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Breeding of variable oystercatchers (*Haematopus unicolor*) at Kaikoura Peninsula, South Island, New Zealand

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Abstract The nesting of variable oystercatchers (*Haematopus unicolor*) on the Kaikoura Peninsula was studied at 6 sites over 8 years. Only in 1 year were birds known to have laid eggs at all 6 sites and only at 2 sites was nesting observed every year. Loss of nests often resulted in re-nesting and at 1 site birds made 4 attempts in 1 season. Over the 8 years, 117 eggs were found in 53 nesting attempts between mid-Oct and late Jan. The average size of 114 eggs was 58.2 x 40.6 mm. Thirty of 53 nesting attempts were completed and averaged 2.4 eggs/clutch (range 1–3 eggs). Twenty three chicks hatched from observed nests: this comprised 20% of eggs laid, 32% of eggs from completed clutches, and 72% of eggs from successful nests. At least 7 more chicks hatched from nests not found. A total of 17 chicks fledged including 6 chicks from nests not found. The other 11 fledglings came from 13 nests with hatchlings (0.84 chicks/nest; 41% of the eggs laid), 30 completed nests (0.37 chicks/nest; 15% of the eggs from these nests) and 9.4% of all eggs laid. Including chicks from 3 nests not found increases fledging to 1.06 chicks/nest with hatchlings, 0.51 chicks/completed nest and about 14% of eggs laid. Newly fledged young were seen from 26 Dec until mid-Mar. High tides washed away several nests, seals squashed eggs in 1 nest, and 1 adult was probably killed by a cat. While people walk in the vicinity of nesting, there was no evidence that they caused egg or chick losses.

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Keywords breeding success; clutch size; egg size; *Haematopus unicolor*; Kaikoura Peninsula; variable oystercatcher

INTRODUCTION

The population of variable oystercatchers (*Haematopus unicolor*) in New Zealand has risen from about 2000 birds (1300 black phase; 400 intermediate phase; 300 pied phase) in the 1970s (Baker 1973, 1985) to nearly 4000 birds in the early 1990s (Heather & Robertson 1996; Sagar *et al.* 1999; Marchant & Higgins 1993). Variable oystercatchers have been reported as scarce on the South Is east coast between Cloudy Bay and Dunedin (Heather & Robertson 1996; Marchant & Higgins 1993) with only small numbers present at the Kaikoura Peninsula (Fig. 1): 3 birds reported by Baker (1973), 10-20 birds reported in Marchant & Higgins (1993), and <25 birds by Sagar *et al.* (1999). On 2 Jul 2005, I counted 48 variable oystercatchers along the shoreline between South Bay and Point Kean, 40 of the birds being the black phase. Further counts were made on 21 Aug 2005 (30 black birds and 7 pied/intermediate phase birds) and 24 Jun 2006 (31 black and 5 pied/intermediate phase birds). These observations indicate that there may now be a greater number of variable oystercatchers resident in the area, a trend observed further south in Canterbury since 1988 by Crossland (2001).

Few detailed observations of the breeding success and breeding biology of variable oystercatchers have appeared in the literature (Marchant & Higgins (1993). Fleming (1990) reported a comprehensive set of observations of what was believed to have been 1 pair of variable oystercatchers at the Waikanae Estuary. This pair of birds (black male, smudgy female) were successful (defined as chicks fledged) in 11 of 18 years – 22 chicks hatched (17 pied, 5 black) and 18 subsequently fledged. Re-nesting after the loss of a nest was reported for 4 years. High tides were the cause of nest losses in 2

