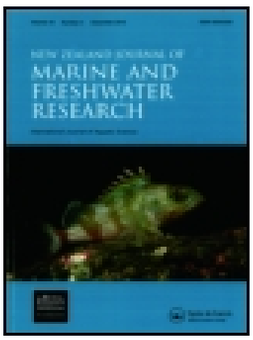

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Population status and breeding of New Zealand fur seals (*Arctocephalus forsteri*) in the Nelson-northern Marlborough region, 1991–94

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Abstract The population size, distribution, breeding, and onshore habitats of New Zealand fur seals in the Nelson-northern Marlborough region, New Zealand, were investigated. Breeding occurs at four relatively new rookeries along the southern shores of Cook Strait: at Stephens Island in the outer Marlborough Sounds, at Archway Islands and Pillar Point near Cape Farewell, and at Tonga Island in Tasman Bay. These rookeries were established in about 1970, 1980, 1988, and 1988, respectively. In 1993–94 about 500 pups were born and the extant population breeding or born at the four rookeries was assessed as 2410. There were also 17 hauling grounds, each with 25 or more seals ashore in winter, and about 50 other sites where lesser numbers hauled out regularly. Comparison with earlier estimates indicates that the summer population increased from about 70 in 1973 to about 1000 in 1994—a sevenfold increase of yearling and older seals. The number of pups produced increased at a mean annual rate of 23% since 1970–71. The population in this region is expanding rapidly in both numbers and breeding range, and similar trends have been reported from elsewhere in New Zealand and Australia. These changes relate to a re-colonisation of traditional breeding grounds following cessation late last century of nearly 1000 years of human exploitation of New Zealand fur seals.

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Keywords *Arctocephalus forsteri*; New Zealand fur seal; population status; breeding status; Cook Strait

INTRODUCTION

For almost 1000 years following their discovery by Polynesians, and later by Europeans, New Zealand fur seals were hunted to local extinction. Once abundant and breeding from northern Northland to the subantarctic and in South Australia and Western Australia, they survived only in very low numbers by the turn of the present century, with breeding in New Zealand confined to South Westland, Fiordland, Stewart Island, the Chatham Islands, and the subantarctic islands (Wilson 1992).

Since becoming fully protected by New Zealand law in 1894 (Sorensen 1969), the New Zealand fur seal population has increased in size—very slowly at first, but more markedly over the last 20 years, with pups being born at rookeries progressively further north on the New Zealand coastline (Wilson 1981, 1984; Taylor 1982, 1990, 1992; Crawley 1990; Dix 1993a).

Fur seals come ashore at "breeding rookeries" to give birth, mate, and nurse their young; and at favoured sites—known as "hauling grounds"—to bask, rest, and moult in widely varying numbers at all times of year, but particularly in winter (Miller 1975; Crawley 1990). During the breeding season and late summer, young seals sometimes congregate in distinct "immature colonies" remote from breeding rookeries (Wilson 1974, 1981; Taylor 1992). Breeding rookeries are on exposed coasts, usually where there are stable piles of large boulders (which provide cover for pups) and some sheltered water or intertidal pools (Crawley & Wilson 1976).

Very little is known about numbers, breeding distribution, or population dynamics of New Zealand fur seals. There is even less knowledge of fur seal numbers and distribution at sea (Hawke 1991), and overall population trends can only be inferred from counts of animals ashore.

The size of a fur seal population is best estimated from the numbers of young pups in breeding rookeries (Bonner 1958; Crawley & Brown 1971; Taylor 1982), as these are easily recognised and are confined to the shore. Counts of other age groups give at best only a very rough index of relative abundance (Alterio et al. 1991), since the proportion ashore fluctuates markedly with season, time of day, weather conditions, and other factors.

The lack of accurate information on the population dynamics and numbers of New Zealand fur seals is helping to fuel controversy regarding the threat to the species from fishing operations (Duncan 1991) and the perceived effects of increasing numbers of seals on fish stocks (Talley 1991). Of particular concern is the impact of fisheries by-catch, when fur seals are accidentally caught and drowned in trawl nets. Without knowing how many New Zealand fur seals there are, where they breed, or how their numbers are changing, it is impossible to say how this by-catch is affecting population trends.

Observations of fur seals along the southern shores of Cook Strait and in Tasman Bay and Golden Bay during the early 1970s indicated that they then bred only on Stephens Island (3 or 4 pups yearly), and that the total population numbered about 70 in summer and 350 in winter (P. Aplin pers. comm.; Wilson 1974, 1981). Archway Islands, near Cape Farewell, was a winter hauling ground for many years before fur seals started to breed there during the early 1980s (Wilson 1981, 1984). On 28 February 1984, Wilson (1984) counted 38 seals, including 5–8 pups, making this the northernmost breeding colony in New Zealand.

The present study was initiated in 1991 to establish current numbers and a baseline against which further changes could be assessed. The population size, distribution, breeding, onshore habitats, and potential for new rookery sites and further expansion of the fur seal breeding population were investigated. In particular, data were sought on how many pups were being born, and where.

