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OLD AND NEW STORM PETREL ROOKERIES IN PORT PHILLIP BAY

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Abstract

It is suggested that the breeding colony of white-faced storm petrels (*Pelagodroma marina* Latham) established on South Channel Fort Island formed from descendants of birds breeding on the Mud Is 2 m. away. The old established Mud Is rookeries are degenerating and petrel burrow density is less than in the more recent Fort I. rookery.

On the Mud Is collapse of the petrel burrows due to interference by man, grazing of vegetation by rabbits and the removal of guano in the latter half of last century have aided soil erosion. Loss of soil depth where the underlying rock is near the surface results in decrease of rookery area as burrowing becomes impossible. These factors are not important on Fort I.

The vegetation of the Mud Is in rookery areas is extremely degenerate and consists of an incomplete cover of introduced annuals. Fort I., although man-made and only 80 years old, has a much less artificial flora of native perennials.

The unfavourable areas of Fort I. were almost fully utilized by the 1959-60 breeding season, so that further transfer of the storm petrel population from the Mud Is is likely to be restricted. At least some portions of the rookeries on the Mud Is might be preserved by enclosure with rabbit-proof fencing to enable the flora to regenerate and by minimization of the disturbances occasioned by collapse of the petrel burrows due to trampling by man.

Introduction

Keble and others (1947, p. 131) write of the Mud I. Group, 30 m. S. of Melbourne—'The investigation was of peculiar importance, as it was considered that the islands are of recent origin . . . at the most little more than 3,500 years old, and that they would furnish the material for an interesting ecological survey'. Later in the same paper Willis (p. 141) states—'The Mud Islands, so relatively circumscribed and free from interference, would form an admirable subject for a detailed ecological survey'.

The present paper confirms the undoubted ecological interest of the group, but for different reasons. Although 'new' geologically, the islands may be considered 'old' biologically in regard to the age and degeneracy of both the plant and animal communities, when compared with those of the adjacent, more recent South Channel Fort Island (hereafter referred to as Fort I.). Further, the very high degree of interference now suffered is of undoubted significance in the present unstable biosystem of the islands.

Populations of seabirds have already come and gone, as shown by the old bone beds and guano beds. The existing population of white-faced storm petrels (*Pelagodroma marina* Latham), estimated at approximately 10,000 pairs in 1958 by W. R. Wheeler, appears to be decreasing in size.

The Mud Is are the only places in Port Phillip Bay where consolidated dune limestone or aeolianite is exposed above H.W.M. (Chapman 1928; Keble and others 1947). Some of this rock has been covered by sand, but the depth of this is often slight and collapse of burrow roofs serious because of lack of sufficient soil depth for burrows to be replaced or repaired.

One such extensive area (Pipit Flat) on Middle I. was the site of considerable guano gathering resulting in the removal of 'hundreds of tons of the sand and soil constituting the main petrel rookery, the birds of which have now to dig laboriously amongst the roots of the shrubs for their nesting burrows' (Chief Inspector of Fisheries and Game, May 1912, in a recommendation to the Secretary for Lands requesting the refusal of future applications for rights to operate on the islands). The burrows in this area are now sparse and confined to patches of shingly sand between exposed ridges of aeolianite. The Middle I. rookery was proclaimed a sanctuary for storm petrels in 1898 by authority of a Mr MacLean of the Ports and Harbours Branch (J. P. Larkin, personal communication). In 1902 the Game Act then in force was invoked to provide complete protection for the white-faced storm petrels breeding on the Mud Is. This was repealed in 1931 and replaced by a new proclamation declaring these islands a sanctuary for all native game.

After the cessation of guano collecting and enforcement of protection, the storm petrel rookeries on the Mud Is appear to have expanded at least until 1936, when Heathcote (1936) recorded increased numbers of the birds, and new rookery areas as compared with earlier observations. Tarr (1954) considered that the population of storm petrels had still further increased by 1953, and attributed this tentatively to a decline in the rabbit numbers on the islands. The more recent decrease, apparent during banding work, has probably been occasioned by progressive destruction of vegetation and denudation of soil resulting in collapse of burrows on the Mud Is.

