BREEDING HABITATS OF THE WHITE-FACED STORM PETREL (PELAGODROMA MARINA) IN EASTERN BASS STRAIT

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Contents

SUMMARY

The vegetation of eight storm petrel rookeries in the Furneaux Group of Eastern Bass Strait is described in relation to deposition of guano and sea salt. The principal difference between this vegetation and that of the adjacent mutton bird islands is that the dominant *Poa poiformis* forms a dense bluish mat on the petrel islands instead of the more usual yellowish-green tussocks of the mutton bird islands.

Petrel burrows are not necessarily associated with bare soil and many penetrate dense vegetation or are insinuated beneath "false floors" where foliage trampled by Cape Barren geese has become incorporated with soil thrown up by excavating blue penguins.

On three islands Pacific gulls occur with the petrels and their predation and trampling is causing an apparent diminution in the area occupied by petrels. Nowhere are storm petrels associated with short-tailed shearwaters, which burrow on almost all other islands of the group. Cape Barren geese graze in all the petrel rookeries, some of which form transitory nesting sites for silver gulls and crested or caspian terns.

The Furneaux Group petrel vegetation is compared with that of the more severely modified petrel vegetation in the lower latitudes of Victoria and Western Australia.

1. INTRODUCTION

White-faced storm petrels or frigate petrels are locally numerous off the Australian coast, but come ashore only on small, fairly remote islands, so that the type of breding habitat is not generally well known to ornithologists.

During a 2½ year sojourn in Australia visits were made to 17 storm petrel colonies, 8 in the Furneaux Group off N.E. Tasmania, 2 off Victoria and 7 off Western Australia. The present paper places on record the type of terrain utilised in the Tasmanian habitats (latitude 40° S.).

None of the 8 storm petrel islands in the Furneaux Group are more than a few acres in extent and all occur in the relative shelter of Franklin Sound between the 2 major islands of the group, Flinders I. and Cape Barren I.

Their vegetation resembles that of other small islands in the group except for one important feature. This is the life form adopted by the dominant, needle-leaved grass, *Poa poiformis*. The vernacular name of this grass is "Silver Tussock" and on most islands plants do, in fact, form silver tussocks. On all the storm petrel islands, however, but on none of the others visited by the author, they form level swards of soft, bluish-green shoots similar in taxonomic features to the normal form but differing widely in morphological habit.

Mr. J. H. Willis of the National Herbarium, Melbourne, has examined material from a variety of sources and maintains that there are no taxonomic peculiarities. It would be of interest to grow the 2 forms under culture conditions to ascertain whether the storm petrels are as responsible as they seem for inducing what may be termed the "petrel ecotype".

In considerable portions of the Furneaux Group petrel rookeries the *Poa* is replaced by mats of succulent-leaved plants, principally *Tetragonia implexicoma* (New Zealand or bower spinach or green vine) and other members of the Aizoaceae.

Plant lists for the petrel islands will be included in a more comprehensive list for Bass Strait which is in course of preparation by Willis and Gillham.

2. BURROWS

The islands are composed basically of Devonian granite and much humus is incorporated with the derived sands which form the burrowing medium. Where the depth of this is adequate, burrow density is commonly 2-4 per sq. m. and as many as 9 entrances have been seen opening on to an area of this size.

Burrows are short, sometimes as little as 30 cm. long. They may be only 5 cm. diameter at the entrance, broadening into an underground chamber into which short lengths of *Poa* are dragged as nesting material. Larger entrances may be found with several small tunnels leading from them, and it is suspected that these are abandoned blue penguin (*Eudyptula minor*) burrows which have been taken over by petrels. Some of the longer burrows are twisted and a few have more than one entrance.

Where soil is shallow burrows may consist merely of channels roofed by dense carpets of *Tetragonia* or other mat plants. The same type of "burrow" is constructed where soil is adequate but unattainable on account of the overlying vegetation. Association with Cape Barren geese (*Cereopsis novae-hollandiae*) or sheep is helpful in such circumstances, as these animals form tracks through the tall vegetation during the course of their foraging and these tracks allow the petrels access to ground level.

On Apple Orchard Reef off the N. coast of Cape Barren I. an extensive zone of *Stipa teretifolia* (coast barb grass) tussocks 1-1¼ m. high are intersected by goose tracks and the outer leaves of the tussocks are trampled to form uneven platforms. Penguins and a few petrels excavating burrows beside the tracks throw earth onto these platforms and more grass becomes incorporated so that a "false floor" which sags underfoot is formed. Petrels are able to alight on these open strips and burrow beneath them, finding it unnecessary in many instances to penetrate the true ground surface. It is unlikely that the weight of passing geese would inflict damage on the sitting petrel while the stiff *Stipa* leaves retained their springiness.

