

SCIENCE AND RESEARCH INTERNAL REPORT NO.59

**MOLLYMAWKS
ON CAMPBELL ISLAND**

by

Peter J Moore and Roger D Moffat

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Head Office
Department of conservation,
P.O. Box 10-420,
Wellington,
New Zealand.

July 1990

ISSN 0114-2798
ISBN 0-478-01182-2

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MOLLYMAWKS ON CAMPBELL ISLAND

Peter J. Moore¹ and Roger D. Moffat²

¹Science & Research Division, Department of Conservation,
P.O. Box 10,420, Wellington

²2/40 Lancewood Drive, Christchurch 3

SUMMARY

1. There are two species of mollymawk on Campbell Island, the grey-headed mollymawk (*Diomedea chrysostoma*) and the black-browed mollymawk (*D. melanophrys*). The latter species is mainly represented by the endemic subspecies, the N.Z. black-browed mollymawk (*D. m. impavida*), although there are a few of the more widespread subspecies (*D. m. melanophrys*) present also.
2. The combined population of both mollymawk species on Campbell Island in September 1988 was estimated at approximately 29,000 breeding pairs. The estimate was achieved by counting the mollymawks in photographs of the colonies, supplemented by ground counts of some smaller colonies. Errors in the estimates were caused by factors such as photograph quality, the obliqueness and proximity of the view from the photopoints, and the assumption that each bird (or two birds standing close together) represented a nest.
3. The proportion of each species could not be determined accurately because they could not be distinguished in most photographs. Grey-headed mollymawks were estimated to number 3,000-10,000 pairs (with the lower end of the range more likely). This represents at least 4% of the total population of this widespread species. The grey-headed component of the population in September 1988 represented an unknown proportion of the total breeding population, because it is a species that normally breeds biennially. The 19,000-26,000 pairs of the N.Z. black-browed mollymawk, which breeds annually, represent the world breeding population of this endemic subspecies. There were nine black-browed mollymawk individuals found at Bull Rock South, where most detailed observations were made. It is not known if this subspecies was present at other colonies.
4. The mollymawk colonies are situated in four main localities at the northern tip of the island. The largest colony is on the Courrejolles Peninsula. Grey-headed mollymawks predominate over N.Z. black-browed mollymawks at some of the smaller colonies.
5. Photographic evidence suggests that the mollymawk population has declined by about 38-57% since the 1940s, when there were possibly between 47,000 and 67,000 pairs. Some colonies, such as Courrejolles Isthmus, have declined by up to 88% during this period, particularly in areas where grey-headed mollymawks predominate. The least change has occurred at the larger colonies, such as Courrejolles and Bull Rock South. The population figures are very broad estimates because of the problems of comparing photographs of differing quality, angle, year or season, and extrapolating colony totals to areas or years for which there was no photographic evidence.

6. The mollymawk population has probably fluctuated between 27,000 and 32,000 breeding pairs during the 1980s, with lowest numbers apparent in 1987.
7. Grey-headed mollymawks on Campbell Island are smaller than those elsewhere in their range. N.Z. black-browed mollymawks are smaller than the other more widespread black-browed subspecies (*D. m. melanophrys*),
8. The breeding seasons of Campbell Island mollymawks, particularly N.Z. black browed mollymawk, are earlier than elsewhere in the species' range. Mean hatching date at Bull Rock South Colony was 7 December 1987 for N.Z. black-browed and 12 December for grey-headed mollymawks. The fledging age of chicks was 130 and 152 days respectively.
9. Fifty-two percent of N.Z. black-browed mollymawk pairs fledged chicks in the 1987-88 season at Bull Rock South Colony. This was a higher overall breeding success than average for the conspecific black-browed mollymawk on South Georgia. Only 16% of grey-headed mollymawk pairs fledged chicks at Bull Rock South, which is a lower level of success for the species than recorded previously on Campbell Island, and lower than average for the species on South Georgia.
10. Larger numbers of grey-headed mollymawk breeding pairs were present at the beginning of the 1988-89 season than during the 1987-88 season. This may have been a consequence of the poor breeding success in 1987-88; birds present in 1988-89 including greater than normal numbers of failed breeders.
11. Grey-headed mollymawk chicks grew faster and were larger than N.Z. black-browed chicks. Their respective fledging weights were 3.5 and 3.0kg.

CHAPTER 1. INTRODUCTION

1.1 General

Mollymawks are members of the albatross family. This common name possibly originated from seafarers using the Dutch word 'mollemawk', which means foolish gull (Harrison 1983). There are five species, found only in the Southern Hemisphere, and two of these breed at Campbell Island in the New Zealand subantarctic region.

The blackbrowed mollymawk (*Diomedea melanophrys melanophrys*¹) has a widespread breeding range of Crozet (Weimerskirch *et al.* 1986), Staten, Falkland, South Georgia, Kerguelen, Heard, Antipodes, and Macquarie Islands (Harrison 1983). The world population of this mollymawk is in the order of 475,000 breeding pairs (Appendix 4). At Campbell Island there is an endemic subspecies, the New Zealand black-browed mollymawk (*D. m. impavida*), and a few members of the more widespread subspecies.

The grey-headed mollymawk (*D. chrysotoma*) also has a widespread breeding range of Diego Ramirez, South Georgia, Marion, Prince Edward, Crozet, Kerguelen, Macquarie and Campbell islands (Harrison 1983) with an overall population (excluding Campbell Island) of approximately 66,000 breeding pairs each season (Appendix 4).

Black-browed and grey-headed mollymawks have been subjects of intensive research, particularly on South Georgia (e.g. Tickell and Pinder 1975), and also Crozet (Weimerskirch *et al.* 1986) and Kerguelen Islands (Weimerskirch *et al.* 1988). Black-browed mollymawks breed annually, whereas grey-headed mollymawks breed biennially when they successfully rear chicks. Both species lay a single egg per nest.

1.2 Campbell Island

Campbell Island lies about 660 km south of New Zealand and 350 km south-east of the Auckland Islands. It is over 11,000 ha in area, with much of the coastline consisting of steep shores and cliffs. The island lies near the southern margin of the extensive Campbell Plateau, an area of continental shelf less than 1000m below sea level (Department of Lands and Survey 1953). There is a permanently staffed Meteorological Service (Ministry of Transport) weather station on the island.

N.Z. black-browed mollymawks return to Campbell Island at the beginning of August, lay between 24 September and 8 October, and chicks fledge in mid-April (Robertson 1985a). Grey-headed mollymawks return at the beginning of September, lay between 28 September and 9 October, and chicks fledge in early to mid May (Robertson 1985b). It is believed that grey-headed mollymawks normally breed biennially on Campbell Island, as evidenced by empty nest sites in their colonies (C. Robertson pers. comm.).

¹ Nomenclature in this report follows Kinsky (1980)

In 1975 the population of mollymawks on Campbell Island was estimated at 74,800 pairs of N.Z. black-browed mollymawks and 11,500 pairs of grey-headed mollymawks (Robertson 1980, 1985a, b).

Both species occupy colonies on steep slopes and ledges above sheer coastal cliffs in the northern part of the island (Fig. 1). The largest colony is on the Courrejolles Peninsula.

Comparison of historical and recent photographs of some of these colonies indicated that a decline in numbers of mollymawks may have occurred (G. Taylor, D. Cunningham pers. comm.).

Because of the relative isolation of Campbell Island, mollymawks have received little attention by scientists. J.H. Sorensen made many observations during the 1940s while stationed on the island with the 'Cape Expedition', the wartime coast-watching operation (Bailey and Sorensen 1962). Robertson (1980) and Taylor (1986) have made some observations on the breeding of mollymawks at Bull Rock South Colony. Since the late 1950s over 19,000 chicks and over 3,800 adult mollymawks have been banded on the island, the majority being N.Z. black-browed mollymawks (data from Banding Office, Department of Conservation, Wellington). Most of this banding has been done by meteorological station staff.

1.3 1987-88 Expedition

From October 1987 to October 1988 Peter Moore (Science and Research Division, Department of Conservation, Wellington) and Roger Moffat (contracted DOC technician) were based on Campbell Island. A variety of research and management projects were undertaken (Moore and Moffat 1990a, b), including a study of the mollymawks on the island, which is the subject of this report.

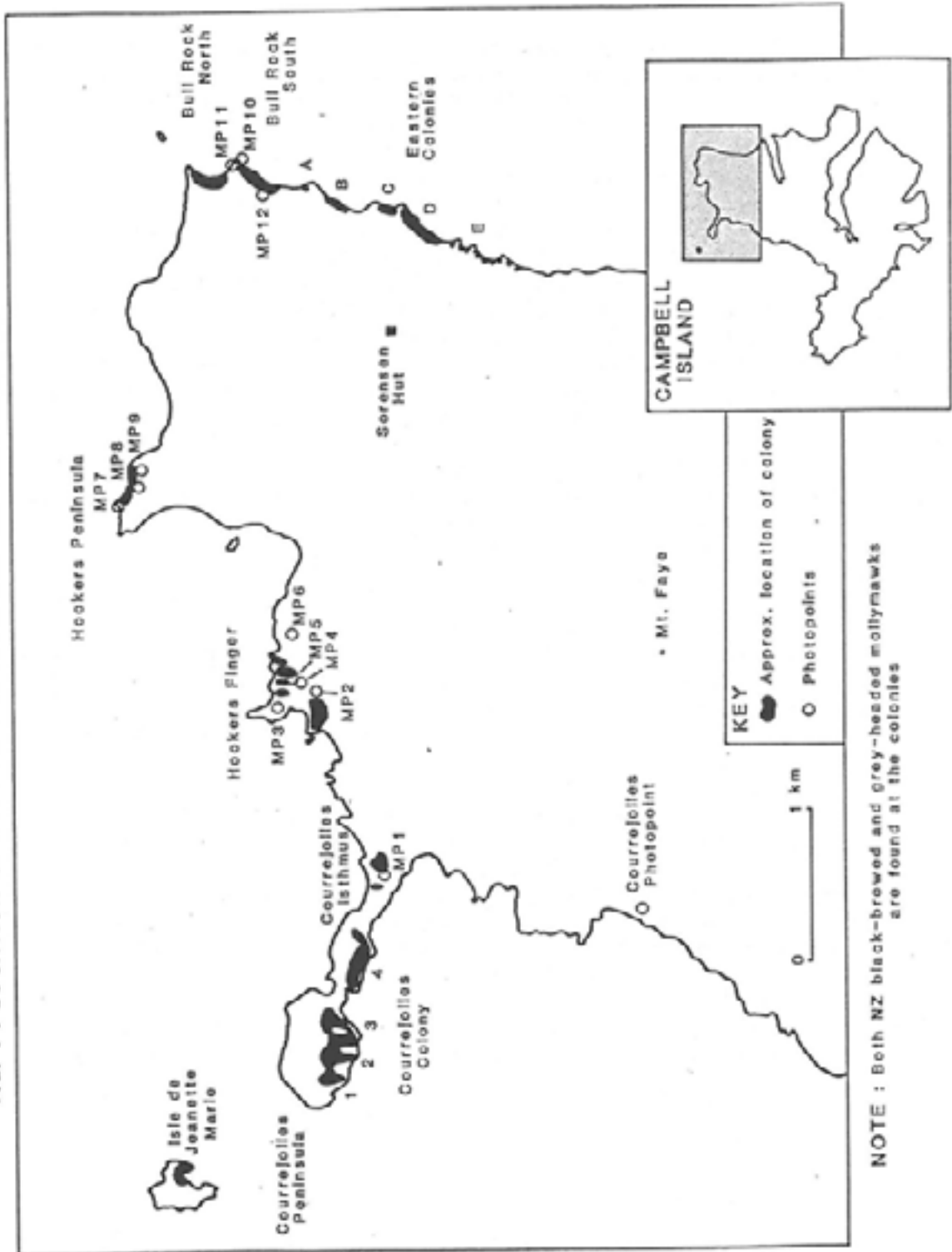
This was the first opportunity on Campbell Island for scientists to systematically study mollymawks throughout the breeding season. Stimulus for aspects of the study came from C. Robertson, G. Taylor and D. Cunningham.

