‘Ecological Risk Assessment’ of the four options for managing potential acidification of the Lower Lakes, including introduction of seawater to Lake Alexandrina’ – Birds

Daniel J Rogers
Paul Wainwright

Department for Environment and Heritage, South Australian Government

1 Relevant Bird Species

The list of bird species provided under ‘Ecological Components’ to be considered for this Risk Assessment lists all known species that are considered Matters of National Environmental Significance (NES). However, some of the species listed under ‘Ecological Components’ are either unlikely to interact (directly or indirectly) with the CLLMM waterbodies (or hydrologically associated systems), or are so rarely encountered in the CLLMM region that they can be considered vagrant. With regard to the former, species were generally excluded where they are exclusively associated with either terrestrial or pelagic habitats.

Table 1 provides a list of those species excluded from the subsequent risk assessment, providing reasons for the exclusion of each species.

Table 1. List of bird species excluded from 'Ecological Components' to be considered for Risk Assessment, as they are highly unlikely to interact with considered management options.

Common Name	Species	Reason
Glossy Black-Cockatoo	*Calyptorhynchus lathami halmaturinus*	Terrestrial
Spotted Quail-thrush	*Cinclosoma punctatum anachoreta*	Terrestrial
Gibson's Albatross	*Diomedea exulans gibsoni*	Pelagic
Chestnut-rumped Heathwren	*Hylacola pyrrhopygia parkeri*	Terrestrial
Southern Giant-Petrel	*Macronectes giganteus*	Pelagic
Northern Giant-Petrel	*Macronectes halli*	Pelagic
Buller's Albatross	*Thalassarche bulleri*	Pelagic
Shy Albatross	*Thalassarche cauta cauta*	Pelagic
Salvin's Albatross	*Thalassarche cauta salvini*	Pelagic
Campbell Albatross	*Thalassarche melanophris impavida*	Pelagic
Rainbow Bee-eater	*Merops ornatus*	Terrestrial
Malleefowl	*Leipoa ocellata*	Terrestrial
Southern Royal Albatross	*Diomedea epomophora epomophora*	Pelagic
Northern Royal Albatross	*Diomedea epomophora sanfordi*	Pelagic
Wandering Albatross	*Diomedea exulans (sensu lato)*	Pelagic
Amsterdam Albatross	*Diomedea exulans amsterdamensis*	Pelagic
Blue Petrel	*Halobaena caerulea*	Pelagic
Swift Parrot	*Lathamus discolor*	Terrestrial
Western Whipbird	*Psophodes nigrogularis leucogaster*	Terrestrial
Soft-plumaged Petrel	*Pterodroma mollis*	Pelagic
Black-browed Albatross	*Thalassarche melanophris*	Pelagic
Tristan Albatross	*Diomedea exulans exulans*	Pelagic
Yellow-nosed Albatross	*Thalassarche chlororhynchos*	Pelagic
Grey-headed Albatross	*Thalassarche chrysostoma*	Pelagic
Black-browed Albatross	*Thalassarche melanophris*	Pelagic
Black-eared Miner	*Manorina melanotis*	Terrestrial
Red-lored Whistler	*Pachycephala rufogularis*	Terrestrial
Regent Parrot (eastern)	*Polytelis anthopeplus monarchoides*	Terrestrial
Mallee Emu-wren	*Stipiturus mallee*	Terrestrial

A number of additional species were excluded as they were considered rare or vagrant in the region.

Common Name	Species
Greater Sand Plover	*Charadrius leschenaultii*
Grey-tailed Tattler	*Tringa brevipes*
Lesser Sand Plover	*Charadrius mongolus*
Oriental Plover	*Charadrius veredus*

In addition, a number of species were not included in the list of 'Ecological Components' provided, presumably because they do not meet the criteria for Matters of NES. We have included these species in the subsequent Risk Assessment, as we consider their omission an oversight, or they are species that are on the priority assessment list for the current EPBC assessment period. While these species may not be directly relevant to the requirements of this EIS, we suggest that including them will improve the outcomes of the overall assessment of risks to birds. In particular, the omission of the two tern species listed, but the inclusion of Little Tern *Sterna albifrons*, appears inconsistent.

Table 2 provides a list of these species, with a reason for why we considered that they should be included in this assessment.

Table 2. List of additional species (not included in the list of 'Ecological Components' provided) that are have been considered in subsequent Risk Assessments.