Furneaux Group petrel burrows, unlike those in the non-organic sandy soils of the Western Australian islands, are not necessarily associated with bare ground, as are those of the short-tailed shearwater (*Puffinus tenuirostris*) on the neighbouring mutton bird islands. The smaller petrels seem more adept at insinuating themselves among plants than are the larger shearwaters and their tunnels may go through more than 15 cm. of "packed" grass shoots before reaching the ground beneath. The birds start excavating in October and keep the burrows open during the plants' principal growing season of spring and early summer. Soil thrown onto the sward in the course of digging is shaken or washed down and the unobstructed grass shoots grow over the entrances and obscure them not long after the burrows are vacated in March.

TABLE 1

Plant species of storm petrel colonies, in order of decreasing abundance

(For explanation of frequency values see text)

Species	Grass Communities	Succulent Communities	All Communities
Poa poiformis	35	23	58
Tetragonia implexicoma	17	35	52
Stipa teretifolia	18	13	31
Rhagodia baccata	4	17	21
Disphyma australe	5	10	15
Apium prostratum	4	10	14
Bulbine semibarbata	4	9	13
Carpobrotus rossii	6	7	13
Lavateria plebeja	1	11	12
Senecio lautus	4	8	12
Muehlenbeckia adpressa	11	—	11
Pelargonium australe	5	—	5
Dichelachne crinita	5	—	5
Sonchus asper	4	1	5
Distichlis distichophylla	—	4	4
Apium (large form)	4	—	4
Aira caryophyllea	3.5	—	3.5
Dichondra repens	3.5	—	3.5
Leucopogon parviflorus	3	—	3
Lolium loliaceum	—	3	3
Senecio glomeratus	3	—	3
Bromus diandrus	—	2	2
Lepidium foliosum	—	2	2
Brachycome diversifolia	2	—	2
Gnaphalium japonicum	2	—	2
G. luteo-album	2	—	2
Scirpus nodosus	1	—	1
Dianella revoluta	1	—	1
Correa alba	1	—	1
Trifolium dubium	1	—	1
Vicia sativa	1	—	1
Olearia phlogopappa	1	—	1
Hypochoeris radicata	1	—	1
Sonchus oleraceus	1	—	1

PLATE 1

PHOTO 1.—Three storm petrel burrows in organic-rich sandy soil on Apple Orchard Reef. The soft-leaved *Poa poiformis* mat, which is characteristic of storm petrel rookeries, is partially overgrown by succulent members of the Aizoaceae (*Tetragonia implexicoma* and *Carpobrotus rossii*).

