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PERTH

THE WILDLIFE OF SALISBURY ISLAND, ARCHIPELAGO OF THE RECHERCHE, WESTERN AUSTRALIA

BY

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I INTRODUCTION

Salisbury Island is the largest of the South East Islands of the Archipelago of the Recherche, a group of over 100 islands off the south coast of Western Australia between longitudes 121°E and 125°E. Salisbury itself lies in 34°21'S, 123°33'E. Salisbury Island is the third largest island in the Archipelago, having an area of about 320 ha.

The whole of the Archipelago of the Recherche is included in Class A Reserve No. 22796. All islands, except Middle Island, were reserved in 1948 (Government Gazette 21 May 1948, p. 1103). Middle Island was added on 21 November 1958 (p. 3032) and the Reserve was proclaimed Class A on 26 September 1969 (p. 2920). On the same date the Reserve was vested in the Western Australian Wildlife Authority (p. 2921). The name "Recherche Archipelago Nature Reserve" was officially applied on 4 May 1979 (p. 1147).

The Archipelago has long been recognised as an area of extremely high nature conservation value. The islands have similar conservation values to other offshore continental islands world-wide. Particular additional values provided by the Recherche include the presence of small populations of terrestrial mammals, including species or sub species now rare or extinct on mainland Australia and the presence of significant seabird and seal breeding colonies.

In 1980 two mineral claims covering Salisbury Island were lodged under the Mining Act 1904. These claims were in the name of Genesis Pty Ltd and were for Guano, Phosphate and Limestone Rock. The Western Australian Wildlife Authority and the Conservator of Wildlife lodged objections to the claims with the Wardens Court and arranged for the Department of Fisheries and Wildlife to examine the island's plants and animals and assess possible impact if mining were to proceed.

Staff from the W.A. Wildlife Research Centre attempted to land on Salisbury from the sea in the period 27 March to 1 April 1982. After one attempt, which was terminated due to strong winds and rough seas, and after discussions with local professional fishermen experienced in these waters, it was decided that although a landing could be effected in calm weather it would be difficult to land and retrieve a large party of scientists and their equipment to any schedule. Furthermore, sea landings are only possible near the northern tip of the island making an examination of the whole island difficult.

Accordingly, the party returned to Cape Arid on 15 April with a Bell Jet Ranger II helicopter chartered from Vowell Air Services. The party set up camp on Salisbury Island that day and departed on 19 April. The campsite was toward the northern end of the migmatite and on the crest of the island. The party comprised Dr A.A. Burbidge (leader), Dr J.E. Kinnear, Mr N.L. McKenzie and Mr P.J. Fuller. Mr K.E. Cashin operated a base camp at Cape Arid.

II HISTORY

The history of the Archipelago of the Recherche has been discussed by Béchervasise (1954). The first European to sight the islands was Pieter Nuyts in 1627. Further visits were made by Vancouver in 1791 and D'Entrecasteaux in 1792; the latter named, but did not land on, the South East Isles.

Matthew Flinders examined the Archipelago closely in 1802 but again no landing was made on Salisbury Island. By 1825 sealers were operating on the islands and this continued until at least 1850 and probably sporadically until 1892 when seals were legally protected. One further year of sealing was permitted in 1920 (Serventy 1953). Doubtless Salisbury Island was visited by sealers who made their headquarters at Middle Island, but the lack of a sheltered anchorage, good campsite or fresh water would not have encouraged them to stay.

Salisbury Island was the scene of a dramatic rescue in 1894. The "Rodondo" a ship of 1 000 tons bound for Fremantle from Adelaide struck Pollocks Reef on 6 October of that year (Bechervaise 1954). The 196 passengers and crew were rescued from Salisbury Island by the schooner "Grace Darling". A fire is reputed to have swept the island at this time (Willis 1953); presumably this was lit to attract attention.

Salisbury Island was named by Commander J.W. Combe, who carried out a hydrographic survey of the Recherche in 1900-1901. The origin of the name is unknown.

There are only two recorded visits to Salisbury Island by biologists. The first was during the Australian Geographical Society expedition to the Recherche in November 1950 (Willis 1953-54) and the second by Dr I. Abbott and Dr G. Maynes in April 1977 (Abbott and Black 1978). Both visits were for only a few hours duration. Both groups landed near the northern end of the island and consequently they examined only a small part of it.

III GEOLOGY AND PHYSIOGRAPHY

The geology of the Malcolm - Cape Arid 1:250 000 map sheets have been mapped and briefly described by Lowry and Doepel (1974) and the rocks of some islands of the Recherche have been described by Morgan et al. (1968). The physiography and geology of Salisbury Island has been described in greatest detail by Fairbridge and Serventy (1954). The following description is from these publications, augmented slightly by our own observations and from examination of 1:40 000 air photographs (Department of Lands and Surveys, WA 1323 Cape Arid: (Salisbury Island) Run 5 (5039-5041). Project G86. Photographed 25 February 1971).

Salisbury Island is about 5.2 km long. It is fairly narrow, being about 1.3 km across the widest point, reducing to 200 m at the narrow neck and 150 to 300 m across the northern peninsula. The long axis is aligned in a north-east south-west direction.

Except for the northern peninsula and the southern peak the island consists of an undulating, high limestone plateau with steep cliffs. It is highest in the centre of the island, north of the narrow neck, where it reaches 120 m. The northern peninsula is mostly limestone but is much lower.

The southern peak, which reaches 100 m, and its surrounds consist of a Proterozoic migmatite, composed of granitic rocks, metamorphosed basic rocks and minor schists and quartzites. The migmatite extends northwards and is exposed as a fringing platform surrounding most of the island, one to five metres above sea level and up to 40 metres wide. The limestone unconformably overlies the migmatite and appears to be mostly a Quaternary eolianite, mapped by Lowry and Doepel as "altered eolian deposit - calcareous and siliceous : phosphatic in part". Between the eolianite and the migmatite is a narrow band of limestone or sandstone, possibly of Tertiary age.

Interest in possible local phosphate deposits during World War II led to a visit by Dulfer (1943) who described his visit as follows:

"Salisbury Island is a narrow island 3 miles long from northeast to southwest and lies parallel to the direction of the most frequent winds in the area. Unlike most of the islands in the Recherche Archipelago the granite, where visible, only raises from 10 to 20 feet above sea level. For a width of from 50' to 250' the granite is bare and forms a serrated reef on which the surf breaks continuously.

