COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF EXTERNAL AFFAIRS

AUSTRALIAN NATIONAL ANTARCTIC RESEARCH EXPEDITIONS

INTERIM REPORTS

16

THE LEOPARD SEAL AT HEARD ISLAND, 1951 - 54

By

K. G. BROWN

ISSUED BY THE ANTARCTIC DIVISION, DEPARTMENT OF EXTERNAL AFFAIRS, MELBOURNE,
MARCH, 1957

THE LEOPARD SEAL AT HEARD ISLAND, 1951-54.

by K. G. Brown.

INTRODUCTION

The leopard seal was first described by de Blainville in 1820 from two skulls and a skin. The records of antarctic expeditions since that date contain scattered references which indicate the rarity of the species. Thirty-seven leopard seals sighted in eighteen months by Worsley was considered an unusually large number (Hamilton 1939).

The localities from which the leopard seal has been recorded are set out in Table I:-

TABLE I

DISTRIBUTION OF THE LEOPARD SEAL

Locality	Population	Authority
Antarctic Continent	Fairly common	Mawson, 1915, etc.
Circumpolar Pack-ice	Common	Worsley Ms. cit. Hamilton, 1939.
Falkland Is.	Common	Matthews, 1929; Hamilton, 1939.
South Georgia	Common	Hamilton, 1939.
South Orkney Is.	Fairly common	Hamilton, 1939.
South Sandwich Is.	Fairly common	Hamilton, 1939.
South Shetland Is.	Fairly common	Hamilton, 1939.
Heard I.	Common	Gwynn, 1953.
Iles de Kerguelen	Fairly common	Author(1)
Australia	Scarce	Le Souef, 1921.
New Zealand	Scarce	Hamilton, 1939.
Campbell I.	Scarce	Waite, 1909.
Macquarie I.	Fairly common	Gwynn, 1953.
South America	Scarce	Hamilton, 1939.

Scarce:- Occasional single animals.
Fairly common:- Regular though sometimes seasonal haul outs of up to 20 animals.
Common:- Regular haul outs sometimes in large numbers of up to 250 animals

(1) 400 leopard seals have been reported at Iles de Kerguelen by Moseley (1879, sealers' statement). This record is doubtful. Information from the current French expeditions indicates medium numbers in the areas visited regularly.

Hamilton (1939) published the first comprehensive account of the leopard seal, assembling what was already known and adding his own observations on age determinations and anatomy.

In 1947-8 the Australian National Antarctic Research Expeditions set up research stations at Heard Island and Macquarie Island. During 1949, with the commencement of programmes of biological research at both islands, leopard seal counts revealed that at Heard Island the species occurred in greater numbers than had been recorded anywhere else in the world. In 1950 Dr. A.M. Gwynn, who had spent the previous year at Macquarie Island, began work on the leopard seal at Heard Island and subsequently (1953) published a paper on the results of his investigations.

The present writer who succeeded Dr. Gwynn as A.N.A.R.E. biologist at Heard Island worked on the leopard seal population from April 1951 to February 1952. Observations made in the three following years by L.F. Gibbney, Dr. A.M. Gwynn and Dr. G.M. Budd have furnished additional data.

POPULATION STUDIES

There are eleven beaches at Heard Island on which leopard seals may haul out (Figure 1). Of these the four within easy reach of the A.N.A.R.E. Station - Corinthian Beach, South West Beach, Atlas Cove Beach and West Bay Beach - were visited almost daily during the winter of 1951 and often contained large numbers of leopard seals. The other seven beaches, which were visited only on occasional field trips, gave evidence of very few animals. Red Island Beach was visited on seven occasions throughout 1951 but, though some seals were noticed in the water, none was ever sighted ashore. Saddle Point Beach never had more than one leopard seal ashore on the four occasions that parties were there in spring and midwinter. Spit Bay, which has a sandy beach stretching for about five miles, was visited several times in spring and once in midwinter. The spring trips failed to reveal any leopards and in midwinter, though a full week was spent there with conditions ideal for large haul outs, only a few single animals were sighted. Gilchrist, Skua and Fairchild Beaches were passed twice during this trip but only one seal was observed. One animal was sighted in three days spent at Long Beach in December 1951 when the leopard seal population as a whole was very diminished. It is therefore assumed that numbers in the Four Bays area approximate to the total for Heard Island.

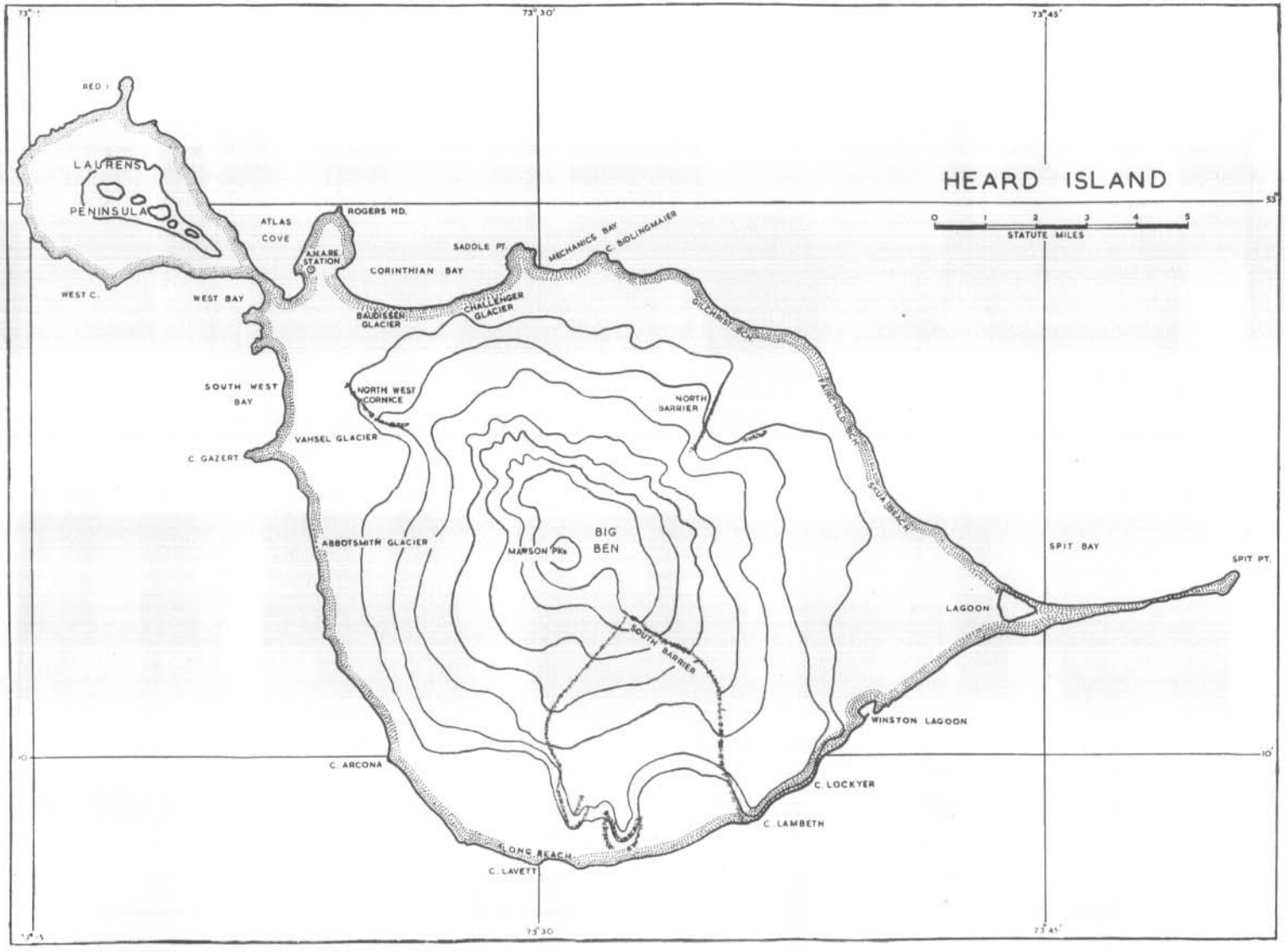
HEARD ISLAND
STATUTE MILES
0 1 2 3 4 5
73°15'
73°30'
73°45'
53°
10'
RED I.
LAURENS
PENINSULA
ATLAS
COVE
ROGERS HD.
A.N.A.R.E.
STATION
SADDLE PT.
MECHANICS BAY
C. BIDLINGMAIER
CORINTHIAN BAY
WEST C.
WEST BAY
BAUDISSER
GLACIER
CHALLENGER
GLACIER
GILCHRIST
SOUTH WEST
BAY
NORTH WEST
CORNICE
NORTH
BARRIER
VAHSEL GLACIER
C. GAZERT
FERGUSON
SPIT
ABBOTSMITH GLACIER
BIG
BEN
MAWSON Pk.
SPIT BAY
SPIT PT.
LAGOON
SOUTH BARRIER
WINSTON LAGOON
C. ARCONA
C. LOCKYER
C. LAMBETH
LONG BEACH
C. LAVETT

FIG. 1.

Estimate of total population. Between 1 April and 31 May a total of 113 leopard seals were branded in the Four Bays area. Of 35 in which the sex was later determined, 16 were female and 19 male, which agrees with the sex ratio in the population as a whole. The branded animals also included a normal proportion of adolescents, and are consequently considered to be a random sample of the total population. Seventeen of them were not seen again (some of them may have been present, but with illegible brands); six were re-sighted at least once, but were not seen after 31 May; and 90 were seen during the four months June - September. During these four months the leopard seals ashore in the Four Bays were counted on 103 days usually at about 5.00 p.m., and at midnight and in the early morning on 13 occasions. All brands seen were noted. The movements of branded individuals showed that there was free interchange of population between the four beaches.

Now if:-

T = the total number of animals seen in a given period,

B = the total number of branded animals seen, and

b = the number of different brands seen,

$\frac{T}{B} \times b = t$ = the number of different individuals seen during that period.

Table 2 presents the figures obtained for the four months separately and together.

TABLE 2

b LEOPARD SEAL POPULATION AT HEARD ISLAND, WINTER 1952.

Month	T	B	b	T/B	t
June	553	114	66	4.85	320
July	1004	100	54	10.04	542
August	859	99	56	8.68	486
September	936	77	42	12.16	511
June-September	3352	390	90	8.59	773

For this estimate to be approximately correct, the population must have consisted of the same individuals throughout the period. The number of branded individuals seen (b) fell over the period, and the proportion of branded to total animals seen also fell, as shown by the rise in T/B. However, the brands were not expected to be permanent and early fading of some of them could account for this. It is also assumed that every individual was counted at least once during the period. However, as intervals of over a month between successive haul outs are quite common (p.6) figures for the four-month period are more accurate than those for separate months. Since more leopard seals were ashore by night than by day (p.6) and night counts were made on 13 occasions only, the final figure of 773 must remain as the lower limit of the leopard seal population at Heard Island during winter.