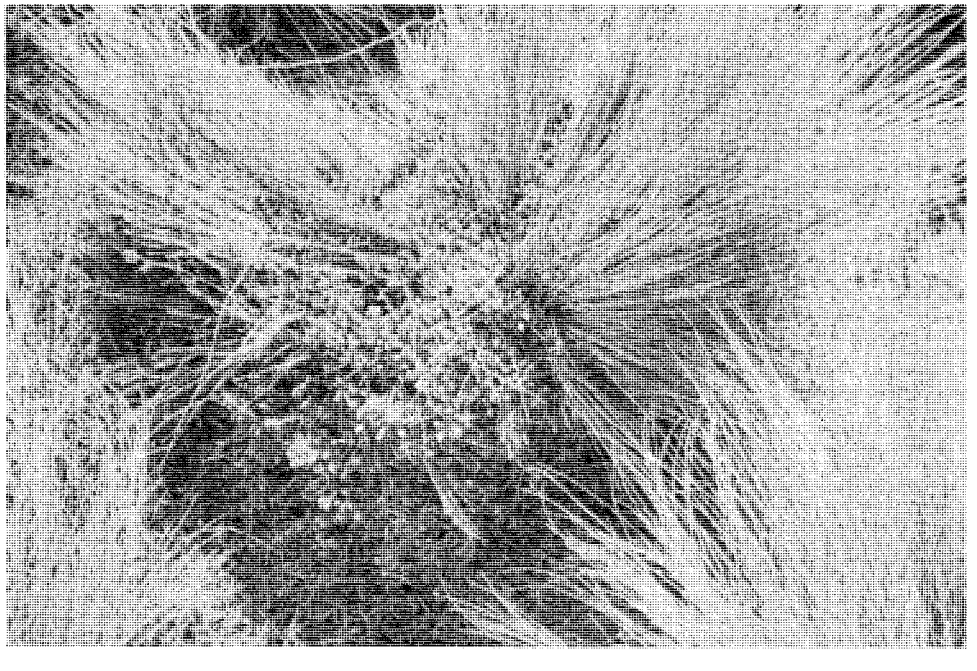


PHOTO 2.—The stiff-leaved tussock form of *Poa poiformis*, which is characteristic of short-tailed shearwater rookeries, overgrown by succulent, Aizoaceous *Disphyma australe*, Fisher Island Mutton bird rookery.

3. PLANT COMMUNITIES OF PETREL ROOKERIES

Rookery vegetation is of two main types, deep *Poa* swards and thinner mats of succulents or of succulents draped around the bases of *Stipa* tussocks. (See plate 1.)

Eight communities of each type have been analysed and results are shown in the accompanying table, where arbitrary values have been given to the plants as follows:—dominant species (5), abundant (4), frequent (3), occasional (2) and rare (1). The sum of these values is depicted for each type of community and for the two types together, plants being listed in order of decreasing abundance.

The 10 commonest species (7 succulents and 3 non-succulents) occur in both types of community. The remaining 24 species (only 2 of which are at all succulent) are more limited in their distribution.

The glaucous-blue mats of *Poa poiformis* are 20-40 cm. deep and a similar type of growth has been observed only in a colony of diving petrels (*Pelecanoides urinatrix*) on Dannevig I. in the Glennies Group of Victoria. There it is less spectacular, however, as the petrels are mixed with short-tailed shearwaters which are commonly associated with the ordinary tussock form of the grass.

Mat plants exhibit a type of vegetative reproduction seen much less commonly in tussock plants. This takes the form of spherical bunches of radiating shoots produced on the creeping stems and resembling the 20 cm. diameter fruiting heads of the sand dune grass, *Spinifex hirsutus*. Like these they become detached, bowl along the ground and put out adventitious roots to form new plants.

Rhagodia baccata (seaberry saltbush) forms low bushes usually not much more than 30 cm. high in these habitats and offers no obstruction to burrowing petrels (which are found only sparsely under larger shrubs). Most of the other succulents are creepers, often occurring in the more maritime habitats in association with *Stipa* tussocks. *Lavatera plebeja* (Austral hollyhock), the only non-succulent among the 10 most abundant species apart from the 2 grasses, is characteristically associated with areas manured by seabirds.

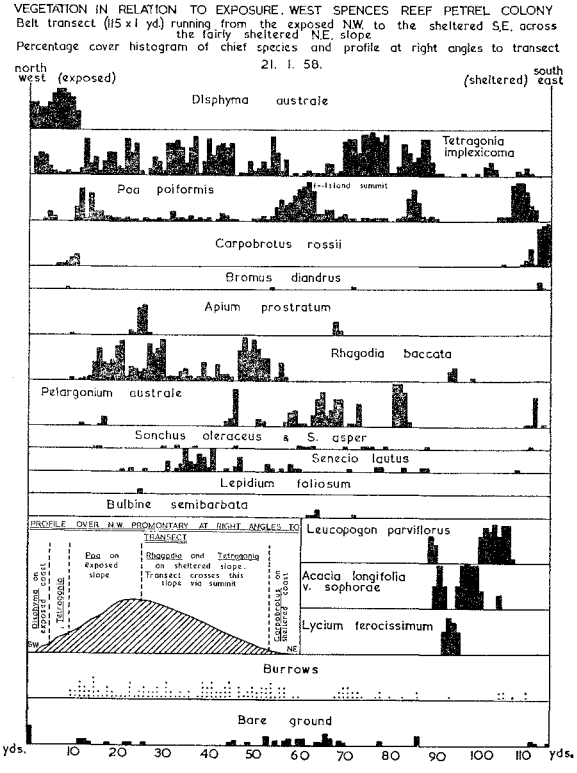
4. PLANT ZONATION IN RELATION TO EXPOSURE

The accompanying figure shows the distribution of the principal plants along a strip passing from W. to E. across the petrel colony of West Spences Reef.

The exposed coast is occupied by *Disphyma australe* (rounded pig-face) the sheltered coast by the less salt-resistant *Carpobrotus rossii* (angular pig-face). The sparsity of petrel burrows among these 2 species (shown at the foot of the diagram) is due to the rocky nature of the substrate. Burrows occur frequently among both where there is sufficient soil.

