designs should be constructible and be able to be efficiently executed in the field.

THE CURRENT LANDSCAPE

Since trenchless technologies such as HDD, were first introduced in Australia, the price of using these methodologies has become increasingly more affordable. At the same time, the expertise and reliability of HDD contractors has increased, and so the use of HDD in pipeline construction has become widespread.

In fact, today, very few pipelines are built that do not include directionally drilled crossings somewhere along the route. For example, the recent installation of an 180km pipeline in Victoria used HDD to complete over 80 crossings of roads, rivers, drains, sensitive habitats and difficult terrain.

For oil and gas projects, the design process is driven by a risk based approach, whereas for some utility projects, price tends to be the driving factor. Oil and gas projects proceed through a number of development phases that allow risks to be fully evaluated, both before and after tender. This ensures the design evaluation process is driven by best for project outcomes. Adopting this risk-based approach ensures, good safety, environmental or quality performance.

INTRODUCING CHARLES STOCKTON

UK-born Charles Stockton, Managing Director of Stockton Drilling Services, has been a part of the HDD sector in Australasia since 2003.

Charles graduated with civil engineering degree from Loughborough University in the UK before joining the family business Stockton Pipelines. Stockton Pipelines pioneered the development of HDD in the UK in the 1990s, with Charles managing the drilling side of the operations. Charles was part of the first HDD drilling crew in the UK, and in those early, pioneering days, he worked with crews to meticulously plan and execute HDD crossings across the country and northern hemisphere. They successfully completed a number of complex projects discovering and developing innovative solutions along the way, which are now part of normal HDD operations.

During his tenure at Stockton Pipelines, Charles became an industry leader, and received three drilling awards from the UK Society for Trenchless Technology for new technologies and projects of special interest.

Two years after arriving in Australia, Charles established Stockton Drilling Services, a premier engineering consultancy specialising in HDD and other trenchless pipeline installation methods, bringing his wealth of experience to the Australian market.

The company's client base includes companies in the oil and gas, water, electrical, mining, communications and pipeline engineering industries; local and state government departments; and HDD and pipeline contractors. Charles received the Engineers Australia Environmental Award for his part in Chevron's Gorgon Project, which required nine shore approaches to be constructed by HDD on the hostile west coast of Barrow Island in Western Australia.

Charles has a team of highly experienced project engineers, managers, supervisors and HSEQ personnel, who provide a range of services including concept evaluations, feasibility studies, engineering design, project management, quality control, risk management, HSE services and pipeline mapping.

Stockton Drilling Services personnel ensure the quality of planning and construction of their HDD projects by using a risk-based design approach, mentoring both clients and contractors on the use of industry recognised best practice.

In response to industry need, Charles developed a HDD quality control package that has already had excellent outcomes for ExxonMobil, QGC and APLNG. As part of the HDD quality control package, Stockton Drilling Services provide FEED engineering and quality control inspection services during construction.

Major projects that Charles has provided engineering services for include:

- Esso, Longford Liquids Pipeline
- Chevron, Gorgon Gas Project
- ExxonMobil, Longford Gas Conditioning
- QCLNG/APLNG, Narrows Crossings
- Arrow Energy, Curtis Island LNG and Bowen Pipeline Projects

WHAT ARE THE CURRENT CAPABILITIES OF HDD?

As an installation method, HDD has been used for more than thirty years now on projects around the world. The capabilities of HDD equipment have grown considerably over this time period.

In the industry today, there certainly appears to be a recognisable trend developing – longer drills. Nowadays, pipelines are being installed in lengths of up to (and even in excess of) 4.5km by HDD.

Advancements such as intersect technologies (which allow crossings to be drilled from both sides meeting in the middle), larger capacity drilling rigs and the availability of pipe thrusters to aid pipe insertion, have all allowed for much longer lengths to be regularly and reliably achieved. Of particular note is the use of intersect drills, which has effectively allowed drill lengths to be doubled overnight.

The industry is also able to competently install pipelines of significant diameters, with steel pipelines of up to 48-inches being regularly installed with HDD. It's important to note that end users rarely require diameters over this size to be installed. Once the diameter does become larger than 48 inches, the construction of a concrete tunnel is generally advocated as lower risk, and accepted as the norm.

It is reasonable to infer that lengths of 4.5km of 12-inch pipe and 2.5km of 42-inch pipe are now well within industry capability.

This capability will allow for greater flexibility in construction options, and clients should be incorporating this advancement into their concept designs and studies.

I believe the HDD industry will drill longer yet, aided by further developments such as:

» Industry-specific software for analysing drill pipe pressures, fatigue and stress
» Telescopic casing to provide hole support whilst reducing torque and drag
» Mud programs and modelling for better hole cleaning and hole support, and
» Equipment advancements including telescopic rigs for faster tripping times

HDD will also continue to adapt and expand into new markets as new demands emerge. For example, HDD can be used to place a permeable membrane in an exact underground position to allow for the introduction or removal of fluids. This process can then be used to control water flows, as was employed by Stockton Pipelines to control groundwater levels associated with the construction of the Cardiff Bay Barrage. A similar process may also be used for applications including mine dewatering and extraction of minerals rich sands.