1.4 AIMS

The aims of the study of mollymawks during the 1987-88 season were to:

1. Establish a series of photopoints to monitor changes in the Campbell Island population;
2. Determine the breeding success of the mollymawk species at Bull Rock South colony;
3. Monitor the growth of chicks at Bull Rock South.

FIG. 1 : LOCATION OF MOLLYMAWK COLONIES ON CAMPBELL ISLAND



CHAPTER 2. METHODS

2.1 Population monitoring

Twelve photopoints were established at most of the major mollymawk colonies. These were positioned to give good views of the colonies, and where possible, repeat photographs taken in the past. The photopoint sites were marked by labelled aluminium or wooden pegs. Peg positions in Fig. 1 were recorded in detail on a 1:10,000 map series, copies of which are held by DOC (Wellington and Invercargill) and on Campbell Island. Photographs of some of the peg positions were also taken to aid future photographers.

The photopoint series (comprising 18 photographs at 12 points) was repeated almost every month from October 1987 to April 1988. Photographs were taken on 14, 15 September, 29, 30 October, 18, 19 November, 19, 20 December 1987, 19, 20 January, 23 February, 22, 23 March, 19 April and 26, 27 September 1988. A full set of black and white prints for these months is held by P. Moore (DOC, Wellington). Most photographs were taken using general purpose 125 ASA black and white film. Larger format 120 roll film (60 x 45mm) was used in December 1987 and September 1988. Sample sets of the series are held by DOC (Invercargill) and on Campbell Island to assist future photographers.

In September 1988, to obtain a population estimate for the entire island, photographs were taken of colonies, or parts of colonies, that were not included in the regular photopoint series. These were mainly parts of Bull Rock South Eastern colonies. Photographs were also taken of the large Courrejolles colony using a telephoto lens on 19 Nov 1987, 22 Mar, 4 Apr, 27 Sept 1988.

Population estimates for late September 1988 were made by counting the birds on nests in the photographs, usually using a binocular microscope and marking the birds on the photo or on a transparent overlay. Nests in historical photographs were counted by this method, and compared with photographs taken in the same month during the 1987-88 season, or in September 1988. Colour slides taken in 1975 and 1985 were counted by marking the birds on the projected image.

The accuracy of counting mollymawk nests in the photographs varied depending on the quality of the image, the photopoint's proximity to the colony, the obliqueness of the view and whether the angle of view was comparable between years (e.g. most 1975 photos were taken from offshore on a boat and 1985 photos from a helicopter, whereas the others were taken from more oblique angles on land). It was not possible to tell which birds were sitting on nests in the more distant photographs. Therefore it was assumed that each bird, or pair of birds standing close together, represented a nest. This may over-estimate the actual number of nests if breeders and failed breeders are present, and off-duty partners are standing far enough from the nest to be counted separately. Counts using photographs taken from oblique angles probably under-estimated the number of nests because some were obscured by birds or vegetation.

2.2 Breeding success

In late October 1987, 50 nests of each of the two species, N.Z. black-browed and grey-headed mollymawks, were selected for study at the Bull Rock South colony. Nests chosen were those that contained an egg and had an attending adult which was banded. Where necessary, partners were banded and their bill lengths measured. Nests of the uncommon black-browed mollymawk subspecies were also monitored.

Nests were marked with numbered metal plates, which were held in place with wire passed through the nest pillar to metal backing plates.

From 30 October 1987 to 21 May 1988, 27 visits were made to the colony. The visits were, on average, 8 days (4-14) apart, with shorter intervals at the time of hatching and fledging.

At each visit the status of study nests was recorded. The presence of the egg was noted and whether pipping had commenced. During the hatching period, if an egg disappeared between visits and there were small shell fragments or membrane in the bottom of the nest, it was assumed to have hatched, rather than have been preyed on. This enabled estimation of losses at the egg and chick stages. The date of hatching was determined accurately if the chick was just out of the egg, or in the process of hatching. Otherwise the date was estimated from the size of the chick and the state of the egg (ie. amount of pipping) on the previous visit. Similarly, chick disappearance or fledging dates were estimated based on the interval between visits. Towards the end of the fledging period the disappearance of healthy chicks was assumed to represent successful departures from the colony.

In late March, prior to their departure from the colony, chicks from the study area and elsewhere in the Bull Rock South colony were banded using size M stainless steel bands. Band numbers of previously banded birds were read during the season. Worn bands were replaced and poorly applied bands corrected.

2.3 Growth of chicks

The growth of 16 N.Z. black-browed and 18 grey-headed mollymawk chicks was monitored at the Bull Rock South colony. Weights, using spring balances and plastic bags, and dimensions, using vernier calipers, were obtained at each visit from hatching to fledging. Consistent toe measurements were attempted by flattening the foot out on a piece of hardboard.

Four measurements were taken:

Bill length -length of culmen;

Tarsus length -length from anterior of the distal end of the (ie. front of "ankle" when the foot is bent downwards) to the posterior of the distal end of the femur (ie. back of "knee"). Note that this is not the standard tarsus measurement as it includes part of the femur;

Mid-toe and claw;

Weight.

2.4 Sampling

Miscellaneous sampling included:

- a) body feathers from 5 black-browed, 30 N.Z. black-browed and 30 grey-headed mollymawks for analysis of mercury content by R.W. Furness (Applied Ornithology Unit, Zoology Department, Glasgow University, Scotland);
- b) tissue samples and blood smears from several dead chicks for epidemiological analysis by G. De Lisle (Wallaceville Animal Research Centre, Ministry of Agriculture and Fisheries, Upper Hutt);
- c) ticks from mollymawks, for identification by A. Heath (Wallaceville Animal Research Centre).

CHAPTER 3. RESULTS

3.1 Population

Table 1 provides a population estimate of mollymawks on Campbell Island in late September 1988. The location of colonies and photopoints are shown in Fig. 1. Birds at colonies were counted from photographs, supplemented for the smaller localities by counts in the field. The only area not photographed was on Isle de Jeanette Marie. A long-distance view by binoculars indicated that this was a small colony and its size was estimated from aerial photographs taken by C. Robertson in 1985.

Only parts of the Bull Rock South colony could be accurately counted from photopoints MP10 and MP12. The rest of the colony was photographed from several positions and a population estimate made by fitting the 'jig-saw' together.

The sizes of the eastern colonies, particularly area E, were under-estimated because parts of the coast were obscured from the vantage point used (this was revealed by studying Robertson's 1985 aerial photographs).

The Courrejolles count may be slightly low because three ridges obscured small areas of the colony from the photopoint.

The combined number of both species of mollymawk on the island in late September was estimated at about 29,000 pairs (Table 1). The largest colony was on the Courrejolles Peninsula, the next largest being the Bull Rock colonies.

N.Z. black-browed outnumbered grey-headed mollymawks, but by what extent is unknown because grey-headed numbers were probably underestimated in most photos and the two species could not be distinguished in the Courrejolles photographs. Unfortunately, because Courrejolles Peninsula was inaccessible, a closer view was not possible. When the inland portion of the peninsula was scanned with binoculars there appeared to be areas of grey-headed mollymawks amongst the predominant N.Z. black-browed mollymawks. Accurate field counts were made only at the smaller colonies, and in several cases, particularly at Courrejolles Isthmus and Hookers Finger, grey-headed outnumbered N.Z. black-browed mollymawks. The colonies at the latter area represented the largest known concentration of grey-headed mollymawks on the island. A minimum of 2300 pairs of grey-headed mollymawks was estimated to occur at all colonies except Courrejolles, Isle de Jeanette Marie and Eastern Colony E. Nine black-browed mollymawk individuals were found at Bull Rock South. It is probable that other members of this subspecies were present in colonies that were not studied intensively.

Photographs of mollymawk colonies taken since the 1940s were compared (Appendix 2) to obtain indices of population change (Table 2). The quality of photographs, and hence the accuracy of counts, vary but general trends were apparent. Of the three colonies for which there are photographs from as early as the 1940s, Hookers Finger and Courrejolles Isthmus have suffered the greatest change, with up to 88% fewer nests by 1988. Bull Rock North was apparently slightly more populous in the 1960s than 20 years previously, but by 1988 had declined by 40%. The colonies at Bull Rock South and Courrejolles have shown less change, each declining by about 20% since the 1960s. In the 1980s, mollymawk numbers appeared to fluctuate, possibly with a low point in 1987.

TABLE 1: Population estimate of mollymawks on Campbell Island, September 1988

Locality	Colony/ Photopts.	NZBB	%	Pairs of mollymawks			Grand Total
				GH	%	Total	
Jeanette Marie							
Courrejolles	1					2744	
	2					3667	
	3					5305	
	4					4386	
							16102
Courrejolles Isthmus	JDK	20		52		72	
	MP1	47		279		326	
			17		83		398
Hookers Finger	MP2/3a	160		406		566	
	MP3b/4	28		239		267	
	MP5a-c	583		80		663	
	MP5d	62		37		99	
	MP6	338		200		538	
			55		45		2133
Hookers Peninsula	MP7	402		73		475	
	MP8/9	131		208		339	
			65		35		814
Bull Rock North	MP11	2304		236		2540	
			91		9		2540
Bull Rock South	MP10/12 + extra series	5176		300		5476	
			95		5		5476
Eastern Colonies	A	20		0		20	
	B	184		0		184	
	C	73		107		180	
	D	1025		105		1130	
	E					56	
			86		14		1570
Total							29183

KEY NZBB : New Zealand black-browed mollymawk

GH : grey-headed mollymawk

: no photo in 1988, therefore estimated from photo by Robertson in 1985 (Table 3).

NOTE Numbers of mollymawk pairs at the colonies were estimated by counting the birds in photographs with the aid of a binocular microscope. At Courrejolles Isthmus, Hookers Finger and Eastern Colony C counts were made in the field.

TABLE 2 :Estimated population changes at Campbell Island mollymawks colonies, 1942-88.

Area	Percent Decline or Increase to Sept. 1988 Since Historical Photograph								
	1942	1966	1975	1981	1984	1985	1986	1987	1988
Courrejolles		-19	+1			+5		+22	0
Courrejolles Isth.	-88	-73					+5	+89	0
Hookers Penin.			-41			-11		+35	0
Hookers Finger	-75						-9	+15	0
Bull Rock North	-35	-40	-18	+8	+14		+2	+9	0
Bull Rock South		-20	-20		+7			+7	
Overall % Change to 1988 (corrected for colony size)	-57	-26	-5	+8	+12	+4	-1	+20	0
Total Population Estimate (thous).	67	39	31	27	26	28	29	24	29

NOTE: Estimates of population change are based on counts of nests in photographs (Appendix 2). Late September 1988 has been used as a reference point. Where necessary, the counts in Appendix 2 have been adjusted to late September-early October levels using the index of monthly change at Bull Rock North in (Appendix 3). The estimate of overall change was based on the cumulative photopoint totals for the particular year, in relation to the same photopoints in late September 1988. The total population estimate was derived using these percentage figures to extrapolate back from the total count of 29,200 nests in September 1988 (see line 1, Fig. 2).

The evidence for change was used in Tables 2 and 3 and Fig. 2 to estimate the populations of the colonies and hence the total population of the island over the last 45 years. It was necessary to make extrapolations in some cases, or, where photographic evidence was lacking, assume that the change would have been similar to neighbouring colonies. Consequently, the estimates are provided only as a guide to the trends rather than a definitive statement. The evidence suggests that the 1940s population was between 47,000-67,000 pairs of mollymawks, which represents a decline of 38-57% to the present day. In the 1960s the population was approximately 36,000-44,000 pairs, representing a decline of 26-34% by 1988.

