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Some observations of Australian Pied Oystercatcher on Worimi Conservation Lands

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Survey records of Australian Pied Oystercatcher *Haematopus longirostris* (oystercatcher) on the Worimi Conservation Lands (WCL) from 2014-2017 were analysed. Nine breeding territories were identified on the northern section of WCL. Between 5 and 7 of these territories were occupied during the breeding season from August to December. The mean distance between occupied territories was 1.2-1.3 km and the annual breeding density was 0.7-0.9 pair/km. During the breeding season non-breeding birds were displaced to other sections of WCL or dispersed to other locations, returning in the non-breeding season.

The age structure of the population varied from month to month, although adult and immature (2+ year) birds predominated. Numbers declined temporarily in September at the start of the breeding season. The sporadic presence of banded birds from Victoria and northern New South Wales provides evidence of long-distance movement of birds to and from WCL.

The distribution of oystercatchers on WCL is strongly influenced by morphodynamic processes operating along the beach. The northern section of beach has dissipative characteristics that support higher biodiversity and prey availability. The southern section has reflective characteristics with potentially lower prey availability. Breeding pairs of oystercatchers preferentially established their territories along the northern section of the beach where high densities of Pipis *Donax deltoides* were present. The lower prey availability on southern sections of WCL may be a factor influencing temporary movements of non-breeding birds to other locations during the breeding season. The increase in oystercatcher numbers since 2009 corresponds with an increase in commercial Pipi stocks over the same period.

INTRODUCTION

Worimi Conservation Lands (32° 48'S, 151° 56'E), extend 25.5 km along Stockton Bight, between Fern Bay and Anna Bay. The southern boundary is 5.7 km north of the Hunter River mouth and the northern boundary is at Birubi Beach. WCL comprises 4,029 ha of ocean beach, sand hills and coastal woodland. The beach has a concave shape facing south-east. It is bordered in most part by a frontal dune with a wide swale to the rear. Mobile sand hills up to 40 m high and 1- 2 km wide are present behind the swale and merge to the north with stabilized sand hills covered by a variety of coastal woodland communities (Office of Environment and Heritage 2015). WCL forms part of the Worimi National Park. The location is shown in **Figure 1**.

WCL is owned by the Worimi community and leased to the NSW Government to be jointly managed on behalf of the traditional owners. NSW National Parks and Wildlife Service (NPWS) conducts day to day management (Office of Environment and Heritage 2015). Birubi Beach is located at the northern end of WCL and is used extensively by recreational beach goers while the remainder of the beach is used by 4WD vehicles and fishermen.

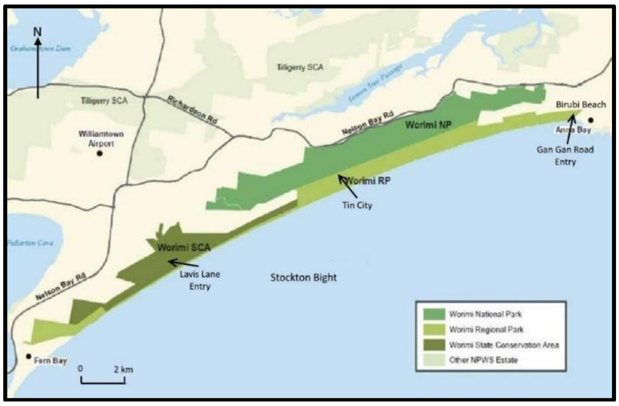

Figure 1. Location map, Worimi Conservation Lands

A population of 50-100 Australian Pied Oystercatcher (oystercatchers) is present along Stockton Beach on Worimi Conservation Lands (WCL). This population, together with those in adjacent Port Stephens, is the largest in New South Wales with 150-200 birds recorded in winter and summer surveys in 2016 (Stuart 2017). In the non-breeding season the birds are present as mixed flocks of adult and immature birds mainly along the northern two-thirds of the beach. During the breeding season, pairs of adult oystercatchers establish defended territories along the northern section of the beach. The displaced non-breeding birds form flocks generally to the south of these territories. The main source of food for oystercatchers on WCL was observed to be Pipis, *Donax deltoides.*

A previous review of avian surveys on WCL from 2009 to 2013 (Lindsey & Newman 2014) documented known breeding attempts by oystercatchers and noted that 'breeding is primarily restricted to an area approximately seven kilometres in length near and north of Tin City'. Russell & George (2012) identified five breeding territories within a 4 km section of beach in the north of WCL. The current study analysed records of oystercatchers from surveys of WCL to determine the following:

- the number, location and size of oystercatcher territories present during the breeding season;
- changes in the distribution of oystercatchers between the breeding and non-breeding seasons; and
- temporal changes in population numbers and age structure.