ESSENTIAL FACTORS FOR A SUCCESSFUL HDD INSTALLATION

When undertaking a HDD installation, the key factors for consideration that often come to mind are geotechnical conditions, alignment geometry, installation constraints, and pipe strength rating. While these are all important, there are three other key factors that Clients and Contractors should take into account for a successful HDD installation.

D_O_N_'T_ _T_A_K_E_ _S_H_O_R_T_ _C_U_T_S_ _

After spending 25 plus years working on major HDD projects around the world, there is one golden rule that comes up time after time, and that is: don't take shortcuts. Do the right thing first time, every time.

If you speak to any experienced driller or superintendent who has worked on large-scale projects they will all tell you the same thing – don't take shortcuts.

Quite often site crews start to feel pressure from both the client and their own head office if they start to fall behind program.

Typically there is a reason that the schedule is slipping, and generally it is not inefficiencies or inexperience. It is more likely that the initial program was unrealistic or didn't correctly factor in some of the challenges or risks of the project, such as site constraints, geology or weather conditions, or complying with client requirements.

This is the time when crews will then be tempted to try and save time by initiating a shortcut that they know isn't good practice, but they think they can get away with. This is when small problems start to compound.

As most people have experienced with drilling, the stars very rarely align and you must make your own luck. Sticking to best practice and avoiding short cuts, even when all those around you are screaming for more progress, does this.

LEARN LESSONS

In larger companies with multiple crews, each driller or superintendent will tend to have their own way of doing things; their own favourite tooling configurations, preferred mud formula and site layouts.

Each supervisor will often be reluctant to heed the advice of other supervisors, until they too have learned the lesson firsthand.

This type of process can be hazardous and costly for the company (and the client). Even though each crew will be having these types of discussions on site about what is working for them in this particular condition and evaluating their performance, this valuable knowledge is rarely captured formally and is unlikely to be shared throughout the organisation.

If they are not doing this already, contractors should start to hold lessons learnt sessions at the end of each project to start developing their own rule book of best practice, that they can then rollout and employ throughout the company.

Only by continually evaluating performance can you start to achieve a professional outcome each and every time you go to site.

This feedback loop should also include head office to help them plan, create more accurate scheduling and develop more accurate pricing.

MAKE QUALITY DECISIONS

Quality decisions can only be made if a company encourages open dialogue throughout all levels of the organisation.

If the the Project Manager is dictating the course of action without first hearing and evaluating what others have to say, it will rarely be a good-quality decision. Supervisors should use reasoning, including the evaluation of facts and figures, over intuition.

To make a good-quality decision you should:

- Define the problem clearly
- Evaluate achievable alternatives
- Collate meaningful reliable information
- Determine required outcomes
- Use logically correct reasoning to commit to a course of action

INTEGRITY, MAINTENANCE AND SAFETY IN HDD OPERATIONS

ntegrity, maintenance and safety on HDD projects have come a long way, with more clients and contractors now aware of their importance on sites, and equipment designed to take these into account.

INTEGRITY AND MAINTENANCE

Due to this difficulty of accessibility and repair, a HDD section is usually designed with different parameters to a mainline, including being hydro-tested separately prior to insertion, and the use of increased coating thickness such as an abrasive resistant overcoat where deemed necessary. So not only is the HDD string pre-inspected, it is also then subject to a current drain test on completion of the pullback and prior to the tie-in to mainline to ensure the coating integrity of the HDD section. These additional quality checks, both before and after installation of steel pipelines, ensure the HDD section is unlikely to be the location of future integrity concerns.

If a defect exists which could potentially lead to a leak, the increased burial depth of the pipeline, which generally will be greater than 10m when installed by HDD, does provide added safety. Adversely the increased burial depth, along with the terrain being crossed – which may include a waterway or sensitive environment – makes dig up and repair prohibitive in most cases requiring the section to be replaced.

The coating system for the HDD's is required to be tolerant to coating damage during installation. Results of comparative testing have previously indicated that the coating thickness is directly related to the level of damage likely to be experienced during installation. For this reason, the preferred coating system for the HDD crossings should consider overall coating thickness that can be applied. Where it is likely the coating will encounter sections of gravel, rock and sand during insertion, it is recommended the outer layer is considered as a sacrificial wear/abrasion coating with the base layer providing the anti corrosive protection.

Initially the HDD pipe section must be pulled over rollers and supports which create the over-bend for the pipe to enter the bore at the correct angle. For this phase of the works the coating should have good gouge resistance from potential contact with rollers and supports and also have flexibility to allow for the temporary over-bend radius to be formed.

