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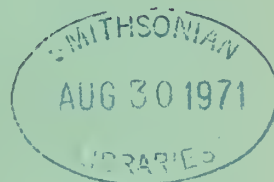
ATOLL RESEARCH BULLETIN

149. Geography and Ecology of Diego Garcia Atoll, Chagos Archipelago

Edited by D. R. Stoddart and J. D. Taylor



Issued by
THE SMITHSONIAN INSTITUTION
Washington, D.C., U.S.A.



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No. 149

**GEOGRAPHY AND ECOLOGY OF DIEGO GARCIA
ATOLL, CHAGOS ARCHIPELAGO**

Edited by

D. R. Stoddart and J. D. Taylor

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THE SMITHSONIAN INSTITUTION

Washington, D.C., U.S.A.

August 27, 1971

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"I make it my province to dwell in this preliminary discourse on those objects only, which most excited my attention. Among the number of these I reckon, for instance, the harbour of Diego Garcia, and the prospect of the island itself is pleasant. We judged to have twelve leagues in circumference. Its form resembles a horse shoe. Its greatest breadth is not above a quarter of a league; the ground is however sufficiently elevated to serve as a fence and shelter to a vast reservoir of sand, which affords spacious room to the most numerous fleets. This level is four leagues long, and its main breadth is about one league. Its excellent harbour has two entrances to the north. The roads are extremely fine. Its situation I ascertain it to be in the 7 deg. 14 min. South Latitude, and in the 68 degree east longitude from the meridian of Paris."

ABBÉ ROCHON (1793, 48-49)

"This Island is one of the wonderful phaenomena of this globe."

JAMES HORSBURGH (1809, 131)

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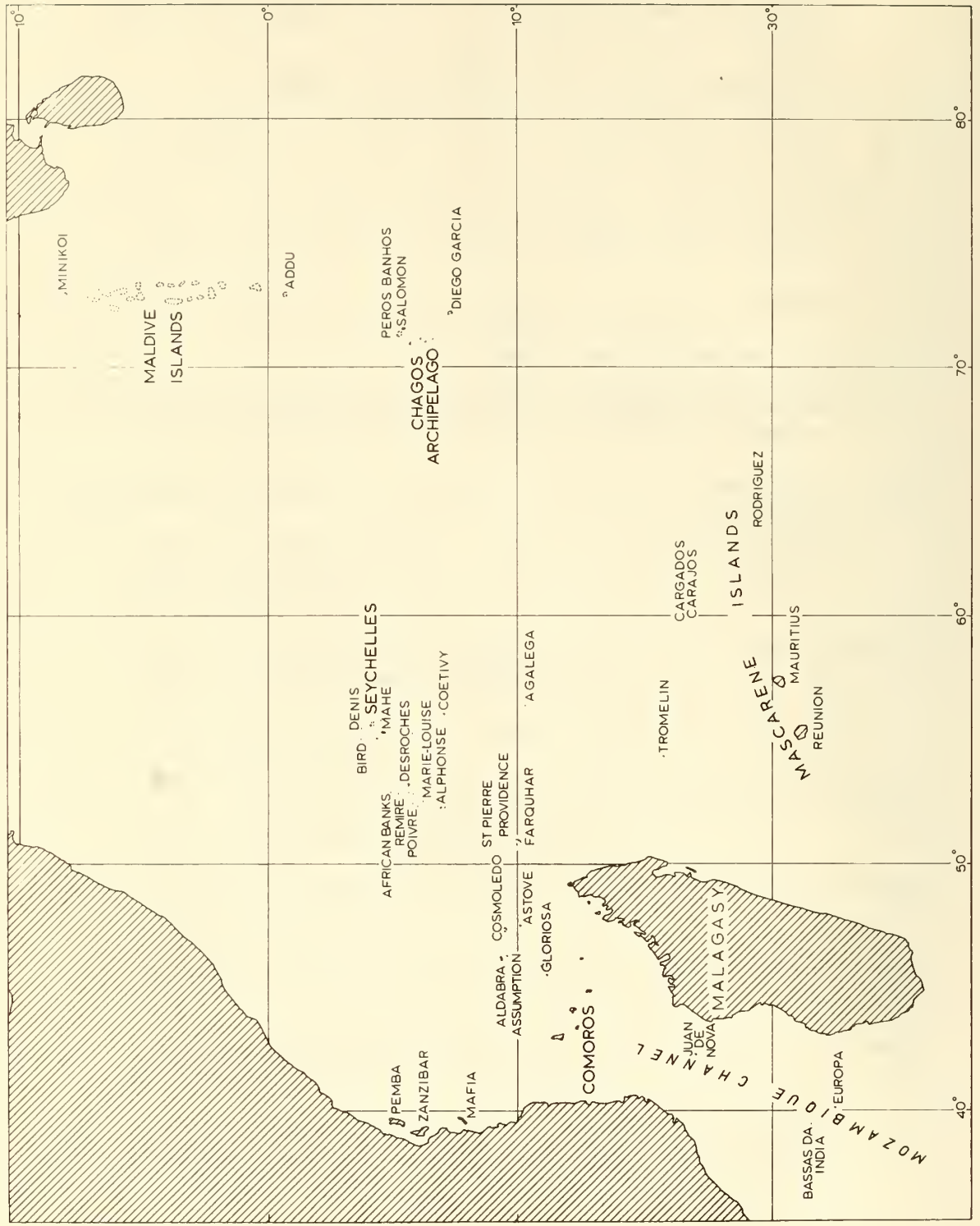


Fig. 1. The western Indian Ocean, showing the location of Diego Garcia.

1. SCIENTIFIC STUDIES AT DIEGO GARCIA ATOLL

D. R. Stoddart

Introduction

The islands of the Chagos Archipelago (Fig. 1) are of interest for several reasons. First, they are the wettest coral islands in the Indian Ocean, with mean annual rainfalls of up to more than 3700 mm: one would thus expect marked ecological differences between these islands and the much drier ones in the western Indian Ocean. Second, the Chagos islands are situated in the centre of the Indian Ocean and form the termini of sequences of islands (the Maldives and Laccadives in linear array to the north, and the more scattered array of islands in the western Indian Ocean) which display marked differences in distance from continental land, in area, climate, and habitat diversity. Any analysis of Indian Ocean island biotas must thus take into account the status of the islands of the Chagos Archipelago. And finally, in common with areas on the Mid-Ocean Ridge, the present dry-land areas of the Chagos represent only a minute proportion of the total land area exposed during the last Pleistocene low stand of the sea. It is probable that 17,000 years ago Great Chagos Bank had a dry land area of 13,500 sq km, with other large land areas in Speaker's Bank and Pill Bank and smaller ones in the present atolls of Peros Banhos, Salomon and Diego Garcia. The flora and fauna present on such areas would be potentially much larger than on the present islands, and it would be at least theoretically possible that some elements of this larger biota survived during the Holocene transgression of the sea. In the event, no such survivals have been found, at least on Diego Garcia: all the plants and animals, other than deliberate introductions, have probably reached the Chagos by trans-oceanic dispersal in Holocene times.

The opportunity to visit Diego Garcia Atoll during a hydrographic survey by H.M.S. Vidal in 1967 was therefore a most welcome one. In recent years there has been renewed interest in Indian Ocean coral islands, taking up many of the problems explored by J. Stanley Gardiner and R. B. Seymour Sewell 30-70 years ago. These recent studies have concerned both reef and shoreline ecology (Stoddart and Yonge, eds., 1971)* and the terrestrial ecology of islands, in the Maldives (Stoddart,

* References cited in Chapters 1, 2, 3, 11, 14 and 18 are grouped in Chapter 19 of this report; in other chapters the references are grouped at the end of the chapter.

ed., 1966), at Aldabra (Stoddart, ed., 1967), and at other western Indian Ocean islands (Stoddart, ed., 1970). A general picture of variation in Indian Ocean coral islands, and of the factors contributing to it, is now emerging (Stoddart 1969, Peake 1971), based partly on the recent studies but also to a considerable extent on the records contained in a voluminous literature resulting from earlier expeditionary work. The present study of Diego Garcia Atoll adds to this body of knowledge: with the exception of a short visit by the Yale Seychelles Expedition to Peros Banhos Atoll in 1957 (Kohn 1964) it represents the first modern study of any of the Chagos group of atolls.

Previous Work

There have been three main scientific investigations on Diego Garcia in the past: by G. C. Bourne from September 1885 to January 1886; by the Deutsche Tiefsee-Expedition in the Valdivia, in February 1899; and by the Percy Sladen Trust Expedition, with J. Stanley Gardiner, C. Forster Cooper and T. Bainbrigge Fletcher, from 7 to 13 July 1905. Collections were also made by J. Morin in July 1937, and an excellent but unpublished general account was written by P. O. Wiehe following a visit in May-June 1939. Wiehe made further small collections in September 1961. Each of these, except for G. C. Bourne and the Valdivia Expedition, also visited Peros Banhos, Egmont and Salomon Atolls.

Table 1 briefly lists the main scientific visitors to Diego Garcia since 1884, with their fields of interest and the general publications resulting from their work. The earlier history of the atoll, including hydrographic surveys made before 1884, is outlined in Chapter 18 of this volume, and more extensive references to the earlier scientific work are given in several later chapters but particularly in Chapter 14. A full bibliography of the atoll is given in Chapter 19.

Early general accounts of Diego Garcia are those by Moresby (1844, Anon. 1845), Pridham (1846) and Finsch (1887). G. C. Bourne, after four months' fieldwork, published a general paper (1886a) and papers on the geomorphology (1888a, 1888b); his plants were worked up by Hemsley (1887) and his birds by Saunders (1886). Chun (1903) published a long general account of the atoll, with the first published photographs, after the Valdivia Expedition, and references to collections made there are scattered through the *Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition*: on birds (Reichenow 1900, Vanhoffen 1901), marine algae (Reinbold 1904), echinoderms (Döderlein 1906, Hertz 1927, Heding 1940), Crustacea (Balss 1912, Doflein 1904, Doflein and Balss 1913), Mollusca (von Martens 1904, Thiele and Jaeckel 1931), and Phytoplankton (Karsten 1907). The most substantial accounts are, however, those resulting from the week's visit of H.M.S. Sealark with the Percy Sladen Trust Expedition in July 1905. During this time Gardiner with Fletcher worked mainly on the land and Cooper in the lagoon. General descriptions were published by Gardiner and Cooper (1907) and by Gardiner

Table 1. Scientific studies at Diego Garcia

<u>Date</u>	<u>Investigator</u>	<u>Field of study</u>	<u>References</u>
1883	A. Hume, H.M.S. <u>Moorhen</u>	Plants	Hemsley 1884
1884 July 9	O. Finsch	Birds	Finsch 1887; Finsch and Blasius 1887
1885	Cdr F.C.P. Vereker H.M.S. <u>Rambler</u>	Hydrographic survey	Admiralty chart 920
1885 Sept. 15- 1886 Jan.	G. C. Bourne	General, geology, birds, plants	Bourne 1886a, 1886b, 1888a, 1888b
1889	R. F. M. Wilson	Lichens	Wilson 1889
1899 Feb.	Deutsche Tiefsee- Expedition, <u>Valdivia</u>	General, marine fauna, birds	Chun 1903
1905 July 7- 13	Percy Sladen Trust Expedition, H.M.S. <u>Sealark</u>	Geomorphology, marine fauna, terrestrial fauna and flora	Gardiner 1903, 1905, 1906, 1936; Gardiner and Cooper 1907
1936	J. Morin	Mollusca, Crustacea	Madge 1946; Viader 1937; Ward 1942
1937 July	J. Morin	Plants	
1938	J. Closel	Mollusca	
1939 May- June	P. O. Wiehe	General, plants, insects	Wiehe 1939
1941-2	H.M.I.S. <u>Clive</u> , Cdrs J. W. Jefford and R. R. Caws	Hydrographic survey	Admiralty chart 920
1948	Mauritius-Seychelles Fisheries Survey: J.F.G. Wheeler and F. D. Ommanney	Fish	Ommanney 1952
1960 Nov.- Dec.	P. Loustau-Lalanne	Birds	Loustau-Lalanne 1962
1961	P. O. Wiehe	Plants	
1961	<u>Vitiaz</u>	Beach fauna	Bezrunov 1963
1964 July- Aug.	Lt P.G. Odling-Smee	Birds	Bourne 1966
1967	<u>Vitiaz</u>	Geomorphology	Dolotov 1968; Leont'yev 1969
1967 June- July	H.M.S. <u>Vidal</u> , Capt. C.R.K. Roe	Hydrographic survey	
1967 June- July	H.A. Fehlmann, C. F. Rhyne, D.R. Stoddart, J.D. Taylor	Geography and eco- logy, marine and terrestrial	This volume; Ripley 1969; Benson 1970

(1936, 416-420, also 1931). Table 2 lists papers resulting from the Percy Sladen Trust Expedition dealing with marine fauna and flora; Table 8 in Chapter 14 lists the many papers dealing with insects. Willis and Gardiner (1931) list the land flora. Most of the Percy Sladen collections are in the British Museum (Natural History), except for the plants, which are at the Royal Botanic Gardens, Kew.

After the Percy Sladen Trust Expedition, no further collections appear to have been made until J. Morin's visit. Morin was a museum assistant in Mauritius and his zoological collections are in the Mauritius Institute, Port Louis. Crustacea collected by him at Diego Garcia, Peros Banhos and Salomon in 1936 were described by Ward (1942), his land Mollusca by Madge (1946), and his marine Mollusca by Viader (1937) (but without localities). The Mauritius Herbarium at Réduit also contains a number of sheets of plants from Diego Garcia, dated June-August 1937: it is not known whether Morin made two visits to the archipelago, or whether some mislabelling has occurred. Further marine mollusca in the Mauritius Institute from Diego Garcia were collected by J. Closel in 1938. Wiehe's visit in 1939 resulted in a large collection of plants, now in the Mauritius Herbarium (Wiehe 1939), not only from Diego Garcia but also from Salomon and Peros Banhos, together with some insects (Mamet 1941, 1943). More plants in the Herbarium were collected on these three atolls and also on Egmont in 1961, again by Wiehe.

Subsequent visits have resulted mainly in sight records, particularly of birds, and Loustau-Lalanne (1962) has contributed a general account of the birds of the Chagos Archipelago following a visit in 1960. For other recent visits, see Table 1.

Present Investigation

The present investigation was carried out during June and July 1967 by four scientists attached to a British Ministry of Defence hydrographic survey carried out by H.M.S. Vidal. These were Dr. H. A. Fehlmann, Smithsonian Oceanographic Sorting Center, and Mr. C. F. Rhyne, Smithsonian Institution and now, the University of North Carolina, both nominated by the Smithsonian Institution; and Dr D. R. Stoddart, Cambridge University, and Dr J. D. Taylor, British Museum (Natural History), both nominated by The Royal Society. Stoddart and Taylor were on Diego Garcia from 1-29 July, Rhyne and Fehlmann from 10 June to 29 July. The purpose of the scientific party was to make a survey of the present status of the geography and ecology of the atoll and if necessary to make conservation recommendations.

Responsibilities were divided as follows. Fehlmann made large collections of fish, which are being distributed by the Smithsonian Oceanographic Sorting Center; he also made smaller collections of other marine groups; of birds, particularly the Little Green Heron (Ripley

Table 2. Studies of marine biota by the Percy Sladen Trust Expedition

MARINE ALGAE

Foslie 1907
Gepp and Gepp 1909
Weber-van Bosse 1913, 1914

PORIFERA

Dendy 1913, 1916, 1922

COELENTERATA

Browne, 1916, 1926
Cooper 1909
Gardiner 1909
Hickson and England 1909
Horst 1922, 1926
Jarvis 1922
Matthai 1914, 1928
Thomson and Mackinnon 1910

BRYOZOA

Thornely 1912

ANNELIDA

Potts 1910

ECHINODERMATA

Bell 1909

ARTHROPODA

Borradaile 1907b, 1910, 1917
Coutière 1921
Laurie 1926
Rathbun 1911

MOLLUSCA

Eliot 1910
Melvill 1909

VERTEBRATA

Regan 1908

1969) and the Turtledove (Benson 1970); of reptiles; and of insects. Rhyne specialised on marine algae, and also collected land plants. Stoddart studied geomorphology and sedimentology, including lagoon floor sediments, and also collected land plants. Taylor concentrated on intertidal ecology and on the lagoon reefs, collecting corals, Mollusca and Crustacea; he also made some terrestrial collections, notably of land Mollusca and of earthworms. Most of these collections are reported in this volume. The main group very inadequately represented in the 1967 collections was the insects, and it is hoped that some work can be done on these in the near future.

Acknowledgements

We thank particularly the Hydrographer, Ministry of Defence (Navy) and Captain C. R. K. Roe, D.S.C., R.N., and the officers and men of H.M.S. Vidal for making this investigation possible. We are grateful to Lt Cdr D.P.D. Scott, R.N., for his help with practical details. We also thank the leader of the United States survey party, Lt. G. Robinson, and the Manager of the Atoll for their aid with transport and accommodation. The participation of Stoddart and Taylor was made possible by the Royal Society, London, and the Ministry of Defence, and that of Fehlmann and Rhyne by the Smithsonian Institution, Washington, and the Department of Defense. The Ministry of Defence also kindly made available to us the chart of Diego Garcia made in 1967 and tidal information collected by H.M.S. Vidal, and loaned us aerial photographs of the atoll flown in 1967. We are also grateful to all those who have worked on collections made during this expedition, and who have contributed to this volume, and to Mr. E. G. Davey, Meteorological Department, Mauritius, for climatic information. Most of the illustrations have been drawn by Mr. M. Young, Mr. M. Ampleford, and Mr. C. Lewis of the Department of Geography, Cambridge, and the photographic work is by Mr. R. Coe of that Department. We thank Mr. R. Balmforth for xerox work in connection with this project.

Stoddart also thanks the Southern Zone Research Committee of the Royal Society for the opportunity to visit Mauritius in July 1969, to see collections in the Mauritius Institute, Port Louis, and the Mauritius Herbarium, Reduit; he thanks Dr. R. E. Vaughan and many others for their great assistance during that visit.

Finally, we are grateful to the then Commissioner of the British Indian Ocean Territory, Sir Hugh Norman-Walker, and to the Administrator, Mr. J. Todd, for their interest in this work and for their hospitality in the Seychelles.

2. GEOMORPHOLOGY OF DIEGO GARCIA ATOLL

D. R. Stoddart

Diego Garcia Atoll (Fig. 2), Chagos Archipelago, has a total area of 170 sq km, of which the lagoon occupies 124 sq km and the peripheral reef (including the land rim) 47 sq km. Diego Garcia has one of the most continuous land rims of all coral atolls, and the land itself covers 30 sq km, or rather more than one-sixth of the total atoll area.