Common Name	Species	Reason
Fairy Tern	*Sternula nereis nereis*	possibly migratory; EPBC priority assessment
Whiskered Tern	*Chlidonias hybrida*	probably migratory within Australia
Australasian Bittern	*Botaurus poiciloptilus*	EPBC priority assessment

2 Bird Response Groups

Rather than presenting a risk assessment for each of the bird species to be included, we will present risk assessments in three parts. First, the direct impacts for those 'stressors' for which only general information are available will be dealt with in a general nature across all of the bird species listed. These general stressors are pH and metal concentrations, and salinity. A second assessment will be undertaken on selected bird groups that are likely to respond differently to water level regime, one stressor that was not listed among those provided, as water level regime will affect different bird groups in different ways. Finally, given that the primary impacts of environmental change in the CLLMM region on waterbirds will be indirect (see 3. below), we have attempted to describe in a general way how these indirect impacts are likely to manifest in different bird groups, through a general description of the relevant biotic interactions for these bird groups.

Terrestrial species: These are species that are associated with terrestrial habitats, but have been included as these habitats are likely to interact with the surface hydrology of the CLLMM region. Physicochemical changes to the aquatic environment may impact on these species through changes in the distribution of terrestrial habitat species and terrestrial food resources.

Species associated with fringing aquatic vegetation: These are species that depend on fringing and emergent aquatic vegetation to provide suitable habitat. The species in this group use a range of fringing vegetation types, but are typically associated with reed-beds. They also often require some direct interaction between these habitats and the waterbody. thus the presence of reed-beds (for example) is not necessarily a good indicator of habitat quality. Species in this group may be impacted indirectly by physicochemical changes to the aquatic environment, through changes in the distribution of important plant habitat species, changes in the distribution and abundance of aquatic prey species, and changes in the relative distribution of biotic (plant) habitats and aquatic habitats.

Generalist shorebirds associated with mudflats: These species are associated with mudflats and shorelines, across a relatively wide range of aquatic conditions (e.g. salinity). Their generalist nature relates to the fact that they are able to forage on a range of food sources. The species in this group are generally associated with fine-sediment mudflats (with some exceptions, e.g. Sanderling and Ruddy Turnstone), and are typically very sensitive to water level regime. Species in this group may be impacted indirectly by physicochemical changes to the aquatic environment, through changes in the distribution and abundance of prey species, and changes in the distribution of water level regimes. The response of these species can be compared with those shorebirds associated with estuarine-fresh aquatic environments (see below).

Shorebirds associated with mudflats in estuarine-fresh areas: As with the previous group, these species are associated with fine-sediment mudflats, but tend to be restricted within the region to areas whose salinity is typically at or below sea water. This restriction appears to be driven by the response of their preferred prey items to salinity, as these bird species tend to have more specialised preferences than the group above. The prey specialisation varies among these species, and includes bivalve and gastropod molluscs, larger polychaete species, and crabs. Species in this group may be impacted indirectly by physicochemical changes to the aquatic environment, through changes in the distribution and abundance of prey species, and changes in the distribution of water level regimes. However, in comparison with the generalist group above, these species are less likely to be able to prey-switch following changes in the distribution of preferred prey species, and may be more sensitive to change, particularly in the Murray estuary.

Fish-eating species: This group is comprised of species for which fish form a significant part of their diet. The species in this group vary with regard to the aquatic habitats they use (e.g. Fairy Tern and Little Tern are almost exclusively marine-hypermarine), the size classes of fish they are able to harvest (primarily dependent on behaviour and morphology), and their sensitivity to water depth regime. Some species historically bred in the CLLMM region, and an important limiting factor for these species is the distribution of prey species *relative to the distribution of suitable nest sites*. Species in this group may be impacted indirectly by physicochemical changes to the aquatic environment, through changes in the distribution and abundance of suitably-sized prey species, and changes in the distribution of water level regimes.

Table 3. List of bird response groups, and the species that comprise these groups. Species were grouped to response group on the basis of their likely direct and indirect responses to environmental change in the CLLMM region.