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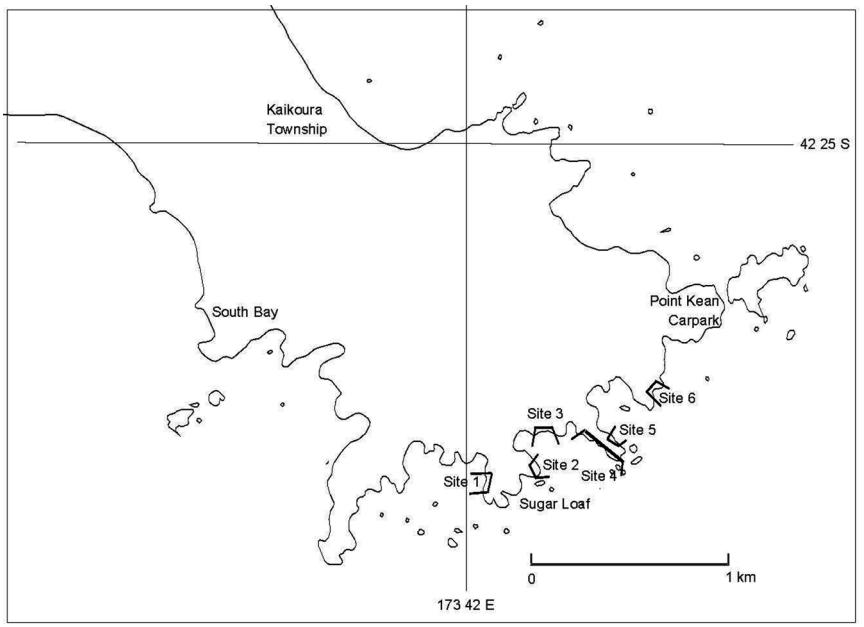

Fig. 1 The study site at the Kaikoura Peninsula showing the nest territories.

years; in 1 of these years both the original and the replacement were washed away in very high tides. More comprehensive studies are lacking, and in this paper, I report observations on the breeding success of variable oystercatchers at the Kaikoura Peninsula over 8 breeding seasons.

METHODS

Oystercatchers were studied on the Kaikoura Peninsula (173E 42′ E, 42E 26′ S; Fig. 1). The study area was a 2 km stretch of shoreline from the Point Kean carpark to "Sugar Loaf" (Fig. 1). This is a popular area with tourists walking the shoreline. Breeding birds in the area include red-billed gull (*Larus novaehollandiae scopulinus*), white-fronted tern (*Sterna striata*), black-backed gull (*Larus dominicanus dominicanus*) and variable oystercatchers. The shoreline consists of rock outcrops with stoney beaches between.

Observations began in summer 1999-2000 and continued annually to summer 2006-07. In the first 2 summers, intervals between visits were up to 4 weeks, and a number of attempts at nesting may have gone unnoticed. In later seasons, observations were usually made between intervals of 3 to 14 days. All adult birds were unbanded and black phase, so it was not possible to use plumage colour to identify individuals. I thus refer to nests by their location (Site 1, Site 2, etc.) and not to a particular pair, although it is likely that the majority of nests at any single site were by the same pair.

Measurements of eggs were made with dial vernier calipers (0.1 mm divisions). Eggs were measured on the 1st visit and were numbered with a waterproof marker; this enabled re-nesting to be confirmed. An egg shape index was calculated using Coulson (1963) and is given by the formula: 100 x width/length. Egg volume was calculated using the formula: volume = factor x width^2 x length, where the factor ranges from about 0.51 for several species measured by Stonehouse (1963) and Hoyt (1979) to 0.4825 for red-billed gulls (Mills 1979). As oystercatchers were not included in any of these studies a factor of 0.5 was used as it is mid-range of previous estimates. Bill length, defined as the length of the bill from the edge of feathering to the tip of the bill, was measured in most chicks to 0.1 mm with dial vernier calipers. Many 1st measurements were made several days after hatching and few measurements were possible at the stages before flying when chicks were not easily found or caught. Bill measurements had an error of about 1 mm because defining the point at which feathering began was not always clear cut.

Statistical tests used are those in Conover (1980) and the significance level chosen is 95%.

RESULTS

Territories

Nesting in the study area occurred at 6 sites (Fig. 1). Both within and from season to season, nests at a given site were found over 30–40 m of shoreline.

Table 1 Summary of variable oystercatcher breeding success by season at Kaikoura Peninsula.

	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
Sites with nesting	5	4	4	6	5	4	4	4
Sites with re-nesting	1	4	2	4	2	1	0	2
Total known attempts	6	11	6	11	7	5	4	6
Eggs laid	13	25	16	22	12	10	12	14
Eggs hatched	3	2	0	3	7	5	6	4
Young flown	3	0	0	1	4	4	4	1

Three mid-winter visits to the study area in 2005 and 2006 found a pair of birds present at each of the summer nesting sites, suggesting territories are occupied year round.

