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Impacts on Birds from Offshore Wind Farms in Australia

An ecological risk assessment

Updated November 2025

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Cataloguing data

This publication (and any material sourced from it) should be attributed as: Reid, K. and Baker, G.B (2025), *Impacts on birds from offshore wind farms in Australia: an ecological risk assessment*. Department of Climate Change, Energy, the Environment and Water, Canberra. CC BY 4.0.

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Acknowledgements

The authors thank DCCEEW impact assessment staff and Lucy Porter and Kerri Woodcock, in particular, for valuable input during the development of the risk assessment process. The authors also thank Deya Andulo Chinas, Mandy Bamford, Mike Bamford, Jeremy Bird, Cathy Bulman, Rohan Clarke, Gus Daley, Mike Double, Will Dunlop, Sheryl Hamilton, Golo Maurer, Peter Menkhorst, Arvid Pluschke, Elias Polymeropoulos and Kerri Woodcock who participated in an expert workshop to identify key knowledge gaps and assess input parameters to the risk assessments. A peer review of the Reid et al. (2022) report undertaken by Dr Jeremy Bird provided important input into this revision of the risk assessment.

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Acknowledgement of Country

We acknowledge the Traditional Owners of Country throughout Australia and recognise their continuing connection to land, waters and culture. We pay our respects to their Elders past and present.

Executive summary

Project purpose

The construction and operation of offshore wind farms pose potential risks to birds. Risks may include direct collisions with turbines, displacement from preferred habitats and barrier effects (the physical and visual obstruction of flight paths) leading to altered movement patterns. This report updates Reid et al. *Impact on birds from offshore wind farms in Australia* (2022), using ecological attributes of all birds that occur in marine regions of Australia to assess risks to them from offshore wind farms. It presents the outcomes in a user-friendly format that can be used by proponents and regulators. A harmonised, consistent approach to identifying species at highest risk from offshore wind farm developments in Australia will help to streamline assessment processes and reduce impacts on birds.

Categorising relative risk at a regional scale highlights those bird taxa that are at highest risk from the potential impacts of wind farms. It indicates where more detailed, site-specific consideration is required for a proposed development area. Importantly, the outcomes of the ecological risk assessment should guide survey design to ensure they are appropriate for the ecological characteristics of high-risk species. This risk assessment provides regulators with supporting information when considering the key species of concern in an area during the assessment process. See *Section 1 Introduction* for further information.

This updated report provides greater clarity for proponents and regulators on the method, purpose, use and limitations of the previous research. There have also been changes to the methods, including removing seasonal adjustments related to exposure to risk for migratory species, and a change to the number of marine subregions. See *Section 1 Introduction* for further information.

Methods used

An ecological risk assessment was undertaken using the intrinsic ecological, morphological and life-history attributes of 270 bird taxa (covering all birds that regularly occur in, or migrate over, marine regions of Australia). This provides a relative ranking of the risk to different bird taxa of having negative interactions with offshore wind farms in Australia. Ecological attributes of these birds indicate the likelihood of interactions with a wind farm and the population-level resilience to such impacts. The likelihood of interactions was scored based on attributes of flight activity (time spent flying and height relative to the height of turbines), flight characteristics (based on wing morphology and body weight), and habitat specialisation for each taxon. The estimated resilience of the current population to immediate impacts as well as the estimated duration of recovery from any potential impacts was scored using a contemporary assessment of the population status and trends along with the generation time of each species. Each individual attribute was scored on scale of 1−5 and combined to give an overall risk score for each taxon.

The limited availability of species-specific empirical data was addressed by using peer-reviewed, publicly available data, trait-based ecological groupings and testing with experts who reviewed input parameters and risk assessment methods. Acknowledging the well-recognised limitations in data availability, experts reviewed and refined the details of the ecological traits used in parameterising the risk frameworks, in a workshop setting. See *Section 2 Methods* for further information.

Summary of the results

The marine area of Australia was divided into eight regions, primarily by state/territory boundaries perpendicular to the coast (Figure 2). Each region was further divided into two subregions: 'coastal' (the intertidal shoreline to 5km from the coast) and 'offshore' (areas > 5km from the shore). In coastal subregions the species with the highest risk scores were, the Swift Parrot (*Lathamus discolor*), Furneaux White-fronted Tern (*Sterna striata incerta*) and Australian Gould's Petrel (*Pterodroma leucoptera*). In offshore subregions the highest risk species were all albatrosses, including Eastern Antipodean Albatross (*Diomedea antipodensis antipodensis*) and Wandering Albatross (*D. exulans*). In general, coastal subregions included a greater number of taxa, but a much lower proportion of those were categorised as high-risk, compared to the adjacent offshore subregion. See *Section 3 Results* for more information.

Details of the individual attribute scores and the resulting overall risk categories are provided in spreadsheets that are filterable by marine subregion. See *Appendices 2 and 3* for more information.

Confidence, constraints and caveats

This is a general risk assessment and doesn't account for site-specific characteristics that a proponent would need to consider when determining the environmental impacts of a proposal. The limited availability of species-specific data means that the final risk assessment relies on generalised, trait-based data and expert opinion to estimate an overall score of relative risk. Importantly, the approach used here recognises the need to make progress using the best information currently available to undertake an ecological risk assessment, rather than being hindered by incomplete data. The inherent data limitations and contingent uncertainties underscore the need to use methods that allow for risk scores to be updated as new information becomes available.

The information in this document is intended as an initial guide. The actual level of risk to which individual taxa are exposed cannot be fully known due to limitations of available data. Overall, the area of greatest uncertainty is the relative amount of time that different species are likely to spend at collision risk height over an annual cycle. This includes dispersive or migratory behaviours of birds as well as nocturnal flights, for which empirical data is severely limited. The criteria applied to determine whether a taxon is included in a particular region may mean that some species that occur infrequently, or are under-reported there, may not be included in individual lists. Sharing of data from offshore bird surveys, especially those in association with offshore wind farms, will help to improve and update our understanding of the behaviours and distribution of all taxa, especially for those that are at high-risk from interactions with wind farms.

The intent of an ecological risk assessment is not to provide a definitive assessment of the risk of an individual wind farm project. By categorising the relative risk to different species, it informs proponents and regulators about those taxa that are at highest risk from the impacts of wind farms at a regional scale.

The ecological risk assessment provides a measure of potential risk. It is not feasible to conduct surveys for carcasses of birds in the offshore environment in the way this is done for onshore wind farms. In the offshore environment there is a much greater emphasis on using various technologies, including bird-borne tracking devices, radar and cameras, to collect data on the behaviour of birds around offshore wind farms. A system of consistent methods and centralised reporting will be required to develop landscape-scale sensitivity maps to guide siting decisions to best avoid and mitigate impacts of offshore wind farms in Australia. See *Section 4 Response, impacts, and mitigation* for more information.

How to use this report

This ecological risk assessment is an essential precursor to the development of baseline data required to assess, avoid, mitigate and manage impacts of offshore wind farms. It allows proponents and regulators to identify species that should be investigated further in relation to impacts from specific proposed developments. The approach provides a rigorous method to identify taxa that may be at high risk of negative impacts from offshore wind farms. Furthermore, the attribute score can be used to determine whether a taxon's status as high risk is driven by wind farm-specific risks, relevant impact pathways, low population resilience or a combination of these factors. In clarifying this, it provides proponents and regulators with an important tool for determining the best ways to identify and manage risks to birds from offshore wind farms. See *Section 5 Conclusion and future work* for more information.

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1.

2. Introduction

This report provides an update to the ecological risk assessment by Reid et al. (2022) which categorised the risk of negative interactions of birds and offshore wind farms in Australia. That analysis provided risk scores for 272 bird taxa according to their occurrence in eight marine zones based on state/territory boundaries perpendicular to the coast that were each divided into three sub regions: 1) 'coastal' (intertidal shoreline to 2km from the coast), 2) 'inshore' (2-20km from the shore), and 3) 'offshore' (> 20km from the shore).

The overall aim of this update is to reflect feedback received on Reid et al. (2022) based on user comments since publication as well as a dedicated peer review process including an expert workshop (Baker and Reid 2025) held in March 2025. The updated ecological risk assessment forms an essential precursor to the development of baseline data and mitigation strategies required to inform both regulatory decision-making and proponent proposals to ensure that the risks to birds can be effectively and efficiently included in the planning and operation of offshore wind farms in Australia. The main areas of updates/changes in this report compared to Reid et al. (2022) are:

- Greater explanation of the role of an ecological risk assessment in the overall risk assessment process for the impacts of offshore wind farms on birds.
- A structured approach to the consideration of species for inclusion in the ecological risk assessment based on both ecological and legislative considerations and an update to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and state listings for those species.
- Using a trait-based approach to categorising relative amount of time spent at collision risk height rather than displaying percentages of time in order to avoid an illusory level of knowledge and precision that creates a risk of misinterpretation.
- Removing seasonal adjustments for the exposure to risk for migratory species.
- A change from three to two marine subregions ('coastal' (intertidal shoreline to 5km from the coast) and 'offshore' (> 5km from the shore)) to harmonise ecological and legislative maritime boundaries in Australia.

This report does not provide an update to the review included in Reid et al. (2022) on best and emerging practices and approaches to mitigate the impacts on birds of offshore wind energy developments.

Determining the potential impacts of offshore wind farms on birds in Australia requires a structured approach to identify those taxa that may be vulnerable to impacts at broad scales and those in need of detailed evaluation at specific sites at which wind farms are proposed. Confusion can arise when different descriptions of 'risk' are conflated, underlining the importance of clearly describing the level (either at an individual or population level) at which the risk is being assessed. The structured approach outlined in Figure 1 is intended as a schematic, rather than prescriptive, structure that also provides for greater clarity of terminology and an understanding of the progression from qualitative to quantitative assessment of risk through the stages of the overall risk assessment process.

The initial part of the structured approach outlined in Figure 1 is the use of a regional scale ecological risk assessment to identify those species likely to be at the greatest risk from interactions with wind farms and this helps in identifying the appropriate level of risk assessment. This is based on intrinsic ecological, morphological and life-history characteristics, as these determine the likelihood of an individual being impacted by a wind farm and their population-level resilience to an increased rate of mortality. This provides a relative index of risk across a wide range of species that might potentially be exposed to impacts from wind farms.

The intent of an ecological risk assessment is not to provide a definitive assessment of the risk of an individual wind farm project. By categorising the relative risk to different species, it informs proponents and regulators about those taxa that are at highest risk from the impacts of wind farms at a regional scale. This does not mean that these taxa will necessarily be impacted by an individual development, but it provides a guide to ensure that those high-risk taxa are included in the review of impact pathways and constraints analysis in the initial stages of a development proposal in that region. Similarly, taxa that are identified as lower risk should not be disregarded outright, as project-specific studies may still be required depending on the factors contributing to the risk level. Risk ratings should therefore be interpreted within the appropriate context.

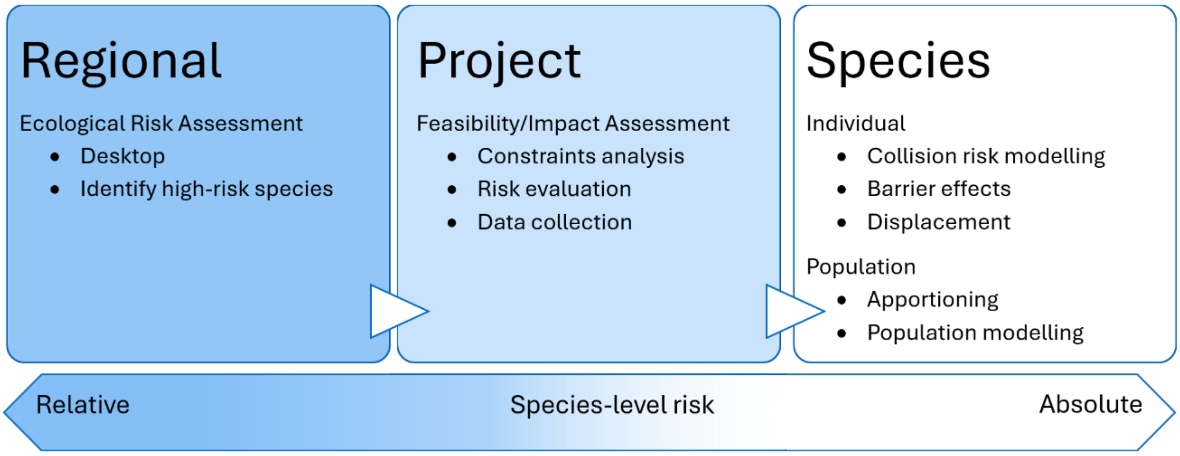

Figure 1. Conceptual structure of the process to assess the population-level risk to a bird species from a wind farm project

Assessing the risks associated with an individual wind farm requires site-specific data from surveys of the birds present in the proposed (or operational) development area. Importantly the outcomes of the ecological risk assessment should guide the appropriate choice of survey to ensure that they are appropriate for the ecological characteristics of the high-risk species. It also provides regulators with supporting information to review the treatment of key species of concern in an area when evaluating project referrals.