Contemporaneous with these changes has been the initiation and spread of a new storm petrel colony on the 80-year-old man-made Fort I., and it is suggested

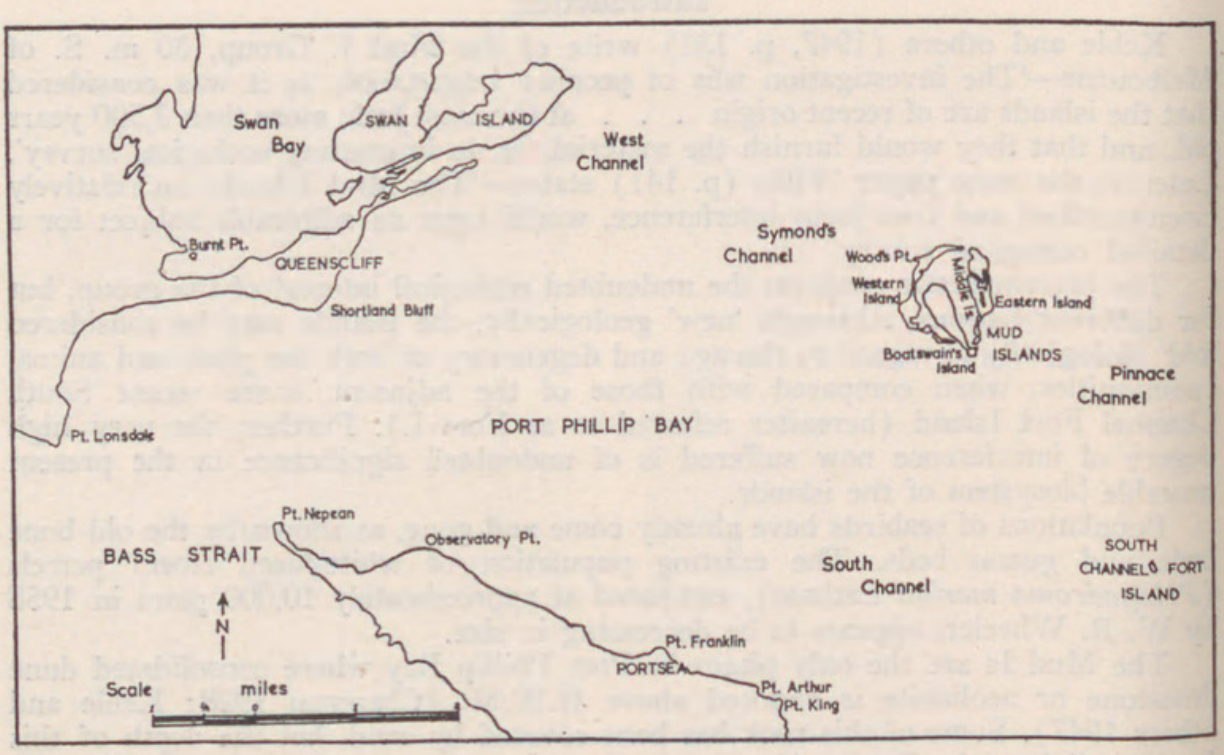

Fig. 1—Sketch map showing positions of the Mud Is and South Channel Fort I. in Port Phillip Bay.

in this paper that this represents a transfer of population. Mud and Fort Is are only 2 statute miles apart (Fig. 1); the nearest known breeding colonies of storm petrels to these two islands are in the Furneaux Group off NE. Tasmania, 250 m. away. The recent discovery of diving-petrels (*Pelecanoides urinatrix*) and short-tailed shearwaters (*Puffinus tenuirostris*) on islands of the Glennie group (Gillham 1960a, b, c) suggests, however, that unrecorded colonies of storm petrels may exist on some of the lesser known islands S. of Wilson's Promontory.