FIG. 2 : ESTIMATED CHANGE IN CAMPBELL ISLAND MOLLYMAWK POPULATION

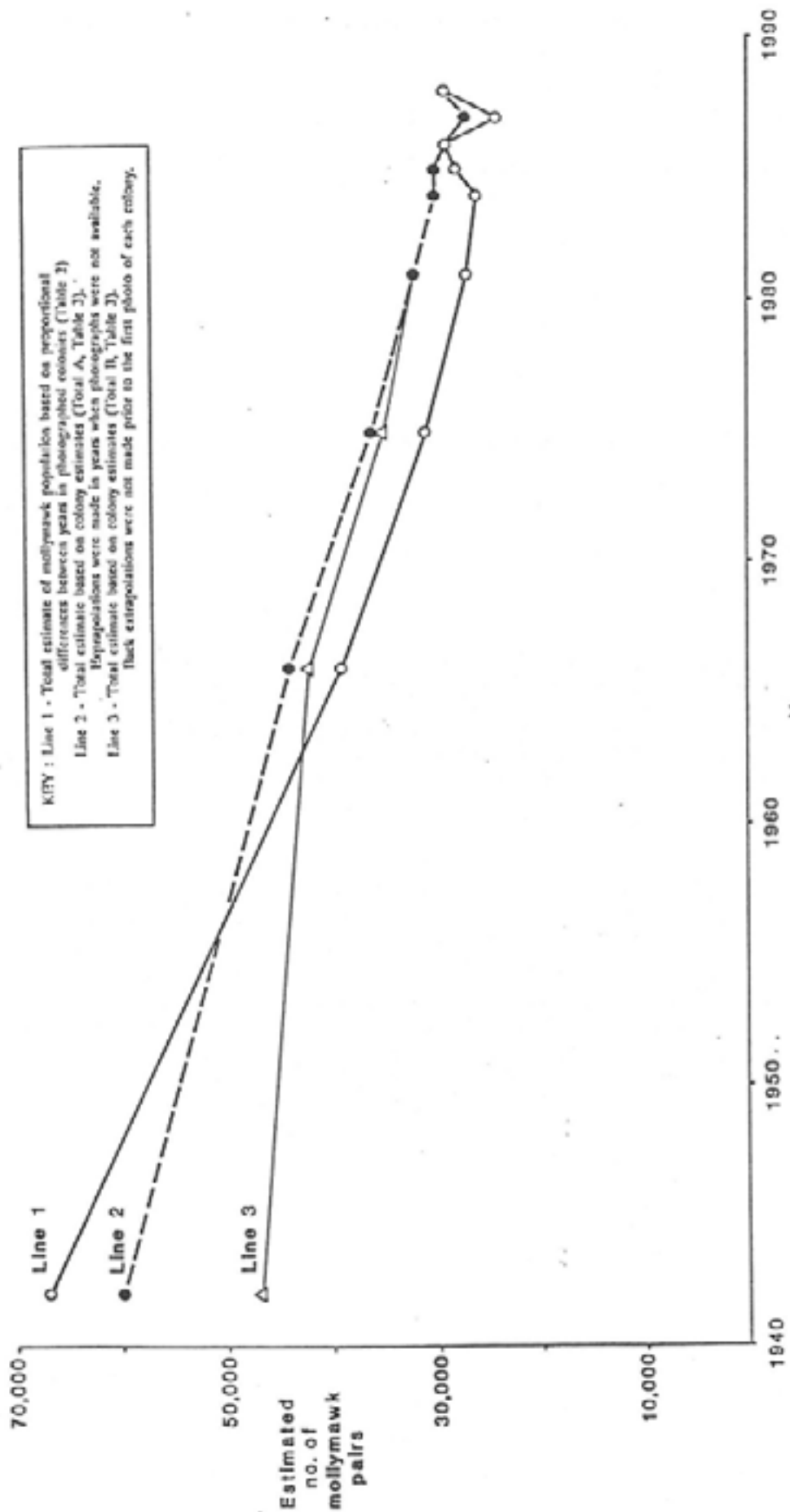


TABLE 3: Estimated populations of Campbell Island mollymawk colonies, 1942-1988

	Estimated number of mollymawks pairs in late Sept-early Oct.								
	1942	1966	1975	1981	1984	1985	1986	1987	1988
Jeanette Marie	280	190	150	140	140	140	130	120	150
Courrejolles	30440	19880	15920	15590	15420	15370	14280	13190	16100
Courrejolles Isth.	3320	1470	980	650	490	430	380	210	400
Hookers Finger	8520	5140	3880	3030	2610	2470	2330	1860	2130
Hookers Penin.	2940	1810	1390	1110	970	920	770	610	810
Bull Rock North	3900	4260	3090	2350	2220	2360	2500	2330	2540
Bull Rock South	6850	6850	6850	5700	5120	5120	5120	5120	5480
Eastern	4160	4160	4160	3460	3110	3110	3110	3110	1570
Total A (thous.)	60	44	36	32	30	30	29	27	29
% change to 1988	-52	-34	-19	-9	-3	-3	0	+7	0
Total B (thous.)	47	42	35	32	30				
% change to 1988	-38	-31	-17	-9	-3				

KEY Numbers in bold represent estimates derived from photographic evidence (Table 2, Appendix 2). It was assumed that the change at the photopoints was representative of the whole area if the photographs were of a small part of that area. In these cases (e.g. Courrejolles Isthmus, Hookers Finger, Bull Rack South) the difference the count in September 1988 and the total count of the colony or area was used to adjust the total in earlier years. In years with no photographic information, estimates were derived by extrapolation. For colonies with little photographic (Jeanette Marie and Eastern) it was assumed that change was similar to the closest neighbouring area.

TOTAL A: Grand total of colony estimates (line 2, Fig. 2)

TOTAL B: It was assumed that there had been no population change prior to the first photograph of the colonies, extrapolations were not made (line 3, Fig. 2).

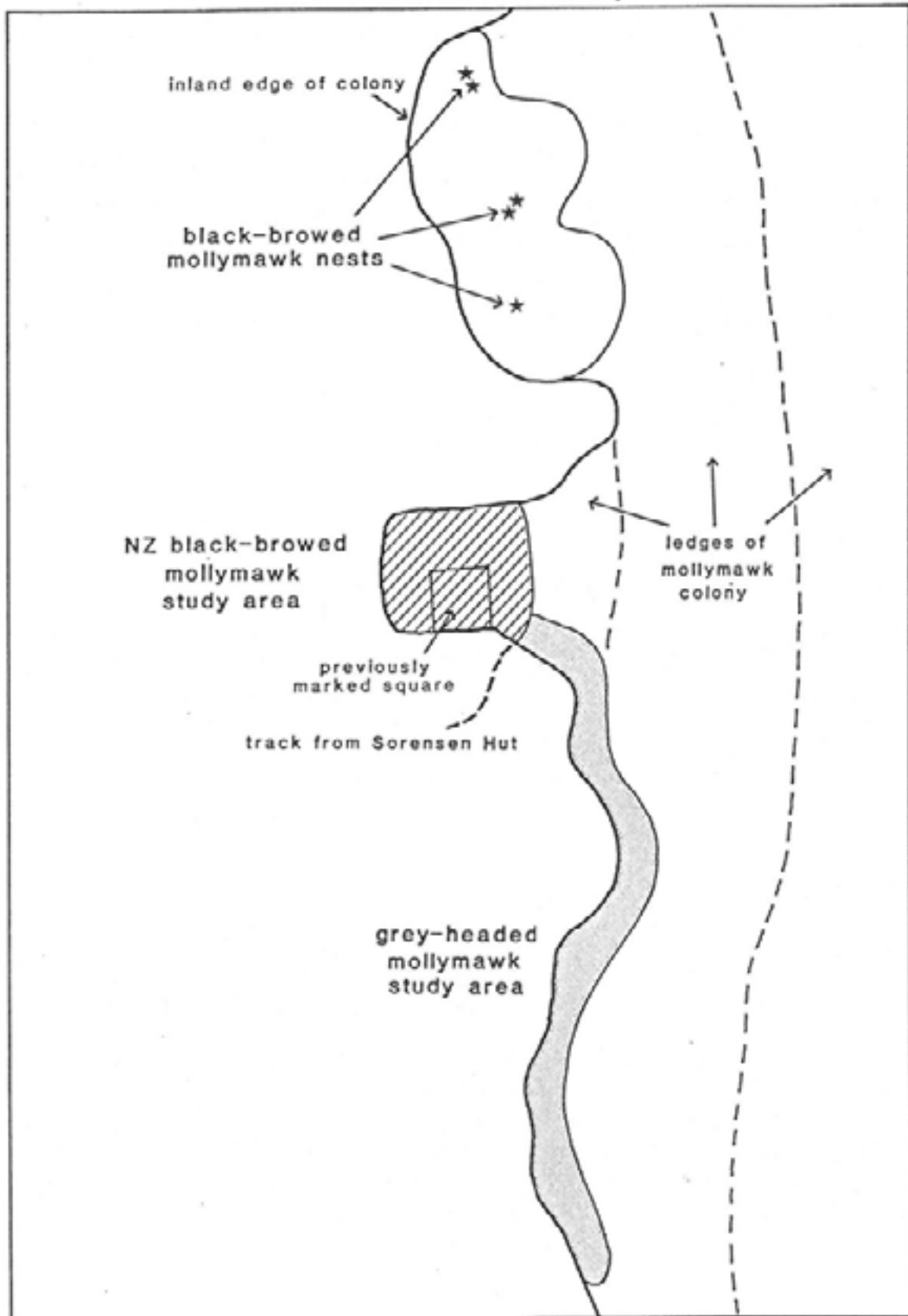
3.2 Breeding data

3.2.1. Study Area

N.Z. black-browed mollymawks predominated at the Bull Rock South Colony. The smaller number of grey-headed mollymawks occupied the inland periphery of the colony.

The study area was at the southern inland portion of the colony (Fig. 3). The 50 N.Z. browed mollymawk study nests were amongst a square of over 200 nests. The 50 grey-headed mollymawk study nests were nearby, running in a scattered line along the edge of the colony, amongst at least 100 grey-headed nests. Five nests of black-browed mollymawks, consisting of three *melanophrys x impavida* and two *melanophrys x melanophrys* pairs were scattered amongst the upper ledge north of the main study areas.

**FIG 3: DIAGRAM OF MOLLYMAWK STUDY AREA, BULL ROCK SOUTH ,
 CAMPBELL ISLAND**



3.2.2. Adult Size

Bill lengths (Table 4) of N.Z. black-browed and grey-headed mollymawks were very similar. Although the sample size for black-browed mollymawks was small, the mean bill length was significantly longer than for the other two taxa ($t=2.8$, $d.f.=37$, $p<0.01$).

TABLE 4: Adult mollymawks bill lengths, Campbell Island 1987-88

	Bill Length		
	Mean	S.D.	N
Black-browed	116.0	3.5	9
N.Z. black-browed	112.5	3.2	30
Grey-headed	112.4	3.3	2

3.2.3. Egg Size

All study nests had one egg at the outset of monitoring (i.e. a complete clutch).

Grey-headed mollymawks had significantly longer ($t=4.9$, $d.f.=98$, $p<0.001$) and narrower eggs than N.Z. black-browed mollymawks (Table 5).

TABLE 5: Mollymawk egg sizes, Campbell Island 1987-88

	Length (mm)		Width (mm)		N
	Mean	S.D.	Mean	S.D.	
Black-browed	102.8	2.6	67.2	1.6	2
N.Z. black-browed	102.2	4.1	65.9	2.1	50
Grey-headed	106.0	3.6	67.9	2.1	50

3.2.4 Hatching and Fledging Dates

The dates of hatching and fledging of the study mollymawks are compared in Table 6. Individual dates were estimated depending on the interval between visits and information from the previous inspection. Therefore the error is likely to be from 2-4 days.

Grey-headed mollymawk eggs on average hatched on 12 December, 5 days after N.Z. browed eggs. Only one black-browed (*melanophrys x melanophrys*) pair hatched a chick, on 14 December.

The average fledging dates for N.Z.black-browed chicks was 14 April, or 130 days after hatching. In contrast, grey-headed chicks fledged nearly one month later (Table 6).