A. Structure and regional relationships

The atoll (Fig. 3) lies 55 km south of the Great Chagos Bank, a largely submerged platform of drowned atoll form, approximately 13,500 sq km in area, with maximum depths of 70-80 m and a broad rim at 7-17 m. The Bank is separated from the Maldives and Laccadives plateaux by a channel 500 km wide and 2200-3300 m deep. Both the Great Chagos Bank and the Maldives-Laccadives plateau are outlined bathymetrically by the 2000 m isobath, and together they form a major topographic lineament extending in a north-south direction across the Indian Ocean for 3000 km. The Chagos Bank lies adjacent to the Mid-Ocean Ridge close to its ENE-WSW intersection by the Vema Trench. The Mid-Ocean Ridge is a complex structure in this area, and is adjoined to the west by the Mascarene Plateau, the part granitic, part basaltic coral-capped arc extending from the Seychelles to the Mascarenes (Fisher, Johnson and Heezen 1967, 1261). Unlike the Maldivian-Chagos plateaux, the Mascarene Plateau is apparently interrupted by ENE-WSW displacements.

In contrast to the extensive geophysical work in the northwest Indian Ocean, the structure of the Maldives and Chagos has been relatively neglected, and little is known in detail of the relationship between these features, the Indian sub-continent and the Mid-Ocean Ridge. Geophysical work on the Seychelles Bank and Cargados Carajos indicates a granitic basement covered with coral limestone (Matthews and Davies 1966), and on Saya de Malha a basaltic basement, also covered with coral (Shor and Pollard 1963); the inferred thicknesses of the coral in these cases range from 0.5 to 1.5 km. Seismic refraction profiles in the Maldives indicate a volcanic layer 4-5 km thick, capped with coral (Francis and Shor 1966, 431); Glennie (1936) observed large negative gravity anomalies throughout the Maldives, and large magnetic anomalies have also been reported. A seismic refraction profile is described by Francis and Shor (1966) near the Great Chagos Bank south of Peros Banhos and Salomon Atolls. This shows a layer 0.6-1.7 km thick with velocity 3.01 km/sec, interpreted as coral, over-

lying 3.6-5 km of volcanic rock (velocity 4.76 km/sec) and basic crustal material (velocity 6.79 km/sec). Water depth in this area averaged about 1000 m. Presumably over the shallow Chagos Bank, and over Diego Garcia, the coral and possibly the volcanic layers are thicker.

The Maldives and Chagos plateaux lack the characteristic features of the deeper (c. 3 km) Mid-Ocean Ridge, i.e. high heat flow, seismicity and volcanicity. The plateaux are notably aseismic (Stover 1966). Francis and Shor (1966) suggest that, on the analogy with many Pacific linear volcanic belts, the Maldives-Chagos vulcanism began in the south and moved northwards, culminating in the outpouring of the Eocene Deccan Traps. This would imply that subsidence of reef foundations has been greatest and most prolonged in the south. It is possible that the Chagos and Maldives volcanic belt represents the track of drift of the Indian sub-continent to the north during the late Mesozoic and early Tertiary disruption of Gondwanaland (Le Pichon and Heirtzler 1968, 2115), though this interpretation remains speculative.

Little is known of the ocean floor to the east of the Chagos, where depths are generally 3.5-4.5 km. A north-south trending trench, the Chagos Trench, with depths greater than 5 km, has been identified along the east side of the Chagos Plateau (Francis and Shor 1966, 428).

The relationship of Diego Garcia itself to the Great Chagos Bank remains unclear. There are soundings of 1-1.3 km between the two. Similar depths are found to the north, between the Bank and Peros Banhos and Salomon Atolls, where Francis and Shor (1966) shot their refraction profile. Depths of less than 1.8 km extend for 130 km southwest of Diego Garcia, but for only 30 km to the east. No geophysical work has been done on Diego Garcia itself, which from the regional situation can be inferred to be a typical mid-ocean atoll, with a reef limestone cap 1.5 km or more in thickness resting on a subsiding volcanic basement.

B. Geomorphology of the land rim

The geomorphology of Diego Garcia has been briefly described by Bourne (1888a, 1888b) and Gardiner and Cooper (1907). The atoll is unusual in the length and continuity of its land rim, which extends round 90 per cent of the atoll circumference. Because of the narrowness of the rim, however, land covers only 18 per cent of the total area of the atoll.

Because of its length and continuity, the land rim is difficult to describe. It varies in width, height and surface features from place to place, and some sectors are clearly older and more stable than others. The nature of both the lagoon and seaward coasts varies with differences in exposure and sediment supply. For convenience the continuous rim is divided into three main types: normal rim, barchois

rim, and narrow rim (Fig. 2). The terminal ends of the rim represent a fourth type, and the lagoon-mouth islets a fifth.

1. Normal rim

The term "normal rim" is applied to those sectors with a mean width of about 0.5 km, possessing a prominent seaward ridge, a less pronounced lagoon ridge, and either a gentle slope between the two or an interior depression. This type of rim has been described from many other atolls.

Between Cust Point and East Point, a distance of 7 km, the rim is 0.4-0.6 km wide, reaching 1 km at East Point. Figure 4a shows a levelled section north of East Point. The seaward ridge is topped by a belt of low dunes 120 m wide, rising to 5 m above low water level (Plates 5-6). The lagoon ridge is less pronounced, rising to little more than 2 m above low water. Apart from a central depression most of the rim surface is horizontal or falls gently lagoonward, with an elevation of only 1-2 m. The central depression is close to or slightly below the level of high water springs. The beaches and rim surface consist of fine to coarse sand, with organic debris forming a black deposit in the depression. After heavy rain the depression holds standing water several decimeters deep for some days.

The rim northwest of Pointe Marianne is very similar, being 8 km long and 0.4-0.75 km wide. The seaward ridge (Plate 8) is higher here than on the east rim, and the levelled transect at Pointe Marianne (Fig. 4b) reaches almost 7 m above low water springs in the seaward dunes. Inland from the dunes there is a horizontal surface at 3 m, formed by a gravel spread on which the dunes stand. The lagoon ridge here is low and insignificant.

Part of the southeast rim also falls into this category. From some 4 km northeast of Barachois Sylvain the rim has a width of 0.4-0.9 km. A transect on this coast (Fig. 4c) shows a rather lower seaward ridge (3-4 m above low water springs), with a gentle slope from the seaward beach crest to the lagoon. This sector is entirely built of sand.

Rims of this type have presumably formed by the gradual accretion of sand on the face of seaward beaches, with occasional washovers of sand and gravel raising the rim surface inland during storms. Lower beach ridges on the lagoon coast also grow by accretion. Where the rim is wide or sediment supply deficient, the two ridges may be separated by a depression, but generally there is a continuous gentle surface slope over bedded sands and gravels, part wind-blown and part washover. The width of these sectors implies formation over a considerable period of time, and they probably represent the oldest and most stable portions of the land rim. Two of the sectors described trend NNE-SSW, and the other at right-angles, NW-SE.

2. Barachois rim

In places the lagoon shore of the land rim is highly crenulate, with deep indentations enclosing areas of intertidal sands and gravels. These indentations are surrounded by the normal sandy island surface, and the seaward shore is formed by a normal beach ridge, in places topped by dunes. These indentations are known as barachois (Plate 12). The two main barachois systems are those at the South Point (Barachois Sylvain, 2 km long and 1.5 km wide) and at Horsburgh Point (Barachois Maurice, 4 km long, 0.9-1.4 km wide). In the case of Barachois Sylvain the seaward beach ridge is low and narrow, but at Maurice it has its usual high and wide development. In each case the lagoon beach ridge is weakly developed and is actively retreating, exposing a low cliff of consolidated cay sandstone at its foot. This sandstone is massive and lacks the strong seaward dip of true beachrock. It is not only exposed along the lagoon shore near the mouths of barachois, but also within the mouths and round the margins of the indentations.

Gardiner and Cooper (1907, 47) give a useful description of the barachois:

"Their entrances are all relatively small, but inside they open out with horns branching off in every direction; the whole is fringed with tall coco-palms. At high water all parts are covered, but at low tide they form vast expanses of glaring white sand or mud, with perhaps shallow streams in their centres. They are evidently growing, dead and falling coconuts fringing their sides, soon to be buried by the Cardisoma crabs, whose immense holes and heaps of soil give a rough appearance to the ground. On the flats, too, which are regularly covered by the tide, any coral-mass or stone is as quickly buried by Uca."

The main features of barachois may be seen in the maps compiled from air photographs in Figures 5 and 6. Figure 7 gives a series of sections surveyed across one arm of Barachois Maurice, and shows the vertical separation of the Cardisoma and Uca zones. In the former the surface is formed of algal-blackened coral sticks and gravel, overlying sandy and silty deposits. Segregation of the coarse sediments is clearly caused by crab activity. The burrowing crabs bring unblackened sediments to the surface to form white conical mounds up to 0.3 m high; these are very conspicuous against the grey surface. Much of the surface is underlain by burrows, and collapses when walked over (Plate 13). This zone is probably only infrequently flooded. Toward the centre of the barachois it often passes into a pavement of cemented sandstone, and may be separated from the lower Uca zone by a low sandstone cliff which marks the upper limit of ordinary high tides (Plate 29). The Uca zone consists of sandy and silty deposits penetrated by large numbers of Uca burrows. Slightly more elevated areas are vegetated with a sward of a sterile grass similar to Paspalum, which

may be regarded as the first stage in salt-marsh development (Plate 14). At lower levels the Uca zone is intersected by meandering creeks, in which deeper pools and abandoned arms contain very fine silty sediments. Uca is absent from these lower levels (Plate 15).

Gardiner interpreted the barachois as largely erosional, and the evidence of undercut sandstone cliffs round their margins and of dying coconuts standing in brackish water supports his argument. Bourne (1888b, 457) considered that the lagoon could be raised to abnormally high levels by northwesterly winds, and high salinity of the flood waters killing land vegetation, and scouring and deepening of the barachois occurring as soon as a channel is opened through the lagoon beach ridge. Not all barachois are growing, however. Air photographs show several small barachois on the coast between Sylvain and Maurice which are now dry and being colonised by vegetation. Between Maurice and Carcasse, another such barachois is being filled by fans of storm gravels washed over the lagoon beach ridge, and this too is being vegetated.

Barachois may thus represent an early stage in land rim formation, rather than, as Gardiner (1936, 418) thought, a late stage in land rim destruction. The main barachois occur on a lagoon coast where the dominant winds are from the south, i.e. offshore. Sediment movement on both the east and west sides of the lagoon is clearly northward, and the south side lies in an area of sediment deficit, with no sediment source except for material from the seaward reef carried over the seaward beach ridge, and lagoon floor sediment transported onshore during storms. Such supplies are necessarily limited: material from the seaward side will decrease in quantity as the rim becomes higher and wider, and living reefs are not well represented in the southern lagoon. In this interpretation, spits and projections on the inner margins of the barachois are probably original depositional features, probably washover deposits, stabilised by subsurface cementation and slightly modified by subsequent marginal erosion. Spits and recurves at the mouths of barachois are formed by small-scale longshore sand movement on the lagoon coast after the lagoon beach ridge has been breached; these features, like the original beach ridge, are subject to subsurface cementation and erosional modification.

It is difficult to estimate long-term trends in the barachois. It is possible that they are in approximate equilibrium, with the deposition of fine sediments and of new biogenic material, mainly crustacean and molluscan, balancing any loss by tidal flushing. The fact that no conspicuous changes have occurred since the first maps of the atoll were made in 1824 probably is the result of the absence of a mangrove swamp or salt marsh flora: mangroves or even a cover of Sesuvium or Arthrocnemum would certainly promote sedimentation and transition to a dry land vegetation at the higher levels. Colonisation by such vegetation is at present certainly prevented by the extreme environmental conditions, particularly of salinity and insolation, experienced on the flats, and by continuous reworking of the sediments by crabs.

The more remote arms of several barachois, especially Maurice, stand at a high level and are occupied by brackish standing water, as noted by Gardiner and Cooper (1907, 48). Gardiner considered these to be the advancing arms of enlarging barachois, with the rising water level killing the coconuts. There is no doubt that coconuts are being killed in these situations today, and their trunks stand or lie in brackish water. At Barachois Maurice the water surface in one such arm was shown by levelling to stand at the same elevation as the main Cardisoma flat and well above the Uca zone and the active creek system. It is possible that waterlogging has occurred as a result of the formation of a cemented horizon below the Cardisoma zone: this horizon outcrops in a cliff between the Cardisoma and Uca zones, and the perched pool is drained by a spillway over the edge of the cliff. Erosion in this spillway is not significant, and the marginal pool has clearly not been flooded as a result of backward erosion from the main barachois. These data suggest that Gardiner's explanation of the phenomenon may not be correct.

3. Narrow rim

Two distinct types of narrow rim are found. The first and most simple extends from Barton Point to Cust Point on the northeast side, a distance of 9 km. The width here varies from 45 to 250 m. The seaward ridge is low, generally less than 3 m. and lacks dunes; the lagoon ridge is in places higher and may be topped by low dunes (Plate 10). Along this sector the seaward beach is retreating and the lagoon beach stable or aggrading. The section surveyed at Cust Point (Fig. 8) represents a very narrow section; where the rim is broader incipient interior depressions are found. Because of the narrowness of the rim in this sector, breaches and washovers from sea to lagoon are not uncommon: Bourne found recent cuts in 1883 (1888b, 457-458). As both Bourne (1888b, 442) and Gardiner and Cooper (1907, 46) recognised, this sector of narrow rim is a recent and unstable link between the more permanent land areas at Observatory Point and south of Cust Point.

The second type of narrow rim is more complex. Between Pointe Marianne and Barachois Sylvain, a distance of 14 km, the rim varies in width from 100 to 500 m. The seaward beach ridge is similar to such ridges elsewhere round the atoll; it is lower in the south, where the beach is retreating, and higher in the north where dunes are building. At one point 4 km south of Pointe Marianne the sandy seaward beach-ridge is topped by a spread of gravel and cobbles, probably of storm origin. The lagoon shore is of diverse character. In the south it is lined by an intertidal rock platform up to 30 m wide (Plate 11), the inner 7-10 m being covered by wave-tossed loose blackened coral boulders. The beach is low and less than 1 m in thickness; it is usually only 5-10 m wide; and it is only intermittently attached to the main land area of the rim. The ridge thus effectively encloses small barachois at a higher level than the main southern barachois, lying mostly in the Cardisoma zone. Sediment transport is from south to north,

and the lagoon beach thus forms a series of en echelon spits and headlands, each enclosing small barachois-like depressions. The headlands have been stabilised by intertidal cementation, and are made conspicuous by their tall clumps of Hernandia and Ficus. The low beach ridges south of each headland, enclosing the Barachois, are often breached, but the main entrance to each barachois is normally to the northwest of the headlands.

The largest of these barachois is at Mamzelle Adélie. Unfortunately this could not be visited, but air photographs show a well-developed creek system in a surface covered with what is probably a Paspalum turf. A larger indentation of a different type is found at Pointe Marianne itself, where the trend of the lagoon coast changes from N-S to NW-SE. Here the lagoon beach ridge encloses a large expanse of standing water (Plates 16-17), densely vegetated with the pondweed Bacopa monnieri. The inner margins of this pool are lined with dead and dying coconuts and Casuarina trees (Plates 18-19), and several islets also bear dead and decapitated coconuts. Gardiner and Cooper (1907, 417) reported a similar situation, and gave the maximum depth of water as 4-5 ft (1.2-1.5 m). It is similar in size to the large southern barachois, but does not dry at low water. The pool can only have been formed by the growth across a former arm of the lagoon of a sand spit where the coastline changes trend; it has remained open because of deficient sediment supply and because of its exceptional size, suggesting that here the reef itself was unusually wide. How coconuts formerly grew in now waterlogged conditions presents a major problem. Gardiner's account suggests little change during the last sixty years; it has already been shown in the discussion of the main barachois that Gardiner's views that "more barachois have formed" and "all have enlarged" since Moresby's 1837 survey (Gardiner 1931, 140) are not supported by the 1824 charts, and that waterlogging in the southern barachois may have a different explanation.

4. Rim ends

At both its northeast and especially its northwest terminations, the land rim widens. Seaward and lagoon beaches diverge, without marked change of character, and the low-lying interior contains marshy areas with sedges and standing water. At the northwest point the area of standing water is large and surrounded by dense coconut thicket; unfortunately it was not possible to visit it in 1967. Both points have considerable dune fields, described in Section B.6, p. 15. At northeast point the dunes are being eroded, and there are vertical sand cliffs up to 3 m high at Observatory Point. Gardiner (1931, 139) observed these in 1905. At Barton Point, at the entrance to the lagoon, the reef flat is covered with boulders 0.5-1 m in diameter for a distance of several hundred meters (Plates 3-4). This is unusual on Diego Garcia reef flats, and may have resulted from the effects of a single major storm.

5. Lagoon-mouth islands

There are three small islets at the entrance to the atoll lagoon. West Island stands at the end of a spit-like reef extending 1.4 km from Eclipse Point; Middle Island stands at the northeastern point of an isolated reef 1.7 km long and 1.0-1.3 km broad; and East Island stands on a much smaller isolated reef only slightly larger than the island itself. West Island (Fig. 9) is a narrow strip of sand and cobbles 450 m long and 75 m wide standing on a rock platform which dries at low water springs; the area of the islet itself is 3.4 ha and of the islet and platform together 5.4 ha. Middle Island (Fig. 10) has a total area of about 6 ha, but a large area enclosed by a shingle rampart on the south side consists of standing water. East Island (Fig. 11) is the largest of the three, 800 m long and 200 m wide, and has an area of 11.75 ha.

Middle Island is the least interesting physiographically. It is built of cobbles and gravel at the windward edge of Spur Reef, and has maximum dimensions of 340 x 230 m. An intertidal tail of rubble more than 0.5 km long, with occasional sandbores, extends southwards from the cay across the reef surface. Rubble forms a subtidal carpet round the island shores. The shingle rampart enclosing the pools is largely unvegetated: spread of sand and gravel in the pools show that the rampart is often overtopped or breached by storm waves.

West and East Islands, though very different in size, are similar morphologically and of considerable interest. In each case bedded cemented sands outcrop to form horizontal or slightly dipping platforms along the north and east shores of the islands ("promenades"). At East Island (Plates 31-34) these bedded calcarenites rise at the east point to 3 m above the surrounding reef flat, decreasing in height towards the southwest. The deposits show cross-bedding, with dominant dip away from the island. The platform formed by the calcarenite increases in width to nearly 90 m near the east point; it is surrounded by a platform with similar width at about the level of low water neaps. The junction between the two is formed by a cliff, generally 1-2 m high and slightly undercut. The surface of the calcarenite above is rough and pitted, and the cliff is retreating by fracturing and detachment of quadrangular blocks. The lower outer surface is smoother, coated with algae, and marked by deep round potholes and by trenches presumably eroded along vertical joints. Its outer edge is straight and steep, with a coating of encrusting calcareous algae. Stacks and residuals of calcarenite rise at intervals from the lower platform, demonstrating its erosional origin. Blocks detached from the calcarenite platform during storms, which may reach several meters in length, form a massively imbricated sediment overlying the platform at the east end of East Island, bringing the total height above low water springs to 5.6 m. The island beaches of gravel and cobbles are perched on the conglomerate platform; the island sediments are 2-3 m thick.

The calcarenites are considered further in section C. 4, and the vegetation of the islands is described in Chapter 11, p. 127.