Nests

Nests consisted of a scrape in fine gravel. A few were lined with small pieces of chip-like driftwood. At one site, some birds nested beside large driftwood while others had no driftwood or vegetation within several metres of the nest. Most nests were located just above the high tide mark amongst fine, dried seaweed, but a few were on a higher terrace up to 20 m from the sea but still less than 1.5 m above the spring high tide. As well as nesting on the shingle beaches, birds at 3 sites (Sites 2, 3 and 4) sometimes nested out on rock outcrops up to 50 m from the high tide shoreline and surrounded by the sea at high tide.

Several unusual nest sites were observed. At Site 1, single eggs were found simultaneously in 2 adjacent scrapes only 40 cm apart on 10 Dec 2002. By 15 Dec only 1 scrape had an egg and this had gone by 22 Dec. Another nest at Site 3 was lined with grass/weed and built on a rocky outcrop connected to the shore at low tide but separated from it by about 50 m of sea at high tide. A 3rd unusual nest was observed at Site 4 in 2006-07. This pair re-used the large, abandoned nest built by a pair of black-backed gulls where oystercatchers had nested in the previous year. They laid 3 eggs before the gulls built a new nest 1.5 m away and laid 2 eggs. The oystercatchers hatched at least 2 chicks which reached a size large enough to be banded but which did not survive until fledging.

Nesting by season

1999-2000 Nests were found at 5 sites (Table 1). The earliest egg was found on 29 Oct and the latest was laid between 26 and 30 Dec; an egg was still present in a nest on 20 Jan (the nest was empty at 4 Feb). Only at Site 2 was there evidence that birds re-nested after a failure. Here a nest was found close to an earlier failed nest. Site 1 was not visited until 28 Dec and earlier attempts may have been missed. Similarly, at Sites 3 and 4, no early nests were found. In total, 13 eggs were found from which at least 3 chicks hatched and fledged.

2000-2001 Nests were found at 4 sites (Table 1). Birds were present at Sites 4 and 5, but no nests were found. The 1st eggs were laid prior to 29 Oct; eggs were still present 11 Jan. At 3 sites the 1st attempts were washed away by high tides. Birds at 2 sites were known to have nested twice, while at Site 3 there were 3 known attempts, and at Site 2 birds tried 4 times. At least 25 eggs were produced at the 4 sites of which only 2 hatched (Site 3 between 11 and 15 Jan). One of the 2 chicks reached a size where a metal band could be used, but neither chick could be found 5 days later, nor subsequently, and were assumed to have died.

2001-2002 Six nests were found at 4 sites only (Table 1), with birds present at Site 5 but no nests were found. The earliest eggs were found on 10 Nov and the last on 15 Dec (gone at 22 Dec). No eggs hatched and there was little activity on the sites after Dec.

2002-2003 Birds nested at all 6 sites (Table 1). Three attempts were made at Site 2 but all failed. In total, 22 eggs were found, the 1st on 19 Oct, and the last eggs were laid between 27 Dec and 3 Jan. From 11 nesting attempts, 3 chicks hatched, 1 died before leaving the nest, 2 survived until they could be banded but only 1 fledged.

2003-2004 This was the most successful season of the study. Ten eggs were laid in 6 nests at Sites 1 to 5, and 2 chicks were the 1st indication that there was at least a 2nd nesting attempt at Site 2. At least 7 chicks hatched (all banded) and 4 were known to have flown. The other chicks were presumed to have died as they were not seen after they were 4 weeks old and fledging is usually 6-7 weeks (Marchant & Higgins 1993).

2004-2005 Observations began late and at the 1st visit (8 Dec) chicks were found at Site 4; chicks

Table 2 Summary of variable oystercatcher nesting attempts by site over 8 summers (1999-2007) at Kaikoura Peninsula.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Seasons nested	7	8	8	7	4	2
Seasons re-nested	2	6	5	1	1	1
Maximum attempts per season	2	4	3	2	2	2
Maximum clutch size	3	3	3	3	3	3
Eggs laid in 8 seasons	19	35	29	21	13	6
Most eggs laid in a season	6	7	7	3	5	5
Eggs hatched in 8 seasons	0	7	9	10	3	1
Most eggs hatched in a season	0	2	2	3	3	1
Young flown	0	7	5	5	0	0
Most young flown in a season	0	2	2	2	0	0

found on a later visit indicated nesting at Site 2. Only at Site 3 was renesting observed after a failure. None of the 5 eggs found at Sites 1 and 3 hatched, at least 5 chicks hatched at Sites 2 and 4, and 4 of these chicks fledged (3 banded).