"Overlying the granite base of the island sedimentary beds of limestone and calcareous sandstone rise steeply from the

granite base. The upper surface of the island is formed of travertine, wind blown sand and sandy soil, on which stunted vegetation grows profusely.

"Low grade phosphate rock was found in the eroded cliff face approximately 3500' from the north eastern point of the island, and situated between the granite and sedimentary beds, where the calcareous sandstone cliffs were undercut for a depth of 4 to 6 feet.

"Description and quality of this material is as under:

(a) Soft calcareous sandstone with a maximum thickness of 18" containing 7.24% of calcium phosphate and 7.2% of water.

(b) White chalky material approximately 12" thick containing 34.27% of calcium phosphate and 6.8% of water.

(c) Hard brecciated rock about 12" thick and similar to Christmas Island rock phosphate. The analysis of a grab sample of this material showed it to contain 50.9% of calcium phosphate and 5.7% of water....

"The phosphate deposits of the islands of the Recherche Archipelago are generally of low grade and contain large proportions of calcium carbonate and/or silica....

"The narrow beds of low grade phosphate found in the cliff face at Salisbury Island are not encouraging in quality. To determine the quantity available a large amount of tunnelling or drilling would be necessary. If substantial deposits exist, the grade needs to be comparatively high to offset the high cost of underground mining, shipping facilities and probably delays to shipping because of unfavourable seas, of which we had good evidence during our visit to the Archipelago."

Soils are for the most part thin and apparently derived in situ. Only at the narrow neck is there any depth of soil; here

there is a small low dune of pale sand. In places there is deep leaf litter.

Time of Separation

According to the current literature (Thom and Chappell 1975; Hope and Peterson 1973; Burrows 1979), recent changes in mean sea level relevant to Australian and New Zealand shorelines have involved a general increase from 160 metres below current depth (-160 m) at 17 000 years BP (before present), to -25 m by 9 000 - 10 000 years BP. and $\pm$ 1 m at 6 000 years BP. This increase in sea level corresponds to the transition from a full glacial (ending about 14 000 years BP) to a full interglacial condition (by about 8 000 years BP). Between 6 000 years BP and the present, little change in mean sea level has been detected.

There were a number of more minor, but well marked, stadials (cool periods) during this period (14 000 years BP to present) that would have resulted in brief intervals during which southern hemisphere sea levels were slightly lowered - but such variation is expected to have been small compared with the general trend.

From such a "time-depth " curve, the time of isolation of Australian continental islands can be calculated using bathymetric data. Salisbury Island is separated from the mainland coast by a broad channel 45 fathoms (82 m) deep. Even allowing for isostatic processes, such as sea bed depression, the marine transgression of Western Australia's southern continental shelf would have isolated Salisbury Island at least 13 000 to 14 000 years ago if the figures quoted by Thom and Chappell (1975) are correct.

Comparisons of channel depths separating a variety of larger islands in the Archipelago of the Recherche and elsewhere in south-west Australia from the mainland are presented in Table 1. It is evident that Salisbury was separated before any other major island. Thus we might expect greater genetic

differences in resident species on Salisbury than on other islands in south-west Australia when compared with mainland populations.

TABLE 1. SIZE AND ESTIMATED TIME OF SEPARATION OF SOME SOUTH WESTERN AUSTRALIAN ISLANDS

ISLAND	AREA (ha)	CHANNEL DEPTH (m)	ESTIMATED TIME OF SEPARATION (Years B.P.)
Archipelago of the Recherche			
Middle	1 060	27	9 000-10 000
Mondrain	790	44	10 500-11 500
Salisbury	320	82	13 000-14 000
North Twin Peak	310	16	8 000- 9 000
Figure of Eight	275	44	10 500-11 500
Sandy Hook	270	35	10 000-10 500
Daw	250	55	11 000-12 000
Wilson	125	50	11 000-12 000
Westall (Combe)	95	55	11 000-12 000
Other islands			
Dirk Hartog	62 000	18	8 000- 9 000
Dorre	4 640	26	9 000-10 000
Bernier	4 430	26	9 000-10 000
Rottnest	1 550	9	7 500- 8 000
Garden	1 170	9	7 500- 8 000
Bald	780	27	9 000-10 000
West Wallabi	600	47	10 500-11 500
East Wallabi	360	47	10 500-11 500

IV VEGETATION AND FLORA

Vegetation

The vegetation of the limestone plateau is Dense Heath B over Tall Open Grass/Very Open Tall Sedges (terminology of Muir 1977), the main species of shrubs were *Acacia cyclops*, *Leucopogon parviflorus*, *Spyridium globulosum*, *Pimelea clavata*, *Boronia alata* and *Olearia axillaris*. The grass is *Poa*

porphyroclados and the sedge Scirpus nodosus. In some areas the shrubs are more open and grasses more common. The sword sedge Lepidosperma gladiatum is common in places, mainly in depressions.

On limestone scree slopes the vegetation is Low Heath C/Dwarf Scrub C of Calocephalus brownii, Myoporum adscendens, Olearia axillaris and Frankenia tetrapetala. Succulent mat plants such as Threlkeldia diffusa, Rhagodia crassifolia, Zygophyllum cf. billardieri and Carpobrotus ? virescens occur throughout as does the herb Senecio lautus.

The migmatite area has a different vegetation. It is a Dense Heath B or Heath B over Open Tall Grass, Very Open Tall Sedges and Open Mat Plants. The shrub layer is dominated by Leucopogon revolutus and Acacia cyclops with extensive areas of Albizia lophantha near the peak. Other shrubs include Spyridium globulosum, Olearia axillaris and Pimelea clavata. Near the edge of migmatite rocks are low spreading shrubs such as Rhagodia baccata, Myoporum adscendens, Muehlenbeckia adpressa and Calytrix tetragona. The grass Poa porphyroclados, the sedge Scirpus nodosus and the mat plant Carpobrotus ? virescens are common and are the dominant vegetation in some places.

Two "meadows" occur either side of the island opposite the campsite. The eastern one is on migmatite and consists of a large area of Dwarf Scrub C of Atriplex paludosa ssp. baudinii with adjacent Tall Grass/Mat Plants (Poa and Carpobrotus). The western "meadow" is on limestone and the vegetation was an Open Dwarf Scrub C (Calocephalus brownii, etc.) and Mat Plants, e.g. Zygophyllum cf. billardieri and Disphyma clavellatum.