6. Sand dunes on aggrading coasts

While most of the seaward and lagoonward coasts of Diego Garcia are slightly retreating, as shown by the presence of erosion ramps and cliffing, sectors totalling about 17 km possess coastal dune belts. The two main dune areas both face the southwesterlies and trend NW-SE: one, from Simpson Point to Pointe Marianne, is a seaward coast; the other, from Observatory Point to Cust Point, is a lagoon coast. Both lie to the north of slightly retreating sectors of coast, and the direction of sediment movement in each case is clearly from south to north. A third dune sector lies on the eastern seaward coast between East Point and Cust Point: again this lies to the north of a retreating sector, and the sediment supply is from the south.

In all of these sectors, dune accumulation takes the form of a single ridge of varying width rather than of discrete dunes. Vegetation cover is usually so dense that the dune ridge often only becomes apparent when the vegetation is cleared (Plate 10). At the northeast point the dune ridge widens and covers much of the end of the land rim, with a rolling but subdued topography. Generally the ridge is 40-150 m wide. According to Bourne the highest point on Diego Garcia is 30 ft (9 m) high (1888b, 441) and the dunes reach 25 ft (7.5 m) (1886, 385). Gardiner first stated that dunes at Northeast Point varied up to 30 or 40 ft (9-12 m) in height (Gardiner and Cooper, 1907, 46), but he later said that there was "no evidence that they ever reached more than 20 to 30 ft [6-9 m] above sea level" (1936, 417). In places the dunes are being eroded, as at Observatory Point (Dolotov, 1968), but generally they overlook a wide sand beach.

It is interesting that dunes are not developed on the southeast coast, facing prevailing winds. It is probable that, with little lateral sand movement on this coast, sand supply across the reef is inadequate for dune building, and that intermittent storm action is mainly destructive. The main dunes only form where alongshore sand movement from the south provides a supply. In the field it is noticeable that even slight changes in beach orientation can lead to changes in sand accumulation and dune formation on the berm.

7. Land sediments

Land sediment samples were collected at several stations round the atoll rim (Fig. 16): no attempt was made to secure uniformity of coverage, but the samples were chosen to illustrate the sedimentary characteristics of particular environments. Coarse sediments (cobbles and larger particles) were not sampled. Table 3 lists Folk and Ward parameters for mean size, sorting, skewness and kurtosis (M_z , σ_I , SK_I ,

Table 3. Characteristics of some beach, dune and barachois sediments at Diego Garcia (ϕ units)

Environment	Sample number	D ₅₀	M _z	σ_I	Sk _I	K _G
Lagoon beach	DG 2	2.05	2.05	1.46	-0.34	2.79
	DG 3	1.78	1.80	0.45	-0.01	1.19
	DG 4	1.95	1.68	1.09	-0.46	0.80
	DG 5	1.43	1.48	0.25	+0.39	1.93
	DG10	0.54	0.41	1.09	-0.29	1.06
Seaward beach	DG 6	-0.16	-0.25	0.70	-0.22	1.51
	DG11	1.62	1.61	0.61	-0.07	1.02
	DG12	1.70	1.69	0.45	-0.05	1.00
	DG16	1.40	1.17	0.94	-0.46	1.48
	DG19	0.30	0.23	1.15	-0.33	1.65
Dune	DG14	2.01	2.03	0.42	+0.01	0.89
	DG15	2.40	2.40	0.33	0	1.29
	DG21	1.72	1.75	0.48	+0.03	1.01
Barachois	DG 9	1.30	1.46	1.66	+0.17	1.06
	DG13	-0.52	-0.54	0.96	+0.02	1.31
	DG17	1.52	1.50	1.33	+0.02	1.17
	DG22	0.80	1.09	1.67	+0.24	1.14
	DG24	0.94	0.94	1.13	+0.04	0.96

and K_G)* for samples from seaward beach, lagoon beach, dune and barachois environments, and cumulative frequency curves for these samples are given in Figure 17.

Beach samples are generally moderately well to well sorted, with negative skewness. Seaward beach samples are coarser than lagoon beach samples. Lagoon beach samples are either well sorted if homogeneous or less well sorted if more than one kind of sediment is represented, particularly in quiet water environments. The beach samples do not differ in any major way from those of other atolls, such as those of Addu Atoll previously reported (Stoddart, Davies and Keith, 1966), except that seaward beach sediments on Diego Garcia are generally of finer calibre than those of other, especially Trade Wind, atolls.

Dune sediments are well sorted and show no marked skewness. The mean grain size of about +2 ϕ is smaller than that of seaward beach sediments, and would closely approach that of lagoon beach sediments were it not that the mean size of the latter is often increased by the inclusion of coarse material in the sample.

* For definitions of these parameters, see R. L. Folk, Sedimentology 6: 73-93, 1966.

Barachois sediments show greatest diversity. Whereas both beach and dune sediments are formed by an active sorting process, either by waves or wind, in the barachois the sediments have complex origins. Partly they are transported and deposited by tidal currents, though this is probably of minor importance; partly they result from the in situ deposition and disintegration of organic skeletons. As a result the sediments are poorly sorted (σ_1 equal to or greater than 1.0). Most have a fine fraction (smaller than $+3.4\phi$) of about 10 per cent, whereas such fine sediments are rare or non-existent in other land environments. Barachois sediments are subject to continuous post-depositional disturbance by the activities of Cardisoma, Uca and other organisms, which themselves add material in the form of skeletons and faeces to the sediments.

Diego Garcia terrestrial sediments are entirely composed of calcium carbonate, except for fragments of stranded pumice. These are fairly plentiful on the berms of aggrading beaches on seaward coasts, for example on the east coast between East Point and Minni Minni. Most of the fragments are less than 5 cm in diameter, a few reach 20 cm. Finsch (1887, 42) and Wilson (1889, 144) noted large amounts of pumice on the atoll, but their visits took place in 1884, the year following the great explosion of Krakatau. Earlier observations of pumice in the Chagos Archipelago had been made by Moresby (1844, 309). Pumice now forms a quantitatively insignificant proportion of the land sediments, though often local concentrations are formed by the practice of piling pumice fragments around newly planted coconuts. No other non-calcareous material was seen on the atoll.

C. Beach conglomerates and beach rocks

Most of the seaward beaches of the atoll are lined with some form of lithified reef-derived sediments; the total outcrop is greater than on any other Indian Ocean atoll visited by the writer. Rock outcrops are found more intermittently round the lagoon shores, and on the lagoon-mouth islets. The origin and relationship to sea level of these rocks is important in interpreting atoll history, particularly in view of the references made to sea-level change by Gardiner.

Categories of lithified sediments were first recognised at Diego Garcia by Bourne (1888b, 443), who distinguished four types:

1. reef rock, of compacted coral debris with horizontal stratification, formed under the sea or intertidally;
2. boulder rock, formed above high tide by salt spray, outcropping as a low rampart with seaward dip;
3. shingle rock, which is either (a) horizontally stratified but finer in calibre than reef rock, formed under the sea or intertidally, and including corals in the position of growth in sheltered parts of the lagoon; and (b) a seaward-dipping rock, similar in features and origin to boulder rock, but of finer calibre;

4. sand rock, formed from sediment accumulated above water level by wind action and cemented by spray, the outcrops possessing seaward dip.

These categories are not mutually exclusive, and Bourne's use of both morphologic and genetic criteria leads to confusion, but it is clear that considerable differences do exist in the form, composition and origin of the coastal rock.

1. Seaward coast erosion ramp and beach rock

Rocks on the seaward coast are of similar form round the whole atoll rim, though in general they are not well exposed on aggrading coasts with dune development (e.g. East Point to Cust Point; Pointe Marianne to Simpson Point). Typically the base of the beach is formed by an erosion ramp or low-angle surface bevelling a coral conglomerate (Plate 23). Where wave action is considerable the surface of the ramp may be highly polished, but it is generally smooth, with rounded erosion furrows oriented normal to the beach (Plate 28). The surface of the ramp clearly truncates corals embedded in the conglomerate. In many places (e.g. southeast of Barton Point, northwest of Horsburgh Point, northeast of South Point) the ramp surface passes smoothly, without visible break, into the bevelled horizontal surface of the inner reef flat, suggesting that the underlying rocks are continuous and that the difference in form results from erosion. Between East Point and Horsburgh Point, this is further suggested by the continuity of erosion furrows of the rock surface between reef flat and ramp. The ramp rock is often a conglomerate filled with corals, particularly Pocillopora, also suggesting that this may be an elevated reef rock much modified by erosion during the formation of the present reef flat surface.

Elsewhere round the atoll the erosion ramp outcrops only intermittently across the lower beach: the middle part of the beach consists of sand or cobbles, and on the upper beach there is a vertical or overhanging clifflet cut into the conglomerate rock (Plates 25-26). The rock surface above the cliff is horizontal or rises slightly inland, and is overlain with sand or humic soil. Where the cliff is cut in conglomerate similar to that of the planed Pocillopora ramp, the corals can be seen to be wave-tossed and not in the position of growth. This can also occasionally be seen lower on the beach when vertical sections are revealed on the ramp by spalling of slabs. Near East Point there is a section showing on the lower beach a cemented conglomerate of jumbled coral colonies, and on the upper beach a wave-eroded cliff in unconsolidated sediments consisting mainly of coral colonies of the same size and type as those in the conglomerate (Plates 20-22). The only apparent difference is that the unconsolidated deposits contain more rounded cobbles than the conglomerate. No case was seen anywhere on the seaward coast where corals in the position of growth in the conglomerate indicated emergence. In many places, of course, the rock is a calcarenite (e.g. in the upper beach clifflets near South Point) and corals are completely absent.

The relationship of the erosion ramp and upper beach clifflet to tidal levels is of interest. The erosion ramp lies between approximate low water springs and mean sea level. The highest parts of the ramp and of the upper beach clifflet may lie above the still-water level of high water spring tides, but are within the range of swash. Thus, if the cementation process is intertidal (Stoddart and Cann 1965), all the rocks on the seaward coasts could be formed at their present elevation by cementation of clastic deposits and subsequent erosional modification. The East Point section indicates that some of the ramp rocks closely resemble contemporary beach sediments in composition. This interpretation would suggest that the erosion ramp rocks are similar in origin to ordinary beach rocks. The absence of normal morphologic features of beach rock and the continuity of ramp and reef flat in many places, on the other hand, suggest that the comparison with normal beach rock is an over-simplification.

Special attention was given in the field to observing whether beach-foot rock exposure possessed any morphological features of beach-rock, such as seaward dip, land-facing scarp, and undercut along stratification lines, to determine whether the smooth erosion ramps could be degraded beach rock. The results were ambiguous. In some places smooth erosion ramp passes into true beach rock with characteristic seaward dip; the beachrock features then disappear further along the beach and the ramp again becomes continuous with the reef flat. Northeast of South Point "morphologic beach rock" of sandy composition overlies conglomeratic ramp rock, and slabs of the beach rock are being peeled from the underlying ramp (Plate 24). But laterally this clear distinction fades, and becomes difficult to make as the beach rock often contains much coral debris. Sandy beach rock is found near Simpson Point, but again its relationship to the erosion ramp elsewhere is not clear. No relict beach rock was seen on the reef flats seaward of the present beaches anywhere round the atoll.

Provisionally, all the rocks seen on the seaward coast are interpreted as formed at present sea-level by cementation of beach deposits, and subsequently much modified by erosion. There is no clear evidence of elevation or relative sea level movement in any of these rocks.

2. Lagoon coast beach rock

"Morphologic beach rock" with seaward dip, at low intertidal levels, following the trend of the beach, and of clearly recent origin, is uncommon on Diego Garcia beaches. The best exposure is found in the wide sandy bay between Barton Point and Observatory Point at the lagoon entrance. Elsewhere beach rock is generally found slightly offshore on slowly retreating sandy coasts: for example between Observatory and Cust Points (30-40 m offshore), between East Point and Carcasse, and between Eclipse Point and Pointe Marianne (up to 30 m offshore). In the southern half of the lagoon, beaches with plentiful sand supply are absent, and normal beach rock is not found on the slightly cliffed shores. All the beach rocks seen on the lagoon coast are clearly related to the present sea-level stand.

3. Barachois rock

The massive calcarenitic ledges at the mouths and round part of the margins of the large southern barachois (Plates 29-30) have already been described (Section B.2). Gardiner, who figured "overhanging cliffs" of rock in one of the barachois (1906, 459), believed that it indicated a relative change in sea level. The rock at the mouth of Barachois Maurice was "such as might have been formed in the elevation of an encircling reef" (Gardiner 1936, 419). South of East Point the rock "was sometimes of coral in its growth position bedded by sand, not algae; it must have been of lagoon formation and its present position can only have been due to a fall in the water level of the lagoon" (Gardiner 1936, 419).

No trace was seen in 1967, at Barachois Maurice or elsewhere, of corals in the position of growth in this barachois rock. The rocks are fine-grained calcarenites formed from clastic sediments, generally massive and without marked bedding, but in places with a slight lagoonward dip resulting in the formation on the upper surface of the rock of small-scale cuestas which are, however, distinct from those of normal beach rock. The cementation is firm but superficial, and at Barachois Maurice decreases inland away from the lagoon until it becomes only a thin superficial crust.

The origin of the barachois rock is clearly linked to that of the barachois. It must be stressed, however, that all the outcrops seen are intertidal: Gardiner's photograph of "overhanging cliffs" was clearly taken at low water spring tide, and at high water springs almost all the barachois rock is submerged, with the sea reaching beaches perched on the rock surface. No evidence was found to support Gardiner's hypothesis of recent emergence.

The cemented pavements of the smaller barachois on the narrow western rim lack the cliffed form of the southern outcrops, but their surfaces lie at high intertidal levels, and they probably have a similar origin.

These rocks most resemble the cay sandstones outcropping on retreating sandy shores of Caribbean atolls (Stoddart 1962, plate 1; 1963, 108-109) and ascribed to ground-water cementation. The barachois rocks may have similar origin.

4. Island "promenades"

The outcrops of bedded calcarenites on the windward sides of East and West Islands have been described in Section B.5. They extend to about 3 m above low water spring tide level, and thus are clearly higher than intertidal. Bourne (1888b, 446-447) described this rock from East Island, and argued that it indicated a slight elevation. He described well sections on the island, showing 2.5 ft (0.8 m) of thick horizontal "shingle rock" with some corals, over 1.5 ft (0.46 m) of

loose sand, over 3 ft (0.9 m) of coral rock, over more sand, over a basement of solid reef rock. Bourne thought that the alternation of sand and rock represented an alternation of coral growth and sedimentation under lagoon floor conditions. The upper rock surface he estimated to be 4 ft (1.2 m) above high springs, thus giving a minimum estimate of the amount of elevation. Gardiner (1931, 35) also briefly mentioned stratified rock forming cliffs 10 ft (3 m) high on the islands.

It is difficult to see how these bedded sands could be formed at their present elevation under present conditions. They probably indicate emergence of a few metres, following accumulation on the lagoon floor under conditions of active water movement. Strongly bedded sands of very similar form, though with a large terrigenous element, have been found in the Gulf of Mannar, South India, and undoubtedly originated as nearshore bay-floor sediments subsequently elevated (Stoddart and Pillai, in preparation). The restriction of these rocks on Diego Garcia to the two lagoon-mouth islets presents a considerable problem if they do indicate emergence. They could indicate that some at least of the seaward coast ramp rocks were also formed by the same elevation movement. The island promenades thus form a crucial problem in the recent geomorphic history of the atoll, and merit further study.

D. Seaward reefs

The seaward reef flats of Diego Garcia are remarkably uniform around the atoll. They vary in width from a minimum of 50 m to a maximum of 250 m, but are usually about 150 m wide. They also vary slightly in height: most of the flats remain slightly submerged even at low water spring tides, though some sections (e.g. at the South Point) dry. These characteristics differ from those of Addu in the southern Maldives, where the seaward reef flat varies in width from 50 to 750 m (the total width is from 1 to 2 km) and much of the flat dries completely at low spring tides.

The surface of the flat is rocky, with thin patches of rippled sand, gravel and boulders. Corals are generally rare, and the main organisms are Cymodocea (= Thalassodendron), benthic algae, and a crust-forming bivalve Modiolus. Boulders are in many cases scattered over the whole flat and there is no well-marked boulder zone. Local exceptions are, however, found, for example at Barton Point, where the inner flat is covered with large boulders (Plate 3). Where bare rock is exposed it is often polished, especially near the shore where it passes either beneath the beach or into an erosion ramp. The surface is intersected by long straight cracks with variable orientation. Toward the seaward side it may be dissected by erosional channels normal to the reef edge. The seaward edge is intermittently marked by an algal ridge forming a slight topographic feature. This is best developed on the west coast near Pointe Marianne (Plates 1 and 2), where, however, it extends for only a few hundred metres.

Surge channels through the ridge are found here but were not seen well developed elsewhere; the reef edge on the southeast coast could not be properly inspected because of surf. In general the algal ridge is less well developed at Diego Garcia than at Addu Atoll in the Maldives. Small and scattered coral colonies are found in places on the reef flats, particularly species of Pocillopora, Platygyra and Porites, and of Acropora near the edge, but these contribute little to the morphology of a mainly erosional landform. There is no evidence at all that "the reef is growing seawards on all sides and the gain of the island to seaward exceeds its loss", as Gardiner (1936, 416) supposed.

We have no data, apart from aerial photography, on the seaward reef slopes around the atoll, except outside the lagoon entrances on the north side where H.M.S. Vidal carried the 1967 survey to depths of 300-400 m. Figure 12 shows 8 profiles in this area from the 1967 chart. The mean slope of the outer reef to a depth of 25 m is $6^{\circ}30'$; the slope then steepens to 17° down to 50 m and to 48° down to 230 m, before declining to 20° between 230 and 410 m. Aerial photographs suggest a similar low-angle shelf, 200-300 m wide, outside the breakers round much of the atoll. We have no information at all on reef communities on these outer slopes.

E. Lagoon

1. Topography

The lagoon of Diego Garcia is large, shallow, and almost completely enclosed by land. It has a total area of 124 sq km, and a maximum depth of 31 m. It was first charted by R. Moresby in 1837, and the northern half was charted in great detail by F. C. P. Vereker in 1885. A detailed survey of the whole lagoon was made by Capt C. R. K. Roe, H.M.S. Vidal, in 1967. Diego Garcia lagoon is thus topographically one of the best known atoll lagoons in the world. Sounding density in the 1967 survey ranged from 100 to 200 soundings per sq km, giving a total number of soundings on the 1:25,000 chart of about 18,000. This sounding density is rather less than those for Addu and Eniwetok, but substantially greater than that of any other atoll.

The main features of the lagoon floor are given in Figure 13, reduced from the 1967 chart, and in the profiles from the same source in Figure 14. The lagoon consists of three main basins: a large northern basin with its floor at 25-30 m depth; a central basin with its floor at 16-20 m depth; and a southern basin with more intricate topography, isolated by a ridge with depths of only 2-4 m extending entirely across the lagoon. For an atoll of this size the lagoon is unusually shallow. Most of the Maldivian atolls have depths of 40-70 m, and the southernmost, Addu, has a maximum depth of 78.6 m. Peros Banhos in the Chagos has a maximum depth of 75 m, and though Salomon has the same maximum as Diego Garcia it is a much smaller atoll (overall 36 sq km).

