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Contemporary population estimates for Eastern Hooded Plover, *Thinornis cucullatus*, and Australian Pied Oystercatcher, *Haematopus longirostris*, in Tasmania

Eric J Woehler, BirdLife Tasmania

Abstract

Analyses of data obtained during dedicated surveys since 1992–93 indicate that Tasmania currently (2020–21) supports at least 750 breeding pairs of Eastern Hooded Plover, representing approximately 62% of the sub-species population. Tasmania also supports a minimum of 1000 breeding pairs of Pied Oystercatcher, with a total population estimated to be more than 30% of the Australasian and global population. Population data for the three Tasmanian NRM regions and the 20 coastal councils that support breeding populations clearly show local and regional differences in the distributions of the two species around Tasmania.

Introduction

Tasmania has long been recognised as supporting significant breeding populations of Eastern Hooded Plover, *Thinornis c. cucullatus*, and of Australian Pied Oystercatcher (hereafter Pied Oystercatcher), *Haematopus longirostris* (e.g. Newman 1982, Bryant 2002, Spruzen *et al.* 2006, DoE 2014, Taylor *et al.* 2014, DoE 2018). Various estimates of breeding and total populations for these species have been made since the early 1980s when surveys were initiated (e.g. Newman and Patterson 1984, Delany and Scott 2006, Garnett *et al.* 2011, Taylor *et al.* 2014) with varying assumptions and extrapolations.

In 2014, the Eastern Hooded Plover subspecies (hereafter Hooded Plover), *T. c. cucullatus*, was formally listed as *Threatened* under Federal and State legislations on the basis of decreasing populations in south-east Australia and Tasmania; the associated Conservation Advice (DOE 2014) suggested a total population of approximately 3000 individuals in NSW, Victoria, Tasmania and South Australia combined, based on the synthesis in Garnett *et al.* (2011). The Hooded Plover was one of the 20 priority bird species for the Federal Threatened Species Strategy (DoE 2018). In contrast, Pied Oystercatcher presently has no conservation status under the *EPBC Act 1999*.

The aim of this brief synthesis is to provide a contemporary (December 2020) estimate of the minimum breeding and total populations of Hooded Plovers and Pied Oystercatchers in Tasmania, including King, Maria and the Furneaux islands, based on dedicated mapping and census surveys undertaken annually since 1992–93. Additional studies and analyses of Tasmanian populations of Red-capped Plover, Sooty Oystercatcher, Fairy and Little Terns are presently underway, and are not included here.

Methods

For this synthesis, pre-breeding refers to immature birds that have yet to commence breeding, non-breeding refers to birds capable of breeding but not holding territories, and breeding birds are those with a territory and which are engaged in breeding efforts. The total population is the sum of these three categories, and does not include pre-fledged chicks.

All surveys outside of the Tasmanian Wilderness World Heritage Area (TW WHA) and the Tasmanian south coast have been undertaken by the author to eliminate inter-observer variability introduced into surveys involving multiple observers. The surveys are typically undertaken between mid-August and the end of March each summer. Beaches are walked close to the water line, with frequent and regular scanning of the beach to locate breeding territories and birds ahead of the observer.

Attempts have been made to survey beaches on approximately a 4–5 year rotation in light of the life expectancies of the focal species (e.g. Newman and Woehler 2017); beaches close to Hobart are typically surveyed more frequently, while remote(r) and/or logistically challenging beaches have been surveyed less often. This study does not include the data from four 'statewide' surveys organised in the period 1982–96 (e.g. Newman and Patterson 1984), nor does the study include roosting counts from the annual Summer and Winter Wader Counts as the sources, ages and breeding status of roosting birds can not be assessed.

No nest searches were made during surveys, but nests were encountered as a result of tide height, beach topography and geomorphology, etc., and all efforts were also made to avoid disturbing feeding shorebirds at the water's edge. Where nests with eggs or chicks were encountered, the GPS coordinates of the nest were captured in preference to the breeding territory centroid on the foreshore, which was based on the locations of the resident pair. Birds encountered as pairs on beaches, and/or displaying behaviours and vocalisations linked with nesting were considered to be breeding (Weston *et al.* 2009, E.J. Woehler, pers. obs.).

Data for the coast south of Cape Sorell and the TW WHA were provided by J. Marsden-Smedley. These data were based on observations made during annual removal of Sea Spurge, *Euphorbia paralias*. Data for the south coast from Bathurst Harbour to Southeast Cape were provided by B. Arthur, who used the methods described above. For both of these data sets, the data provide the minima estimates of breeding Hooded Plovers and Pied Oystercatchers on beaches visited.

All GPS data are captured with a Garmin 12-channel GPS receiver in real time. The coordinates of shorebird breeding territories' centroids and any nests encoun-

tered were recorded as UTM coordinates based on the WGS 84 datum and converted to latitude °S and longitude °E for mapping.

The population data were tabulated for 20 coastal councils and for the three Natural Resource Management (NRM) agencies in Tasmania to provide land managers and other coastal stakeholders with contemporary (December 2020) assessments of municipal populations in national and international contexts.

The study is different from efforts on the mainland in a number of key facets. The project's surveys report the numbers of breeding pairs and total numbers of individuals (breeding, non-breeding and pre-breeding birds) per beach. Calculations generating, 'mean densities' (i.e. birds/km) as generated in mainland studies are deliberately avoided as these overlook the non-regular distributions of these species on Tasmania's beaches (Webster 2014, Teo 2019); consequently, no extrapolations are made of un-surveyed sites based on 'densities' of birds along coasts.

Finally, no assumptions of what is deemed to be or may be, 'suitable habitat' (as used in mainland studies) are made to avoid preconceptions as to the distribution and abundances of the species in Tasmania. Differences exist in the habitats used by Hooded Plovers between mainland sites and Tasmania (Weston *et al.* 2020).

Results

As of December 2020, more than 1200 surveys have been undertaken on more than 450 beaches in Tasmania, comprising approximately 8000 records (figure 20, page 21). There are 2300 and 3600 records of Hooded Plover and Pied Oystercatcher, respectively for the period 1992–93 to 2020–21, comprising observations of breeding and non-breeding birds, figures 21 and 22, page 22.

Eastern Hooded Plover

As of December 2020, Tasmania supports a minimum of 750 breeding pairs of Eastern Hooded Plover, with a minimum total population comprising pre-breeding, non-breeding and breeding adults to be no less than 1850 birds, or approximately 62% of the Eastern subspecies population of 3000 birds (DoE 2014).

Pied Oystercatcher

As of December 2020, Tasmania supports a minimum of 1000 breeding pairs of Pied Oystercatcher, with a minimum total population comprising pre-breeding, non-breeding and breeding adults estimated to be no less than 3300 birds, or approximately 30% of the Australasian and global population of 11,000 birds (Taylor *et al.* 2014).