We saw no evidence of past fires on Salisbury Island. This is remarkable considering that Willis (1953) states "The shrubs are intergrown forming dense, nearly inpenetrable thickets to about 5 feet in height; this probably represents old regrowth from a fire which is reputed to have swept over Salisbury at the time of the Rodondo wreck there in October 1894" (p. 13).

However an examination of contemporary accounts of the wreck in "The Western Mail" of 13 October, 27 October and 3 November 1894, suggests that the survivors merely lit a fire to keep warm or cook food and there is no suggestion of a bushfire.

It would appear, therefore, that the vegetation of Salisbury Island has remained unburnt for a very long time, making it a valuable research resource for studies on the effects of fire on the vegetation of south-west Australia.

Flora

LIST OF SPECIES

Poaceae	
Poa poiformis	W.?A
Poa porphyroclados	B
Cyperaceae	
Lepidosperma gladiatum	W A.B
Scirpus nodosus	W,A.B
Liliaceae	
Dianella revoluta	A.B
Urticaceae	
Parietaria debilis	W
Polygonaceae	
Muehlenbeckia adpressa	W.B

Chenopodiaceae

Atriplex cinerea	W
Atriplex paludosa ssp. baudinii	A,B
Rhagodia baccata	W,A,B
Rhagodia crassifolia	B
Salicornia blackiana	W
Threlkeldia diffusa	W,A,B

Aizoaceae

Carpobrotus aequilaterus	W,A
Carpobrotus ? virescens	B
Disphyma clavellatum	A,B
Tetragonia implexicoma	W,B

Ranunculaceae

Clematus ? microphylla	B
Clematus pubescens	W

Crassulaceae

Crassula miriamae	W

Mimosaceae

Acacia cyclops	W,B
Acacia rostellifera	A
Albizia lophantha	B

Rutaceae

Boronia alata	W,A

Zygophyllaceae

Zygophyllum cf. billarderi	W,A,B

Sapindaceae

Dodonaea oblongifolia	B

Rhamnaceae

Spyridium globulosum	W,A,B

Frankeniaceae

Frankenia tetrapetala	W,A,B

Thymeleaceae

Pimelea clavata	W,A,B
Pimelea ferruginea	B

Myrtaceae

Calytrix tetragona	B

Apiaceae

Apium prostratum	W

Epacridaceae

Leucopogon parviflorus	W,A,B
Leucopogon revolutus	B

Primulaceae

Samolus repens	B

Myoporaceae

Myoporum adscendens	W,A,B

Asteraceae

Calocephalus brownii	W.A.B
Olearia axillaris	W.A B
Senecio lautus	W A,B

KEY: A Abbott and Black 1978
B This study
W Willis 1953.

Thirty-nine species are now known from Salisbury Island. Doubtless collecting in a more favourable season, especially spring, will yield additional species - all work on the island so far has been in summer or autumn.

Prior to our visit 28 species were known from the work of Willis (1953) and Abbott and Black (1978). One notable feature of the known flora is the high number (six) of species of Chenopods. At the time of the separation of Salisbury Island from the mainland the climate would have been drier and cooler than at present, favouring such species. Chenopods are uncommon on the adjacent mainland today.

V MAMMALS

MARSUPALIA

Macropodidae

Petrogale lateralis Gould Black-flanked Rock-wallaby

The first record of rock-wallabies on Salisbury Island resulted from the wreck of the "Rodondo" in 1894. Survivors who landed on the island caught wallabies for their subsistence ('The Western Mail' 13 October 1894). This record was overlooked by scientists until the species

was rediscovered by the 1950 Australian Geographical Society Expedition. At this time the Salisbury Island rock-wallabies were considered to belong to subspecies hacketti Thomas, named in 1905 from specimens from Mondrain Island.

The taxonomy of rock-wallabies Australia-wide has for some time been confused. Recent work by Professor G.B. Sharman and others at Macquarie University has shown that there are two forms in the Recherche - hacketti on Mondrain, Westall (or Combe) and Wilson Islands and lateralis on Salisbury Island (Prof. G.B. Sharman, pers. comm., Poole 1979). Whether these forms warrant subspecific or specific distinction is unclear at present.

Population Size

We made counts of rock-wallabies on Salisbury Island both by day and, with the aid of a spotlight, at night. Daytime counts produced higher numbers and we have discarded spotlight counts in the calculations of population size.

Migmatite area. The best count on the migmatite (southern) portion of the island was of 28 animals. Work by one of us (JEK) at Nangeen Hill, near Bruce Rock, has shown that, at the most, only 30% of the number of rock-wallabies actually present are sighted during traverse counts. If this correction is applied to the Salisbury Island data the estimated population on the southern migmatite area is 93. The area of the southern migmatite portion is approximately 20% of the island, i.e. 64 ha. This gives a density of 145/km^2.

Limestone area. The best count of the limestone area was of 42 animals. This is the sum of sightings from two groups covering different sides of the island on consecutive days, but excluding the northern peninsula. Using the same correction the estimated population is 140.

The peninsula accounts for approximately 10% of the limestone - if rock-wallabies occurred on the peninsula at the same density the estimate becomes 156. This gives a density of 55/km^2.

The sum of the two estimates, i.e. the estimated population of the whole island, is 249.

The only other study which may be of assistance in verifying our estimates is one on the Yellow-footed Rock-wallaby (Petrogale xanthopus) in South Australia (Copely 1981). Here observers counting animals on standard traverses saw 50% to 66% of the actual population. If we apply these corrections we get 148 animals if we sighted 50% and 112 if we sighted 66%.

The major problem on Salisbury is visibility. On the migmatite area rock-wallabies were relatively easily flushed and sighted because of the more sparse vegetation and a scarcity of deep caves. On the limestone, however, the vegetation was extremely dense and there were a number of deep caves in the cliffs. On Salisbury, we believe that we saw a much higher proportion of the animals present on the migmatite area than on the limestone. It is reasonable, we believe, to assume that we saw 50% of the animals on the migmatite (estimated population 56) but only 30% on the limestone (estimated population 156). This gives an estimated total population of 212. Difficulty of sighting in the dense vegetation in the limestone area suggests that we may have seen less than 30% and the total population could be greater than this, perhaps around 300.

Main and Yadav (1971), who examined macropod populations on a number of islands off Western Australia, concluded that the smallest viable insular macropod population is about 200.