The colonization of a completely new breeding habitat is of particular interest in the case of burrowing birds, these tending to return more habitually to the ancestral site than do many surface-nesters—probably because of the smaller likelihood of their guano, trampling, etc., rendering the rookery untenable (Gillham 1961). There are instances in SE. and NW. Tasmania, however, where short-tailed shearwaters (*Puffinus tenuirostris*) have spread from island rookeries onto adjacent arms of the mainland.

Approximately 4,000 petrels have been banded during the past 4 - 5 years on the Mud Is by members of the Altona Survey Group and it would be of interest to see if any of these could be recovered on Fort I. to indicate if a transfer is still in progress. The first record obtainable is of a well-established colony on Fort I. in 1932 (J. P. Larkin, personal communication). By 1947, when the island was visited by Tarr (1948) who estimated the population as 2,000 birds (suggesting 1,000 burrows), the colony had grown considerably. Colonization may have ceased some years ago and the present population may be substantially home-bred.

Degeneration of Petrel Colonies of the Mud Island Group

Factors Contributing towards Degeneration

1 Marine Erosion

Keble (in Keble and others 1947, p. 133) comments on the changes in surface level occurring in this part of Port Phillip Bay and (p. 135) on the fact that the islands are level and rise only about 5 ft above H.W.M. except at their outer fringes. Petrel burrows are scarce or absent in the mobile sand of the dunes which reach to heights of up to 12 ft—almost all occurring on the low-lying flats. A high proportion lie below the upper drift line and are thus vulnerable to inundation by the sea.

Old stumps of *Leucopogon parviflorus* standing in the water at both ends of the islands show where former scrub communities have been destroyed. At least 3 shrub species observed by Campbell (Mattingley 1907) are thought by Willis (in Keble and others 1947) to have been exterminated by marine erosion. As most of the rookeries occur in areas which are not stabilized by scrub, they are even more subject to soil movement but leave no trace to indicate where they might formerly have existed.

Wheeler (personal communication) points out that eggs or chicks in the entire rookery of 5,000 burrows on Boatswain's I. (half the number of burrows on the whole group) could be destroyed by a spring high tide.

2 Inhibition of Plant Growth on Old Guano Beds

Guano beds were previously exploited on the islands (Ports and Harbours Branch, Public Works Department 1959), and, although they are estimated to have been only 1–2 ft thick (Keble, in Keble and others 1947), their presence indicates a destruction of any protective cover of vegetation which might have

existed in the old rookeries. Destruction would have occurred and the substrate consequently become exposed to erosive forces both at the time of guano deposition and at its subsequent removal.

There is no record of the species of bird responsible for the guano. The burrowing petrels are never responsible for building up such deposits but large numbers of black swans (*Cygnus atrata*) and pelicans (*Pelecanus conspicillatus*) were present when the islands were first sighted in 1802 by John Murray (Lee 1915). The fish-eating pelicans are more likely to be responsible for excreta deserving of the term 'guano' than are the herbivorous swans. The deposits were described by MacIvor (1879) as containing 23·64% of non-nitrogenous organic matter consisting chiefly of vegetable debris, so it is possible that both species contributed. The extensive, partially exposed bone beds of Boatswain's I. are composed virtually entirely of the bones of pelicans, both adults and juveniles being represented.

3 Wind Erosion and Degeneration of Flora following Denudation of the Soil by Rabbits

The flora is rabbit-dominated and so much of the perennial vegetation has been eaten off that large areas of soil are exposed to wind erosion. Burrowing by both rabbits and petrels exposes more ground and increases the amount of soil lost.

Many of the succulent plants such as *Disphyma australe* and *Tetragonia implexicoma* (the dominant species on Fort I.) which would be expected in this maritime habitat are absent and *Spinifex hirsutus*, previously unrecorded, was but a tentative colonist in 1960.