Council and NRM populations

Table 3 shows the percentages of Hooded Plovers and Pied Oystercatchers in 20 coastal councils around Tasmania, and the corresponding totals for the three NRM regions in the state. The estimated minimum breeding populations of Hooded Plovers and Pied Oystercatchers in the three NRM regions in Tasmania are shown in Table 4.

Table 3: *Estimated minima, expressed as percentages) of Hooded Plover (HOPL) and Pied Oystercatcher (PIOY) populations (all birds) per coastal council, arranged clockwise and summed for NRM regions in Tasmania (figures 20–22). Percentages are given for national (global) and Tasmanian populations. Councils supporting internationally significant populations of either or both species are denoted by an asterisk (*).*

	HOPL	PIOY	HOPL	PIOY
Council/NRM	**National/global**		**Tasmania**	
West Coast*	9	3	14	10
King Island*	3	1	5	4
Circular Head*	12	6	20	21
Waratah–Wynyard	0	0	0	1
Burnie	0	0	0	0
Central Coast	0	0	0	0
Devonport	0	0	0	1
Latrobe	0	0	0	1
CC NRM total	**24**	**11**	**39**	**38**
West Tamar	0	0	1	1
George Town*	1	1	1	2
Dorset*	4	1	6	5
Flinders*	9	4	15	13
Break O'Day	7	2	11	7
NRM North total	**21**	**9**	**34**	**28**
Glamorgan Spring Bay*	9	4	15	13
Sorell*	1	3	1	9
Tasman*	3	1	5	2
Clarence*	0	1	0	2
Hobart	0	0	0	0
Kingborough*	1	1	4	3
Huon Valley*	2	1	4	3
NRM South total	**16**	**10**	**29**	**34**

The largest Hooded Plover and Pied Oystercatcher populations are present in the Circular Head municipality (12% and 6% of the national populations, respectively); similarly, these populations represent 20% and 21%, respectively, of the Tasmanian populations. West Coast, Flinders and Glamorgan Spring Bay municipalities support 9% each of the national Hooded Plover population, each equal to c.15% of the Tasmanian population.

A total of 12 of 20 municipalities support 1% or more of the global populations of Hooded Plovers and Pied Oystercatchers, exceeding the threshold for international significance for both species. Clarence municipality supports internationally significant numbers of Pied Oystercatchers (table 3).

The Cradle-Coast region, extending from Port Sorell on the central north coast to the north and west to Bathurst Harbour and includes much of the TW WHA coast, King Island and the Hunter Group, supports at least 40% and 36% of the estimated populations for the Eastern Hooded Plover subspecies and Pied Oystercatchers, respectively.

Table 4: *Estimated minimum breeding populations (pairs) of Hooded Plover,* Thinornis cucullatus*, and Pied Oystercatcher,* Haematopus longirostris*, in the three NRM regions in Tasmania, 2020–21 (figures 20–22).*

NRM region	Hooded Plover (pairs)	Pied Oystercatcher (pairs)
Cradle Coast	300	360
North	260	290
South	190	350
Total	**750**	**1000**

The NRM North region, extending from Port Sorell to the east and south to just north of Bicheno on the east coast and including the Furneaux Island Group (many of which have not been surveyed in this project), supports at least 35% and 29% of the estimated populations for Eastern Hooded Plover and Pied Oystercatchers, respectively. Finally, the NRM South region that extends from just north of Bicheno on the east coast southward to the Tasman Peninsula and west to Bathurst Harbour in the TW WHA, including Maria and Bruny Islands, supports at least 25% and 35% of the estimated populations for Eastern Hooded Plover and Pied Oystercatchers, respectively.

Discussion

Newman and Patterson (1984) estimated the Tasmanian Hooded Plover population to be 1730 birds, based on extrapolation of density data calculated from 'potentially suitable beaches' around Tasmania. This was the first quantitative estimate for the species in Tasmania,

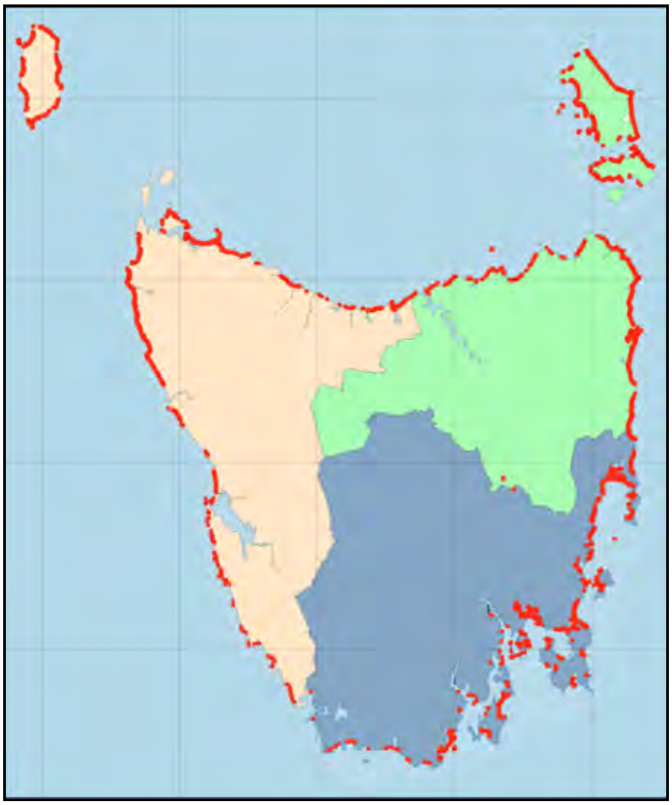

Figure 20: *Map showing survey effort for 1992–93 to 2020–21 (red symbols) for resident shorebirds in Tasmania and adjacent islands;* n *= 8100 records on more than 450 beaches as of December 2020. The three NRM regions are shown: Cradle Coast (orange), North (green) and South (blue). The grid shows 1° x 1° latitude and longitude.*

albeit based on c.50 beaches at varying times in 1981 and 1982. Woehler and Park (1997) provided the first evidence for decreases in Tasmanian Hooded Plover populations based on initial analyses of survey data collected on more than 50 beaches between 1982 and 1996, suggesting some beach populations were decreasing at up to 5% annually. Bryant (2002) noted decreases in populations both of Hooded Plover and Pied Oystercatcher in Tasmania, and estimated current populations to be 2000 and 2000–2500, respectively

Delany and Scott (2006) and Spruzen *et al.* (2006) both adopted the estimates in Bryant (2002) and estimated Tasmania to support approximately 20% of the (Eastern) Hooded Plover and 45% of the national Pied Oystercatcher populations. Taylor *et al.* (2014) reviewed the data in Watkins (1993) and generated initial state-based estimates and a revised global population estimate of 12,000 to 14,000 Pied Oystercatchers, of which 3300 (27.5%) were present in Tasmania.