Quantifying the risk to individual species requires an estimate of the number of birds expected to be involved in collisions and the impact that the removal of that number of individuals is expected to have on their population. Estimating the numbers of individuals of a given bird species that are expected to collide with wind turbines is assessed at a site-specific level using collision risk modelling (Masden and Cook 2016). There are a range of collision risk models that have been used to estimate the total number of birds exposed to risk of collision (see Cook et al. 2025). All of these models use some combination of the characteristics on the wind farm design/construction (i.e., the number of turbines, hub height, length and width of blades, rotation period) and the total number and characteristics of birds that may pass through the wind farm (i.e., flight speed, body length, wingspan, time at collision risk height). An important parameter in collision risk models is the dispensation for birds taking action to avoid collisions, referred to as the avoidance rate, that is usually derived from the comparison of collision risk models results with no avoidance rate and the subsequent validation of those model outcomes through collision monitoring (Ferrer et al. 2012).

Determining the potential for the effects of wind farms to have significant population level effects depends on the life-history/demographic characteristics of a species, including the spatial and habitat requirements. The potential impact of an increase in mortality rate on the population of a species can then be assessed using population models. Demographic parameters typically include population size and current growth rate, mortality/survival rates, and fecundity/ breeding output. Intrinsic rates can be measured and/or estimated or co-opted from closely related species. There are a range of modelling approaches that can be used to examine the population consequences of additional mortality (see May et al. 2019) all of which use some combination of these vital rates to project the population forward in time with different levels of mortality based on the estimated additional number of deaths from wind farm collisions.

A major challenge in quantifying the potential population-level impact is the definition on the population that is being impacted. In the context of assessing the impacts of wind farms on birds May et al. (2019) defined a population as "*a group of individuals from the same species which live in the same space at the same time and reproduce*". Within the EPBC Act a 'population of a species' is defined as "*an occurrence of the species in a particular area. In relation threatened species, occurrences include, but are not limited to:*

- *a geographically distinct regional population, or collection of local populations, or*
- *a population, or collection of local populations, that occurs within a particular bioregion."*

Therefore, while these definitions provide a framework for understanding the temporal and spatial scale of impacts it also highlights the need for a clear, shared definition of the impacted population in order to avoid misaligned objectives. For example, if a project developer defines the 'population' of a species as the numbers occurring within the development site whereas a regulator's view of that population is at a regional or national level then the interpretation of impacts on the 'population' is likely to be quite different. Allied to the definition of the population being impacted there is need to determine what proportion of the population is likely to interact with the wind farm, as with the definition of the population differences in the 'apportioning' of the population exposed to risk will result in different interpretations of the perceived risk.

As recognised by Reid et al. (2022) that ecological risk assessment was a first attempt to extend established methods, using available data, to provide relative risk indices for birds that are potentially impacted by offshore wind farms in Australia. In doing so they also indicated that the approach taken was chosen so that it could be updated when new data, analytical approaches and legislation became available. This is the first such update of Reid et al. (2022) and it is anticipated that subsequent revisions will be undertaken commensurate with the development of the offshore wind industry in Australia.

The outcomes of the ecological risk assessment are provided in a spreadsheet format that will assist in identifying which species require further assessment before a decision to approve or not can be made. Furthermore, highlighting those species at risk will also provide a trigger for research to gather more species-specific detail to refine the risk scores for those species and to ensure that survey and monitoring programmes are designed so that they can deliver the required data on high-risk bird species.

The process of allocating species by states is designed to assist regulators, proponents and researchers in refining the list of species that they need to include in their considerations. However, we recognise that where other search tools are used to compile site-specific species lists these might use different species distribution data and inclusion criteria. For this reason, we have also included a single list of all species, without the regional filtering, to allow flexibility in how the data can be accessed by users. In this report we have sought to harmonise the species taxonomy and nomenclature across the different data repositories that we have used and note the need for caution when combining data from other sources and search engines.

3. Methods

3.1. Species

The methodology used by Reid et al. (2022), and further developed in this updated assessment, follows the approach taken by Garthe and Hüppop (2004) and Furness et al. (2013) to categorise the risk of negative interactions of birds and offshore wind farms. Garthe and Hüppop (2004) provided risk scores for 26 marine bird species in the German exclusive economic zone (EEZ) while Furness et al. (2013) assessed the risk for 38 marine bird species in Scottish waters. Expanding the approach to include the suite of birds that might interact with offshore wind farms in Australia inevitably involves a much greater number of taxa than those previous studies.

In compiling the list of bird taxa that have the potential to interact with offshore wind farms, we have followed the taxonomy and nomenclature of the working list of Australian Birds (BirdLife Australia WLAB 4.3, hereafter simply referred to as WLAB). In doing so we have adopted the ultra-taxon approach to reflect genetically distinct regional populations (following Schodde and Mason 1999) and have included taxa as either subspecies or monotypic species. The taxa included in WLAB were filtered to remove those with the Population categories of 'Domestic', 'Extinct' or 'Failed introduction', along with those records that are recognised hybrids or species groups.

The EPBC Act and relevant state listings for each taxa were downloaded from the SPRAT database (download 1 April 2025) and then linked to the WLAB using the scientific name as the linking field. Differences in the taxonomy used within SPRAT and between SPRAT and WLAB required a process of alignments and refining to match records based on the scientific name. Data tidying in SPRAT and amendments to taxonomy/naming are described in Appendix 1. Taxa with WLAB Population categories of 'Vagrant' or 'No confirmed records' were also removed unless those taxa were listed as Threatened, Migratory or Marine under the EPBC.

Implementing the changes in Appendix 1 resulted in 12 taxa that are listed in the SPRAT output that do not link to the WLAB. For 10 taxa there are no confirmed records of the species in Australia, and the listing of those species arises from their inclusion in international agreements/conventions to which Australia is a signatory. However, there are two subspecies that are listed under EPBC but not recognised as subspecies in WLAB:

- Fairy Prion (southern), (*Pachyptila turtur subantarctica*), Vulnerable

- Western Beautiful Firetail, Beautiful Firetail (Mt Lofty Range and Kangaroo Island), (*Stagonopleura bella samueli*), Endangered

All subspecies inherit the status of the species for EPBC Threat Status, Migratory, Marine, and all State Threat listings, unless the subspecies has a listing in its own right.

For example, in the case of Bar-tailed Godwit (*Limosa lapponica*) and Black-tailed Godwit (*Limosa limosa*)*:*

- Bar-tailed Godwit is listed as Migratory and Marine at the species level and two of the subspecies have an EPBC Threat status of Endangered.
- Black-tailed Godwit is listed as Endangered and as Migratory and Marine (but the subspecies (*Limosa limosa melanuroides*) does not have any subspecies level listing).

In the final bird taxa list all subspecies of Bar-tailed godwit inherit the Migratory and Marine status from the species level listing but retain the subspecies level EPBC Threat Status (there is a third subspecies in the WLAB that inherits the Migratory and Marine status but does not have an EPBC Threat Status). For Black-tailed Godwit the subspecies inherits the EPBC Threat Status as well as the Migratory and Marine status from the species level. Where there are differences in the taxonomy/nomenclature used in the EPBC Act and individual state/territory legislation (Table 1) and the latter have been aligned with the EPBC Act.

Table 1. Relevant State and Territory legislation that lists threatened species

State/Territory	Abbreviation	Legislation
Australian Capital Territory	NC Act	Nature Conservation Act 2014
New South Wales	NSW BC Act and FM Act	Biodiversity Conservation Act 2016, Fisheries Management Act 1994 (FM Act)
Northern Territory	TPWC Act	Territory Parks and Wildlife Conservation Act 1976
Queensland	NC Regulations	Nature Conservation (Animals) Regulation 2020
South Australia	NPW Act	National Parks and Wildlife Act 1972
Tasmania	TSP Act	Threatened Species Protection Act 1995
Victoria	FFG Act (Advisory Lists)	Flora and Fauna Guarantee Act 1988
Western Australia	WA BC Act	Biodiversity Conservation Act 2016

We followed the approach of Ehmke et al. (in prep) to divide bird taxa according to the spatial "bird group" classification on the habitat types in which they typically feed (as defined by Garnett et al. 2015). The classifications are:

- Terrestrial – taxa that depend on terrestrial habitats
- Wetland – taxa that depend on inland water habitats
- Shoreline – Taxa associated with linear habitats such as coastal shorelines
- Marine – taxa that depend on oceanic habitats.

Based on these groupings a subset of the WLAB was created that included all taxa in a family where that family included any Shoreline and Marine taxa and all taxa in the Terrestrial and Wetlands groups that are EPBC listed as migratory and/or marine. In addition, those taxa that are known to cross Bass Strait as either obligate or occasional migrants (e.g., Zhou et al. 2025) were also included.

The relatively large number of taxa included reflects the large biogeographic scales involved, as well as the consideration of all bird taxa, not just seabirds, that have the potential to interact with offshore wind farms.

3.2. Spatial Distribution

The marine area of Australia was divided by state/territory boundaries perpendicular to the coast into eight regions (Figure 2). Definition of the regions was based on state/territory boundaries and species assemblages to provide a workable assessment tool for DCCEEW assessment teams. Western Australia was divided at approximately 27° S to reflect the differences in bird species assemblages between the northern and southern areas of the state and, in particular, the internationally important shorebird areas in the northern region. To reflect the regional interest in offshore wind farm proposals, and the migration and dispersive movement of birds through the region, we also created a Bass Strait region bounded by the northern coast of Tasmania between Woolnorth Point and Cape Portland and extending to the coast of Victoria. A separate Tasmania Region, for all areas south of approximately 40.5°S was also created.

Each bird taxon was assigned to one or more of the marine regions based on the extent of the overlap between the marine region and the core range polygons for each taxon. The core range polygons for birds were based on those in Menkhorst et al. (2017) and were constructed using regionally subsetted Minimum Convex Polygons (MCPs). This approach intersects taxon records with a regionalisation (chosen based on the overall extent of the taxon) then constructs a single MCP per region (where >2 points exist). Following the intent of extent of occurrence metrics, i.e., a contiguous hull encompassing all the known occurrence of a taxon, excluding cases of vagrancy or extirpation (IUCN 2019), these polygons were then dissolved, and remnant gaps rationalised to ensure a continuous hull based on nearest neighbour with reference to known or suspected taxonomic boundaries (e.g., ultrataxon geographic boundaries – Schodde and Mason 1999) or habitat mapping. Vagrant zones were then subtracted from the main hulls based on low percentiles local reporting rates, commonly at least an order of magnitude less than the median. Finally, historic zones, i.e., areas from which taxa have been locally extirpated, were subtracted with reference to years since the last record (commonly 1990), weighed against search effort and expert review.

A taxon was included in the marine region list where its range polygon covered >2.5% of the area of the marine region. Where the core ranges of the distribution of subspecies are not well described, the subspecies were given the distribution of the parent species, noting that this could lead to apparent extra-limital occurrence of some subspecies in some states. Furthermore, the list of bird taxa includes a large number of highly mobile marine taxa that have extensive secondary/non-core range distributions, however, for the purposes of this process we have used the core range for consistency. For those taxa where there was no species-level core range polygon the allocation to marine regions was manually assigned based the known distribution in HANZAB (BirdLife Australia 2023) and Menkhorst et al. (2017). In addition, the 2.5 % overlap criteria was relaxed for range-restricted EPBC listed Migratory terrestrial taxa overlapped with a marine region by less than 2.5% but that marine region contained 100% of the core range polygon for that taxon (see Appendix 1 for taxa list and amendments).

Each region was further divided into two sub regions: 1). 'coastal' (intertidal shoreline to 5km from the coast), 2) 'offshore' (> 5km from the shore). These align with maritime boundary definition in Australia and reflect that, even for an offshore wind farm that is situated more than 5km from the shore, there will be associated coastal infrastructure. The allocation to the coastal and offshore subregions was based on Families as follows:

- Coastal
  - Laridae
  - Stercorariidae
  - Scolopacidae
  - Charadriidae
  - Glareolidae
  - Haematopodidae
  - Burhinidae
  - Recurvirostridae
  - Spheniscidae [only little penguin]
  - +terrestrial/wetland taxa that are listed as EPBC Migratory and/or Marine
- Offshore
  - Diomedeidae
  - Phaethontidae
  - Procellariidae
  - Fregatidae
  - Sulidae
  - Hydrobatidae
  - Oceanitidae

The only exception to these allocations was to include all seabird taxa that breed on the Australian mainland (or an insular islands) and those seabird species that have been recorded from collision surveys at onshore wind farms in Australia (Hull et al. 2013). The highly mobile nature of many species of seabirds means that making this division between coastal and offshore taxa is inevitably subject to question for non-breeding species that are periodically observed in coastal waters. However, we feel that the consistent application of the decision criteria that we have used allows for greater transparency and reproducibility of results.