Cakile maritima, Tetragonia expansa and *Carpobrotus rosii* are succulents recorded in 1906 (Mattingley 1907) but not in 1945 (Willis and others 1947) nor by the present investigators in 1960. The first two are palatable, the third is normally avoided but is eaten by quokkas (*Setonix brachyurus*) on Rottnest I., W.A., for its moisture in later summer when little else is available (Storr 1957). The poor water-retention of the porous aeolianite on Mud Is creates a waterless habitat similar to that of the Rottnest aeolianite and may present the rabbits with a similar thirst problem to that experienced by the Rottnest quokkas, so that even the unpalatable *Carpobrotus* has been grazed out.

The succulent *Rhagodia baccata* is rare and nibbled off almost flush with the ground, and much of the area, including all the larger rookeries, is occupied by annuals, predominantly introduced ones. Of these *Cucumis myriocarpus*, one of the most widespread, is poisonous and probably avoided. *Cucumis* was green and thriving during the summer food shortage of January 1960, when more palatable members of the now prevalent rookery flora were dead. Many of the latter are characteristic of heavily rabbited country in Britain (e.g. *Anagallis arvensis, Carduus tenuiflorus, Cerastium glomeratum, Chenopodium murale, Sonchus oleraceus, Urtica urens* and *Vulpia bromoides*).

The increase of alien plants which has accompanied the floristic degradation is indicated by the following figures—

1906—12% aliens (25 sp. recorded) Mattingley (1907).
1945—33% aliens (30 sp. recorded) Willis (in Keble and others 1947).
1960—61% aliens (18 sp. recorded). This investigation rookeries only.

Other aliens observed in 1959 for the first time but not seen in the rookeries are *Ammophila arenaria* and *Glaucium flavum*.

30% of the total recorded flora are aliens and 37·5% annuals.

4 Human Disturbance Resulting in Widespread Collapse of Burrow Roofs

Disturbance by man is thought to have increased since 1945 when Willis (Keble and others 1947) described the islands as being 'so relatively free from interference'.

Trampling by picnickers and fishermen has an important detrimental effect on the rookeries when the petrels are in residence during the summer, and as many as 70 visitors at a time have been counted on the islands (Wheeler 1959). It is impossible to walk through the rookeries without breaking through the fragile burrow roofs and there must be heavy mortality among the eggs and chicks, apart from mechanical damage to the burrows themselves .

Members of the Altona Survey Group have banded approximately 4,000 petrels on the islands during recent years, 30 members having spent 3 days there during January 1957, 1958, 1959 and 1960. The impression was gained in 1960 that far fewer burrows were occupied although no change was noticed in burrow frequency (possibly because a collapsed roof may simulate the entrance to a second burrow). Gradual dwindling of the colony is also indicated by the estimate made in January 1928 by A. G. Campbell that 22,000 burrows, almost all occupied, were present in the 4½ acres of rookery.

Because of the recognized vulnerability of burrows to damage, banding was carried out only in areas of compacted sand or where the aeolianite cropped out on the surface. Damaged burrows were repaired and artificially roofed where necessary, the chick being placed as near as possible to the original position in the newly constructed burrow (Wheeler, personal communication). Desertion and mortality were not estimated, but the British storm petrel (*Hydrobates pelagicus*) is known to desert readily if the nest is disturbed. However, the time of banding, when the chicks are almost ready to leave the burrows, would minimize the importance of this factor.

Degenerate Rookery Flora

1 Burrows among Saltbushes (*Arthrocnemum* and *Atriplex*)

Arthrocnemum arbusculum dominates some of the lowest-lying rookeries where birds nest fairly sparsely (Pl. VIII, fig. A). Most burrows lie below one or more algal drift lines and the moist soil bears a weft of filamentous green algae. The only subordinate species seen were *Rhagodia baccata, Suaeda maritima* and *Samolus repens,* all rare.

Atriplex cinerea is dominant on the looser sand of low dunes and such areas are mostly unburrowed, although a few petrels nest beneath it in places. No subordinate species were recorded.

