

Supplementary Material

Tide-excluded banked wetlands on the marine plains of northeastern Australia provide important habitat for migratory shorebirds, other threatened bird species and the Capricorn Yellow Chat

Wayne A. Houston^{A,}, Roger Jaensch^B, Rod J. Elder^A, Robert L. Black^A, Allan Briggs^C, and Damon Shearer^D*

^ASchool of Health, Medical and Applied Sciences, Central Queensland University, Bruce Highway, Rockhampton, Qld, Australia.

^BJaensch Ornithology & Conservation, Rangeville, Qld, Australia.

^CBirdLife Capricornia, 192 Palm Valley Road, Coowonga, Qld, Australia.

^DDepartment of Environment and Science, Queensland Parks & Wildlife Service, Gladstone, Qld, Australia.

*Correspondence to: Wayne A. Houston School of Health, Medical and Applied Sciences, Central Queensland University, Bruce Highway, Rockhampton, Qld, Australia Email: w.houston@cqu.edu.au

Supplementary Information and Appendices

Site descriptions

Upper West Broad Sound is a complex site comprising multiple separate plains and extending north from the Styx River to the southern bank of the St Lawrence River. It consists of plains on the Wumalgi Peninsula, at the outflows of Waverley and Home Creeks, and east and west of St Lawrence. Tide-exclusion banks are a mixture of extensive low banks and seawalls (Fig. 1b) plus some small block banks at the southern end of the complex. Some banks at this site were relatively low in the tidal gradient with relatively large areas of bare salt flat behind them. These banks had spillways to allow floods to overtop them.

Lower West Broad Sound has one extensive seawall enclosing a segment of the marine plain. The bank extends along the western side of the estuary of Herbert Creek in Broad Sound for approximately 14 km and the banked plain is up to 3 km across in places. The marine plain at this site receives freshwater inflow from several small creeks and has a rapid transition to higher ground on its western edge where it is bordered by coastal ranges. Extensive tall banks such as at Lower West Broad Sound result in extensive pooling of freshwater in the wet season with little connectivity to the downstream estuarine or marine habitat. The shallower wetlands enclosed by this bank are mostly well vegetated and relatively fresh.

The Torilla Plain lies on the Torilla Peninsula on the eastern side of the Broad Sound. There are several main creeks supporting wetlands at this site including Bark Hut Lagoons Creek, Wadallah Creek, Coonyan Creek and Couti-outi Creek. This plain has a vast, extremely dense and complex network of channels, gutters, ponds and playas (Fig. 1a), providing a high total length of wetland edge habitat for waterbirds and other wetland-dependent species. In terms of modifications, it is characterised by the presence of numerous small block banks (20-50 m in length) targeting a single narrow channel, several kilometres from the mangrove margins at the junction of the channels with saline flats. Some block banks are also positioned farther upstream. The aim of small block banks is to prevent or limit tidal ingress and to slow freshwater runoff, rather than to form extensive pools. In flood events, freshwater flows typically go around these small banks, allowing connectivity with the downstream estuarine or marine habitat at this stage; some tidal inflow may occur occasionally. In extreme flood events, water briefly covers most of the marine plain, irrespective of block banks. At this site, vegetation is representative of the pre-banked landscape with extensive areas of salt-tolerant vegetation such as Marine Couch and samphires present, as well as wet meadows and basins

dominated by Water Couch and *C. alopecuroides* on the upper marine plain and freshwater swamps densely vegetated with spike-rush *Eleocharis* spp. and aquatic plants; also some *Melaleuca* wooded swamps around the landward margins. Salt-dominated vegetation occupies around 40% of the bank-influenced plain, freshwater vegetation about the same, with another 15% of open water (channels, large basins and unvegetated areas). The main change in the vegetation on the Torilla Plain has been the proliferation of introduced grasses such as Para Grass and Bermuda Grass.

Torilla South lies on the southwestern part of the Torilla Peninsula and is separated from Torilla Plain by a *Melaleuca* woodland. This site has low banks across the plain that slow freshwater runoff and prevent tidal ingress. It has a relatively small catchment compared to Torilla Plain. Vegetation is dominated by salt-tolerant species such as *S. subulatus*, Marine Couch and samphires. Another salt-tolerant species, Beetle Grass *Leptochloa fusca*, is also common at this site.