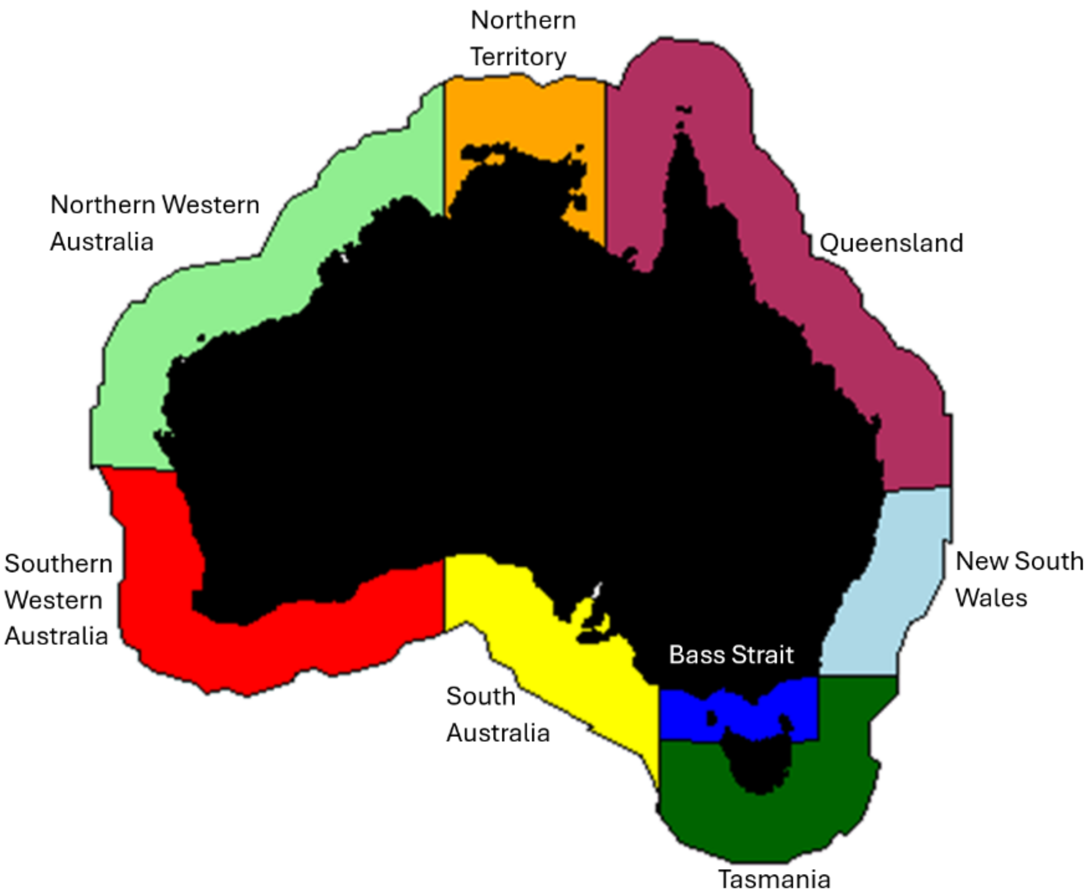

Figure 2. Spatial Regions used in the risk assessment for offshore wind farms

Regions are Southern Western Australia (red), Northern Western Australia (pale green), Northern Territory (orange), Queensland (maroon), New South Wales (pale blue), Bass Strait (dark blue), Tasmania (dark green), and South Australia (yellow). Each region was subsequently divided into two subregions (see text).

3.3. Risk assessment approach

Garthe and Hüppop (2004) and Furness et al. (2013) expressed overall risk as a combination of a 'vulnerability' and a 'conservation' score. In adapting this nomenclature to that of a semi-quantitative (level 2) ecological risk assessment (Hobday et al. 2011), we have considered vulnerability to be equivalent to susceptibility and the conservation score to be equivalent to productivity. In this context the productivity is an index of the resilience of a population to the impact of increased mortality arising from a wind farm development.

To identify key knowledge gaps and assess input parameters to the risk assessment process a workshop was held in Hobart, Tasmania, on 19 March 2025 (Baker and Reid 2025). The workshop was attended by invited experts with detailed knowledge of bird ecology and morphology, ecological risk assessment methodologies, and an understanding of the wind energy industry. Attendance at the workshop drew experience from the scientific, government and non-government sectors. Acknowledging the well-recognised limitations in data availability the workshop focused on the suitability of the use of the trait-based approach to parameterising the risk frameworks.

Research on bird interactions with offshore wind farms is a relatively new field in Australia compared to that in Europe and North America and this is reflected in the very limited availability of empirical data of key attributes that have been included in the risk assessment approaches used elsewhere. This means that is most cases the details of a particular attribute of a species (or subspecies) are not available, for this reason we have developed a consistent, quantitative basis for attribute scoring using peer-reviewed, publicly available data. Where modifications or corrections to any data field were necessary these were implemented and documented in order to allow for reproducibility of results and a structured updating process when new information become available. Major sources of data used in this assessment process are outlined in Table 2.

Table 2. Major sources of data

Attributes	**Source**
Population Status	Garnett and Baker 2021
Generation time	Bird et al. 2020
Australian distribution, feeding habitats,	Garnett et al. 2015
Morphology (wing dimensions and body mass)	Tobias et al. 2022

3.3.1. Productivity

A productivity risk score was calculated based on the following attributes that were scored on 5-point scales:

1) Generation Time
2) Population Status

3.3.1.1. Generation Time

The generation times for each species were taken from Bird et al. (2020) who used the age of first reproduction, maximum longevity and annual adult survival to model generation times for all bird species globally. Increasing generation time provides a proxy for the life-history strategy of a species on a continuum from R-selected (fast) to K-selected (slow) species. Avian life histories scale with increasing generation time following a logarithmic relationship (Sæther et al. 2005) and therefore the Generation Time score was based on logarithmic divisions of generation times as in Table 3.

Table 3. Allocation of Generation Time scores

Generation time	**Generation Time score**
<2.6 years	1
>=2.6 < 4.7 years	2
>=4.7 <= 8.5 years	3
> 8.5 <= 15.4 years	4
>15.4 years	5

3.3.1.2. Population Status

For Population Status, we used the 2020 Action Plan for Australian Birds (APAB) status (Garnett and Baker 2021) as this provides the most contemporary national overview of the conservation status of all birds occurring in Australia. The assessments presented in Garnett and Baker (2021) present a synthesis of population size and trend in relation to life-history. Population status was assessed in the APAB by strictly following the IUCN Red List guidelines (IUCN Standards and Petitions Committee 2019). This is a similar approach to that taken by Furness et al. (2013) who derived a conservation score that included the proportion of biogeographic population in Scotland, adult survival and UK threat status.

We recognise that generation time is used as a relative scalar for population trends in Garnett and Baker (2021) as part of the conservation status assessment. However, a long generation time does not automatically mean that a taxon will have an adverse conservation status. Therefore, in the context of the current assessment we have included the conservation assessment as it provides additional information about those species where other factors may be impacting the ability of the population of that taxon to withstand additional mortality impacts.

In using the outcomes of the conservation assessment in Garnett and Baker (2021) we recognise the importance of the EPBC Act and relevant state and territory listing in a statutory context. Therefore, while the EPBC Act listing was not include in the actual risk scoring we have included the EPBC status and whether the taxon is listed as Migratory and/or Marine as well as the relevant state and territory listing in the output files. For those taxa occurring in Bass Strait the state listing for both Victoria and Tasmania are included.

Population Status was scored as in Table 4.

Table 4. Allocation of Population Status scores

APAB status	Population Status score
Least Concern	1
Near Threatened	2
Vulnerable	3
Endangered	4
Critically Endangered	5

Where Garnett and Baker (2021) had not assessed the status of a taxon it was assumed to be equivalent to Least Concern and given a score of 1.

3.3.1.3. Productivity Risk Scoring

As the Population Status for each taxa includes an assessment of population size, population trend and threats, and reflects a measure of the overall health of the population of a species, it was given a higher weighting relative to the Generation Time, such that the overall Productivity score for each taxon was:

Productivity (P) = ((Generation Time + Population Status * 1.5)/2

3.3.2. Susceptibility

A susceptibility risk score was calculated based on the following four attributes that were scored on 5-point scales:

1) Flight Height
2) Flight Time
3) Flight Manoeuvrability
4) Habitat Specialisation

3.3.2.1. Flight Height

The height at which birds fly, relative to the swept area of wind turbine blades, is clearly one of the most important attributes that influences the risk of collision with wind farms. However, there is little empirical data for Australian birds with which to estimate flight altitude. In order to develop an index for input into the ecological risk assessment the relative amount of time that species would be expected to fly within the typical swept area of turbine blades was estimated using behavioural and ecological classifiers, following the approach of Hull et al. (2013) in describing the collision risks of birds with onshore wind farms.

Accordingly, each bird taxon was assigned to a trait-based group based on an understanding elucidated through expert opinion of their foraging and flight characteristics to provide an index of the relative amount of time that birds would be expected to fly below, inside and above the typical swept area of turbine blades (also known as collision risk height) (Figure 3). The assignment to trait groups was initially made at the family level and any individual taxa where this was seen to be a poor description of their foraging ecology were allocated to a more appropriate group. The assignment to the trait/taxon grouping and any subsequent revisions was refined as part of the expert review process (Baker and Reid 2025).

Figure 3. Trait-based grouping for relative amount of time spent at collision risk height. The relative height of the bars are illustrative of the relative amount of time that birds in this trait group are expected to fly below, within and above collision risk height (i.e., within the area encompassed by the rotating blades).

Based on the traits-based approach in Figure 3 the final Flight Height attribute score was applied on a scale of 1 -5 as in Table 5.

Table 5. Allocation of Flight Height scores

Trait groups	Flight Height score
A	1
B, C, D	2
E, F	3
G, H, I	4
J,	5

Terrestrial migrants that do not normally feed in coastal subregions (non-foraging taxa) were assumed to occur in these subregions as they transit through them on migration. In offshore subregions these non-foraging external migrants are assumed to be flying at high altitude and therefore unlikely to interact with any offshore infrastructure (see Piersma et al. 1997, Liechti et al. 2018, Galtbalt et al. 2021); therefore, they are not included in the taxa list for that subregion.

3.3.2.2. Time spent in flight

The Flight Height attribute applies only to the time when a bird is flying, however, there are substantial differences in the relative proportion of the overall time-budget of different species that they spend flying. To account for these differences in the amount of time spent flying, a similar, trait-based approach was taken to assigned bird families to one of five trait-based group based on an understanding of their foraging and movement characteristics to provide a relative index of the amount of time that birds would be expected spend flying over the course of a year (a timescale chosen to accommodate migratory/nomadic movements). The assignment to trait groups was initially made at the family level and then modified to account for the migratory/movement patterns of individual taxa (Table 6).

Table 6. Trait-based grouping for relative amount on time spent flying

Group	Trait group	Example
A	Flightless and resident obligate ground foraging	Rails and crakes (resident), Grassbirds, Chats
B	Arboreal foraging, resident, foliage gleaner, nectarivore, frugivore	Bowerbirds and Catbirds, Whistlers, Shrike-thrushes, Kingfishers (resident), Parrots, Lorikeets and Rosellas (resident)
C	Foraging traits as in A or B but are internal migrants/nomadic	Kingfishers (migratory), Parrots, Lorikeets and Rosellas (nomadic/migratory), Gerygones (internal migrants), Cuckoos, Monarchs
D	Aerial predator, long distance/external migrant	Birds of prey, Gulls, Terns and Noddies, shorebirds
E	Aerial insectivores, marine surface feeders	Swifts, Swiftlets, Swallows and martins Albatrosses, Petrels and Shearwaters

Based on the traits-based approach to the time spent flying in Table 6 the final Flight Time attribute score was applied on a scale of 1 -5 as in Table 7.