To provide context for these observations, some of the factors influencing the distribution of oystercatchers have been qualitatively assessed.

METHODOLOGY

Between 2009 and 2017, 70 surveys were conducted by members of the Hunter Bird Observers Club (HBOC) and NPWS Visitor Services personnel from the Worimi community. NPWS provided a 4WD vehicle for the surveys. The surveys commenced on an *ad hoc* basis in 2009, but since 2014 have been conducted monthly except when adverse weather makes the beach inaccessible. The surveys were conducted on the day prior to the monthly Hunter Estuary waterbird surveys and occur close to high tide, between 8.30 and 11.00 am. The survey route was divided into three sections of roughly equal length; from the southern boundary of WCL to the Lavis Lane entry (southern section), from the Lavis Lane entry to Tin City (central section) and from Tin City to the Gan Gan Road entry (northern section) (see **Figure 1**). Numbers of all species present were recorded and locations of oystercatchers were identified using GPS. Counts of oystercatchers with fully developed plumage (includes adult and 2-3 year-old immature birds), first-year birds and dependent young were recorded, together with any distinguishing features such as leg bands, injuries or deformities. First-year birds were distinguished by the partial dark bill tip, dull orange orbital ring and dull greyish-pink legs. Dependent young were birds that remained with parents, including when fledged (i.e. capable of flight).

The distribution of oystercatchers during the breeding and non-breeding seasons was analysed for years 2014-2017. The breeding season on WCL is from August to December. This corresponds with the southern Australian breeding season as reported by Marchant & Higgins (1994). There are no records of breeding outside of these months.

Records from breeding season observations for each year were plotted using a GIS system and the distance from the Gan Gan Road entry determined. Clusters of records of adult pairs and single adult birds occupying defended territories or adult birds accompanied by dependent young in the same location over several months were identified as breeding territories. (The latter point assumes adult pairs with recently fledged young do not relocate during the breeding season.) The location of territories was further confirmed by comparison with records of previous known breeding attempts (nests with eggs or adults with dependent young).

When a territory for a particular year was identified, the mean of monthly distances from the Gan Gan Road entry was determined to estimate the centre of each territory. Territory centres were determined separately for each year. Breeding density for each year was calculated as the number of breeding territories/km of occupied beach. The distance to flocks of non-breeding birds outside the territories was also determined. Reporting rates were determined for the presence of oystercatchers in the three survey sections for the breeding and non-breeding seasons.

To provide an insight into short-term change in total numbers, the mean monthly totals were determined for 2014-2017. The age structure of the population was analysed by determining the monthly numbers of first-year and older birds (2+ years) present from 2014-2017. Dependent young were included with first-year birds.

To provide some context for a discussion of the distribution patterns and temporal changes in oystercatcher numbers, the morphodynamics of the beach and information on Pipi abundance were qualitatively evaluated.

RESULTS

The monthly survey data showed that from January to July, oystercatchers were distributed along all sections of WCL in mixed flocks of adult and immature birds. However, from August to December, a number of pairs established defended territories along the northern section of WCL while the displaced non-breeding birds formed flocks away from these territories.

The distance to the centre of each territory from the Gan Gan Road entry and the distance apart for years 2014-2017 are summarized in **Table 1**. The data indicate that as many as nine territories were occupied at various times over the period with territories 2, 3, 4, 5 and 7 being the most consistently occupied.

In 2014 six territories were identified extending from 5.2 to 11.8 km south of the Gan Gan Road entry. The breeding density was 0.9 pair/km. The most distant territory was located 1 km south of Tin City. The mean distance between occupied territories was 1.2 ±0.4 km. All flocks of non-breeding birds were located 1.1 to 13.3 km south of the territories.