2005-2006 Birds at Sites 1 to 4 nested once only and laid 12 eggs in total. At least 6 chicks hatched and 2 more eggs showed sign of pipping when last seen; 4 banded chicks fledged.

2006-2007 Birds were present at Sites 1 to 5 with 14 eggs laid in at least 6 nesting attempts. None were noted at Site 1. Four chicks were found, and 1 fledged. The 1st chick hatched at Site 3 but was lost for an unknown reason within a week, and renesting took place. The 1 egg in the 2nd attempt hatched, and the chick flew in the 2nd half of Mar, which was later than any other fledging in the study to date.

Nesting success by site

Table 2 summarises the observations by site.

Site 1 Eggs were laid in all but the last season. Renesting occurred in 2 seasons but no further attempts were observed when eggs were lost by early Dec; maximum clutch size was 3 eggs; at least 9 nesting attempts were made; a minimum of 19 eggs were laid without success. Two of 3 egg were found pipping in a nest in 2005-06, but no chicks were found at the next visit.

Site 2 Birds nested every season at this site. At least 14 nesting attempts were made with 4 in 2000-2001. In the first 3 seasons, nests were always by the spring high-tide mark. The 2nd nesting attempt in 2002-2003 was on the edge of a grass/weed covered plateau 20 m from the original nest site. Nests were not located in the next 2 seasons with the 1st indication of success being chicks. In all, a minimum of 35 eggs were known to have been laid with up to 7 in one season, at least 7 chicks hatched and all flew. In 2006-2007, the 2nd attempt at nesting was ended by seals squashing eggs.

Site 3 Nesting occurred each season, but there was variation in nest position relative to the shoreline between attempts and seasons. After the 1st unsuccessful attempt on the shoreline in 2004-2005, the replacement nest was found on a ledge on a rocky outcrop 50 m from, and at high tide isolated from the shore. Nesting attempts in the last 2 seasons were back on the shore. Birds at this site were known to have laid a minimum of 29 eggs of which at least 9 hatched and 5 young flew. This was also the site where single chicks were hatched in 2 nesting attempts in 1 season, the 1st chick did not survive more than about a week and the 2nd fledged successfully.

Site 4 Nests during 5 of 6 seasons were on the shingly shoreline except for one re-nest located on the plateau between this site and Site 5. Nesting in the last 2 years took place on rocky outcrops isolated from the shoreline at high tide. It was at this site in 2006-07 that the pair took advantage of the abandoned black-backed gull nest. At least 21 eggs are known to have been laid at this site, with at least 10 hatched and 5 flying young.

Site 5 Nests were found in only 4 of 8 seasons. Initially nests were located on the shoreline, but after 3 seasons they moved to the grass/weed covered plateau. Nests at this site were often lined with wood fragments. None of the 3 chicks that hatched from the 13 eggs successfully fledged.

Site 6 This was the least successful site and the one closest to the Point Kean carpark. In the first 6 seasons, only 6 eggs were found and the 1 chick found did not survive. In Oct 2005, a dead, partly eaten, adult

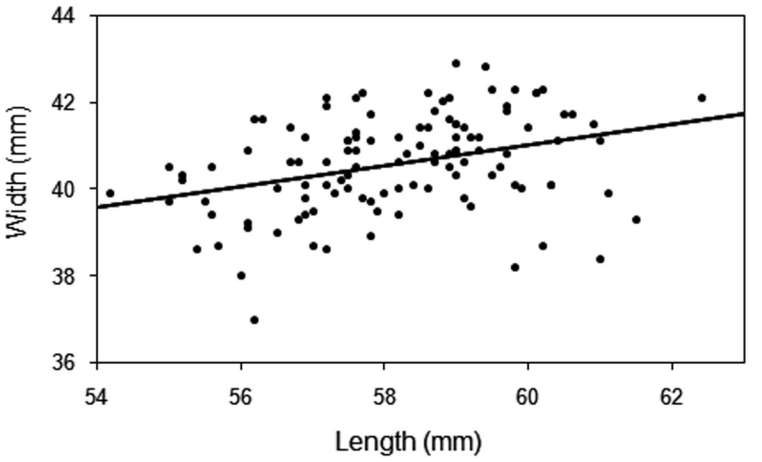

Fig. 2 Relationship between width and length of variable oystercatcher eggs at Kaikoura.