At the beginning of the 1988-89 season the first N.Z. black-browed egg was seen at Bull Rock on 18 September. By 26 September in one area there were eggs in 12 (30%) out of 40 N.Z. black-browed nests and 2 out of 6 black-browed nests. The first grey-headed egg was seen on 26 September 1988.

TABLE 6 : Estimated hatching and fledging dates of Campbell Island mollymawks, 1987-88

	Breeding Season Dates		
	Black-browed	N.Z. Black-browed	Grey-headed
HATCH DATE			
Mean	14 Dec	7 Dec	12 Dec
Range		1-13 Dec	3-21 Dec
S.D.		3.2	3.8
N	1	40	28
FLEDGING DATE			
Mean		14 Apr	12 May
Range		9-27 Apr	29 Apr-19 May
S.D.		4.8	6.7
N		26	8
FLEDGING AGE			
Mean (days)		130	152
Range		122-141	143-157
S.D.		4.8	4.2
N		26	8

3.2.5 Nesting Success

Table 7 compares the breeding success of the two mollymawk species. New Zealand black-browed mollymawks were more successful, as 80% of the nests produced chicks and 52% successfully fledged chicks. Of the chicks that hatched, 65% fledged. In contrast, grey-headed mollymawks had only 56% of nests produce chicks, 16% of nests fledged chicks and 29% of the chicks fledged. Of the five black-browed mollymawk nests, two *melanophrys x impavida* and one *melanophrys x melanophrys* chicks hatched, but none survived longer than 28 days.

TABLE 7: Breeding success of mollymawks on Campbell Island, 1987-88

	Success (No. or %)			
	N.Z. black-browed		Grey-headed	
	Egg	Chick	Egg	Chick
No. nests	50		50	
Hatched	80% ^a	40	56% ^a	28
Fledged		26		8
	52% ^b	65% ^c	16% ^b	29% ^c

SUCCESS DEFINITIONS

a : percent of eggs laid that hatched out chicks

b : percent of the original number of eggs that fledged chicks

c : percent of chicks that fledged

NOTE : Both species lay only one egg per nest.

Most egg losses could not be assigned to a cause, since usually a nest was found deserted and without an egg. Skuas were very quick to take any unattended eggs. Human disturbance was responsible for one N.Z. black-browed mollymawk nest failure when a newly banded adult accidentally broke its egg. Two other eggs were broken through unknown causes. One egg failed to hatch and another six disappeared between visits.

Grey-headed mollymawks were much more nervous and more likely to leave an egg unattended for a short time if handled or disturbed. Three nest failures were attributed to human disturbance. One egg was broken by a newly banded adult, and two were preyed on by when the adult stepped off the nest. Subsequently, unattended eggs were screened from by covering them with grass until the adult was coaxed back on to the nest.

3.2.6 Survival of Chicks

Chick loss appeared mostly to be a result of malnutrition with consequent susceptibility to cold and wet conditions, particularly after the guard stage. One chick from each species broke a leg and died. Most chicks had ticks on their feet or body, samples of which were collected and identified as *Ixodes uriae* (A. Heath, Animal Research Centre, MAF, Upper Hutt), however it is unknown if these influenced mortality.

The guard stage of N.Z. black-browed mollymawks lasted approximately 23 days (range 15-34, S.D.=4.6, N=33) whereas grey-headed mollymawk chicks were guarded for about 27 days (range 15-39, S.D.=7.7, N=13).

The survival of chicks of the two species is compared in Fig. 4. During the guard stage, or the first 25 days after hatching, 14 (50%) of the 28 grey-headed mollymawk chicks died. Another six chicks died, leaving 8 (20%) to fledge.

During the same initial 25 day period, only 7 (17.5%) of the 40 N.Z. black-browed chicks died. Their decline was spread over a longer period and by day 50, 11 (27.5%) of the chicks had died, and subsequently three more, leaving 26 (65%) of the original cohort alive.

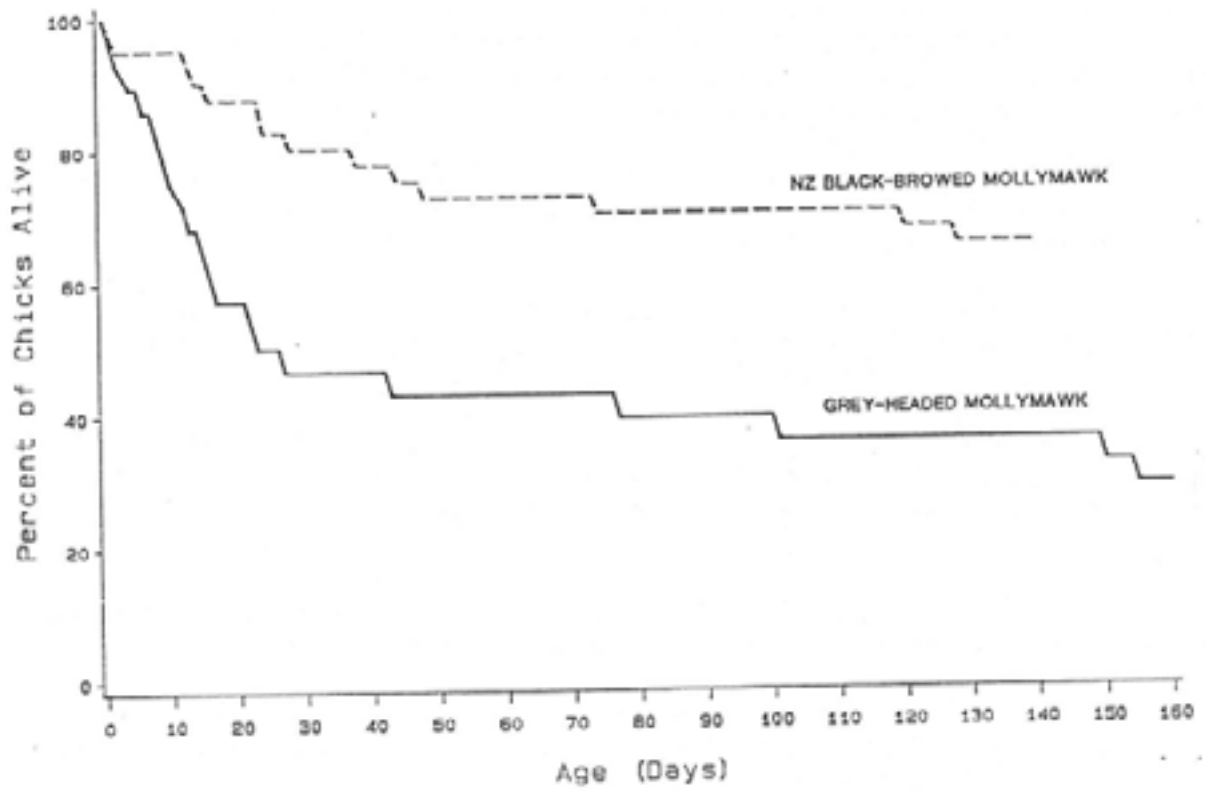
3.2.7 Banding

Adults banded included 34 N.Z. black-browed, 3 black-browed and 33 grey-headed mollymawks, mostly in November-December 1987. Thirty-seven mollymawks were rebanded.

Recoveries of previously banded birds are in Appendix 1. The oldest known-age birds of both species were 22 years old, but one N.Z. black-browed mollymawk, which had been banded as an adult, was at least 27 years of age in 1987-88.

In late March 1988, 807 N.Z. black-browed and 44 grey-headed mollymawk chicks were banded.

Fig. 4: Mollymawk chick survival
Campbell Island 1987-88



3.3 Growth of mollymawk chicks

Figs. 5-10 (Appendix 5) illustrate the growth of mollymawk chicks at Bull Rock South colony. Because chicks chosen for study were different ages and visits to the colony were at irregular intervals, the growth data were grouped into 10 day intervals. The first point on the graphs represents average data for 1-4 days after hatching, the second point represents 5-14 days, the third 15-24, and so on. The means and standard errors are plotted in Figs. 7-10, and in addition, the standard deviations and sample sizes are provided in Appendix 5.

Sixteen N.Z. black-browed mollymawk chicks were monitored initially, but the data for one chick has been excluded because of its particularly retarded growth before dying. Four of the 15 study birds died and 11 chicks fledged. The growth of 18 grey-headed mollymawk chicks was monitored but only 8 fledged. Hence, the sample sizes decline with age. For some points, the sample size is greater than the number of chicks because some were measured twice in the 10 day interval.

Comparisons of the growth curves of the three body measurements for each species are shown in Figs. 5 and 6. These show that for both species the tarsus and toe measurements approached asymptotal length after about 70 days of age. The bill grew throughout the fledging period, but gradually slowed in growth after 100-120 days.

Figs. 7-10 illustrate the differences between the growth curves of the two species, and Table 8 presents the data of fledging weights and measurements. The mean figures for grey-headed mollymawks on day 130 are also presented because this was the age at which N.Z. browed mollymawks fledged.

3.3.1 Bill Length (Fig. 7)

The growth curves were similar for each species, although the curve for the grey-headed mollymawk was more strongly sigmoidal. The slope of the curve for the N.Z. black-browed mollymawk was quite even for the first 70 days when the bill grew at about 0.9mm per day. The rate of growth slowed gradually, until by day 100 the average bill length was 103.4mm and by day 130, 105.4mm. This was still 7mm shorter than the average adult bill length (Table 4).

The fastest period of grey-headed bill growth was from day 20-40, slowing to 108.5mm by day 110. By day 150, 110.7 was the average length reached. This was approaching the average adult bill measurement of 112.4mm (Table 4). By 130 days after hatching, the grey-headed bills were on average 4.5mm longer than their black-browed counterparts ($t=4.4$, $d.f.=17$, $3<0.001$).

3.3.2 Tarsus Length (Fig. 8)

Although the growth curve of the grey-headed mollymawk was more sigmoidal than that of the N.Z. black-browed mollymawk, the asymptotes were approached at about the same time. The black-browed tarsus grew to by day 70, whereas the grey-headed tarsus was 100.2mm at this age. The difference in tarsus length between the two species at 130 days was not significant ($t=11$, $d.f.=17$, $p=0.27$. Note that the standard errors overlap in Fig. 8).