In 2015 seven territories were identified extending from 2.6 to 10.2 km south of the Gan Gan Road entry. The breeding density was 0.9 pair/km. The most distant territory was located 0.6 km north of Tin City. The mean distance between occupied territories was 1.3 ±0.4 km. All flocks of non-breeding birds were located 2.3 to 10.4 km south of the territories.

In 2016 six territories were identified extending from 3.0 to 11.2 km south of the Gan Gan Road entry. The breeding density was 0.7 pair/km. The most distant territory was located 0.4 km south of Tin City. The mean distance between occupied territories was 1.2 ±0.5 km. Flocks of non-breeding birds were located 0.7 to 2.9 km north and 1.0 to 14.3 km south of the territories.

In 2017 five territories were identified extending from 4.3 to 10.3 km south from the Gan Gan Road entry. The breeding density was 0.8 pair/km. The most distant territory was located 0.6 km north of Tin City. The mean distance between occupied territories was 1.2 ±0.5 km. Flocks of non-breeding birds were located 1.5 to 4.1 km north and 1.7 to 11.3 km south of the territories. In September a flock of non-breeding birds was recorded between the two southern territories.

The numbers of breeding territories identified for each year and their centres should be treated with some caution. As nesting sites are established in the swale some distance behind the beach (Russell and George 2012), all birds and territories may not have been located by the monthly surveys which were restricted to the beach. For some territories only one record was available over the annual breeding season and in other instances only one bird was observed on a territory. For some territories, the determined centre points were only 600 m apart creating some uncertainty regarding interpretation of which pair occupied a territory. Also, some pairs that established territories may not have bred.

All of the identified territories and confirmed breeding records are located on the northern section of WCL along a section of beach extending from 2.6 km south of the Gan Gan Road entry to 11.8 km south, near Tin City.

Table 1. Distance to centre of territories from the Gan Gan Road entry with standard deviation and distance apart for 2014-2017.

	Territory	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2014	Distance from Gan Gan Rd. entry (km)	-	-	5.2 ±0.1	7.2 ±0.2	8.1 ±0.0	-	9.9 ±0.0	11.0 ±0.1	11.8 ±0.2
	Distance Apart (km)				1.9	1.0		1.8	1.1	0.9
2015	Distance from Gan Gan Rd. entry (km)	2.6 ±0.0	4.5 ±0.1	5.4 ±0.1	6.6 ±0.4	8.1 ±0.2	9.5 ±0.2	10.2 ±0.2	-	-
	Distance Apart (km)		1.9	0.9	1.2	1.5	1.4	0.7		
2016	Distance from Gan Gan Rd. entry (km)	3.0 ±0.4	3.8 ±0.1	5.0 ±0.1	6.9 ±0.0	7.7 ±0.2	-	-	11.2 ±0.3	-
	Distance Apart (km)		0.8	1.2	2.0	0.8			3.5	
2017	Distance from Gan Gan Rd. entry (km)	-	4.3 ±0.1	5.4 ±0.1	7.2 ±0.1	7.8 ±0.1	-	10.3 ±0.0	-	-
	Distance Apart (km)			1.1	1.8	0.6		2.5		

To quantify the change in distribution of oystercatchers between the breeding and non-breeding seasons, reporting rates were determined for the three survey sections along WCL for the period 2014-2017. The results are presented in **Table 2**.

Table 2. Reporting rates, median and maximum counts of oystercatchers for breeding and non-breeding seasons for survey sections, 2014-2017.

Breeding Season August - December					
	No. of Surveys	Records	Reporting Rate	Median	Maximum
Southern section	19	9	47%	0	20
Central section	19	19	100%	6	36
Northern section	19	19	100%	13	48
Non-Breeding Season January - July					
	No. of Surveys	Records	Reporting Rate	Median	Maximum
Southern section	21	8	38%	0	11
Central section	18	16	89%	11	30
Northern section	18	18	100%	22	52

The data show that during the breeding season, fewer numbers of oystercatchers are present on the northern section compared to the non-breeding season. At the same time, numbers in southern and central sections increase. Conversely, during the non-breeding season, there are increased numbers present in central and northern sections while in the southern section they are recorded infrequently. The reporting rate in the northern section (100%) remains constant during both seasons. During the breeding season, the reporting rate in the central section increases from 89% to 100% while in the southern section it increases from 38% to 47%, consistent with the birds being displaced from the northern section. As breeding activity finishes, newly fledged birds, immature birds and non-breeding adults form large flocks along the northern and central sections of WCL.