In the next phase the pipe is pulled through the bore. A wide variety of geology maybe encountered including alluvium consisting of sand, clay and gravel or bedrock, which should all be well defined in the site geological investigations. For sections in sand and rock the coating should have good wear resistance. For the sections in gravel the coating should have good gouge / shear protection and impact resistance as there's a potential the pipe will be pulled through unconsolidated sections which have partially collapsed.

In *Design and Coating Selection Considerations for Successful Completion of HDD Crossing* by A.I. Williamson and J.R. Jamerson, 3LPE performs well for abrasion, flexibility and impact but is ranked lower for gouge resistance. The 3LPE performed very well in the impact resistance test which is design to represent damage from falling rock. In the abrasion test the 3LPE also showed better performance than the other coatings. The polyethylene coatings appear to better resist wear due to the lubricity of the polyethylene particles compared to the harder nature of the particles from the other coatings.

It is difficult to say which of these tests (the gouge resistance, abrasion or impact resistance) best replicates the conditions downhole and it is likely to be a combination of all of these properties. Ideally the coating should be tough but not too hard where it has the potential to also become brittle.

SAFETY

Even though drilling crews are generally well established and familiar with all aspects of the work, management and supervision should continually use tools such as pre-start discussions, JHA's, SWMS and 5x5 to maintain crew focus on potential impacts from stored energy. These may be in the form of suspended loads, high pressure mud and hydraulic hoses, or rotating drill pipe and pipe tongs, to name a few. Crew should be trained to continually look for and identify these potential impact and then implement ways to prevent injury or damage.

HDD operations rely heavily on implementing safe working procedures and having sufficient experienced and trained personnel on site to manage the frequent lifting operations. During a pullback or during tripping drill pipe it may be necessary to lift pipe clear from the rig and stock piled them every two minutes for duration of several hours often in wet and slippy conditions. This process has the potential to become hazardous if clear systems of communication are not established and maintained.

HDD operations have the advantage that the sites are static and therefore allow for greater control of the work area. This allows for the site layout to be planned prior to mobilisation and include considerations such as a prepared hardstand; cables and hoses routes that can be buried or suspended; personnel access and egress that are clearly defined; include the use of bunds under static equipment; all of which allows for personnel to be familiar with their work environment.

The safety culture on HDD sites, like pipelines, has come a long way and all personnel now realise safety as a core value, not just a set of rules to be obeyed. Stockton Drilling Services is proud to have recently provided HDD Clients Representative for a pipeline project that installed over 18km and 70 HDD's with three maxi rigs and three mini rigs without incident.

DEALING WITH FRAC-OUTS

A 'frac-out' is the unintentional return of drilling fluids to the surface during horizontal directional drilling (HDD).

A frac-out occurs when the down hole mud pressure exceeds the overburden pressure (i.e. shallow or loose sections of the bore), or the fluid finds a preferential seepage pathway (such as fault lines and fractures, infrastructure or loose material).

These fractures can be natural or induced by over-pressurising the formation.

It is relatively common for a frac-out to occur on a HDD project. Most frac--outs, however, are usually minor, within construction right of way and close to the bore entry or exit.

VARYING LEVELS OF SERIOUSNESS

The seriousness of a frac-out depends on where it occurs. If the frac-out occurs in an environmentally or culturally sensitive area (which you are generally trying to avoid by using HDD), there is reason for concern.

The drilling fluid itself may not be toxic, but the fine particles can smother plants and animals, particularly in an aquatic environment. If a saltwater polymer fluid is used, the salt can also impact on freshwater systems and terrestrial vegetation. Neighbouring landowners do not appreciate frac-outs on their land.

In most states a frac-out outside of the working area is generally considered a "reportable incident". In Victoria all frac-outs must be reported to the regulator within two hours.

Frac-outs may also damage infrastructure or nearby services. There are reports of sections of roads rising, nearby water pipelines failing as the frac-out washed away the bedding sand, power boxes filling with fluid and vegetation disappearing into a sinkhole caused by a frac-out.

On the other hand, the frac-out may be small (less than 20L), occur within a disturbed or non-sensitive area and be easily contained and cleaned up. In these cases, there is no lasting impact or damage and no real reason for concern.

These frac-outs are still better avoided as they utilise resources and time in the cleanup and reporting.

Generally with frac-outs, the perception and association with other industries means the perceived threat is far worse than reality.

PREVENTING FRAC-OUTS WITH GEOTECHNICAL INFORMATION

There are a number of steps that can be taken to prevent a frac-out from occurring.

The first step is to assess the risk of frac-out prior to drilling. This can be done using specially designed software (e.g. DGeo Pipeline by Deltares) or pressure calculations.

These methods compare the maximum allowable fluid pressure against the expected drilling fluid pressure.

To ensure they are reliable, they require detailed information on the soils, drilling fluids and bore profile, and should be conducted by experienced personnel.

The modelling will predict if and where frac-outs are likely to occur, if profile changes are required (e.g. increasing the depth), the maximum drilling pressures (the driller can then set alarms at these pressures) and if other management strategies are required.