Hypsometric curves have been drawn for the Chagos (Fig. 15) and Maldive atolls, and hypsometric integrals* calculated. Diego Garcia has the highest hypsometric integral of all of these atolls, 51.0, indicating the least-basined form, compared with 48.7 for Peros Banhos and 38.4 for Salomon. Most Maldive atolls have values ranging from 25-30, and a few from 38-44 (Stoddart, in preparation). Median depths of the Chagos atolls read from hypsometric curves are: Diego Garcia 17 m; Salomon 21 m; and Peros Banhos 40 m. The hypsometric curve for Diego Garcia was constructed from a subjectively-generalized contour map of the lagoon floor based on the 1967 chart: it thus excludes the many knolls and irregularities and represents gross topography only.

2. Knolls

The extremely detailed sounding in 1967 clearly demonstrated the irregularity of the lagoon floor and the presence of large numbers of knolls. It is however remarkable, as Gardiner (1936, 419-420) pointed out, that outside the 10 m line virtually none of these knolls reaches the surface: Diego Garcia must be almost unique among atolls in the absence of surface patch reefs in the lagoon.

In the main northern basin of the lagoon, with its floor at 25-30 m, large numbers of knolls rise to 15-18 m depth, but only five reach 2-5 m. Knolls are especially concentrated in the north, near the lagoon entrances, where the basin-like form of the lagoon floor is in places almost obscured. In the central basin, with its floor at 18-20 m, the knoll summits are shoaler, many reaching 5-8 m and some even 3 m depth. The small southern basin is so encumbered with winding ridges and knolls mostly reaching 7-9 m but some reaching 2-4 m depth, that the intervening floor at 16-20 m is almost obscured. The variation of lagoon and knoll characteristics from north to south forms a problem second only to that of the absence of surface reefs in the Diego Garcia lagoon.

Knolls in atoll lagoons may be either contemporary growth features or karst-eroded limestone hillocks formed during periods of low sea-level. The fact that most of the Diego Garcia knolls fail to reach the surface and are apparently not actively growing suggests the latter explanation. Conversely the great concentration of knolls near the lagoon entrances suggests that coral growth may be restricted to this area and inhibited elsewhere in the lagoon by low water circulation, resulting from encirclement by land. There are problems in this explanation, however, for the shoalest knolls, with actively growing corals,

* This measure is defined and measurement procedures are described by A. N. Strahler, *Bull. Geol. Soc. Am.* 63: 1117-1142, 1963.

are in fact found in the southernmost part of the lagoon, where water circulation is probably minimal. The problem of knolls and lagoon reef growth forms one of the most intriguing problems for future research at Diego Garcia.

3. Entrances

The unusual degree of enclosure of the lagoon has already been mentioned. There are three gaps, all in the north, and all shallow. Main Pass, the westernmost, is 1.6 km wide and about 10 m deep. Middle Pass is 0.6 km wide and 6-7.5 m deep, except for a narrow steep-walled trough more than 30 m deep cutting back into it. Barton Pass is 1 km wide, and again only 6.5-7.5 m deep.

The volume of the Diego Garcia lagoon is of the order of 1900×10^6 cubic meters. With a comparatively small tidal range, such shallow passes, and no possibility of water entering or leaving across reef flats as is usual in other atolls, the residence-time of water in the lagoon must be considerable and exchange with the open ocean much inhibited. The effects of this on the physical and biological characteristics of the lagoon require study. The Diego Garcia lagoon contrasts with those of many other landlocked atolls, which have very shallow and often hypersaline lagoons.

4. Lagoon sediments

Fifty-one lagoon-floor sediment samples were taken in 1967: their location is shown in Figure 16. Folk and Ward characteristics for some of these samples are given in Table 4, and cumulative curves for certain samples in Figure 18. These sediments will be reported in greater detail elsewhere. They fall into two groups: first, sediments with size and sorting characteristics similar to those of lagoon beach sediments, with mean size about 2ϕ and moderate sorting. These sand-size sediments are clearly subject to wave-sorting processes; they are found in shallow nearshore areas and adjacent to some knolls. Second, there is a group of sediments with a wide range of mean sizes, poor sorting, and a high proportion (50-90%) finer than $+3.5\phi$. These fine sand and silt size sediments with occasional coarse skeletal fragments are found in the deep northern basin, especially towards the east side, in depths of 15-30 m. A sample of this "coral mud" was collected by Gardiner and was described by Murray (1910, 390). Electron micrographs of this fine fraction show that the material is largely of detrital origin. Similar fine sediments in other lagoons are not often found in such shallow depths (at Addu they are restricted to the deepest part of the lagoon) and their occurrence at Diego Garcia probably results from the encirclement and restricted movement of lagoon waters.

Table 4. Characteristics of some lagoon sediments at Diego Garcia (ϕ units)

Environment	Sample number	D_{50}	M_z	σ_I	Sk_I	K_G
LAGOON FLOOR	B 8	1.10	1.28	0.94	+0.30	0.94
	B 9	1.72	1.91	1.02	+0.20	0.93
	B10	1.55	1.59	1.00	+0.04	1.18
	B20	1.67	1.71	0.89	+0.06	0.97
	B24	1.08	1.15	0.83	+0.11	0.96
	B25	2.21	2.17	0.60	-0.09	0.96
	B28	1.24	1.20	1.49	-0.16	1.00
	B36	1.80	1.71	1.01	-0.17	0.95
	B39	1.44	1.30	1.06	-0.28	1.23
	B51	1.76	1.74	0.91	+0.01	1.00
	B52	2.23	2.16	1.05	-0.07	0.85

5. Lagoon changes

The availability of hydrographic charts made in 1837 and 1885 suggested to Gardiner (1931, 139-141; 1936, 419-420) the possibility of demonstrating topographic changes resulting from either solution or infilling over this 48 year period. Comparison of the charts of the northern lagoon basin led him to conclude that the total area had increased from 19.31 to 21.75 sq miles, and of the basin below 5 fathoms from 16.5 to 17.42 sq miles. He concluded that the lagoon was expanding by solution at the same rate as the outer reef was growing outwards, so that there was no change in gross form of the atoll. The detail of the earlier charts, however, was not sufficient to show the complexity of the lagoon floor topography revealed by the 1967 survey. The bottom variability is such that no inferences concerning changes in depth can be made from the data on earlier charts. Gardiner's calculations were made at the time when Daly (e.g. 1934, 221) was even using the Diego Garcia lagoon as one of his examples of lagoons with smooth horizontal floors. These interpretations are clearly untenable with present knowledge.

F. Conclusion

The main problems raised by this outline of the geomorphology of Diego Garcia concern (a) the origin of the various lithified sediments and their relationships to sea-level change, and (b) the status and origins of knolls and other lagoon floor features, and their relationship to sea-level changes. We have, however, no data from Diego Garcia from which an absolute chronology of sea-level change could be established. Many of the features of the atoll must remain unexplained until such a chronology is available. Except in the case of the calcarenites at East and West Islands, the evidence of lithified sediments for recent sea level change is equivocal. On the other hand many features of the

land rim might more easily be explained if recent sea-level change were admitted. These include the formation of barachois and the general occurrence of beach retreat. Documentary evidence of the form of the atoll, going back to 1824, suggests, however that changes since that time have been minor. Future geomorphological research at Diego Garcia might concentrate on the problem of sea-level change, since this probably forms a key to most of the outstanding problems of the atoll geomorphology.

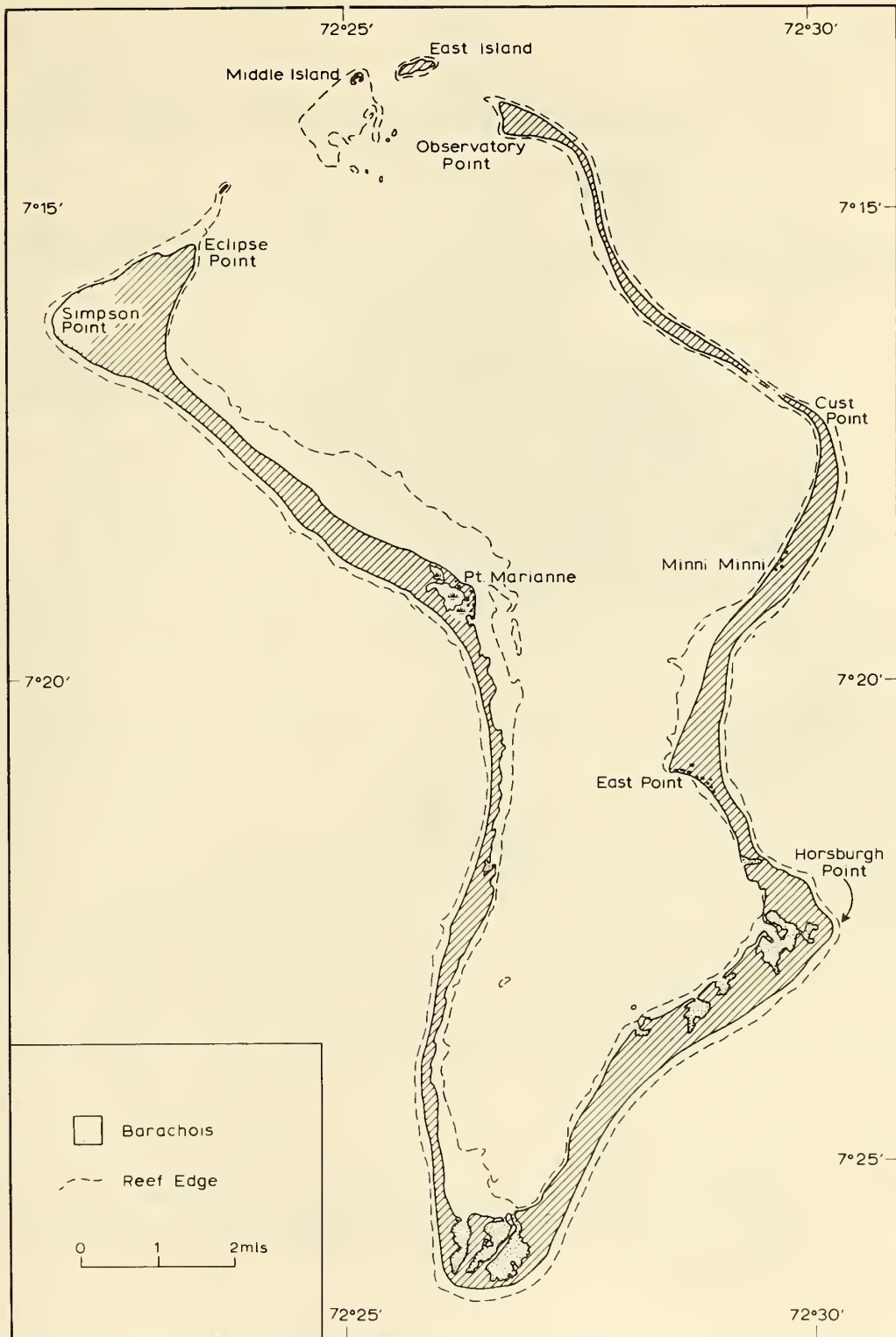


Fig. 2. Diego Garcia Atoll. From a survey by HMS Vidal 1967 and reproduced with the sanction of the Controller, Her Majesty's Stationery Office and of the Hydrographer of the Navy.

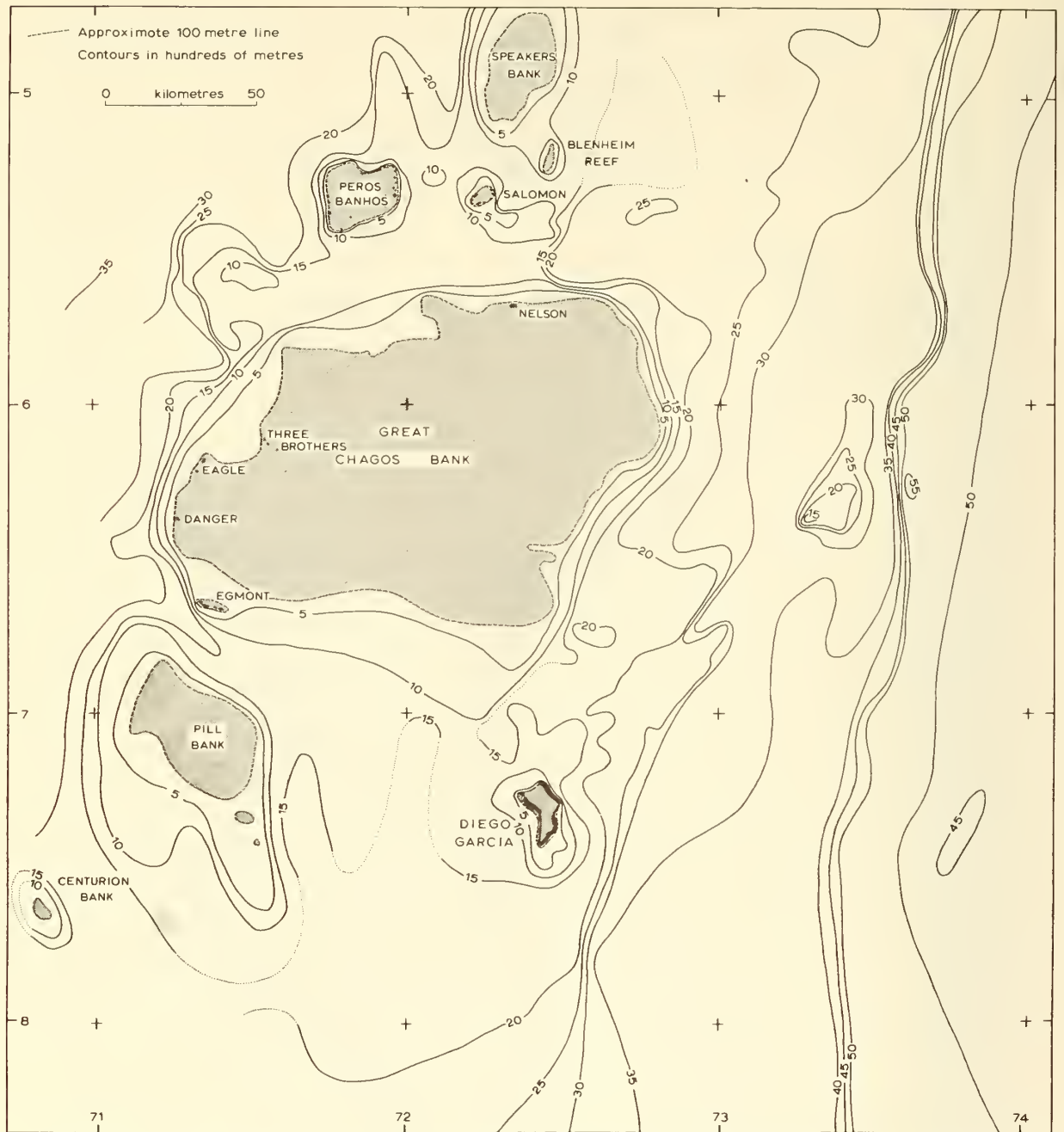


Fig. 3. Bathymetry of the Chagos Archipelago. From Admiralty Charts and Ocean Plotting Sheets and reproduced with the sanction of the Controller, H.M. Stationery Office and of the Hydrographer of the Navv.

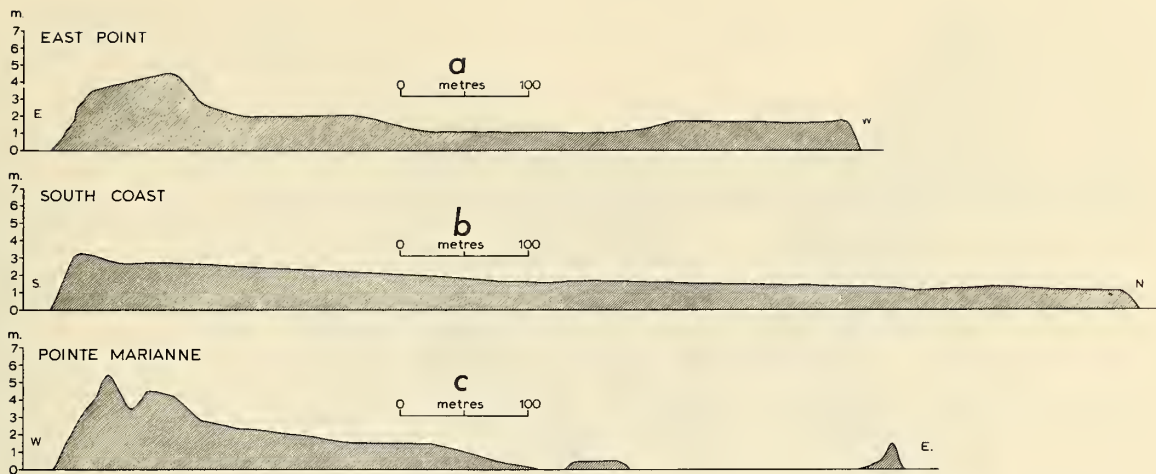


Fig. 4. Profiles of the land rim of Diego Garcia: (a) East Point, (b) Pointe Marianne and (c) South rim.

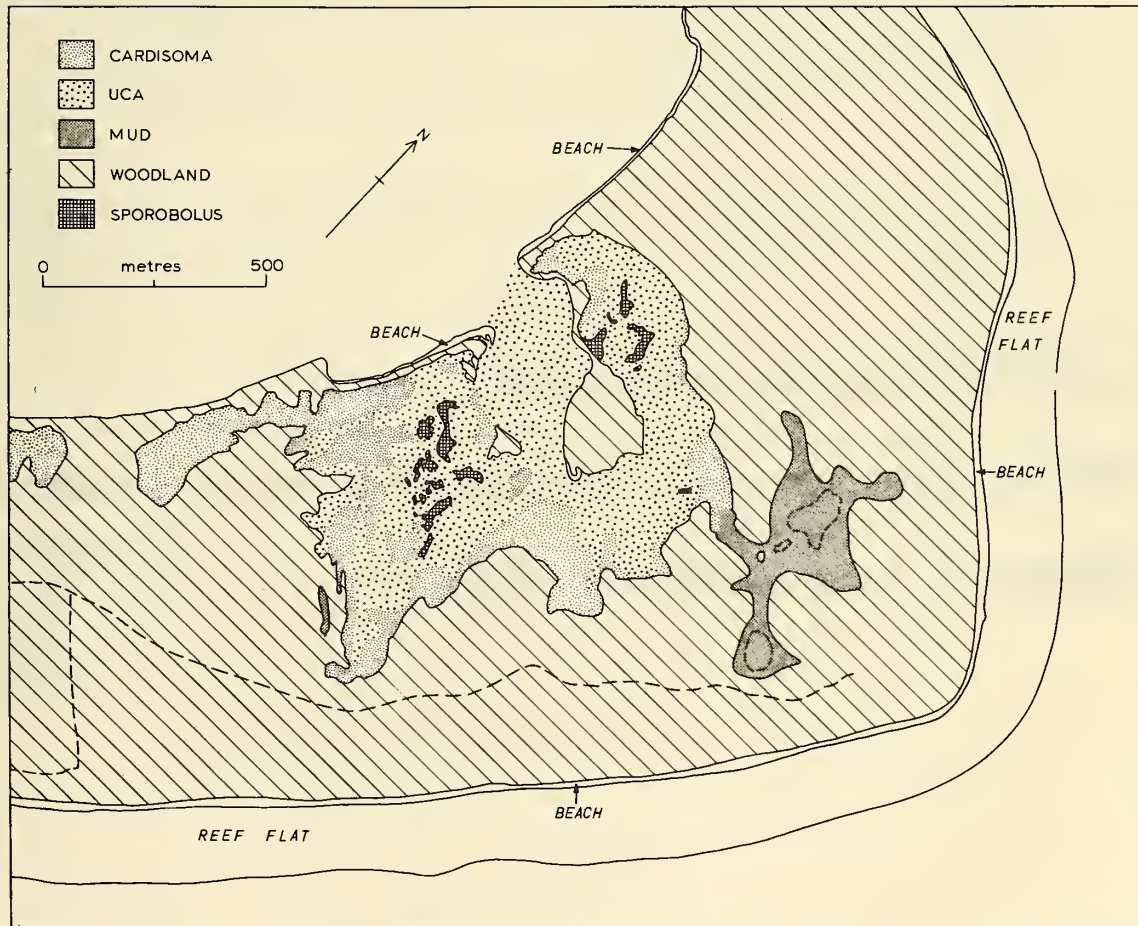


Fig. 5. Barachois Maurice. Based on Crown Copyright air photographs.