Distribution on island

All the island except the northern peninsula was traversed during the visit. Rock-wallabies were found throughout. Scats showed that all areas were used. Both rock-wallabies and scats were more abundant in the "meadows" on the north-west and south-east sides of the islands opposite the campsite. During the daytime rock-wallabies were concentrated in areas affording good rock shelters but they were not restricted to them. Many were flushed from diurnal resting places beneath dense shrubs.

Food

Rock-wallabies were observed eating Poa, Atriplex and Acacia. Scats from seven localities on the island were examined microscopically employing the method of Griffith and Barker (1966). At this stage it has been possible only to allocate the material to monocotyledonous or dicotyledonous plants. Results are given in Table 2.

TABLE 2. DICOT PROPORTION OF ROCK-WALLABY SCATS FROM SALISBURY ISLAND

Area	Percent Dicot
East side limestone plateau & scree	54
West side limestone plateau & scree	65
West "meadow"	61
East "meadow"	70
Migmatite shelter, west side	68
Migmatite slope, west side	67
Migmatite slope, east side	63

It can be seen that dicots dominate the diet of Petrogale lateralis from both migmatite and limestone areas. This contrasts sharply with data from mainland P. lateralis populations and from P. rothschildi from the Dampier Archipelago (J.E.K. unpublished), where monocots dominate. Identification of scat material to species level has not been completed, however most monocot material appears to be Poa while Atriplex and Acacia figure prominantly among the dicots. Many other dicotyledonous plants are present.

Condition

South-western Australian insular macropods studied so far show considerable loss of body condition in late summer and autumn. This is due to a combination of low nutritional value herbage and lack of water in the Mediterranean-type climate of extremely low summer rainfall. The Salisbury Island rock-wallabies were, however, in excellent condition. We have never seen such sleek macropods, especially considering the time of year. Conditions on the island indicated that little or no rain had fallen during the summer preceding our visit (the Esperance region had been suffering drought conditions) so this appears to be the normal situation. The high concentration of rock-wallabies on the "meadows" which are frequented by Australian Sea Lions suggests that the nutrients added to these areas via seal droppings is allowing a higher carrying capacity. The role played by sea birds elsewhere on the island is unknown but it is of interest to note that a number of other small south-west islands with mammal populations have high numbers of breeding sea birds - e.g. Bald Island (Quokka - Great-winged Petrel, Little Penguin), Combe Island (Recherche Rock-wallaby - Little Shearwater), Mondrain Island (Recherche Rock-wallaby - Fleshy-footed Shearwater), Daw Island (Short-nosed Bandicoot - Great-winged Petrel, Fleshy-footed Shearwater, Little Penguin; also Sea Lions).

Status and conservation of *Petrogale lateralis*

The Black-flanked Rock-wallaby is found only in Western Australia. On the mainland it occurs in the Cape Range, in the Murchison River Gorge at Kalbarri, and on granite rocks in the wheatbelt. Other island populations occur on Depuch and Barrow Islands in the Pilbara.

On the mainland *P. lateralis* has become extremely rare. The Cape Range population has not been studied but both the Kalbarri and wheatbelt populations have declined. From being a widespread and fairly common animal in the wheatbelt it is now reduced to five small populations in the Quairading - Kellerberrin - Bruce Rock area totalling between 75 and 100 animals (Kinnear, unpublished). The reasons for this decline are unclear but appear to be linked to clearing for agriculture and predation by the Red Fox and feral cats.

Studies on the genetics of *P. lateralis* populations show that the wheatbelt animals have no genetic variability. Forty animals were tested at 16 loci and all were homozygous at all loci. The only other wild mammal population known to be so inbred is the Northern Elephant Seal (*Miroungia angustirostris*) which was reduced to about 20 animals by over-hunting (Bonnell and Selander 1974). The only *P. lateralis* population known to have some heterozygosity is the Salisbury Island one (Prof. G.B. Sharman, pers. comm.). This leaves the way open for the introduction of Salisbury Island genes to the mainland in an attempt to produce some hybrid vigour.

RODENTIA

Muridae

Rattus fuscipes (Waterhouse) Southern Bush Rat

Taxonomy and Distribution

The first Australian Rattus was collected at King George Sound, Western Australia, in March 1836 during the famous voyage of H.M.S. Beagle. It was subsequently described by Waterhouse in 1839 as Mus fuscipes. The specimen was subsequently lost following transfer of a portion of the collection of the Museum of the Zoological Society of London (Taylor and Horner (1973). The loss of the "Type Specimen" resulted in a chaos of taxonomic opinion that was eventually resolved by Taylor and Horner (ibid).

The species occurs in coastal and sub-coastal areas from Jurien Bay to the Esperance area in South-western Australia, and from the Eyre Peninsula in South Australia to Cooktown in Queensland. Populations occur on many of the adjacent continental islands.

Four sub-species are currently recognised: R. f. fuscipes being the sub-species in South-western Australia. It is in no danger of extinction. It is very common in appropriate habitats on the mainland and insular populations occur from the Abrolhos Islands to the Recherche Archipelago. On the Recherche Archipelago alone it is known from four islands and may occur on others.

Studies by Schmitt (1975; pers. comm.) on R. f. greyi have shown that insular populations in South Australia differ from adjacent mainland populations, and from each other, on about one of 16 genetic loci examined. These differences are not enough to prevent successful interbreeding so the populations all belong to the same species.

Seventeen specimens (9 females, 8 males) were preserved during our field survey of Salisbury Island and will be lodged in the Western Australian Museum. A further seven live specimens were brought back to Perth for '1080' tolerance trials by Agriculture Protection Board Research Scientists, and for genetic comparison with Western Australian mainland populations by Lincoln Schmitt of the Anatomy and Human Biology Department at the University of Western Australia.

Data on '1080' tolerance were provided by Mr A.J. Oliver, Research Officer-in-Charge, Agriculture Protection Board of Western Australia.

Insufficient animals were available for a statistical estimate of LD_{50} (median lethal dose) so pilot dosing of '1080' was carried out at 21°C to get an indication of the order of magnitude of susceptibility. The results of the six R. fuscipes tested are given in Table 3.