In some cases it may be necessary to install casing at the entry point where reduced cover and bearing pressure exists, or drill pressure relief wells to give the fluid a controlled place to go.

The modelling also allows for the optimum pilot hole bottom hole assemblies to be configured for the formation, allowing the correct bit size to be selected for the drill pipe dimensions.

During drilling, contractors should continually monitor the drilling fluid properties i.e. mud weight, viscosity, gel strength, volume and pressure, to prevent frac-outs.

They can also include a pressure sub for real-time down hole pressure monitoring by the driller, allowing actual annular pressure readings to be obtained in real-time and then plotted against the modelled values.

If any unexpected variations or trends are observed then drilling should immediately cease and the cause investigated.

Common causes include a restricted or blocked annulus created by a buildup of cuttings which requires mechanical agitation and fluid flow to re-suspend and remove the blockage.

Contractors should be prepared with frac-out contingency plans and response equipment such as sand bags, vac-trucks and the like in place. Regular inspections should also be conducted along the drill path during pilot hole drilling.

Both contractors and client can take steps to prevent frac-outs, especially in sensitive areas, by undertaking adequate assessment and planning before drilling, and ensuring sufficient controls and monitoring are in place during drilling.

AVOIDING DAMAGE DURING HDD INSTALLATIONS

There are risks when undertaking a HDD installation, especially in urban areas where the risk of damaging underground and aboveground facilities greatly increases. However, there are several things that can be done to help mitigate risks and avoid damage to the installed pipeline.

The five most important things to think about are as follows:

PILOT HOLE PROFILE

The as drilled profile of the bore will have an effect on the pull force and abrasion the pipe is exposed to during pullback.

This may be in areas where doglegs (rapid change in direction) have been created, which often occur at formation changes from soft to hard or hard to soft, or where radii of the pipe have not been maintained.

The driller's log, the steering engineers log and survey data should be examined on completion of the pilot hole to identify any potential areas that could be out of specification or cause potential problems during reaming and insertion.

HOLE REAMING

The speed of the reaming pass should be calculated to ensure the correct pump volume has been used for the given penetration rate.

For example, the cut volume of a 24-inch ream following a 12-inch pilot hole is approximately $2m^3$. If the solids being removed are measured at 20 per cent of mud volume and pump rate is 1,000Lpm, then the ream should take ten minutes (1,000 x 0.2 x 10 = 2,000 L) ($2m^3$).

The driller's log should indicate the time per joint, and the mud logs/test report should indicate the percentage of solids in the mud returns. Also, as a rough guide, a volumetric check of the cuttings stockpiled on site can be equated against the complete hole volume.

MUD PROPERTIES

On completion of the pilot hole, and once the bore is open at both ends, the fluid must be configured to adequately suspend the cuttings indicated in the geotechnical investigations. The fluid viscosity and velocity must be tailored to create sufficient carrying capacity to facilitate the removal of the largest anticipated cutting size.

Cuttings suspension and transportation should be observed at the entry pit, and often cuttings will be deposited directly after exiting the bore.

This implies the fluid velocity, along with the viscosity (gel strength), is important in cuttings transport, but as soon as the velocity decreases after exiting the bore the cuttings fall out of suspension.

Mud logs and test records should be examined regularly to appreciate optimised fluid properties that were employed for each reaming stage, and their ability to suspend and remove coarse grained cuttings such as sand and gravel.

CLEANING PASS

It is good practice to conduct a cleaning pass with a under gauge barrel reamer after completing the reaming pass. For example, the barrel I would recommend for a 24-inch hole would be 20-22-inches. A smaller barrel would not correctly identify problem areas and potentially skip over or under any cuttings beds/restrictions/instability.

This pass should be used to gauge the condition of the bore and its readiness for pipe insertion.

Sometimes it will be observed that sections generate higher drill string torque, which would indicate cuttings, collapse or hole shrinkage. The driller should then swab back through the section to ensure hole stability before completing the pass. If any concerns remain, an additional cleaning pass can be re-run.

PULLBACK

The pipe must be correctly aligned with the borehole and enter the HDD central to the hole at the correct angle. A overbend plan should be developed to confirm the position and height of the supports and ensure that the pipe bend radius is maintained.

For large diameter steel pipelines and HDPE or FPVC pipes, the buoyancy of the pipe should be considered, as it displaces the drilling fluid from the bore. It may be necessary to fill or partially fill the pipe to create neutral buoyancy to reduce drag and therefore the insertion force and potential coating abrasion.

SHORE CROSSINGS WITH HDD

Working in the nearshore environment, especially on Australia's exposed coastlines, can be very challenging and inhospitable for both land-based and water-based construction equipment. Neither construction method is ideally suited to construction in the shallow, tidal, high-energy zone; it is too shallow for marine vessels, which risk grounding, and too deep and exposed for land-based work, which risks flooding and equipment damage. This is the zone that neither the offshore contractor or the onshore contractor are ideally placed to manage – it is not their normal working environment and iIt is this challenge that makes shore crossings very interesting to design and construct.