Terrestrial species

Common Name	Species	Likely indirect response pathways
Orange-bellied Parrot	*Neophema chrysogaster*	in other regions, habitats are associated with samphire & sedgelands, although in the Coorong generally associated with 'weedy' habitats that aren't necessarily related to the CLLMM waterbodies
Mt Lofty Ranges Southern Emu-wren	*Stipiturus malachurus intermedius*	linked to CLLMM hydrology through low, dense emergent & riparian vegetation along lower tributaries associated with Lake Alexandrina (Finniss River, Tookayerta Creek & Currency Creek). While these habitats will be affected by stream hydrology, at low lake levels these catchments are unlikely to be connected to the lakes

Species associated with fringing aquatic vegetation

Common Name	Species	Likely indirect response pathways
Australian Painted Snipe	*Rostratula australis*	rare in region; associated with fringing emergent vegetation. Found in association with vegetation/water interface; probably requires healthy emergent vegetation in close proximity to waterline. Feeds primarily on aquatic molluscs and arthropods, again suggesting that foraging habitats require dense emergent vegetation over shallow water.
Latham's Snipe	*Gallinago hardwickii*	generally recorded in range of habitats, from inundated sedgelands and tall samphire, to tall grasslands and woodlands in terrestrial ecosystems. Feeds on range of food resources, can feed in terrestrial habitats.
Australasian Bittern*	*Botaurus poiciloptilus*	Strongly associated with dense fringing emergent vegetation; requires vegetation to be over shallow water. Area of vegetation required is often significant to support breeding pairs. Feeds on range of aquatic organisms, particularly small-bodied fish and large macroinvertebrates.

Generalist shorebirds associated with mudflats

Common Name	Species	Likely indirect response pathways
Double-banded Plover	*Charadrius bicinctus*	Feeds on range of food resources on mudflats, shingle and low pasture.
Grey Plover	*Pluvialis squatarola*	Feeds primarily on aquatic animals on mudflats.
Marsh Sandpiper	*Tringa stagnatilis*	Feeds mainly on molluscs and aquatic insects in shallow water on mudflats.
Red-necked Stint	*Calidris ruficollis*	Feeds on range of food resource of mudflats, including larvae of Chironomidae, small polychaetes & plant material (*Ruppia* sp.)
Sharp-tailed Sandpiper	*Calidris acuminata*	Feeds on range of food resource of mudflats, including larvae of Chironomidae, small polychaetes & plant material (*Ruppia* sp.); occasionally on irrigated pasture.
Curlew Sandpiper	*Calidris ferruginea*	Feeds on range of food resource of mudflats, including larvae of Chironomidae, small polychaetes & plant material (*Ruppia* sp.)
Terek Sandpiper	*Xenus cinereus*	
Common Sandpiper	*Actitis hypoleucos*	
Ruddy Turnstone	*Arenaria interpres*	Associated with rocky habitats. Rare in region.
Sanderling	*Calidris alba*	Associated with sandy habitats (cf mudflats), particularly ocean beaches.

Shorebirds associated with mudflats in estuarine-fresh areas

Common Name	Species	Likely indirect response pathways
Bar-tailed Godwit	*Limosa lapponica*	Feeds on estuarine mudflats and in water <15cm; prey made up of range of aquatic animals
Black-tailed Godwit	*Limosa limosa*	Feeds on estuarine mudflats in water and mud; prey made up of range of aquatic organisms
Eastern Curlew	*Numenius madagascariensis*	Feeds primarily on crabs & small molluscs, also large polychaetes, on estuarine mudflats.
Great Knot	*Calidris tenuirostris*	Primarily bivalve molluscs on mudflats.
Little Curlew	*Numenius minutus*	Feeds primarily on crabs & small molluscs, also large polychaetes, on estuarine mudflats
Pacific Golden Plover	*Pluvialis fulva*	Feeds on range of aquatic organisms, including large polychaetes in Coorong. Forages primarily along shoreline.
Red Knot	*Calidris canutus*	Feeds on range of aquatic organisms, often in mixed flocks with Godwits and Great Knot.
Whimbrel	*Numenius phaeopus*	Feeds primarily on crabs & small molluscs, also large polychaetes, on estuarine mudflats
Wood Sandpiper	*Tringa glareola*	Almost exclusively freshwater ecosystems, feeding along shorelines.

Fish-eating species

Common Name	Species	Likely indirect response pathways
Caspian Tern	*Hydroprogne caspia*	Feeds on small-medium bodied fish in range of aquatic ecosystems.
Little Tern	*Sterna albifrons*	Rare in CLLMM region. Feeds on small-bodied fish in sheltered marine ecosystems.
Fairy Tern*	*Sterna nereis*	Feeds on small-bodied fish in sheltered marine ecosystems. In Coorong, sensitive to link between suitable nest sites and feeding sites.
White-bellied Sea Eagle	*Haliaeetus leucogaster*	Primarily feeds on large-bodied fish in range of aquatic habitats.Requires terrestrial/floodplain woodlands for breeding habitat.
Cattle Egret	*Bubulcus ibis*	Feeds on range of aquatic animals. Often associated with irrigated pasture.
Great Egret	*Ardea alba*	Feeds on range of aquatic animals, primarily small-bodied fish. Often associated with estuaries and reed-beds.
Common Greenshank	*Tringa nebularia*	Primarily feeds on small-bodied fish in shallows (<20cm), as well as large macroinvertebrates