Fig. 5: N.Z. black-browed mollymawk chick growth
Campbell Island 1987-88

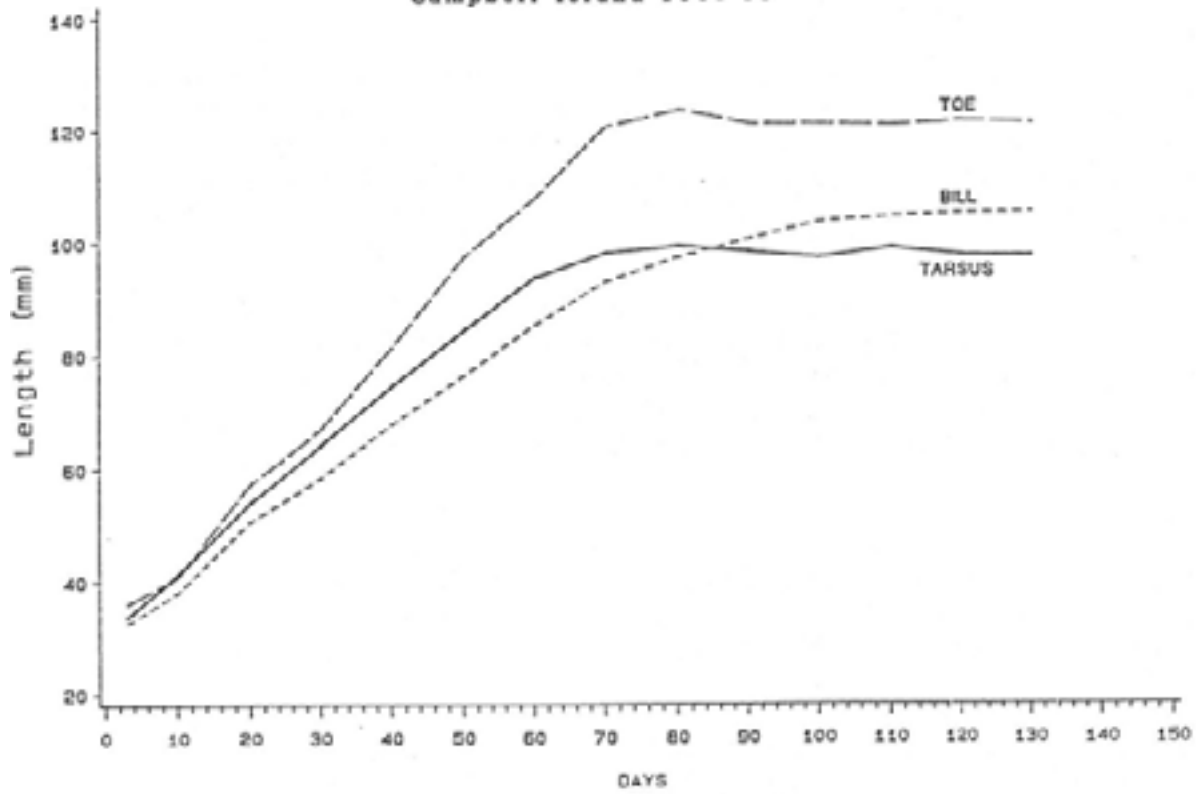


Fig. 6: grey-headed mollymawk chick growth
Campbell Island 1987-88

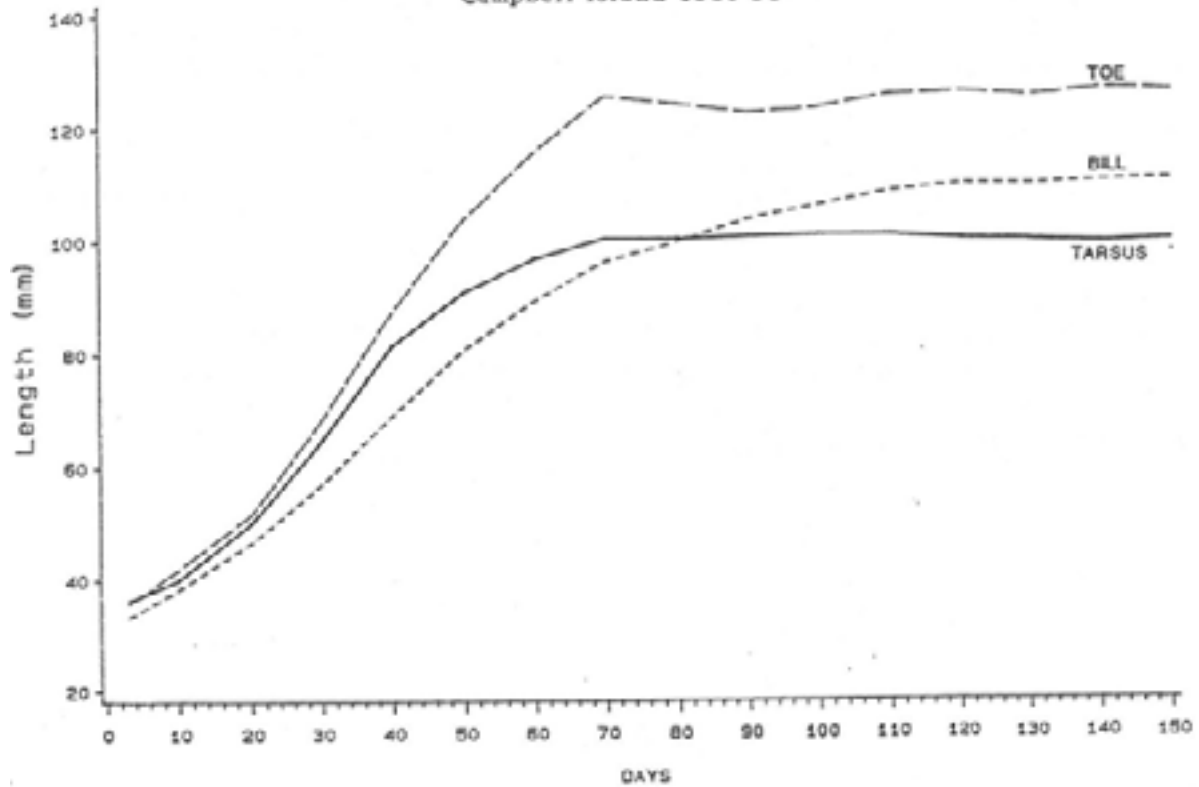
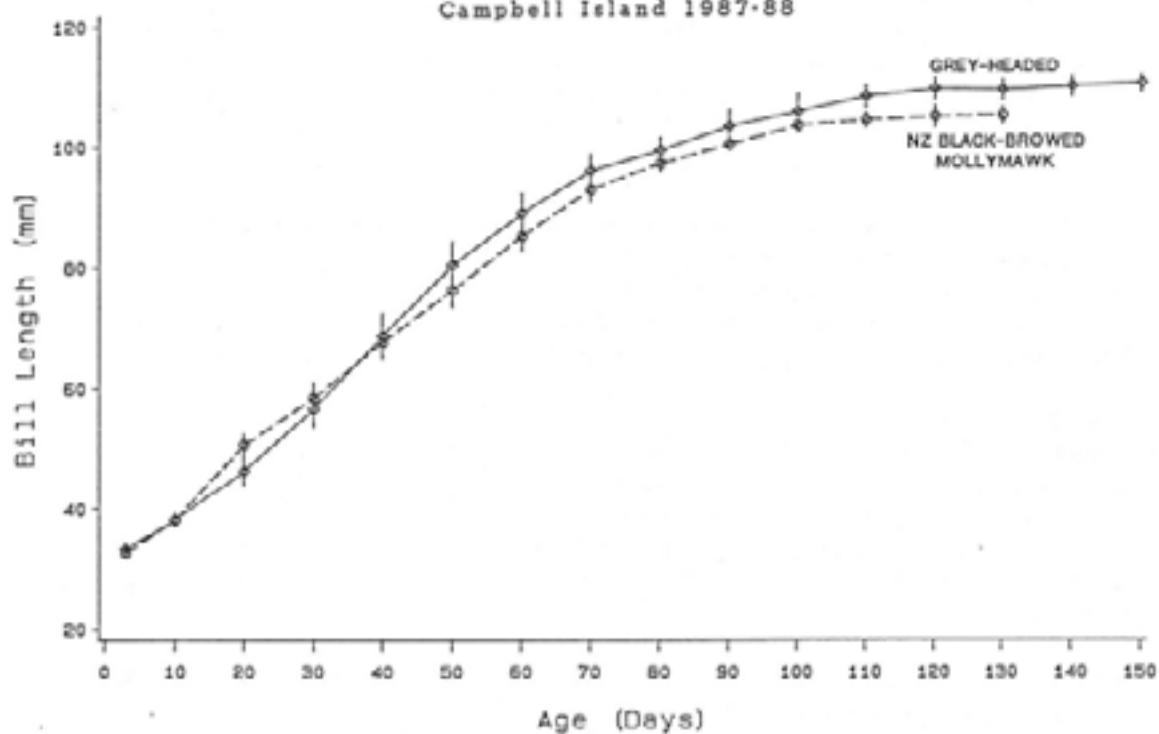
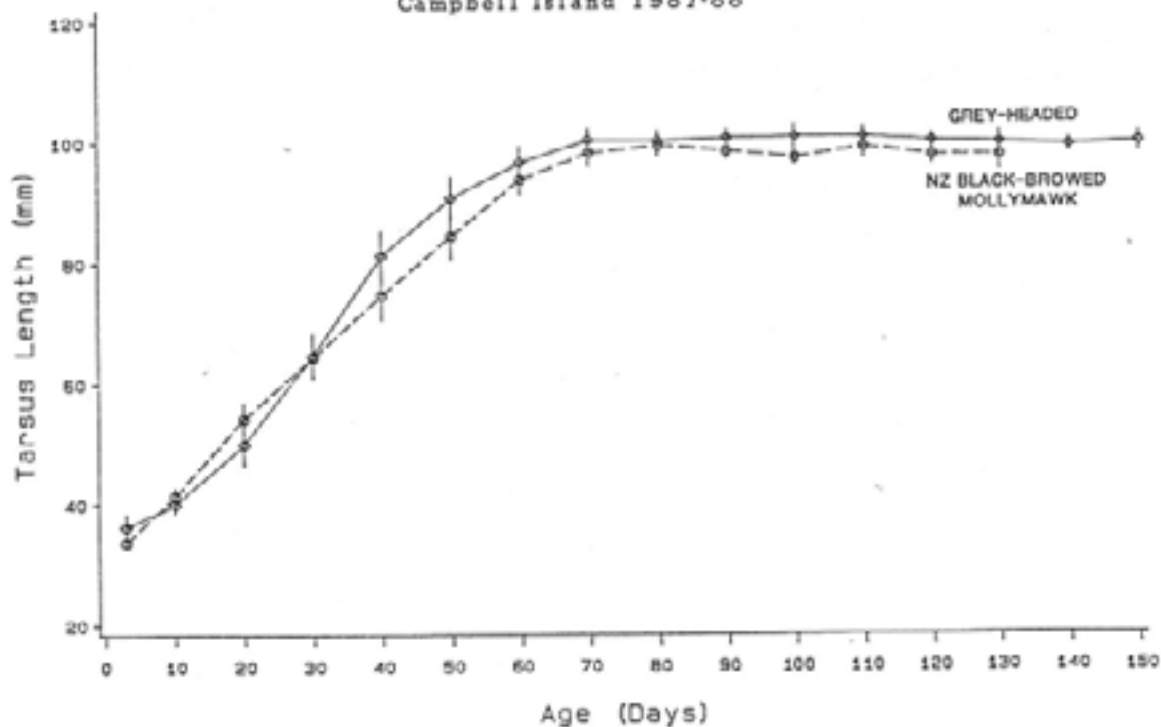


Fig. 7: Mollymawk chick growth : BILL LENGTH
Campbell Island 1987-88



Plot of mean bill length +/- standard errors for 10 day intervals

Fig. 8: Mollymawk chick growth : TARSUS LENGTH
Campbell Island 1987-88



Plot of mean tarsus length +/- standard errors for 10 day intervals

3.3.3 Toe Length (Fig. 9)

The mid-toe and claw of N.Z. black-browed mollymawk chicks grew about per day until 70 days of age, when an asymptote of about 121mm was approached. The graph shows that toe length decreased from day 80-110, presumably because of difficulties in taking this measure accurately. This was the least repeatable measurement because of the flexible nature of the large foot.

The grey-headed mid-toe and claw had a less marked period of exponential growth than the tarsus, although it also approached its asymptote of 125.5mm by day 70. There was some variation in the measurements subsequently, but by day 150 there had been little further growth, and the average measurement was 126.2m. At day 130 the average grey-headed toe was 4.4mm longer than the black-browed counterpart ($t=3.6$, $d.f.=17$, $p<0.01$).