Tetragonia is dominant more or less throughout the transect with *Rhagodia* co-dominant on windward slopes, although not descending very close to sea level. Throughout this area burrows average 2 per sq. yd., ranging from 0 to 5. The sparsity of burrows in the tussock community which occupies the island summit is again due to rockiness of substrate.

Mixed scrub occurs on sheltered slopes (*Leucopogon praviflorus* (sea currant bush), *Acacia longifolia* v. *sophorae* (coast wattle) and *Lycium ferocissimum* (African boxthorn)). These form a dense thicket about 1½ m. high and few burrows occur beneath them (an average in the transect of 1 per sq. yd.).



5. PETREL ROOKERY VEGETATION ON INDIVIDUAL ISLANDS

Detailed field reports, species lists and sketch maps of the vegetation have been lodged with the C.S.I.R.O. Wildlife Survey Section Laboratories in Canberra, Hobart and Perth and in the C.S.I.R.O. field research hut on Fisher I. in the Furneaux Group.

a. Isaballa Reef

A *Poa poiformis* mat occupies this rookery with tall *Stipa teretifolia* tussocks encroaching from the windward side and woody lignum (*Muehlenbeckia adpressa*) trailing through it on the leeward side. The large oceanic form of sea celery (*Apium prostratum*?) (see Gillham, 1961) occurs along the W. margin, *Carpobrotus rossii* and *Scirpus nodosus* (sand sedge) are scattered through the sward and *Olearia phlogopappa* (coast daisy bush) occurs in sheltered positions. Few burrows penetrate beneath the bushes and the dense mat of grass had grown across the entrances of most of the burrows in the open by 5th April in 1958.

b. Mid Woody Island

The dominant *Poa poiformis* mat has *Correa alba* (white Correa) bushes scattered through it and *Pelargonium australe* (Austral storks-bill) with *Bulbine semibarbata* (leek lily) and *Rhagodia baccata* occupying protruding rocks. A hummocky *Tetragonia implexicoma* community occurs in the N.E. and centre of the island but contains few burrows. The petrels are concentrated mainly in the S.W. where the *Poa* gives way to a narrow coastal strip of *Tetragonia*.

c. Apple Orchard Reef

This small island is so named because it was once covered with 4 ft. high kangaroo apple (*Solanum aviculare*). This was burned off about 35 years ago and it is not known whether storm petrels ever nested in its cover. No communities of this type have been observed to shelter petrels elsewhere.

Petrel burrows now occur over about $\frac{3}{4}$ of the island and were probably previously present on that part of the N.E. now occupied by Pacific gulls (see section 6 below). The densest population, averaging 4 burrows per sq. m. and ranging from 1-9 per sq. m., occurs in a fairly pure *Tetragonia* community of the following composition:— *Tetragonia* 80%, *Poa* 16%, *Bulbine* 2%, *Carpobrotus* 2%. As *Rhagodia* comes into the community and the number of subordinate species increases burrows become fewer, and in fairly pure *Poa* swards they number only about 1 per sq. m. In the coastal community of succulent *Carpobrotus* and *Apium prostratum* (normal small form) on the S. they average 3 per sq. m. (range 1-8). This density is maintained among tall *Stipa teretifolia* tussocks in the W. where *Tetragonia* floors the "lanes" between the tussocks. *Apium* is again abundant here with *Disphyma australe* and *Senecio lautus* (variable groundsel). Where the *Stipa* is fairly pure about 4 petrels per sq. m. occur, many of them beneath the "false floors" of goose-trampled shoots mentioned above.

d. West, East and South Spence's Reefs

The flora of these three islands is a mixture of smooth *Poa* sward and low hummocks of coastal succulents. That of the westernmost island has been discussed in relation to exposure and petrels burrow more or less throughout apart from the rocky island summit and the scrub patch of the east.

Burrows are less abundant on the eastern reef but extend beneath the windward margin of the *Leucopogon parviflorus* scrub. *Tetragonia implexicoma* is stimulated and straggles up through the marginal branches (see plate 2, photograph 1) and a number of annuals find living room on the bare, manured soil beneath the shrubs where colonisation by most light-loving perennials is inhibited by shading. European aliens which occur are *Aira caryophyllea* (silver hair grass), *Trifolium dubium* (yellow suckling clover), *Vicia sativa* (vetch) and *Hypochoeris radicata* (cat's ear).