3 Assessment of Risks to Bird Response Groups

The most significant impacts of environmental change to bird species in the CLLMM region are likely to be indirect, primarily through impacts on:

- food web dynamics
- availability of preferred food species
- distribution of plant species that are key structural habitat requirements

These indirect impacts will both interact with some direct impacts, and will vary in their relative importance to different bird response groups and bird species. We also consider it worthwhile pointing out that, while the importance of these indirect impacts (relative to the importance of the direct impacts of changes in water quality and hydrology) are most significant for birds, they will also need to be considered across all of the biotic components of the ecosystem, given that all of these components interact, and therefore changes in the distribution and abundance of one component will necessarily impact on the distribution and abundance of other interacting components. In general, these indirect impacts will not be dealt with here, except as general comments regarding the probable nature of these.

Bird species are still likely to respond directly to a small number of the 'stressors' provided, namely pH and metal concentrations (and their interaction), salinity (only potentially relevant), and, most significantly, water level regime (not currently provided as a 'stressor').

pH, metal concentrations, and their interaction

As the nature of the available information regarding the response of waterbirds to pH and metal concentrations is general, only a general assessment of physiological impacts on birds can be undertaken here.

The strongest evidence for physiological impacts of pH and metal toxicity come from artifical wetlands associated with industrial sites generally, and mine sites in particular. However, much of this evidence is inferential and correlative in nature, with observed bird mortality being inferentially associated with presumably toxic concentrations of metals and, particularly for mine sites, cyanide. Much of the concern regarding waterbird exposure to metals stems either from the bioaccumulation of such metals through the food web, or changes to ecological processes and food webs (Stenson and Eriksson 1989; Scheuhammer 1991), and, for the purposes of this assessment, may be considered indirect impacts. Some ecotoxicological investigations have been performed looking at the direct, acute effects of directly ingesting acidic, metalliferous water (e.g. Isanhart 2008); however, these effects are likely to be limited to those species that are required to ingest water directly, e.g. waterfowl (rather than access water indirectly through food resources).

The greatest risks of toxicity, however, are likely to stem from the bioaccumulation of toxic metals through the food chain. These effects are primarily chronic and can lead to reductions in recruitment over time, but in cases of rapid and extremely high increases in metal concentrations (e.g. in response to a rapid drop in pH), direct mortality can result from ingesting food items that contain high concentrations. This risk may be particularly relevant following mass mortality of preferred food items (e.g. fish kills), where the availability of these food items becomes temporarily high.

Little to no quanitative information exist regarding lethal or sublethal doses for heavy metals in waterbirds to determine threshold values. Risks do exist, particularly where either bird species drink water directly (there is some evidence that waterfowl do not discriminate between freshwater sources based on toxic metal concentration), and particularly where prey species are still available for consumption (leading to the chronic and acute effects of bioaccumulation described above). Except in cases where food availability becomes so low that behavioural decisions are made to avoid impacted waterbodies, birds may not necessarily behaviourally avoid these impacted waterbodies on the basis of pH and/or toxic metal concentrations alone.

Salinity

As with pH and metal concentration, the strongest impacts of elevated salinity on waterbirds are likely to result from changes in the availability of prey species, that respond directly (physiologically) to salt concentration. However, the physiological tolerance of waterbirds to ingested salt may also influence how waterbird species respond to spatiotemporal changes in salinity. This response will also vary among bird species, depending on anatomical, physiological and behavioural adaptations to dealing with the accumulated salt (e.g. the development of salt glands in many marine bird species). For example, a requirement of many waterfowl (including Black Swan and Australian Shelduck) to access freshwater relates to their relative inability to release salt from salt glands above marine concentrations. A review of the impacts of wetlands salinisation on shorebirds (Rubega and Robinson 1996) suggested that, while some evidence existed for salt gland acclimation (in response to chronic exposure to highly saline environments), the size of salt glands across a range of species was small when compared to typically marine (e.g. pelagic) bird species. This review went on to say that, in addition to accessing sources of freshwater (either directly or through ingestion of low-salt prey items) the most common strategy for avoiding salt accumulation was to avoid high salinity environments. However, this strategy presumes that habitat/wetland choices exist at relevant spatial scales, a presumption that may be false if salinisation is occurring across wetlands at a regional scale.