Rookeries on aeolianite are uncommon in SE. Australia and the vegetation bears a more striking resemblance to that of the aeolianite rookeries of temperate W.A. over 2,000 m. away than to the average Victorian rookery (Gillham 1960a, b, c, 1961). The flora of both is markedly halophytic, due primarily to occasional inundation by sea-water on the Mud Is and to concentration of soil solutes by evaporation during summer droughts in W.A. The porosity of the non-retentive aeolianite would increase the salt concentration in both regions.

Arthrocnemum is represented in W.A. rookeries by *A. arbusculum* and *A. halocnemoides, Atriplex* by *A. isatidea* and *A. paludosa,* which latter also occurs on the Mud Is. Important aliens common to aeolianite rookeries on both sides of the continent are *Vulpia, Urtica, Chenopodium* and *Anagallis.*

2 Extensive Rookeries Dominated by Introduced Annuals

(i) The most extensive rookeries investigated, including that occupying Pipit Flat, possess a degenerate plant community in which 68% of the recorded species are introduced and the remaining 32% represented by few indivdiuals, 68% of the species (again including all but some of the poorly represented ones) are annuals.

Anagallis arvensis is dominant, *Vulpia bromoides* seasonally so earlier in the year in places; *Atriplex hastata* is abundant. The sparse *Rhagodia baccata* is a relict of a former community and grazed to ground level by rabbits.

(ii) The second community type which is extensively burrowed is also floristically degenerate. 3 annuals succeed each other to dominance as the season advances. Tall *Senecio* sp? (*Erechthites* group) appears to be dominant in winter and early spring, being represented by dead stems in January. This is followed by mats of *Anagallis arvensis* which have begun to die off by January when new growths of *Cucumis myriocarpus* are becoming established as the autumn dominant (Pl. VIII, fig. B). The alien *Carduus tenuiflorus* and *Sonchus oleraceus* are the only other species recorded apart from marginal *Samolus repens.*

(iii) In a third type of rookery the annual mats of *Anagallis* and *Cucumis* are mingled with *Samolus.* Although perennial, it is likely that the native *Samolus* is never completely dominant as the 2 aliens appear to have their peak growing seasons at different times of the year.

Species represented in these 3 degenerate rookery floras are tabulated below.

Species (Aliens marked *)	Rookery type			Occurrences
	i	ii	iii	
**Vulpia bromoides*	ld			1
Agrostis avenacea	r			1
**Urtica incisa*	r			1
**Atriplex hastata*	a		r	2
Rhagodia baccata	r			1
**Chenopodium murale*	r			1
Salsola kali			r	1
**Cerastium glomeratum*	r			1
**?Lavatera* sp.	r			1
**Anagallis arvensis*	d	cd	cd	3
Samolus repens	r		cd	2
**Cucumis myriocarpus*	r	cd	cd	3
Senecio sp.?		cd		1
**Carduus tenuiflorus*		o		1
**Sonchus oleraceus*		r		1
Aliens 63%	68%	80%	60%	
Annuals 70%	68%	100%	70%	

d—dominant, ld—locally dominant, cd—co-dominant, a—abundant, o—occasional, r—rare.

Note—The following species observed by the McCoy Society in November 1959 (unpublished), and the authors in January 1960, do not appear in earlier lists for the island (Mattingley 1907, Keble and others 1947).

Spinifex hirsutus (1960)
Agrostis avenacea (1960)
**Ammophila arenaria* (1959)
**Chenopodium* sp.? *album* (1959)
**C. murale* (1960)
**Glaucium flavum* (1959, 60)
**?Lavatera* sp. (1960)
Wilsonia humilis (1959)
Senecio sp.? (1960)

(Aliens marked *)

New Petrel Rookery of South Channel Fort Island

Fort I. was constructed on a sand bank over which the minimum depth of water at low tide was about 3 ft 6 in. Contemporary press accounts (*The Argus* 28 April 1880, *Australian Sketcher* 1880) describe placement of the stone foundations on which work commenced on 4 August 1879. These were completed in February 1880 at a cost of £8,996. 14,000 tons of bluestone were transported from Walsh's Quarries, Laverton, by sailing craft and lighters and placed to form an annulus surrounding the site of the fort proper. Temporary wooden gun emplacements were in use in 1885 (*Australian Sketcher* 1885) and a small casemented stone fort had been built by 1891. This was subsequently replaced by a larger concrete structure with protective earthworks on which a garrison was maintained until 1919. In 1923, Fort I. was taken over by the Ports and Harbours Branch of the Public Works Department to serve as an explosives magazine.

