Chalcoponera sp. – adults, *Pheidole* sp. – alate adults; Arachnida, Araneae, Lycosidae (wolf spiders) – adult. Chordata, Aves, Zosteropidae: *Zosterops lateralis* – nestling; Passeridae: † *Passer domesticus* – nestling. Mammalia, Canidae: † *Vulpes vulpes* – carrion.

Grey Currawong *Strepera versicolor*

P; Dicotyledons, Rosaceae: † *Pyracantha angustifolia* – fruit, † *Pyracantha fortuneana* – fruit.

Australian Raven *Corvus coronoides*

P; Dicotyledons, Moraceae: † *Morus alba* – fruit, † *Morus nigra* – fruit.

A; Arthropoda, Insecta, Isoptera, Rhinotermitidae (termites): *Coptotermes* sp. – adults (soldiers, workers); Orthoptera, Acrididae (grasshoppers): *Austroicetes* spp. – adults, nymphs, *Phaulacridium vittatum* – adults, nymphs, *Praxibulus* sp. – adults, nymphs; Coleoptera, Scarabaeidae (scarab beetles): *Anoplognathus* sp. – adult. Chordata, Mammalia, Muridae: *Rattus* sp. – adult.

The Effect of Prevailing Wind Direction and Tidal Flooding on the Reproductive Success of Pied Oystercatchers *Haematopus longirostris*

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Prevailing wind direction may influence nest site choice and reproductive success for some species of birds. Cactus Wrens *Campylorhynchus brunneicapillus* positioned nests in the direction of the wind to reduce thermoregulatory overheating (Facemire *et al.* 1990). Several species of raptors faced nests into the wind for the purpose of taking flight (Lokemoen & Duebbert 1976). However, nesting in the face of prevailing winds may be disadvantageous to shorebirds (Charadriiformes) that place eggs on the ground near the water edge. Winds may increase tidal height and wave action, particularly during spring tides and storms, flooding eggs and nest sites. (Hartwick 1974; Burger 1984; Pugh 1987; Lauro & Burger 1989; Bildstein *et al.* 1991). Yet, general nest location (e.g. in the lee of prevailing winds) or the topography of the nest site (e.g. nest elevation or distance to water) may provide protection from wind-induced tidal flooding. However, very little information is available on how the combination of habitat selection, winds and tides affect reproductive success of coastal birds. This is because destructive environmental events occur sporadically and are difficult to document.

Oystercatchers (Haematopodidae) are shorebirds that breed along the coastlines of the world (Hayman *et al.* 1986). Their nests may be vulnerable to the effects of tidal flooding since they are often placed at close distances to the water edge at elevations just above the high tide line (Hartwick 1974; Lane 1987; Lauro & Burger 1989). This study examined how the general location of nests with respect to prevailing wind direction influenced tidal flooding and reproductive success of Pied Oystercatchers *Haematopus longirostris* at the Furneaux Islands, Bass Strait, Tasmania. The Bass Strait is located in the 'the roaring forties' and is known for its windy climate (Edgecombe 1986).

Methods

The study was conducted during the 1988–89 and 1989–90 field seasons at two main study sites: (1) on the west coast of Flinders Island (40°00′S, 148°00′E), the large Island of the Furneaux Group, from the area of Blue Rocks south to Fergusons Jetty; and (2) on Big Green Island (40°11′S, 147°59′E), a small island three kilometres west of the village of Whitemark on Flinders Island (Fig. 1). Nests on the west coast of Flinders Island were in the direct path of prevailing westerly winds while nests on Big Green Island were located mainly in the lee of winds.

In the 1988–89 field season, distance to the high tide line and elevation was measured at breeding sites

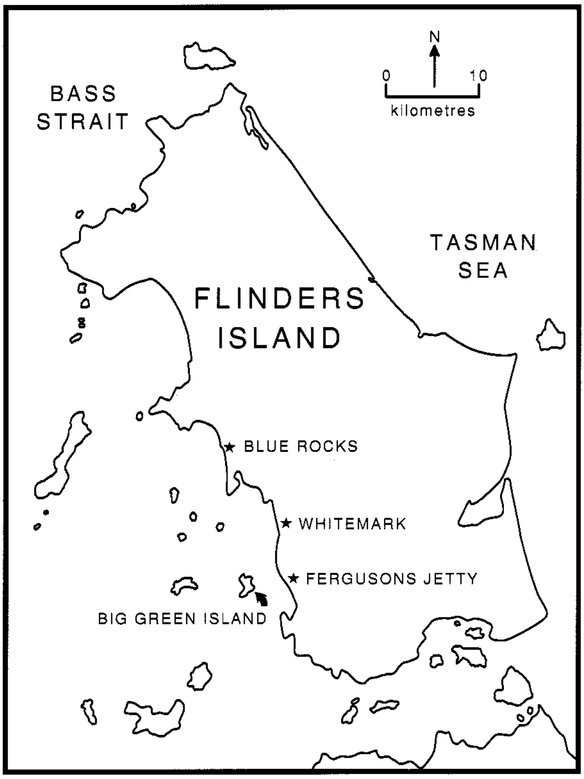

Figure 1 Map of the Furneaux Island Group illustrating study locations.