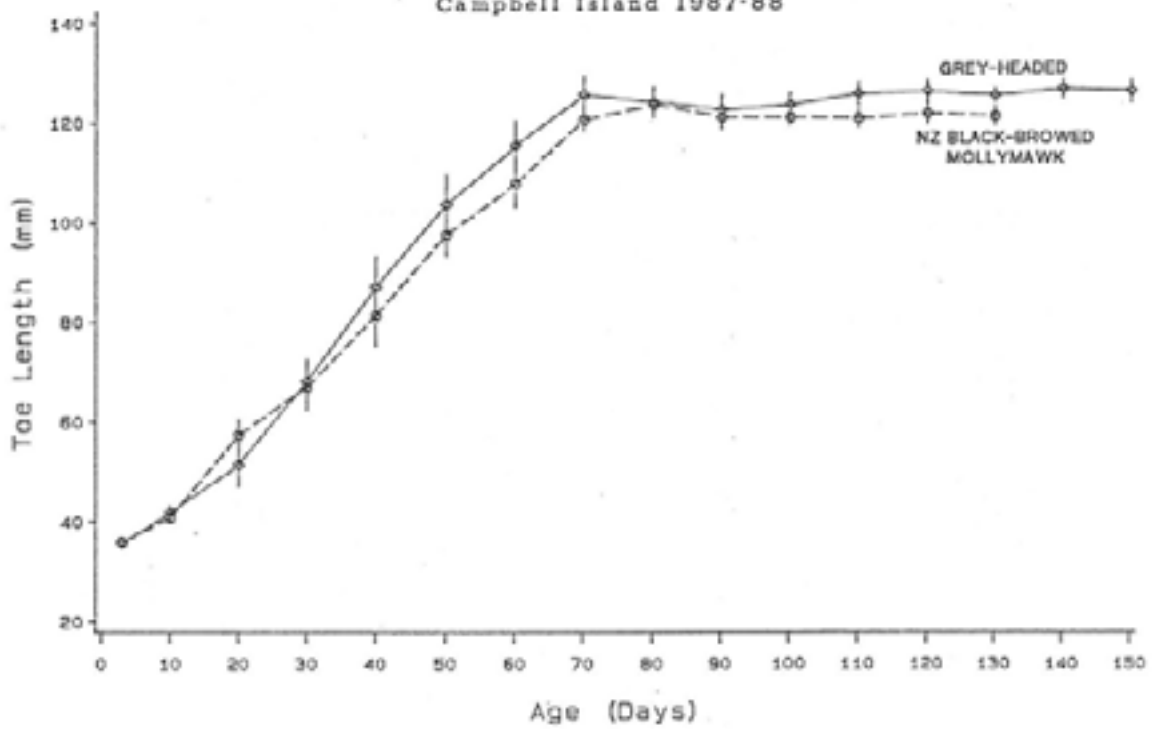
3.3.4 Weight (Fig. 10)

The weight of N.Z. black-browed mollymawk chicks increased steadily until 70 days after hatching, when an average of 3.2kg was attained. From this point chick weights fluctuated with wide individual variation. On day 90 the highest average weight of 3.8kg (including a maximum of 4.9kg) was reached. By day 130 the weights had dropped to 2.7kg, although some heavier chicks had left before this. The average fledging weight of the 11 surviving chicks was 30kg (range = 2.4-3.7kg).

The weight of grey-headed chicks increased steadily for the first 60 days when the average of 3.7kg was reached. The fastest rate of growth of about 80g per day occurred between 20 and 40 days after hatching. After day 60 the average weight fluctuated to a peak of 4.8kg (including one individual of 5.4kg) at day 110, followed by a decline to 3.5 kg by day 150. This represented the fledging weight for this species.

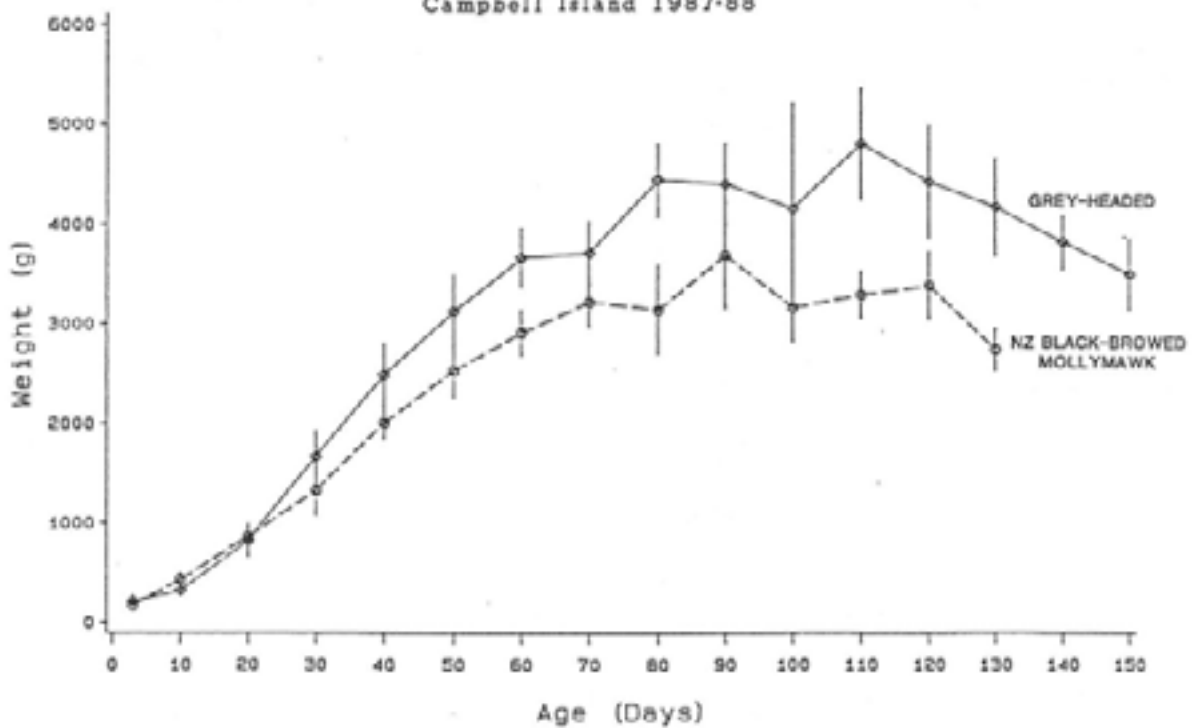
After day 20 grey-headed mollymawks were always heavier, on average, than NZ black-browed mollymawks. From day 80-130 the grey-headed mollymawk chicks were 0.8-1.5kg heavier, and at 130 days this difference was significant ($t=5.3$, $d.f.=17$, $p<0.001$). By fledging time the grey-headed chicks were only 0.5kg heavier than the black-browed fledging weight, but the difference was still significant ($t=2.6$, $d.f.=17$, $p<0.05$).

Fig. 9: Mollymawk chick growth : TOE LENGTH
Campbell Island 1987-88



Plot of mean mid-toe and claw length +/- standard errors for 10 day intervals

Fig.10: Mollymawk chick growth : WEIGHT
Campbell Island 1987-88



Plot of mean weight +/- standard errors for 10 day intervals

TABLE 8: Size of mollymawk chicks at or near fledging, Campbell island, 1987-88.

	N.Z. Black-browed Fledging ^a	Day 130 ^b	Grey-headed Fledging ^a
Bill length			
Mean	105.4	109.9	110.2
S.D.	2.2	2.2	2.1
N	11	8	8
Tarsus length (mm)			
Mean	97.7	100	99.8
S.D.	2.5	2.5	1.9
N	11	8	8
Toe length (mm)			
Mean	121.7	126.1	126.0
S.D.	2.3	3.0	2.7
N	11	8	8
Weight (kg)			
Mean	3.0	4.3	3.5
S.D.	0.4	0.6	0.4
N	11	8	8

Key a: final measurement before departure from colony
b: measurement at 130 days, the average fledging age of NZ black-browed mollymawk

CHAPTER 4. DISCUSSION

4.1 Population

Most previous descriptions of the distribution of mollymawk colonies and estimates of the size of their population on Campbell Island are sketchy and vague. For instance, Filhol (1885) mentioned that mollymawks bred on the cliffs between Southeast and Perseverance harbours, but Westerskov (1960) pointed out that the precipitous cliffs were unsuitable for nesting colonies. Filhol's information was probably second hand and therefore unreliable (Westerskov 1960). Oliver (1930) and Sorensen (1951) knew of an "immense" colony at the north-east of the island, undoubtedly the area south of Bull Rock, yet Westerskov (1960) failed to locate it despite viewing the coast from 500m offshore. Sorensen (1951) stated that there were "hundreds of thousands of mollymawks" nesting in the north of the island during the 1940s, but there was no attempt to estimate numbers (Bailey and Sorensen 1962).

The first real attempt to describe the distribution and estimate the population size was by Robertson (1980). He estimated that there were 74,800 N.Z. black-browed and 11,500 grey-headed mollymawk pairs in nine colonies at the north end of the island. This assessment was not accurate, because it was derived mainly from brief visual impressions of the colonies (C. Robertson pers. comm.). Counts of Robertson's photographs of Courrejolles, Bull Rock North and Hookers Peninsula colonies taken in November-December 1975 suggest that he over-estimated by 2.5, 2.6 and 4.5 times respectively.

A more detailed assessment of the mollymawk population was attempted during the study, combining photographic counts with some field counts. Standard photopoints allowed comparisons to be made with historical photographs and set up baseline data for monitoring population trends in the future. The total population in late September 1988 was estimated at about 29,000 breeding pairs.

Photographs taken since the 1940s suggest that there may have been an overall decline in the mollymawk population of about 38-57%. The changes have not been uniform, with some areas not declining until after the 1960s. The most substantial changes have been at Hookers Finger and Courrejolles Isthmus, the latter having only 12% of the numbers that was present 45 years ago. Hookers Peninsula may also have suffered a long-term decline, as evidenced by a drop in numbers of 40% since 1975. These three areas support colonies where grey-headed mollymawks predominate, implying that this species may have suffered a proportionately greater decline than the N.Z. black-browed mollymawk, or that the latter species has declined proportionally more there than at other parts of the island.

Interpretation of mollymawk population estimates is complicated by the fact that there will be natural fluctuations occurring. This is particularly the case for the biennial breeding grey-headed mollymawk, populations of which can vary by up to 45% between years (Prince 1985). This depends on the level of breeding success the previous season (ie. biennial breeders will usually return to breed the year following a nest failure) and the proportion of the population able to attain breeding condition. The breeding population of grey-headed mollymawks in September 1988 on Campbell Island may have been higher than usual because of the poor level of breeding success the previous season. The estimated annual population variation of both species combined in the

1980s was up to 20%. Overall, the apparent decline in the breeding populations since the 1940s would seem to represent long-term changes, rather short-term or seasonal fluctuations in numbers.

There was a minimum of 2300 grey-headed mollymawk pairs on Campbell Island in September 1988. Because of its inaccessibility, Courrejolles Peninsula was not assessed for the proportion of each species. Robertson's (1980) superficial assessment of this area was that 4% of birds were headed mollymawks. If that was the case in 1988, there were at least 3000 grey-headed pairs on the island, and at the most, 26,000 N.Z. black-browed mollymawks. The overall mean proportion of grey-headed mollymawks at the other colonies was estimated at 20% (range 5-83%, Table 1). If this figure was applied to the whole island, there would have been 5,800 grey-headed and 23,400 N.Z. black-browed mollymawk pairs. Although it is unlikely that grey-headed numbers at Courrejolles approached those of N.Z. black-browed mollymawks, this gives the extreme estimates of 10,000 and 19,000 pairs respectively. Thus, the ranges are 3,000-10,000 grey-headed and 26,000 N.Z. black-browed mollymawk pairs (see Appendix 4 for comparison with populations elsewhere). Campbell Island is of particular significance for the N.Z. black-browed mollymawk because it is the only breeding locality for the subspecies.

It is not clear what influence human activities have had on the mollymawk populations since the island's discovery in 1810. Despite the effort required, mollymawk eggs were collected from Courrejolles Peninsula during the farming era (1895-1931) because "they were good to eat too, bigger than a goose egg" (Kerr and Judd 1978). Before sheep were eliminated from the north of the island in 1970 they were attracted to the mollymawk colonies by the lush growth of grasses. They allegedly forced adults from their eggs, exposing them to skua predation (Westerskov 1960) and later in the breeding season caused chicks to fall from their nest pillars and die (Sorensen 1951).

The main predator at the mollymawk colonies is the Southern skua (*Stercorarius lonnbergi*) which takes eggs from 'careless' parents (Sorensen 1951) and preys on weakened chicks (Taylor 1986). Northern giant petrels (*Macronectes halli*) also prey on mollymawk fledglings by forcing them into the water on their first flight from the colony and drowning them (pers. obs.). Ticks parasitise mollymawk chicks and adults and may also affect mortality through the transfer of viruses to the birds (A. Heath pers. comm.). Norway rats (*Rattus norvegicus*) apparently act only as scavengers, as they cannot break into intact mollymawk eggs (Taylor 1986).