Composition of population. Sex was determined in as many leopard seals as possible from August 1951 to February 1952. Tables 3 and 4 give the results for adults and first-year animals respectively:-

TABLE 3

SEX RATIOS OF ADULT AND ADOLESCENT LEOPARD SEALS 1951-52

Month	Males	Females	Total Sexed	Ratio Male/Female
August	93	112	205	0.8
September	239	117	356	2.0
October	52	13	65	4.0
November	25	6	31	4.2
December	15	26	41	0.6
January	52	46	98	1.2
February	11	3	14	3.6
TOTAL	487	323	810	1.5

TABLE 4

SEX RATIOS OF FIRST YEAR LEOPARD SEALS, 1951

Month	Males	Females	Unknown	Total	Ratio Male/Female
August	16	12	21	49	1.3
September	16	8	15	39	2.0
October	2	2	10	14	1.0
November	1	2	7	10	0.5
TOTAL	32	24	54	110	1.3

Determinations were made on 8-16 days a month, except for February (two days). Both in adults and first-year seals there was a slight excess of males[1], the average ratios of males to females being 1.5 and 1.3 respectively. In adults the ratio rose in October and November, indicating that females tend to leave the island earlier than males, and again in February.

No figures are available of the number of adolescents (two- and three-year-old seals), but it was the author's impression that from May to mid-September they were seen regularly but in relatively low numbers. From October to December they formed the majority of the seals ashore.

Yearlings (first-year animals) were first seen about the end of May or June in different years. Total numbers remained low, but the relative proportion of yearlings in the population increased during October and the first half of November, showing that they remained at Heard Island rather longer than adults. Between 22 November and 4 December the author was absent from the A.N.A.R.E. station and no counts were made. No yearlings were noticed after he returned, which confirms Gwynn's observation that they leave Heard Island about the middle of November.

TABLE 5

YEARLING LEOPARD SEALS IN RELATION TO TOTAL POPULATION, 1951.

Month	No. of Yearlings	Total Leopard Seals	Yearlings as % of total
August	49	859	4.3
September	39	936	4.1
October	14	160	8.75
November[2]	10	49	20.5

In 1953 Gwynn recorded yearlings up to the first half of November. In September, October and November 10,

(1) The apparent excess of females in August is probably attributable to the fact that most females were then in late pregnancy and easily recognizable. For comparison, the ratios of males to females obtained in 1952 and 1953 were: August, 1.6 and 1.8; September, 7.2 and 1.4; October, 3.2 and 3.8.

(2) 1 - 22 November.

16 and three were seen, or 2.9, 15.0 and 37.5 per cent of the total number of leopards seen. This confirms the trend noted in 1951.

Frequency of hauling out. Of the 113 leopard seals branded, 96 were seen again once or more in the months April-October. The interval between successive sightings of the same seal varied from one to 136 days. Figure 2 is a frequency diagram of the sighting interval, which shows that an interval of one day is the most frequent, followed by one of four days. Twenty-six individuals were sighted on two successive days on the same beach, seven of them more than once. One animal was seen on three successive days and one on four. Eleven were seen by day and the following night, or vice versa. It is probable that some, at least, of these short intervals are caused by the seals remaining ashore for two or more days. In general terms it can be stated that the majority of the branded sea leopards hauled out at Heard Island at intervals of a month or less.

The complex way in which weather and conditions on the beaches affect the hauling out of leopard seals has been described by Gwynn (1953), and confirmed by later observers(1).

Variations in twenty-four hours. On 13 occasions in the winter of 1951 counts were made at Corinthian Beach at intervals round the clock, and the results are presented in Table 6. It should be noted that all counts were made in favourable weather (except for that on 12-13 August when the weather worsened considerably after 5.00 p.m.). Typically, numbers ashore increased by 100 per cent or more between 5.00 p.m. and midnight, and decreased again to 4.00 a.m. and 8.00 a.m. No special trend was noticed between 8.00 a.m. and 5.00 p.m.; numbers might increase, decrease or remain constant. During 1953 regular observations at Atlas Cove showed that, when large numbers of leopard seals were present, a few regularly came ashore in the course of the morning. Night counts made by Gwynn in 1953 confirmed in essentials the sequence given above. It is of interest that one branded animal was seen at night on six of nine occasions.

---

(1) Notes made on sea and beach conditions in 1951 were insufficient to relate these conditions to leopard seal counts

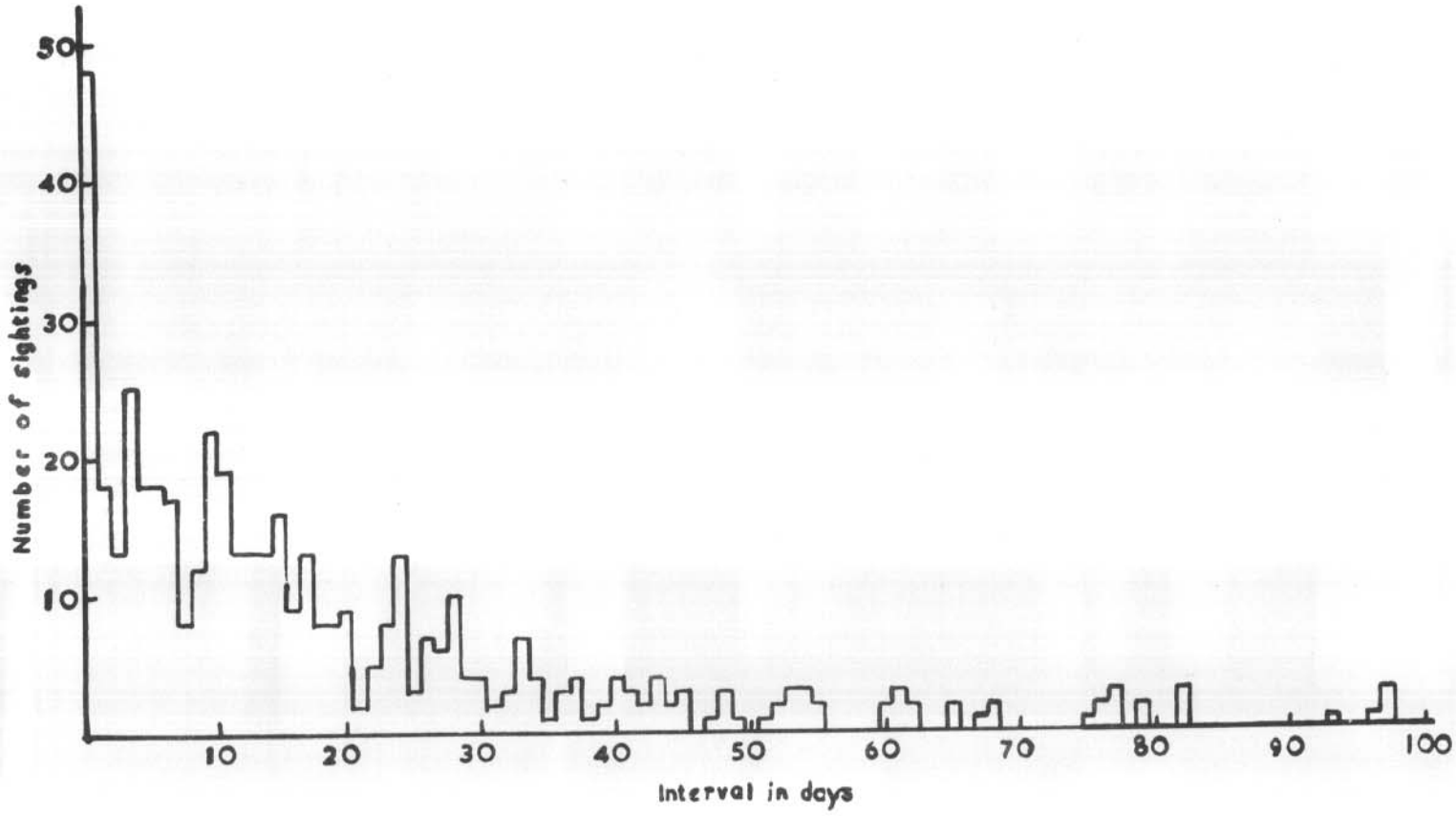

FIG. 2. FREQUENCY OF SIGHTING BRANDED SEALS, APRIL–OCTOBER, 1951.

TABLE 6

24-HOUR VARIATIONS IN LEOPARD SEAL COUNTS,

CORINTHIAN BAY, 1951.

Date	2 p.m.	5 p.m.	Midnight	4a.m.	8 a.m.	5 p.m.
June 16-17		2	60			14
June 17-18		14	23			24
July 12-13	28	45	121	62	24	17
July 15-16		1	14		1	9
July 16-17		9	64		26	0
August 9-10	10		93		10	
August 11-12		20	120		18	15
August 12-13		15	10			1
August 21-22		23	44			0
August 26-27		57	95			19
September 1-2		45		143	78	
September 5-6		4			34	30
September 6-7		30	78			0

Variations between beaches. Of a total of 3,642 leopard seals seen by day in the Four Bays between April 1951 and February 1952, 58.7% were seen at Corinthian Bay, 14.9% at Atlas Cove, 25.5% at South-West Bay and 0.8% at West Bay. The beach at Corinthian Bay is the largest of the four and is sheltered from the prevailing wind; Atlas Cove, though equally sheltered, is smaller and the leopard seals were liable to be disturbed by human activity at the A.N.A.R.E. Station. South-West Bay has a long sandy beach, but it is exposed to the prevailing wind. West Bay is small, exposed and rocky, and few leopard seals ever haul out there.

The branding of leopard seals was carried out at Corinthian Bay, and 55 of the 96 branded animals remained faithful to this beach throughout the winter, 29 being seen on five or more occasions. One exceptional individual, which was seen regularly from April 1951 to February 1952, only returned to Corinthian Bay on two isolated occasions but was seen 16 times at South-West Bay. Twenty-one leopard seals were seen five or more times on one beach as opposed to four or fewer times on others. This shows that individuals have definite preferences for certain beaches.

Yearlings showed rather different preferences

from adults. Of 112 seen in the four months August - November, 49% were at Corinthian Bay, 29% at Atlas Cove, and 19% at South-West Bay. The relatively high number of yearlings at Atlas Cove is more striking when it is considered that they formed 14.9% of the population there, as opposed to 5.6% of the total Four Bays population, in these four months. It has been suggested that the adult seals learned to avoid Atlas Cove when men and dogs were there, while yearlings still frequented it.

Variations with season. Table 7 gives the total, average and maximum monthly numbers of leopard seals seen by day in the Four Bays area in 1951-52. (The totals differ from those in Table 2 because the latter include counts made at night). Figure 3 shows these variations graphically.

TABLE 7

SEASONAL VARIATIONS IN NUMBERS AT FOUR BAYS BY DAY, 1951-52.

Month	Total count	Average count	Maximum count	No. of counts
April	312	26.0	78	12
May	602	20.8	70	29
June	420	16.2	73	26
July	645	22.2	139	29
August	440	15.2	88	29
September	603	31.7	106	19
October	160	11.4	36	14
November(1)	49	3.8	9	13
December	59	3.9	15	15
January	221	13.0	35	17
February(2)	132	14.6	32	19

The total number is the most useful figure provided counting was done regularly on all or most days of the month. The average number is useful in cases such as November and February, when counting was regular but only

(1) 1 - 22 November.

(2) 1 - 19 February.