TABLE 3. PILOT DOSING OF SALISBURY ISLAND RATTUS FUSCIPES WITH '1080'

Animal No.	Dose 1080 (mg kg^{-1})	Time (mins) from dosing to death
1	10.0	360
2	2.5	72
3	1.23	165
4	1.23	85
5	1.23	survived
6	0.25	survived

McIlroy (in press) has shown that R. fuscipes from the A.C.T. and South Australia have a LD_{50} of 1.13 mg kg^{-1} sodium fluoroacetate (equivalent to 1.23 mg kg^{-1} '1080' (92% sodium fluorocetate) used by the A.P.B.).

The results in Table 3 suggest that the susceptibility of R. fuscipes from Salisbury Island is of the same order as that of R. fuscipes from South Australia in the A.C.T. Using tolerance to fluoroacetate as a genetic indicator the Salisbury Island population is clearly distinct from any other W.A. mainland or island population so far examined except that from the nearby Daw Island.

L. Schmidtt (pers. comm.) screened 16 loci and found no difference between Salisbury Island R. fuscipes and animals from mainland populations at Cape Arid and Cape Le Grande.

Abundance

Traps were set on both geological surfaces present on the island and were positioned so that the variety of vegetations recognised were sampled except the "meadows" which are of limited extent (Table 4).

Trap results are presented in Table 5. Capture rates were near saturation; nearly all metal traps, when examined each morning, had captured a specimen of Rattus fuscipes. Failures were caused by traps having been sprung by Egernia spp. or an unknown cause; unsprung traps had had their bait stolen. Deep pit traps (60 cm) caught up to six rats each night; shallow pits (35 cm) were unsuccessful, rats jumped out after taking the bait.

Clearly, R. fuscipes was very common throughout the island although it is not possible to estimate the population size and density on the island without a more detailed mark-and-release trapping programme. Hobbs (1971) and Robinson (1975) estimated that R. fuscipes on islands in Bass Strait achieved densities of 60 to 160 rats per hectare compared with 11 to 25 rats per hectare for mainland populations. Abnormally high population densities for insular populations were also recorded by

Schmitt (1975) on Pearson Island and Wheeler (1970) on Kangaroo Island. Thus the large number encountered on Salisbury is not atypical.

TABLE 4 TRAP EFFORT ON SALISBURY ISLAND

Surface Type	Trap Type and Numbers		
	Elliott Traps	Breakback Traps	Pit-Fences
Migmatite	75	35	3
Limestone	40	40	4

TABLE 5 TRAP RESULTS ON SALISBURY ISLAND

Date (Apr.1982)	Migmatite			Limestone		
	Elliott*	Break-back	Pit-fence	Elliott	Break-back	Pit-fence†
16	15/15	9/15	3/1	19/20	17/20	-††
17	8/20	10/20	5/1	15/20	13/20	4/2
18	19/20	-	6/1	-	-	7/2

* : number of R. fuscipes captured/number of traps set.

† : each unit of pit-fence comprised one deep pit, five shallow pits and 50 m of fence.

†† : no traps set.

Habitat Preferences

Rattus fuscipes is known from a wide variety of habitats ranging from heathlands and dry sandy coastlines to the wet tropical closed-forests. It is most common in areas of dense undergrowth and friable soil including wet

habitats around streams and swamps in south-western Australia (Watts and Aslin 1981). It occurred in all habitats sampled on Salisbury Island. An analysis of Table 2 showed no difference in trap results between limestone and migmatite habitats nor was any difference detected in the sex ratios or age classes of rats captured on limestone and migmatite surfaces.

Diet

On two occasions, R. fuscipes was recorded feeding in Olearia bushes (specimen number FW1898, 15 April 1982, 2100 hrs, migmatite surface; 17 April 1982, limestone surface). In both cases the bush involved was in flower.

An examination of the stomach contents of eight individuals, including FW1898, showed that the rats were eating insect material (represented by fragments of chiton) as well as vegetable matter. Watts and Aslin (1981) indicate that the species has an opportunistic omnivorous diet - it eats plant tissues, insect material and the occasional small vertebrate.

Reproduction

Mainland populations breed all year round although most births occur in spring and summer (Watts and Aslin 1981). The age classes present in the population, and the condition of the reproductive systems of specimens captured on Salisbury Island in April 1982, are consistent with the mainland pattern. No females were lactating; of the seven adult females dissected, none had enlarged uterine horns suggesting pregnancy or recent parturition. All males, irrespective of age, had abdominal (inactive) testes. Captures included individuals with body weights from 45 to 60 gram (estimated 2 to 3 month old sub-adults), as well as adults (65 to 100 gram), indicating a previous period of births that terminated in early to mid-February.

CARNIVORA

Otariidae

Neophoca cinerea — Australian Sea Lion

Between 30 and 40 sighted. Groups of up to eight as well as single animals basking and resting all around the island. Major resting areas on "meadows" on both sides of the island opposite the campsite. In these areas Sea Lions move up to 300 m from the sea and up to 50 m above sea level. Elsewhere on rocks.

Two pups seen, approx. 100 and 150 cm long. In Western Australia Sea Lions breed on islands from the Beagle Islands, off Dongara, to the Recherche Archipelago. Only one mainland colony is known. It occurs in limestone cliffs at the edge of the Nullarbor Plain in the Nuytsland Nature Reserve.

Australian Sea Lions range from the Houtman Abrolhos, W.A. to Kangaroo Island, S.A. Abbott (1979) estimated the Western Austalian population at about 700. Ling (1982) estimated the W A population at 750 to 1 000 and the South Australian population at 3 000 to 4 000. It is one of the world's rarer species of seals.

Arctocephalus forsteri — New Zealand Fur Seal

Between 500 and 600 on Salisbury at the time of our visit. A major breeding colony was found on a migmatite platform below limestone cliffs on the north western corner of the island. Here, on 18 April 1982, counts revealed that there were about 500 Fur Seals. Only two of these were wigs (males); each was defending a territory including a group of clapmatches (females) and pups. About 70% of the 500 odd animals present were pups, ranging in size from 50 cm to 90 cm long. On the same day we counted 63 adult Fur

Seals, including wigs, hauled out on an islet in the bay on the west of the narrow neck, and a further 9 in ones and twos elsewhere around the island.

The size of the pups indicates that they were about 1.5 to 3 months old with most at about 2 to 2.5 months (J.K. Ling, pers. comm.). Arctocephalus forsteri is known to be a summer breeding species. Fur Seal clapmatches produce only one pup per year (twinning is extremely uncommon) so there must have been about 350 clapmatches in the colony - many would have been at sea feeding at the time of the count. Based on studies in South Australia the total size of the Salisbury Island colony may have been in the order of 1 000, consisting of 350 females, 75 to 100 breeding males, 350 pups and perhaps 200 to 250 sub-adult males and females (J K. Ling, pers. comm.).