to examine susceptibility to tidal flooding. These habitat characters were measured at each nest site and at one random site around each nest site. Random sites were compared to nest site characteristics to determine how Pied Oystercatchers selected nest sites with respect to surrounding habitat. A random site was selected within a 100 m radius of a nest. The coordinates of a random site with respect to a nest were chosen from a random numbers table. Further, nest site characters were compared at Flinders Island and Big Green Island to determine whether topographic differences at the two sites influenced susceptibility to tidal flooding.

The elevation of nest and random sites were measured with respect to the high tide line using a clinometer and were then converted to height above sea level for data presentation. The high tide level for a day was assumed to equal the height above sea level on tidal charts. Data were collected on fine days (low wind, no storms) when the high tide level was not likely to vary from the predicted height on tidal charts.

Reproductive data were collected during the 1988–89 and 1989–90 field seasons from 15 September through 28 February. Nests were marked and checked on a near weekly basis and during flood tides and storms when possible. Hatching success was recorded for first nests and re-nests. Pairs commonly re-nested when their first set of eggs were lost. Pairs that hatched but subsequently lost chicks from first nests were not known to re-nest. Pairs that hatched at least one egg from first nests, or from re-nests when first nests had failed, were considered to successfully hatch. Overall hatching success for all pairs for a season was also recorded. If a pair hatched at least one egg from a first nest or a re-nest its overall hatching ability was considered successful. Pairs that fledged at least one chick from a first nest or a renest were considered a successful fledge. Finally, in the 1990–91 breeding season the Flinders Island study area was surveyed twice between 2 and 25 January 1991.

Results and discussion

Nest site selection

Pied Oystercatchers nested just above the high tide line at the edge of coastal heath habitat and they did not lay eggs at sites further from the water edge where susceptibility to tidal flooding would be less. Nests were significantly closer in distance to the high tide line than random sites at Flinders Island and at Big Green Island (Table 1). Since birds nested just above the high tide line and the elevation of terrain rose moving inland it

Table 1 A comparison of the elevation (height above sea level) and distance to the high tide line (DHTL) for Pied Oystercatcher nests and random sites around nest sites at Flinders Island and Big Green Island. Means ($\bar{X}$) and standard errors (*s.e.*) provide sources for comparison but the data were not distributed normally so Mann-Whitney comparisons were used for tests of significance.

	Nest or Random	N	Elevation (m) $\bar{X}$	Elevation (m) *s.e.*	*	DHTL (m) $\bar{X}$	DHTL (m) *s.e.*	*
Big Green	Nest	12	491	0.397	a	11.50	3.491	a
	Random	12	5.75	0.659	a	34.17	6.529	b
Flinders	Nest	18	4.15	0.393	a	7.44	1.936	a
	Random	18	5.95	0.693	a	27.56	5.856	b

*: similar letters indicate no significant differences while different letters indicate significant differences at $P < 0.01$.

was found that when the data for the two locations were combined, nest sites were lower in elevation than surrounding random sites ($n = 30$, $Z = -2.6726$, $P < 0.01$). However, when each location was considered separately no differences occurred because sample sizes were low (Table 1).

Pied Oystercatchers selected nest characters differently from American Oystercatchers *H. palliatus* since the latter chose nest sites that were higher in elevation and at greater distances to high tide line than randomly selected sites (Lauro & Burger 1989). Differences were related to topography since the preferred sandy sites on salt marsh, where American Oystercatchers nested, were higher in elevation than the surrounding *Spartina* grass habitats and at comparatively greater distances from creeks.

Pied Oystercatchers may have selected nest site locations that were close to the water edge even though they were vulnerable to flooding here because other factors at sites further inland may have caused greater egg and chick loss. Hartwick (1974) suggested that American Black Oystercatchers *H. bachmani* nested close to the water edge at open sites even though nests were commonly flooded there because at higher elevated sites, in denser vegetation, eggs and chicks were more susceptible to predation by nesting gulls.