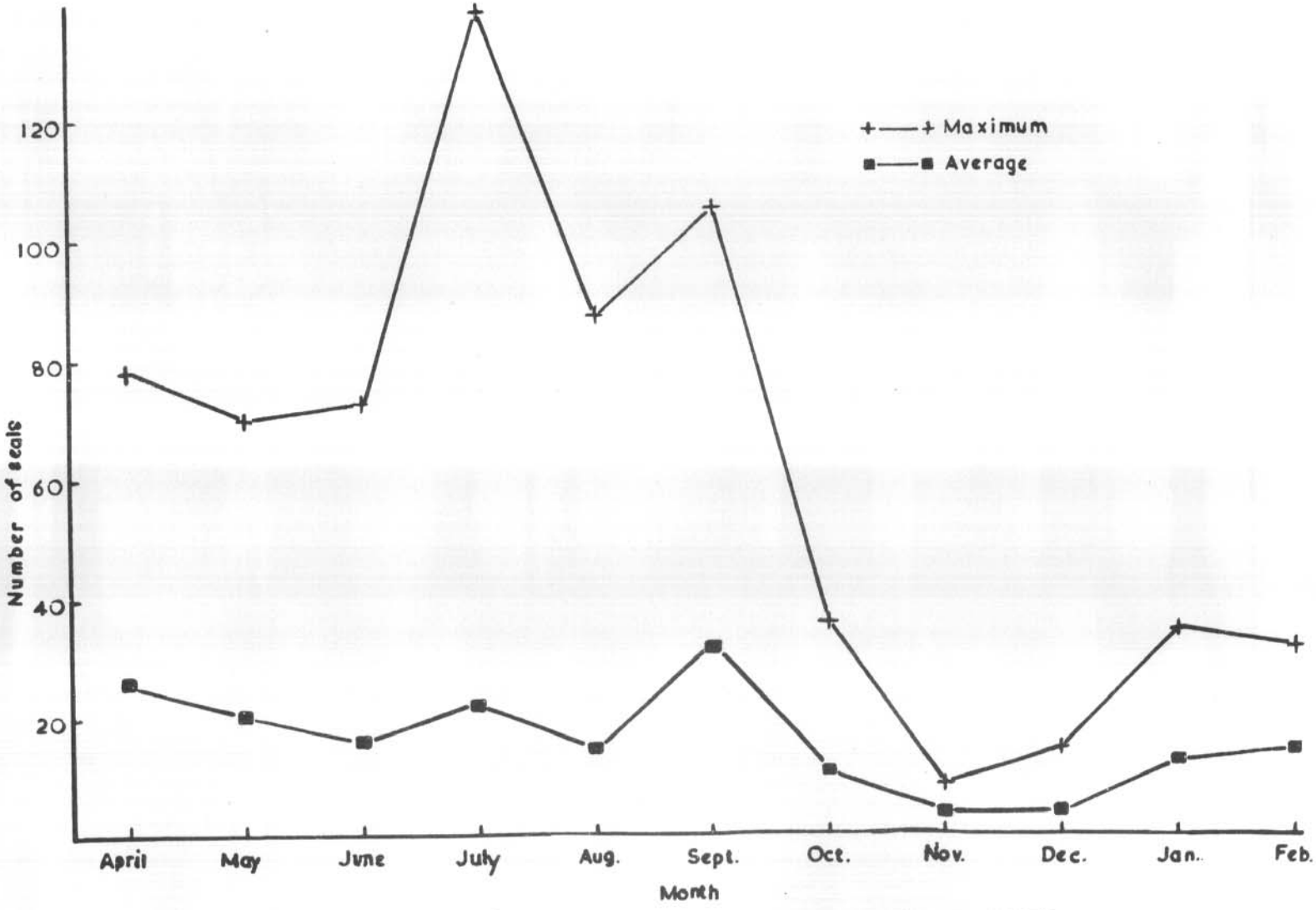

FIG. 3. AVERAGE AND MAXIMUM NUMBERS OF LEOPARD SEALS ON ALL BEACHES, APRIL 1951 – FEBRUARY 1952.

covered two-thirds of the month. Maximum numbers are most useful when counting was irregular.

All three show that leopard seals were numerous during the winter, with fluctuations from month to month probably due to weather conditions. Numbers decreased after September, were lowest in November and December, and increased slowly in January and February. Tables 3 and 5 show that females tended to leave before males and it was observed that the number of pregnant females decreased rapidly during September until by late October none remained. Adults left before yearlings, but no yearlings were noticed after November. The summer population consisted chiefly of adolescents, with some old males. Adults of both sexes reappeared after late December, and Table 3 suggests that males return first.

Table 8 gives the numbers of leopard seals seen by day at each of the Four Bays in each month and the percentage of the monthly total seen on each beach. Figure 4 shows the percentage variations graphically.

TABLE 8

MONTHLY VARIATIONS IN COUNTS BETWEEN BEACHES, 1951-52.

	Total Day Counts			
Month	Corinthian	Atlas	South-West	West
April	196	64	52	0
May	434	74	88	6
June	245	81	90	4
July	466	96	82	1
August	285	82	67	6
September	323	69	207	4
October	73	38	43	6
November (1)	20	9	18	2
December	19	8	32	0
January	49	19	152	0
February (2)	29	4	99	0
TOTAL	2139	544	930	29

(1) 1 - 22 November.

(2) 1 - 19 February.

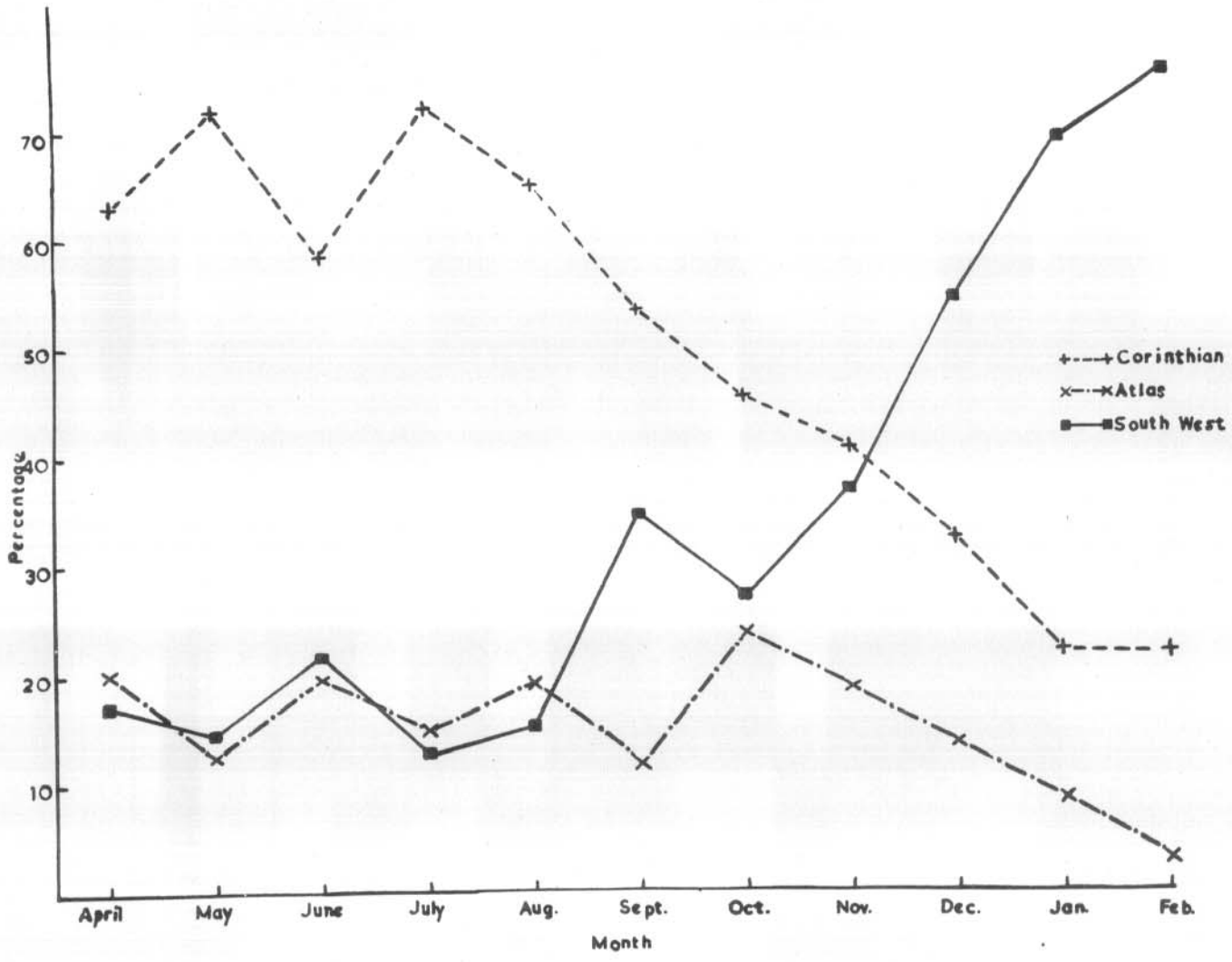

FIG. 4. PERCENTAGE OF TOTAL LEOPARD SEALS ON THREE BEACHES, APRIL 1951 – FEBRUARY 1952.

Counts as % of Total				
Month	Corinthian	Atlas	South-West	West
April	63.0	20.0	17.0	0.0
May	72.1	12.3	14.6	1.0
June	58.3	19.3	21.4	1.0
July	72.3	14.9	12.7	0.1
August	64.8	19.1	15.2	0.9
September	53.6	11.4	34.3	0.7
October	45.6	23.7	26.9	3.8
November(1)	40.8	18.4	36.7	4.1
December	32.2	13.5	54.2	0.1
January	22.1	8.6	68.9	0.4
February(2)	22.0	3.0	75.0	0.0
TOTAL	58.7	14.9	25.5	0.8

These figures show that the population of different beaches varied seasonally. In winter about 85% of the Heard Island leopard seals were found in Corinthian Bay and Atlas Cove, but in September the numbers seen in South-West Bay rose both absolutely and relatively. During the summer the few seals present were concentrated at South-West Bay, and in January and February numbers there rose more rapidly than elsewhere, so that this beach held 75% of the population and had a higher average number than in any other month but September. Observations in later years confirm this shift of population, e.g. in February 1955 two counts were made: South-West Bay held 31 and 37 leopards, while Corinthian Bay held seven and none respectively. Few counts of leopard seals have ever been made in March, but in March 1953 Gwynn recorded 35 in Corinthian Bay (seven counts) and 31 in South-West Bay (six counts), showing that the population was increasing and Corinthian Bay was regaining its dominance.

From the sightings of branded individuals it appears that the increase in numbers at South-West Bay in September was due to individuals transferring from Corinthian Bay. Twelve, previously seen at Corinthian,

(1) 1 - 22 November.

(2) 1 - 19 February.

appeared at least once in South-West Bay between August and October, and were not seen again for three months or more. On the other hand, 25 animals were last seen at Corinthian Bay in September. Fourteen reappeared in December and January, nine at South-West Bay and five at Corinthian Bay. Seals leaving from one beach reappeared at the same or another indiscriminately.

Three branded leopard seals summered at Heard Island, being seen from May 1951 to February 1952. All were males and at least one was adult. Two were at South-West Bay and one at Corinthian Bay.

It is, therefore, assumed that in September and October leopard seals leave the Heard Island region to pup and mate in the pack-ice. The high counts in September may be due to a large proportion of them coming ashore to rest before the migration. Those remaining during the summer are non-breeding individuals. The breeding population returns between late December and some time in March or April. Adolescents are present at all times of the year, and in November and December form the bulk of the population. Yearlings are present from June to November, but the date of their first appearance is a little doubtful, as small second-year leopard seals are often taken for first-year animals if definite measurement and comparison are not undertaken.

Variations between years. Tables 9 and 10 give the maximum numbers of seals at Corinthian Bay and Atlas Cove in certain months over a six-year period. It can immediately be seen that although relatively few counts were made in the first two years at either beach, the maxima recorded then were lower than later years. In other respects the seasonal variations in numbers followed very much the same course in all years.