Prior to our discovery of the Salisbury Island breeding colony major breeding colonies were known on Middle Doubtful Island, near Bremer Bay (about 100 animals) and on Daw Island in the Eastern Group of the Archipelago of the Recherche (about 100 to 150 animals). We visited Daw Island on 19 April and estimated the Fur Seal colony there at about 100 (50% of these were pups). Thus Salisbury Island has by far the largest known breeding colony of Fur Seals in Western Australia. Drs I. Abbott and G. Maynes visited Salisbury Island in April 1977 (Abbott and Black 1978). They saw only 30 Fur Seals, including one pup. They were on the island for only a few hours and inspected only a small part of it. Whether they did not locate this breeding colony or whether it did not exist at that time is not clear.

In Australia, the New Zealand Fur Seal ranges from Cape Leeuwin, Western Australia to Kangaroo Island and other small islands off South Australia. Abbott (1979) estimated the W.A. population at about 300 to 400. Our data suggest it is larger than this, perhaps as much as 1 500 to 2 000. The South Australian population is about

3 000 (J.K. Ling, pers. comm.). In south-eastern Australia and Tasmania A. forsteri is replaced by A. doriferus, the Australian Fur Seal. A. forsteri, as its English name suggests, also occurs in New Zealand, where it is more abundant.

The New Zealand Fur Seal was heavily over-exploited by sealers during the nineteenth century and further exploitation was permitted in the Recherche in 1920. Only recently has the species shown any sign of recovery in Western Australia, and it is still an extremely rare animal.

VI BIRDS

Scientific and English names follow Storr and Johnstone (1979).

ANNOTATED LIST

Eudyptula minor — Little Penguin

Although no birds were seen, a fresh burrow, presumed to belong to this species, was found beneath the limestone cliffs at the south-eastern end of the island. Abbott and Black (1978) found a dead bird and signs of moulting birds in 1977. Almost certainly breeds on Salisbury Island.

Diomedea chlororhynchos — Yellow-nosed Albatross

Two single birds observed at sea off south-eastern side of island.

Pterodroma macroptera — Great-winged Petrel

Common.

Areas of deeper soil, flying over island at dusk and after dark . Freshly excavated burrows were found in two areas.

Phalacrocorax fuscescens — Black-faced Cormorant

Four birds roosting on a migmatite islet adjacent to the narrow neck.

Haliaeetus leucogaster — White-breasted Sea Eagle

Two birds flying over northern end of island.

Falco cenchroides — Australian Kestrel

A single bird adjacent to high limestone cliffs to the north of the narrow neck.

Haematopus longirostris — Pied Oystercatcher

Two birds on the shoreline to the north-west of camp.

Haematopus fuliginosus — Sooty Oystercatcher

Moderately common.

Shorelines and wave platforms.

Larus novaehollandiae — Silver Gull

Moderately common.

Shorelines and wave platforms.

Larus pacificus — Pacific Gull

Moderately common.

Around shorelines and resting on migmatite boulders in water.

Hirundo neoxena — Welcome Swallow

Common.

Most areas of island.

Many seen flying in and around large caverns on south-eastern side, probably feeding on mosquitoes which were abundant in the caves.

Sericornis frontalis — White-browed Scrub-wren

Common.

Throughout island in thickly vegetated areas. Probably resident and breeding on island.

Zosterops lateralis — Grey-breasted White-eye

Common.

Throughout island, in thickly vegetated areas. Probably resident and breeding on island.

Corvus coronoides — Australian Raven

Uncommon.

A pair at the Fur Seal colony, a single bird foraging on meadow area west of camp.

DISCUSSION

Fourteen species were recorded. Of these five were land birds: Australian Kestrel, Welcome Swallow, Grey-breasted White-eye (or Silvereye), White-browed Scrub-wren and Australian Raven; two were breeding seabirds and six were sea and shore birds resting on the island. The Yellow-nosed Albatross does not

come ashore except to breed.

Of the four land birds the Scrub-wren, White-eye, and Kestrel would be resident breeding species; the Welcome Swallow is a probable breeding species. Of the seabirds the Great-winged Petrel certainly breeds on Salisbury and the Little Penguin appears to be a breeding species. (Our visit was outside the breeding season.)

Visits in other seasons may reveal additional breeding sea and shore birds, e.g. the White-faced Storm-Petrel, Caspian Tern, Crested Tern, Cape Barren Goose, Little Shearwater, Pacific Gull, Silver Gull and Sooty Oystercatcher.

VII REPTILES

ANNOTATED LIST

Gekkonidae Geckoes

Phyllodactylus marmoratus (Fitzinger) Marbled Gecko

9 specimens, common.

Under migmatite and limestone slabs.

Phyllurus millii (Borg) Barking Gecko

3 specimens.

Limestone, under rocks, active at night on rock.

Skinkidae Skinks

Egernia kingii (Gray) King's Skink

1 specimen, common.

Throughout island, under rocks and in vegetation.

Egernia multiscutata Mitchell & Behrndt

3 specimens.

Under migmatite and limestone slabs, one dug from burrow in sand over limestone.

Egernia napoleonis (Gray)

7 specimens, common.

Abundant under migmatite slabs, also in limestone area.

Hemiergii peronii peronii (Fitzinger)

4 specimens

In deep litter and soil, migmatite area.

Leiolopisma trilineatum (Gray)

1 specimen.

Migmatite area, in grass (Poa) at camp.

Tiliqua rugosa (Gray)

2 specimens.

Migmatite area.

Elapidae Front-fanged Snakes

Notechis coronatus (Schlegel) Crowned Snake

3 specimens.

Migmatite and limestone areas, active during daytime, one with head in Stick Ant (Idiomyrex) nest.

DISCUSSION

Nine species of reptiles were collected comprising two species of geckoes, six of skinks and one species of snake. It is likely that additional work will reveal further species - the cool weather, the thickness of the vegetation and the ineffectiveness of pit trapping because of interference by Bush Rats meant that collection of small cryptic species was difficult.

