Appendix: Coastal high-tide shorebird habitat management guidelines

1. Useful reference documents

Background

1. Paper that explains what roosting is, and how coastal shorebirds choose where to roost at high tide:

> *Rogers, D.I. (2003) High-tide roost choice by coastal waders. Wader Study Group Bulletin, 100, 73–79.*

2. Paper explaining that a lack of undisturbed roosting habitat may limit how many shorebirds can use a local area:

> *Rogers, D. I., Piersma, T., Hassell, C. J. (2006). Roost availability may constrain shorebird distribution: Exploring the energetic costs of roosting and disturbance around a tropical bay. Biological Conservation, 133, 225–235.*

3. Papers that explain why disturbance can harm shorebirds:

> *Van der Kolk, H., Krijgsveld, K.L., Linssen, H., Diertens, R., Dolman, D., Jans, M., Frauendorf, M., Ens, B.J., van de Pol, M. (2020). Cumulative energetic costs of military aircraft, recreational and natural disturbance in roosting shorebirds. Animal Conservation 23, 359– 372.*
>
> *Lilleyman, A., Franklin, D.C., Szabo, J.K., Lawes, M.J. (2016) Behavioural responses of migratory shorebirds to disturbance at a high-tide roost. Emu, 116, 111–118.*
>
> *Yasué, M., Dearden, P., Moore, A. (2008) An approach to assess the potential impacts of human disturbance on wintering tropical shorebirds. Oryx, 42, 415–423.*
>
> *Kim, H.-C., Yoo, J.-C. (2007) Responses of shorebirds to disturbance at roosting sites. Journal of Ecological Field Biology 30, 69–73.*

4. Papers that discuss waterbirds breeding at an artificial high tide roost site:

> *Lei, W., Wu, Y., Wu, F., Piersma, T., Zhang, Z., Masero, J.A. (2021) Artificial Wetlands as Breeding Habitats for Shorebirds: A Case Study on Pied Avocets in China's Largest Saltpan Complex. Frontiers in Ecology & Evolution 9, 622756.*
>
> *Wu, F., Lei, W., Lloyd, H., Zhang, Z. (2020) Predictors of Gull-billed tern (Gelochelidon nilotica) nest survival in artificial coastal saltpans, Bohai Bay, China. PeerJ 8, e10054.*

5. Paper that explains how some shorebirds can feed on small prey in the water column that is sometimes found at supratidal sites*:*

> *Estrella, S.M., Masero, J.A. (2007) The use of distal rhynchokinesis by birds feeding in water. The Journal of Experimental Biology, 210, 3757–3762.*

6. Paper that explores use of artificial habitats by shorebirds in the East Asian-Australasian Flyway:

> *Jackson, M. V., Choi, C.-Y., Amano, T., Estrella, S. M., Lei, W., Moores, N., Mundkur, T., Rogers, D. I., Fuller, R. A. (2020) Navigating coasts of concrete: pervasive use of artificial habitats by shorebirds in the Asia-Pacific. Biological Conservation 247, 108591.*

Box 1 - Shorebirds

7. Paper that outlines the different habitat strategies (coastal, generalist and inland) used by shorebirds:

> *Piersma, T. (2003) "Coastal" versus "inland" shorebird species: Interlinked fundamental dichotomies between their life and demographic histories? Wader Study Bulletin, 100, 5–9.*

Box 2 – Migratory shorebirds in the EAAF

8. Conference presentation that explains the "flyway" concept:

Boere, G.C., Stroud, D.A. (2006) The flyway concept: what it is and what it isn't. In: Boere, G.C., Galbraith, C.A., Stroud, D.A. (Eds.), Waterbirds Around the World. The Stationery Office, Edinburgh, UK, pp. 40–47. WEB LINK

9. Report that introduces the migratory shorebirds of the East Asian-Australasian Flyway:

Bamford, M., Watkins, D., Bancroft, W., Tischler, G., Wahl, J. (2008) "Migratory Shorebirds of the East Asian – Australasian Flyway; Population Estimates and Internationally Important Sites". Wetlands International – Oceania: Canberra. WEB LINK

10. Paper that discusses governance structure for conserving shorebirds in the East Asian-Australasian Flyway:

Gallo-Cajiao, E., Morrison, T.H., Fidelman, P., Kark, S., Fuller, R.A. (2019) Global environmental governance for conserving migratory shorebirds in the Asia-Pacific. Regional Environmental Change 19, 1113–1129.

11. Papers that document shorebird population declines based on national-scale data:

Clemens, R.S., Rogers, D.I., Hansen, B.D., Gosbell, K., Minton, C.D.T., Straw, P., Bamford, M., Woehler, E.J., Milton, D.A., Weston, M.A., Venables, B., Weller, D., Hassell, C., Rutherford, B., Onton, K., Herrod, A., Studds, C.E., Choi, C.-Y., Dhanjal-Adams, K.L., Murray, N.J., Skilleter, G.A., Fuller, R.A. (2016) Continental-scale decreases in shorebird populations in Australia. Emu, 116, 119–135

Amano, T., Székely, T., Koyama, K., Amano, H., Sutherland, W.J. (2010) A framework for monitoring the status of populations: An example from wader populations in the East Asian–Australasian flyway. Biological Conservation, 143, 2238–2247.

12. Papers signalling that migratory shorebird declines are driven by habitat loss, especially in East Asia:

Studds, C.E., Kendall, B.E., Murray, N.J., Wilson, H.B., Rogers, D.I., Clemens, R.S., Gosbell, K., Hassell, C.J., Jessop, R., Melville, D.S., Milton, D.A., Minton, C.D., Possingham, H.P., Riegen, A.C., Straw, P., Woehler, E.J., Fuller, R.A. (2017) Rapid population decline in migratory shorebirds relying on Yellow Sea tidal mudflats as stopover sites. Nature Communications, 8, 14895.