Nankin Ck Plain is enclosed by a seawall of approximately 10 km that runs parallel to the Fitzroy River in the delta. This site includes a large oxbow. This wetland and adjacent swamps receive water from Nankin Creek. Extensive patches of *S. subulatus* occur in the oxbow. Around the margins of the oxbow and along connected channels and swales are patches of freshwater adapted vegetation such as *C. alopecuroides* and Para Grass. An extensive natural seasonal swamp, "Goose Swamp" occurs at the upstream end of this system.

Curtis Island Marine Plain has been included to provide an example of a non-banked marine plain wetland. It is a single area of marine plain on the northeastern end of Curtis Island that receives freshwater flow from several small seasonal creeks plus groundwater input from tall dune systems along its eastern edge. Historically, a low levee bank lay across the plain, but this was extensively breached during floods in 1974 and has had little or no influence on overland flows and ponding of water. It is part of 'Northeast Curtis Island' on the Directory of Important Wetlands in Australia and is regarded as a highly significant wetland at regional, state and national levels (DEWHA 2009). Featuring in this listing, were the extent of the marine plain at Curtis Island, its location as an intact example of marine plain at the southern limit of this habitat type, the presence of threatened fauna, migratory shorebirds, notable landscape features and the overall near natural condition of the area.

Several of the banked sites are also listed in the Directory of Important Wetlands: Upper West Broad Sound, Lower West Broad Sound, Torilla Plain and Torilla South form part of ‘Broad Sound’ while Nankin Ck Plain forms part of ‘Fitzroy River Delta’ (DEWHA 2009). These were listed because they both provide good examples of marine/estuarine/freshwater wetland complexes and the presence of threatened fauna and migratory shorebirds.

Additional tables

Table S5: An evaluation of the “regular” occurrence of Sharp-tailed Sandpiper at each site (see Table 1 for site names)

Regular usage evaluation based on the Sharp-tailed Sandpiper	UWBS	LWBS	TP	TS	NCP	CIM P
Number of consecutive years with at least two surveys in the non-breeding season	3	na	6	5	5	7
Percentage of the number of consecutive years that nationally significant numbers of STS present	67%	na	83%	60%	80%	57%
¹ Mean of the yearly maxima of STS based on consecutive years’ data	1,134**	na	405*	132*	465*	222*

¹ Indicates that the average count for the period of consecutive years for which data was available at that site exceeds national* or international numbers**

References

DEWHA. (2009) Australian Wetlands Database. Available from <http://www.environment.gov.au/water/wetlands/australian-wetlands-database>. Accessed November 12, 2018. Australian Department of the Environment, Water, Heritage and the Arts, Canberra.

Appendices

Appendix 1: Species list and scientific names

Common Name	Scientific Name
DUCKS, GEESE & SWANS	
Magpie Goose	<i>Anseranas semipalmata</i>
Plumed Whistling-Duck	<i>Dendrocygna eytoni</i>
Wandering Whistling-Duck	<i>Dendrocygna arcuata</i>
Freckled Duck	<i>Stictonetta naevosa</i>
Black Swan	<i>Cygnus atratus</i>
Radjah Shelduck	<i>Radjah radjah</i>
Australian Wood Duck	<i>Chenonetta jubata</i>
Cotton Pygmy-goose	<i>Nettapus coromandelianus</i>
Green Pygmy-goose	<i>Nettapus pulchellus</i>
Pacific Black Duck	<i>Anas superciliosa</i>
Australasian Shoveler	<i>Spatula rhynchotis</i>
Grey Teal	<i>Anas gracilis</i>
Chestnut Teal	<i>Anas castanea</i>
Pink-eared Duck	<i>Malacorhynchus membranaceus</i>
Hardhead	<i>Aythya australis</i>
GREBES	
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>
Great Crested Grebe	<i>Podiceps cristatus</i>
DARTER, CORMORANTS & PELICAN	
Australasian Darter	<i>Anhinga novaehollandiae</i>
Little Pied Cormorant	<i>Microcarbo melanoleucos</i>
Great Pied Cormorant	<i>Phalacrocorax varius</i>
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>
Great Cormorant	<i>Phalacrocorax carbo</i>
Australian Pelican	<i>Pelecanus conspicillatus</i>
HERONS, EGRETS, IBIS, SPOONBILLS & STORK	
White-faced Heron	<i>Egretta novaehollandiae</i>