The variation in the mean monthly count of oystercatchers for 2014-2017 is shown in **Figure 2.** It reveals a pronounced reduction in mean numbers in September.

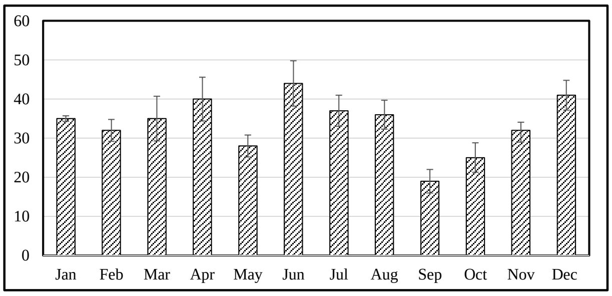

Figure 2. Mean monthly oystercatcher count and standard deviation, 2014-2017

The long-term trend of monthly oystercatcher numbers on WCL since the commencement of surveys in 2009 is shown in **Figure 3**. It shows that numbers vary considerably from month to month but overall there has been a steady increase since 2009. Post 2014 there may have been some under-reporting of numbers as surveys were restricted to the beach foreshore at high tide. Other factors that may impact the numbers recorded are prevailing weather, breeding activity, human disturbance and disturbance by predators.

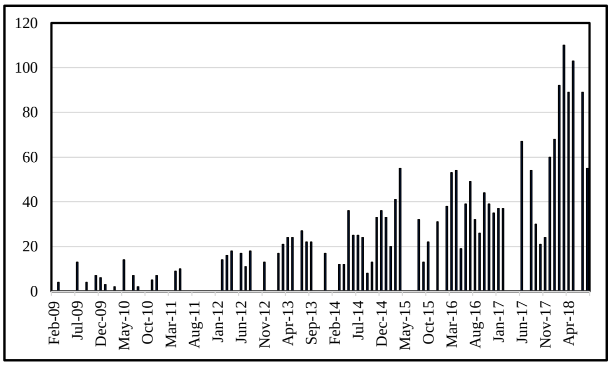

Figure 3. Monthly oystercatcher count, 2009-2018

To evaluate the age structure of the flocks on WCL and identify any temporal patterns of change, the numbers of first-year and older birds (2+ years) were determined for surveys from 2014 to 2017. The results are presented in **Figure 4**. There were a limited number of monthly surveys in which the age structure of all flocks was recorded. The chart shows that older birds comprise the majority (mean 63%) of the population over the survey period but with no consistent monthly trend. Difficulty in distinguishing the age of some 1- and 2-year-old birds may have resulted in first-year birds being over-reported as they approach their second year.