Changes to the food supply undoubtedly have important effects on seabird populations. Admittedly, it is largely supposition to suggest that this is the reason for the decline in mollymawk numbers at Campbell Island. Nevertheless, huge amounts of food are required to maintain breeding populations of thousands of birds. It has been estimated that 13 million tonnes of food per year are taken by seabirds and seals from the seas around South Georgia, including 64,000 tonnes by 240,000 mollymawks (Croxall *et al.* 1985). A change in the food supply caused by oceanic warming has been implicated in the dramatic 90% decline of the rockhopper penguin (*Eudyptes chrysocome*) population at Campbell Island from over one million birds in the 1940s (Moors 1986).

The impacts of fishing activities on the food supply or survival of mollymawks in the New Zealand region are unknown. Brothers (in press) estimated that 44,000 albatrosses,

including 19,250 black-browed and 1375 grey-headed mollymawks, may be killed annually in the southern oceans by the Japanese tuna long-line fishery. On the Kerguelen Islands, the decline in the black-browed mollymawk population may have been a consequence of trawling operations, which killed large numbers of birds (Weimerskirch *et al.* 1987). Similarly, 44% of black-browed mollymawks which were banded on South Georgia and recovered off South Africa were trapped in fishing gear, and probably many of these were killed for food by fishermen (Morant *et al.* 1983).

Competition between species is alleviated by preference for different types of prey, for example grey-headed mollymawks take a greater proportion of squid than black-browed mollymawks, which tend to eat more krill (Prince 1980). Resource partitioning is also brought about by the species using different foraging zones. Black-browed mollymawks have been linked with productive waters over continental shelves (Stahl *et al.* 1985, Weimerskirch *e al.* 1986, 1988), whereas grey-headed mollymawks are apparently less aggressive competitors and forage further afield in pelagic waters. At the Kerguelen Islands grey-headed mollymawks travel up to 1850km to collect food for their chicks (Weimerskirch *et al.* 1988), and at South Georgia they travel up to 500-800 km (Prince and Francis 1984).

One of the probable reasons for the presence of a large population of N.Z. black-browed mollymawks at Campbell Island, and their numerical superiority over grey-headed mollymawks, is that they are favoured by the presence of an extensive continental shelf around the island.

The 1987-88 results on Campbell Island support the findings of Robertson (1980) that mollymawks were smaller there than on South Georgia. Grey-headed mollymawk bill lengths of 112.4mm (Table 4) were significantly shorter ($t=2.8$, $d.f.=49$, $p<0.01$) than the South Georgian mean of 114.8mm (S.D.=2.7 N=29, Tickell and Pinder 1975). The N.Z. black-browed mean bill length of 112.5mm (Table 4) was also significantly shorter ($t=6.7$, $d.f.=52$, $p<0.001$) than for the black-browed mollymawk (mean=117.6 S.D.=2.3 N=24, Tickell and Pinder 1975). This is possibly because of the isolation of Campbell Island mollymawks from other stocks. Mollymawks (the majority N.Z. black-browed) banded on Campbell Island have not been recorded beyond New Zealand, Australia and the Pacific Islands (provisional data, Banding Office, DOC, Wellington). One juvenile N.Z. black-browed mollymawk was found in New Zealand only seven days after it was banded on Campbell Island (Robertson 1979). Other stocks also show segregation, with South Georgian black-browed mollymawks wintering off South Africa, and Falkland Island birds off South America (Tickell 1967). There is some overlap in non-breeding ranges though, with Kerguelen black-browed mollymawks being found mainly off Australia (Weimerskirch *et al.* 1985). There is insufficient banding data for grey-headed mollymawks to determine dispersal patterns. Because of the subspeciation of black-browed mollymawks on Campbell Island, and the great variety of albatrosses in the New Zealand region, it has been suggested that the New Zealand marine ecosystem has narrower niches for albatrosses than elsewhere (Tickell 1976).

Further banding on Campbell Island, particularly of grey-headed mollymawks, would refine our knowledge of mollymawk movements outside the breeding season. Dietary studies are also desirable to reveal potential competition between species, or differences between populations.

4.2 Breeding

The overall breeding success of N.Z. black-browed mollymawks during this study was 52%. This result compares well with the observations of Taylor (1986) in the same part of the Bull Rock colony where 64% of nests had chicks in March 1985 and at least 50% had chicks in April. These figures are higher than the average success of black-browed mollymawks on South Georgia of 32% in 1962-63 (Tickell and Pinder 1975) and 38% from 1975-82 (Prince 1985), although the success varied from complete failure in one season to 67% in another. The difference appears to be mainly at the egg stage, since 80% of Campbell Island eggs hatched, yet only 39% (Tickell and Pinder 1975) and 68% (Croxall and Prince 1979) of the South Georgia eggs hatched. Surprisingly, the marginal population of about 70 pairs of black-browed mollymawks on Macquarie Island had a consistently high success of 67% (range 43-86%) over 7 seasons (Copson 1988).

The 16% breeding success at Campbell Island grey-headed mollymawk nests in 1987-88 was very low compared with 1984-85 when at least 50% of nests had chicks in April (Taylor 1986). The species on South Georgia generally has a higher success, on average 46%, with much less variation (22-64%) than black-browed mollymawks (Prince 1985). Similarly, the small population of about 90 pairs on Macquarie Island had an average success of 72% (range 58-86%) (Copson 1988). The higher average success of grey-headed relative to black-browed mollymawks has been attributed to grey-headed mollymawks being less reliant on krill, which varies more in productivity than their more favoured squid (Prince 1980, 1985). It would appear that the food supply for grey-headed mollymawks around Campbell Island was very poor in 1987-88. Other factors such as observer interference, or the location of all grey-headed nests at peripheral positions in the colony may also have been involved, but they appear to be discounted by the fact that the two species had similar breeding success in 1984-85 (Taylor 1986).

TABLE 9: Comparative breeding cycles of mollymawks

		Range of Dates			
		Campbell ^{a,b}	Macquarie ^c	South Georgia ^d	Crozet ^e
Black-browed	laying		26 Sept-early Oct.	19 Oct-11Nov	12-30 Oct
	hatching	14 Dec	8 Dec-late Dec	26 Dec-11 Jan	19 Dec-5 Jan
N.Z. black-browed	laying	18 Sept-8 Oct			
	hatching	1-14 Dec.			
Grey-headed	laying	26 Sept-9 Oct	mid-late Oct	12-31 Oct	1-19 Oct
	hatching	3-21 Dec	20 Dec-early Jan	24 Dec-5 Jan	12-30 Jan

references a: This study
b: Robertson (1980)
c: Copson (1988)
d: Tickell and Pinder (1975)
e: Weimerskirch *et al.* (1986)

The timings of the breeding cycles of mollymawks on Campbell Island are earlier than those of South Atlantic mollymawks (Table 9). The N.Z. black-browed cycle on Campbell Island is 3-4 weeks earlier than the black-browed cycle on Crozet and South Georgia, whereas the black-browed cycle on Macquarie Island is intermediate between these extremes. The grey-headed cycle on Campbell is 1-3 weeks earlier than the three other areas listed in Table 9. These different seasonal patterns may reflect differences in peak prey abundance in waters south of New Zealand from those at other subantarctic regions.

4.3 Growth

The growth pattern of mollymawks on Campbell Island in 1987-88 showed a consistent pattern for all measurements. After 20-30 days of age, grey-headed chicks grew faster and were larger than their black-browed mollymawk counterparts. This differs from growth studies on South Georgia, where grey-headed mollymawks grew more slowly than black-browed mollymawks (Ricketts and Prince 1981). It was suggested that a squid/fish diet had less nutrients and energy than a krill/fish diet and consequently grey-headed mollymawks grew more slowly over a longer fledging period (Clarke and Prince 1980, Prince and Ricketts 1981, Prince 1985).

These growth pattern differences may reflect the subspeciation at Campbell Island, with N.Z. black-browed mollymawk being a smaller subspecies. For example, the mean fledging weights of Campbell Island birds (3.0kg) were significantly ($t=5.7$, $d.f.=84$, $p<0.001$) lighter than South Georgian fledglings (Tickell and Pinder 1975). In contrast, grey-headed mollymawk departure weights of 3.5 kg and 3.4 kg at the two respective areas were not significantly different. South Georgian and Campbell Island mollymawk chicks were similar, in that they reached peak weights and then declined before fledging. During the decline there was still very active growth of body tissues, especially of plumage and bones (Prince 1985).

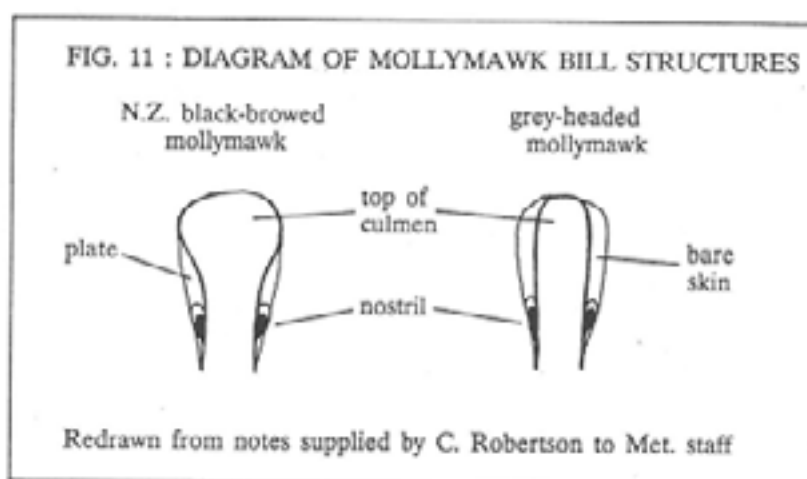
The average Campbell Island fledging periods of 152 days for grey-headed and 130 days for N.Z. black-browed mollymawks were longer than previously found for the two species. The chick periods on South Georgia were 141 and 116 days respectively (Tickell and Pinder 1975) and on the Crozet Islands they were about 145 and 125 days (Weimerskirch *et al.* 1986). It has been suggested that the longer breeding season may have led to biennial breeding by grey-headed mollymawks, which is offset by lower post-fledging mortality than for black-browed mollymawks (Prince 1979). Although the breeding strategies of mollymawks on Campbell Island have not been confirmed, the long breeding season of grey-headed mollymawks indicates that they are probably biennial breeders there also.

CHAPTER 5. CONCLUSIONS

1. The mollymawk (N.Z. black-browed and grey-headed combined) population on Campbell Island has declined from an estimated 47,000-67,000 pairs in the 1940s to 29,000 in 1988. This is a percentage decline of between 38-57%. Grey-headed mollymawks may have suffered a proportionally greater decline than N.Z. black-browed mollymawks.
2. Mollymawks on Campbell Island appear to be isolated from other stocks and differ in size, timing of the breeding cycle and growth.
3. N.Z. black-browed mollymawks had a breeding success in 1987-88 that was comparable to results for the species elsewhere. Grey-headed mollymawk success was very low.
4. Grey-headed mollymawk chicks grew faster and were larger than their N.Z. black-browed mollymawk counterparts.

CHAPTER 6. RECOMMENDATIONS

1. The photopoint series should be repeated regularly, every 5-10 years, to monitor population changes. The survey should run for at least two consecutive seasons to allow for short-term population changes. For instance, a poor breeding season for grey-headed mollymawks may increase the proportion of the population breeding in the following season (normally they breed biennially, whereas N.Z. black-browed mollymawks are annual breeders). The best time for surveys is October or November when single adults are incubating eggs. It would also be valuable to conduct a census, by ground counts and telescope viewing, to determine the actual numbers of grey-headed and N.Z. black-browed mollymawks, to supplement the estimate of both species that the photographic surveys allow.
2. The breeding success of mollymawks should be further studied to determine differences between seasons at the Bull Rock South colony. A comparison at a colony where headed mollymawks predominate would also be valuable.
3. The diets of mollymawks should be determined to determine whether N.Z. black-browed and grey-headed mollymawks are likely to compete for food. This may also illustrate differences in diet between Campbell Island and other parts of the species' range.
4. Banding of chicks at Bull Rock in early April by meteorological station staff should continue to provide data on breeding age, longevity, dispersal patterns etc. As many grey-headed mollymawks should be banded as possible, but care is needed that identification of the species is correct. Grey-headed mollymawks have narrow, sided culminicorn plates (part of bill behind the nostrils) whereas black-browed plates are more rounded in shape (Fig. 11).