Absence of Disturbing Factors

Of the 4 factors contributing to floristic degeneration on the Mud Is rookeries, none is of importance on Fort I. The man-made island is walled around the periphery with large rocks and none of the soil is subjected to inundation by the tide. No recent large scale disturbance of surface vegetation has occurred and rabbits are absent. There are few signs of interference by man with the storm petrel rookeries on the island.

Colonization by Plants

Fort I. as it appears today is oval in shape, being about 200 yds wide. The earth embankments protecting the gun emplacements reach a height of 23 ft above sea level (Ports and Harbours Branch, Public Works Department 1959). It seems likely that the sand used in construction of the earthworks was dredged from nearby shipping channels and in that case could not have contained viable seeds of land plants. Further, such seeds were probably not transported with the rock used for foundations.

In view of its artificial origin, it is remarkable how little of the island is occupied by alien plants, particularly when the flora is compared with the predominantly alien rookery flora of the Mud Is. The only important aliens present are *Coprosma repens* and *Stenotaphrum secundatum*.

Only 19 species were recorded in January 1960, and these are as follows (aliens marked *). No previous records of the flora have been located.

**Stenotaphrum secundatum*
**Bromus diandrus*
Sporobolus virginicus
Poa australis?
**Lagurus ovatus*
Scirpus nodosus
Lepidosperma gladiatum.
Dianella revoluta
Muehlenbeckia adpressa
Atriplex cinerea
Rhagodia baccata
Carpobrotus rossii
Tetragonia implexicoma
**Fumaria officinalis*
**Melilotus indica*
Leucopogon parviflorus
**Lycium ferocissimum*
**Coprosma repens*
**Sonchus oleraceus*
Moss spp.

Coprosma, Tetragonia implexicoma which dominates the vegetation as a whole, and several other important species have succulent fruits known to be eaten by silver gulls (*Larus novae-hollandiae*). These birds are common in Port Phillip Bay and it seems likely that they are at least partly responsible for the introduction

of the following 5 species—*Coprosma repens, Tetragonia implexicoma, Rhagodia baccata, Leucopogon parviflorus, Lycium ferocissimum*; possibly *Dianella revoluta* may also have been transported in this way.

Arable 'weed' seeds are commonly found in gull pellets mixed with the elytra and cuticular fragments of beetles, etc., and it is conceivable that any of the following might have arrived in this way—*Bromus diandrus, Lagurus ovatus, Fumaria officinalis, Melilotus indica, Sonchus oleraceus.*

Stenotaphrum secundatum is a useful sand binder which forms a close sward on the central mound within the main fortification and is likely to have been introduced by man as a stabilizer. It was not found in the native communities away from this central area and a more random distribution might be expected if it had been introduced by gulls.

The fruits of salt-resistant species such as *Sporobolus virginicus* and *Atriplex cinerea* may have drifted to the island in tidal currents. Such dispersal is assisted in the case of the latter species by the extra buoyancy resulting from spongy swellings on the broad fruit valves.

Any comments on the initial colonization of such an area must remain purely conjectural, but the importance of species known to be transported by gulls is of significance. Mr J. P. Larkin, formerly Marine Surveyor of Victoria, states that the island was fully vegetated at least as early as 1932.

Rookery Flora

Much of the island is burrowed by the storm petrels. 2 main types of rookery vegetation may be distinguished.

1 Predominant Vegetation of Succulent Native Species

Tetragonia implexicoma is an important element throughout and is widely dominant. It forms fairly pure mats a few inches deep with a burrow density of approximately 1 per sq. yd. Ground cover in 2 typical areas (A and B) in rookery with predominantly succulent native vegetation is tabulated below.