Up to 15 years ago, these crossings would have required large-scale open battered excavations onshore, which would connect to a piled cofferdam through the surf zone, followed by a dredged channel offshore. A concrete-coated pipe section would be floated into position using floatation devices and hydraulic winches. The process was very susceptible to adverse weather conditions and tidal variations, as well as presenting numerous challenges for managing worker safety and large-scale disturbance to the environment.

By using HDD to construct a shore crossing, you are totally eliminating the requirement for works to be constructed in the nearshore environment. Using HDD allows for the crossing length and depth to be increased, which positions the rig back on level land, and also allows for the exit to be beyond the surf zone. The rig can be placed well behind the dune system, preventing impact to the dune and any flora and fauna within the coastal corridor, e.g. shorebirds and turtle nesting areas.

The pipeline can be prefabricated onshore and thrust through the bore from entry to exit. Alternatively, the HDD rig can be used to pull back the pipeline from offshore if the pipe is fabricated by a laybarge or towed offshore from a spool base/launching area. This is especially convenient if the product pipe is HDPE, which will float without the use of external buoyancy control measures.

UNDERSTANDING THE CHALLENGES

Selecting an appropriate exit location. The exit point needs to be selected to provide appropriate conditions for positioning subsea structures or providing a suitable transition to the offshore pipeline. The exit location must provide sufficient water depth to allow safe vessel access and anchoring, as well as diving operations.

Obtaining reliable, cost-effective offshore geotechnical information. For shorter crossings it may be possible to interpolate onshore and nearshore boreholes, but for longer crossings it is extremely important to develop an understanding at the exit topography and geology. This is critical for developing the HDD methodology, determining whether the hole will be forward reamed or back reamed, and if the pipe will be thrust or pulled into the bore.

Weather and sea conditions. Even though the majority of the works can be conducted onshore, marine vessels and divers will still need to be deployed during a number of critical stages of the operation. Having these windows well identified, and then having contingency planning for delays, is essential. Clearly setting out what conditions the marine vessels can operate in, and determining how this risk will be costed will be important to prevent cost escalation and potential disputes between parties.

Specifying and managing a marine spread. A key difference with an onshore HDD operation is that the pipe-side will be managed over water by a marine spread. Marine activities may include seabed preparations, diving, lifting and recovery of downhole tooling, winching, tow-out, alignment and hook up of pipe string, placement of clump weights/mattresses for temporary stabilisation, as well as flooding and gauging of the pipeline. It is essential to correctly scope the marine work, specify the vessel requirements and establish the responsibilities and operational parameters. This is where using HDD contractors or consultants with previous experience working with marine operations is critical.

Discharge of drilling fluids at the exit point. Some shore crossings are undertaken in sensitive marine environments and discharge of drilling fluids and cuttings from the bore hole is not desirable. One technique that has evolved is to drill the pilot hole and leave the bore closed just prior to exit or plug it with an inflatable plug. This then allows for the bore to be opened by forward reaming, and drill fluids are returned to entry for recycling rather than being lost to the ocean floor. The final section of the bore can then be reamed out using biodegradable fluids to limit any potential environmental impacts of the break through to the seabed.

EXPERIENCE MATTERS

Stockton Drilling Services has been involved with a number of complex shore crossings constructed in Australia over the past 15 years, including:

- Minerva Shore Crossings (two) in Victoria for BHP Billiton
- Gorgon Shore Crossings (nine) in Western Australia for Chevron
- Kupe Shore Crossings in New Zealand for Technip/Origin Energy
- Victorian Desalination Pilot Plant Shore Crossings in Victoria for Department of Sustainability and Environment
- Narrows Shore Crossings (four) in Queensland for APLNG/QGC
- Gladstone Harbour Crossing Feasibility Study for Arrow Energy
- Anglesea Water Reclamation Plant (WRP) Shore Crossing in Victoria for Barwon Water

Two projects that are interesting to note are the Gorgon Shore Crossings and the Anglesea WRP Shore Crossing Replacement.

The Gorgon Shore Crossings were constructed on a Class A Nature Reserve, and won the national Environmental Engineering Excellence Award at the Australian Engineering Excellence Awards in Canberra. Ian Pedersen, Chair of the National Engineering Excellence Awards Judging Panel, said "the uncompromising environmental commitment to this project suggests engineering construction techniques can be ecologically sensitive, allowing us to maintain our natural environment for the future".

The second project, which clearly indicates how the development of new construction techniques have allowed for improved design, is the Anglesea WRP Shore Crossing Replacement, located 25m above sea level on the Anglesea coastal cliffs. The previous outfall consisted of a 30m deep drop structure which transferred flows from the treatment plant level to the base of the cliffs. A 185m outfall pipe then discharged flows from the base of the drop structure to the ocean.