Table 7. Allocation of Flight Time scores

Flight time group	Flight Time score
A	1
B	2
C	3
D	4
E	5

3.3.2.3. Flight Manoeuvrability

Furness et al. (2013) suggested that the scores for the attribute of flight mobility were 'considered to be a consequence of morphology rather than behaviour'. Therefore, we have used wing loading, which is the mass of a bird divided by the wing area, as a consistent metric of morphology that provides a proxy for flight manoeuvrability. The assumption underlying this approach follows Warham (1990) and Gauld et al. (2022), such that the taxa with a low wing loading are light and manoeuvrable (i.e., low risk), in contrast to taxa with a high wing loading that have relatively small-winged rapid flight and have lower manoeuvrability (i.e., high risk). Data from Tobias et al. (2022) on the wing length, wing width and body mass of all bird taxa were used to determine a Flight Manoeuvrability (wing loading) index (FM) where FM= body mass / (wing length * wing width). Consistent with the logarithmic nature of allometric relationships the Flight Manoeuvrability attribute for birds was scored on a scale of 1-5 as in Table 8.

Table 8. Allocation of Flight Manoeuvrability scores for birds

Flight Manoeuvrability (FM) value	Flight Manoeuvrability score
< 0.002	1
>= 0.002 and < 0.004	2
>= 0.004 and < 0.080	3
>=-0.017 and <= 0.034	4
> 0.034	5

Although there was a positive relationship between the wing loading index and the flight time index in birds ($F_{(1,1093)=}$35.12 p< 0.001) both of these indices were retained in the assessment of susceptibility in birds given the wide range of morphologies from passerines to seabirds.

3.3.2.4. Habitat Specialisation

Garnett et al. (2015) provides a species-specific characterisation of the non-trivial utilisation of 31 feeding habitat types defined by Commonwealth of Australia (2006). Each species was given a Habitat Specialisation score to reflect its ability to switch to an alternative feeding habitat as a result of disturbance or displacement resulting from an offshore wind farm according to the number of the 31 habitat types (HA) in which it occurred, such that a low HA value represents a habitat specialist (high score) and a high value reflects a habitat generalist (low score, see Table 9). Those bird taxa for which habitat data were not included in Garnett et al. (2015) were assigned the median HA value for all birds.

Table 9. Allocation of Habitat Specialisation scores

Habitat Specialisation (HA) value	Habitat Specialisation score
>=9	1
6, 7or 8,	2
4 or 5	3
2 or 3	4
1	5

3.3.2.5. Susceptibility Risk Scoring

The relative importance of the component attributes of the susceptibility were reflected by giving a higher weighting to the flight profile and a lower weighting to habitat specialisation, such that the susceptibility score for each bird taxon was:

Susceptibility (S) = ((Flight Height*2) + Flight Time + Flight Manoeuvrability + (Habitat Specialisation *0.5))/4

3.3.3. Overall risk

The overall measures of relative risk (R) for each taxa were then estimated following the method of Williams et al. (2011) as the Euclidean distance from the taxa to the origin for a two-dimensional plot of P on S such that $R = ((P - X_0)2 + (S - Y_0)^2)^{1/2}$ where X_0 and Y_0 are the x, y origin coordinates (in this case these are equal to zero). The allocation to risk groups was then based on percentiles of the distribution of overall risk scores, taxa in the Low risk in the lower 25th percentile, High risk in the upper 25th percentile and all other taxa being Medium risk.

All analyses were conducted in R (R Core Team 2021).

4. Results

4.1. Species

Of the initial list of 381 taxa that met the criteria for inclusion based on core range overlap and/or EPBC listing there were 111 that were deemed to be 'External' taxa (typically highly mobile seabirds/vagrants that were initially included because they are EPBC listed as Migratory or Marine). This resulted in a final list of 270 taxa being included in the in the ecological risk assessment

The median susceptibility score was 3.38 with an approximately symmetrical distribution around this value (Figure 4a, left panel). The median productivity score was 2.25, and in contrast to the susceptibility score, the distribution of scores was skewed towards low scores (Figure 4b, right panel) reflecting the high proportion of species with a conservation status of least concern.

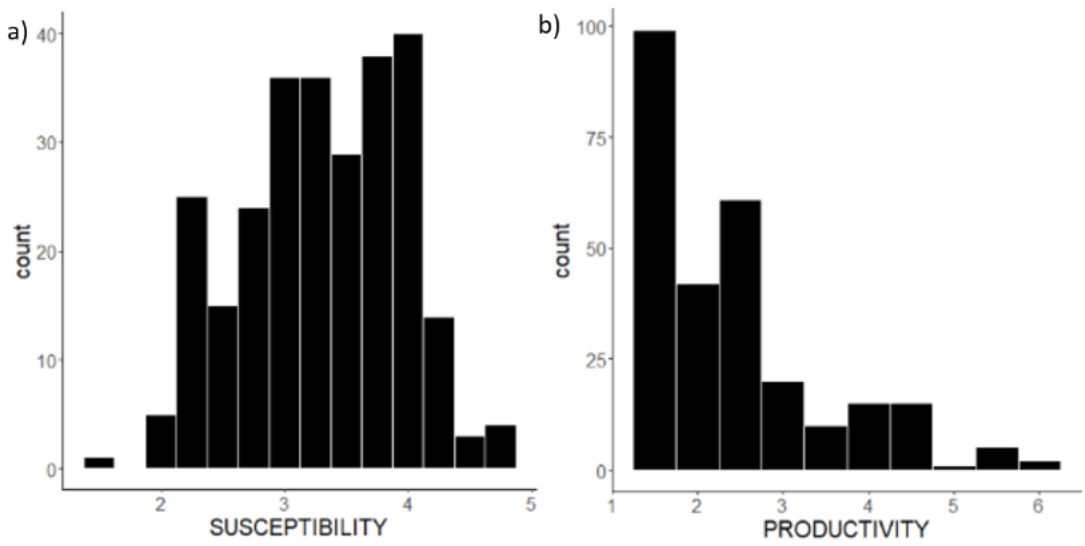

Figure 4. Distribution of a) Susceptibility, and b) Productivity scores for all taxa

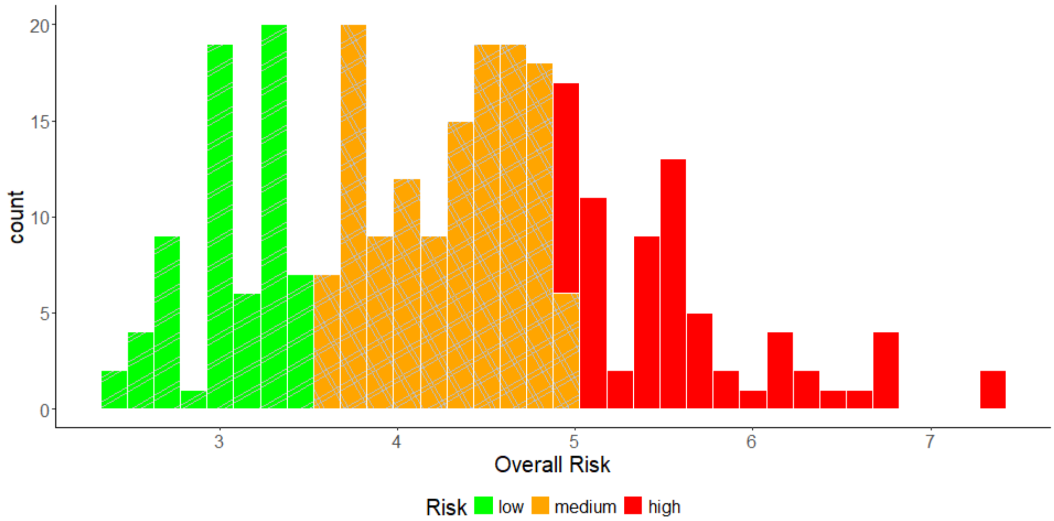

Figure 5. The distribution of overall risk scores for birds with the transition between risk groups shown as stacked bars to show the number of species in each risk group. Green (diagonal stripe) indicates low risk; orange (cross-hatched) indicates medium risk and red (no line) indicates high risk

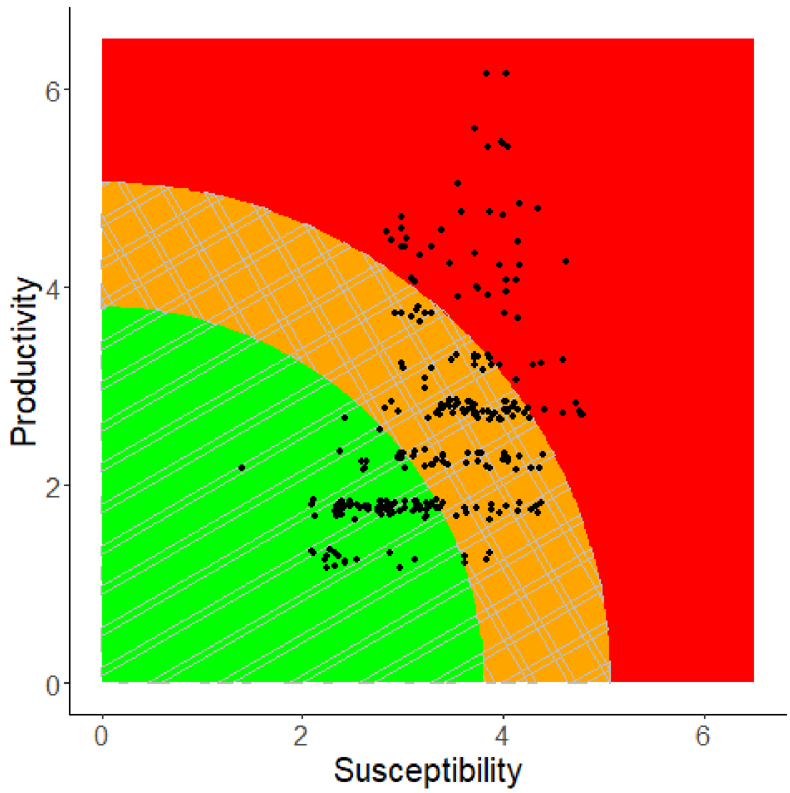

Figure 6 The productivity-susceptibility plot for birds (the points have been jittered to avoid overprinting of multiple points with the same values). Green (diagonal stripe) indicates low risk; orange (cross-hatched) indicates medium risk and red (no line) indicates high risk

In each of the regions the coastal subregions with the exception of Tasmania had a greater number of taxa, but a much lower proportion of those were high-risk, compared to the respective offshore subregion. There were no low-risk taxa in the offshore subregions (Table 10).

In coastal regions the species with the highest risk scores were Swift Parrot (*Lathamus discolor*), Furneaux White-fronted Tern (*Sterna striata incerta*), Australian Gould's Petrel (*Pterodroma* *leucoptera leucoptera*), Sooty Shearwater (*Ardenna grisea*), Recherche Cape Barren Goose (*Cereopsis novaehollandiae grisea*), Tasman Little Tern (*Sternula albifrons placens*), Shy Albatross (*Thalassarche cauta*) and Orange-bellied Parrot (*Neophema chrysogaster*).

In the offshore regions in southern Australia the highest risk species were all albatrosses, including Eastern Antipodean Albatross (*Diomedea antipodensis antipodensis*), Tristan Albatross (*D. dabbenena*), Gibson's Albatross (*D. antipodensis gibsoni*), Northern Royal Albatross (*D. sanfordi*), Grey-headed Albatross (*T. chrysostoma*), Amsterdam Albatross (*D. amsterdamensis*), Indian Yellow-nosed Albatross (*Thalassarchecarteri*) , Wandering Albatross (*D. exulans*), Campbell Albatross (*T. impavida*), and Shy Albatross (*T. cauta*). The prevalence of these high-risk scoring taxa in the offshore subregions is apparent in the Productivity – Susceptibility plots for each of the subregions (Figure 7).