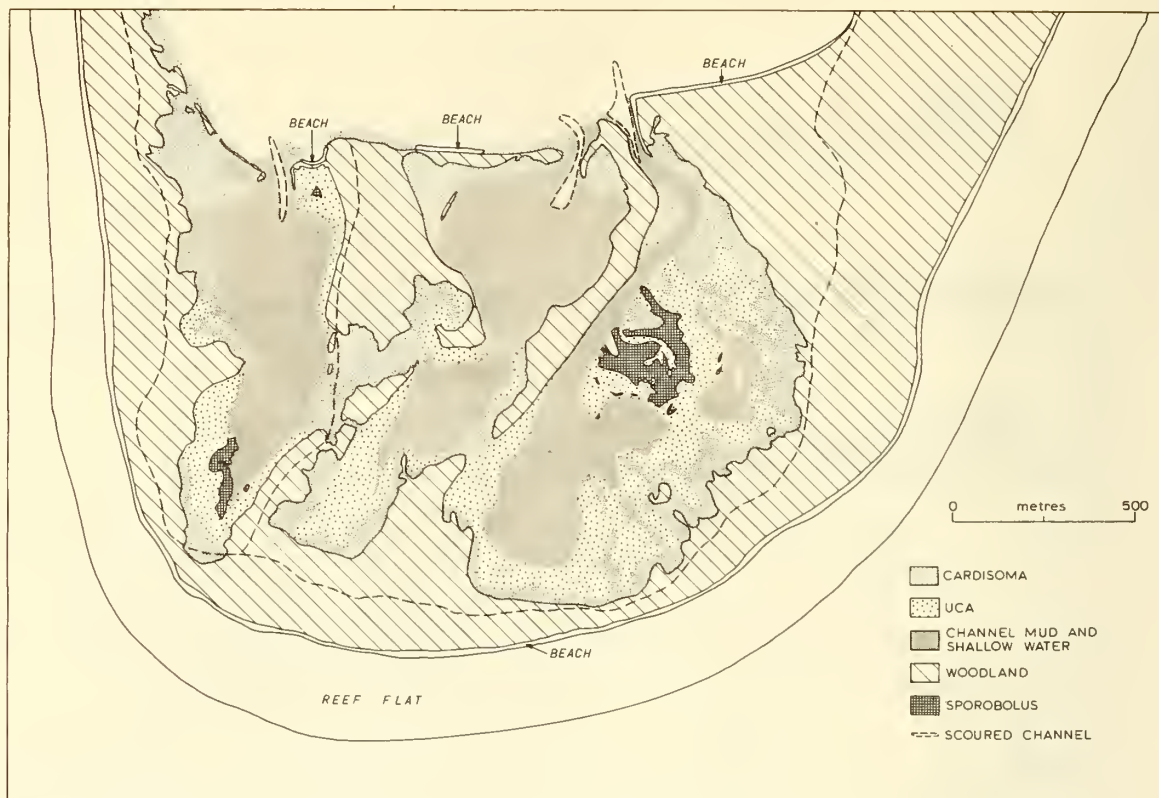


Fig. 6. Barchois Sylvain. Based on Crown Copyright air photographs.

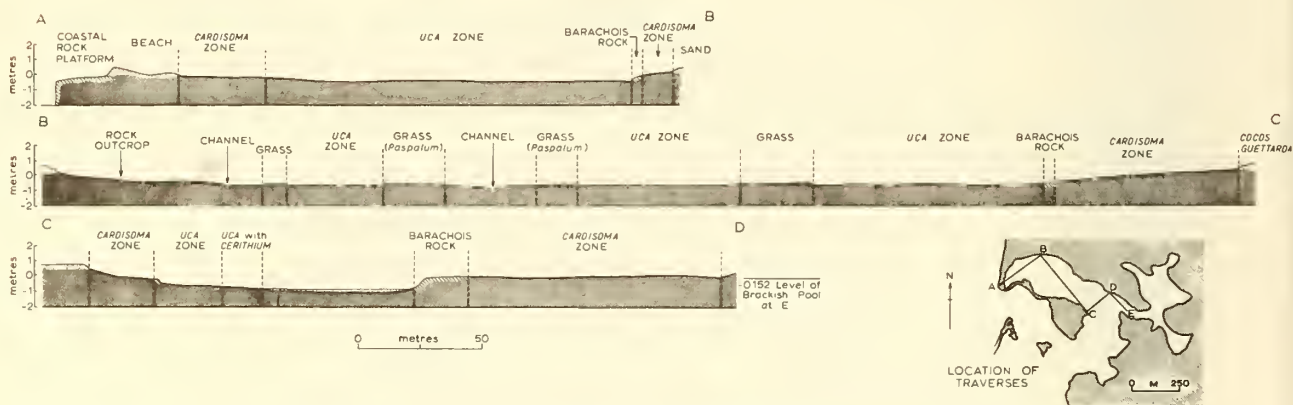


Fig. 7. Profiles in Barchois Maurice.

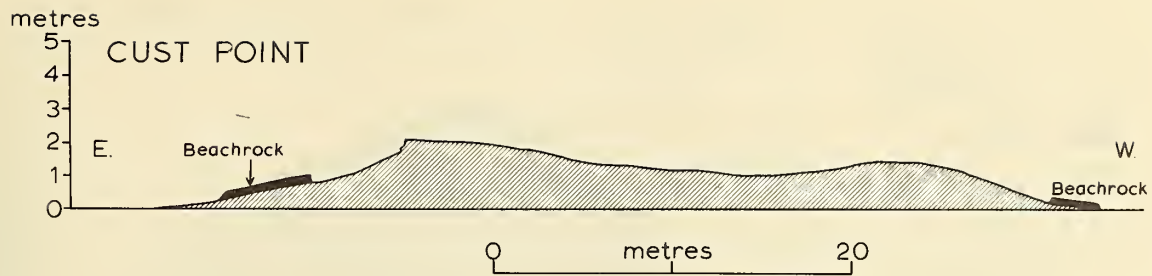


Fig. 8. Profile of the land rim at Cust Point.

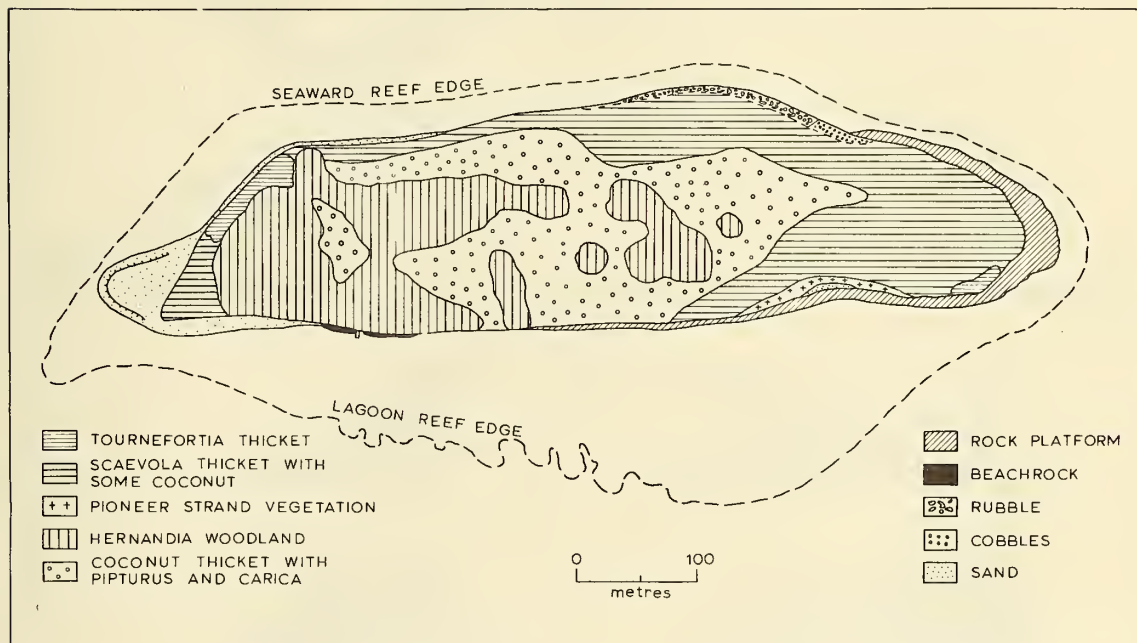


Fig. 9. West Island.

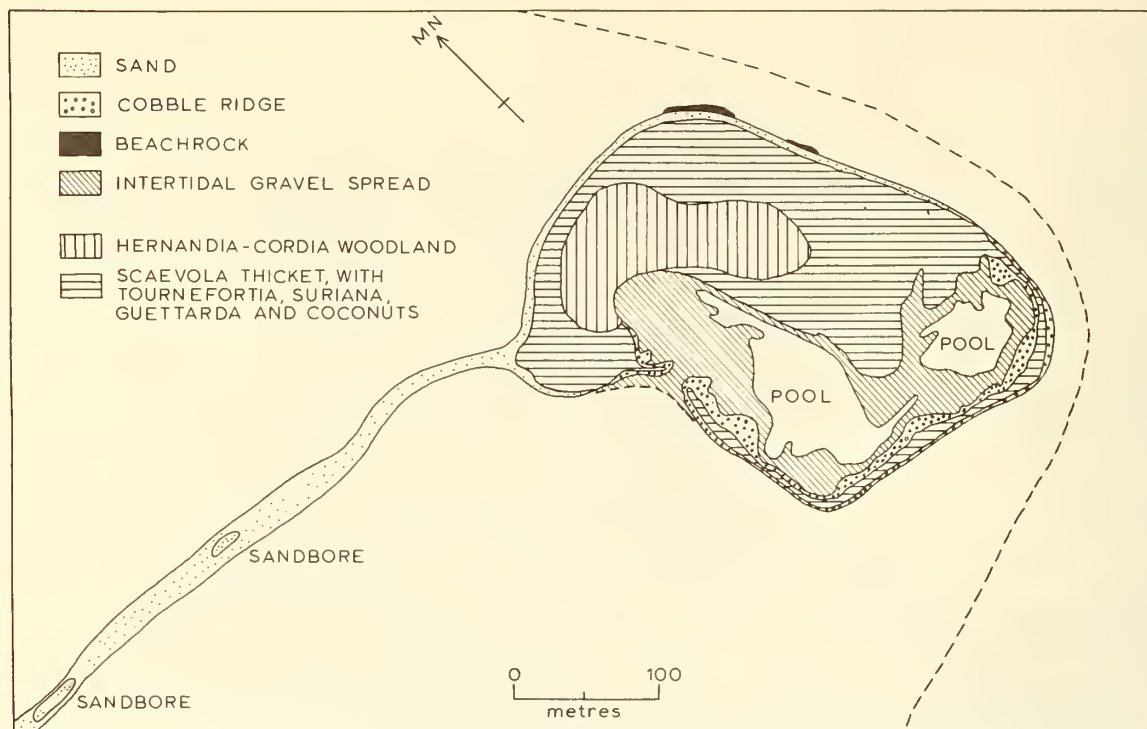


Fig. 10. Middle Island.

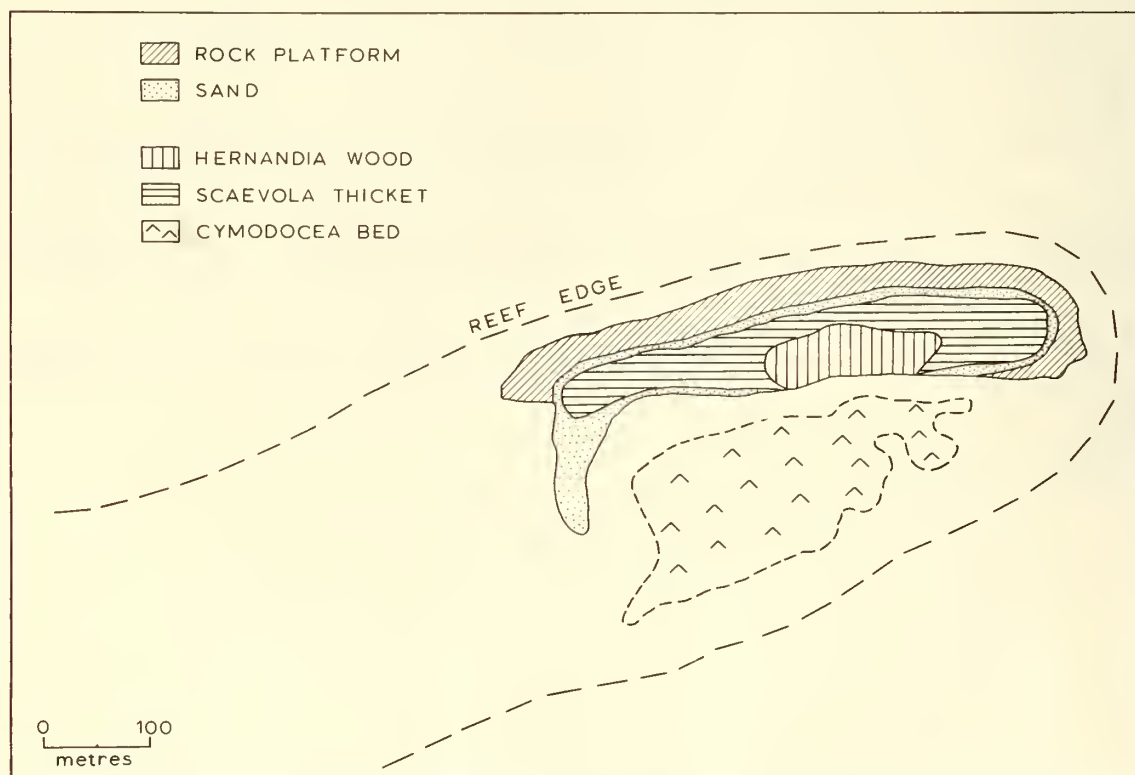


Fig. 11. East Island.

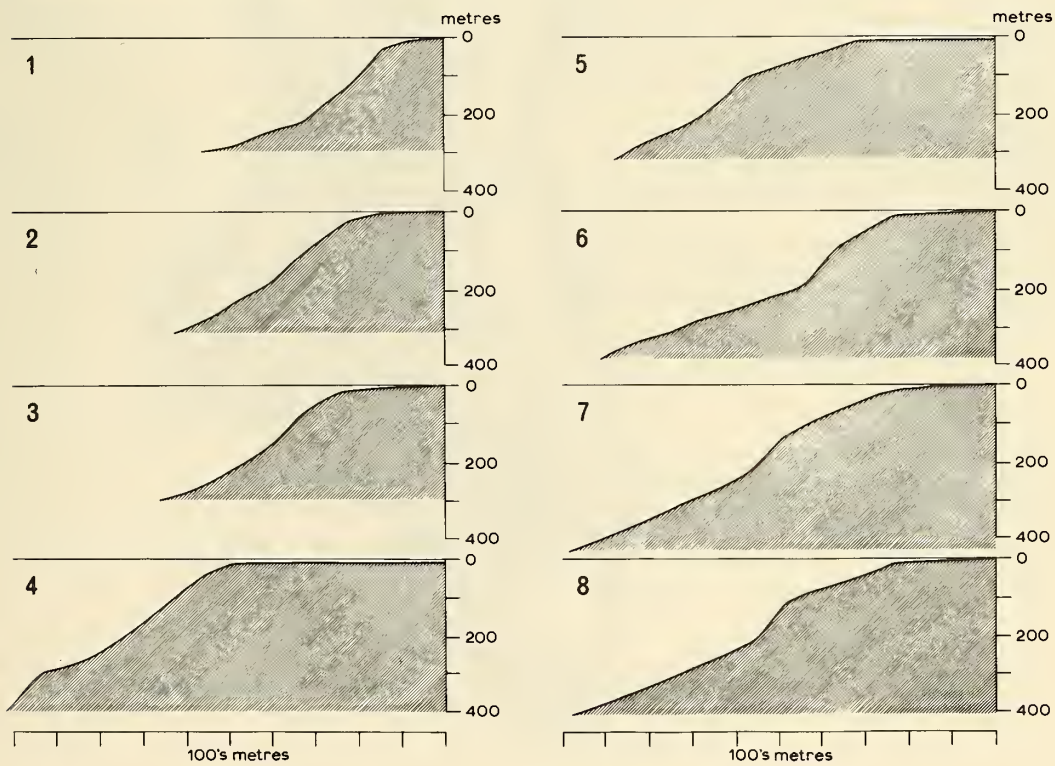
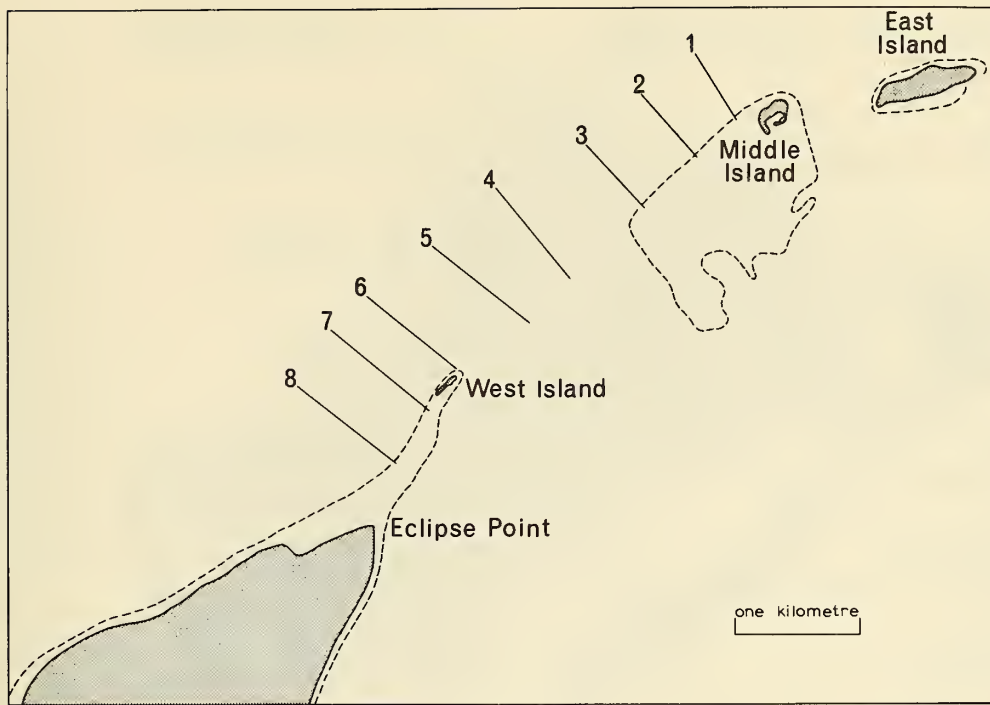


Fig. 12. Profiles of the seaward reef front, north side of the atoll. From a survey by HMS Vidal 1967 and reproduced with the sanction of the Controller, Her Majesty's Stationery Office and of the Hydrographer of the Navy.