TABLE 9

MAXIMUM NUMBERS IN CORINTHIAN BEACH, 1949-55.

Month	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	Night 1951	Night 1953
April	30(2)[1]	21(2)	50	8(1)	54	18	-	42
May	28(2)	6(2)	47	11(1)	47	16(2)	-	63
June	9(3)	90(3)	34	65(4)	61	78	60	100
July	39(2)	6(2)	111	78(2)	67	27	121	73
Aug.	160(3)	143	57	42	51	58	120	110
Sept.	124(3)	155	64	40	56	74	148	79(1)
Oct.	74(2)	26	25	16(2)	21	36(4)		

[1] When less than five counts were made in any month, the number is given in brackets.

TABLE 10

MAXIMUM NUMBERS IN ATLAS COVE, 1949-1955.

Month	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55
	(1)					
April	7(1)	6	14	-	6	3(3)
May	18(2)	25	8	-	7	4(3)
June	78(4)	32(2)	29	1(1)	10	18
July	65	7(3)	18	2(1)	9	21
August	85	67	10	7	3	11
September	46	50	17	11	6	22
October	36(2)	22(4)	6	5(1)	2	6(3)

Gwynn suggests, in a personal communication, that the decrease was due to the presence of sledge dogs at the A.N.A.R.E. Station after 1950. He states that the dogs were kept chained up, but occasionally one would break loose, and wander along the beaches scaring the seals away. Probably the general human activity of the Station would play a part in frightening the seals. It is, however, possible that these six years covered part of a natural fluctuation in population, or that some change in climate or distribution of pack-ice made Heard Island less accessible or less attractive to leopard seals.

GENERAL BEHAVIOUR AND HABITS

Food. Hamilton (1939) has described the stomach contents of 32 seals killed by himself and others from which it appears the food of the leopard seal consists chiefly of squid, fish, penguin and seal. Examinations have also been carried out by A.N.A.R.E. workers. From 18 stomachs Gwynn (1953) secured squid on five occasions and fish on one. From 23 stomachs the writer found penguin twelve times, fish three times, seal twice, and on six occasions the stomach was filled with a yellow fluid which, according to Hamilton, is caused by the action of intestinal and stomach enzymes on the ink of Loligo.

Of eight stomachs examined at Heard Island in 1952 and 1953, two contained fish bones, two the yellow fluid,

(1) When less than five counts were made in any month, the number is given in brackets.

one penguin feathers and one elephant seal carrion. One of those with squid "soup" also contained the shoulder girdle of a diving petrel; one previous record of this is known (Hamilton, 1939) but it must be exceptional.

Gwynn records that leopard seals were never seen to eat ashore during 1950 and this was the writer's experience also. A number of attempts was made to feed a female which was caged in 1951 but, although two live gentoo penguins and fresh seal meat were left in the cage, the animal made no attempt to touch them.

To test the leopard's olfactory response a seal was killed and allowed to bleed freely into the water about 100 yards from the shore. Though several leopard seals were present in the water at the time no attraction towards the carcase was noticed during the two hours it was under observation.

Locomotion. To ascretain the swimming speed of the leopard seal the following experiment was carried out. A cord, 460 feet long, was attached to a copper wire loop and divided into 20 foot sections, each section being marked off with coloured ribbons. The loop was placed round the neck of a leopard and after the animal had been released in the water the passage of each section was timed by three stop watches. The speed ranged from 1.4 to 4.6 m.p.h. with an average of 3.4 m.p.h.

Dives of 15 minutes duration have been observed at Heard Island. The normal diving times of other species of seal appear to be from 15 to 20 minutes. Scholander (1940) submerged grey seals, strapped into an elaborate apparatus, for up to 18 minutes without ill effects.

On snow-covered land the leopard propels itself with its flippers at a speed comparable to a man's normal trot. On sand, by contrast, the flippers are scarcely used at all and most of the animal's impetus is obtained by arching the back and thrusting with the tail like a caterpillar, with a rest every ten yards or so. The speed is roughly equivalent to a normal walking pace.

Noises. Sounds made by leopard seals are of two distinct kinds. The "alarm" sound is a throaty "k-k-k" made by expelling air through the mouth and rapidly vibrating the tongue. The mouth is held open with all the teeth exposed. This noise is made whenever the animal is disturbed.

The other noise has been described as "singing",

"crooning" or "trumpeting", and varies considerably in pitch and frequency. Different observers at Heard Island have distinguished up to six variations. They include a high-pitched chirrup described as resembling a cricket or a canary, a fairly high-pitched bubbling or rolling sound, and a continuous low-pitched booming, with or without pulsations. More than one of these sounds may be made by the same animal on the same occasion, and no sexual difference can be distinguished. The sounds are usually made after a deep breath has been taken and the glottis closed, but occasionally during inspiration as well. They are apparently involuntary, and are frequently made by sleeping animals. L.F. Gibbney in 1952 noticed urination or defaecation after "singing" on two occasions, and suggested that the "song" was a response to discomfort. As it has also been observed in obviously sick animals, this may be correct.

Shivering. Shivering occurs frequently in seals of all ages and both sexes throughout the year. The phenomenon(1) was observed at Heard Island only during sleep, but at times it became so violent that it would awaken the animals. On many of the occasions on which it was observed the air temperature was well above that of the sea, with no wind blowing.

PHYSIOLOGICAL AND ANATOMICAL INVESTIGATIONS

The following investigations were carried out in 1951. Although insufficient examinations were made for statistical analysis they are some guide to the physiology of the leopard seal.

Pulse and respiration rates. Heart beats of leopard seals are easy to observe, and pulse rates were recorded in seven cases. The rate varied from 35 to 51 beats per minute with a mean reading of 45 beats per minute.

The respiration rate was recorded in five cases, one of which was a foetus. Excluding the foetal reading (which was obviously abnormal, as the animal died some hours later) it varied from 5.0 to 6.2 breaths per minute, with a mean reading of 5.6 breaths per minute.

The pulse rate is low when compared with the recorded rates of other seal species - 70 to 90 per minute

---

(1) The writer can find no reference to shivering in other seals and it certainly does not occur in elephant or fur seals.

(Irving, 1939), and 140 per minute (Scholander, 1940). However, these rates were obtained while investigating the bradycardia associated with diving, while the author's was obtained while the seals were resting ashore.

Blood tests. These were confined to one animal from which a large number of samples was collected. Three counts of red blood cells were made, giving results of 4.05, 4.73 and 4.41 x 10^5 cells per ml. or a mean figure of 4.4 x 10^5 red blood cells per ml. One leucocyte count of 4,406 per ml. was made. Two haemoglobin determinations were carried out, giving 19.84 and 19.36 g. per 100 ml., the mean being 19.60 g. per 100 ml.

The oxygen depots of seals and other marine mammals have been investigated for many years and the foregoing figures agree with the findings of other workers in the field. The high haemoglobin content and low red cell count indicate that there is an increased concentration of haemoglobin in the corpuscles, a fact already established in the porpoise (Green & Redfield, 1933). The blood volume of the leopard would be interesting but its determination was impracticable at Heard Island. Irving (1939) estimated the blood volume of a seal at 10% of its total weight and Scholander (1940) arrived at a figure of from nine to ten per cent by direct bleeding, concluding that the real percentage was about 15.

Blubber thickness. The blubber thickness of most elephant and leopard seals killed for dog food during 1951 was recorded. In the elephant seal this thickness increases before the breeding season and at its close is considerably reduced. It was anticipated that the leopard seal would not show such a definite change since it does not spend long periods ashore without food(1).

Blubber thickness was measured on the ventral side, between the navel and the mammary glands. In 12 individuals killed between 20 April and 23 August it was between two and three and a half inches. There was no difference between sexes, or between adults and two-year-olds, and there was no apparent increase before the breeding season. However, the earliest measurements were made in April, when any blubber lost during the breeding season would have been regained further, the point at which thickness was measured may not be a reliable indication of the total blubber storage. Pregnant females late in winter appear to have enlarged

---

(1) Examination of the teeth of the leopard seal does not show the "starvation ridges" found in those of the elephant seal.

necks and since in elephant bulls a lot of blubber is stored in the neck region this may also be the case in the leopard seal.

Os penis. From an examination of seven "os penis" bones Hamilton was able to obtain additional evidence for the separation of his four age-groups. Twenty specimens were collected from Heard and Macquarie Islands during 1949-51 and their measurements are set out in Table 11 in Hamilton's age-groups.

TABLE 11

MEASUREMENTS OF 20 LEOPARD SEAL "OS PENIS" BONES,

HEARD AND MACQUARIE ISLANDS, 1949-51.

Age	Date	Length mm.	Weight gm.	Length of animals
First Year	20/ 9/50	95	3.0	7' 1"
	-	90	3.0	-
	-	100	3.5	-
	21/10/50	105	3.2	6' 8"
	-	105	4.5	-
Second Year	-	130	5.0	-
	21/ 5/49	134	12.0	8' 3"
	20/ 9/50	145	12.0	8' 4½"
	-	155	8.5	-
Third Year	-	165	25.0	-
	20/ 7/50	180	20.0	8'10"
Fourth Year and Over	14/ 5/51	225	51	9' 3½"
	22/ 9/50	225	43	9' 0"
	14/ 5/51	230	54	9' 5½"
	3/ 5/50	235	73	9' 5"
	30/10/50	240	69	10' 3"
	12/ 6/51	250	69	9' 3"
	-	260	72	-
	3/ 7/51	270	58	9' 3½"
	16/ 7/51	300	79	9' 6"

Dentition. The adult dental formula has previously been recorded as:

$$i\frac{2}{2}.\ c\frac{1}{1}.\ pc\frac{5}{5}.$$

However, in view of the position of the three milk post-canines the true dentition is

$$I\frac{2}{2}.\ C\frac{1}{1}.\ PM\frac{4}{4}.\ M\frac{1}{1}.$$

This is slightly different from Weddell and crabeater seals but the same as in elephant seals.

All the incisors have undergone some modification and the second incisors, particularly the upper ones, are very caniniform. The first upper incisors are widely spaced to allow the two lower and very reduced firsts to fit between them. As is to be expected, the canines are well developed, the upper attaining an average length of about 80 mm. The three premolars and two molars are of relatively equal size and structure, each consisting of a main crown with two lateral cusps and two long, curved roots. The complete length of an adult molar is about 40 mm. The upper and lower molars interlock with the lateral cusps of the lower teeth flanking the central cusp of the upper teeth. The first lower premolar is adjacent to the upper canine.

The leopard seal is unique amongst the Pinnepedia in that no abberant dentition has ever been noted; in this respect it is approached only by the crabeater, in which one case of post-canine aberration has so far been recorded. Since over 100 skulls from leopards have been measured or examined aberrations, if they do occur, are extremely rare.

Tooth wear. In the older seals at Heard Island both worn and broken teeth are very common. Of particular interest is the wear on the canines caused by frictional between upper and lower sets of teeth. The upper canines wear on the posterior edge of the central region from abrasion against the lower ones and the latter wear on the inside surface from rubbing against the upper second incisors. The affected area may be up to 8 mm. in width, extend for almost 2 cm. and at times be very deep.

Seals which show marked wear on the canines usually have one or more damaged post-canines and, at times, chipped or broken incisors. The central cusp of the premolars and molars is rarely broken whereas either or both of the lateral ones are frequently missing. This is in marked contrast to the crabeater seal, in which damage to the cheek teeth is apparently a rarity (Bertram, 1940), and may be related to the difference in diet.