Thresholds for behavioural avoidance of saline wetlands will vary significantly, both with species and with the range of habitats (salinity regimes) that individuals and populations have experienced (and have acclimated to). Many species may behaviourally avoid wetlands (and will have difficulty managing salt accumulation) at salinities as low as 18 ‰. In the Coorong, the distribution of many waterbird species can be correlated to a salinity range (Paton *et al.* 2009), although the causative relationship is likely to be driven by changes in the distribution of available food items at least as much as physiological salt accumulation (see, e.g. Rogers and Paton 2009). Additionally, the hypermarine components of the Coorong have historically been considered high quality habitat for many shorebird species (particularly small Calidrine shorebirds), even where salinity exceeds 100 ‰, suggesting that these species can tolerate highly saline environments where food resources are available.

Water Level Regime

While this has not been listed as a potential stressor, water level regime is one physical feature that many waterbirds are most likely to respond directly to. Shorebirds and waders in particular are extremely sensitive to water depth. Calidrine shorebirds (Red-necked Stint, Curlew Sandpiper, Sharp-tailed Sandpiper) have been shown to respond behaviourally to changes in water level over depth changes of 3-5cm (Rogers and Paton 2009), and while a species sensitivity to water level will depend on its morphology (size, leg length) and ecology (prey type, foraging mode), these data demonstrate the importance of water level regime to the foraging success of these species. While water depth may relate to the abundance of food items, this parameter is likely to be at least as important to shorebirds through the role that it plays in the ability of birds to access food items (independent of their abundance).

In addition to showing extreme sensitivity to water depth, shorebirds also show sensitivity to distance above the waterline (Rogers and Paton 2009), presumably in relation to desiccation of substrates above the waterline (leading to declines in both the abundance of prey and te ability of birds to access remaining prey). For many shorebirds, this leads to a relatively narrow topographic window within which they can forage effectively.

From the perspective of water level management, the implications of these findings are twofold. First, mudflats must be periodically exposed (or at least only inundated by very shallow water) at times of the year when birds need to access these habitats (e.g. Spring-Autumn for long-distance migratory shorebirds). However, this periodicity must have a reasonably high frequency, to avoid exposed mudflats from desiccating and no longer supporting foraging shorebirds. Second, mudflats that are frequently exposed and inundated allow the narrow topographic window available to many shorebirds to move geographically. This presumably allows the shorebirds to shift their foraging effort, such that no one area is harvested for long enough to deplete the local food resource. The requirement by shorebirds of frequently inundated and exposed mudflats provided at least some of the justification for the maintenance of an open Murray Mouth.

Water level regime affects waterbird species beyond shorebirds. Piscivores are likely to be sensitive to water depth, particularly small terns such as Fairy Tern, that may be additionally impacted by water level through changes in the availability of nest sites (Rogers and Paton 2009). Waterfowl have also shown to be sensitive to water level regime, particularly those species whose diet consists almost exclusively of aquatic macrophytes (e.g. Black Swan; Bonner 2007). In summary, for many of the waterbirds of the Coorong, Lower Lakes and Murray Mouth region, water level regime may be the most important *direct* determinant of food availability (acknowledging, again, that salinity and water quality will affect the ecology of waterbird species indirectly, through impacts on the abundance of food items and habitat).

Summary

The direc t effects of physico-chemical parameters on aquatic birds in the Coorong and Lower Lakes are not well established, although there are likely to be direct impacts primarily through the ingestion of food items and subsequent bio-accumulation of metals and salt. However, the impact of physico-chemical changes on aquatic birds are more likely to be be indirect, through either:

- changes in food item abundance
- changes in the distribution of plants that form important habitats

These two indirect impacts, as well as the direct impacts related to water level regime, will vary significantly between species, depending on their ecological requirements. Groups of bird species that are likely to interact with their physical and biotic enviroments in similar ways are presented in Table 3.

As pointed out above, the indirect impacts of physico-chemical changes to aquatic ecosystems are unlikely to be restricted to birds. However, the relative importance of these indirect impacts are likely to be higher for birds than for other organisms. Another important point to consider for waterbirds is the high level of interaction that birds have with different components of the system and broader region. More than any other group of organisms, birds are able to select among habitats from the different wetland systems of the CLLMM region, as well as other wetland systems in the broader region (and elsewhere). This poses a challenge to measuring the response of waterbirds to changes in particular parts of the system. In addition, management decisions must ensure that hydrological and ecological responses to management are assessed across the entire region, and not just for the component of the system most directly affected, to ensure that suitable habitats remain available somewhere in the system at appropriate times.

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