(likely a male based on bill-length measurements in Marchant & Higgins 1993) was found near Site 6 together with a number of dead white-fronted terns. All were probably killed by a cat. For the remainder of that season 1 bird was seen in the vicinity but none were seen in the next season.

Egg laying

The earliest egg was found on 19 Oct 2002; this was 1 of only 4 eggs found in Oct although other eggs were laid in Oct as 3-egg clutches were found on 2, 3, and 5 Nov. Last eggs were laid in late Dec/early Jan although 1 egg was laid between 12 and 28 Jan 2007. At all sites the maximum clutch size was 3 eggs.

As eggs are generally laid at 48 hour intervals (Heather and Robertson 1996), all nests with the same marked eggs spanning a period of at least 4 days were considered complete; a number of 2- and 3-egg clutches were disregarded as the next visit could not verify if the clutch was complete before being lost. Using this criterion, clutch sizes were: 1 egg at 3 nests, 2 eggs at 11 nests, and 3 eggs at 16 nests. The average clutch size for these 30 nests was 2.4 eggs. Fourteen nests from which chicks hatched and had eggs counted averaged 2.5 eggs/clutch.

Egg size

Over the 8 seasons, a total of 114 eggs were measured (Table 3). There was a significant relationship between width and length (Fig. 2) but only 12% of variance could be explained by the regression: width = 26.6±7.1 + (0.24±0.12) X length ($p<0.001 n$ = 114, $F_{1,114}$ = 15.3, r^2 = 0.12, n = 114).

For sites where renesting occurred within a season, eggs in 1st clutches were compared to later clutches, using volume as an index of egg size. Although the mean volume of 1st laid eggs was slightly larger (mean = 48.3 cm^3; n = 34; se = 0.7 cm^3) than later eggs (mean = 47.8 cm^3; n = 38; se = 0.5 cm^3), this difference was not significant (Kruskal-Wallis: T = 0.31, df = 1, p = 3.84).

Incubation

Because intervals between visits were more than a day apart, and most nests were found after completion of laying, it was not possible to estimate incubation periods in most cases. The longest period for which all eggs were observed in any nest was 29 days at Site 1 but no chicks had hatched by the time observations ended.

At Site 4 in 2003-04 one egg was present on 16 Nov. This became a 3-egg clutch, and as eggs are laid at 48 hour intervals (Baker 1985; Heather & Robertson 1996), incubation likely started on 19 or 20 Nov. Three eggs were still present on 14 Dec, and only 1 egg 18 Dec, the other 2 having hatched and the chicks left the nest. As chicks leave the nest after 1 or 2 days (Baker 1985; Marchant & Higgins 1993; Heather & Robertson 1996) this suggests that hatching took place between 15 and 17 Dec. The incubation period would then fit in the range 26 to 29 days.

Similarly, at Site 1 in 2004-5, 1 egg was present on 20 Nov, 3 were present on 25 Nov, and the 2 eggs that survived had chicks pipping on 21 Dec, about 29 days after laying would have been completed; no chicks were found 1 week later.