Table 10. Number of taxa, and proportion in each risk class in the coastal (coast) and offshore(off) subregions of Bass Strait, New South Wales (NSW), Northern Territory (NT), Queensland (QLD), South Australia (SA), Tasmania (TAS), Western Australia north (WA.north) and Western Australia south (WA.south) subRegions

SubRegion	**Taxa**	**n_high**	**Prop_high**	**n_medium**	**Prop_medium**	**n_low**	**Prop_low**
Bass.Strait.coastal	113	30	0.27	50	0.44	33	0.29
Bass.Strait.offshore	51	28	0.55	23	0.45		
NSW.coastal	123	27	0.22	62	0.50	34	0.28
NSW.offshore	46	26	0.57	20	0.43		
NT.coastal	100	15	0.15	67	0.67	18	0.18
NT.offshore	7	5	0.71	2	0.29		
QLD.coastal	134	24	0.18	73	0.54	37	0.28
QLD.offshore	35	18	0.51	17	0.49		
SA.coastal	94	25	0.27	46	0.49	23	0.24
SA.offshore	46	27	0.59	19	0.41		
TAS.coastal	42	12	0.29	21	0.50	9	0.21
TAS.offshore	51	28	0.55	23	0.45		
WA.north.coastal	95	17	0.18	59	0.62	19	0.20
WA.north.offshore	15	8	0.53	7	0.47		
WA.south.coastal	80	21	0.26	40	0.50	19	0.24
WA.south.offshore	38	23	0.61	15	0.39		

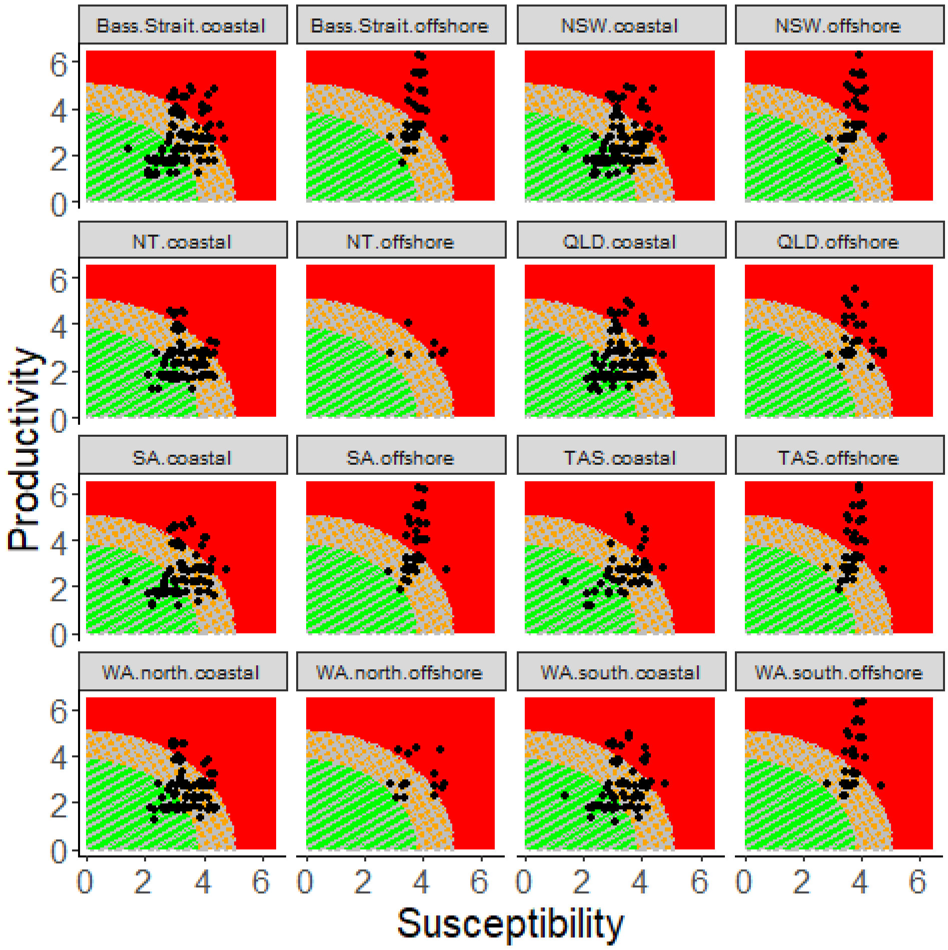

Figure 7. Regional productivity-susceptibility plot for birds, with regional labels in the header bar of each plot are as in Table 10. The points have been jittered to avoid overprinting of multiple points with the same values. Green (diagonal stripe) indicates low risk; orange (cross-hatched) indicates medium risk and red (no line) indicates high risk.

Details of the overall risk, productivity and susceptibility scores along with the attribute scores are provided for each subregion in a spreadsheet format at Appendix 2. In addition to the main output, which is filterable by states/regions, we have included a separate list of all birds with no separation by states/regions. These are provided in Appendices 2-3.

5. Response, impacts, and mitigation

Please note this is a duplicate of Chapter 3 from Reid et al. 2022 and is duplicated here for completeness in this report.

5.1. Introduction

The interaction between birds and offshore wind farms has been studied extensively, primarily but not exclusively in Europe (eg: Cook et al. 2011, Peschko et al. 2020, Lloret et al. 2022). Here we report on best and emerging practices and approaches to manage and mitigate the impacts on birds during the pre-construction, construction, and operational phases of offshore wind energy developments, and provide advice on their applicability and implementation in Australia. The aim is to provide a synthesis of available information to support regulators and proponents in determining:

1) if an offshore wind farm development has the potential to have significant impacts on birds
2) the potential data collection methods and mitigation measures that could be required to address any such impacts.

Offshore wind farms have been in operation in Europe for over 20 years and there is a large body of experience in the assessment and mitigation practices that provide a benchmark for the conduct of impact assessment elsewhere. Offshore wind farms are a much more recent area of interest in Australia (see Briggs et al. 2021), and although there are differences in the species assemblages involved, the macro-ecological nature of the risk assessment processes for birds and offshore wind farms means that there is general applicability of the best-practice approaches to location selection, mitigation strategies and monitoring of impacts in the Australian context. Reviewing the data requirements of the methods and approaches outlined also provides an opportunity to highlight any knowledge/information gaps that should be addressed to support the emerging Australian offshore wind farm industry.

The information in this document is intended as an initial guide; the dispersive or migratory behaviours of birds will require surveys at local, regional, and national scales to provide baseline information on populations to inform a biologically meaningful assessment of the potential effects of offshore wind farm projects.

5.2. Responses of birds to offshore wind farms

There is a range of behavioural responses shown by birds to the presence of turbines and associated infrastructure, including construction and support vessels. Within the spectrum of behavioural responses, the reviewed literature places most of the emphasis on avoidance behaviour that occurs in both the horizontal (flying around a wind farm) and vertical (flying over or under a wind farm) planes (Masden et al. 2010). However, birds can also be attracted to wind farm infrastructure and support vessels as potential roosting sites or in response to a localised increase in food availability (Leopold et al. 2012, Krijgsveld 2014, Vanermen et al. 2015, Dierschke et al. 2016, Peschko et al. 2020).

Birds may be displaced during specific migration periods or throughout some or all of the year during foraging trips. The behavioural responses are species-specific (Dierschke et al. 2016, Welcker and Nehls 2016), and involve flying birds (for example, species migrating or dispersing across Bass Strait) and feeding birds (such as penguins and other seabirds). At its most extreme level, an adverse impact would see a wind farm acting as a barrier to migration of birds or excluding birds from a foraging area (Drewitt and Langston 2006, Masden et al. 2010).

The behavioural responses have been loosely divided into three broad spatial scales: macro and micro, with an intermediate meso-response category proposed (Band 2012, Cook et al. 2014, see Box 1).

Box 1. Responses by birds to offshore wind farms

Macro-response - the response of birds to the presence of the wind farm outside its perimeter, defined as a 500m buffer surrounding the outermost turbines. Responses may include attraction to the wind farm, displacement from preferred foraging habitat or an alteration to flight paths as a result of seeing the wind farm as a barrier. These may occur in either horizontal or vertical planes.

Meso-response - a redistribution of birds, or alteration of flightpaths within a wind farm in response to the presence of the turbines. This may encompass both horizontal and vertical responses. These responses are in contrast to micro-avoidance.

Micro-response – last-second action taken by birds flying at rotor height to avoid collision, encompassing both horizontal and vertical movements, within a 10m buffer surrounding turbine rotor-swept areas.

Identifying the potential impacts on birds of a proposed offshore wind farm, and designing mitigation approaches, begins with identifying the species that are likely to be present in the proposed installation area. This is because the biological characteristics and the regulatory status of the species involved will determine the mitigation approaches to be used.

The ecological risk assessment approach presented in this report provides a rigorous method to identify species that are potentially at high-risk of impact from an offshore wind farm. The identification of those high-risk species in an ecological risk assessment means that appropriate survey designs, suitable for detecting those high-risk species, can be used. Furthermore, this information on high-risk species can be included with species composition data collected during pre-construction surveys, where there is the potential for high-risk species (particularly rare species and nocturnal migrants) to be under-reported or absent during such surveys. In this way the ecological risk assessment provides an essential precursor to the development of baseline data and mitigation approaches as part of the management of risks associated with offshore wind farms.

The European Commission provides guidance on best practices relevant to screening and assessment procedures for the establishment of an offshore wind farm. Guided by the examples and case studies provided in European Commission (2020), Section 5.3.1 describes approaches for establishing baseline data series and the assessment of the likelihood of a plan or project having significant effects on birds. Knowledge gaps, and potential means to address them in the context the development of offshore wind farms in Australia, are also highlighted.

To conduct the assessment and screening process there is a need to identify the type and extent of effects and the likely causal factors for those effects, as well as the area and timeframe of the assessment. Conducting assessments will require the collection of baseline data that is relevant and proportionate to the needs of the assessment of a particular plan or project. The baseline describes the ecological context of the plan or project location, important sites and/or species involved and the interactions between the plan or project and those attributes.

5.3. Measuring impacts of birds from offshore wind

5.3.1. Baseline data

The creation of a relevant suite of baseline data to underpin the assessment process can be considered to comprise three major components:

1) Desk-based review to identify protected habitats and species that occur or are likely to occur in the study area. In the case of birds, part 1 of this report provides an example of a risk-based process to identify species likely to be impacted by offshore wind farms.
2) A reconnaissance site visit by a suitably qualified and experienced ecologist to determine if existing data remains appropriate (i.e., is it up to date), whether the proposed study area cover the entire area that could be affected by the proposed development and to provide context for survey design and methods.
3) Undertake surveys to collect the required data. The methods should specify the survey effort/duration and why these are justified and should sample over a sufficient period for each species of interest. The method and design for these surveys should be applicable for collecting comparable data during all of the construction and operational stages of the wind farm development to ensure consistent outcomes.

Examples of baseline survey methods relevant to the assessment of potential impacts on birds of proposed offshore wind farms include:

- Land-based vantage-point surveys if turbines are close to shore.
- Boat-based and/or aerial transect surveys (including digital or video) to determine species abundance, distribution at sea, and potentially flight-heights.
- Radar-based estimation of bird flux, bird densities, flight direction, and flight height, particularly where migratory birds are likely to be present in large numbers.
    - Radar data should be used in conjunction with visual observation to identify species and may be useful in circumstances where data cannot be obtained through direct visual observation or through GPS tracking.
    - As well as observations from radars used specifically for a project there is an increasing use of existing weather surveillance radars to examine large-scale bird movement. Australia's weather radar network is operated by the Bureau of Meteorology and potentially provides a data resource to examine bird movements in areas of interest for offshore wind farm developments (Rogers et al. 2020).
- Bird-borne tracking devices to understand behaviour and bird movements throughout the year.

Where there are important bird breeding colonies and or feeding areas within or adjacent to the proposed site of an offshore wind farm and count data are not available, or where they are not reliable for the purposes of an impact assessment, census data should be collected using an accepted peer-reviewed methodology that is suitable for the species and habitat.

Achieving the best overall picture of how birds use the area of interest will likely involve using a range of available methods, recognising the strengths and limitations of each method. For example, boat-based visual surveys provide the best species-specific identification but are limited in spatial and temporal coverage, whereas aerial surveys have greater spatial coverage with lower species identification resolution, and radar provides extensive temporal coverage, including at night, but with no resolution to species. Relying on a single type of survey is unlikely to generate an overview of the use by birds of areas at the scales required for the assessment of offshore wind farm projects. Using data from all available sources will pose analytical challenges, however, accessible statistical methods for combining data from different sources, to gain the maximum insights into seabird distribution, have been developed by Matthiopoulos et al. (2022).

5.3.2. Types of impacts

The main types of impacts of birds from offshore wind farms are:

Collisions

Collisions between birds in flight and wind turbine structures are perhaps the highest profile of all impacts. The main factors that influence the risk of collision (Box 2) are the heights that birds fly in relation to rotor swept area and the speed and direction of flight (relative to the wind farm configuration). The risk of fatal collisions will be modified by avoidance behaviour (resulting in decreased collision risk) and attraction behaviour (resulting in increased collision risk).

Displacement and barrier

Displacement and barrier effects occur when birds incur additional flight distances to circumnavigate a wind farm. Repeated diversions around an offshore wind farm by local breeding birds moving between breeding and foraging areas may incur greater energetic costs compared to migratory birds (see for example Welcker and Nehls (2016)).

Disturbance

Disturbance effects result in changes in the behaviour and/or reproductive success of birds in response to a wind farm, for example Dahl et al. (2012) demonstrated a significant decrease in the proportion of successful breeding attempts of White-tailed Eagles (*Haliaeetus albicilla*) as a function of how close the breeding locations were to a wind farm.

Habitat

Habitat loss and degradation effects of a wind farm occur where the removal or damage to a habitat changes the behaviour of birds that would otherwise use an area (see for example Marques et al. (2019) on the changes in habitat use by Black Kites (*Milvus migrans*) in association with onshore wind farms). The impact of these impacts will depend on the flexibility of a species in its habitat use, and the extent it can respond to changes in habitat conditions.