STUDY AREA

The study area covers the coastline (> 1500 km) and offshore islands from Whahariki Beach (40°31′S, 172°40′E), near Cape Farewell on the west coast of South Island, to Needles Point (41°52′S, 174°10′E), 30 km south of Cape Campbell on the east coast (Fig. 1). The region encompasses a wide variety of coastal habitats, ranging from exposed coasts with cliffs, rocky shores, tumbledown piles of huge boulders, and sand or boulder beaches to sheltered bays and sounds with both rocky and sandy shorelines. There are over 70 offshore islands and islets.

METHODS

From November 1991 the coastline of the study area was checked for the presence of fur seals as often as logistics allowed. An attempt was made to survey all sites at least once in each summer and winter. All seals found were counted and classified where possible as to sex and age, following Wilson (1981) and Crawley (1990).

Terrain at breeding rookeries and hauling grounds was assessed to investigate the potential for further rookeries to establish in the study area. The three main topographic characteristics of breeding rookeries (Crawley & Wilson 1976; and pers. obs.)—potential cover for pups, safe water for pups, and isolation from human disturbance—were each rated on a scale of 0–3 at each site. Potential cover for pups was scored as: 0 = smooth ledges with no, or little, overhead cover; 1 = irregular rock surface with some shallow cavities; 2 = many small to medium-sized boulders or rock slabs with cracks and cavities; 3 = many large boulders with deep cavities and tunnels. The scores for availability of safe water for pups were: 0 = open sea only; 1 = exposed coast with only a little sheltered water or small intertidal pools; 2 = some sheltered coast with coves and/or sea caves and intertidal pools; 3 = extensive offshore reefs, coves, and intertidal pools. Isolation from human induced disturbance was scored as: 0 = regularly visited by public with easy access to nearly all parts of rookery; 1 = regularly visited by public with easy access to much of rookery; 2 = public access legal but rookery difficult to visit from land or sea; 3 = public access prohibited or very difficult.

The great majority of the coastline could not be reached by road, nor easily on foot. Boats were used to locate and visit over 90% of the rookeries and hauling grounds. Much of the sea work on sheltered coasts was done from outboard-motor boats. In Cook Strait and exposed parts of the outer Marlborough Sounds a large launch or yacht was sometimes used as a "mother ship" for a small, rigid-hulled inflatable dinghy. Landings were made where needed for more accurate estimates.

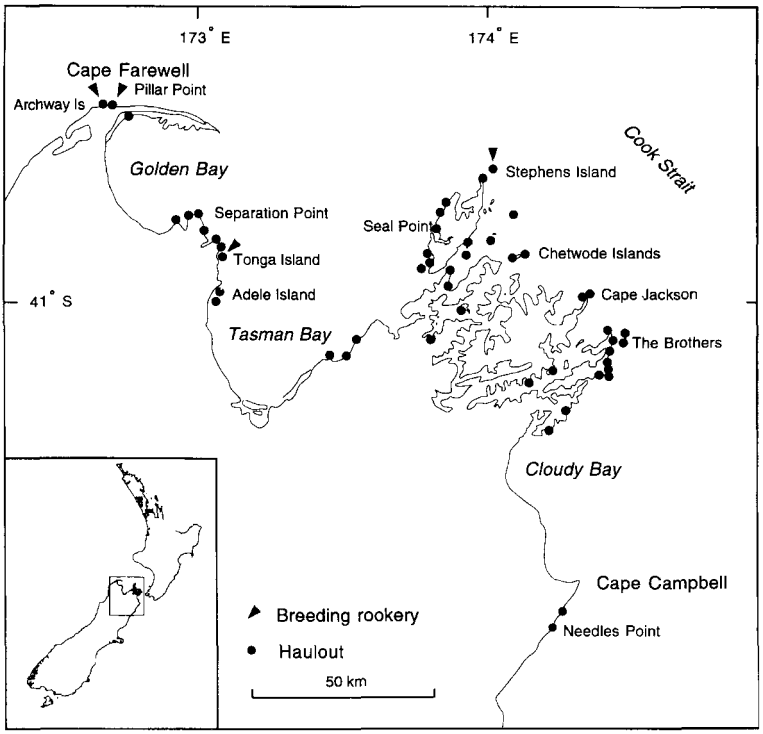

Fig. 1 The Nelson-northern Marlborough region, showing fur seal breeding rookeries and main hauling grounds. Inset shows location on South Island, New Zealand.

Summer surveys were carried out to locate all breeding rookeries. Pups are born between late November and early January. From mid January their numbers at each rookery were assessed by counting, either with binoculars from vantage points on clifftops or from boats close inshore. Where counts from boats were made, subsamples of the rookery were searched on foot, and total estimates were adjusted for missed pups.

The nature of the terrain and the visibility of pups varies markedly between rookeries. At Archway Islands, where there is no cover, all pups are easily seen and the total counted in January/February was taken as the number produced that season. At Pillar Point most pups are readily counted from the cliff top but a few behind boulders or deep in caves will be missed. In estimating pup production at Pillar Point an allowance of 10%, for pups not seen or already dead, was added to the January/February counts.