Hatching

Hatching took place between mid-Nov and end Jan/early Feb: 7 nests in Nov, 17 nests in Dec, and 6 nests in Jan. No eggs were hatched by birds at Site 1 whereas birds at Site 4 were the most successful with a minimum of 10 eggs hatched over 8 seasons

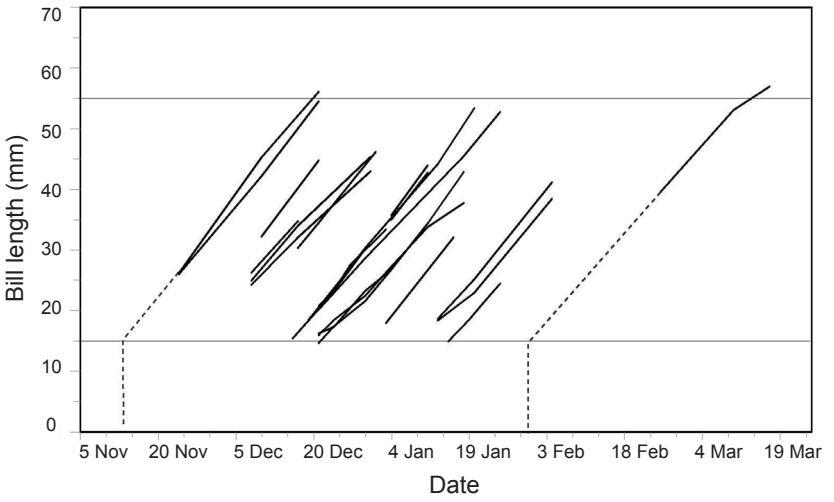

Fig. 3 Growth of variable oystercatcher chicks as indexed by bill length increases.

(Table 2). The number of eggs hatched from all 6 sites ranged from 0 to at least 7. Over the 8 seasons, at least 30 chicks hatched and 3 were pipping when last seen but no chicks were found at the next visit. Chicks hatched from 13 observed completed clutches – at least 23 chicks from 32 eggs (72%). One chick died in the nest, and all but 4 of the other 29 chicks (including 7 where no nest was found) grew to a size where they were able to be banded (i.e., at least 10 days old when the band would stay on the leg).

Growth of chicks

Growth of chick bill length is shown in Fig. 3. The smallest bill measured 13.8 mm, and a further 6 chicks had 1st bill measurements between 14.7 and 16.0 mm; these chicks were less than 3 days old. One chick found dead in its nest had a bill length of 15.4 mm and that of a sibling still wet after hatching was 15.5 mm. At the other extreme, the bill lengths of 5 birds on the verge of flying, or just flying but able to be caught, were between 51.7 mm and 57.0 mm; unfortunately none of these birds had measurements made just after hatching.

Growth of bill length was reasonably linear (Fig. 3). Eleven birds had measurements spanning at least 20 days and the rate of increase for these birds varied between 0.8 and 1.1 mm/day (average 0.95 mm/day). Bill length was also used to estimate the time span of hatching over the 8 seasons. By extrapolating back to a bill of a newly hatched chick (15 mm), the earliest hatching date was about 14 Nov and the latest about 31 Jan. Chicks that could be measured only once also hatched within this time span.

Fledging

No young were known to have flown in 2000-01 and 2001-02; 2003-04 and 2004-05 were the best seasons with 4 flying young observed (Table 1). Birds at Sites 1, 5 and 6 did not produce any flying young whereas 7 chicks at Site 2 flew successfully (Table 2).

From the 53 observed nests less than 10% of the eggs laid had chicks fledge. These 11 chicks comprised 48% of chicks that hatched, and were from 34% of eggs laid in successful nests. The average rate of fledging was 0.21 birds/nesting attempt and 0.37 birds/completed clutch. Another 6 chicks flew from undiscovered nests. Overall, 17 young were known to have flown so 8 were lost after banding. The earliest a chick was seen flying was 26 Dec. Most birds first flew in Jan or Feb while the latest was mid-Mar, the chick being on the verge of flying on 17 Mar. The only reliable estimate of the time to fledging was from Site 4 in 2003-04 where hatching occurred on either 16 or 17 Nov and the 2 chicks were just flying on 25 Jan, a period of about 39 days.

DISCUSSION

Territories

Variable oystercatchers have been described as monogamous, maintaining their pair bond from year to year, and remaining on their territories year round (Baker 1969, 1985; Heather & Robertson 1996; Marchant & Higgins 1993). Heather & Robertson (1996) state the oldest known variable oystercatcher was over 19 years-old while Fleming (1990) reported observations of 1 pair of variable oystercatchers over 18 years. Moon (1967) believed he observed

Table 3 Summary of measurements of 114 variable oystercatcher eggs at Kaikoura Peninsula (length and width in mm; volume in cm^3).