All species of reptiles known from Salisbury Island occur on the adjacent mainland. Most occur also on other islands in the Archipelago of the Recherche. The skinks from Salisbury Island are darker than those from the opposite mainland, e.g. Egernia napoleonis is so dark on Salisbury as to be easily confused with E. kingii.

One species, Egernia multiscutata, is not known to occur elsewhere in the Recherche, nor is it known on any other island off the southern coast of Western Australia. The Salisbury specimens differ markedly in colouration from those from elsewhere in the species range. For example, the black laterodorsal stripe is 2-3 times as wide as the pale vertebral stripe. In mainland populations it is little, if any, wider. The Salisbury Island population is considered worthy of recognition as a distinct subspecies (Dr G.M Storr in litt. to the authors). The mainland population belong to E. m. bos Storr, while the nominate subspecies is found only on Greenly Island, South Australia.

Another skink collected on Salisbury, Leiolopisma trilineatum is known from only one other island in the Recherche - Mondrain (Abbott and Black 1978).

Salisbury Island seems to be the only island with three species of Egernia. viz: kingii, multiscutata and napoleonis, providing an important area for studies to show how these species co-exist in a relatively simple environment and small area.

VIII INVERTEBRATES

MOLLUSCA

Land snails were collected by sorting from leaf litter samples taken from the island. Three species, all from the family Punctidae, were isolated and sent to Dr Frank Climo, National Museum of New Zealand, an expert on this group in the Australasian region (S. Slack-Smith, pers. comm.). The species were:

Paralaoma caputspinulae (Reeve 1852)

A widespread species.

Australaoma brycei Climo (in press)

Known only from the Recherche Archipelago and adjacent coast.

Paralaomita sp.

A new species known only from Salisbury Island. Related species occur in Western Australia, Queensland and on Lord Howe Island.

ARTHROPODA

Crustacea

Amphipods collected from a brackish seepage on Salisbury Island have been identified as belonging to the genus Melita. Three species were known from Western Australia; from estuarine, littoral and sub-littoral situations. The Salisbury Island material appears to be another species which is new to science. The lack of intensive collecting from the south coast of

Western Australia renders any conclusion regarding the endemicity of this species impossible (Dr B. Knott, pers. comm.).

MYRIAPODA

Chilopoda Centipedes

Scolopendridae

Cormocephalus aurantiipes (Newport)

Three specimens of this widespread species were collected.

Cryptopidae

One specimen of an unidentified species was collected. This family is widespread in the south-west of Western Australia.

SCORPIONIDEA

One species of scorpion was collected from beneath migmatite slabs. It was Lycas marmoreus (Koch) of the family Buthidae. It is a widespread species.

ARANEIDEA Spiders

List of species collected on Salisbury Island with notes on geographic range. Identifications and notes by Dr B.Y. Main.

Family	Genus	Species	Geographic Range
DICTYNIDAE	Paramatachia	tubicola	Reevesby Is. S.A , Tasmania. Western-most extension of a "coastal" species. Spiders dependent on very humid conditions; live in holes in dead twigs from which they spread web.
SPARASSIDAE	Olios	diana	Widespread over Australia.
	Delena	cancerides	Widespread southern Australia and offshore islands.
ARANEIDAE	Araneus	recherchensis	Endemic Recherche Islands (recorded only from type locality. Figure of Eight Island).
	Araneus	pustulosus	Widespread southern Australia.
AMAUROBIIDAE	Ixeuticus possibly (=Ixeuticus	martius longinquus	South eastern Australia and southwest W.A. (near Albany).
	Baiami sp.		Genus in southern Australia (W.A., S.A., Victoria only).
GNAPHOSIDAE	Encoptarthria	serventyi	Endemic Recherche (Sandy Hook Island)
LYCOSIDAE	Genus A	sp. (1)	
MITURGIDAE	Miturga sp.		Genus widespread southern Australia.
PISAURIDAE	Undescribed genus and species		Common near Albany, also found on Bald Is., Middle Is. Recherche.

DISCUSSION

Eleven species of ten genera and belonging to eight families were collected on Salisbury Island. One genus (Encoptarthria) and two species (E. serventyi Main and Araneus recherchensis Main) have been previously recorded only from islands of the Archipelago of the Recherche - Sandy Hook and Figure of Eight Islands respectively. The unidentified Pisaurid ("Nursery Web" spiders) are known elsewhere from forest litter, e.g. near Albany, on Bald Island, and on Middle Island in the Archipelago of the Recherche. They require a humid habitat and can probably survive on as dry a place as Salisbury Island because of its maritime climate.

Three taxa are of special zoogeographic interest:

1. Ixeuticus martius (Simon) = I. longinquus (Koch) is a common lace web weaving spider of south eastern Australia and Tasmania. It has recently been recorded from Western Australia (near Albany) but has not been recorded from South Australia. It is dependent on humid habitats and is replaced inland by other species more typical of dryer habitats.

2. Baiami Lehtinen is a southern Australian genus which occurs in mainly humid forest habitats and caves of south-west Western Australia, the Lofty Ranges (South Australia) and south western Victoria (Gray 1981). Two Peoples Bay was the easternmost W.A. locality, apart from a cavernicolous species on the Nullarbor. Salisbury Island probably represents a relictual habitat, being the peripheral part of an earlier wider range during a period of lowered sea level. It is possible that the Salisbury Island species is undescribed.

3. The occurrence of Paramatachia tubicola (Hickman) is of special interest as it represents the westernmost extension of a Tasmanian species which is also known from Reevesby Islands, South Australia (Hickman 1950).

This is another species which requires a humid environment. Paramatachia is particularly vulnerable to desiccation as the spiders live in insect holes in dead twigs from which they spread a snare. Although the vegetation of Salisbury Island may be depauperate compared to the usual Paramatachia habitats the maritime climate has apparently ensured its persistence.

IX FOSSILS

Fossil bone material was collected on Salisbury Island. It was eroding from a face of limestone outcrop approximately seven metres high, lying over migmatite on the east side of the island at the narrow neck. The deposits were exposed where an area of cliff had recently fallen away exposing a fresh face. Three distinct deposits were found over a 15 m length of the face. It occurred in lenses of softer (in patches almost powdery) limestone, approx. 0.5 to one metre from the top of the face. It was eroding rapidly and some bone material was found lodged in crevices and at the foot of the cliff immediately beneath the deposits.

The material was examined by Dr P.V. Rich, of the Department of Earth Sciences, Monash University. She reported (in litt. to the authors):

1. "Most of it is avian; mixed in with it are lizard jaws, mammal toe bones.