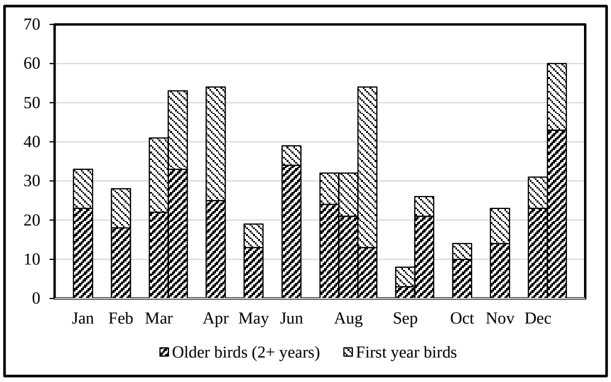

Figure 4. Age structure for monthly oystercatcher population, 2014-2018

DISCUSSION

Breeding season distribution

This study has further refined details of the number and distribution of breeding territories established by oystercatchers on the northern section of WCL, between August and December each year. Nine territories have been identified that were occupied at various times over the period 2014-2017 (**Table 1**). However, most pairs appear to be unsuccessful as there is a lack of evidence of recently fledged young on territories. The location of the territories agreed generally with the location of breeding territories reported by Lindsey & Newman (2014) and Russell & George (2012). However, the extent of territories was greater than recorded by Russell & George (2012) who identified five breeding pairs occupying approximately 4 km of beach, from a nest site 7.1 km south of the Gan Gan Road entry. This corresponded to territory 4 in **Table 1**. In all the years analysed in this paper, one or more territories was recorded north of those described by Russell & George (2012). This observed increase in the extent of defended territories corresponds to an increase in the total number of oystercatchers present and the number of breeding pairs in some years. The availability of food, Pipis, may have been a factor influencing the expanded distribution and will be discussed in a later section.

The distance between occupied territories varied from 0.6 to 1.9 km (**Table 1**) and the mean breeding density varied from 0.7 pair/km in 2016 to 0.9 pair/km in 2015. This is slightly less than the density recorded on Seven Mile Beach near Hobart in Tasmania, another ocean beach (M. Newman pers. comm.)

The southern limit of the territories remained around 1 km south of Tin City over the study period. In 2014, the closest territory to the Gan Gan Road entry was 5.2 km distant. In subsequent years territories were established as close as 2.6 km to the entry (**Table 1**). As territories extended to the north, pairs would have encountered increasing levels of disturbance due to recreational beach activity. This extension could represent newly established breeding pairs trading off greater levels of disturbance for access to greater food availability. However, it may also be a function of the change in nesting strategy from beach front to swales behind the fore dune, as described by Russell & George (2012). Potentially, this strategy was not impacted by recreational beach activity as much as nesting on the beach. However, it is highly inefficient with unknown, but probably minimal breeding success; forcing birds to fly in food for chicks and consequently delaying/limiting foraging lessons for young. (Oystercatchers are the only shorebird species which are fed by adults.) The New South Wales Scientific Committee (2008) nominated human disturbance as a key threatening process in oystercatcher breeding success.

During the breeding season the non-breeding birds are displaced to areas distant from the defended territories. Increased numbers were recorded along the southern section of WCL during the non-breeding season (**Table 2**). Non-breeding birds were recorded at least 1 km or more away from the nearest breeding territory. In 2014 and 2015 all of the displaced birds were recorded to the south of the defended territories. However, in 2016 and 2017 flocks of non-breeding birds were also recorded to the north of the defended territories. These northern flocks of non-breeding birds may be trading off increased human disturbance for access to greater food availability. The record of a flock of non-breeding oystercatchers between the two southern territories in September 2017 may have been a flock moving through the area of defended territories.

The displacement of non-breeding oystercatchers from territories at the commencement of the breeding season corresponds with a decrease in mean numbers in September (**Figure 2**) suggesting that some individuals move away from WCL to locations such as Port Stephens, 10 km to the north. There is a population of 100-150 oystercatchers in Port Stephens (Stuart 2010).

Non-breeding season distribution

During the non-breeding season, oystercatchers return from the southern and central sections of WCL to the northern section. Birds are rarely observed south of the Lavis Lane entry in the non-breeding season. This is illustrated in **Table 2** where the reporting rate for the southern section decreased from 47% to 38% and the median numbers of birds on the central and northern sections increased. Following the end of the breeding season, birds tend to become less dispersed and form large flocks along the northern section of WCL.

Marchant & Higgins (1994) report that some birds remain on their territories all year round, only defending them in the breeding season. This is the case for some pairs on WCL. However, the identifiable pair 'Hoppy' and 'Peggy' did not remain on their Tin City territory during the non-breeding season. They were recorded over the full length of the central section and part of the northern section, sometimes as part of a flock and on other occasions individually.

It should be noted that the interpretation of distribution of oystercatchers on WCL is based on monthly data which is biased by the survey methodology. All surveys were conducted in the morning, near high tide and only recorded birds on the beach. At that time the majority of birds were roosting in flocks on the upper sections of the beach and birds nesting in the swales and their unfledged offspring would not have been recorded. While the high-tide behaviour was in accordance with studies reported by Marchant & Higgins (1994), it is not known how foraging behaviour at low tide affects the distribution of oystercatchers on WCL.