The outfall was constructed in 1995. Since construction, cliff erosion had exposed a section of the outfall pipe that runs through the base of the cliff, from the drop structure to the beach. The current rate of erosion is estimated at four meters every 10 years.

In May 2006, a rock fall crushed a section of the exposed pipe and emergency repairs were required. The pipe was repaired and a concrete block was formed around the exposed pipe. However, the cliff continued to erode further, exposing the pipe again, undermining the concrete block and placing the pipe at risk of failure again. The instability of the cliff and risk of further collapse meant it was too dangerous to carry out temporary repairs to the broken pipe.

As a result Barwon Water initiated a project which required the design and construction of a new outfall pipeline and associated works. Stockton Drilling Services provided engineering support and construction supervision for the project.

A geotechnical desktop assessment was undertaken to allow for the design of alternative preliminary drilling profiles, and to define the scope for further geotechnical investigations. The project team then undertook bathymetric surveys and seabed sampling of the works corridor to establish suitable exit point locations. Seabed profile, water depth, currents, geology and environmental impacts were then evaluated to determine the lowest risk and optimised length and location for the drill exit and diffuser installation.

Considering the peak flows from the water reclamation plant and installation forces, it was determined that a 450mm diameter HDPE pipeline would be required. The pipeline would extend 700m from within the plant boundary to approximately 500m offshore to a water depth of 15m, where a 16m-long diffuser would be installed. The pipeline was installed within three weeks of mobilising to site.

UTILISING HDD IN URBAN ENVIRONMENTS

The execution of HDD in an urban environment is technically the same as for an open environment. The main difference is not what is happening below ground, but what is happening on the surface.

BENEFITS OF HDD IN DEVELOPED AREAS

The key benefits enjoyed by both contractors and residents are the reduced amount of open trench excavation, reduced time of construction and reduced amount of reinstatement. Open trenching can be difficult and time consuming in an urban environment due to the need to expose, protect and support existing services that cross the alignment. Often these trenches, curbs, pavements and roadside easements are then prone to future settlement after open trench installation methods have been used, which is eliminated by using HDD. The use of HDD may be essential if a main highway, railway or infrastructure needs to be crossed.

HDD is commonly used for pressurised water supply, pressure or graded wastewater, electrical conduits, telecommunications, and gas supply networks.

TAKING THINGS INTO CONSIDERATION

The crossing design must take into consideration the increased density of infrastructure both above and below ground, including: road, rail, foreign services, foundations, power poles, and overhead cables. Undertaking a dial before you dig (DBYD) enquiry and site inspections should be used to identify all services. These services should then be proven by potholing of ground penetrating radar (GPR) to confirm their exact position and depth.

The presence of infrastructure may also prevent the use of traditional magnetic or walk-over steering systems and alternative steering solutions such as gyroscopic tools may be required.

Space is constricted, a smaller footprint is utilised, and equipment needs to be configured to individual sites to allow for efficient and safe drilling operations. On the pipe side, it becomes increasingly difficult to string long lengths of pipe in one continuous length, so alternatives need to be evaluated. These may include performing tie-in welds during insertion, or using HDPE, which is more flexible than steel and easier to handle. Also, pipe trailers can be utilised for smaller diameter coiled pipes.

The execution of the works should then consider any potential impacts on adjacent residents and businesses, including: traffic management, noise, dirt on roads, dust and light emissions. In such an environment these factors will usually result in restrictions on operations which need to be considered, e.g. restricted working hours, noise control, heavy vehicle movement restrictions.

The risk and potential impact of a frac-out can also be increased in an urban environment. Previous construction activities and installation of other services can reduce the bearing capacity of the soil or introduce pathways for fluid migration.

These crossing require a thorough scoping and risk assessment process to ensure that all potential risks are identified and controls and contingencies are in place. The crossing design needs to allows for safe access, appropriate space for equipment setup, suitable pipe handling methodology, and a profile design that provides adequate separation to all infrastructure and services, both present and future.

A VERSATILE SOLUTION

Due to the vast array of drilling rigs available today, HDD can be used for all types of pipe installation in urban environments [Is this statement really true?]. Compact, silenced, powerful rigs with automated rod loading, built-in power generation and on-board pumps all simplify the drilling operation and reduce the required footprint.

One of the most challenging urban environments I have worked in was, Bangkok, where we had to design and install 28km of 30-inch high-pressure steel pipeline by HDD.

The plan our design team developed was to drill the section as 16 crossings, each between 400m and 1600m long. Due to the rapid development and expansion of the city limits, there was no space available for pipe stringing. Once the project was underway imaginative strategies had to be developed, including welding and stringing on top of shipping containers, and floating strings out by threading them along the canal network of khlongs.

One of the most challenging urban environments I have worked in was in one of the world's most congested cities, Bangkok, where there are over eight million residents. Even though there is hardly space to walk, never mind drive a rickshaw, we had to design 28km of 30-inch high-pressure steel pipeline to be installed by HDD.