Indirect

Indirect effects of offshore wind farms on birds may occur because of changes in the availability of particular habitats or changes in prey abundance, such as increases in local fish populations as a result of the exclusion of fishing pressure (Degraer et al. 2020) that attract birds to a site and increase collision risk.

Box 2. Measuring bird flight heights

The height at which birds fly, relative to the swept area of turbine blades, is recognised as one of the most important attributes of birds that influences the risk of collision with wind farms. A range of methods exist for either measuring or estimating the flight heights of birds. Thaxter et al. (2015) considered that radar was the most commonly used method for measuring flight height in many offshore surveys, however, as species identification is often not possible with this method, other methods of flight height data are also often collected simultaneously to allow cross-validation.

Recent advances in light detection and ranging (LiDAR; light radar) and digital aerial imaging make it possible to collect more accurate estimates of the flight heights of birds. LiDAR is a remote sensing technique that records the three-dimensional location of objects by emitting frequent, short-duration laser pulses. Cook et al. (2018) conducted a trial using LiDAR and digital aerial photography to measure the flight heights of seabirds. A validation of the flight height estimated from LiDAR showed that flight height could be measured to an accuracy of within 1 m. LiDAR might also provide the potential to estimate the general patterns of flight height of birds at night (albeit to a lower level of identification of species etc) including in combination with thermal imaging to determine the presence and identity of birds. The ability to collect flight height data at night is potentially important where there is evidence that flight heights may differ between day and night (for example, Ross-Smith et al. 2016).

Cook et al. (2018) provide recommendations for approaches to studies of the use of LiDAR including minimum altitude and optimum flight speed for survey aircraft, camera repetition rate and ground sampling distance, mounting location of the camera and the LiDAR, and analytical approaches to using the data collected.

5.3.3. Monitoring of impacts

The effects of offshore wind farm developments on birds are typically assessed in a two-step process that involves quantifying the magnitude of bird mortality and then assessing the change in the population that this additional mortality would produce in the light of any conservation objectives of the species/site in question.

As it is not practicable or possible to conduct surveys for carcasses of birds that have been killed by offshore wind farms (compared to onshore settings), the methodological and analytical approaches used to estimate the numbers of bird fatalities for onshore wind farms are not likely to be appropriate in offshore locations.

Collisions with ships and other marine infrastructure are known to be more frequent during periods of poor weather and/or poor visibility, such as fog and misty conditions, and during storms with high wind speeds (for example, Black 2005, Montevecchi 2006, Newton 2007, Hüppop et al. 2016, Rodriguez et al. 2014). The combination of the remote location of offshore wind farms and an elevated collision risk in conditions where visual observation of collisions is not possible requires additional approaches to quantifying actual collisions. Blade borne devices such as cameras and microphones (Clocker et al. 2021) provide a quantitative approach to recording collisions that could be suitable for offshore wind farms given the challenges of conducting direct observations. Blade borne collision detection devices also have the potential to help identify the height above the sea surface that collisions occur and further refine collision risk models.

In addition to direct estimates of collision related mortality the displacement/barrier effects on birds of offshore wind farms are potentially important factors that impacts flight distance and access to preferred feeding areas. These effects have been studied by combining data from bird-borne tracking devices, radar, and cameras to collect data on avoidance/displacement of the bird assemblage in the area around offshore wind farms; such studies have become widespread in offshore wind farms in Europe (for example see Figure 8).

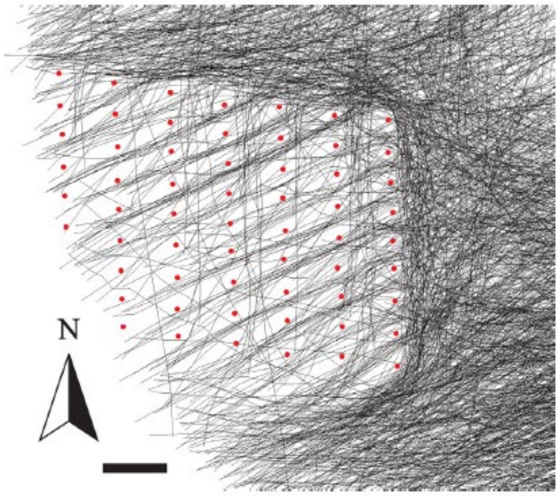

Figure 8 Displacement effect on birds of an offshore wind farm that shows the radar derived flight lines of migrating waterbirds (black lines) in a wind farm (red dots indicate the position of turbines). Reproduced from Desholm and Kahlert (2005).

Depending on existing infrastructure near to a proposed offshore wind farm, it is possible to locate radar installations to examine the use of a specific areas by birds, and how this changes over time and with the scale of construction. Observations of avoidance behaviour, using a combination of radar and cameras, with consistent survey methods, can provide data to examine species specific changes at a site before and after construction as well as comparisons with unimpacted control sites (Skov et al. 2012).

Weather radars have been used to track the departure of migratory shorebirds and the migration routes of landbirds (for example, Lane and Jessop 1985, Tulp et al. 1994, Walsh et al. 2017, Weisshaupt et al. 2018, Sivakumar et al. 2021). The existing network of these stations around Australia provides a potential resource for tracking birds around Australia's coastline, including across Bass and Torres Straits.

5.4. Avoidance and mitigation of the impacts on birds of offshore wind farms

By far the most significant measure to avoid or mitigate any negative impacts on birds and wildlife is the appropriate siting of wind farms and associated infrastructure. It seems obvious that the greater the separation of the wind farm from areas of high numbers or importance for birds, the lower likelihood of impacts. For that reason, the availability of large-scale bird distribution data in areas of potential wind farm development is very valuable.

Wildlife sensitivity maps use a sensitivity or risk score for each species, with the distribution of each species represented by whether it occurs in a grid cell and the risk scores then summed across all species that occur in each grid cell (Allinson et al 2020). This composite risk layer can then be overlayed on other geographical information, such as proposed wind farm locations, buffer zones and existing infrastructure to highlight areas of sensitivity to wind farm development (see Figure 9).

Wildlife sensitivity maps are usually developed at a landscape scale and can be used to inform strategic planning decisions during the initial site selection phase (Allinson et al. 2020). Where there are gaps in the underlying data these can be addressed using modelling approaches that predict the values of empty regions based on the available data (see for example Vasilakis et al. 2017). Sensitivity maps represent a natural progression from the very large-scale regional approach taken with the ecological risk assessments to map much finer scale processes and risks. However, the data requirements, especially on the spatial distribution of species of interest, are considerably greater than the regional ecological risk assessments presented in this report.

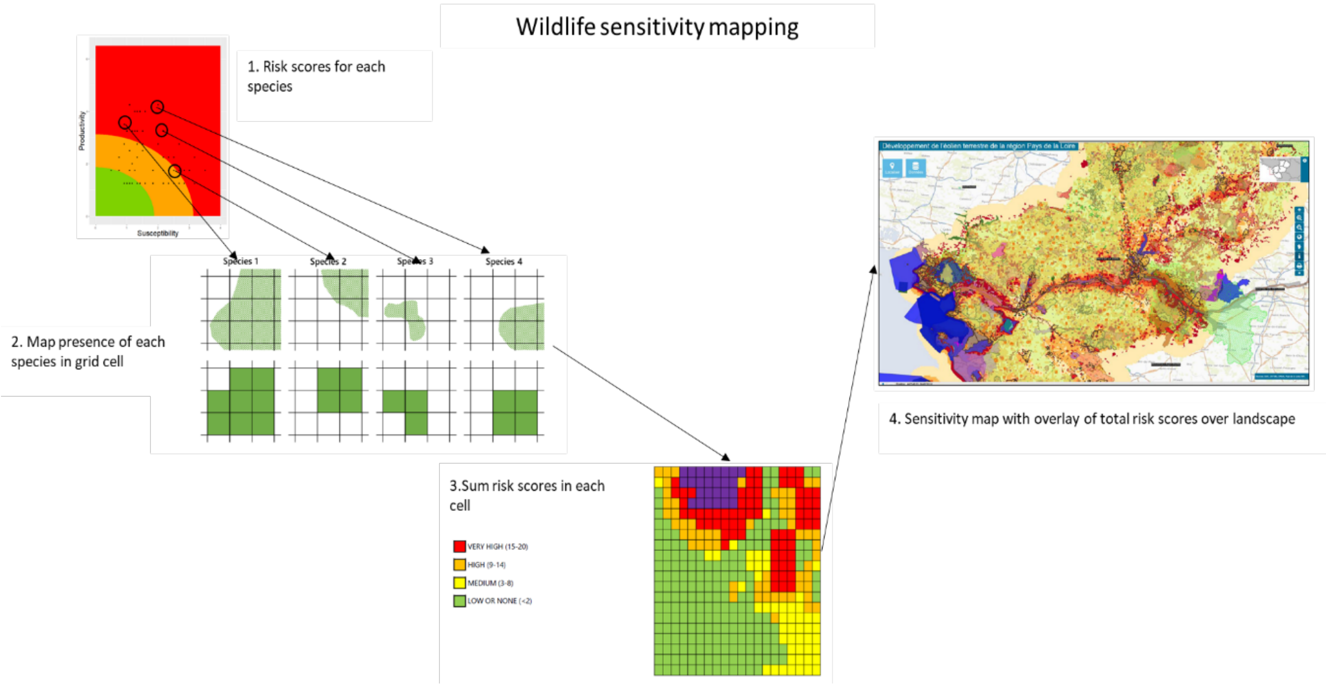

Figure 9. General approach to wildlife sensitivity

Box 3. A coordinated approach to mapping bird distribution at sea

The European Seabirds at Sea Partnership (ESAS) is a collaboration between researchers from north-west Europe conducting boat-based seabird surveys using standardised protocols and data storage. Outputs from this Partnership have been used to establish protected areas, to map sensitivity to pollution and in marine spatial planning across Europe (see for example Stone et al. 2005, Bradbury et al. 2014).

There is no comparable coordination of seabird data in Australia, although there are quantitative records of seabirds from within the Australian EEZ collected over the last 70 years (Australasian Seabird Group, unpublished.) as well as 'citizen science' data (for example Gorta et al. 2019) that could contribute to a coordinated approach to improve baseline mapping of the offshore distribution of birds. There are also tracking studies that have been undertaken of seabirds within the Australian EEZ (for example, Berlincourt and Arnould 2014, Carey et al. 2014, Priddel et al. 2014, Rodríguez-Malagón et al. 2020), migrations of shorebirds (for example., Choi et al. 2016, Chan et al. 2019, Melville et al. 2020), waterfowl (McEvoy et al. 2019, Zhao et al. 2020) and Australian woodland birds (for example, Hatton et al. 2015, Yeap et al. 2015, Brawata et al. 2019). There would be considerable benefit in developing a collaborative, coordinated approach, similar to ESAS, in Australia to add value to existing and future research on seabird distributions.

Once a location has been identified that avoids the overlap of areas of high-risk to birds and the offshore wind farm then additional technical measures to mitigate impacts should be considered. These include:

5.4.1. Infrastructure design: number of turbines and technical specifications (including lighting)

Using baseline field-survey data or operational monitoring data with predictive modelling (such as collision-risk models) makes it possible to explore the influence of turbine design and the number of turbines, to arrive at an optimal design of low ecological risk. For example, modelling by Johnston et al. (2014) demonstrated that raising hub height and using fewer, larger turbines are effective measures for reducing bird collision risk. This approach increases the distance between the lowest point of the turbine and the sea surface. This may be particularly relevant in an area used by many seabirds (such as petrels, shearwaters, and albatrosses) that use a flight technique known as dynamic soaring that utilises the wind shear stress near to the sea surface, meaning they are predominantly at heights less than 30 m above the surface.

5.4.2. Scheduling and curtailment

Scheduling, which involves avoiding, reducing, or phasing activities during ecologically sensitive times of the year may be of most use during construction, repowering and decommissioning, rather than during operation. An example of mitigation through scheduling could include construction activities being either suspended or reduced during migration and/or nesting periods.

The timing of turbine operation can be effective in avoiding or reducing the risk of bird collision at offshore wind farms. Curtailment requires temporary shutdown of turbines and is one of the measures that can help reduce the risk of bird collision (Brabant et al. 2021). Large numbers of migratory shorebirds are known to fly to Australia from northern hemisphere breeding grounds in the spring and depart in the autumn, providing temporal windows of elevated potential collision risk (Howell et al. 2020). There are also regular spring and autumn movement between the Australian mainland and Tasmania that involve species of high conservation status such as Orange-bellied and Swift Parrots (Menkhorst et al. 2021; Webb et al. 2021). There are also waterfowl and waterbirds that migrate/disperse across Bass Strait to Tasmania during periods of mainland drought (Kramer 2021). While not as predictable as movements of obligatory migrants, understanding the conditions that lead to these movements as well as evidence from regular surveys could be used as triggers for curtailment measures.