The estimates generated in the present synthesis represent minima for both species' current populations in Tasmania, as they are based on recent (and ongoing) mapping and census surveys of breeding populations on more than 450 beaches around Tasmania (figure 20). The data for the TW WHA and south coast contribute to the first statewide estimates for both species based on empirical data. Consequently, the estimates generated

here have significantly higher degrees of confidence than previous estimates.

With minimum population estimates of 1850 and 3300 for Eastern Hooded Plover and Pied Oystercatcher, respectively, Tasmania supports no less than some 62% and 30% of the national populations for these taxa. Based on initial analyses of the survey data and of that from the mainland (Adams *et al.* 2019, Maguire *et al.* in press), the greater precision of the Tasmanian data compared to mainland estimates and extrapolations strongly suggests that Tasmania supports even higher proportions of the two taxa's national breeding populations. Ongoing analyses are investigating the relative sizes of breeding and non-breeding populations for both taxa in Tasmania (E.J. Woehler unpubl. data).

Figure 21: *Map showing the distribution of Hooded Plover,* Thinornis cucullatus*, in Tasmania, 1992–93 to 2020–21 (black symbols),* n *= 2300 records as of December 2020. Grid shows 1° x 1° latitude and longitude. Orange symbols indicate surveys where no Hooded Plovers were observed.*

Figures 22 and 23 clearly show the widespread nature of both species in Tasmania, albeit with obvious gaps in Hooded Plovers in the Derwent and Pittwater–Orielton areas and in the central north coast of the State. These gaps reflect the absence of suitable habitats and the high levels of anthropogenic disturbance. The larger gaps in the Hooded Plover distribution (figure 22) reinforces the greater vulnerability of Hooded Plovers compared with Pied Oystercatchers.

Based on the data presented here, it is clear that Tasmania is of national and international significance for both taxa, supporting substantial proportions of their global populations. The analyses reinforce the speculations of Newman (1982) of the importance of Tasmania for Eastern Hooded Plovers almost 40 years ago. Many threats are common to both species (Bryant 2002, Spruzen *et al.* 2006, Maguire *et al.* in press), with the spectrum of threats increasing in frequency and intensity (Woehler in press). With mainland populations of Hooded Plover decreasing more rapidly than those in Tasmania (Maguire *et al.* in press, E.J. Woehler unpubl. data), there can be no doubt that Tasmania is already the refugium for both taxa. As the mainland populations for both taxa decrease, so the proportion of the populations in Tasmania will increase, further reinforcing Tasmania's critical role in the conservation of both taxa.

Figure 22: *Map showing the distribution of Pied Oystercatcher,* Haematopus longirostris*, in Tasmania, 1992–93 to 2020–21 (black symbols),* n *= 3600 records as of December 2020. Grid shows 1° x 1° latitude and longitude. Orange symbols indicate surveys where no Pied Oystercatchers were observed.*

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Numerous PWS staff around Tasmania have provided extensive logistical and other support for the coastal surveys, especially of remote areas and islands over the three decades of the study. Similarly, many land-owners have permitted access to beaches through private property. Recent surveys of coastal lagoons have been supported by fin-fish and shellfish aquaculture companies. Numerous individuals and community care groups have supported the surveys, as have the three NRM agencies. To all, my most sincere thanks.

The surveys have been conducted under multiple

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An overview of the major threats to resident and migratory shorebirds and small terns in Tasmania

Eric J. Woehler, BirdLife Tasmania

Abstract

Threats to resident and migratory shorebirds and small terns in Tasmania were reviewed under 14 categories: off-road vehicles, bicycle riding, dogs, horse riding, beach walking, livestock, invasive plants, native and introduced vertebrate predators, light spill, drones and UAVs, entanglement, coastal and nearshore resource harvesting, urban sprawl, coastal infrastructure and development, and projected sea-level rise. Many of these threats co-occur in time and space, thus generating synergistic pressures on shorebirds and terns, particularly during their breeding seasons. Seven broad recommendations (three for research and four for management) are detailed to aid in the conservation and management of these species in Tasmania.

Focal resident species

The focal resident species for this review are Australian Pied Oystercatcher, *Haematopus longirostris* (hereafter Pied Oystercatcher), Hooded Plover, *Thinornis cucullatus*, Red-capped Plover, *Charadrius ruficapillus*, Fairy Tern, *Sternula nereis*, and Little Tern, *S. albifrons*. Sooty Oystercatcher, *H. fuliginosus*, are included for completeness, but the majority of the Tasmanian population occur on rocky foreshores and offshore islands and are considered to be under fewer threats than their congeners in Tasmania.

Introduction

Coastal areas are amongst the most densely populated and developed areas on the planet (McGranahan *et al.* 2007). In Australia, approximately 21 million people (85% of the national population) live within 50 km of the coast, and more than 6 million live within 3 km of the coast (Smith 2020). In Tasmania, more than 99% of the human population lives within 50 km of the coast, or within an hour's driving. Beach management regimes typically focus on maximising and prioritising recreational opportunities for beach users over environmental issues such as minimising disturbance to coastal-obligate wildlife.

Beach-nesting shorebirds and small terns are facing an increasing spectrum of threats in Australia. These threats are increasing in their intensities, durations and frequencies to the point where human recreational activities are essentially occurring year-round on many beaches and foreshores around Australia. The east and south-east coasts of Australia are used for recreational activities by millions of people annually, often year round. Australians see the coast — and beaches in particular — as a resource: a case of, 'What can we do at the beach?' or 'What can we do with the beach?'.

Natural events in natural systems do not threaten breeding species. In the absence of human disturbance, breeding populations of shorebirds and terns will persist as their breeding and life-history strategies can overcome even catastrophic breeding failures. However, when humans are active on beaches used for breeding by these species, resultant disturbance introduces added cumulative pressures of varying intensity to the extant natural pressures on the breeding shorebirds and terns.

Breeding shorebirds and terns may find the combination of natural and human-related activities overwhelming, resulting in complete breeding failures despite repeated attempts to produce replacement clutches. Persistent disturbance throughout a breeding season may result in a local population decrease and the potential loss of the beach as a breeding locality for the species. The cumulative impacts associated with human activities in addition to natural events are typically beyond the capacities of populations to accommodate, with the result that the breeding population decreases — and, if the pressures persist, the population is extirpated at the site.

Natural events are typically episodic, infrequent and unpredictable in time and space, whereas human activities and associated disturbance to shorebirds is near-constant, frequent and often spatially and temporally predictable — particularly in Australia with our coastal human population and coastal-centric society. Sheltered lagoons and embayments often

provide refugia to breeding shorebirds, providing critical habitats for sustaining their populations with decreased or absent anthropogenic pressures; clearly, these and other identified refugia must be afforded the highest levels of protection.