At the Tonga Island rookery, in February-March 1993 and February 1994, as many pups as possible were marked with a numbered red plastic tag (disc-shaped ALLFLEX "small tag") on each fore-flipper to allow a more precise estimate of total numbers (N) from repeated mark/recapture ratios using the formula:

$$N = \frac{(M+1)(n+1)}{m+1} - 1$$

where M = number of pups tagged, m = number of tagged pups in sample, and n = number of pups in sample (Seber 1982).

The standard error of the estimates was calculated from:

$$SE = \sqrt{\frac{(M+1)(n+1)(M-m)(n-m)}{(m+1)^2(m+2)}}$$

At Stephens Island, as at Tonga Island, there is abundant cover behind and beneath boulders and many pups cannot be counted from a boat. Walking counts give much higher tallies, but even then many pups are overlooked. For Stephens Island where counts from boats were made, subsamples of the rookery were searched on foot, and total estimates adjusted for missed pups. A multiplier of 2.4 was derived from all Tonga Island ratios of "pups estimated from walking counts" : "mark/recapture estimate of total pups", and used to roughly assess total pup production.

Table 1 Numbers of fur seals at sites in Nelson-northern Marlborough region, 1991–94.
Note: Haulouts with maximum counts of less than 5 and showing no yearly pattern have been omitted. Winter, June–September; summer, December–March; *n*, number of counts.

Location		Winter			Summer		
		Mean	*n*	Range	Mean	*n*	Range
Archway Is	40°30'03"S 172°40'20"E	26.8	4	14–36	17.0	4	9–21
Pillar Point	40°30'10"S 172°42'35"E	66.0	4	17–119	151.3	4	105–203
Puponga Point	40°31'45"S 172°44'03"E	10.5	2	1–20		–	
Abel Tasman Point Islets	40°48'00"S 172°55'25"E	11.0	2	8–14		–	
N of Taupo Hill	40°47'10"S 172°57'35"E	36.5	6	9–86	0.3	3	0–1
Separation Point	40°47'05"S 172°59'50"E	156.1	8	85–257	7.0	6	0–31
Totaranui Point	40°49'00"S 173°00'55"E	6.3	4	0–21	0	1	–
Skinners Point	40°50'00"S 173°00'35"E	2.0	3	0–4	0	1	–
Awaroa Head	40°51'12"S 173°02'48"E	11.7	3	2–25		–	
Abel Head	40°51'32"S 173°03'30"E	45.5	6	30–58	0	2	0
Boulder Point	40°52'40"S 173°03'58"E	7.6	5	2–13	2.0	2	1–3
Wharf Rocks	40°52'50"S 173°03'57"E	5.0	3	0–13	0.5	2	0–1
Tonga I.	40°53'40"S 173°04'00"E	179.1	9	123–307	131.9	7	83–194
Adele I.	40°00'40"S 173°03'30"E	25.6	8	2–50	0	3	0
Fisherman I.	40°00'00"S 173°03'00"E	1.9	7	0–5	0	3	0
Pepin I.	40°08'15"S 173°25'00"E	18.6	8	0–36	0.3	8	0–1
N of Red Point	41°08'00"S 173°30'20"E	3.8	4	0–13	0	2	0
Whangamoa Head I.	41°06'15"S 173°30'45"E	14.5	4	9–21	0	2	0
Paddock Rocks	40°55'05"S 173°45'40"E	33.8	4	12–43	14.0	3	2–38
Hapuka I.	40°54'00"S 173°46'20"E	32.0	1	–		–	
Te Horo I.	40°53'45"S 173°47'10"E	6.8	4	0–16	0	2	0
Seal Point	40°48'00"S 173°48'25"E	4.0	2	2–6	48.3	3	34–71
Punaatawheke Bay	40°46'05"S 173°50'00"E	1.5	2	0–3	8.0	3	0–16
Otu Bay	40°45'35"S 173°50'05"E	1.0	1	–	8.0	1	–
Cape Stephens	40°41'40"S 173°57'10"E			–	6.0	1	–
Stephens I.	40°40'25"S 173°50'00"E	256.0	4	230–283	361.8	4	286–464
Jag Rocks	40°46'35"S 174°03'20"E	8.0	2	7–9		–	
South Trio I.	40°50'50"S 173°59'30"E	19.0	1	–	5.0	2	5–5
Bonne Point	40°51'50"S 173°54'50"E	0	2	0–0	9.5	2	9–10
Stewart I.	40°53'25"S 173°53'50"E	1.3	4	0–3	3.3	3	0–10
Clayface Point	40°55'55"S 173°51'15"E	11.3	4	7–14	0	2	0
Garden Point	40°57'30"S 173°50'40"E	3.5	2	1–6	0	1	–
Ngawhakawhiti Bay	41°06'15"S 173°46'30"E	10.3	4	1–19		–	
Maud I.	41°01'50"S 173°52'30"E	12.3	11	1–31	0	2	0–0
Treble Tree Point	40°59'45"S 173°55'15"E	3.0	2	2–4		–	
Nukuwaiata I.	40°54'00"S 174°04'00"E	3.3	3	2–4	7.5	2	6–9
Te Kakaho I.	40°53'05"S 174°06'25"E	31.0	4	11–45	8.5	2	1–16
S Onehunga Point	41°01'00"S 174°18'20"E	4.5	2	3–6	0	1	–
Cape Jackson	41°00'00"S 174°19'00"E	10.0	2	9–11	8.5	2	0–17
Kurakura Point	41°11'00"S 174°12'00"E	7.5	2	6–9		–	
Okahu Bay Point	41°13'30"S 174°06'40"E	8.5	2	2–15		–	
1–2 km S of Cape Koamaru	41°06'10"S 174°23'25"E	2.5	2	0–5		–	
Brothers I. (lighthouse)	41°06'15"S 174°26'30"E	12.0	1	–	0.5	2	0–1
Brothers I. (south)	41°07'00"S 174°25'50"E	24.0	1	–	19.5	2	19–20
Tungongo–Kipirita	41°07'30"S 174°23'15"E	7.5	2	7–8		–	
Kipirita Point	41°07'55"S 174°23'15"E	2.5	2	1–4	0	1	–
N of Narawhia Stream	41°10'40"S 174°22'10"E	4.0	2	2–6		–	
ESE of Narawhia Hill	41°11'40"S 174°22'20"E	15.0	2	14–16		–	
N of Perano Head	41°11'50"S 174°22'10"E	5.5	2	4–7	0	1	–
Raukawa Rock	41°12'15"S 174°21'45"E	37.0	3	9–92	52.5	2	30–75
W of Raukawa Rock	41°12'00"S 174°21'15"E	2.0	2	1–3	8.0	2	7–9
Jordy Rocks and Point	41°15'05"S 174°17'40"E	1.0	2	1–1	0	1	–
W of Bushy Point	41°16'25"S 174°15'50"E	2.0	2	2–2	0	1	–
S side of Glasgow Bay	41°18'00"S 174°14'50"E	5.5	2	1–10	0	1	–
Coombe Rocks and Point	41°21'05"S 174°09'30"E	7.0	2	1–13	5.0	2	4–6
Chancet Rocks	41°50'18"S 174°11'48"E	95.4	5	38–150	19.0	3	4–40
Needles Point	41°52'30"S 174°09'50"E	431.0	3	376–504	68.0	3	43–92
Totals		1751.0			987.8		