Broken teeth are probably caused by the older animals fighting during the breeding season, or result from damage sustained during the capture of seals and penguins.

Coat coloration. The coloration of adult skins is dealt with fully by Wilson (1907). From the many leopard seals sighted in 1951 it is apparent that there is a good deal of individual variation. Two main types can be differentiated, the first having a black to dark grey dorsal surface and a light grey ventral surface, and the second, light grey dorsal and ventral surfaces spotted with black markings.

Moult. There is little to add to the account of the annual moult given by Gwynn (1953). Moulting has begun in January when leopards are beginning to return to Heard Island. February is the peak month, but individual moulting animals have been recorded much later, e.g. on 27 April, 1 May and 11 June 1953 Gwynn found leopards from which loose hairs could be removed. By midwinter the moult is complete (except in a few doubtful or pathological cases).

The character of the moult in the leopard seal resembles that in the Weddell and crabeater. The former moults "at any time during the summer months from the third week in November to the end of March" and the latter in January and February (Wilson, 1907). In both, normal activities continue during the moult, in contrast to the elephant seal, which remains ashore for the entire period, sloughing off the old hair in large patches with attached epidermis. In this species the time of the moult and its duration (three to eight weeks, Laws, 1956) depend on the age and sex of the individual.

REPRODUCTION

It is not known when copulation or fertilization occurs in the leopard seal. Three mature females killed on 4, 11 and 13 February 1952 contained no visible foetus. However, in view of recent work indicating that delayed implantation is the rule in the Phocids all estimates of the gestation period among antarctic seals except for the elephant seal[1] are guesswork.

Parturition. The following data on parturition is based mainly on the birth of a pup to a female which was

---

(1) 11½ months.

caged at Heard Island during 1951 (Brown, 1952).

Uterine and vaginal contractions were easily discernible some days before pupping. Movements of the foetus reached their maximum intensity about three days before birth. These contractions were often accompanied by low moaning noises and considerable restlessness on the part of the animal. A few days before birth a thick mucous discharge from the vagina occurred.

The pup was born between 2130 hours on 14 November and 1645 hours on 15 November, but whether parturition was rapid or slow is unknown since it was not observed. From the positions of the mother, pup, and placenta it is assumed that the pup was born head first. The umbilical cord attached to the placenta was probably broken by the female in her movements, leaving a stub about four inches in length on the pup. The placenta, which was of the zonary type, showed no special peculiarities and had a weight of six pounds.

The behaviour of the mother towards the pup must be regarded conservatively in this case since at the time of observation the latter was dead. However, the female was very affectionate towards the pup and though quite accustomed to humans, she snarled continually when approached. She also showed a definite desire to warm the pup, keeping closest possible bodily contact with it and partly covering it with her fore flipper.

As the pack-ice is the normal summer habitat of the leopard seal it is almost certainly there that the pregnant females normally bring forth their young. Leopard seals are rare in the vicinity of the Antarctic Continent(1), for few animals have been sighted by expeditions based there. Bagshawe (1939) records that, although leopard seals were present off the Danco Coast of Graham Land in March, April, June, August, October and November, they were absent from 25 November 1921 to 13 January 1922, the time when parturition and lactation are assumed to occur. The fact that no birth on the pack-ice has yet been observed is not very significant, for even in the abundant crabeater seal birth has rarely been witnessed.

In the past it has sometimes been suggested that

---

(1) Except for the Graham Land Peninsula which because of its geographical situation is more comparable with the northern limit of the pack-ice.

leopards are born in the sea. Ainsworth (Mawson, 1915) observing the precocity of the foetuses he obtained at Macquarie Island, assumed that birth took place in the water. Foetuses collected at Heard Island in August, September and October were kept alive for up to 20 hours, though it is now assumed that they were premature, as were those of Ainsworth, and Borchgrevink (1901). According to the available records (Bertram, 1940) no seals whether Otariidae, Odobaenidae or Phocidae have ever been known to bring forth their young in the sea and there is no evidence at present to indicate that the leopard seal is an exception.

Lactation. The only evidence as to length of lactation is given by Wilson (1907) who collected a female leopard seal in full milk in the pack-ice in mid-January. No pup was seen or obtained.

The birth of the full-term pup at Heard Island occurred on 15 November 1951 and premature births occurred there on 26 September 1950 and 24 September 1954. This would indicate a lactation of at least two months, which is nearer to the average of 50.3 days given by Lindsey (1937) for the Weddell seal than to that of 23 days given by Laws (1956) for the elephant seal.

Missed pregnancies. Between April and October 1951 14 females were killed at Heard Island, 11 of which were pregnant. Two were recorded as non-pregnant, one having a uterine cyst. The last was not recorded as either pregnant or non-pregnant, but the latter may be presumed as no foetus was obtained. This gives a missed pregnancy rate of 21%(1) comparable to those calculated by Bertram for Weddell and crabeater seals (16 and 21% respectively). In this calculation only those females are considered which were killed when the foetus, where present, would be macroscopically visible. Three females killed in February 1952 had no visible foetuses, but the probability of delayed implantation makes it impossible to say whether they were pregnant or not.

On 27 August 1952, L.F. Gibbney shot a sick and emaciated female leopard seal, nine feet long. There was no obvious pathology, except that the stomach was inflated with gas and contained clotted blood and a quantity of dark brown fluid. However, on examining the uterus, which

---

(1) This is high enough to cause considerable error if "corpora lutea" are used as a method of age-grouping and if the "corpora lutea" of non-impregnated seals do not leave the same permanent records as the corpora of pregnancy.

was completely involuted, it was found to contain very definite healed placental scars in both horns. The ovaries each contained a corpus luteum extensively invaded by scar tissue, measuring nine and 11 mm. in diameter respectively. This seems to be a clear case of a twin conception which had aborted some time previously. It is thought unlikely that the scars and corpora lutea could have persisted from the previous year. In the elephant seal Gibbney found that placental scars were difficult to recognize four months after the birth of a pup.

FOETAL DEVELOPMENT.

Ten leopard seal foetuses and one full-term pup were obtained at Heard Island in 1951. The development of the dentition and coat and the growth rate were studied. Data obtained in other years have been inserted where appropriate.

Milk dentition. Bertram's X-ray studies of the milk dentition of both the Weddell and crabeater seals have acted as a stimulus for further studies in this field. Rand (1950) investigated the milk dentition of the Cape fur seal, Arctocephalus pusillus, by means of X-rays and traced out the eruption and subsequent loss of each tooth; Laws (1953) studied the milk dentition of the elephant seal in the same way. The author's investigations on the leopard seal consisted of an examination of foetuses to determine the milk formula and any similarities to other antarctic Phocidae. The development of the milk and adult teeth and the reabsorption of the former was found to resemble the elephant seal rather than the Weddell and Crabeater seals. The differences from the latter lay in being less precocious and in the position of the milk post-canines.

When the foetus was 40 cm. long the milk teeth were readily discernible and the adult dentition had begun to develop. At 94 cm. foetal length the milk teeth had reached their maximum size and reabsorption had commenced, particularly in the upper jaw (Figure 5). At 109 cm. the incisors were already reduced, the permanent canines were pushing well forward, and the cusps of the adult post-canines were more conspicuous (Figure 6). At 135 cm. the milk canines and post-canines were completely absorbed and the only remaining vestiges of the milk dentition were the upper incisors (Figure 7). At birth all traces of the milk dentition had disappeared and the adult teeth were just beginning to show through the gums in places.

By contrast, Bertram found that reabsorption of

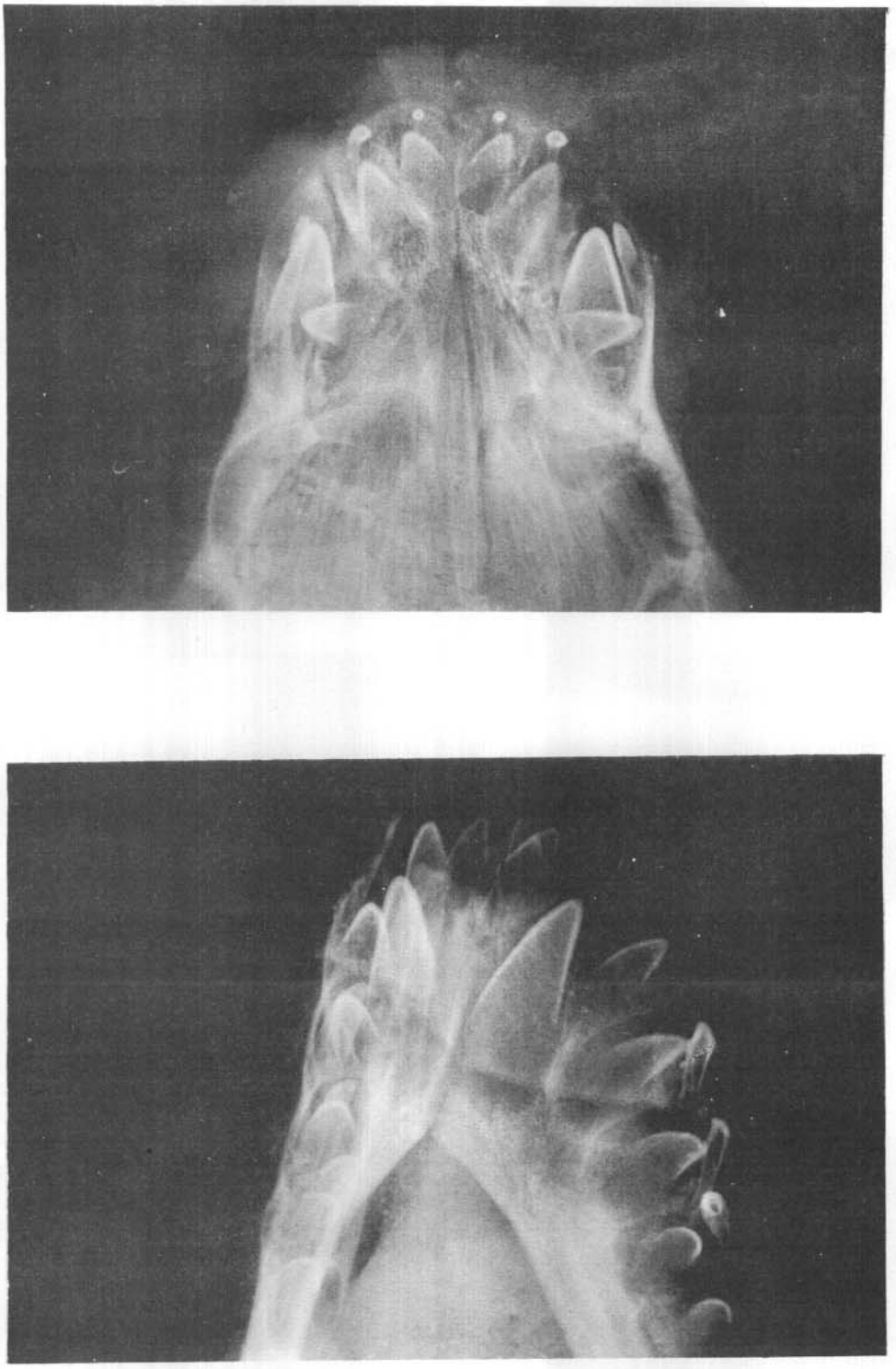

FIG. 5. X–RAY OF MILK DENTITION OF LEOPARD SEAL FOETUS 94 CM. LONG.