Survival of shorebird populations depends primarily on sustained breeding success and the survival of the pool of non-breeding and pre-breeding individuals. Pied Oystercatchers and Hooded Plovers are able to produce replacement clutches in response to losses from natural events (Newman 1983, Newman 1986, Weston 2000); Binns (1998) documented the repeated breeding attempts of Fairy Terns in north-east Tasmania that experienced disturbance from human recreational activities. Resident shorebirds have extended breeding seasons, and can take up to three months to raise a single brood and up to five months if there are replacement clutches. Nesting shorebirds can tolerate the vagaries of the weather, which may see nests covered with drifting sand.

The range of human recreational activities on beaches, listed below, is likely to increase in number, frequency, intensity and extent in the future (e.g. sand boarding and 'fat tyre' biking on beaches are novel recreational coastal activities that are gaining traction and commercial interest in Tasmania). This broader range of activities can only increase the level of disturbance to beach-nesting birds, resulting in greater frequency of nesting failure and long-term population decreases. Further, it is likely that the range of activities will occur on previously undisturbed coastal areas that are currently unaffected or impacted, either through remoteness or increasing access caused by changes in contemporary property ownership and/or land management practices.

The increasing use of beaches by people for recreational activities in Tasmania (and throughout Australia) is a major issue with respect to the breeding success of beach-nesting birds, and, ultimately, their long-term survival. Human recreational beach activities occur both above and below the high-water mark and the frequencies of these activities increase substantially in summer months during the shorebirds' and terns' breeding season (Priest 2001).

Within Tasmania, human impacts have been acknowledged as serious management issues both for Fairy and Little Terns (Binns 1998, Bryant 2002), Hooded Plovers (Newman and Patterson 1984, Woehler and Park 1997, Hanisch 1997–98, Bryant 2002) and Pied Oystercatchers (Trinder 1998, Priest 2001). In Tasmania, these are coastal-obligate breeding species that rely on foreshores for nesting, feeding and roosting year-round. More arid conditions inland prevent these species utilising wetlands and saltmarshes away from the coast.

A statewide population decrease in Hooded Plovers in Tasmania between 1982 and 1996 was documented by Woehler and Park (1997). This study showed an accelerated rate of decrease in the final four years of the 14-year study from an earlier 1.6% per year to nearly 5%, indicating clearly that the rate of loss was increasing over time. Local extirpations were noted on several beaches (primarily on the East Coast) and it was considered unlikely that Hooded Plover populations would recover while human disturbance from vehicles and recreational activities, horses and domestic pets continued on beaches around Tasmania. Similar conclusions were made by Bryant (2002), Jones *et al.* (2002) and Spruzen *et al.* (2006).

Clear, statistically significant differences were observed in the behaviours of breeding Pied Oystercatchers in south-east Tasmania between birds breeding in areas disturbed by recreational activities and those breeding at undisturbed sites. Marked differences in nest attendance patterns, frequency of nest departures and the amount of time spent running while attempting to incubate, were all documented by Priest (2001).

Fairy Tern numbers have more than halved in Tasmania since 2010 (E.J. Woehler unpubl. obs., DEE 2020, Greenwell *et al.* in press). Fewer breeding colonies are known, and most colonies support fewer breeding pairs than in the past (Rounsevell 1983, Bryant 2002, Greenwell *et al.* in press, E.J. Woehler unpubl. data). Intensive management efforts to reduce human disturbance to nesting birds during breeding seasons is implemented at a number of colonies, with limited support from the local communities.

Repeated exposure to disturbance can force nesting shorebirds into adopting sub-optimal nesting and feeding habitats with concomitant lower breeding and feeding success rates. Pied Oystercatchers have been observed attempting to nest as far as 200 m inland on sports grounds, roadside verges, pastures and open ground, with very low breeding success. Birds being forced to use remote nest sites and feed their young away from the water line (i.e. fly food to their young) increases the fledging period, increases the predation risk for unattended young while the adults are foraging, and, in the case of oystercatchers, deprives the juveniles of valuable experience in learning how to feed (as oystercatchers are the only shorebird to feed their young). Nesting in these sub-optimal areas also potentially increases the risk of predation to incubating adults.

Paton *et al.* (2000) noted that habituation to human disturbance is often used to justify allowing human recreational activities to continue without controls on the types of activities, sites used or the frequency(ies) of the activities. They found there was no scientific evidence of habituation of shorebirds to human recreational activities, so arguments by recreational vehicle proponents (and other beach users' advocates) that birds become 'accustomed' to human activities on beaches must be ignored until scientific evidence that

demonstrates otherwise is available.

This overview and synthesis draws on earlier reviews by Bryant (2002), Jones *et al.* (2002), Priest *et al.* (2002) and Spruzen *et al.* (2006) that were specific to Tasmania, and from national reviews and species' assessments by Garnett *et al.* (2011, 2013), Garnett and Franklin (2014), Hansen *et al.* (2014), Taylor *et al.* (2104), Jones (2016), Department of the Environment and Energy (2020) and Garnett and Baker (in press). An earlier and shorter review by Woehler (2016) forms the basis for this expanded and updated synthesis. It is not intended to be a comprehensive literature review, instead this synthesis aims to provide an overview to the current state of knowledge with respect to recognised primary and emerging threats to resident and migratory shorebirds and small terns in Tasmania, drawn from recent selected and relevant studies.

Threats

The threats to shorebirds and small terns in Tasmania are examined in this review under the following 14 categories. No implied hierarchy or priority should be inferred from this list or the subsequent material, but see the concluding texts for a brief discussion on synergies and cumulative impacts. Relevant studies in Tasmania are cited in preference to those studies undertaken on the Australian mainland.

- Off-road vehicles
- Bicycle riding
- Dogs
- Horse riding
- Beach-walking
- Livestock
- Invasive plants
- Native and introduced vertebrate predators
- Light spill
- Drones and UAVs
- Entanglement
- Coastal and nearshore resource harvesting
- Urban sprawl, coastal infrastructure and development
- Projected sea-level rise

1 Off-road vehicles

Off-road vehicles (four-wheel drives, trail bikes, motorbikes, quad-bikes and dune buggies) threaten breeding efforts of shorebirds and terns in numerous ways (Bryant 2002, DSEWPC 2011).

(a) Direct impact

Off-road vehicles have a direct impact on breeding success by driving over nests and crushing eggs. There is significant overlap in the parts of the beach used by vehicles and breeding birds. This increased at high tides when vehicles had to drive closer to the dune line. There was a very high probability that a vehicle would run over a nest and its eggs before they had hatched.