2. "It is scientifically important and, if finances and personnel permitted it, it would be well worthwhile taking a trained palaeontologist out to look at the site in more detail.... It would be worth identifying the material in detail and reporting on as our understanding of avian distribution, even in the last 20 000 years, is based on far too little material.

3. "Several different taxa present. The bulk of the material belongs with the Procellariidae. Some appears to be Puffinus sp. but there are at least 3 different procellariids present probably. The bones have many different types of preservation. Some appear to be very recent, but some are more permineralized and presumably older. Some may even have been burned."

X DISCUSSION

Nature Conservation Values

Salisbury Island is an extremely valuable nature conservation reserve. Its values to nature conservation can be summarised as follows:

1. It harbours the only insular population of the Black-flanked Rock-wallaby south of the Pilbara and the only one known to have genetic diversity.

2. It is the site of the largest known breeding colony of the New Zealand Fur Seal in Western Australia.

3. It is an important sea bird breeding island.

4. Its fauna includes a number of other species of scientific interest including a genetically unique population of the Southern Bush Rat, an undescribed subspecies of lizard, an undescribed species of snail and species of spider well outside their normal geographic range.

5. It provides a valuable scientific laboratory for studies on such subjects as island biogeography, rates of evolution and changes in species diversity following separation, as well as broader ecological work.

6. Because it is the oldest island of any size off the south-west coast of Australia, resident, non-migratory

species can be expected to show greater genetic differences compared to mainland populations than on other islands. This is reflected in our discovery of an undescribed subspecies of Egernia multiscutata. More intensive study, not possible during our brief visit, may show similar divergence in other species of animals and plants.

Possible Impact of Mining and other Disturbance

(a) Rock Wallabies

The population of Black-flanked Rock-wallabies on Salisbury Island is in excellent condition. It numbers at least 200 (see Mammals) and perhaps as much as 300. Available data on sea levels suggest that Salisbury Island was separated from the mainland in the order of 13 000 to 14 000 years BP and that it would have reached its minimum size about 6 000 years BP and retained that area since. Any activity on Salisbury Island causing disturbance to habitat or the animals would result in a reduction of the area available to rock-wallabies and hence a reduction in numbers. Main and Yadav (1971) have shown that the minimum viable size of a population of macropods in the long term is about 200. Even a short term reduction in numbers below this figure could cause sufficient inbreeding to reduce genetic diversity making the island population especially vulnerable to environmental modification.

Human occupation and use of Salisbury Island might have other impacts on the rock-wallaby. The introduction of exotic predators like cats, dogs or foxes would have a disastrous effect. Evidence on the effect of cats and foxes on small macropod populations is available from Dolphin Island, Dampier Archipelago (Kinnear, unpublished), the Montebello Islands (Burbidge 1971), Dirk Hartog Island (Burbidge and George 1978) and Rottnest and Garden Islands. The introduction of weeds which would compete

with, and possibly eliminate, species currently providing food for the rock-wallabies could also have a major impact, as could frequent fire.

The long term survival of Petrogale lateralis as a species may depend on island populations. Work currently underway at the Western Australian Wildlife Research Centre indicates that Black-flanked Rock-wallabies may be doomed to extinction on the mainland due to loss of habitat, predation by foxes and inbreeding of the resulting very small populations. One possible management technique to try to save the species on the mainland is to interbreed them with genetically more diverse stocks; Salisbury Island offers the only known such population.

The Black-flanked Rock-wallaby has been declared to be a species "which is likely to become extinct, or is rare, or otherwise in need of special protection" under Section 14(2)(ba) of the Wildlife Conservation Act 1950-79. (Declaration was under the name Petrogale penicillata because of taxonomic problems with W.A. rock-wallaby populations.)

(b) Seals

Seal breeding colonies are highly susceptible to disturbance. Fur seals, in particular, tend to be very timid and take to the sea when disturbed. It is most important that fur seal breeding sites are not disturbed during pupping and nursing, in order to reduce disruption to breeding (Ling 1982). Salisbury Island is by far the most important New Zealand Fur Seal breeding place in Western Australia; available data indicate that over half the total Western Australian population breeds there.

It is clear the Arctocephalus forsteri populations in Australia are only just beginning to recover from the depredations of sealers during the nineteenth century and

in 1920. The total Australian population, in the order of 4 000 to 5 000 (at the most), is still very small.

Fur Seals need particular kinds of places to breed. Colonies are located in areas that are close to the sea but protected from waves while providing calm bays or pools in which the pups learn to swim. Very few islands off the south coast of Western Australia provide such situations; most Recherche islands plunge steeply into the sea. Even on Salisbury Island, which has a relatively flat migmatite platform around much of the shoreline, there is only one place meeting fur seal requirements.

(c) Other Species

Observed species richness - island area relationships (e.g. Main and Yadav 1971, Diamond 1976, Simberloff and Abele 1976) show that smaller islands have fewer species. Any reduction in the effective area of Salisbury Island by disturbance or the invasion of weeds would be expected to lead to a depletion in the number of species present. As discussed above Salisbury Island has never been significantly smaller than it is at present.

(d) General

Mining (including exploration activities) is contrary to the purpose for which Salisbury Island is reserved. Any exploration or mining activity would be contrary to Wildlife Conservation Regulations 42, 44, 45 and 46.

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Plate 1. Migmatite area, looking south from southern peak.

Plate 2. Looking north-east from southern peak : migmatite in foreground, limestone dome in background.

Plate 3. Looking north-east from campsite : migmatite in foreground, limestone dome in background, narrow neck to right.

Plate 4. "Meadow" area on north-west side of island at junction of limestone and migmatite. Atriplex in middle distance.

Plate 5. Looking south-west from limestone dome towards southern peak.

Plate 6. Vegetation on limestone dome. Dense Heath B of *Acacia cyclops*, *Pimelea clavata*, *Leucopogon parviflorus*, *Spyridium globulosum* and *Boronia alata* with sedge (*Scirpus*) leaves emergent.

Plate 7. Black-flanked Rock-wallaby (Petrogale lateralis) on Salisbury Island.

Plate 8. Australian Sea Lion (Neophoca cinerea) : clapmatch and pup on Salisbury Island.

Plate 9. New Zealand Fur Seal (Arctocephalus forsteri) : clapmatch and pups on Salisbury Island.