The German Ministry of Environment (cited in European Commission 2020) defined curtailment as:

- temporarily shutting down turbines during known migration times to reduce collision risk (especially in bad weather and visibility conditions); and
- rotating the rotor plane out of the direction of migration.

The Ministry also specified that implementation of these measures requires:

- good prediction models for migration routes and timing; and
- surveys of migration intensity in the immediate surroundings of wind farms.

Automated curtailment systems have been developed for use in terrestrial wind farms and have been successful in detecting eagles approaching turbines. Mclure et al. (2021) describe the use of

IdentiFlight®, a camera system integrated with an artificial intelligence system, that detect objects, estimates the line-of-sight distance to the object and takes 10 photographs per second to track movement. The probability that the object will enter the rotor-swept zone is then used to trigger a curtailment.

5.4.3. Acoustic and visual deterrents

Oil rigs, lighthouses and ships at sea have long been known to kill birds as a result of collisions with infrastructure, particularly during periods of poor weather (for example, Wiese et al. 2001, Black 2005, Drewitt and Langston 2008, Rodriguez et al. 2014). Typically, the birds are disoriented by artificial lights that are diffused in fog, mist and spray, then collide when they try to land on the infrastructure. While there are important safety requirements for these structures to be lit for navigational and staff safety purposes, reducing the light spill from required illumination, changing to low intensity LED bulbs and the use of red/orange lights, rather than white light, should be encouraged especially during periods of poor weather (Commonwealth of Australia 2019).

Deterrents typically involve the installation of devices that emit audible or visual stimuli constantly, intermittently, or when triggered by a bird-detection system. Passive deterrents such as painting turbine towers and blades can also change the detectability of infrastructure. The effectiveness of particular deterrent techniques is inevitably site and species-specific, however, evidence of 70% reductions in fatality rates associated with turbines with one blade painted black, compared to unpainted turbines, have been reported in onshore wind farms (May et al 2020). Trials are underway of this approach in offshore settings.

5.4.4. Construction noise

Construction and support vessel operations will generate substantial noise profiles both above and below the water surface. This sub-surface noise has the potential to adversely affect seabirds foraging underwater, such as penguins, cormorants, shearwaters, diving petrels (Favaro and Pichegru 2018, Hansen et al. 2020, Pichegru et al. 2017).

While the potential impacts to marine mammals from underwater has been recognised for many years, and national and international guidelines have been produced to minimise the impacts of underwater noise, the potential impact to diving birds, including penguins, has only recently been recognised, and applicable guidelines should be developed for diving birds in Australia. (for example, EPBC Act Policy Statement 2.1 - Interaction between offshore seismic exploration and whales: Industry guidelines, Marine Seismic Surveys and the Environment, and CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities).

6. Conclusion and future work

The approach taken in this update was to include all bird species considered likely to occur in coastal and offshore marine habitats that could potentially be impacted by the development of offshore wind farms. Including such a large number of species necessitated a consistent approach to using the available data, which inevitably requires a number of assumptions and generalisations. However, by extending the species included beyond what might typically be considered ‘marine birds’, this has highlighted the importance of terrestrial species such as Swift parrots and Orange-bellied parrots in the Bass Strait region. The overall aim of the risk assessment is to highlight species likely to be at high risk of impacts from offshore wind farms to ensure that those species are considered in proposals for and assessment of offshore wind farm projects. Ideally, this process should provide a trigger for research to gather more species-specific detail to refine the risk scores for these high-risk species.

Australia's offshore wind energy industry is in its infancy and has a valuable opportunity to learn from the experience of processes and technologies that have been used to mitigate the impacts of wind farms on seabirds in Europe. While there are few bird species in common between the northern and southern hemispheres, the biological characteristics identified as informing guidelines to minimise risks to birds are transferable to Australia (e.g., flight characteristics, productivity and habitat specialisation). However, the migratory behaviour of Australian passerines shows considerable differences to those of their northern hemisphere counterparts, with many species being non-obligatory migrants, i.e., a variable proportion of the population undertakes migration annually, or they are nomadic, i.e., they undertake movements in response to prevailing conditions rather than following a repeated route from breeding and wintering areas. An important aspect of these differences is in the use of the migratory behaviour of northern hemisphere passerines, especially the height at which birds fly when passing over areas of ocean, as an analogue for Australian birds.

Our risk-based approach showed that in the coastal sub-region's migratory shorebirds, such as Bar-tailed Godwit and Eastern Curlew, feature heavily in the list of high-risk species. As these species tend to have well-defined distributions and migration pathways (e.g., Galtbalt et al. 2021) this information should be used in developing detailed sensitivity maps to guide decisions on wind farm siting (Bradbury et al. 2014).

Similarly, in the Bass Strait region the critically endangered Orange-bellied and Swift Parrots are both high-risk species and undertaking tracking studies to better define the migration routes used by both species when crossing Bass Strait would form an important element of sensitivity mapping and wind farm siting in that region.

Since 2022 offshore development zones (declared areas) have been declared in Bass Strait (Gippsland and Northern Tasmania), NSW, SA, and WA. Different bird taxa occur in those regions, highlighting the benefit of taking a regional approach to risk assessment.

It should also be recognised that the division between coastal and offshore zones as a function of the distance from the coast is probably more suitable for terrestrial species that do not feed in marine habitats. However, for many marine bird species it is water depth and/or the distance to areas of greater depth that dictate the distribution of many species. However, species occurrence patterns arising from project-scale monitoring should help to elucidate these finer-scale patterns.

Table 11. Review of the relative level of confidence in the attributes used in the ecological risk assessments and recommendations for prioritising future research to address knowledge gaps

Attribute	Source	Confidence	Recommendation for research
Generation Time	Bird et al. (2020)	High: Peer-reviewed publication	
Conservation Status	Garnet and Baker (2021)	High: Peer-reviewed publication	
Flight Profile	Trait-based - Expert elicitation	Medium	Collect empirical flight height data for species • with high overall risk scores • with high susceptibility scores • migrant passerines especially for nocturnal movements
Flight Morphology	Tobias et al. (2022)	High: Peer-reviewed publication	
Flight Time	Trait-based- Expert elicitation	Medium	Collect empirical time budget data for • with high overall risk scores • with high susceptibility scores. • migrant passerines especially for nocturnal movements
Habitat Specialisation	Garnet et al. (2015)	High/Medium: Peer-reviewed publication	Refine habitat specialisation scoring using a measure of the spatial extent of available habitats

In reviewing the data available to parameterise this ecological risk assessments (Table 11) it is apparent that the key knowledge gap when evaluating the impact of offshore wind farms on birds is flight behaviour, particularly species-specific flight height distributions, nocturnal and migratory flight behaviours, and avoidance behaviour (and both macro and micros scales). Improved parameterisation of all of these attributes can be used to improve ecological risk assessments as well as providing key inputs into the assessment of collision risk. Many of these 'gaps' are frequently viewed in the context of assessing the risks from individual wind farm projects, but that they would also provide important opportunities to improve parameterisation of ecological risk assessments. Knowledge of population size for key species also restricts the use of models to assess the population level impacts of wind farms on high risk and other species and improving knowledge in this area should be a priority.

While collection of new data remains important, it needs to be recognised that an enormous body of data collected by proponents and ecological consultants is not currently accessible for analysis due to Non-Disclosure Agreements/commercial in confidence reasons. Ensuring release and open access to these datasets should be a priority of the regulator and industry alike, noting that collection of these data is often government funded or required by government to regulate industry development.

The offshore wind energy industry in Australia has a unique opportunity to learn from the experience of processes and technologies that have been used to evaluate risk and mitigate the impacts of wind farms on seabirds in Europe. Despite differences in the taxa involved, the same approaches to identifying high-risk taxa, and to the monitoring and mitigation of negative impacts, should be applied in a coordinated, regional-scale approach to the development of offshore wind farms in Australia's EEZ.

Appendix 1: Linking the taxonomy of the Working List of Australian Birds to the EPBC status from the SPRAT database

This describes the workflow to link records from the WLAB 4.3 to data from the SPRAT database using the scientific name as the linking field.

Data Preparation

SPRAT data - download 1 April 2025

The specification of the SPRAT output is to include all fields for Species names and Taxon Group for species and subspecies along with EPBC Threat Status, Migratory and Marine listings and the State Threat listed and IUCN Red List status.

This data was downloaded from SPRAT was filtered for those records where Taxon Group is 'birds'; providing 661 records.

Records where the only non-empty field was for the IUCN Red List status of Least Concern were removed.

Records where the EPBC status is extinct, or the only non-empty field is a State/Territory status of extinct (this is only present in the NSW BC Act and FM Act field) were deleted.

There are some species that are not true duplicates (i.e. where the species is the same, but the attributes are different) and these have been updated as follows:

- Herald Petrel is duplicated in the SPRAT as *Pterodroma heraldica* and '*Pterodroma arminjoniana s. lat.* (Herald Petrel (includes P*. arminjoniana* and P*. heraldica*))'. The latter is only included because it is listed as Marine. The record for *Pterodroma heraldica* was not listed as Marine.

Action: *Pterodroma heraldica* listed as Marine and '*Pterodroma arminjoniana* s*. lat.* (Herald Petrel (includes P*. arminjoniana* and P*. heraldica*))' deleted.

- Tasmanian Masked Owl (*Tyto novaehollandiae castanops*) is duplicated as '*Tyto novaehollandiae castanops* (Tasmanian population)' which is listed under EPBC Threat as Vulnerable, whereas *Tyto novaehollandiae castanops* is listed as Endangered in Tasmania.

Action: *Tyto novaehollandiae castanops* includes both the EPBC and State listings status and "*Tyto novaehollandiae castanops* (Tasmanian population)" is deleted.

- Elegant Parrot (*Neophema elegans*) (Vulnerable in Victoria) is duplicated as 'Eastern Elegant Parrot (*Neophema elegans elegans*)' (Rare in SA NPW Act). The latter is no longer recognised as a valid subspecies.

Action: *Neophema elegans* includes both the State and EPBC listings and ‘Eastern Elegant Parrot *Neophema elegans elegans’* is deleted.

- Rock Parrot (*Neophema petrophila*) (EPBC Marine) is duplicated as ‘*Neophema petrophila zietzi’* (Rare in SA NPW Act). The latter is no longer recognised as a valid subspecies.

Action: *Neophema petrophila* includes both the State and EPBC listings and ‘*Neophema petrophila zietzi*’ is deleted.

- Arctic Tern (*Sterna paradisaea*) (which is listed as Marine) is duplicated as ‘*Sterna paradisaea* (Atlantic populations)’ this is listed a as Migratory.

Action: Arctic Tern (*Sterna paradisaea*) is listed as Migratory and Marine and ‘*Sterna paradisaea* (Atlantic populations)’ is deleted.

- Royal Penguin is not recognised as a species in EPBC and is implicitly included as *Eudyptes chrysolophus.*

Action: The EPBC record for ‘*Eudyptes chrysolophus* sensu lato' becomes *'Eudyptes schlegeli'*, Royal Penguin and *'Eudyptes chrysolophus* (sensu stricto)' becomes *'Eudyptes chrysolophus'*, Macaroni Penguin.

- Ruff is duplicated as *Philomachus pugnax* (EPBC Migratory and Marine) and *Calidris pugnax* (Rare SA NPW Act). The WLAB only includes *Calidris pugnax*.

Action: *Calidris pugnax* includes both the EPBC and State listings (i.e it is listed as Migratory, Marine under EPBC and Rare under the SA NPW Act. *Philomachus pugnax* is deleted.

- Buff-breasted Sandpiper is duplicated because it has a different scientific name in the EPBC listing (*Tryngites subruficollis*, where it is listed as Marine) and the IUCN Redlist (*Calidris subruficollis*). The WLAB only includes *Calidris subruficollis*.

Action *Calidris subruficollis* is listed as Marine and *Tryngites subruficollis* is deleted.

- Broad-billed Sandpiper is duplicated because it has a different scientific name in the EPBC listing (*Limicola falcinellus*, where it is listed as Migratory and Marine under EPBC and Vulnerable under NSW BC Act and FM Act) and the IUCN Redlist (*Calidris falcinellus*). The WLAB only includes *Calidris falcinellus*.

Action *Calidris falcinellus* includes both the EPBC and State listings and *Limicola falcinellusis* is deleted.

- The Little Egret is duplicated as *Egretta garzetta nigripes* in the SA NPW Act and Victoria. FFG Act (Advisory Lists) but as *Egretta garzetta* for EPBC listing. The subspecies *Egretta garzetta nigripes* is no longer recognised as a valid subspecies in WLAB.