On the southern reef petrels burrow more or less throughout the *Poa* sward and beneath *Stipa* tussocks.

e. Penguin Island

This island consists of two portions separated by a low neck which is occupied by salt marsh. The southern half, like Isaballa Reef, is covered by a dense *Poa poiformis* mat containing *Stipa teretifolia* on the windward side and *Muehlenbeckia adpressa* on the leeward side. *Tetragonia implexcoma* is widespread but depauperate, and very little else is able to compete in the dense growth. Petrels burrow at the rate of about 1 pair per 2 sq. m.

The S.W. part of the obliquely orienated northern portion of the island resembles the southern portion except that part of the western *Stipa* is replaced by *Carpobrotus rossii* and *Disphyma australe*. Petrels are more numerous, burrowing at the rate of about 1 pair per sq. m. In the N.E. this community passes through a transition zone of *Tetragonia* into a *Lepidosperma gladiatum* (sword sedge) community in which petrel burrows are sparse.

f. Rabbit Island.

The *Poa poiformis* mat which occupies most of the island is burrowed almost throughout by petrels where soil is sufficiently deep but burrow density varies widely. The 2 grasses *Dichelachne crinita* and *Aira caryophyllea* and the creeping herb, *Dichondra repens*, are locally frequent with the succulents mentioned above. In the S.W. petrels burrow in *Stipa teretifolia* tussocks thickly draped with *Disphyma australe*. Salt marsh grass (*Distichlis distichophylla*) and *Tetragonia implexicoma* are abundant here. Elsewhere birds burrow in mixed *Poa/Tetragonia* swards.

6. ASSOCIATION WITH PACIFIC GULLS

Colonies of Pacific gulls (*Larus pacificus*) have been located in large numbers on only 2 of the 33 islands visited in the Furneaux Group and both of these are storm petrel islands. In both localities gulls have established themselves on areas formerly occupied by petrels, possibly finding the fairly smooth swards of *Poa poiformis* more suitable as roosting sites than the taller tussocks which characterise the mutton bird islands. Their nests, however, are found principally among the adjacent *Stipa teretifolia* tussocks which afford more adequate cover for eggs and young chicks.

PLATE 2

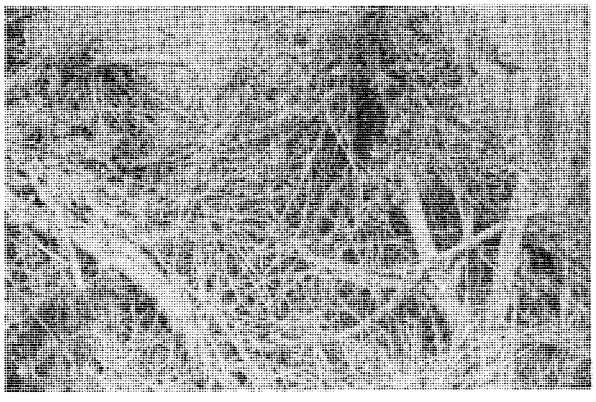


PHOTO 1.—Representatives of the 3 main stages of the degenerative plant succession seen in colonies of burrowing birds—viz: shrubs—tussock grasses—creeping succulents. As bushes of *Acacia longifolia* v. *sophorae* die out the increased light intensity permits growth of *Poa poiformis* and *Helichrysum bracteatum* (left front). Both these and the dead *Acacia* become overrun by succulent *Tetragonia implexicoma*, which, in its turn, degenerates to leave bare soil.

Petrel burrows have disappeared from all the margins of the gull colonies, and it is likely that the nightly landfall might have proved too hazardous a procedure for their survival here. It is also probable that local extermination of the petrels has been hastened by trampling of the burrows as well as predation.

Storm petrels appear to form an important article of food for this species of gull on islands other than the 2 named above. On South Spence's Reef an isolated Pacific gull's nest was located among *Poa, Disphyma* and *Carduus tenuiflorus* (slender thistle). Many of the petrel burrows in the vicinity had been scratched out and the nesting material of dead grass was scattered outside the damaged entrances, together with down and feathers from the victim.

Among the more usual residue of crab claws, mollusc shells, caterpillar skins, &c., around the gull's nest were 10 storm petrel carcases and the legs of many more. There were also the broken shells of about 20 petrel eggs which had apparently been pulled out of the burrows just as the northern greater black-backed gull (*Larus marinus*) removes the progeny of the manx shearwater (*Puffinus puffinus*) from their burrows. More petrel remains were found at three other feeding rocks in the vicinity.