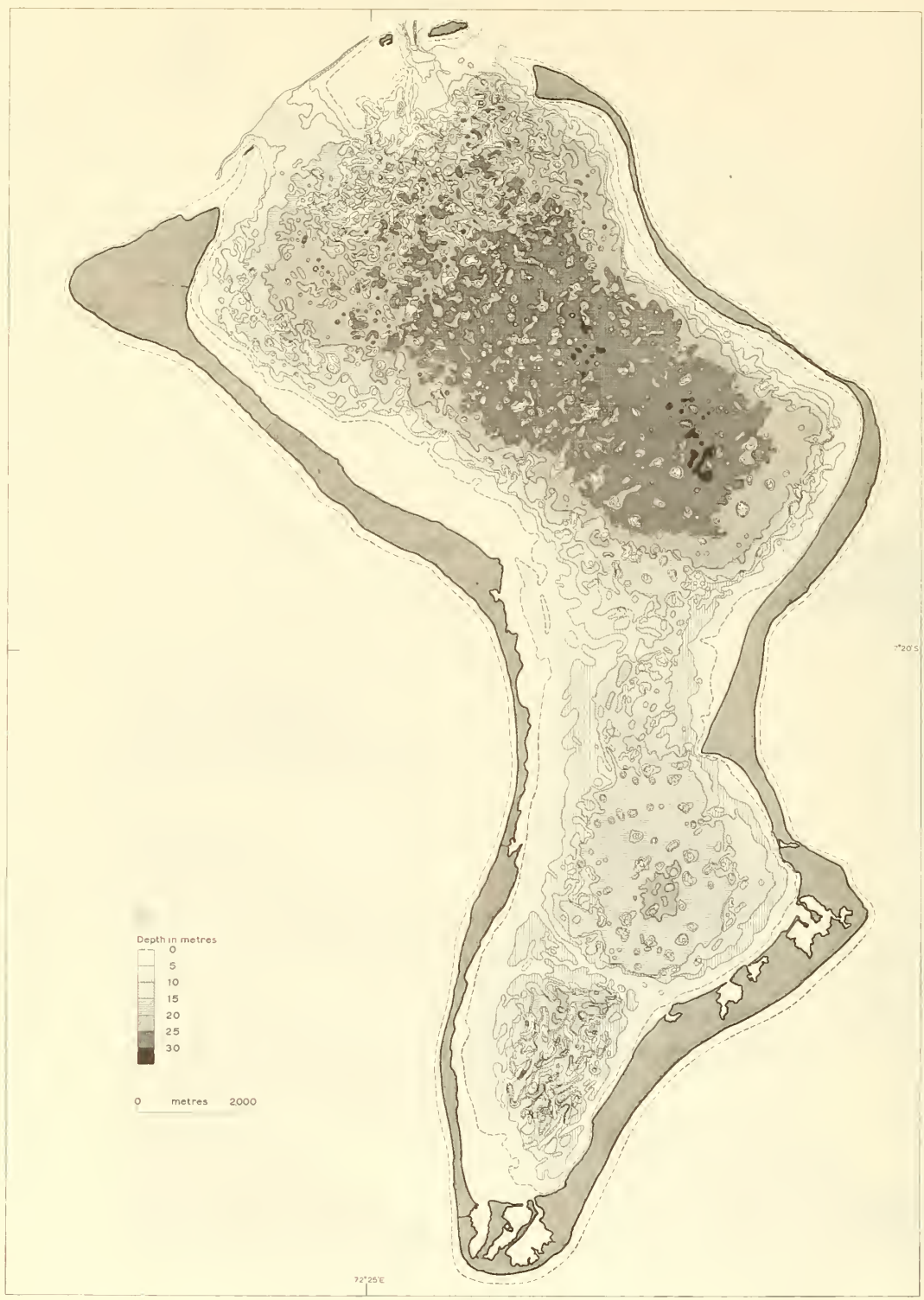


Fig. 13. Bathymetry of the lagoon floor. From a survey by Captain C.R.K. Roe, DSC, RN, HMS Vidal 1967 and reproduced with the sanction of the Controller, Her Majesty's Stationery Office and of the Hydrographer of the Navy.

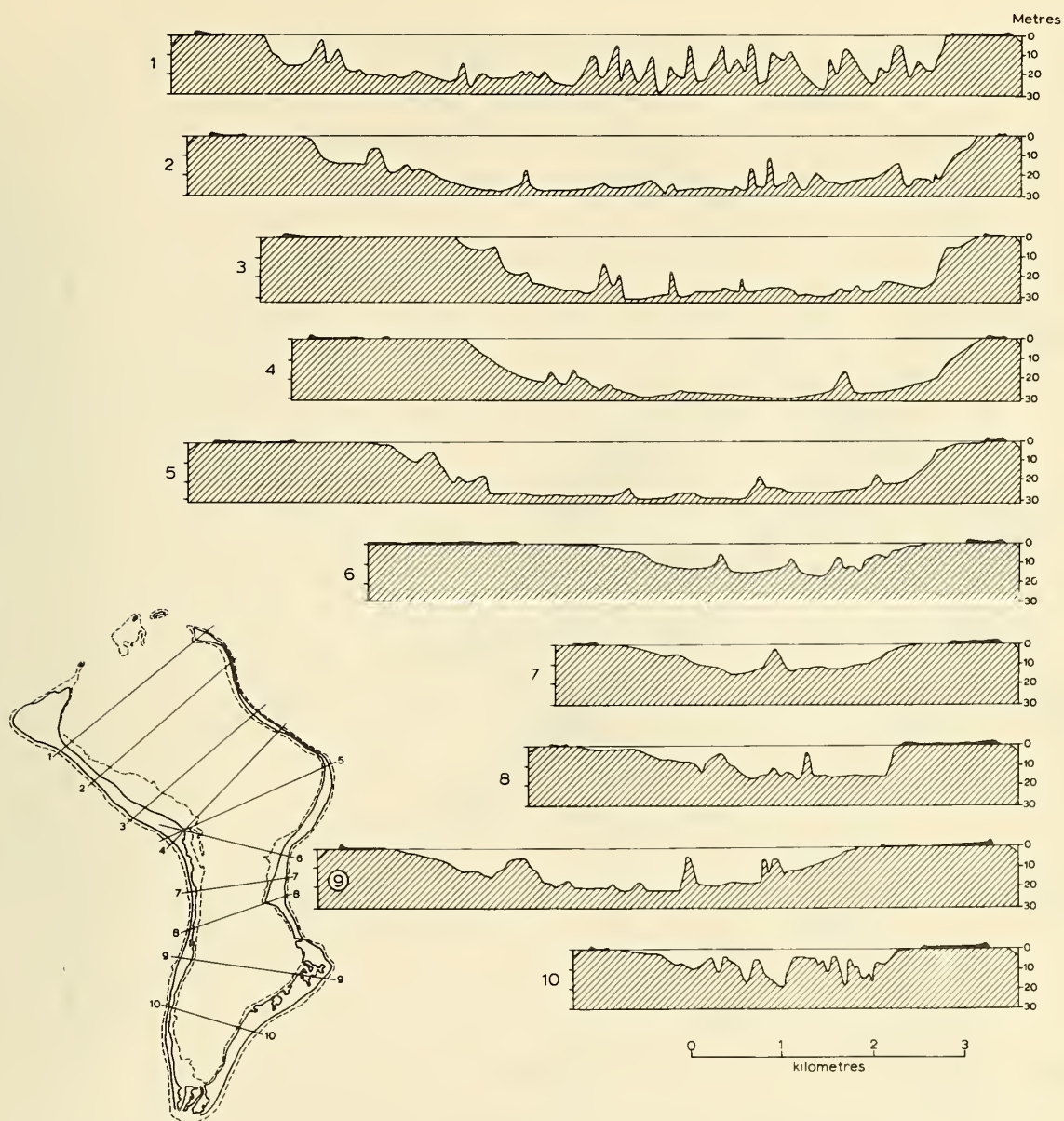


Fig. 14. Profiles of the lagoon floor. From a survey by HMS Vidal 1967 and reproduced with the sanction of the Controller, Her Majesty's Stationery Office and of the Hydrographer of the Navy.

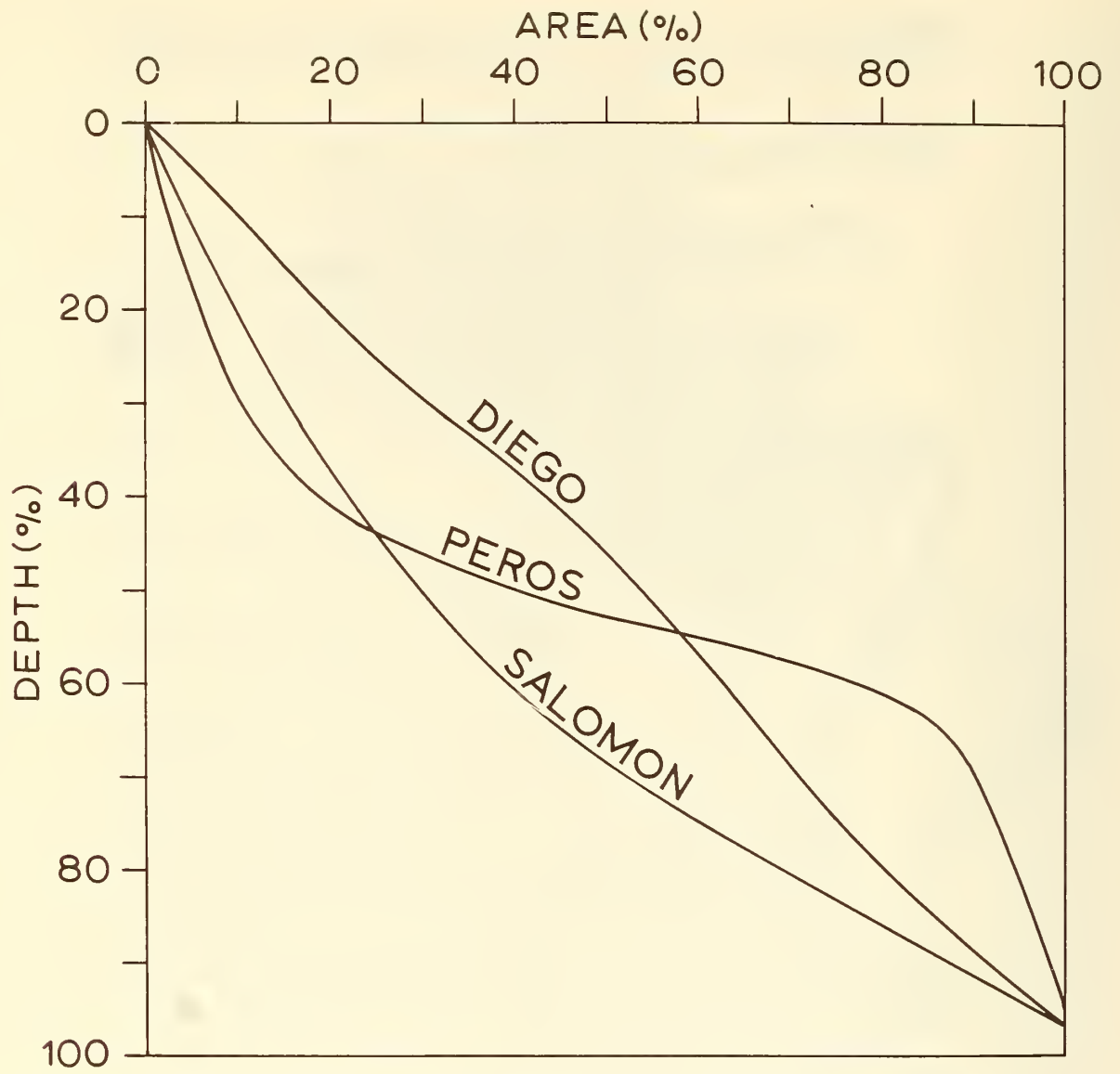


Fig. 15. Hypsometric curves for lagoons of atolls in the Chagos Archipelago.

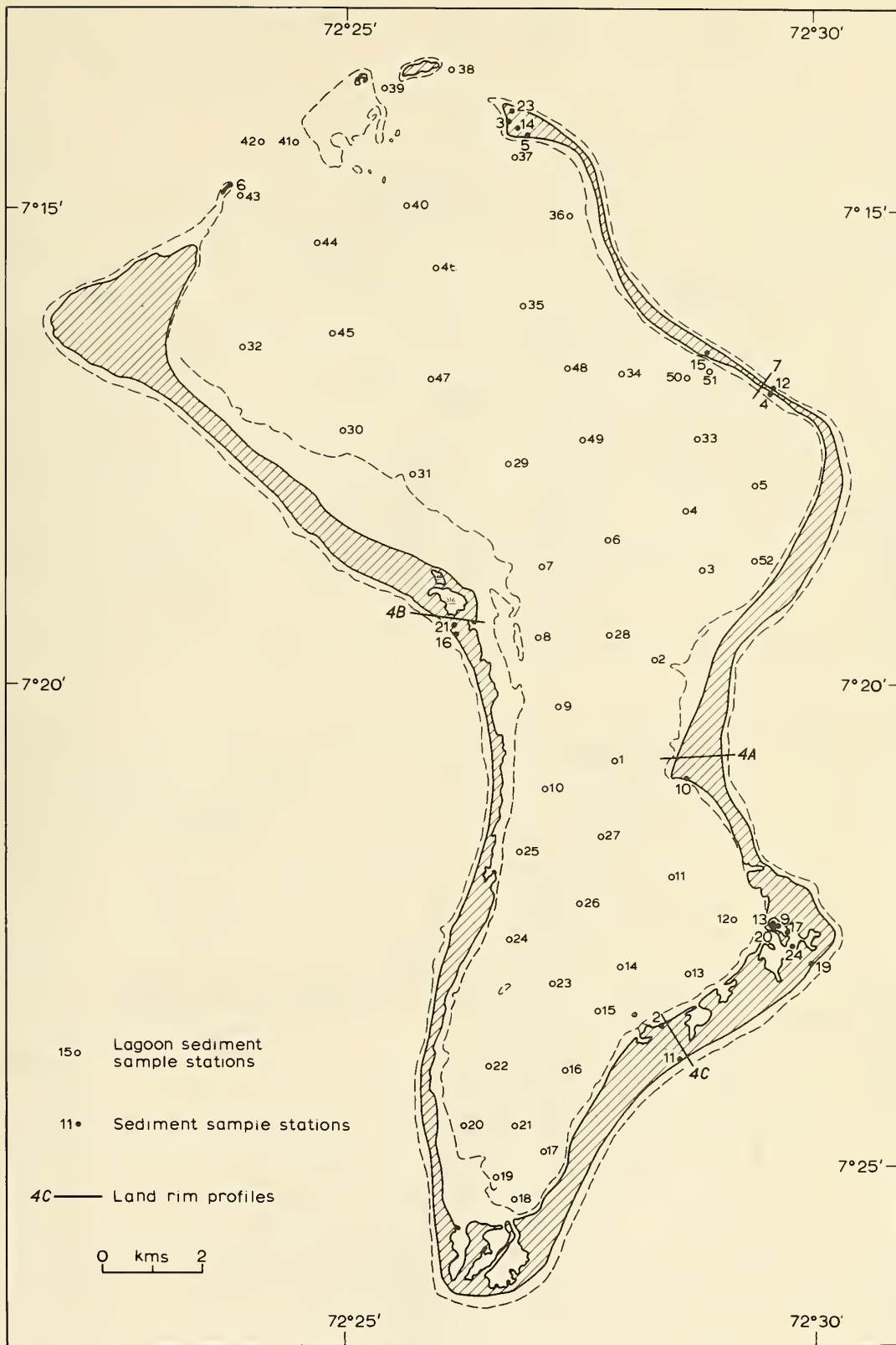


Fig. 16. Location of sediment samples. (a) Land rim and (b) Lagoon floor.

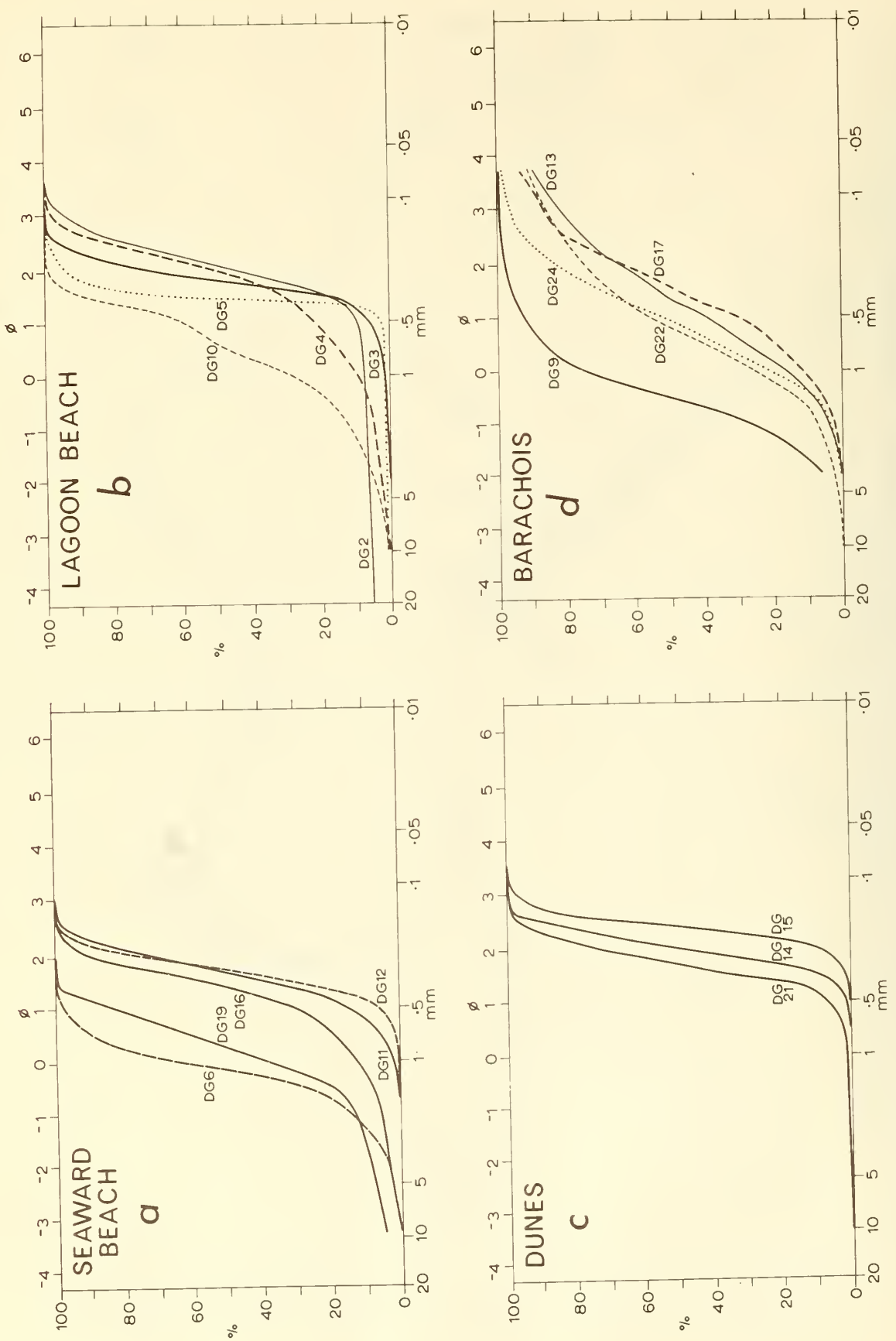


Fig. 17. Cumulative frequency curves for sediment samples from (a) seaward beach, (b) lagoon beach, (c) dunes, and (d) barachois environments.