Common Name	Scientific Name
Little Egret	<i>Egretta garzetta</i>
White-necked Heron	<i>Ardea pacifica</i>
Pied Heron	<i>Egretta picata</i>
Great Egret	<i>Ardea alba</i>
Intermediate Egret	<i>Ardea intermedia</i>
Cattle Egret	<i>Bubulcus ibis</i>
Striated Heron	<i>Butorides striata</i>
Nankeen Night Heron	<i>Nycticorax caledonicus</i>
Australian Little Bittern	<i>Ixobrychus dubius</i>
Black Bittern	<i>Ixobrychus flavicollis</i>
Glossy Ibis	<i>Plegadis falcinellus</i>
Australian White Ibis	<i>Threskiornis moluccus</i>
Straw-necked Ibis	<i>Threskiornis spinicollis</i>
Royal Spoonbill	<i>Platalea regia</i>
Yellow-billed Spoonbill	<i>Platalea flavipes</i>
Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>
BROLGA & GALINULES	
Brolga	<i>Antigone rubicunda</i>
Buff-banded Rail	<i>Hypotaenidia philippensis</i>
Pale-vented Bush-hen	<i>Amaurornis moluccana</i>
Baillon's Crake	<i>Zapornia pusilla</i>
Australian Spotted Crake	<i>Porzana fluminea</i>
Spotless Crake	<i>Zapornia tabuensis</i>
Purple Swamphen	<i>Porphyrio porphyrio</i>
Dusky Moorhen	<i>Gallinula tenebrosa</i>
Black-tailed Native-hen	<i>Tribonyx ventralis</i>
Eurasian Coot	<i>Fulica atra</i>
SHOREBIRDS	
Latham's Snipe	<i>Gallinago hardwickii</i>
Swinhoe's Snipe	<i>Gallinago megala</i>
Black-tailed Godwit	<i>Limosa limosa</i>
Nunivak Bar-tailed Godwit	<i>Limosa lapponica baueri</i>

Common Name	Scientific Name
Little Curlew	<i>Numenius minutus</i>
Whimbrel	<i>Numenius phaeopus</i>
Far Eastern Curlew	<i>Numenius madagascariensis</i>
Marsh Sandpiper	<i>Tringa stagnatilis</i>
Common Greenshank	<i>Tringa nebularia</i>
Common Sandpiper	<i>Actitis hypoleucos</i>
Red-necked Stint	<i>Calidris ruficollis</i>
Pectoral Sandpiper	<i>Calidris melanotos</i>
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>
Curlew Sandpiper	<i>Calidris ferruginea</i>
Australian Painted-snipe	<i>Rostratula australis</i>
Comb-crested Jacana	<i>Irediparra gallinacea</i>
Australian Pied Oystercatcher	<i>Haemotopus longirostris</i>
Pied Stilt	<i>Himantopus leucocephalus</i>
Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>
Pacific Golden Plover	<i>Pluvialis fulva</i>
Red-capped Plover	<i>Charadrius ruficapillus</i>
Lesser Sand Plover	<i>Charadrius mongolus</i>
Oriental Plover	<i>Charadrius veredus</i>
Black-fronted Dotterel	<i>Elseyornis melanops</i>
Red-kneed Dotterel	<i>Erythronys cinctus</i>
Banded Lapwing	<i>Vanellus tricolor</i>
Masked Lapwing	<i>Vanellus miles</i>
Australian Pratincole	<i>Stiltia isabella</i>
GULLS & TERNS	
Silver Gull	<i>Larus novaehollandiae</i>
Gull-billed Tern	<i>Gelochelidon macrotarsa/G. nilotica</i>
Caspian Tern	<i>Hydroprogne caspia</i>
Whiskered Tern	<i>Chlidonias hybrida</i>
White-winged Black Tern	<i>Chlidonias leucopterus</i>
WETLAND-DEPENDENT RAPTORS	

Common Name	Scientific Name
Whistling Kite	<i>Haliastur sphenurus</i>
White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>
Swamp Harrier	<i>Circus approximans</i>
WETLAND-DEPENDENT PASSERINES	
Capricorn Yellow Chat	<i>Epthianura crocea macgregori</i>
Eastern Yellow Wagtail	<i>Motacilla tschutschensis</i>
Australian Reed-Warbler	<i>Acrocephalus australis</i>
Little Grassbird	<i>Poodytes gramineus</i>
Zitting Cisticola	<i>Cisticola juncidis</i>