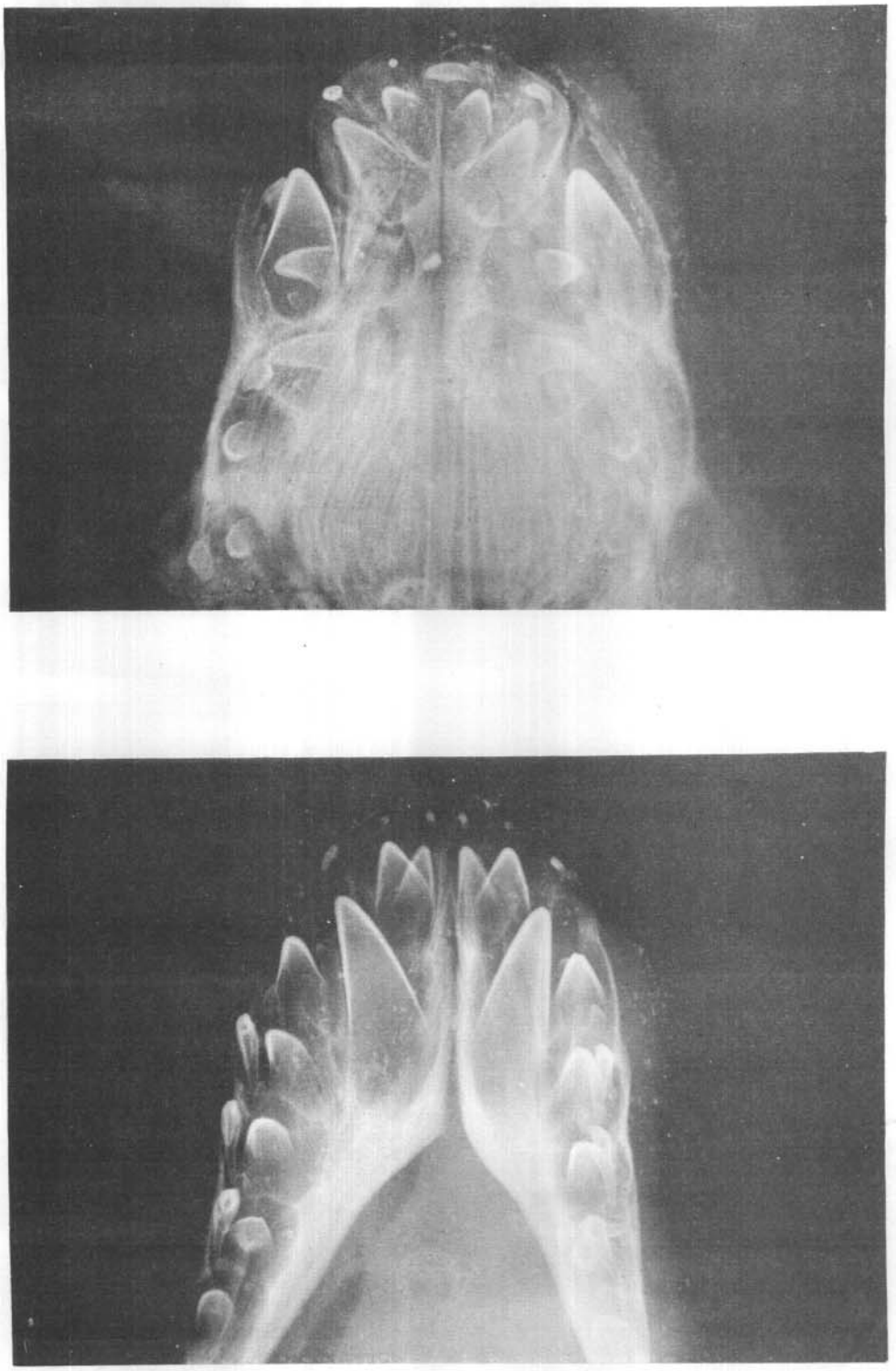

FIG. 6. X–RAY OF MILK DENTITION OF LEOPARD SEAL FOETUS 109 CM. LONG.

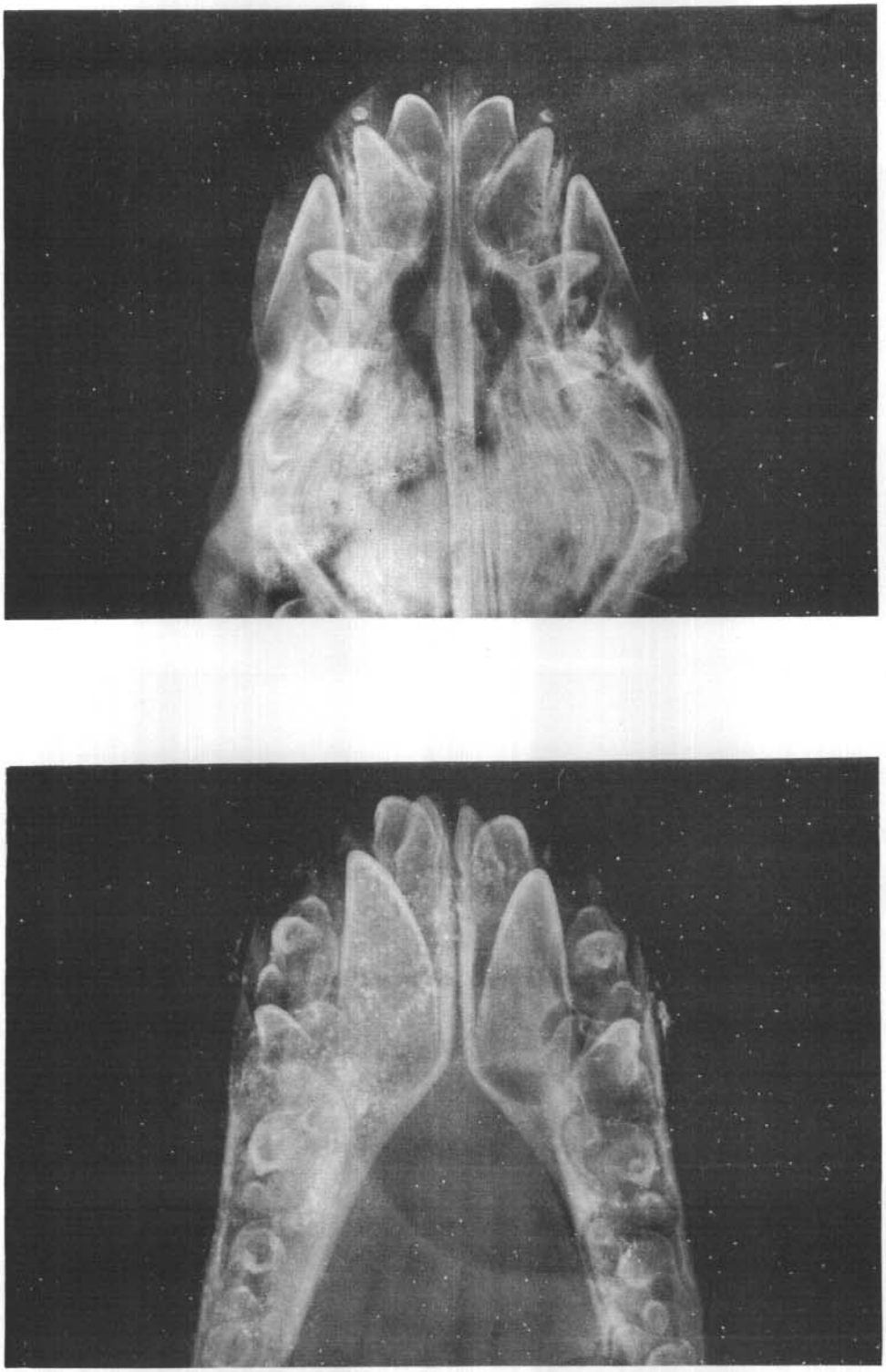

FIG. 7. X–RAY OF MILK DENTITION OF LEOPARD SEAL FOETUS 135 CM. LONG.

milk teeth had begun in a 36 cm. crabeater foetus, and was well advanced in a 50 cm. Weddell foetus. The permanent canines were visible in X-rays of a 33.5 cm. crabeater and a 33 cm. Weddell foetus, but not in the elephant seal under 49 cm. foetal length. Laws did not X-ray larger elephant seal foetuses, but his drawing of the teeth in an 89 cm. specimen resembles the X-ray of the 94 cm. leopard seal.

In an Otariid, the Cape fur seal, Rand (1950) found that the milk incisors were resorbed at or immediately after birth, but the milk canines and post-canines persisted for some months.

The structure of the leopard seal's milk teeth can be seen from the plates. The faint cusping of the lower post-canines contrasts with those of the Weddell and crabeater(1). The milk canines are curved in shape whilst the incisors appear to be quite straight.

The milk dentition is easily discernible from the 95 cm. foetus. The formula is:

$$I\frac{2}{2}.\ C\frac{1}{1}.\ PC\frac{3}{3}.\ = 24$$

Although this agrees with the formula of the milk dentition in the Weddell and crabeater the position of the post-canines in the leopards does not agree with Bertram's descriptions of the former but rather with the position in the elephant seal (Laws, 1953). From Figure 5 it can be seen that the milk post-canines correspond in position to the second, third and fourth permanent post-canines. Such being the case the adult dentition becomes

$$I\frac{2}{2}.\ C\frac{1}{1}.\ PM\frac{4}{4}.\ M\frac{1}{1}.\ = 32$$

as in the elephant seal, instead of $\frac{2}{2}.\ \frac{1}{1}.\ \frac{3}{3}.\ \frac{2}{2}.$ as in the Weddell and crabeater. As Bertram has not published any X-ray photographs of the adult and milk dentition in a very late stage it is not possible to compare the actual positions in the two cases.

Foetal coat. The skins of one new-born pup a two foetuses were collected during 1951 and later tanned. The only other skin of a new-born pup known to exist is that

---

(1) In the latter the third upper post-canine is faintly cusped.

discussed by Hamilton. This skin, which is now in the British Museum, was secured in the Falklands by R. Vallentin. It is 100 cm. (about 39 inches) long. Hamilton's Plate 1 and his and Gwynn's descriptions correspond closely with the following description of a foetal skin obtained on 13 September.

Length: 49 inches
General Appearance: Silvery grey
Dorsal: Predominantly light silvery grey with a darker central stripe. Where the pure black shows through the appearance is of a second coat. The light grey hairs are typically foetal with curling patterns.
Ventral: Basically pale yellow with a faint greenish tinge but with the silver grey foetal hair continuing the patterns from the dorsal surface. The change in colour from dorsal to ventral is gradual. The surface exhibits the spotted appearance of the new-born pup, though it is not so marked.
Head: Black and dark grey with light markings above each eye, and half-inch whitish-yellow margins to the lips.
Flippers: Fore: Whitish grey with dark grey areas
Hind: Light grey with ill-defined yellow stripes.

A second foetal skin was secured on 2 October. It differs markedly from the former, resembling more nearly the new-born pup.

Length: 54 inches.
General Appearance: Dorsal dark grey, ventral pale yellow (Figure 8).
Dorsal: The dorsal region, measuring approximately 30 cm. across at the fore flippers, consists of three separate bands. The central one is black and tapers from 10 cm. anteriorly to 4 cm. at the base of the tail. The two lateral bands are dark grey, irregularly spotted with yellow markings about one cm. in diameter. The silvery appearance present in the earlier specimen has for the most part been lost.
Ventral: Predominantly pale yellow with little trace of the previous green tinge. Black and grey spots about one cm. in

FIG. 8.