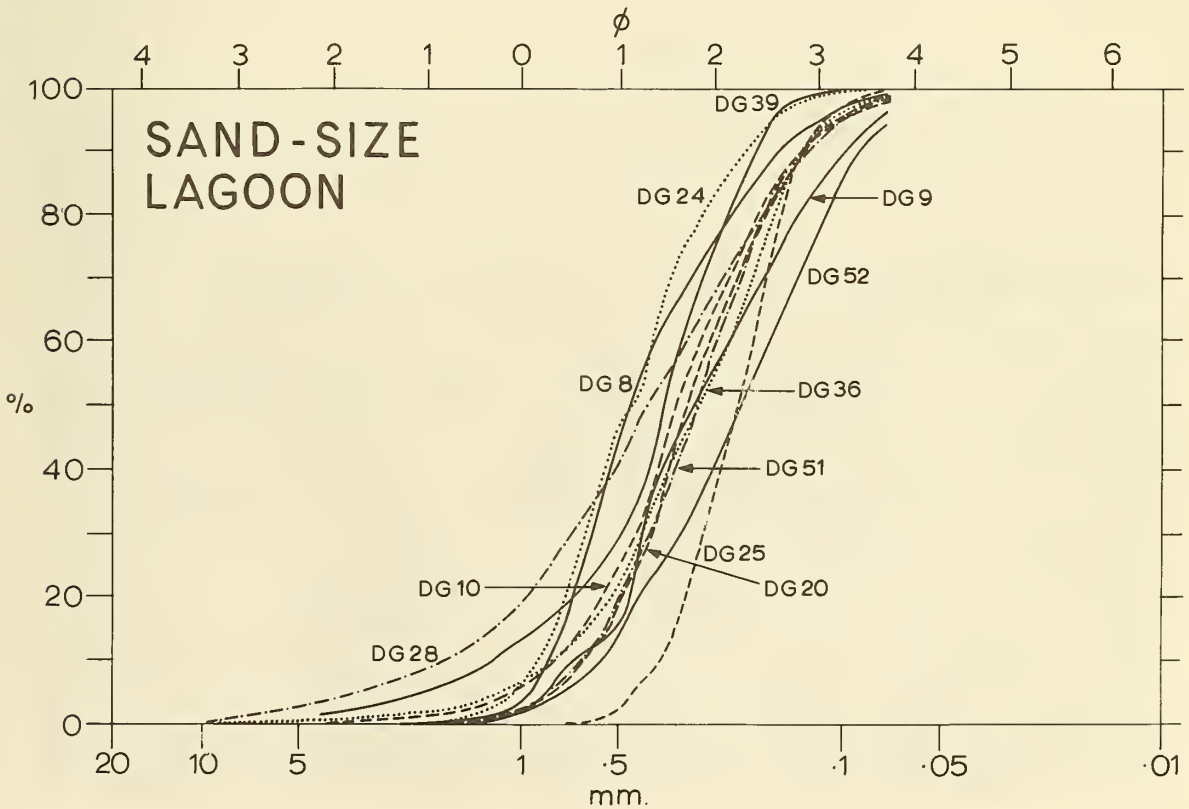
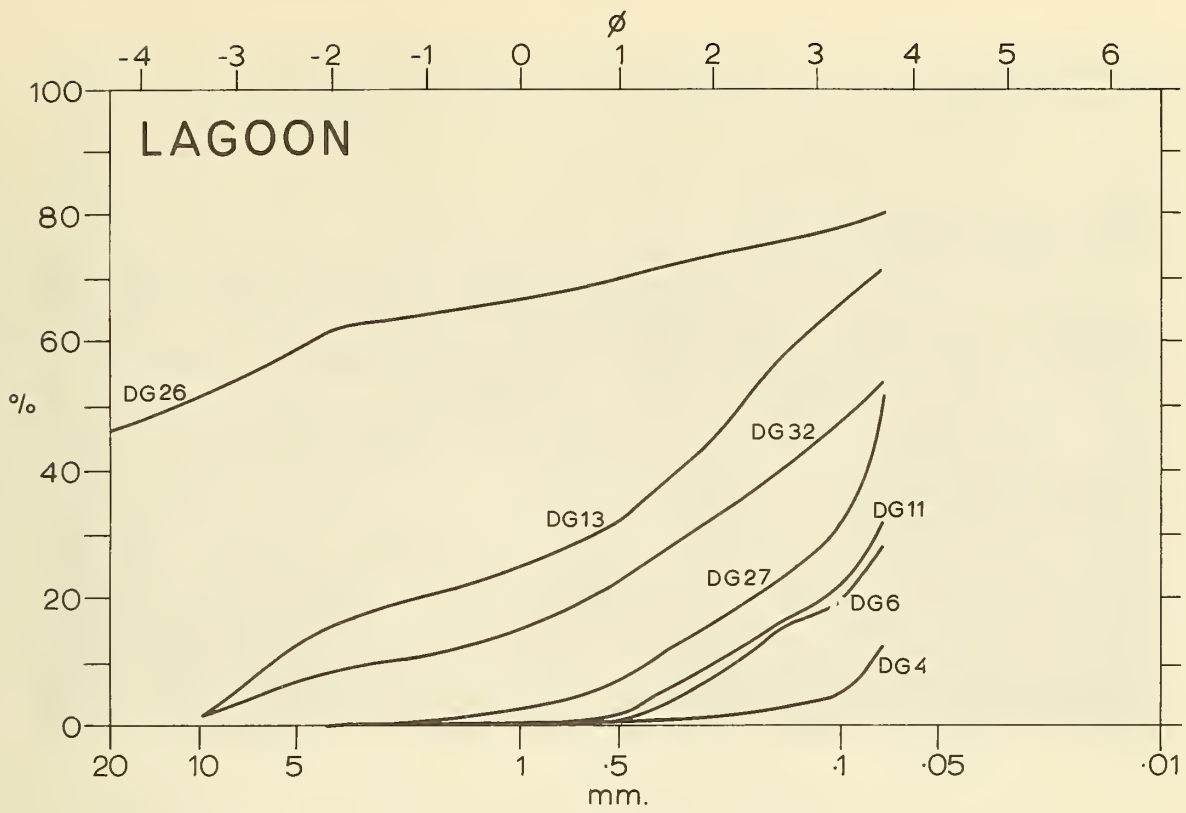
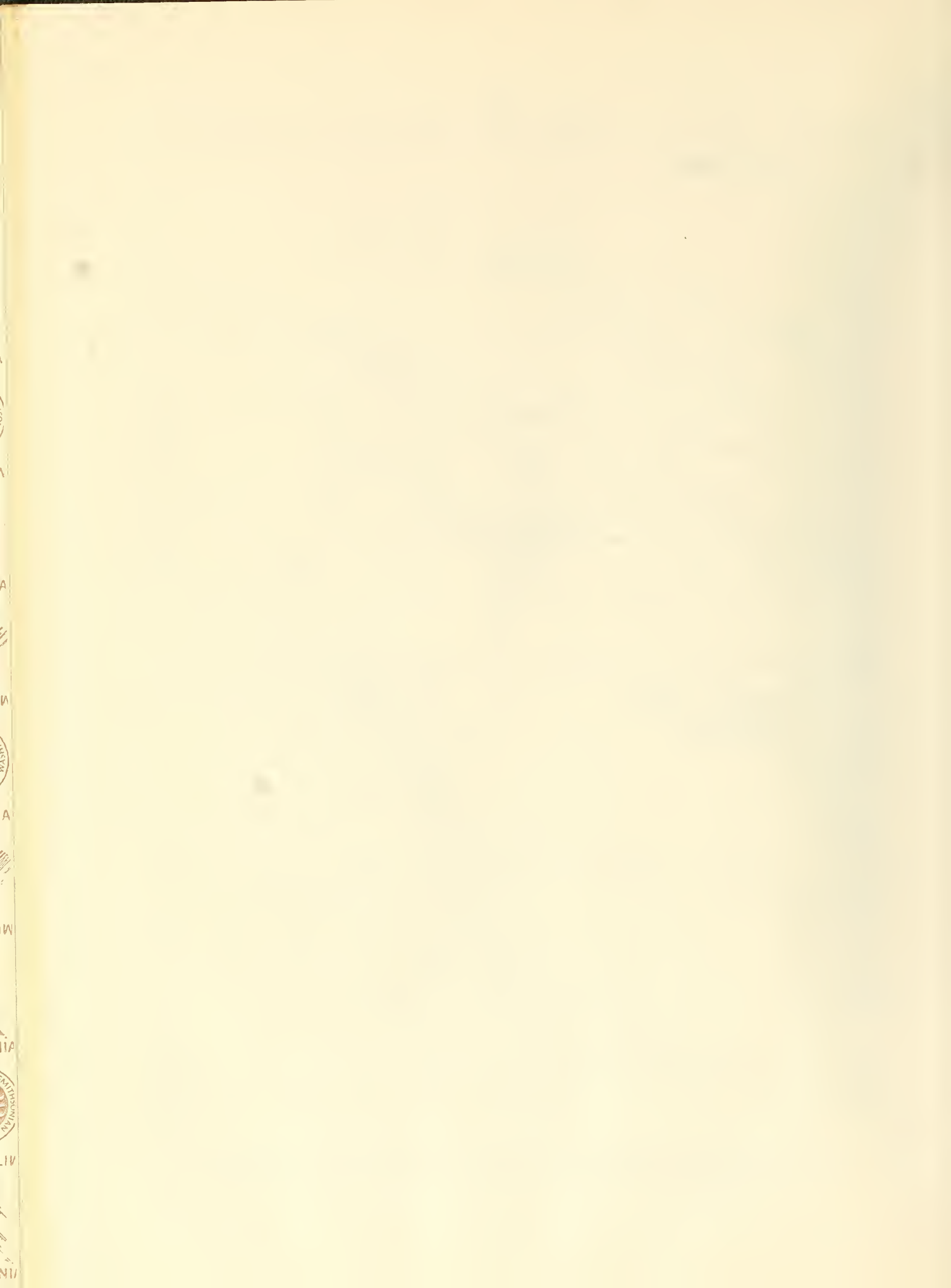


Fig. 18. Cumulative frequency curves for lagoon floor sediment samples.



A
A

A

W



A



W

A



A



A



1. Algal rim of seaward reef flat, west coast reefs near Pointe Marianne

2. Surge channels in the algal rim; same locality as Plate 1





3. Boulder spread on the seaward reef flat at Barton Point

4. Low sand beach with boulders on the inner reef flat, seaward coast south of Barton Point





5. Wide sandy beach with Scaevola hedge and coconut woodland, seaward coast at East Point, looking south to Horsburgh Point

6. East coast sand and gravel beach at Horsburgh Point, looking north to Cust Point





7. Cobble beach on exposed and retreating seaward coast, southeast coast 4 km northeast of Barachois Sylvain
8. Wide low-angle sandy beach, west coast, looking north from Pointe Marianne to Simpson Point





9. Retreating sandy beach with slightly cliffed dunes covered with Scaevola, seaward coast at Simpson Point
10. Lagoon coast, northeast rim between Cust Point and Observatory Point: most of this coast is lined with Scaevola, but at this point the vegetation has been cleared to reveal the lagoon dune ridge





11. Lagoon coast near Mamzelle Adélie, west rim: the coast is formed by a low eroding rock platform and there is no beach

12. Small barachois at Carcasse, looking from the seaward beach ridge towards the lagoon entrance





13. Barachois Maurice: blackened surface gravel with cones of white sand excavated by Cardisoma
14. Paspalum turf in the higher parts of Barachois Maurice; immediately below the turf is the Uca zone, and many of these crabs can be seen





15. Meandering tidal channels, floored with calcilutite, and incised into the sandy Uca flats, Barachois Maurice
16. Large barachois at Pointe Marianne, surrounded by coconut woodland, and with Bacopa monnieri growing in the water





17. Large barachois at Pointe Marianne, surrounded by coconut woodland, and with Bacopa monnieri growing in the water

18. Dead coconut trees near the margins of the barachois at Pointe Marianne





19. Casuarina woodland on the margin of the Pointe Marianne barachois

20. Ledge of conglomerate rock exposed in the mid and upper beach on the seaward coast at East Point: the rock contains many corals, mainly Acropora species, but not in the position of growth





21. Ledge of conglomerate rock exposed in the mid and upper beach on the seaward coast at East Point: the rock contains many corals, mainly Acropora species, but not in the position of growth
22. Eroded upper beach on the seaward coast at East Point, near to the rock exposure shown in Plates 20-21. The sediments are not cemented, but otherwise they closely resemble in calibre and composition the conglomerates exposed nearby





23. The conglomerate ledge of Plates 20-21, which shows no clear dip, passes laterally southwards into an eroded beach-foot platform which is in places surmounted by seaward-dipping calcarenites which resemble typical beach rock

24. Well-developed flaggy beach rock on the southeast seaward coast, 6 km northeast of Barachois Sylvain





25. Massive fine-grained calcarenites forming an eroding ledge on the upper beach, western seaward coast north of the southern point

26. Massive calcarenites showing a slight seaward dip and also undercutting, near the exposure shown in Plate 25; a rock platform also outcrops on the lower beach





27. Smooth flaggy beach rock on a fine sand beach at Simpson Point

28. Grooved and fluted fine-sand beach rock at Simpson Point





29. Undercut cliffs in cemented sands round the inner margins of Barachois Maurice: the Uca zone is immediately below the cliffs, and the surface above the cliffs is covered with an algal mat
30. Isolated remnants of a formerly more extensive cemented surface, similar to that of the marginal cemented sands, are found within Barachois Maurice itself, surrounded by the Uca zone





31. Massive bedded calcarenites, dipping to the south, exposed on the southeast coast of East Island

32. Same as 31





33. Details of the East Island bedded calcarenites

34. Details of the East Island bedded calcarenites. Towards the eastern end of the island the calcarenites are much broken by wave erosion, forming large blocks



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3. DIEGO GARCIA CLIMATE AND MARINE ENVIRONMENT

D. R. Stoddart

A. Climate

The climate of the Chagos Archipelago is governed primarily by the seasonal migration north and south across the area of a zone of equatorial westerlies separating the Northeast Trades and the Southeast Trades. The zones of convergence between the Equatorial Westerlies and the trades form shear zones with unsettled and often squally weather. The same controls are also recognisable at Addu Atoll, 650 km to the north (Stoddart, ed., 1966, 7-9), but in the higher latitude of Diego Garcia the seasonal distinctions are more clearly defined.

Recording began at the atoll in January 1951, covering temperature, rainfall, and surface winds; some rainfall records are also available for earlier years. Upper wind data are also recorded using a Decca radar wind finder and in some cases theodolite, and upper air soundings are made with M-60 Graw radio-sondes. The service is maintained by the Meteorological Department, Mauritius, and records are published in the Department's monthly series Meteorological Observations and Climatological Summaries. I am indebted to Mr E. G. Davy, Director, Meteorological Services, Mauritius, for providing me with abstracts of the Diego Garcia records. Meteorological records are also kept at Peros Banhos and Salomon Atolls, further north in the Chagos, in both cases since 1951, and the rainfall data from these and other Indian Ocean coral island have been reported separately (Stoddart 1970c).

1. Wind

Figure 19 plots wind frequencies for each month at 0000, 0600 and 1200 GMT for 1956-60, and Figure 20 the same for 0000, 0600, 1200 and 1800 GMT for 1961-1965. Four wind seasons may be distinguished:

- (1) During December-March winds are variable but mainly westerly. The westerlies are most pronounced in February, when easterlies are absent or nearly so.
- (2) April and May represent transitional conditions, with the westerlies weakening and the south-easterlies becoming more important.
- (3) June, July, August and September form the season of the Southeast Trades, with dominant direction 120-150°. Diurnal varia-

tions in constancy are apparent, with maxima at 1200 hrs. By September the Trades are beginning to weaken, and to spread from east round to south.

- (4) October and November represent a second transition period. Winds are variable, though still concentrated at 90-120°. By December, season 1 is again established, with approximate co-dominance of easterlies and westerlies.

The occurrence of calms (Fig. 21) shows a similar seasonal distribution with some diurnal variability; during the Trades calms are infrequent at all times. Modal wind speeds during the period of the westerlies lie in the class 0-2 knots (0.5-1 m/sec) throughout the day; during the Trades the modal class is either 3-7 or 8-12 kts (1.5-3.6 or 4.1-6.2 m/sec). In the period 1961-65 more than 15 per cent of wind velocities recorded in both July and August were of 8-12 kts (4.1-6.2 m/sec). Winds in excess of 18 kts (9.3 m/sec) are not common, though they occasionally occur during the Trades. No wind speeds higher than 25 kts (12.9 m/sec) are recorded.

2. Temperature

The temperature regime follows the seasonal wind pattern. During the period of Equatorial Westerlies and calms, temperatures are higher than during the Trades (Fig. 22). Mean monthly temperature varies from a maximum of 30.75°C in March to a minimum of 28.03° in August, an annual range of 2.7°. Similar variations occur in monthly mean maximum and minimum temperatures:

	<u>Highest</u>	<u>Lowest</u>
Mean maximum	30.75 (March)	28.03 (August)
Mean minimum	25.39 (April)	23.89 (August)

The highest temperatures recorded in each month follow the same seasonal pattern, and are generally 3° higher than the monthly mean maximum, but the lowest temperatures are more erratic. These data are very similar to those for Addu Atoll in the southern Maldives, though the Diego Garcia figures are slightly higher. The highest temperature recorded so far is 33.4°C on 23 January 1958, and the lowest 19.4°C on 16 August 1965, an absolute range of 14°. The diurnal temperature range, as would be expected in such a maritime location, is less than 10°.