Regional movements and variation in numbers

Interpretation of monthly change in numbers of oystercatchers on WCL was difficult as the extent of recruitment to WCL from other locations and dispersal from WCL were unknown. It is known that birds dispersing from southern Victoria and northern NSW are present on WCL on occasions (Lindsey & Newman 2014). A number of banded birds have been recorded on WCL: 'VW' banded Corner Inlet, Victoria; 'R4' banded Dart Island, Clarence Estuary, NSW; and 'S3' banded Red Rock, NSW. The latter has been recorded on several occasions in recent years. The bird 'Lucky' which was rescued, banded (silver metal band on right tibia) and released on WCL in March 2014 has been noted as absent from WCL for several months at a time during 2014-2017. Marchant & Higgins (1994) report seasonal movements by sections of oystercatcher populations along the coast and in some instances, long-distance movements. This was probably happening at WCL with regular movement to and from Port Stephens. The temporal change in the age structure of the population shown in **Figure 4** indicates that the composition was highly variable. Marchant & Higgins (1994) report oystercatchers show some fidelity to non-breeding flocking sites, although there was much movement between flocks by individuals, both between years and within one season. It is thought that a similar pattern of movement occurs on WCL.

Lindsey & Newman (2014) noted that the number of oystercatchers on WCL increased over the period 2009-2013. This trend has continued over the period of this study. **Figure 3** shows a steady increase since 2009. Lindsey & Newman (2014) concluded that until 2011, the majority of birds on WCL were 'mainly resident breeding adults' and since then it is thought that numbers have increased as more non-breeding adult and immature birds use the beach. Over the period 2014-2017, first-year oystercatchers was 37% (mean value) of the population but numbers were highly variable (**Figure 4**). It is noted that the number of breeding pairs on WCL could not produce the observed increase in oystercatcher numbers and that the majority of the increase has resulted from the recruitment of birds dispersing from other locations.

Factors influencing distribution

There are many factors that influence the distribution of oystercatchers along ocean beaches. Some of these are availability of food, beach morphodynamics, fore dune geometry, density of avian competitors, human disturbance, 4WD vehicles, weather and tidal cycles (Marchant & Higgins 1994, Owner & Rohweder 2003, Harrison 2009). Two of these, beach morphodynamics and availability of food, are considered here to explain the steady increase in numbers since 2009 and why defended territories are established exclusively on the northern section of WCL. Marchant & Higgins (1994) report oystercatcher food consists of molluscs, worms, crabs and small fish. On WCL, oystercatchers are observed foraging almost exclusively on Pipis plus the occasional beach worm. However, foraging observations have been made dominantly at high tide. Prey availability and foraging behaviour at low tide has not been observed.

Stockton Beach is continually nourished by sediment transported out to sea by the Hunter River and by material dredged from Newcastle Harbour and dumped offshore near the southern end of the beach. Hydrodynamic processes including waves, tides and inshore currents transport the sediment to the north along the beach (WorleyParsons Resources and Energy 2012) sorting the sand grains in the process. Sand on the southern end of the beach is poorly sorted, beach conditions are soft and the frontal dune is variable (Office of Environment and Heritage 2015). The beach tends to be steeper with a narrow face comprised of coarse-grained sediment and a narrow, shoaling surf zone. Waves break abruptly on the intertidal zone. Wright & Short (1984) and Short (1999) classify this as a reflective beach. On the northern section of the beach the sand is well sorted, fine grained and beach conditions are firm. The beach is wider and flatter, and the frontal dune system is more intact (Office of Environment and Heritage 2015). Waves break far from the intertidal zone, dissipating their energy progressively along a wide surf zone. Wright & Short (1984) and Short (1999) classify this as a dissipative beach. Observations from monthly surveys and examination of satellite imagery indicate the dissipative section of beach extends approximately 12.5 km south of the Gan Gan Road entry.