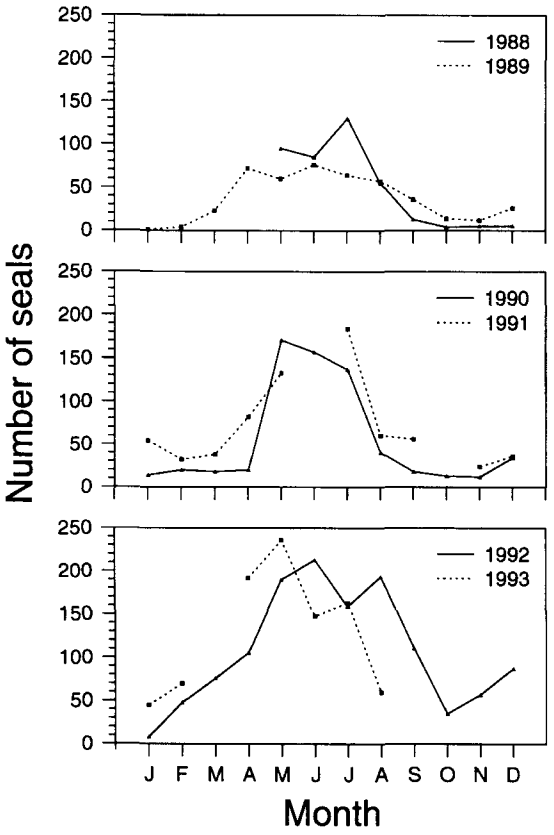

Fig. 2 Monthly seal counts 1988–93, Tonga Island (data from Department of Conservation, Motueka Field Centre).

The total number of seals in a population or associated with a rookery (i.e., all seals breeding or born there, including pups and non-breeders, but excluding temporary non-breeding immigrants) can be estimated by multiplying the number of pups produced annually by a numerical value allowing for the other elements of the population. This multiplier will vary depending on factors such as age at first breeding, age-related mortality, longevity, and whether the population is stable, increasing, or decreasing. In this study we have used the value of 4.9 based on Taylor's (1982) study of the expanding New Zealand fur seal population of the Bounty Islands.

RESULTS

The numbers of seals ashore at breeding rookeries, hauling grounds, and immature colonies vary markedly from month to month during both summer and winter. This is illustrated by counts done from November 1991 to September 1994 (Table 1) and by 6 years' data from Tonga Island (Fig. 2).

Site characteristics

The results of rating all major fur seal sites in the Nelson-northern Marlborough region on their presumed suitability as breeding rookeries are summarised in Table 2. The highest total score possible (9) was achieved only at one site where seals are already breeding, i.e., Tonga Island. The three other breeding sites rated total scores of 8, 7, and 4; but all four existing rookeries scored the maximum (3) for safety from human disturbance. Totals as high as 6 were scored by six fur seal sites where rookeries have not yet established.

Breeding rookeries

Four fur seal breeding rookeries were found: Archway Islands and Pillar Point near Cape Farewell, Tonga Island in Tasman Bay, and Stephens Island in Cook Strait (Fig. 1). In addition, one pup was born at Separation Point in late 1991.