PHOTO 2.—Association of storm petrels and Pacific gulls on Apple Orchard Reef looking N.W. to Strzlecki Peaks on Flinders Island. The white guano crust of the gull roosts is penetrated by succulent, flowering *Bulbine semibarabata*. Storm petrel burrows occur among the *Poa Poiformis* sward (back left) and the *Tetragonia implexicoma* mounds in the foreground, but not in the most gull-fouled zones.

In the two large roosting areas the *Poa* mat becomes trampled and partially coated with a broken crust of dry guano about 2 cm. thick. This forms a "false floor" as in the goose-trampled lanes mentioned above, the guano crust being separated from the peaty soil by a layer of flattened *Poa* leaves 10-12 cm. deep. A scum of green and blue-green algae develops on the guano surface after the gulls vacate the area.

The dead *Poa* gradually disintegrates to give extensive bare patches which are ultimately colonised by succulent plants more guano-resistant than the original *Poa*. The first of these colonists, and one which also penetrates the fouled *Poa* mats, is a russet-leaved form of *Bulbine semibarbata* (leek lily), the species which forms the advancing margin of vegetation encroachng onto vacated parts of the gannet (*Sula serrator*) colony on Cat I. in the E. Furneaux Group.

Plate 2, photo 2, shows a part of the Apple Orchard Reef gull colony with petrel burrows penetrating the *Tetragonia implexicoma* mounds in the foreground. The white area consists of a "false floor" of guano, the tufted plants protruding from it are *Bulbine*, flowering more profusely at the margins than in the centre of the fouled zone. Part of the petrel burrowed *Poa* mat is seen behind.

The composition of this gull roost flora as a whole is as follows:—Guano crust 40%, *Poa poiformis* 45%, *Tetragonia implexicoma* 10%, *Bulbine semibarbata* 5%, *Senecio lautus* v.r.

Two similar areas occur on the northern slopes of Rabbit I., the principal coprophilous species increasing where the *Poa* has succumbed being *Bulbine* and *Lavatera plebeja*. Others are *Rhagodia baccata, Carpobrotus rossii, Tetragonia implexicoma, Pelargonium australe, Senecio lautus* and *Sonchus asper*.

7. ASSOCIATION WITH OTHER BIRDS

Short-tailed shearwaters were not found to be breeding on any of the 8 storm petrel islands. This is of particular interest in that they are present on almost all other islands of the group where conditions are suitable for burrowing. The obvious interpretation of this situation is that two species occupying the same ecological niche are unable to live side by side in the same area, but this explanation does not apply in other instances.

Fairy penguins, which burrow in similar soil and vegetation, are present on all the petrel islands discussed; short-tailed shearwaters burrow among diving petrels on the Glennie Group in Victoria and white-faced storm petrels burrow among little shearwaters (*Puffinus assimilis*) and wedge-tailed shearwaters (*P. pacificus*) on islands of S.W. Australia.

All other common birds of the Furneaux Group are to be found on the petrel islands. Most generally present are Cape Barren geese which, if the quantity of their dung can be said to be any reliable indication, spend more of their time grazing on the softer-leaved mats of the petrel colonies than among the coarser tussocks of the mutton bird colonies. Goose nests were found on some of the islands and 15 young geese have been seen on Rabbit I.

Flocks of silver gulls (*Larus novae-hollandiae*) and crested terns (*Sterna bergii*) change their nesting sites from year to year but favour the smaller islands of 1 to several acres, which are those occupied by storm petrels. In December 1958 42 nests of silver gulls were counted on East Spence's Reef and 6 on Penguin I.

Isolated nests of Caspian terns (*Hydroprogne caspia*) have been recorded on Isabella Reef, Spence's Reefs and Penguin I.

8. RELATIONSHIP TO STORM PETREL ROOKERIES IN OTHER STATES

The smaller Bass Strait islands are not subjected to periodic burning, so the petrels burrow in a substrate which possesses a reasonable amount of incorporated organic matter. Other colonies visited by the author are on open sands less retentive of humus, water and plant nutrients and offering a less hospitable plant substrate.

Organic matter has had insufficient time to accumulate to any extent on the man-made island of South Channel Fort in Port Phillip Bay, Victoria (lat. 38° S.). The vegetation of the storm petrel colony here resembles that of the final stage of the "petrel succession" seen in the Furneaux Group, with the perennial succulent creeper, *Tetragonia implexicoma*, the dominant species and the saltbush, *Atriplex cinerea* (barilla) becoming locally dominant.