Jones & Short (1995) and Short (2000) have shown that as beaches become more dissipative, biodiversity increases. Murray-Jones (1999) recorded Pipis forming dense aggregations in the subtidal and intertidal regions of high-energy, dissipative beaches which support large blooms of surf diatoms from the mouth of the Murray River, South Australia to Fraser Island, Queensland. Owner & Rohweder (2003) and Harrison (2009) demonstrated that prey availability/Pipi abundance and hence oystercatcher abundance was directly related to beach morphology in northern NSW. It is therefore considered that maximum prey availability on WCL occurs on the northern dissipative section of beach, and that oystercatchers preferentially establish breeding territories in this area. The work of Murray-Jones (1999) who regularly sampled Pipi abundance on a 6 km section south of Birubi Beach from July 1995 to November 1997 supports this postulation. She reported high densities of large Pipis present in aggregations across the sample locations. Significant temporal variation in the density and location of Pipi aggregations was observed.

The Sydney Fish Market Annual Reports (2006-2017) show that for much of the period from 1993/94 to 2009/10, Stockton Beach provided over 50% of the total NSW commercial Pipi catch. In 2009/10 the fishery collapsed due to overfishing (McKenzie & Montgomery 2012). The New South Wales Scientific Committee (2008), when determining the endangered status of the Pied Oystercatcher, noted that a key prey species, the Pipi, had undergone a severe long-term decline as a result of commercial over-harvesting. Pipi resources, and consequently commercial catch in NSW have increased steadily since 2010/11 and in 2016/17, 298 tonnes were harvested (Sydney Fish Market Annual Reports 2006-2017). This has been supported by a regimen of enhanced regulation and improved management of Pipi stocks. Commercial harvesting of Pipis on Stockton Beach has continued over this period. Although there is only limited quantitative data for Pipi numbers on WCL, the increase in monthly oystercatcher numbers from 2009 to present (**Figure 3**) reflects the trend of increasing commercial catch over the same period.

A consequence of pairs establishing defended territories in areas of maximum prey availability is that non-breeding birds are forced onto the intermediate and reflective beach sections where prey availability was likely to be less. This may be the reason for the decrease in mean numbers in September (**Figure 2**) as non-breeding birds disperse temporarily to other areas such as Port Stephens. It may also explain why at times flocks of non-breeding birds remain on the northern-most part of WCL during the breeding season (**Table 1**) where they trade off increased levels of disturbance from recreational beach users for increased prey availability.

CONCLUSIONS

The establishment of breeding territories on the northern section of WCL by oystercatchers during the breeding season reflected the higher availability of prey in this area. The higher availability of prey in turn reflects the morphodynamics of a dissipative style of beach supporting high biodiversity including algal blooms that provide food for filter-feeding Pipis. The extent of breeding territories closely corresponds with the extent of dissipative beach.

During the breeding season, non-breeding birds are displaced to areas of WCL with lower prey availability or areas with higher levels of disturbance. This may be the reason some birds disperse temporarily to other locations. Following the breeding season, displaced birds return to areas of high prey availability on the northern section of WCL. Additional surveys at low tide are recommended to confirm distribution of oystercatchers along WCL in response to the varied foraging opportunities.

The age structure and population size of oystercatcher on WCL varies from month to month, indicating that interchange with other populations is continuous. Temporary recruitment from distant regions to the south and north is part of this process. Overall, the majority of the population are adult and immature (2+ years) birds. The increase in numbers of oystercatchers on WCL corresponds to an inferred increase in Pipi stocks over the period of the surveys. For this increase to be sustained long term it is essential that management practices by Fisheries NSW ensure high Pipi stock levels are maintained.

The mean breeding density of oystercatchers on WCL is slightly less than that of similar high-energy beaches studied in Tasmania. Furthermore, not all possible territories appear to be occupied from year to year, and the territories identified do not cover the full extent of potentially suitable beach. This suggests that WCL could support more breeding pairs, if conditions were suitable. It may also indicate the level of disturbance is a deterrent to breeding for less experienced birds.

The activities of recreational beach users and the secondary impact of their activities in attracting avian predators to WCL undoubtedly influence the manner in which oystercatchers use the beach at WCL, particularly in the northern section. However, the adoption of nesting behind the fore dune and the presence of flocks of non-breeding birds near the Gan Gan Road entry suggest that some birds are prepared to trade off a level of disturbance for access to areas with high prey availability.

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