Chicks were found to be most vulnerable during the first few days after hatching, when they spend a large amount of time resting high on the beach. Hooded Plover chicks are unable to fly until 4.5 weeks of age (Newman 1986) and Pied Oystercatchers cannot fly until 7 weeks of age (Newman 1991). During this non-flight period, Hooded Plover chicks do not run out of the way of advancing vehicles, but 'freeze' and rely on their cryptic plumage to blend in with the sand. Those that do manage to reach flying age have a better chance of survival and eventual recruitment into the breeding population (Dowling and Weston 1999).

Buick and Paton (1989) observed Hooded Plover chicks 'crouching in wheel ruts' and found that as many as 30% of chicks could be lost to vehicles in the first seven days after hatching. A study in south-eastern Tasmania (Hanisch 1997–98) showed that the findings of Buick and Paton (1989) were repeated in Tasmania, whereby reproductive success was greatly reduced on beaches where off-road vehicles have unrestricted access to nesting habitat of Hooded Plovers.

(b) Indirect impact

Buick and Paton (1989) reported that if vehicles or people stopped close to a nest, incubating Hooded Plovers would vacate the nest for up to an hour at a time, leaving their eggs exposed. If this occurs on hot days, eggs may overheat and the embryo within dies (Weston 2000). Conversely, the embryo may die on cool days if left unattended.

The increasing use of vehicles and trail bikes on Tasmania's beaches increases disturbance to nesting shorebirds and terns during summer (Bryant 2002), the peak of the breeding season. Where the process of vacating the nest is repeated, incubating birds are forced to make frequent trips to and from the nest. This may provide opportunity for scavenging birds to observe their movements and take unattended eggs and/or small chicks (Fletcher and Newman 2010).

(c) Vehicle impact on shorebird food sources

If vehicles repeatedly drive over the same stretch of beach, sand above and below the high-tide line may become compacted, decreasing the density of aquatic invertebrates upon which shorebirds feed (e.g. Buick 1985, Schlacher *et al.* 2008).

2 Bicycle riding

A bicycle's potential impact is as damaging as the previous recreational activities examined above involving vehicles. The same breeding period exists, the nests and eggs in the dry sand zone may be ridden over, flightless chicks may be crushed, and disturbance may result in nest vacation and subsequent breeding failure through predation or heat stress. Repeated disturbance results in increased incubation and fledging periods, which increases the cumulative risk of predation when the chicks are flightless.

It is possible some cyclists would avoid the dry beach sand at the top of the beach because of its relative instability and the difficulty in travelling over it, and

choose the more comfortable firm sand of the intertidal zone. In either location, however, bird-breeding efforts are at considerable risk from beach cyclists.

As with off-road vehicles, indirect impacts can arise when bicycles and people stop close to a nest, as the incubating adults will vacate the nest for up to an hour at a time, leaving their eggs exposed. If this occurs on hot days, eggs may overheat and the embryo within dies. Conversely, the embryo may die on cool days if similarly left unattended. Further, if bicycles repeatedly use the same stretch of foreshore, the substrate above and below the high tide line may become compacted, decreasing the density of aquatic invertebrates upon which shorebirds feed.

3 Dogs

Dogs are a significant component of recreational life in the community, and beaches are favoured venues for enjoying their company. Unleashed dogs are highly disturbing and capable of predation on shorebirds and terns and their eggs (e.g. Weston 2000, DSEWPC 2011, DEE 2020).

(a) Dogs as predators

Dogs are predators at shorebird breeding sites. Dogs eat eggs and kill shorebird chicks. Garnett and Crowley (2000) refer to, 'predators associated with humans such as dogs' as a threat to Fairy Terns, and include predation by dogs among the causes of breeding failure in this species. Bryant (2002) noted, 'dogs, particularly off-lead, are well documented as a major threat to breeding birds particularly eggs and chicks. Surfers have been noted with dogs that are allowed to roam while their owners are surfing, which is also detrimental to breeding birds, both on the beach and in the surrounding areas'.

Juvenile oystercatchers close to fledging may panic during disturbance by dogs, and enter the territories of adjacent breeding pairs, which can result in attacks by other oystercatchers on the juveniles and which creates territorial disputes between adjoining territories. This results in diminished parental care of the juvenile because territory protection is paramount to breeding birds (M. Newman pers. comm.) Newman (1991) recorded dogs had been seen chasing young Pied Oystercatchers and to point them by smell when they were hidden in the vegetation above the high-tide mark; he reported having seen young birds badly mutilated by dogs in this manner.

In a second study in the same region, Trinder (1998) observed several instances of dogs being unleashed by people at beach access points, of the dogs then chasing after the birds present, including Pied Oystercatchers. Trinder added, 'It is likely that the chicks from these territories were lost to dogs'. Other observations exist of direct persecution of shorebirds by dogs (e.g. Weston 2000). Fairy Tern colonies in Tasmania have been subject to repeated attacks by dogs; in some cases dogs have been deliberately released by their owners at the edges of colonies with the apparent aim of disturbing the colony to the point of abandonment (E.J. Woehler pers. obs.).

(b) Dogs attract other predators

Free-ranging dogs on beaches may draw unwanted attention to breeding sites (Hanisch 1997–98). While dogs inspect shorebird nests, they may be watched by predatory birds such as Forest Ravens, *Corvus tasmanicus* (Hanisch 1997–98, Fletcher and Newman 2010), Silver, *Chroicocephalus novaehollandiae*, and Pacific, *Larus pacificus*, Gulls (P. Park, W. Wakefield, E.J. Woehler pers. obs.). Their trails through the sand to the nests are followed by predatory animals including cats, *Felis catus*, and rats, *Rattus* spp. (Hanisch, 1997–98), which may subsequently take eggs and chicks (Dowling and Weston 1999). Incubating adult Pied Oystercatchers may also be taken by predators (Newman 1991), further reducing the reproductive capacity of the species.

(c) Control of dogs

As noted above, Hooded Plover and Pied Oystercatcher chicks often forage along the waterline zone away from the nesting zone. Tern chicks wait at or close to the nest for parental feeding. For all three, chicks are at risk from off-lead dogs. Leashing dogs can almost halve the disturbance to incubating shorebirds (Dowling and Weston 1999). The depredations of wandering dogs in shorebird nesting territories require the strongest preventative actions. Free-roaming dogs and breeding shorebirds are totally incompatible.

4 Horse riding

Horse riding is currently (2020) less frequent on Tasmanian beaches than are other recreational pursuits (Watt 2001). However, this activity is as potentially destructive to breeding Fairy Terns, Hooded Plovers and Pied Oystercatchers as are all other off-road vehicles. Only one or two galloping horses occasionally ridden through the nesting and/or feeding zones, along the whole length of the beach (and perhaps back again) during the breeding season may be sufficient to cause serious impacts to breeding efforts.