In the hot dry summers of Western Australia organic matter disintegrates more rapidly than in the cooler moister conditions of the Furneaux Group and the sands which form the burrowing substrate in the storm petrel colonies are not far removed from unmodified dune sands. Evaporation rates in summer are high and the porous aeolianite or consolidated dune sand beneath them retains little water so that guano is not diluted. The resulting flora is a mixture of succulent Aizoaceous herbs and salt bushes, principally *Carpobrotus rossii and Atriplex paludosa*.

In the most southerly colony visited in Western Australia (St. Alouarn I. off Cape Leeuwin, lat. 36° S.) a certain amount of *Poa* tussock persists; in the most northerly (West Wallabi I. in the Northern Abrolhos Group, lat. 28° S.) both this and the Aizoaceous herbs are scarce and the saltbush has yielded pride of place to the even more halophytic *Arthrocnemum* spp. (shrubby samphires) (Gillham, 1961b).

Storm petrels burrow beneath *Arthrocnemum arbuscula* and *Atriplex cinerea* on Mud I., Victoria (lat. 38° S.). Summers here are cooler and moister than in Western Australia but the underlying rock is still aeolianite and the high concentration of the soil solution is maintained by occasional inundation with sea water.

In drier parts of the petrel-burrowed flats on this island practically all perennial vegetation and many of the petrel burrows have been destroyed by erosion resulting from overgrazing by rabbits and disturbance by man. A seasonal growth of *Anagallis arvensis* (scarlet pimpernel) and *Cucumis myriocarpus* (gooseberry cucumber) occupies these rookeries (Gillham & Thomson, 1961).

The Furneaux Group rookeries may thus be regarded as occupying the 3 initial stages in the vegetation series set out diagrammatically in table 2. The vegetation of these initial stages is less seriously modified by the presence of petrels than are the later stages seen in the Victorian and Western Australian petrel colonies, where the effects of guano deposition are intensified by climatic and edaphic factors.

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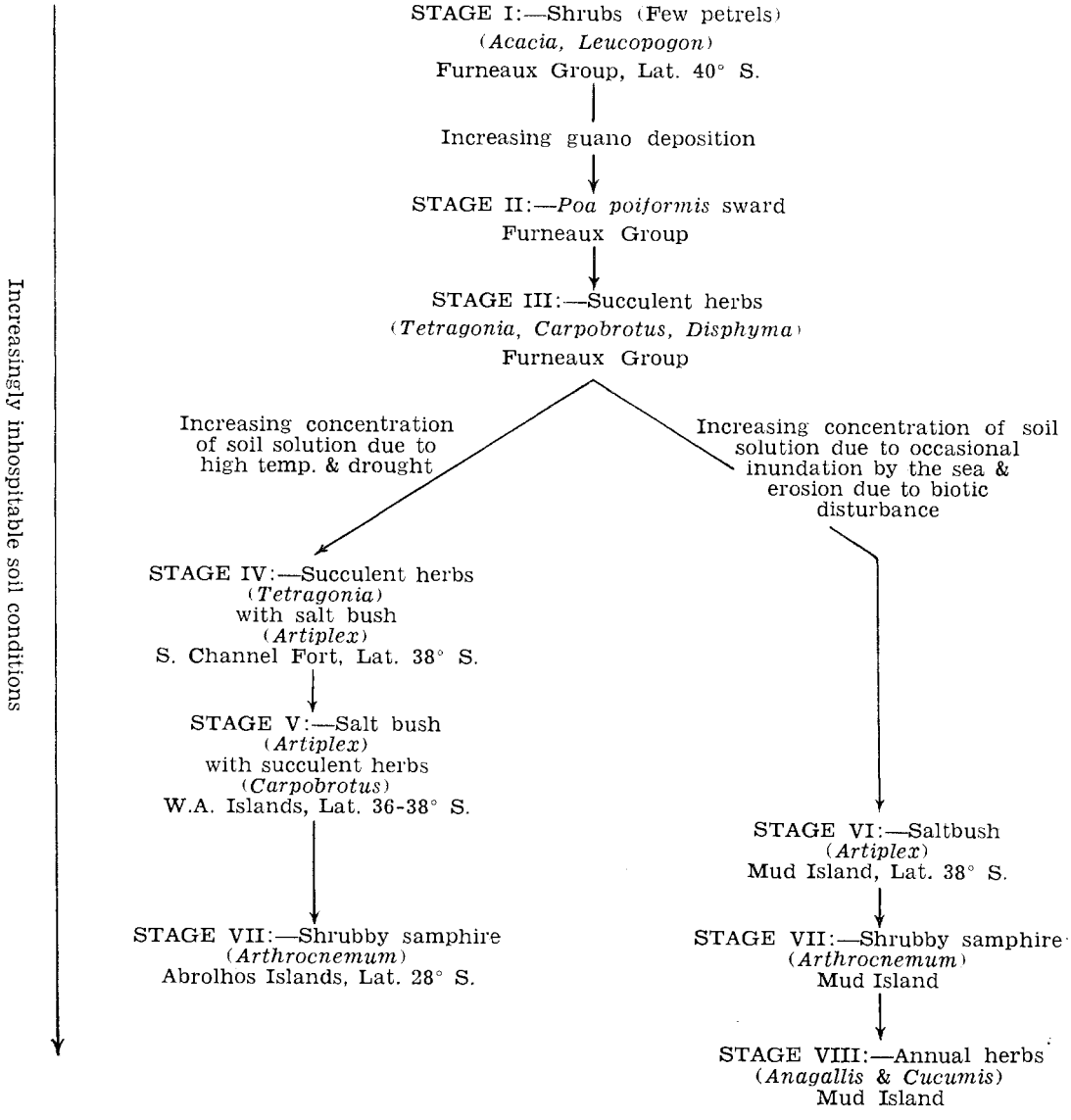
TABLE 2