Action *Egretta garzetta* includes both the State and EPBC listings and ‘*Egretta garzetta nigripes’* is deleted.

This removal of duplicates gives a final list of 625 records from the original SPRAT output.

Preparation of the WLAB 4.3 data.

WLAB 4.3 was downloaded as a csv file from https://birdata.birdlife.org.au/whats-in-a-name. on 1 April 2025.

Each record has a Population field that reflects its status in Australia. All records where the Population status is not 'Australian', 'Endemic', 'Endemic (breeding only)', 'Non-breeding', 'Vagrant' or 'Vagrant?' were removed. This gets rid of Domestic, Introduced, Extinct, No confirmed record etc.

This reduces the original 2106 records to 1927 records

Data linking

Step 1

Link the SPRAT and WLAB data using a left join with the Scientific Name as the linking field results in 62 records in the 625 rows of data not linking.

Step 2

The majority of these non-linked records have differences in the scientific name that are the result of changes/updates to taxonomy. The nomenclature of the non-linked EPBC records has been reviewed and the corresponding name used in WLAB 4.3 (to allow the linking of records) is provided in Appendix 1.

Implementing the changes in Table 12 leaves 12 records in the SPRAT output that do not link to the WLAB. These are identified in the comments field of Appendix 1. In most cases there are no confirmed records of the species in Australia, however, there are two subspecies that are listed under EPBC but not recognised as subspecies in WLAB:

- Fairy Prion (southern), (*Pachyptila turtur subantarctica*), Vulnerable
- Western Beautiful Firetail, Beautiful Firetail (Mt Lofty Range and Kangaroo Island), (*Stagonopleura bella samueli*), Endangered

Step 3

Following the logic s528 of the EPBC Act, in which a "species" is defined as including subspecies, all subspecies have inherited the status of the species for EPBC Threat Status, Migratory, Marine and all State Threat listings unless the subspecies has a listing in its own right.

For example, in the case of Bar-tailed and Black-tailed Godwits:

Bar-tailed Godwit is listed as Migratory and Marine at the species level and two of the subspecies have an EPBC Threat status of Endangered.

Black-tailed Godwit is listed as Endangered and also Migratory and Marine (but the subspecies *Limosa limosa melanuroides* does not have any listing (Table 13).

In the updated listing all subspecies of Bar-tailed godwit inherit the Migratory and Marine status from the species level listing but retain the subspecies level EPBC Threat Status (there is a third subspecies in the WLAB that inherits the Migratory and Marine status but does not have an EPBC Threat Status). For Black-tailed Godwit the subspecies inherits the EPBC Threat Status as well as the Migratory and Marine status from the species level (Table 14).

The taxonomy of the Shy Heathwren is complex. The nominate species *Hylacola cauta* has been renamed *Calamanthus cautus* in WLAB, with consequential renaming of subspecies. *Hylacola cauta* is listed as Vulnerable under the NSW BC Act and FM Act, however, based on subspecies distributions it seems likely that this is Riverina Shy Heathwren (*Calamanthus cautus macrorhynchus*). However, the process by which subspecies inherit the listing status of the species means that all subspecies of *Calamanthus cautus* are included as Vulnerable under the NSW BC Act and FM Act.

Table 12 Changes to the EPBC listed name to allow linking to the WLAB 4.3 scientific name. Where the scientific name change filed is empty there is a corresponding explanatory comment

EPBC Scientific Name	EPBC Common Name	EPBC Threat Status	Scientific Name changed to link to WLAB	Comments
Ptiloris victoriae	Victoria's Riflebird		*Lophorina paradisea*	
Motacilla flava	Yellow Wagtail		*Motacilla tschutschensis*	
Pitta erythrogaster	Red-bellied Pitta		*Erythropitta macklotii digglesi*	
Cuculus saturatus	Oriental Cuckoo, Himalayan Cuckoo			Not in WLAB
Ptilinopus magnificus	Wompoo Fruit-Dove		*Megaloprepia magnifica*	
Stercorarius maccormicki	South Polar Skua		*Catharacta maccormicki*	
Calidris mauri	Western Sandpiper			No confirmed records
Himantopus himantopus	Pied Stilt, Black-winged Stilt		*Himantopus leucocephalus*	
Tadorna radjah	Radjah Shelduck		*Radjah radjah*	
Puffinus lherminieri	Audubon's Shearwater			Not in WLAB
Apus affinis	House Swift		*Apus nipalensis*	
Falcunculus frontatus whitei	Crested Shrike-tit (northern), Northern Shrike-tit	Vulnerable	*Falcunculus whitei*	
Eclectus roratus macgillivrayi	Macgillivray's Eclectus Parrot, Eclectus Parrot (Cape York Peninsula)		*Eclectus polychloros macgillivrayi*	
Phoenicopterus ruber	American Flamingo, Caribbean Flamingo		*Phoenicopterus roseus*	
Hylacola cauta	Shy Heathwren		*Calamanthus cautus*	
Melithreptus gularis laetior	Golden-backed Honeyeater		*Melithreptus laetior*	
Lonchura oryzivora	Java Sparrow			Introduced
Hylacola pyrrhopygia	Chestnut-rumped Heathwren		*Calamanthus pyrrhopygius*	
Phalaropus fulicaria	Grey Phalarope		*Phalaropus fulicarius*	
Lugensa brevirostris	Kerguelen Petrel		*Aphrodroma brevirostris*	
Ducula bicolor	Pied Imperial-Pigeon			No confirmed records
Cyclopsitta diophthalma coxeni	Coxen's Fig-Parrot	Critically Endangered	*Cyclopsitta coxeni*	
Pachyptila turtur subantarctica	Fairy Prion (southern)	Vulnerable		Not in WLAB

EPBC Scientific Name	EPBC Common Name	EPBC Threat Status	Scientific Name changed to link to WLAB	Comments
Cyanoramphus cookii	Norfolk Island Green Parrot, Tasman Parakeet, Norfolk Island Parakeet	Endangered	*Cyanoramphus novaezelandiae cookii*	
Hylacola pyrrhopygia parkeri	Chestnut-rumped Heathwren (Mt Lofty Ranges)	Endangered	*Calamanthus pyrrhopygius parkeri*	
Hylacola pyrrhopygia pedleri	Flinders Chestnut-rumped Heathwren		*Calamanthus pyrrhopygius pedleri*	
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern)		*Melithreptus gularis*	
Stagonopleura bella samueli	Western Beautiful Firetail, Beautiful Firetail (Mt Lofty Range and Kangaroo Island)	Endangered		Not in WLAB
Psophodes leucogaster lashmari	Kangaroo Island Whipbird	Endangered	*Psophodes nigrogularis lashmari*	
Psophodes leucogaster leucogaster	Mallee Whipbird	Endangered	*Psophodes nigrogularis leucogaster*	
Chroicocephalus novaehollandiae	Silver Gull		*Larus novaehollandiae*	
Hylacola cauta halmaturina	Shy Heathwren (Kangaroo Island)	Vulnerable	*Calamanthus cautus halmaturinus*	
Accipiter hiogaster natalis	Christmas Island Goshawk	Endangered	*Accipiter fasciatus natalis*	
Lophochroa leadbeateri	Major Mitchell's Cockatoo, Pink Cockatoo		*Cacatua leadbeateri*	
Lophochroa leadbeateri leadbeateri	Major Mitchell's Cockatoo (eastern), Eastern Major Mitchell's Cockatoo, Pink Cockatoo (eastern)	Endangered	*Cacatua leadbeateri leadbeateri*	
Pezoporus flaviventris	Western Ground Parrot, Kyloring	Critically Endangered	*Pezoporus wallicus flaviventris*	
Stercorarius antarcticus	Brown Skua		*Catharacta antarctica*	
Stercorarius antarcticus lonnbergi	Brown Skua (Lonnberg's), Southern Great Skua		*Catharacta antarctica lonnbergi*	
Leucophaeus atricilla	Laughing Gull		*Larus atricilla*	
Leucophaeus pipixcan	Franklin's Gull		*Larus pipixcan*	
Chroicocephalus ridibundus	Black-headed Gull		*Larus ridibundus*	
Ptilonorhynchus guttatus guttatus			*Chlamydera guttata guttata*	
Amblyornis newtonianus	Golden Bowerbird		*Prionodura newtoniana*	
Procellaria conspicillata	Spectacled Petrel			Not in WLAB
Sterna hirundo hirundo (Western Palearctic populations)	Atlantic Common Tern, Common Tern (Western Palearctic populations)		*Sterna hirundo hirundo*	
Antigone antigone	Sarus Crane		*Grus antigone*	
Amytornis rowleyi	Opalton Grasswren, Rusty Grasswren		*Amytornis striatus rowleyi*	
Falcunculus frontatus frontatus	Eastern Crested Shrike-tit		*Falcunculus frontatus*	

EPBC Scientific Name	EPBC Common Name	EPBC Threat Status	Scientific Name changed to link to WLAB	Comments
Parvipsitta porphyrocephala	Purple-crowned Lorikeet		*Glossopsitta porphyrocephala*	
Parvipsitta pusilla	Little Lorikeet		*Glossopsitta pusilla*	
Sterna virgata	Kerguelen Tern			No confirmed records
Hylacola pyrrhopygia pyrrhopygia	Eastern Chestnut-rumped Heathwren		*Calamanthus pyrrhopygius pyrrhopygius*	
Pseudobulweria becki	Beck's Petrel			No confirmed records
Anas eatoni	Eaton's Pintail, Southern Pintail, Kerguelen Pintail.			Not in WLAB
Ardea intermedia plumifera	Plumed Egret, Intermediate Egret (Plumed)		*Ardea plumifera*	
Larus dominicanus dominicanus	Pacific Kelp Gull		*Larus dominicanus antipodus*	
Northiella narethae	Naretha Bluebonnet, Naretha Parrot		*Northiella haematogaster narethae*	
Gelochelidon nilotica macrotarsa	Australian Gull-billed Tern		*Gelochelidon macrotarsa*	
Anous albivitta	Grey Noddy, Grey Ternlet		*Anous albivittus*	
Antigone rubicunda	Brolga		*Grus rubicunda*	
Calidris minutilla	Least Sandpiper			Not in WLAB

Table 13 SPRAT output for “Godwits”

Taxon Name	Scientific Name	EPBC Threat	Migratory	Marine
Bar-tailed Godwit	*Limosa lapponica*		Listed	Listed
Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit	*Limosa lapponica baueri*	Endangered		
Northern Siberian Bar-tailed Godwit, Russkoye Bar-tailed Godwit	*Limosa lapponica menzbieri*	Endangered		
Black-tailed Godwit	*Limosa limosa*	Endangered	Listed	Listed –overfly marine area
Black-tailed Godwit (Siberian), Black-tailed Godwit (eastern Siberia)	*Limosa limosa melanuroides*			

Table 14 Inherited SPRAT status for “Godwits

Taxon Name	Scientific Name	EPBC Threat	Migratory	Marine
Bar-tailed Godwit	*Limosa lapponica*		Listed	Listed
Alaskan Bar-tailed Godwit	*Limosa lapponica baueri*	Endangered	Listed	Listed
Yakutian Bar-tailed Godwit	*Limosa lapponica menzbieri*	Endangered	Listed	Listed
Anadyr Bar-tailed Godwit	*Limosa lapponica anadyrensis*		Listed	Listed
Black-tailed Godwit	*Limosa limosa*	Endangered	Listed	Listed –overfly marine area
Eastern Black-tailed Godwit	*Limosa limosa melanuroides*	Endangered	Listed	Listed –overfly marine area

Appendix 2: Ecological Risk Assessment table for birds by Subregion

This is provided as an Excel spreadsheet to maximise search and filter functionality.

Appendix 3: Ecological Risk Assessment table for birds

This is provided as an Excel spreadsheet to maximise search and filter functionality.

Glossary

Term	Definition
APAB	Action Plan for Australian Birds
Barrier effects	Where a physical barrier impedes or blocks movement or interaction
EPBC	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
FFG Act (Advisory Lists)	*Flora and Fauna Guarantee Act 1988* (Vic)
FM	Flight memorability
FM Act	*Fisheries Management Act 1994* (NSW)
HA	Habitat types
NC Act	*Nature Conservation Act 2014* (ACT)
NC Regulations	*Nature Conservation (Animals) Regulation 2020* (Qld)
NPW Act	*National Parks and Wildlife Act 1972* (SA)
NSW BC Act	*Biodiversity Conservation Act 2016* (NSW)
P	Productivity
R	Risk
S	Susceptibility
TPWC Act	*Territory Parks and Wildlife Conservation Act 1976* (NT)
TSP Act	*Threatened Species Protection Act 1995* (Tas)
WA BC Act	*Biodiversity Conservation Act 2016* (WA)

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