Archway Islands (40°30′S, 172°40′E)

The rookery is situated on cliff ledges at the south-eastern end of the inner of the two offshore islands

Table 2 Characteristics of major fur seal sites in the Nelson-northern Marlborough region. Breeding rookeries in bold type; site factor rating scale from 0 (poor) to 3 (very good), see text.

Site	Cover for pups	Safe water for pups	Safe from disturbance	Total score
Archway Islands	0	1	3	4
Pillar Point	2	2	3	7
Taupo Hill	0	1	2	3
Separation Point	3	1	2	6
Abel Head	3	0	2	5
Tonga Island	3	3	3	9
Adele Island	2	2	2	6
Pepin Island	0	2	2	4
Paddock Rocks	0	0	3	3
Hapuka Island	2	1	3	6
Seal Point	3	1	2	6
Stephens Island	3	2	3	8
Maud Island	1	2	3	6
Te Kakaho Island	0	1	3	4
Raukawa Rock	2	1	3	6
Chancet Rocks	1	2	1	4
Needles Point	1	3	0	4

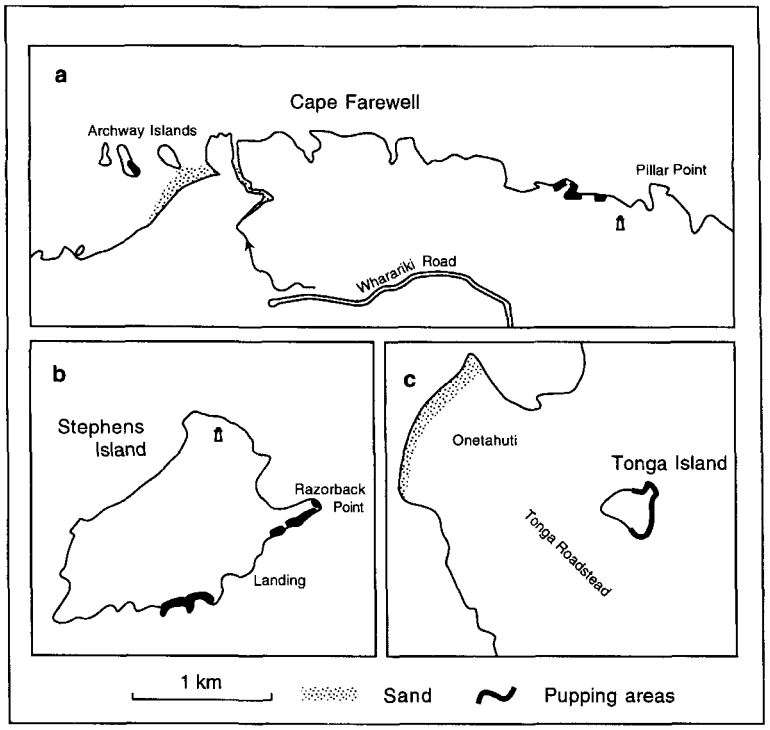

Fig. 3 Detail of Cape Farewell, Stephens Island, and Tonga Island, showing location of pupping areas in 1993–94.

(Fig. 3). Observations are best made with binoculars from the top of the adjacent islet to the east, which is accessible on foot at low tide. From here, pups are readily counted on the smooth rookery ledges or in the intertidal pools on the wave-cut platform below the rookery.

We counted 18 seals including 3 pups at the rookery on 16 December 1992, and 21 seals including 3 pups on 18 January 1993. Pup production for 1992–93 was assessed as three. Eighteen seals including 3 pups were counted on 20 December 1993, and 9 including 6 pups on 19 February 1994. Pup production for 1993–94 was assessed as six.

Pillar Point (40°30′S, 172°43′E)

The rookery extends over about 600 m below exposed coastal cliffs, and is centred on rocks and ledges at the entrance of a large sea cave about 400 m north-west from the Pillar Point lighthouse (Fig. 3). It cannot be reached by land without climbing aids. Nearly all pups and other seals present are readily counted from the clifftops, especially at low tide, when the pups are spread over the rocks, ledges, and sandy floor of the cave.

This rookery is a recent development. On 28 February 1984 there was no sign of breeding, and only three seals were present at the site (K-J. Wilson pers. comm.). We found 17 seals and 8 pups here on our first visit in June 1992. Twenty-seven pups were counted on 16 December 1992, and 64 on 18 January 1993, at completion of pupping. Twenty-two pups were seen on 20 December 1993 and 73 on 19 February 1994. Allowing 10% for a few not seen or already dead, pup production for 1992–93 was assessed as 70, and for 1993–94 as 80.

Tonga Island (40°53′S, 173°04′E)

Fur seals pup along about 500 m of the north-eastern and eastern shore of the island (Fig. 3), where the foreshore is made up of rock outcrops and piles of large boulders backed by steep vegetated slopes. There are many places behind and beneath rocks where pups can shelter. Consequently, counting pups from a boat is highly inaccurate; it is even difficult to find most pups by walking through the rookery.

Tonga Island was first colonised by seals about 1980, and by 1984 up to 50 seals could be found ashore in winter and a few also in summer (G.