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THE IMPORTANCE OF GEOTECHNICAL INFORMATION

Around 90 per cent of HDD work happens below ground, so thorough and well thought out site specific geotechnical investigations are essential for planning any HDD project. Obtaining sufficient and correct geotechnical information can make or break a HDD project. The importance of defining the crossing geology should never be underestimated. This will allow for the profile, downhole tooling, drilling fluids and schedule to be accurately developed and costed.

Initially, a site visit and geological review should be undertaken to provide a geological overview of the area, which should then be used to determine the site specific investigations.

The site investigation needs to obtain sufficient reliable information to permit the safe and economic design of installation and permanent works. The investigation should be designed to verify and expand upon any information previously collected. Site investigations for all drills should include site inspection/surface investigation, topographic survey, identification of existing services and a geotechnical assessment.

Where the client undertakes the investigations, the HDD contractor should assess the completeness of the information provided and ensure it provides sufficient information for planning and execution of the bore.

Where further information is required, the HDD contractor should provide a proposal to the client outlining the objectives, requirements, and budget costs for any additional works required.

CONSIDERING THE BASIC GUIDELINES

Some basic guidelines for planning the scope of the geotechnical investigations include:

The level of geotechnical investigation required is a function of the length of the bore and the anticipated complexity of the subsurface conditions. While typical spacing is at least every 150–250m along the bore alignment, a minimum of two geotechnical boreholes is required for each bore where the bore length is greater than 300m.

Boreholes should be located to track stratigraphy and to detect the geological sequence, structure, and areas of significant change. When results indicate other anomalies or highly varying strata, then additional boreholes may be required.

The boreholes should penetrate through an elevation at least 3-5m below the depth of the proposed HDD profile to provide information for HDD design modifications, pilot hole deviations and ensure any potential rock formations have been identified.

Boreholes should be offset perpendicularly from the HDD centreline where practical by 10m.

Investigations should describe the soils and rocks encountered and recover samples for laboratory testing. Where soils are encountered, in-situ standard penetrometer testing sampling should be undertaken at selected depth intervals within the borehole.

Where frac-out modelling is required, the geotechnical parameters required for undertaking the modelling (e.g. unit weight, shear strength, friction angle, cohesion and Youngs Modulus) should be determined during the geotechnical investigation.

The likelihood of soil/groundwater contamination or acid sulphate soils should be determined prior to undertaking any investigations. If contamination is suspected (i.e. near electrical transformers, fuel storage, petrol stations, industrial land), samples should be tested for likely contaminants in accordance with the relevant guidelines for contaminated sites.

Boreholes should be backfilled to minimise the possibility of drilling fluid migration along the borehole during subsequent HDD operations. The upper 1.5m of land-based boreholes should be backfilled with the surrounding soil. Below 1.5m, a backfill mixture containing cement grout and a bentonite product to promote expansion is recommended. Cuttings from the drilling operation may be incorporated into the backfill mixture if considered beneficial.

A geotechnical report addressing the sampling program, laboratory analysis (including strength testing and particle size distribution), interpretation of geotechnical engineering properties, bore logs and a profile of the subsurface conditions shall be produced. Reduced levels of borehole data shall be included on the HDD profile drawings.

Probably 90 per cent of the work is happening below ground, so thorough and well thought out site specific investigations are the most basic and essential requirement for planning any trenchless construction project.

All formations can be drilled reliably if the soil conditions have been properly defined and considered during the design phase.

WHAT IS HOLDING HDD BACK?

For our industry to continue to grow we need to keep our minds open to new technologies and possible hybrid solutions between open and trenchless construction, such as ploughing and direct lay. Our industries currently coexist, but may well merge further in the future as new methodologies and possibilities develop.

HOW CAN WE IMPROVE THE REPUTATION OF THE HDD INDUSTRY SO THAT IT IS NO LONGER CONSIDERED HIGH RISK?

As our urban centres continue to grow and our demand for resources needs to be met, there will be continued growth for the HDD industry as long as contractors ensure clients the methods and practices are well engineered and reliable. For example, the Australian market has been slow to take advantage of new technology such as gyro surveying, which is widely used in other countries.

One recent application demonstrates its value and the need for accurate and independent confirmation of pipeline as-builts installed by HDD. A civil engineering contractor was engaged to construct a major road underpass and was in the process of drilling in the concrete piles when they severed a 300mm diameter conduit containing a 132kVA cable. According to the as-built supplied, they were more than two metres away from the three HDDs. We mobilised the next day and were able to survey the two remaining conduits, which contained the other phases.

We confirmed the position of the two remaining conduits to +/-150mm along the entire length of the crossing, therefore allowing the works to confidently proceed. In this case, they were lucky no-one was hurt and just had a major power outage to deal with. As most pipe bundles are installed with a spare, I would like to see all HDD crossings re-surveyed with the gyro tool to ensure pipeline owners and service suppliers have accurate and reliable as-builts. This will simply become more and more critical as HDD installed infrastructure continues to grow with population density.