The zoning of sections of Five Mile and Seven Mile Beaches (Llanherne Peninsula) for horse-riding results in persistent disturbance to breeding Pied Oystercatchers (M. Newman unpubl. obs.). Illegal horse riding has been observed on sandy beaches on the east and north-west coasts (E.J. Woehler unpubl. obs.) with associated high levels of disturbance to feeding shorebirds and seabirds observed.

The effective camouflage of the eggs, chicks and adults renders them extremely difficult to see. During the lengthy incubation they are exposed to possible crushing from hooves. Bryant (2002) noted, 'if riding occurs at the top of the beach or at high tide, there is a high risk of trampling of both young and eggs.' Newman (1991) recorded that newly hatched Pied Oystercatcher chicks 'are known to have been trampled by horses while crouched near the high tide mark.'

5 Beach-walking

Beach-walking may appear a recreational activity with a low-impact on the survival of breeding and feeding shorebirds. Lawler (1996) suggested that beach-walking has a low-key effect and tended to cause only localised disturbance by interrupting shorebird feeding, alienating parts of feeding areas or forcing some birds to fly short distances to avoid people. However, more recent studies have shown that beach walkers have severe effects on incubating and brood-rearing birds (e.g. Hanisch 1997–98, Weston 2000).

One study found that nearly half (49.5%) of nest disturbances were caused by walkers without dogs (Weston 2000); walkers on beaches tend to space themselves out, creating multiple, repeated disturbances and prolonged effects on incubating and brooding Hooded Plovers. Foot traffic passing nests on beaches resulted in Hooded Plovers vacating their nests on most occasions (Buick and Paton 1989).

Incubating shorebirds have been observed to stand then move away from the nest when human intruders approached within 50 m of the nest (reviewed in Weston *et al.* 2012). During one observation period in the latter study, a brooding pair spent their entire time, when not foraging in the wave-wash zone, running from intruding people and performing anti-predator distraction displays because they had chicks nearby.

Disturbance by walkers can have several possibly serious consequences:

- Walkers cause the birds to spend more time off nests so disruption in incubation results; this can reduce hatching success by causing thermal stress in eggs (Weston 2000, Weston *et al.* 2012).
- Walkers reduce brooding time, an especially important activity during adverse weather when exposed chicks chill quickly and weakness increases vulnerability to predators (Hanisch 1997–98). One nest of Hooded Plover chicks was recorded as un-brooded for almost five hours (290 minutes) due to disturbance by walkers; only one chick survived (Weston 2000).
- Walkers reduce foraging time for chicks and displace them from their territory (Weston 2000).
- Walkers severely deplete the birds' vital energy reserves that may lead to loss of physical condition and an inability to brood their chicks and protect them from predators (Hanisch 1997–98, Weston *et al.* 2012).

These effects are multiplied at times of heavy beach use, such as during summer holidays that coincide with the peak shorebird-breeding period. When people stop to rest by sitting on the sand, they exert an additional pressure on incubating or brooding birds in adjacent territories. The birds vacate and will not reoccupy until the people depart.

Egg loss occurs through heat stress and predation, as does chick mortality and predation. Human tracks around nests may also provide a visual cue for scavengers searching for food on the sand. Scavengers such as gulls and corvids may be attracted to food scraps and rubbish left on the beach by walkers and coastal campers (Buick and Paton 1989, Hanisch 1997–98, Greenwell *et al.* in press), contributing further to predation and consequent breeding failure.

Because of their slower pace compared with vehicles and horses, walkers might be expected to have a chance of noticing nests and avoiding them. In reality, nests in the sand are extremely difficult to detect. Binns (1998) recorded walkers disturbing a Fairy Tern colony in the St Helens Point Conservation Area, and Dowling and Weston (1999) found that trampling by people was the primary cause (60%) of Hooded Plover nests being destroyed, and over 70% of chick loss in their study on a Victorian beach.

6 Livestock

Livestock on beaches pose significant threats to shorebirds throughout their entire breeding season. Sheep and cattle access beaches in the absence of fencing or where fencing is derelict (Woehler 2014). Animals are attracted to the beach in search of food and to feed on beach-cast seaweeds and sea-grasses for salts and minerals present in the plant tissue (figures 1 and 2).

Figure 1: *Sheep on an east coast beach. © Eric J. Woehler*

Animals can trample nests, eggs and chicks, any of which will result in immediate nesting failure for the shorebirds and terns nesting on the foreshore (Baird and Dann 2003, Dennis and Masters 2006). Livestock can also disturb nesting shorebirds, resulting in incubating or brooding adults leaving nests with their eggs and chicks exposed to weather conditions and to predatory birds such as gulls, ravens and currawongs. Livestock

can separate adults from mobile chicks, leading to trampling or opportunistic predation by birds. Cattle dung can bury nests, eggs and small chicks, and hoof and foot prints in soft sands can result in traps for small chicks (Woehler and Ruoppolo 2015).

Figure 2: *Cattle eating beach-cast kelp.*
Image from www.taskelp.com, 29 August 2020.

7 Invasive plants

Steane (2009) detailed the efforts and activities of the Sand Dune Reclamation Unit within the Tasmanian Lands Department, which was established in the north-east of Tasmania in 1955 to protect the Waterhouse Soldier Settlement from the large sand dunes on Crown Land. The dunes were encroaching on the pastures of the newly developed farms established under the Waterhouse Soldier Settlement Scheme.

Marram grass, *Ammophila arenaria*, allows high tides and storm surges to erode the base of dunes, while their roots bind the top of the dune, thus forming a near-vertical dune face. The base of the dune is unsuitable for shorebird nesting because of a lack of visibility of approaching predators, potential flooding on high tides or storm surges, and the potential for sand to cover the nest (Park 1994, Bryant 2002).

Most resident shorebirds prefer to nest on an open, native grassed and gently sloping dune face; this makes inundation less likely — they nest higher up the beach (Bryant 2002). Newman and Patterson (1986) noted that Pied Oystercatcher chicks would attempt to hide from predators amongst dune vegetation, including marram grass, but that the marram contributed to lower breeding success because the risk of predators approaching nests was increased. On Five Mile Beach (Llanherne Peninsula), the Pied Oystercatchers often nest on ledges on the steep dune faces that readily crumble, causing eggs to be lost. On other occasions, the disturbance of incubating adults results in eggs being dislodged when the adult flies off the nest (M Newman pers. comm.).

Rudman (2003) identified the threats to Tasmania's coastal ecosystems from five species of invasive beach weeds. Invasive plant species on foreshores can alter beach topography (e.g. marram grass), alienate extensive areas of coastal habitat from beach-nesting shorebirds and terns (e.g. Sea Spurge, *Euphorbia paralias*), and prevent foraging and roosting by all species of shorebirds and terns. Park (1994) briefly reviewed the potential adverse effects of marram grass in Tasmania on nesting habitat for Hooded Plovers and Pied Oystercatchers. Encroachment by invasive plants can substantially reduce the extent of suitable nesting habitat for shorebirds and terns on beaches (Garnett and Crowley 2000, DSEWPC 2011, DEE 2020).