Rennison and K-J. Wilson pers. comm.). On 29 February 1984 there was no sign of breeding and only 7 sub-adult males were ashore (K-J. Wilson pers. comm.). We first visited Tonga Island on 5 November 1991, when 45 seals (mostly females, with a few adult bulls, juveniles, and weaned pups) were counted. On 2 February and 27 March 1992 walk-through counts gave 36 and 45 pups, respectively. In 1993, boat counts on 4 February gave 25 pups and walk-through counts on 18 February gave 53 pups.

In February and March 1993, mark/recapture estimates were also used to more accurately assess pup numbers. Tonga Island was visited on four occasions and 56 pups were tagged. Six independent estimates based on mark/recapture counts gave a mean of 92 pups. Two pups are known to have died at the rookery in 1993 before tagging or counting commenced. In February 1994, 75 pups were tagged and five independent estimates based on mark-recapture counts gave a mean of 130 ± 14 (Table 3). Pup production was assessed as 92 for 1992–93 and 130 for 1993–94 (Table 4).

Stephens Island (40°40′S, 174°00′E)

The breeding grounds are on Razorback Point at the eastern end of the island and along the mid-section of the southern shore (Fig. 3). The most favoured area is a steep tumbledown slope of large irregular boulders immediately east of Queen's Beach.

Fur seals started breeding at Stephens Island about 1970. P. Aplin (pers. comm.) reports that "3 or 4 pups" were born there in 1970–71. We began studies on 31 March and 1 April 1992, when a combination of boat counts and walk-through counts tallied 110 pups. Similar counts on 9–10 March 1993 and 1–2 March 1994 tallied 131 and 115 pups, respectively. Using a multiplier of 2.4 (extrapolated from all Tonga Island ratios of "pups estimated from walking counts" : "mark/recapture estimate of total pups") gave rough estimates of

Table 3 Mark/recapture estimates of numbers (± SE) of fur seal pups at Tonga Island, February-March 1993 and February 1994.

Date	Tagged pups in population	Counts of pups		Estimate of number of pups present
		Tagged	Total	
18 Feb 93	21	11	47	87 ± 14
2 Mar 93	37	20	61	111 ± 13
17 Mar 93	48	15	24	76 ± 9
17 Mar 93	50	26	44	84 ± 7
17 Mar 93	50	24	40	83 ± 7
17 Mar 93	50	19	42	109 ± 14
			1993 mean:	**92 ± 11**
11 Feb 94	75	19	33	128 ± 16
11 Feb 94	75	18	34	139 ± 18
17 Feb 94	75	29	50	128 ± 12
17 Feb 94	75	24	41	127 ± 13
17 Feb 94	75	26	44	126 ± 12
			1994 mean:	**130 ± 14**

Table 4 Estimate of fur seal pup production, Nelson-northern Marlborough region.

Location	1970–71	1983–84	1991–92	1992–93	1993–94
Archway Islands	0	c. 6	–	3	6
Pillar Point	0	0	–	70	80
Separation Point	0	0	1	0	0
Tonga Island	0	0	>45	94	130
Stephens Island	4	–	264	314	276
Totals	4	–	–	481	492

pup production on Stephens Island of 264 for 1991–92, 314 for 1992–93, and 276 for 1993–94.

Separation Point (40°47′S, 173°00′E)

Areas of tumbledown boulders south-east and west of the lighthouse have been winter hauling grounds for many years. These are potential sites for a small breeding rookery. One well advanced pup was seen suckling a female at the south-eastern locality on 2 February 1992. No pups were born at Separation Point in the 1992–93 and 1993–94 seasons.

Hauling grounds

In the study area, there are 17 sites where 25 or more seals can be found ashore in winter. These are (with maximum 1992–94 June-August counts) Archway Islands (36), Pillar Point (119), Taupo Hill (86), Separation Point (257), Awaroa Head (25), Abel Head (51), Tonga Island (307), Adele Island (50), Pepin Island (36), Paddock Rocks (43), Hapuka Island (32), Stephens Island (283), Maud Island (31), Te Kakaho Island (45), Raukawa Rock (92), Chancet Rocks (150), and Needles Point (504). Lesser numbers of seals regularly haul out on an additional 50 sites in the study area. The main hauling grounds are shown in Fig. 1, and counts and estimates made of seals ashore at all sites are summarised in Table 1, where precise locality co-ordinates are given.

Immature colony

The Seal Point haul-out on D'Urville Island is the only one that fits the strict definition of an immature colony. Seventy-six seals were counted here on 26 February 1983 (C. Hay and K-J. Wilson pers. comm.), 34 in December 1992, 71 in February 1993, 40 in March 1994, but only 2 and 6 in August 1993 and 1994 respectively. In 1992–94 most were subadult males and juveniles. Elsewhere in the study area, large numbers of immature seals were associated with breeding rookeries or year-round hauling grounds (e.g., Raukawa Rock and Needles Point).