Plant succession of storm petrel colonies showing effect of increasingly inhospitable soil conditions



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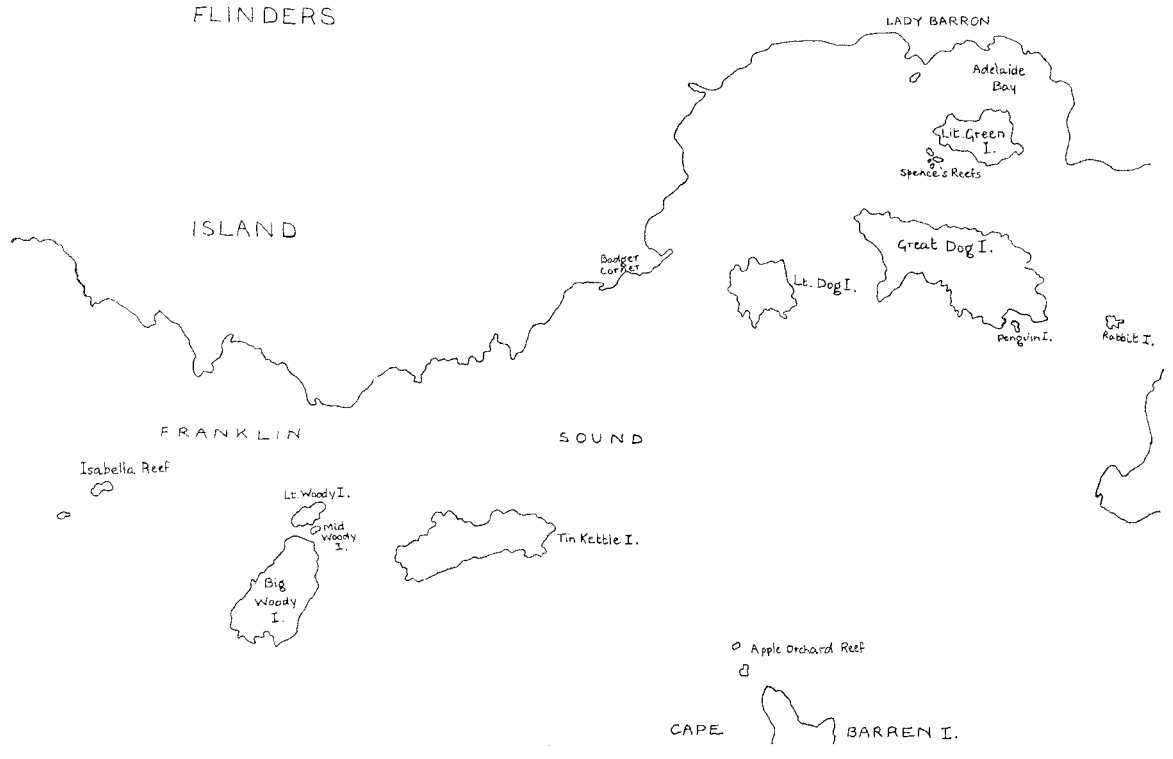

Localities of storm petrel nesting stations in Franklin Sound, Flinders Island.