8 Native and introduced vertebrate predators

There are relatively limited quantitative data on nest predation of resident shorebirds and small terns in Australia. Dennis and Masters (2006) describe feral and domestic cats as 'potential predators' of Hooded Plover eggs and young, and Black Rats, *R. rattus*, as likely opportunistic predators of, 'ground-nesting birds'.

Cat densities are thought to be highest near human habitation (Weston 2003). In Tasmania, cats are known to predate Hooded Plover nests (Hanisch 1997–98). Though cats may be active at any time, they are usually more active at night (Urquhart 2000 in Weston 2003), making their activities hard to monitor without use of camera traps. Rats are known to prey on Hooded Plover nests (Hanisch 1997–98). Rakali, *Hydromys chrysogaster*, footprints have been reported on beaches where Hooded Plovers were breeding, and sometimes the tracks were close to nests (Weston 2003). The extent of predation by rakali on resident shorebirds and small terns in Tasmania is presently unknown (figure 3).

Figure 3: *Rakali. © Eric J. Woehler*

Several native species of birds may take eggs and young of shorebirds and terns on beaches (Weston 2003, Fletcher and Newman 2010, DSEWPC 2011, Ekanayake *et al.* 2015, DEE 2020), although these events are typically associated with human recreational activities that have disturbed nesting shorebirds and terns, and, in so doing, have drawn attention to the nests, eggs and young. Silver Gulls have been seen taking Pied Oystercatcher eggs (P. Park in Weston 2003), and Taylor and Taylor (2005), reported kleptoparasitic interactions between Pacific Gulls and foraging Pied Oystercatchers.

9 Light spill

Illumination of foreshore areas at night can result in changes in the foraging behaviours of shorebirds. Studies have shown some shorebird species actively forage at night in illuminated areas using sight rather

than touch, with an associated increase in foraging success (e.g. Santos *et al.* 2010, Dwyer *et al.* 2013).

However, the preference for illuminated areas over naturally lit (moonlight) areas may increase the shorebirds' risk from predators or draw them into less productive areas for foraging, and further studies are required to assess more completely the overall balance between benefits and risks to shorebirds. Strong lights may also disorient birds in flight at night, increasing the risk of collisions between shorebirds (and potentially other species of birds) with infrastructure, vehicles and other structures.

10 Drones and UAVs

No studies have been undertaken on the potential disturbance to shorebirds or terns from drones or Unmanned Aerial Vehicles (UAVs) in Tasmania. There is an increasing use of UAVs elsewhere to survey shorebirds and terns (e.g. Magness *et al.* (2019), Valle and Scarton (2019), and initial reviews provide conflicting results of both increased and decreased potential for disturbance associated with surveys (Borelle and Fletcher 2017, Mulero-Pázmány et al. 2017).

Hodgson *et al.* (2016) surveyed Crested Tern, *Thalasseus bergii*, colonies and Weston *et al.* (2020) presented preliminary data on escape responses to drones, including Flight Initiation Distances (FIDs) in Australian birds. Only one Pied Oystercatcher was able to be included, with a FID of 14.6 m. No other species of Australian shorebird or tern has been involved in systematic investigations into the potential adverse impacts of drones, but caution is warranted.

There is a moratorium on all drone flights within Tasmania's Reserve Estate (https://parks.tas.gov.au/explore-our-parks/know-before-you-go/drones-in-parks) that is frequently ignored. The use of recreational, non-commercial drones around Tasmania's coasts has seen immediate alarm reactions and escape flights by gulls, terns and oystercatchers on multiple occasions (E.J. Woehler unpubl. data). Disturbance of shorebirds and terns at any time — nesting, roosting or feeding — is likely to have adverse effects on the individuals involved.

11 Entanglement

Lindsay and Newman (2014) reported, 'at least' 11 instances of Pied Oystercatchers with injuries arising from monofilament fishing lines entangled around one or both legs. Two dead Pied Oystercatcher fledglings were observed at Orford in November 2005 with both birds' legs completely entangled in one large mass of monofilament fishing line that prevented them from moving away from each other and rendered the birds unable to walk (figure 4); the entanglement was so severe that it was believed to have been responsible for their deaths (P. Park pers. comm.). An adult Pied Oystercatcher was observed with plastic entangled around one foot at Marion Bay in June 2018 by one of the authors (figure 5). The bird was unable to walk properly and was seen briefly on two visits. It was not present during the 2018–19 breeding season after having been observed breeding at Marion Bay since July 2009 (E.J. Woehler unpubl. obs.).

Figure 4: *Two entangled juvenile Pied Oystercatchers. © Priscilla Park*

Figure 5: *Pied Oystercatcher with monofilament on left leg. © Eric J. Woehler*

12 Coastal and nearshore resource harvesting

Commercial and recreational harvesting of bivalve molluscs, *Katelysia* spp., occurs in Tasmania (Taylor 1995, Taylor *et al.* 2014, Tarbath and Gardner 2015). The commercial harvest of *Katelysia* is confined to Ansons Bay in the north-east, but several species of the genus are harvested for private consumption by ethnic communities, particularly in the south-east.

The estimated biomass of the commercial species *K. scalarina* has decreased by 80% between 2012 and 2015 (Tarbath and Gardner 2015); this species is known to be taken by Pied Oystercatchers, but the extent to which there is competition between the commercial and recreational harvests and Pied Oystercatchers is presently unknown. Other potential impacts to oystercatchers from commercial harvesting may arise from disturbance from harvesting operations.

Commercial and recreational harvesting of Bull Kelp, *Durvillaea potatorum*, occurs around Tasmania and King Island. Commercial harvesting is primarily undertaken in the north-west of the state and on King Island. The collection of beach-cast kelp occurs year round from mostly rocky foreshores, and is likely to have a low impact on Red-capped Plovers and Sooty Oyster-catchers nesting in these areas.

Recreational harvesting of beach-cast seagrasses and seaweeds occurs around much of the Tasmanian coast, particularly from sandy beaches on the north and east coasts where people are able to drive their vehicles, often with a trailer attached, onto the beach to collect loads of up to 2 m^3 of material. These collection activities have the same impacts as do those of other vehicles on beaches (see above). Additionally, these activities prevent valuable mineral nutrients returning to the beaches through decomposition, thus removing invertebrate faunas involved in the breakdown of the vegetation. These fauna provide a critical source of prey to shorebirds.