Statistic	Length	Width	Shape index	Volume
Mean	58.2	40.6	69.8	48.0
SE mean	0.2	0.1	0.2	0.3
Maximum	62.4	42.8	74.9	55.3
Minimum	54.2	37.0	63.0	38.5

1 pair for 9 years and Jones (1979) observed 1 pair for 6 years noting that they were probably together when he started observations. Implicit in each of these studies was the assumption that the same pair of birds was observed throughout.

While it is possible that at any one of the study sites here it was the same pair re-nesting within a given season and returning for each of the 8 seasons to its home territory, this may not be the case. There are observations of South Is pied oystercatchers that show when 1 of a pair disappeared within or between seasons the surviving bird remained on its territory and could take a replacement within a day or so (Paul Sagar, *pers. comm.*); a similar behaviour for variable oystercatchers has also been suggested (John Dowding, *pers. comm.*). Thus, when comparing any given site from time to time, there may have been pair changes and my data may not be the same as that measured on the same birds over time.

On the other hand, after a cat killed one member of a pair at Site 6 at the beginning of the breeding season, only a single bird was found there several times later in that season. There was no evidence of pairing or nesting having occurred despite there being potential replacements as shown by birds seen at the site during the winter surveys, and a flock of up to 15 seen near the Point Kean carpark during the breeding season. If re-pairing typically takes this long, then replacements of birds on each site were probably few and most nests on a given site were probably by the same pair.

Nesting

Most nests found in this study fit descriptions of those reported elsewhere (e.g., Soper 1972, Marchant & Higgins 1993, Heather and Robertson 1996), the exceptions being the opportunistic use of an abandoned black-backed gull nest, and a double nest where 2 nests only a few cm apart had 1 egg in each at the same time. While nesting on rocky outcrops and platforms has been reported (e.g., Soper 1972; Heather and Robertson 1996), it occurred at 3 sites in some years but only for 8 of over 60 nesting attempts. Variable oystercatcher nests on the shore were usually found within a few metres of the spring high-tide mark. High tides have been reported to wash away nests (Fleming 1990; Hansen 1995) and this happened during at least 2 storms in my study. Squashed eggs and brown staining around one nest out on a rocky outcrop are evidence that seals caused at one nest to fail.

Predators such as cats and mustelids cause losses of adult birds from nearby white-fronted tern and red-billed gull colonies and it is probable a cat killed 1 adult variable oystercatcher in the study area. While also a potential source of egg losses, there is no evidence that cats also prey on nests. Despite dogs and other pets (Jones 1969; Ell 1999), beach buggies (Brathwaite 1983), black-backed and red-billed gulls (Marchant & Higgins 1993; Hansen 2005), disturbance (Marchant & Higgins 1993; Hansen 2005), and careless feet (Ell 1999) having been cited as other causes of nest loss, only the last 2 are likely to apply here as the shoreline at the high-tide mark is frequently used by tourists. However, there was no evidence that any specific nest loss could be directly attributed to the actions of people.

Most eggs were laid in Nov and Dec. The earliest an egg was found was 19 Oct in 2002 and the last new egg found was in mid- to late-Jan. This time span is within the reported range of mid-Sep to Feb (Baker 1985; Heather & Robertson 1996; Marchant & Higgins 1993; Hansen 2005). Clutch size was usually either 2 or 3 eggs which fits within the range 1–5 eggs (but generally 2–3 eggs) given in Heather and Robertson (1996) and Marchant & Higgins (1993). At 2.4 eggs/clutch, the average size for observed completed clutches was similar to the mean clutch size of 2.3 eggs/clutch given in Baker (1975).

A total of 114 eggs were measured with mean length of 58.2 mm, and width of 40.6 mm. The values are close to those reported by Heather & Robertson (1996) at 59 mm and 41 mm for length and width, respectively, and by Baker (1969) at 58.6 mm and 40.9 mm for length and width, respectively. These eggs had an average shape index of 69.8 and volume of 48.0 cm^3. A comparison between the average size by volume of eggs in 1st and subsequent clutches did not show any significant differences.