DISCUSSION

Sites used by fur seals during summer for breeding and in winter for haul-outs in the Nelson-northern Marlborough region, as elsewhere in New Zealand (Crawley & Wilson 1976), are usually on exposed coasts—rocky headlands, or tumbledown piles of large boulders backed by rock cliffs or steep stable slopes. Breeding rookeries are exposed to the open sea, with accessible land above the high-tide mark. Other common site characteristics are hollow spaces beneath boulders or rock overhangs, used by pups for protection, and shallow intertidal pools, sheltered coves, or sea-caves.

The most consistent characteristic is that all breeding rookeries are isolated from disturbance—by human beings, dogs, etc.—through being sited below cliffs or on offshore islands (Table 2 and pers. obs.).

Abel Head, Hapuka Island, Seal Point, Te Kakaho Island, and Raukawa Rock—at present summer and/or winter hauling grounds only—do have suitable terrain and freedom from disturbance (Table 2), and may in time become breeding rookeries. Separation Point, where one pup was born during this study, has suitable physical characteristics and has been a winter hauling ground for many years (Wilson 1981, 1984). However, it may be disturbed too much by visitors during summer for a breeding rookery to establish.

Some other highly favoured winter hauling grounds (e.g., Needles Point and Chancet Rocks) are prone to human disturbance and/or have smooth, staggered ledges or large slabs of rock rather than boulders. It is probable that most of these sites will never become breeding rookeries. On the evidence of this study there is considerable potential for fur seals to breed at additional sites in the study area, but disturbance may be the major factor preventing fur seals from breeding on otherwise suitable terrain.

Our surveys have shown that there are now four fur seal breeding rookeries in the Nelson-northern Marlborough region, where a total of nearly 500 pups were born in 1993–94 (Table 3).

At the Archway Island and Pillar Point rookeries the nature of the terrain allows for a fairly accurate assessment of pup production by direct counts. At Tonga Island our mark/recapture mean estimates of pup numbers are fairly accurate, SE ± 14 (Table 3). However, the Stephens Island estimates are less accurate, being based on direct counts from boat and shore multiplied by 2.4 to make allowance for missed pups (the multiplier derived from 2 years' results on Tonga Island, where the boulder-strewn shoreline is somewhat similar).

Transferring correction factors between rookeries, or between days or years at the same rookery may not be valid: topography may vary

between rookeries and the weather, sea conditions, state of the tide, and experience of observers may differ between counts leading to discrepancies. For instance, at Tonga Island in February 1993 the mean number of pups counted on the ground was 49 and in February 1994 was 44, although the mean estimated populations as assessed by mark/recapture methods were 92 and 130, respectively (Table 3). However, without a mark/recapture programme the Stephens Island estimates of 264–314 pups (Table 2) were the best achievable. That they are of the right order of magnitude is suggested by a comparison of the numbers of female seals ashore at Tonga Island (counts 5, mean 47, range 30–70) and Stephens Island (counts 4, mean 97, range 48–115) in the period December-April in 1992, 1993, and 1994.

Judging from historical records and our own observations, it seems that fur seals bred for the first time this century on Stephens Island about 1970, on the Archway Islands about 1980, and at Pillar Point and on Tonga Island about 1988. The Archway Island site provides very marginal and limited terrain for a breeding rookery. It has failed to expand in recent years, probably because other breeding stock has settled on the nearby and rapidly expanding rookery at Pillar Point.

In 1973 the fur seal population of the Nelson-northern Marlborough region was assessed as 70 in summer and about 350 in winter (Wilson 1974, 1981). Twenty years later we tallied about 1000 seals ashore during December-February, including some 492 pups, and more than 1700 during June-September (Table 1), suggesting a sevenfold increase of yearling and older seals during the breeding season, and a fivefold increase of all age classes in winter. Considering that similar mean increases have occurred at 14 sites of known 1973 status, these figures must indicate a real change in abundance of fur seals within the region rather than increased knowledge of where seals haul out.

Little is known of the population dynamics of New Zealand fur seals (Crawley, 1990), so to estimate the total number of seals associated with a rookery from the number of pups produced parameters from studies of other *Arctocephalus* species have been employed. Taylor (1982) used this approach to estimate the size of the expanding fur seal population at the Bounty Islands, and derived a multiplier of 4.9. Applying the same multiplier to the Nelson-northern Marlborough population, a calculation based on four pups in 1970–71 and 492 pups in 1993–94 gives a "local" population (i.e., the extant population breeding or born in the region) of 20 seals in 1971 and 2410 in 1994. The Stephens Island rookery, with around 276 pups in 1993–94, is calculated to have a local population of 1352 seals. More research is needed on the reproductive parameters of New Zealand fur seals before population size can be estimated with any confidence.

The numbers of pups produced at Stephens Island, and in the Nelson-northern Marlborough region, have increased at annual rates of about 20 and 23%, respectively, over the 23-year period to 1994. By comparison, Lalas & Harcourt (1995) found an annual rate of increase in pup production of New Zealand fur seals at Otago Penninsula averaging 25% through the past decade. The Antarctic fur seal (*Arctocephalus gazella*) population of South Georgia grew at an annual rate of around 16% during the 18 years between 1957 (5330 pups) and 1975 (about 90 000 pups) (Payne 1977). At the Bounty Islands, numbers of New Zealand fur seals increased at an annual rate of about 5% between 1903 (approx. 82 pups) and 1980 (approx. 3280 pups) (Taylor 1982). Estimates of the rate of increase of nine other populations of southern fur seals (*Arctocephalus* spp.) range from nil to 16.5% (York 1987).