13 Urban sprawl, coastal infrastructure and development

The increased construction of housing, wharves and jetties and other coastal infrastructure is fragmenting coastal areas used for nesting, feeding and roosting by resident and migratory shorebirds and small terns. With the expected loss of coastal habitat from projected sea-level rises (see below), this phenomenon is known as, 'coastal squeeze' (Mills *et al.* 2016). As Australia's human population increases, so will the pressures on coastal areas, further exacerbating pressures on critical coastal habitats. Coastal developments alienate adjoining habitats and reduce the spatial and temporal availability of foraging, nesting and roosting habitats for shorebirds and small terns.

So far there has been only one attempt to construct a commercial marina and associated coastal community at Lauderdale in south-east Tasmania. This proposal by the Walker Corporation in the early 2000s was defeated on the basis of the expected environmental impacts, including those to migratory shorebirds (Stratford 2009, MacDonald and Feehely 2010).

The channelisation of the Prosser River in 2017–18 by Marine and Safety Tasmania (MAST) resulted in a significant adverse effect on nesting shorebirds (Woehler 2018). Breeding populations of Hooded and Red-capped Plovers and Pied Oystercatchers decreased, and lower breeding success was recorded compared with previous seasons. Numerous cases of intra-specific aggression by adjoining oystercatchers were observed when breeding adults adjusted their territories' extents following the construction and then attempted to access feeding areas throughout the breeding season. Breeding adults and young were consequently forced to cross adjoining territories in order to access foreshore foraging areas.

14 Projected sea-level rise

The potential threat to beach-nesting shorebirds and terns in Tasmania was examined for a subset of 116 beaches and islands in DPIPWE (2016). The study incorporated a series of GIS rules to identify threats to coastal obligate plant species and communities, in addition to nesting shorebirds and terns. The study identified three landscape-scale responses for Tasmania: refugia sites, retreat pathway sites and squeezed-out sites. A series of conservation options were identified to maximise the potential for species' and community persistence in light of projected sea-level rises.

Earlier syntheses examined the potential impacts of climate change more broadly (DPIPWE 2010) and to the fauna values of the Tasmanian Wilderness World Heritage Area (TW WHA) more specifically (Mallick 2013). A consultation draft of the *TW WHA Natural Values Climate Change Adaptation Strategy 2020–30*, which sits under the 2016 TW WHA Management Plan and complements Tasmania's *Climate Change Action Plan 2017*, further examines options for natural values in the TW WHA.

Synergies and cumulative impacts of threats

We can be confident that the pressures on coastal ecosystems and the shorebirds and terns that are dependent upon them will increase in their intensities, frequencies and spatial extents into the future. In addition, novel pressures will emerge, such as ocean acidification, and there will likely be an increase in the frequency and severity of extreme events such as storm surges.

In addition to the adverse effects of individual recreational activities, a further and greater concern is the combined, or synergistic, impacts that arise from multiple pressures or activities co-occurring in time and/or space. A number of activities may coincide, that is, they may be concentrated to certain times such as the summer holidays that occur in the middle of the breeding period, or on long weekends, or activities may focus on one particular part of a particular beach. The inter-action(s) between and among the various effects of these activities in time and space can result in greatly multiplied impacts on shorebirds and terns.

Climate change will act synergistically with all these existing pressures and modifiers to the marine and coastal environments, which will potentially realise additive or multiplicative responses from the current, already perturbed coastal and marine environments (Halpern *et al.* 2008). The present cumulative impacts will, with the addition of climate change, incorporate additional modifications and perturbations, further altering coastal ecosystems' health and functions. The cumulative impacts arising from multiple modifications and perturbations are more likely to result in unexpected and unpredicted outcomes from interactions (Halpern *et al.* 2008).

Conclusions and synthesis

The pressures on breeding and migratory shorebirds and breeding terns from human activities in coastal areas of Tasmania have increased dramatically in the last 20 years, and in particular since 2010 with strong government promotion of Tasmania's east coast in particular, for tourism. An ever-increasing spectrum of threats and pressures from private and commercial activities are occurring more frequently for longer periods on more beaches as human activities in coastal areas increase disproportionately more rapidly than our population increase.

Many of the resident shorebird and tern species are long-lived. Based on banding studies, Pied Oystercatcher are known to live for more than 34 years (Newman and Woehler 2017, E.J. Woehler unpubl. data), Hooded Plover live for more than 18 years, and Fairy Tern live for more than 22 years (https://www.environment.gov.au/topics/science-and-research/bird-and-bat-banding/banding-data/search-abbbs-database). Survey data spanning three or four decades are required to provide meaningful, albeit initial, assessments of breeding population trends in such long-lived species. Population data spanning shorter time periods are less likely to provide insight into observed trends.

As early as the mid-1990s, breeding populations of Hooded Plovers on beaches in south-east Tasmania and on the Tasmanian east coast were known to be decreasing, with some beaches having lost their entire complement of resident Hooded Plovers since the start of dedicated coastal surveys in 1982 (Woehler and Park 1997). Long-term population survey data exist for many of Tasmania's beaches (see Woehler article page 19), and recent analyses of long-term data have shown decreases in Hooded Plover breeding populations at several east coast beaches since the early 1990s (Smith 2020). Associations between disturbance arising from human recreational activities and decreases in Hooded Plover and Pied Oystercatcher breeding populations were identified.

Decreases and losses of breeding shorebird and tern populations are not confined to the east coast of Tasmania, and are solely due to the increased regime of disturbance during the summer months from vehicles, dogs, horses and humans on beaches. Sadly, these population decreases have been observed to occur inside the Tasmanian Reserve Estate; breeding inside a National Park in Tasmania does not afford a resident shorebird or tern any additional protection from the threats identified in this review. In fact, nesting inside a National Park is likely to present a *greater* spectrum of threats and pressure to nesting shorebirds and terns because of the Tasmanian Government's efforts to direct as many people as possible from within the state and from the mainland to Tasmania's beaches.

Recommendations

The following recommendations have been identified as research foci to provide further data to monitor breeding populations and to provide data that will permit assessment of the efficacy of any management strategies and frameworks:

1. Ongoing censuses of breeding populations state-wide of resident shorebirds and small terns to maintain currency in breeding population estimates for all species — without such data, populations' status and trends cannot be assessed;
2. Demographic studies — in particular to determine the causes of breeding failures in all focal species — and studies that will investigate the longevity and dispersion of individuals; and
3. Further research on projected sea-level rise as a habitat fragmentation process — i.e. revisit the investigations reported in DPIPWE (2016) with all relevant contemporary data.

The following recommendations have been identified as management foci to reduce the threats during the critical breeding seasons:

1. Greater protection for small terns at all breeding colonies, including those on the Bass Strait islands;
2. Greater enforcement of existing restrictions of dogs and vehicles on beaches;
3. Greater legal protection for the natural coastal values in Tasmania under State legislation; and
4. Greater involvement of aboriginal communities in all aspects of coastal management and conservation statewide, particularly on the Bass Strait islands.

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