The observations here show that all of the 6 pairs of variable oystercatchers in this study have re-laid in at least 1 season after a clutch was lost. Although many authors report re-nesting can occur after a nest is lost, records of numbers of attempts are few. Fleming (1990) reported renesting by birds

at Waikanae, and Hansen (2005) stated that variable oystercatchers can lay up to 3 clutches after loss. Here, the maximum number of nesting attempts at a site in 1 season was 4.

Marchant & Higgins (1993) noted that the interval between nest failure and re-laying was not known but that pairs have had 2 clutches within 25 days. In this study new eggs were found 10 times at the same site but in different nests at intervals between 14 and 20 days from the last observation of the 1st nest.

The longest period for which all eggs were present in any nest was 29 days but no chicks hatched. At Site 4 in 2003-04 the incubation period was in the range 26 to 29 days and at Site 1 in 2004-05 also about 29 days. These 3 examples fit reported incubation periods of 26 to 29 days (Baker 1985), a mean incubation period of 28.4 days (Baker 1969), and 25-33 days with an average of 28 days (Heather & Robertson 1996).

Hatching

The peak month for hatching was Dec, when 56% of eggs hatched. Hatching was variable between sites ranging from nil at Site 1 to a minimum of 10 hatched at Site 3 in 8 seasons, and year to year, from nil to 7 hatched/year from up to 6 sites. There is little data published on hatching success of variable oystercatchers. In this study, 23 chicks hatched from 32 eggs (72%) in 13 completed clutches. A pair of variable oystercatchers at Waikanae hatched 22 eggs over 18 seasons, a rate of 1.2 chicks/pair-season (Fleming 1990). There were 34 site-seasons in this study where at least 1 observed nest was found at a site. The hatching rate was at least 0.74 chicks/site-season, markedly lower at about 60% the rate at Waikanae. One chick was known to have died in the nest, and all but 4 of the other 29 known chicks grew to size where they were able to be banded (i.e., about 10 days old); 8 chicks that were banded were not known to have flown and presumed died.

Fledging

Fledging success was variable ranging from nil to 4 flying young observed in any season, and nil flying young at Sites 1, 5 and 6 to 7 young at Site 2. In total, 17 young are known to have flown, 6 of these from nests that were not found. These flying young were from 48% of the eggs that hatched from known, completed nests and 14% of all the eggs known to have been laid. The earliest a chick was seen flying was 26 Dec while others were first seen flying as late as mid-Mar.

As for hatching success, there is little information published on fledging success of variable oystercatchers. Baker (1975) reported hatching success (chicks fledged/clutch size) from 16 nests was 69.9%. Jones (1979) saw that 1 pair hatched eggs for 6 seasons but no chicks fledged; Fleming (1990) noted 16 young fledged in 18 seasons (0.88 young/pair-season) and Marchant & Higgins (1993) reported that at protected sites 147 pairs raised 94 young, generally with high but unstated fledging success, which implies a fledging rate less than 0.63 chicks/pair-season. In this study, 17 young were seen flying, a rate equivalent to 0.47 young/site-season and lower than reported above (except for Jones 1979).

Eleven chicks that flew in this study came from known completed nests at a rate of 0.84 chicks/nest, a rate much higher than reported by Hansen (2005) where, at 3 sites, between 0.40 to 0.54 chicks/nest were raised to age 3 weeks (this was assumed to equate to chicks fledging) in a study comparing nests that were fenced against predators and those that were exposed to predators.

Growth of chicks

No published data on the growth rates of variable oystercatcher chicks is available (Marchant & Higgins 1993). In this study bill lengths of newly hatched chicks were about 15 mm and for chicks on the verge of flying were about 53 mm, about 60% of the length of adult bill lengths which average 81.7 mm for males and 90.6 mm for females (Baker 1974). The rate of increase in bill length averaged about 0.9 mm/day.

Fledging period

Similarly to trying to estimate incubation periods, estimates of time to fledging also contained uncertainties. The only reliable estimate is from Site 4 in 2003-04 where, if hatching is assumed to be at 16 or 17 Nov and the 2 chicks were just flying on 25 Jan, the fledging period is about 39 days. This is at the lower end of published data: 6 weeks in Baker (1985), and 6-7 weeks in Marchant and Higgins (1993) and Heather & Robertson (1996).

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