Rebanding and noting band numbers of adults at Courrejolles Isthmus would be a useful exercise as this was not attempted in 1987-88.

Careful application of bands is essential, with the band ends meeting flush, but still having a slight gap to prevent them springing open. Some past banding has been of very poor quality. Old worn bands should be replaced and the numbers of other adults recorded in mid-September, the period before egg-laying to limit disturbance to nesting birds. Later in the breeding season (October-May) band numbers of birds should be read and their breeding status recorded. Good records are essential and must be sent to the Banding Office (DOC, Wellington).

ACKNOWLEDGEMENTS

We are grateful to Scott Freeman, Karl Anderson, Robyn Pope, Wendy Strid, Rob Crawley and Neil Gunn, members of the 1987-88 Meteorological Service expedition, for their help at times with our mollymawk study. Thanks are also extended to the Ministry of Transport for the use of their facilities at Beeman Cove.

Chris Robertson and Duncan Cunningham (Science and Research Directorate, DOC, Wellington) provided very useful advice at the outset of the study. Mike Wakelin collated the banding data. Alan Heath (Wallaceville Animal Research Centre, MAF, Upper Hutt) identified ticks collected from mollymawks. Thanks also to the various people who supplied their photographs of mollymawk colonies.

Drafts of this report were read and commented on by Chris Robertson, Duncan Cunningham, Ralph Powlesland, Don Newman, Mick Clout and Richard Sadleir.

Sorensen's Hut near the Bull Rock South mollymawk colony was a very welcome port of call in our frequent forays to the north of the island. May it shelter many future expeditions.

This report is dedicated to the mollymawks of Campbell Island which made very amenable subjects for study. There is much work still to be done.

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APPENDICES

Appendix 1: Ages of banded mollymawks recorded on Campbell Island 1987-88

Year banded	Grey headed		N.Z. black-browed		Black-browed
	No. seen	No. banded as chicks	No. seen	No. banded as chicks	No. seen
1961			1		
1962					
1963					
1964					
1965					
1966	6	2	29	4	
1967	13	12	23	23	
1968	2	2	52	25	
1969	8	8	10	4	
1970	4	4	28	28	
1971	16	16	3	3	
1972	3	3	19	19	
1973					
1974					
1975					
1976	33	6	53	53	
1977	10	10	35	35	
1978	2	2	19	19	
1979	1	1	9	9	
1980	12	12	30	28	
1981			5	5	
1982			2	2	
1983					
1984	28		30		
1985	1		1	1	
1986	2				3
TOTAL	141	78	349	248	3

Appendix 2: Comparisons between counts of mollymawks in historic photographs and in 1987-88, Campbell Island

Photographer	Date	No. Pairs	Photo-point or Area	Date	No. Pairs	Prop. of earlier Count
Bull Rock North						
Sorensen	11.12.42	3106	MP11	19.12.87	1850	60%
Leigh	10.66	3944	MP11	30.10.87	2020	51%
				26.09.88	2351	60%
Robertson	2.12.75	2024	MP11*	18.11.87	1591	79%
				19.12.87	1460	72%
Robertson	23.02.81	884	MP11*	23.02.88	873	99%
Taylor	6.10.84	2057	MP11	30.10.87	2020	98%
				26.09.88	2351	114%
Taylor	1.87	1551	MP11	19.01.88	1435	93%
Bull Rock South						
Leigh	10.66	1039	MP10*	26.09.88	829	80%
Taylor	6.10.84	774	MP10*	26.09.88	829	107%
Robertson	8.12.75	1088	MP12*	19.12.87	856	79%
Taylor	15.11.84	877	MP12*	18.11.87	875	100%
Hookers Finger						
Sorensen	30.10.42	646	MP4	29.10.87	138	21%
Taylor	1.87	69	MP4	20.01.88	41	59%
Sorensen	30.10.42	1505	MP2	29.10.87	355	24%
Sorensen	19.10.43	2148	MP3a	29.10.87	471	22%
Taylor	1.87	262	MP3a	20.01.88	223	85%
Courrejolles Isthmus						
Sorensen	2.10.45	838	MP1	27.09.88	100	12%
Clark	Early 60s	369	Mp1	27.09.88	100	27%
Taylor	11.86	88	MP1	19.11.87	49	56%
Courrejolles						
Guard	11.01.66	7429				
	Sept equiv?	11088	2, 3	27.09.88	8972	81%
Robertson	12.11.75	14647	1-4	19.11.87	12130	83%
Robertson	12.02.85	7376	1-4			
	Sept equiv?	15367		27.09.88	16102	105%
Isle De Jeanette Marie						
Robertson	12.02.85	69				

Appendix 2 ctd.

Photographer	Date	No. Pairs	Photo-point or Area	Date	No. Pairs	Prop. of earlier Count
Eastern Colonies						
Robertson	12.02.85	1492	A-E			
	Sept equiv?	3107		26.09.88	1570	51%
Hookers Peninsula						
Robertson	12.11.75	1275		19.11.87	557	44%
Robertson	12.02.85	441				
	Sept equiv?	919		27.09.88	814	89%

Appendix 3: Seasonal change in numbers at Bull Rock North compared with nesting success at Bull Rock South, Campbell Island.

Date	Photo Count at Bull Rock North		Count of Study Nests With Eggs or Chicks at Bull Rock South			
	Estimated No. Pairs	% Sept. Count	NZ black-browed		grey-headed	
			No. nests	% Sept Count	No. nests	% Sept Count
15.09.87	2156	100		100		100
30.10.87	2020	94	50	94	50	94
18.11.87	1994	92	46	87	45	85
19.12.87	1850	86	39	74	25	47
19.01.88	1435	67	31	58	13	25
23.02.88	1037	48	28	53	11	21
22.03.88	810	38	28	53	10	19
19.04.88	170	8	4	8	10	19
26.09.88	2351	109				

NOTE For purposes of comparison, the % of September counts have all been set at 94% October because the 50 study nests of each species at Bull Rock South were not chosen until this date.

The monthly change at Bull Rock North is similar to the decline in number of active nests (those still with eggs or chicks) of NZ black-browed mollymawks at Bull Rock South. This species predominated at Bull Rock North.

Appendix 4: Estimated world populations of Black-browed and Grey-headed mollymawks.

Locality	Estimated Annual ¹ No. of Breeding Pairs		Reference
	Black-browed	Grey-headed	
Cape Horn	20,000	10,000	Schlatter 1984 ²
Falkland Is.	390,000	-	Croxall <i>et al.</i> 1984
South Georgia	60,000	37,000	Croxall & Prince 1979
Prince Edward Is	-	4,870	Williams 1984
Iles Crozet	980	5,800	Weimerskirch <i>et al.</i> 1986
Iles Kerguelen	3,200	7,900	Weimerskirch <i>et al.</i> 1989
Heard Is.	300	-	Williams 1984
Macquarie Is.	70	50	Copson 1988
Campbell Is.	23,400 ³	5,800 ⁴	This study
Total	497,950	71,420	

1. Annual to the number of breeding pairs nesting in any particular season, rather than the number of breeding pair in the population.
2. Schlatter (1984) expressed the figures as 40,000 and 20,000 individuals, respectively. totals have been for the purposes of the number of breeding pairs.
3. Based on estimate that the mollymawk population comprises 80% NZ black-browed mollymawks (Probable range 19,000-26,000).
4. Based on estimate that the mollymawk population comprises 20% grey-headed mollymawks (Probable range 3,000-10,000).

Appendix 5: Mollymawks chick growth data, Bull Rock South, Campbell Island 1987-88.

		Measurements of Chicks							
		N.Z. black-browed mollymawk				Grey-headed mollymawk			
Age (days)		Bill (mm)	Tarsus (mm)	Toe (mm)	Weight (g)	Bill (mm)	Tarsus (mm)	Toe (mm)	Weight (g)
3	Mean	32.7	33.7	36.1	175	33.4	36.2	35.8	219
	N	14	14	14	14	11	11	11	11
	S.D.	0.8	1.1	1.4	21.6	1.7	3.4	1.4	30.4
10	Mean	38.1	41.3	40.9	437	38.2	39.9	41.9	325
	N	14	14	14	14	22	22	22	22
	S.D.	2.0	2.5	2.2	121.2	2.7	3.2	3.4	101.1
20	Mean	50.8	54.1	57.5	863	46.5	49.9	51.5	823
	N	25	25	25	25	13	13	13	13
	S.D.	4.6	6.3	7.9	282.7	4.4	6.1	7.6	285.3
30	Mean	58.6	64.2	67.1	1325	56.8	64.5	68.2	1665
	N	15	15	15	15	15	15	15	15
	S.D.	5.0	6.9	8.8	474.1	5.7	7.0	8.6	504.1
40	Mean	67.9	74.6	81.4	1998	68.9	81.2	87.1	2479
	N	12	12	12	12	9	9	9	9
	S.D.	4.9	7.1	10.9	289.2	5.4	6.1	9.0	469.7
50	Mean	76.5	84.4	97.6	2524	80.6	90.7	103.7	3118
	N	8	8	8	8	6	6	6	6
	S.D.	3.8	5.6	6.0	379.1	4.7	4.2	7.2	445.7
60	Mean	85.3	93.7	107.8	2905	89.2	96.6	115.5	3660
	N	11	11	11	11	10	10	10	10
	S.D.	4.1	3.8	7.9	376.5	5.1	4.2	7.8	463.6
70	Mean	93.1	98.1	120.5	3214	96.2	100.2	125.5	3705
	N	11	11	11	11	10	10	10	10
	S.D.	3.2	3.5	3.7	416.0	4.3	3.0	5.7	504.1
80	Mean	97.4	99.3	123.5	3136	99.6	100.1	124.0	4439
	N	11	11	11	11	9	9	9	9
	S.D.	2.3	2.6	3.2	739.6	3.2	2.4	4.4	545.9

Appendix 5 Cont.

		Measurements of Chicks							
		N.Z. black-browed mollymawk				Grey-headed mollymawk			
Age		Bill (mm)	Tarsus (mm)	Toe (mm)	Weight (g)	Bill (mm)	Tarsus (mm)	Toe (mm)	Weight (g)
90	Mean	100.6	98.3	121.0	3680	103.6	100.5	122.4	4394
	N	10	10	10	10	8	8	8	8
	S.D.	1.7	2.0	3.8	840.4	3.7	2.0	4.3	584.6
100	Mean	103.7	97.3	120.9	3160	106.0	100.7	123.3	4150
	N	10	10	10	10	8	8	8	4
	S.D.	2.0	1.7	2.5	543.0	4.2	2.8	3.5	1066.2
110	Mean	104.6	99.0	120.7	3285	108.5	100.7	125.6	4800
	N	10	10	10	10	8	8	8	5
	S.D.	2.0	2.7	2.8	374.2	2.6	2.4	3.3	623.5
120	Mean	105.1	97.6	121.6	3375	109.8	99.9	126.2	4413
	N	8	8	8	8	8	8	8	8
	S.D.	2.5	2.0	3.1	481.1	2.3	1.7	3.1	803.0
130	Mean	105.4	97.6	121.1	2733	109.6	99.6	125.3	4164
	N	6	6	6	6	7	7	7	7
	S.D.	1.8	3.0	2.4	262.0	2.1	2.4	1.9	647.9
140	Mean					110.3	99.2	126.6	3813
	N	0	0	0	0	8	8	8	8
	S.D.					2.4	1.5	2.5	382.4
150	Mean					110.7	99.7	126.2	3486
	N	0	0	0	0	7	7	7	7
	S.D.					1.8	2.0	2.9	475.0