SKIN OF LEOPARD SEAL FOETUS,
135 CM. LONG.

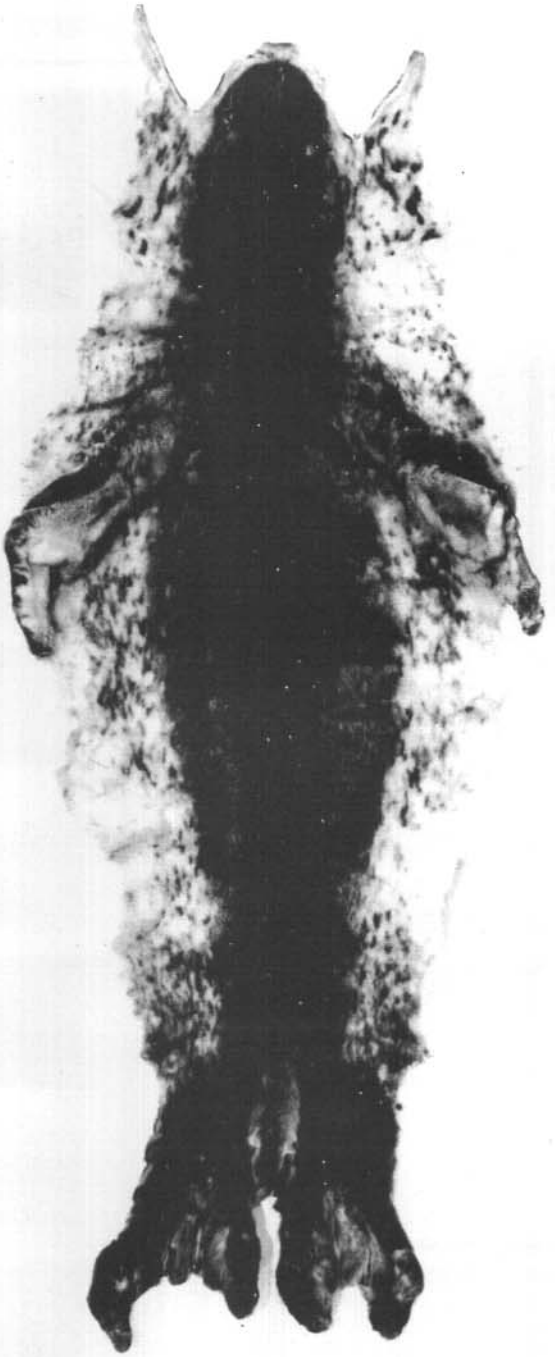

FIG. 9.

SKIN OF FULL–TERM LEOPARD SEAL PUP,
157 CM. LONG.

diameter thin out towards the mid ventral line.

Head: Black with pale yellow margin around lips now about one inch wide. Pale area over eyes now more diffuse.

Flippers: Fore: Dorsal dark grey, ventral pale yellow.

Hind: Black and dark grey with very few yellow markings.

The skin of a new-born pup was secured on 15 November. It is different from the foetal skins, the change in general colour being most noticeable.

Length: 62 inches

General Appearance: Dorsal black and dark grey, ventral yellow spotted with grey. (Figure 9).

Dorsal: Very dark grey but with the central black bank still visible. Silvery appearance now confined to a very few spots. Speckled effect on lateral bands much reduced.

Ventral: Bright yellow with light grey spots in definite patterns. Two dense areas of spots posterior to fore flippers and anterior to hind flippers. Silvery areas reduced, being mostly associated with grey markings.

Head: Black with bright yellow margins from lips now nearly two inches wide. Pale areas above eyes just visible.

Flippers: Fore: Pale yellow light grey dorsal and ventral with diffuse yellow throughout.

Hind: Dark grey with central black bands continuing on from dorsum.

Tail: Black dorsal, yellow ventral.

Hairs from various sections of all three skins were removed and found to measure about three-quarters of an inch, which is almost identical with the adult coat length. Pup hair, however, is much thicker and softer than adult hair.

Growth rate. In Table 12 the lengths of 22 foetuses collected at Heard Island are set out:

TABLE 12

RATE OF FOETAL GROWTH

Date	Foetal length in cm.	Weight	Maternal length in cm.	Collector
16 April 1951	15	-	302	K.G. Brown
16 April 1951	20	-	328	K.G. Brown
14 May 1952	41	21b. 2oz.	295	L.F. Gibbney
2 June 1949	41	-	310	R.G. Chittle-borough and E.H.M. Ealey
12 June 1951	56	-	312	K.G. Brown
26 June 1951	86	-	312	K.G. Brown
27 June 1952	73.5	101b.	(9'0")	L.F. Gibbney
6 July 1951	95	-	318	K.G. Brown
16 July 1952	76	121b. 12oz.	(9'0")	L.F. Gibbney
17 July 1954	77	121b.	-	G.M. Budd
4 August 1952	105	201b.	(9'8")	L.F. Gibbney
7 August 1953	102	241b.	301	A.M. Gwynn
9 August 1951	94	-	318	K.G. Brown
19 August 1950	109	29½1b.	300	L.F. Gibbney
23 August 1951	109	-	287	K.G. Brown
23 August 1951	114	-	345	K.G. Brown
29 August 1950	111	281b.	323	L.F. Gibbney
13 Sept. 1950.	109	361b.	333	L.F. Gibbney
13 Sept. 1951	123	-	-	K.G. Brown
24 Sept. 1954(1)	113	341b.	-	G.M. Budd
2 Oct. 1951	135	-	-	K.G. Brown
15 Nov. 1951(2)	157	651b.	-	K.G. Brown

The complete anatomical details of the new-born pup taken at Heard Island in 1951 are as follows:-

Length	62 inches	157 cms.
Weight	65 pounds	
Flipper length (inside)	16 inches	
Tail Flipper length	16 inches	

(1) This specimen was born spontaneously, but the mother took little interest and next day the pup was found dead and abandoned. It is described as being dark-grey dorsally and yellow ventrally, the eyes not open and no teeth visible. The mother was fairly small, between eight and nine feet long.

(2) Full-term pup.

Girth (behind flippers)	24 inches
Girth (before tail)	19 inches
Neck circumference	17 inches
Width (ventral at flippers)	12 inches

The adult dentition was well developed, the tips of the lower canines and one incisor being visible externally. In general appearance the animal had a very large head and although quite long appeared rather fragile in build. Its eyes were open at birth.

LATER GROWTH

Table 13 gives a rough estimate of the lengths of seals at various ages, although it must be emphasized that the length of seals, especially as estimated in the field, is not a reliable indication of age.

TABLE 13

LENGTHS OF LEOPARD SEALS FOR DIFFERENT AGE GROUPS

Status	Length of Males	Length of Females
First year	160 - 230 cm. 5'4" to 7'8"	160 - 230 cm. 5'4" to 7'8"
Second year	215 - 260 cm. 7'2" to 8'8"	215 - 260 cm. 7'2" to 8'8"
Third year	250 - 280 cm. 8'4" to 9'4"	250 - 290 cm. 8'4" to 9'8"
Fourth year	280 - 320 cm. 9'4" to 10'8"	290 - 380 cm. 9'8" to 12'8"

The normal measurements of mature animals are: males, about 9'4"; females, about 10'4". Sex differences do not appear to manifest themselves in length until the third year, when the females become longer than the males.

The measurements of adult males[1] killed at Heard Island are set out below:

---

[1] See Table 12 for measurements of adult females.

TABLE 14

LENGTH OF MALE LEOPARD SEALS, HEARD ISLAND

Date	Length in cm.	Collector
14 May 1951	283	K.G. Brown
1 July 1951	283	K.G. Brown
20 August 1951	287	K.G. Brown
3 May 1950	287	L.F. Gibbney
14 May 1951	288	K.G. Brown
12 June 1951	296	K.G. Brown
29 March 1951	315	K.G. Brown

Senility and its criteria. Many very old leopard seals were encountered at Heard Island and one was collected at Macquarie Island by Gwynn. Most of these exhibited the same characteristics; these are described below.

In old animals tooth wear is very marked, broken post-canines are common and there are usually one or two teeth with missing lateral cusps. The most characteristic change in the teeth occurs in their coloration, white being replaced by a dingy yellow with dark stains at the base of the teeth. The coat also assumes a dull dingy colour with a definite tendency towards darkening and thinning of the hair. Old seals also appear to be much quieter in disposition than younger ones and do not return as readily to the sea if disturbed.

SUMMARY

Counting and marking of leopard seals were carried out at Heard Island in 1951-52. A tentative estimate was made of the population between June and September, which gave a lower limit of about 775.

The average ratio of males to females is 1.5 : 1, with variations suggesting differences in migratory behaviour.

Most leopard seals at Heard Island haul out at intervals of a month or less, and often stay ashore for two or three days. Although they may come ashore at any hour, the time from 5.00 p.m. to midnight is the most favoured, and numbers are highest then. Individual seals show preferences for different beaches, but in general the

sheltered beaches facing north and east are favoured in winter, and those facing south and west in summer.

The breeding population leaves, probably for the pack-ice, in September and October, and returns between January and March. There is some evidence that pregnant females leave before males, and that males return before females. Yearlings are present from June to November: in August and September they form four per cent of the population. Adolescents are present all the year round.

Seasonal changes were similar over a six-year period, the highest maxima being reached in the first two years.

The swimming speed, blood count, pulse and respiration rates, and blubber thickness were determined. It is established that the moult is prolonged, having been observed in different animals from January to June.

The development of the milk teeth in the foetus was studied by X-ray photography. The leopard seal resembles the elephant seal, and differs from the Weddell and crab-eater seals, in the comparatively late stage at which the milk teeth are fully developed, and in that the first milk post-canine correspond to the second, not the first, permanent post-canine.

The skins of two foetuses and one full-term pup are described. The length, and in some cases weight, of a series of foetuses is recorded.

An appendix by Dr. A.M. Gwynn describes observations on leopard seals at Macquarie Island during the years 1952-54.

APPENDIX A

METHODS AND TECHNIQUES USED AT HEARD ISLAND, 1951.

Counting. Daily counts in the Four Bays area were commenced at 4.00 p.m. and were usually completed at 6.00 p.m. Counts were occasionally made at other hours but only when bad weather made the standard time impracticable. The 24 hour observations consisted of counts at 5.00 p.m., midnight, and one or two morning counts (either 4.00 or 8.00 a.m.).

Marking. A branding iron about three feet long

fitted with interchangeable numeral[1] brands was used and heated with a mobile coke forge. Brands were applied for approximately five seconds to the mid-dorsal region just anterior to the tail.

As the method of branding was 'hit and run', the brands were not very deep, and they were not expected to be legible after the moult. So it is of little significance that sightings in subsequent years were few. Between March and June 1952, Gibbney sighted ten branded leopard seals, in half of which the number was not legible, and the rest were faint, except for number 70, described as 'fairly good', seen on 5 June 1952. This was the last brand recorded.

In 1953 watch was kept for branded leopard seals; one was reported by R. McNair on 23 December, but the brand could not be seen clearly before the animal escaped to sea.

Sex determination. If the animals were lying on their sides their sex was often determined merely be examining the ventral surface. The penile or vaginal orifice could often be seen if a seal were chased into the sea, particularly if it urinated. Females were sometimes identified by their enlarged thorax and pregnant females by their large size, especially late in winter.