In a relatively stable population of New Zealand fur seals at the Open Bay Islands, South Westland, Mattlin (1978) found that females first pupped in their fifth year and that first-year mortality was around 50%. Life span was in excess of 15 years. To maintain a stable closed population with these vital parameters, the mean annual mortality of older age classes would need to be about 15%. For pup production to increase at 21% per year, first-year mortality would need to be as low as 15% and the mean annual mortality of all older age classes about 10%. It seems, therefore, that the annual rate of increase in the Nelson-northern Marlborough region is much higher than can be accounted for by local reproduction alone, and this must imply immigration of females from other rookeries, probably on the West Coast of South Island.

There is still need for a nationwide census of New Zealand fur seals (Cawthorn et al. 1985; Taylor 1990). An estimate commonly quoted for the total population in New Zealand waters is 50 000 (Mattlin 1987; Baker 1990), but this is largely based on data collected during a nationwide survey carried out between 1971 and 1974 (Wilson 1974). More recent regional surveys and observations (Cawthorn et al. 1985; Wilson 1992, unpubl. data;

Taylor 1982, unpubl. data; Crawley 1990) led Taylor (1990) to suggest that the population was now "rapidly expanding", and far in excess of this figure, "perhaps nearer 100 000".

A recent survey of New Zealand fur seals in southern and western Australia shows that populations there have also increased substantially in both numbers and range over the last 20 years (P. Shaughnessy pers. comm.). Our present findings for Nelson-northern Marlborough, those of Dix (1993) for the north of Cook Strait, and those of Lalas & Harcourt (1995) at Otago Peninsula support the contention that the New Zealand fur seal population in New Zealand waters is continuing to increase, and is expanding its breeding range northwards. Obviously some fur seals are emigrating from long-established or overcrowded rookeries, but there is no evidence to support the often-repeated suggestion of Gaskin (1972) that the "apparent increases" may be due to redistribution of an otherwise stable population. We consider this highly unlikely.

The changes now taking place in New Zealand fur seal populations are best understood in the light of their continuing recovery from near extinction following almost 1000 years of Polynesian and European exploitation (Wilson 1992). Archaeological research has shown that when Polynesians first arrived in New Zealand, fur seals were present on virtually all areas of rocky coast. "Breeding populations were resident in the far north of the North Island, on the east coast of the Coromandel peninsula, the western shores of Cook Strait, and the east and south-east coasts of Otago, as well as the Stewart Island, Fiordland and South Westland coasts" (Smith 1989). By AD 1500 fur seals no longer occurred in northern North Island. In the Cook Strait region breeding populations had been replaced by seasonally migrant visitors by about the 16th and 17th centuries, and a similar trend occurred in eastern Otago 100 years later. By the end of the pre-European period, breeding New Zealand fur seals were confined to the western and southern coasts of South Island and to outlying southern and subantarctic islands. These changes can be attributed directly to human predation, as fur seals sustained persistent Maori hunting, particularly at breeding rookeries and in the more densely populated parts of New Zealand (Smith 1985, 1989).

During his three visits between 1769 and 1777, James Cook reported seals only around the South Island (Reed & Reed 1969; Smith 1989). European sealers drastically reduced fur seal numbers in the southern parts of their New Zealand range during the late 18th and 19th centuries. By 1830 the New Zealand fur seal was almost exterminated (Chapman 1893). Following total legal protection in 1894 the fur seal population started a slow exponential recovery, which has now reached a stage of more noticeable growth. Without further direct human impacts it should continue to increase in numbers and fully recolonise its previous breeding range in Nelson/Marlborough and North Island.

Other factors that could affect the recovery of the New Zealand fur seal population include climatic change and possible changes in food supplies. Major climatic warming could preclude recolonisation of traditional New Zealand fur seal breeding sites in the far north, but there is no evidence to suggest that this will occur. Effects on seal numbers from changes in food availability seem more likely. New Zealand fur seals feed mainly on cephalopods (mostly arrow squid, *Nototodarus* spp.) and fish (Crawley 1990). The effect of commercial fishing on squid abundance is unknown. The major fish prey species are small schooling fishes (Carey 1992) such as anchovy (*Engraulis australis*) and lanternfish (*Symbolophorus* and *Lampanyctodes* spp.). As speculated by Robertson (1992), it is possible that these and other small schooling fish species are increasing in numbers as the numbers of their larger predators and competitors are depleted by commercial fishing. Significantly, numbers of Australasian gannets (*Morus serrator*) that consume arrow squid and small schooling fish, and spotted shags (*Stictocarbo punctatus*) that consume crustaceans and small schooling fish, have increased markedly over the last 25 years in our study area (Owen & Sell 1985; Hawkins 1988; and pers. obs.). Scats collected in December 1992 suggest that fur seals on Tonga Island are feeding mainly on small schooling fish (Dix 1993b). Hence it is possible that increased commercial fishing activity is improving the food stocks for fur seals, as well as for gannets and shags.

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