I also feel that we, as an industry, need to increase the quality, reliability and performance of HDD services in Australia.

Our industry continues to expand, at all levels, and there should be a means to standardise performance and ensure product delivery. At the moment there are no real codes of practice that exist that are applicable to current practices and capabilities of the market. Often foreign or out dated references are used in contract documents; but these are rarely applied or used in earnest.

To give pipeline owners, engineers and contractors a valid and recognised guideline would greatly enhance industry performance, reduce construction risk and ensure best practices are employed. It would help put Australian construction practices forefront on the world stage, and would provide the fabric for the development of HDD QA/QC. Every other part of pipeline construction is regulated but often the most challenging part of the works, the HDD, is left without independent inspection and verification.

Stockton Drilling Services is hoping to help facilitate the pipeline industry and trenchless industry in working together to develop a code of practice/guidance note for the planning and execution of HDD projects in Australia.

THE FUTURE FOR HDD

HDD is now employed throughout the construction industry, and these days it's surprising not to see a small HDD rig at the side of the road anywhere a pipeline, cable or conduit is been installed in an urban environment.

It is no longer only for special sections, but an integral part of any pipeline routing and design.

There is a distinct split in the capabilities of HDD contractors; either operating mini/midi rigs and concentrating on small lengths and diameters; or operating maxi rigs (greater than 100 tonnes pullback capacity) for the installation of large diameter pipelines. These two very distinct fields mean that contractors are generally specialists in their own area but not necessarily in both. Therefore it is important that the right contractor, with the appropriate equipment and relative experience, is selected for any works.

Asset owners and builders must enhance the opportunities that trenchless construction offers if they are to stay competitive and embrace safer and more environmentally conscious pipeline construction. Whether you are evaluating a 50m section under a driveway or 4,000m section under an inhospitable coastline, HDD must be part of that evaluation.

HDD will become even more commonplace in the next five to ten years, and owners will need to engage specialist companies such as Stockton Drilling Services to ensure designs are optimised by recognised industry experts, who will ensure there is seamless alignment between the owner's requirements and the contractors capabilities.

In response to industry needs, Stockton Drilling Services has developed a HDD quality control package that has seen some excellent outcomes. HDD is the most technical and often the most challenging part of installing a pipeline, however unlike the other components, there are no inspection and quality controls. The process is often left solely to the contractor or client superintendent, who may have limited HDD experience.

Depending on the project phase, we provide the following:

» FEED engineering design – to ensure a technically feasible and efficient crossing is designed
» Contractor proposal reviews – to ensure the contractor's proposal is technically acceptable and adopts industry best practice
» Quality control inspection during construction – to ensure contractor compliance and quality control

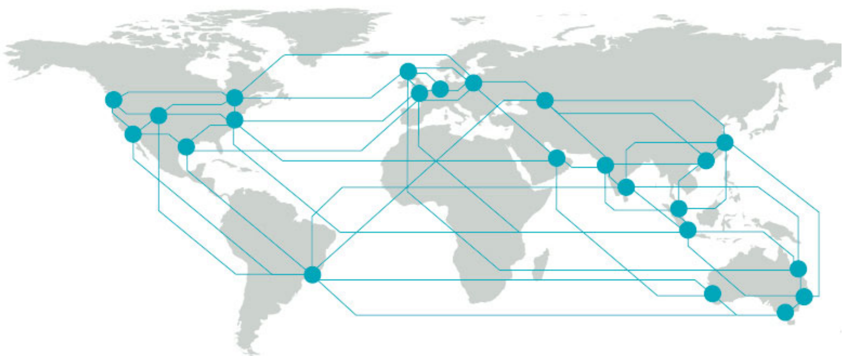
Our expert HDD inspectors are employed by clients in a site-based role to monitor and review the HDD construction process. The technical specialists monitor progress, identify issues before they arise, provide guidance, assist with problem solving, evaluate technical proposals, and monitor breakdown stoppages.

The benefits include:

» Compliance with the scope, specification and industry best practice
» Environmental impacts are avoided or minimised
» Continual monitoring to ensure safe systems of work and equipment
» Avoidance or minimisation of schedule delays and cost impacts by ensuring risks are identified early and managed appropriately

I feel that we, as an industry, need to continue to push the quality, reliability and performance of HDD services in Australia. Whilst our industry continues to expand at all levels Stockton Drilling Services continues to strive to standardise contractor performance and safeguard product delivery

Meanwhile we should all continue to explore new business opportunities that utilise HDD industry capabilities in new or unconventional ways including water management, mining applications and energy sectors such as geothermic. Horizontal Directional Drilling continues to be an exciting industry for clients, engineers and contractors alike and one that we are very proud to be support.



BMT is a leading design, engineering, science and management consultancy with a reputation for engineering excellence. We are driven by a belief that things can always be better, safer, faster and more efficient. BMT is an independent organisation held in trust for its employees.

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