A comparative habitat selection study of breeding Pied and Sooty Oystercatchers at the Furneaux Islands found that Pied Oystercatchers selected higher visibility sites to place nests compared to surrounding habitat (Lauro & Nol unpubl. data). This study and others suggest that high visibility nesting sites provide birds with the opportunity to detect and hence avoid predators (review Gochfeld 1984; Martin 1988, 1992). Therefore, Pied Oystercatchers may be better able to detect predators at open, lower elevated sites, close to the water edge, than in shrubby habitats, at higher elevated sites, further from the high tide line.

Table 2 A comparison of Pied Oystercatcher reproductive success for sites in the direct path of prevailing winds on Flinders Island (FI) and for sites in the lee of winds on Big Green Island (BGI). Chi-square analyses were used to test for differences in success between locations, by year; fledging success is based on more pairs than hatching success since it was known for certain which pairs did not fledge chicks but it was not known for certain if particular pairs hatched chicks. Levels of significance for comparisons between pairs of means are indicated by superscripts: a, $P < 0.05$; b, $P < 0.01$; c, $P < 0.005$; d, $P > 0.05$, *ns*.

	1988–89		1989–90	
	FI	BGI	FI	BGI
Hatching — total number of pairs	13	10	15	20
First nests				
% to hatch	15^b	70^b	13^c	65^c
% to hatch and than fledge	8^d	40^d	7^a	45^a
% lost to floods, wind, & rain	62^a	10^a	80^c	10^c
Re-nests — total number of pairs	5	0	4	4
% to hatch	40	—	25	25
% to hatch and than fledge	40	—	25	0
% lost to floods, wind & rain	40	—	50	25
Overall hatching success	31^d	70^d	20^c	70^c
Fledging — total number of pairs	15	14	18	20
% to fledge	20^d	29^d	11^a	45^a

Reproductive success

In both field seasons, hatching success for first nests was significantly lower at sites in the direct path of prevailing westerly winds on Flinders Island compared to sites in the lee of winds on Big Green Island (Table 2). These differences were directly related to nest destruction associated with wind induced tidal flooding as well as incident wind and rain damage (Table 2). On Flinders Island, in the 1988–89 and the 1989–90 field seasons, 46% and 73% of first nests respectively were lost to tidal flooding; 15% and 7% of nests respectively were destroyed by winds and rain which undercut and eroded nest sites on sand dune ledge (Table 2). On Big Green Island, in 1988–89, no nest was known to be flooded. However, one nest on the south coast was lost because winds eroded the base of the nest. On Big Green Island, in the second season, all environmentally related nest loss was due to tidal flooding (Table 2).

In the second season, overall hatching success and fledging success was lower for pairs on Flinders Island than for pairs on Big Green Island (Table 2). In addition, when the data for both seasons were grouped together it was found that, compared to pairs on Big Green Island, those on Flinders Island had lower hatching success for first nests ($d.f. = 1$, $\chi^2 = 16.382$, $P < 0.0001$), overall hatching success ($d.f. = 1$, $\chi^2 = 22.838$, $P < 0.0001$) and fledging success ($d.f. = 1$, $\chi^2 = 4.542$, $P < 0.05$). Statistical comparisons for renests between locations, by year, were not made since sample sizes were low (Table 2). Finally, in the 1990–91 breeding season on Flinders Island two chicks from one brood were known to fledge from 12 nests. Although we do not have comparable data for Big Green Island in 1990–91 the fledging success on Flinders Island appears to be constantly low (8-20%) over three breeding seasons.

Tidal flooding was a main source of egg loss for other species of oystercatchers: 47% of American Oystercatcher nests at salt marshes were flooded by spring tides over a two-year period (Lauro & Burger 1989) while in one year 32% of American Black Oystercatcher nests were lost to tides and rains associated with storms which washed over eggs. On Flinders Island, prevailing westerly winds and storms caused tidal surges and exacerbated wave action resulting in nest destruction, particularly during spring tides. However, nests on Big Green Island were protected from flooding because sites were sheltered from wind and wave action. When flooding did occur on Big Green Island it was usually during a spring tide and was not associated with storms.

Topographic differences between Flinders Island and Big Green Island did not appear to be related to differences in tidal flooding of nest sites. Pied Oystercatcher nest sites on Big Green Island were not higher in elevation or at greater distances from the high tide line than nests on Flinders Island. When habitat characters for locations were compared no significant differences were found (Table 1). However, sample sizes were low and subtle differences in these characters may not have been detected. In conclusion, it was evident that Pied Oystercatchers choosing a general location in the lee of prevailing westerly winds on Big Green Island had an advantage over birds who nested in the face of winds on Flinders Island because nests were significantly less likely to be damaged by winds and tides.

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