Measurements. Measurements of both foetuses and older animals were made in a direct line from the tip of the nose to the tip of the tail, not the flippers. Yearling measurements were often carried out on sleeping animals by marking the tip of the nose and tail on the ground and then chasing the seal away.

Physiological techniques. Red and white cell counts were carried out at the island using standard medical techniques and differential counts were made with slides stained with Leishman's stain and examined in Australia.

Preservation. Testes and ovaries were fixed in Bouin's solution and preserved in 70% alcohol. Female reproductive systems were preserved in five per cent formalin. Small foetuses were preserved in dilute formalin solution

---

(1) Numbers began at one and ran serially to 249 with all figures one omitted after 20. This was done because of the possibility of confusion between ones and the scars which frequently occur on the bodies of these seals.

but when the length of the foetus was over three feet preservation became a problem. In some cases the abdominal cavities were opened, formalin was injected into the lungs, brain, etc., and the foetuses were then immersed in three percent formalin. Larger specimens were skinned, the blubber was scraped off and the skin treated with powdered borax. Sometimes the skin was soaked in borax solution before final drying.

Skulls after removal were boiled for five or six hours and then left to soak for a few weeks. After this treatment the flesh was easily removed and the brain scraped out with steel wire. The skulls of young animals were not boiled for long periods as it caused them to come apart at the sutures. After boiling the skulls many of the teeth became loose and required securing with glue.

X-rays. Foetal skulls were X-rayed by Dr. O. Rec, A.N.A.R.E. Medical Officer at Heard Island during 1951, using a comparatively long time-exposure. The skulls were not prepared for X-ray in any way but results proved much better with animals that had been skinned.

APPENDIX B

THE LEOPARD SEAL AT MACQUARIE ISLAND, 1952-54

by A.M. Gwynn.

Detailed notes were kept of the appearances of leopard seals at the north end of Macquarie Island by A.N.A.R.E. Medical Officers in 1952 (Dr. Z. Soucek), 1953 (Dr. J.B. Sturrock), and 1954 (Dr. A. Gourin). In 1952 the search was particularly thorough, the entire North Head, Isthmus, and east coast to the land falls being covered in detail three times a week. The watch kept in 1954 was probably comparable with that in 1949; that in 1953 was perhaps less thorough.

Dates of first arrival. All observers were briefed to note the first arrival, and to secure it as a specimen. This showed, rather surprisingly, that the seal noted on 5 May 1949 was unusually early. In all years only one or two leopards were noted before July. The first leopard seals recorded in each year were:-

1949	5 May	Female	206 cm.
1952	26 June	Female	270 cm. (correct length probably about 240 cm.)

but when the length of the foetus was over three feet preservation became a problem. In some cases the abdominal cavities were opened, formalin was injected into the lungs, brain, etc., and the foetuses were then immersed in three percent formalin. Larger specimens were skinned, the blubber was scraped off and the skin treated with powdered borax. Sometimes the skin was soaked in borax solution before final drying.

Skulls after removal were boiled for five or six hours and then left to soak for a few weeks. After this treatment the flesh was easily removed and the brain scraped out with steel wire. The skulls of young animals were not boiled for long periods as it caused them to come apart at the sutures. After boiling the skulls many of the teeth became loose and required securing with glue.

X-rays. Foetal skulls were X-rayed by Dr. O. Rec, A.N.A.R.E. Medical Officer at Heard Island during 1951, using a comparatively long time-exposure. The skulls were not prepared for X-ray in any way but results proved much better with animals that had been skinned.

APPENDIX B

THE LEOPARD SEAL AT MACQUARIE ISLAND, 1952-54

by A.M. Gwynn.

Detailed notes were kept of the appearances of leopard seals at the north end of Macquarie Island by A.N.A.R.E. Medical Officers in 1952 (Dr. Z. Soucek), 1953 (Dr. J.B. Sturrock), and 1954 (Dr. A. Gourin). In 1952 the search was particularly thorough, the entire North Head, Isthmus, and east coast to the land falls being covered in detail three times a week. The watch kept in 1954 was probably comparable with that in 1949; that in 1953 was perhaps less thorough.

Dates of first arrival. All observers were briefed to note the first arrival, and to secure it as a specimen. This showed, rather surprisingly, that the seal noted on 5 May 1949 was unusually early. In all years only one or two leopards were noted before July. The first leopard seals recorded in each year were:-

1949	5 May	Female	206 cm.
1952	26 June	Female	270 cm. (correct length probably about 240 cm.)

1953	15 June	Female	260 cm.
1954	30 June	Male	198 cm.

Total numbers recorded at North End
(including a few noted on Nuggets beach)

	1949	1952	1953	1954
June	1 (25 June)(1)	2 (1 Female)	1 (Female)	1 (Male)
July	16 (1 Male 8 Female)	3 (2 Male)	1 (Male)	13
Aug.	40 (6 Male 21 Female)	17 (8 Male 8 Female)(2)		34
Sept.	21 (7 Male 2 Female)	6 (2 Female)(2)		33
Oct.	7	3	6	12
Nov.	6	2	1	1
Dec.	2	1	1	0

1952: It is clear that relatively few leopard seals reached Macquarie Island in this year. Of eight seals killed, two were small males, the other six were all immature females. Dr. Soucek took his measurements to the end of the hind flippers, not to the tip of the tail: in this case 25 - 30 cm. should be subtracted from each measurement. His figures agree with 1949 in that most of the seals seen were first and second year animals, though he did not find the preponderance of females noted in 1949. The female shot on 26 June was probably a second-year animal.

1953: Numbers were again small. The female shot on 15 June was probably in its third year. Only one other leopard seal was seen in July, a small male. Four more were seen up to 16 August, after which 2 or 3 were seen on most days for the next month, on one occasion four. A "large" female was shot on 10 October, but was not pregnant. Dr. Sturrock noted that many of these animals appeared sick or tired, but the one seen in December, a large seal, was fit and active.

1954: Leopard seals were relatively plentiful. Where the same animal was identified on more than one occasion, this was included only once in the month's total, but there must have been considerable duplication of seals which were not individually recognisable. Interesting examples of

---

(1) Not sexed. Omitted from Table 2 of Gwynn's paper (1953) in error.

(2) See below.

recognisable individuals were:-

(1) A female with a wide scar across its skull sighted on 18 August and again on 15 October;

(2) A seal with one hind flipper missing, seen south of Nuggets Point on 4 August, and again at the Station on 14 August;

(3) A seal with severe skin disease, first seen on 18 September, then subsequently on several occasions, always at the same spot, till it was found dead on 4 November (not included in November total).

These figures suggest that the numbers reaching Macquarie Island fluctuate considerably from year to year, presumably depending on the extent of the pack-ice and weather conditions farther south. This might be expected if, as suggested, Macquarie Island is near the fringe of their normal winter range.

In general, these results support Gwynn's observation that most of the leopard seals reaching Macquarie Island are young animals. All observers report a few "large" or "very large" leopards, usually males where the sex was known, and some of these were undoubtedly adults (e.g. a very large much scarred male, about 290 cm. long seen by Dr. Gourin on 10 August 1954). However, no exact measurements are available, as none were killed. Observers were asked to keep a special look-out for pregnant females, but none were seen. Soucek records a female whose length was estimated at 11 ft. 9 in. to the tip of the hind flippers on 22 August 1952, but this is the only observation which can be regarded as probably referring to a fully adult female. Any adults would appear very large in comparison with the small leopard seals usually seen at Macquarie Island.

All accounts mention seals which were apparently sick or exhausted, and there is some reason for supposing that leopard seals seen ashore at Macquarie Island include a rather high proportion of such animals. The heavy infestation with intestinal worms so often noted could be another reflection of this tendency.

There is some evidence that leopard seals are now seen less frequently at Macquarie Island than during the tenure of the Australasian Antarctic Expedition (1911-14) and also that adult females were then not in-

frequent. Their detailed records are not available, but in "The Home of the Blizzard" Ainsworth mentions a large female killed on 11 May 1912, and further on refers to "several" occasions on which females were killed late in pregnancy. Tulloch (1916) states that "They became rather scarce from February to April, but never wholly disappeared". Their occurrence at Macquarie then appears to have been rather similar to that at Heard Island today. The reason for the change is probably to be sought in some change in the distribution of the pack-ice.

ACKNOWLEDGEMENTS

This paper was being prepared by the author at the time of his death in 1954. The present draft, though based on Brown's field notes, was largely written by other hands. The editors would like to thank Dr. A.M. Gwynn, A.N.A.R.E. doctor at Heard Island in 1950 and 1953, and Miss Susan Ingham, Antarctic Division biologist, for their valuable contributions to the paper.

REFERENCES

AINSWORTH, G.F., 1915. See Mawson, 1915.

BAGSHAWE, T.W., 1939. Two Men in the Antarctic. Appendix D.

BERTRAM, G.C.L., 1940. The Biology of the Weddell & Crab-eater Seals. Brit. Graham Land Exp., 1934-37, Sci. Rep. 1.

de BLAINVILLE, H.M.D., 1820. Sur quelques cranes de phoques. J. Physiol. Path. Gen. 91.

BORCHGREVINK, C.E., 1901. First on the Antarctic Continent.

BROWN, K.G., 1952. Observations on the Newly Born Leopard Seal. Nature, 170: 982.

GREEN, A. and REDFIELD, A., 1933. On the Respiratory Function of the Blood of the Porpoise. Biol.Bull. 64.

GWYNN, A.M., 1953. The Status of the Leopard Seal at Heard Island and Macquarie Island 1948-50. A.N.A.R.E. Interim Rep. 3.

HAMILTON, J.E., 1939. The Leopard Seal, Hydrurga Leptonyx (de Blainville). Disc.Reports 18: 239.

IRVING, L., 1939. Respiration in Diving Mammals. Physiol. Rev. 19: 112.

LAWS, R.M., 1953. The Elephant Seal (Mirounga leonina Linn) I. Growth and Age. F.I.D.S. Sci.Rep. 8.

LAWS, R.M., 1956. The Elephant Seal (Mirounga leonina Linn) II. General Social and Reproductive Behaviour. F.I.D.S. Sci. Rep. 13.

LE SOEUF, A. and BURRELL, H., 1921. Wild Animals of Australia.

LINDSEY, A.A., 1937. The Weddell Seal in the Bay of Whales. J. Mamm. 18: 127.

MATTHEWS, L.H., 1929. The Natural History of the Elephant Seal. Disc. Reports 1: 233.

MAWSON, D., 1915. The Home of the Blizzard. 2: 167 on Macquarie Island by G.F. Ainsworth.

MOSELEY, H., 1879. Notes by a Naturalist on H.M.S. "Challenger".

RAND, R., 1950. On the Milk Dentition of the Cape Fur Seal. J. Dent. Ass. S. Africa. 1950 (Oct. 15).

SCHOLANDER, P., 1940. Experimental Investigations on the Respiratory Functions in Diving Mammals and Birds. Hval. Skrif. No. 22.

TULLOCH, A.C., 1916. Report on Macquarie Island. Parliament of Tasmania. No. 7.

WAITE, E.R., 1909. The Subantarctic Islands of New Zealand 2: 542.

WILSON, E., 1907. Nat. Ant. Exp. 1901-1904. Nat. History 2.

WORSLEY, F., 1914-16. Ms. Journal. cit. HAMILTON, 1939.