Piersma, T., Lok, T., Chen, Y., Hassell, C.J., Yang, H.-Y., Boyle, A., Slaymaker, M., Chan, Y.-C., Melville, D.S., Zhang, Z.-W., Ma, Z. (2016) Simultaneous declines in summer survival of three shorebird species signals a flyway at risk. Journal of Applied Ecology, 53, 479–490.

Important biophysical roost site features

13. Literature review that summarises what studies from the around the world have documented about which features shorebirds prefer in supratidal ponds:

Rogers, D.I., Stamation, K., Loyn, R.H., Menkhorst, P. (2015) "Literature Review: Management of Non-Tidal Ponds for Shorebirds". ARI Technical Report 264. Arthur Rylah Institute for Environmental Research: Melbourne.

14. Papers that discuss which roost site features shorebirds prefer at specific sites:

Yu, C., Ngoprasert, D., Round, P.D., Pierce, A.J., Savini, T., Gale, G.A. (2019) Roost selection of the endangered Spotted Greenshank (Tringa guttifer) in critical habitat in the Inner Gulf of Thailand. Avian Research 10, doi: 10.1186/s40657-019-0148-7

Jackson, M.V., Carrasco, L. R., Choi, C.-Y., Li, J., Ma, Z., Melville, D.S., Mu, T., Peng, H.-B., Woodworth, B.K., Yang, Z., Zhang, L., Fuller, R.A. (2019) Multiple habitat use by declining migratory birds necessitates joined-up conservation. Ecology & Evolution 9, 2505–2515.

He, P., Melville, D. S., Peng, H.-B., Tan, K., Chen, Y., Ma, Z. (2016) Aquaculture pond banks as high-tide roosts: What physical characteristics are more attractive to shorebirds. Stilt 69–70, 62– 65.

Managing shorebird roosts

15. Report with details about how a shorebird roost site can be constructed:

Lawler, W. (1995) Wader roost construction in Moreton Bay – a feasibility study into the construction of migratory wader (shorebird) high tide roosts in Moreton Bay, Qld, using Raby Bay as a case study. Queensland Wader Study Group.

16. Paper discussing a high tide roost site at a port, and how it should be managed for shorebirds:

Lilleyman, A., Rogers, D. I., Jackson, M.V., Fuller, R.A., O'Brien, G., Garnett, S.T. (2020) An artificial site provides valuable additional habitat to migratory shorebirds in a tropical harbor. Pacific Conservation Biology, doi: 10.1071/PC19036.

17. Management plan that discusses how high tide roost sites are being managed at the Mai Po Nature Reserve:

WWF Hong Kong (2019) Mai Po Nature Reserve Management Plan: 2019-2024. WEB LINK

18. Technical document that discusses how high tide roost sites are being managed at the Mai Po Nature Reserve:

WWF Hong Kong (2013) MAI PO NATURE RESERVE HABITAT MANAGEMENT, MONITORING AND RESEARCH PLAN 2013-2018. WEB LINK

19. Summary of literature about using signs and access restriction to reduce disturbance at waterbird nesting sites:

Williams, D.R., Child, M.F., Dicks, L.V., Ockendon, N., Pople, R.G., Showler, D.A., Walsh, J.C., zu Ermgassen, E.K.H.J., Sutherland, W.J. (2020) Bird Conservation. Pages 137-281 in: W.J. Sutherland, L.V. Dicks, S.O. Petrovan & R.K. Smith (eds) What Works in Conservation 2020. Open Book Publishers, Cambridge, UK. WEB LINK

20. Studies discussing the specific distance at which shorebirds are disturbed by people:

Weston, M.A., McLeod, A.M., Blumstein, D.T., Guay, P.-J. (2012) A review of flight-initiation distances and their application to managing disturbance to Australian birds, Emu, 112, 269–286.

Glover, H.K., Weston, M.A., Maguire, G.S. (2011) Towards ecologically meaningful and socially acceptable buffers: response distances of shorebirds in Victoria, Australia, to human disturbance. Landscape and Urban Planning 103, 326–334.

2. Areas for more research

There are still some key areas of high-tide habitat management that require more research. Some of these include:

Exposure to pollutants at roost sites. Research questions include:

- what pollutants are shorebirds exposed to at roost sites?
- what pollutants and concentration levels are harmful?
- how can we determine if shorebirds should be discouraged from using a roost site due to excess pollution exposure?

Potential for disease transmission at roost sites. Research questions include:

- are certain features better or worse to include in roost site design in terms of disease transmission amongst shorebirds?

Nocturnal roosting: in most regions few nocturnal roost site counts are carried out, and consequently relatively little is known about roosting patterns. At some sites it is possible to identify nocturnal roosts by looking for shorebird

footprints or moulted feathers. Radio, GPS and satellite tracking are also techniques that can be used to document the full suite of local roosting patterns.

Neap tide roosting: in many cases, shorebird movement patterns are known from shorebird surveys that are conducted during spring tides (i.e. the highest high tides in the month), when most or all intertidal areas are flooded, and shorebirds gather in supratidal sites where they are easiest to count. The importance of high tide roosts to shorebirds' roosting and feeding during neap tides as well as threats and disturbance factors is generally understudied.

Habitat dynamics: in many places the interaction between feeding and roosting sites is not fully understood, and it is difficult to quantify "how much roosting habitat is enough?". This is a particularly important question if shorebird populations begin to recover towards historic levels as many populations have declined by >50%; it is important to ensure that roost site availability is not limiting the size of the local shorebird population.