Species	Percentage ground cover A	B
Bare sand	20	25
Tetragonia implexicoma	75	65
Atriplex cinerea	5	5
Carpobrotus rossii	–	5
Rhagodia baccata	rare	–
Coprosma repens	rare	–
Sonchus oleraceus	rare	–

A small patch of 6–12 in. high *Rhagodia baccata* has *Tetragonia* trailing through it and gives protection to approximately 1 burrow per 2 sq. yd. A few burrows occur under marginal *Coprosma repens,* an introduced shrub common throughout the island and attaining heights of 6–8 ft. *Coprosma* is the most guano-tolerant shrub of bird islands in N. New Zealand and has risen to local dominance during recent years on some of the Bass Strait bird islands.

Part of the marginal slopes support a 3 – 5 ft high scrub of *Atriplex cinerea* beneath which burrows occur at the rate of approximately 1 per 1 - 2 sq. yd. *Tetragonia* forms an understorey throughout but the canopy is too dense to allow growth of other species apart from an occasional *Lycium ferocissimum* bush up to 5 ft high.

2 Perennial Sward of Alien Grass Providing a Stable Burrowing Medium

Buffalo grass (*Stenotaphrum secundatum*) forms a mat 3-6 in. high with *Tetragonia implexicoma* trailing through and over it and becoming locally dominant in parts. Burrows are somewhat less numerous than in the native communities and there is comparatively little bare sand at the burrow entrances. The floristic composition of 4 such rookery areas (C–F) is set out below, E and F representing intermediate community types between native and alien.

Species	C	D	E	F
Stenotaphrum secundatum	d	d	sub-d	co-d
Tetragonia implexicoma	a	sub-d	d	co-d
Atriplex cinerea	a	-	-	-
Lagurus ovatus	a	o-f	o-f	-
Sonchus oleraceus	r	r	r	-
Lepidosperma gladiatum	-	lf	-	-
Bromus diandrus	-	r	-	-
Dianella revoluta	-	r	-	-
Muehlenbeckia adpressa	-	-	lf	-
Melilotus indica	-	-	-	o
Poa australis?	-	-	-	r
Scirpus nodosus	-	-	-	vr

d—dominant, a—abundant, f—frequent, lf—locally frequent, o—occasional, r—rare, vr—very rare.

Discussion

The storm petrel has a wide range in both E. and W. Australia but breeding colonies are known only from the Mud Is and South Channel Fort I. in Victoria. It would thus seem to merit a certain degree of protection in these localities.

The small area of Fort I. is insufficient to support a large population of birds and it is doubtful if the non-organic sand of which it is composed could be burrowed very much more closely than it is now without the danger of local collapse and erosion of the surface. At present the ground is well vegetated and the rookery in good condition.

An appeal was made in 1947 to have the gun pits covered with wire netting to prevent the 'tremendous mortality' among birds falling into them. This was done, but the wire netting was stolen and the gun pits are still trapping the petrels due to their inability to rise in flight without adequate take-off area.

Human interference should be discouraged both here and on the Mud Is where it is undoubtedly causing serious damage. Enclosure of some of the Mud Is rookeries by rabbit-proof fencing and extermination of the rabbits would give the vegetation a chance to regenerate and stabilize the ground sufficiently to support a greater number of burrows. Even areas subject to inundation by the tide might thus be protected from mechanical damage, although there seems no practicable remedy to combat the possible loss of chicks by drowning.

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Explanation of Plate

PLATE VIII

Fig. A—General view of the Mud Is showing *Atriplex cinerea* on dune crest of Boatswain's I. and *Arthrocnemum arbusculum* on dune slopes and saline flats. January 1960.

Fig. B—Seasonal aspect of annual vegetation in degraded storm petrel rookery on the Mud Is, showing dead stems of a composite (*Senecio* sp.) which is being succeeded by *Anagallis arvensis* and *Cucumis myriocarpus*. Note low mounds of bare sand excavated from burrows. January 1960.