3. Rainfall

Rainfall is high and fairly evenly distributed (Fig. 23). The mean annual rainfall for the periods 1937-38 and 1951-66 is 2599 mm (102.32 inches). Actual annual totals, however, vary from 1465 mm to 3805 mm, and the coefficient of variation for the 20 years of record ($\sigma/X \times 100$) is 17.9. These figures may be compared with those for the other Chagos atolls and for Addu Atoll:

<u>Location</u>	<u>Years of record</u>	<u>Mean annual total mm</u>	<u>Lowest recorded</u>	<u>Highest recorded</u>	<u>Coefficient of variation</u>
Diego Garcia	20	2599	1465	3805	17.9
Peros Banhos	14	3999	1612	5410	29.6
Salomon	14	3751	2585	5679	22.9
Addu	9	2383	1881	2990	13.3

It is clear that a narrow ridge of very high rainfall lies across the northern part of the Chagos between Addu and Diego Garcia: from Diego Garcia to Salomon, a distance of 220 km, there is a rainfall gradient of approximately 6 mm per km. It is also apparent that in this area the higher rainfalls are also least reliable.

Monthly rainfall at Diego Garcia is highest in January, February and October, and lowest during the Trades, in April to August, when the monthly mean is less than 200 mm. Actual monthly rainfalls for each year of record tend to be normally distributed about the means, except for the occasional months (six in the 20 years of record) when exceptionally high rainfalls occurred. Monthly rainfalls of more than 500 mm (20 inches) have occurred six times in the period of record, with a maximum of 757 mm (almost 30 inches) in May 1963. Larger monthly totals are experienced much more frequently, however, at both Peros Banhos and Salomon, where monthly falls greater than 500 mm occurred 31 times in 14 years at the former and 33 times in 18 years at the latter; the maximum recorded in a single month is 1037 mm in June 1952 at Peros Banhos. Abnormally low monthly rainfalls are much less common. At Diego Garcia, monthly totals of less than 25 mm (1 inch) occurred five times during the period of record, once each in July, May, September, October and November. The minimum monthly rainfall recorded is 9 mm in June 1937. The mean rainfall per rain day (Fig. 24) also varies seasonally, with a distinct minimum (less than 10 mm) at the height of the Trades in June and July. The maximum daily fall in each month shows considerable scatter but little seasonal trend. Daily falls of more than 100 mm (4 inches) have occurred at least twice in each month over 1951-1967 in all months except November and December. The maximum recorded daily fall, 328.7 mm, occurred on 19 August 1955.

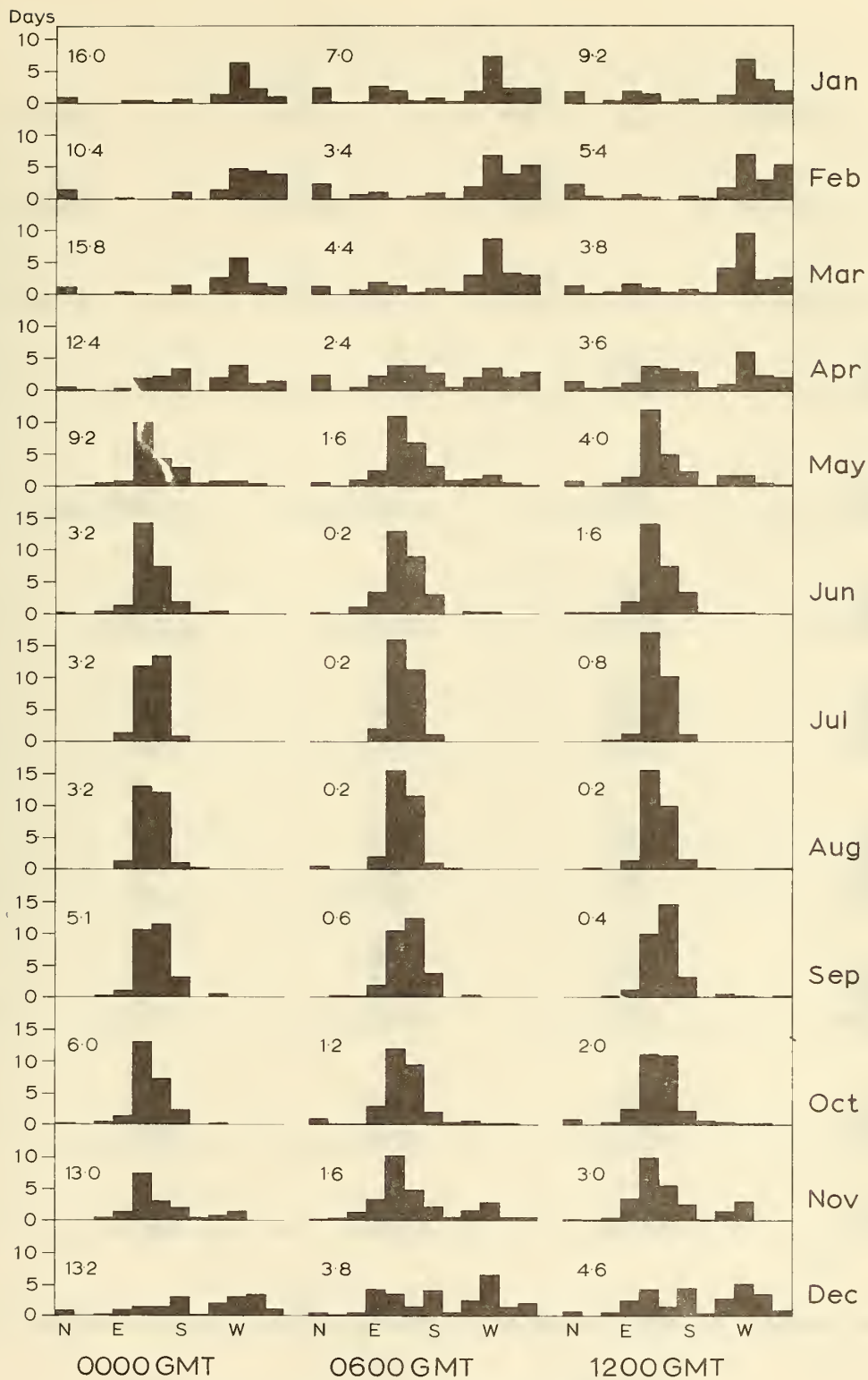
4. Tropical cyclones

Because of the low latitude of Diego Garcia, tropical cyclones are rare, though according to Mr E. G. Davy (personal communication) fresh westerly winds may be experienced when cyclones form or pass to the south of the Atoll. Mr Davy states that "nevertheless, on the 16-17th September 1944, cyclonic winds sufficient to be of importance in ecological studies almost certainly occurred. There are no records of wind speed but a cyclone of moderate strength passed just south of the island and destroyed two Catalina flying boats."

B. Tides

Tides at Diego Garcia are semi-diurnal, and rather greater in amplitude than those of the southern Maldives. Several periods of record are available, the most recent being those made by H.M.S. Vidal from 14 June to 27 July 1967 (Fig. 25). The most complete record is that for the East Point settlement. The maximum range at springs is 1.6 m and the minimum at neaps 0.7 m (compare 0.97 and 0.27 m respectively at Addu Atoll). Records are also available for Eclipse Point, just within the lagoon entrance. Comparison of the two curves shows no significant lag or change in amplitude between the lagoon entrance and a point 15 km within it. This is perhaps surprising in view of the shallowness of the entrances and the degree of enclosure of the lagoon.

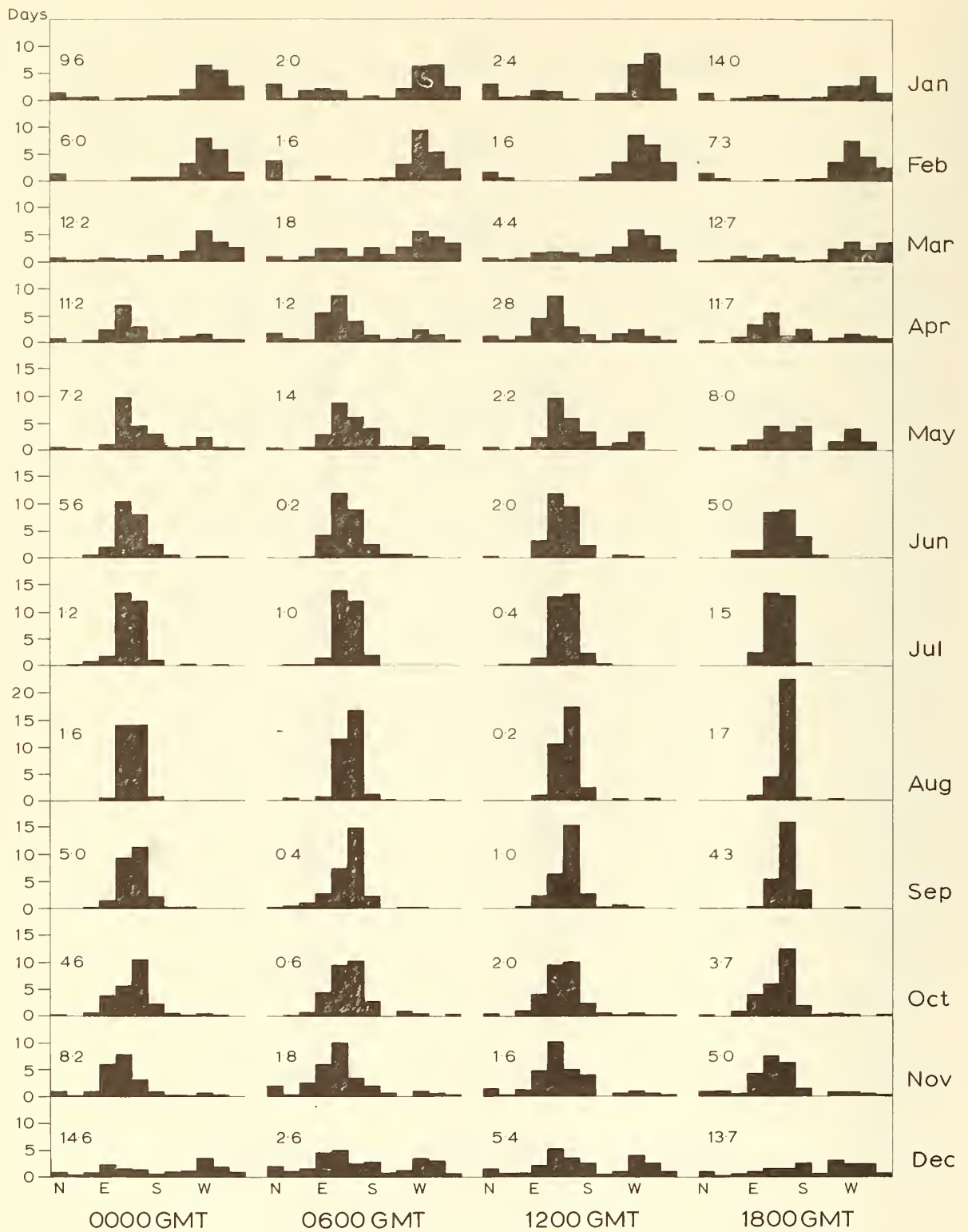
No other data are available from Diego Garcia itself on water temperature and salinity, though the general characteristics of the area can be found in many oceanographic texts.



Surface wind frequencies 1956-60

Figures represent number of observations of calms per month

Fig. 19. Surface wind frequencies for each month at 0000, 0600 and 1200 GMT, 1956-1960.



Surface wind frequencies 1961 - 65
 Data for 1800 GMT for 1961, 1964 and 1965 only
 Figures represent number of observations of calms per month

Fig. 20. Surface wind frequencies for each month at 0000, 0600, 1200 and 1800 GMT, 1961-1965.

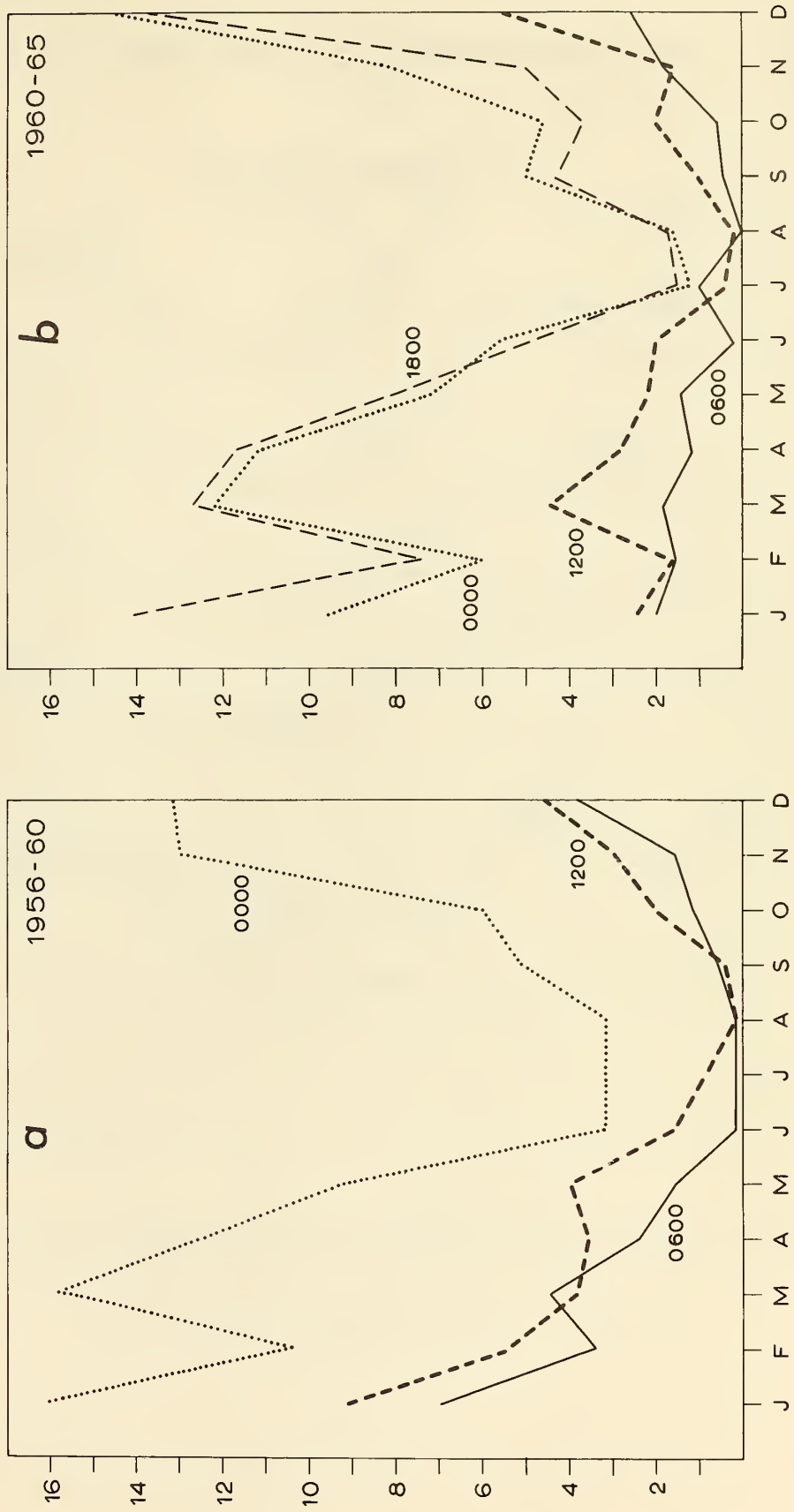


Fig. 21. Occurrence of calms, (a) 1956-1960, (b) 1961-1965.

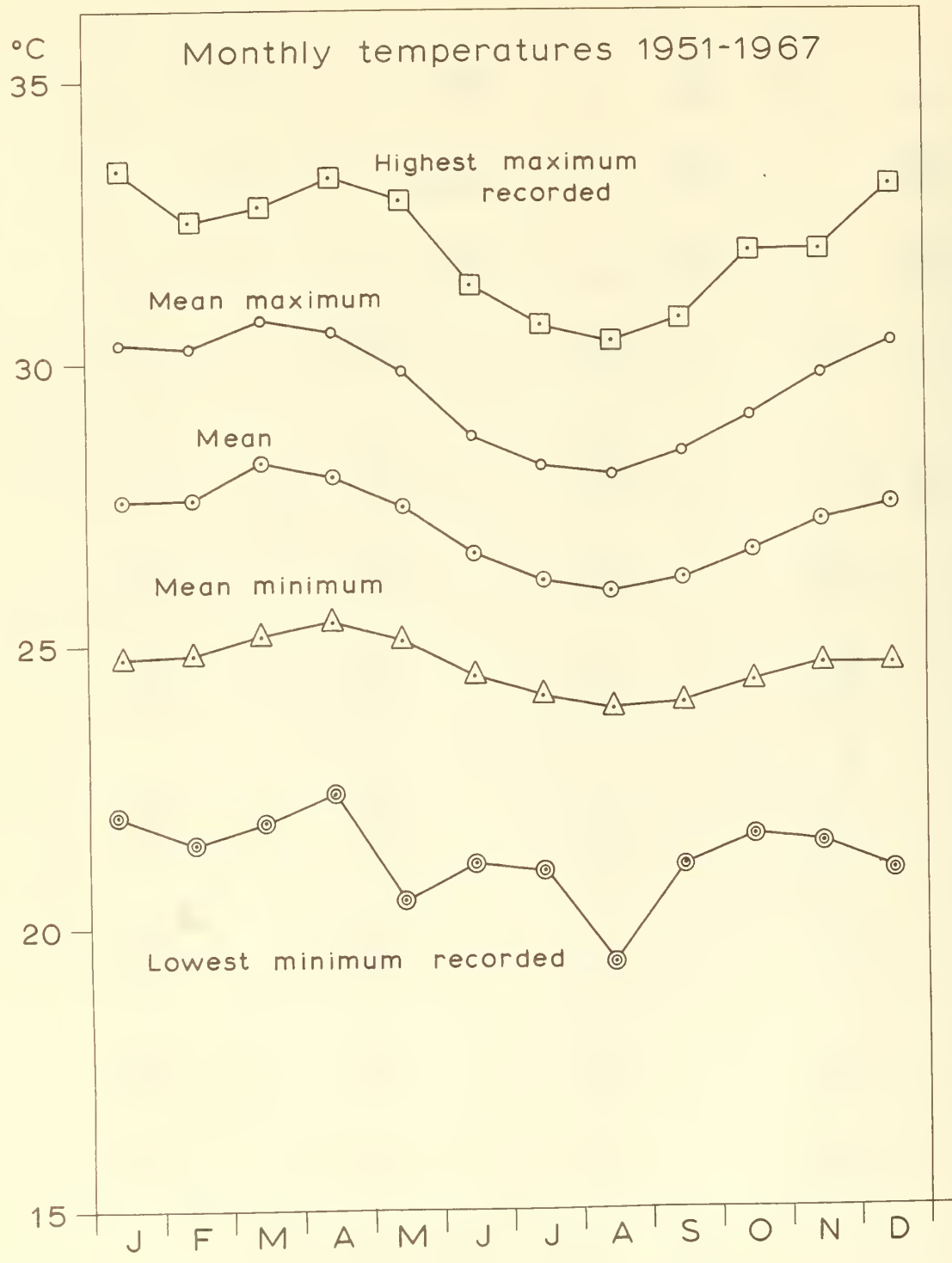


Fig. 22. Monthly temperatures 1951-1967.

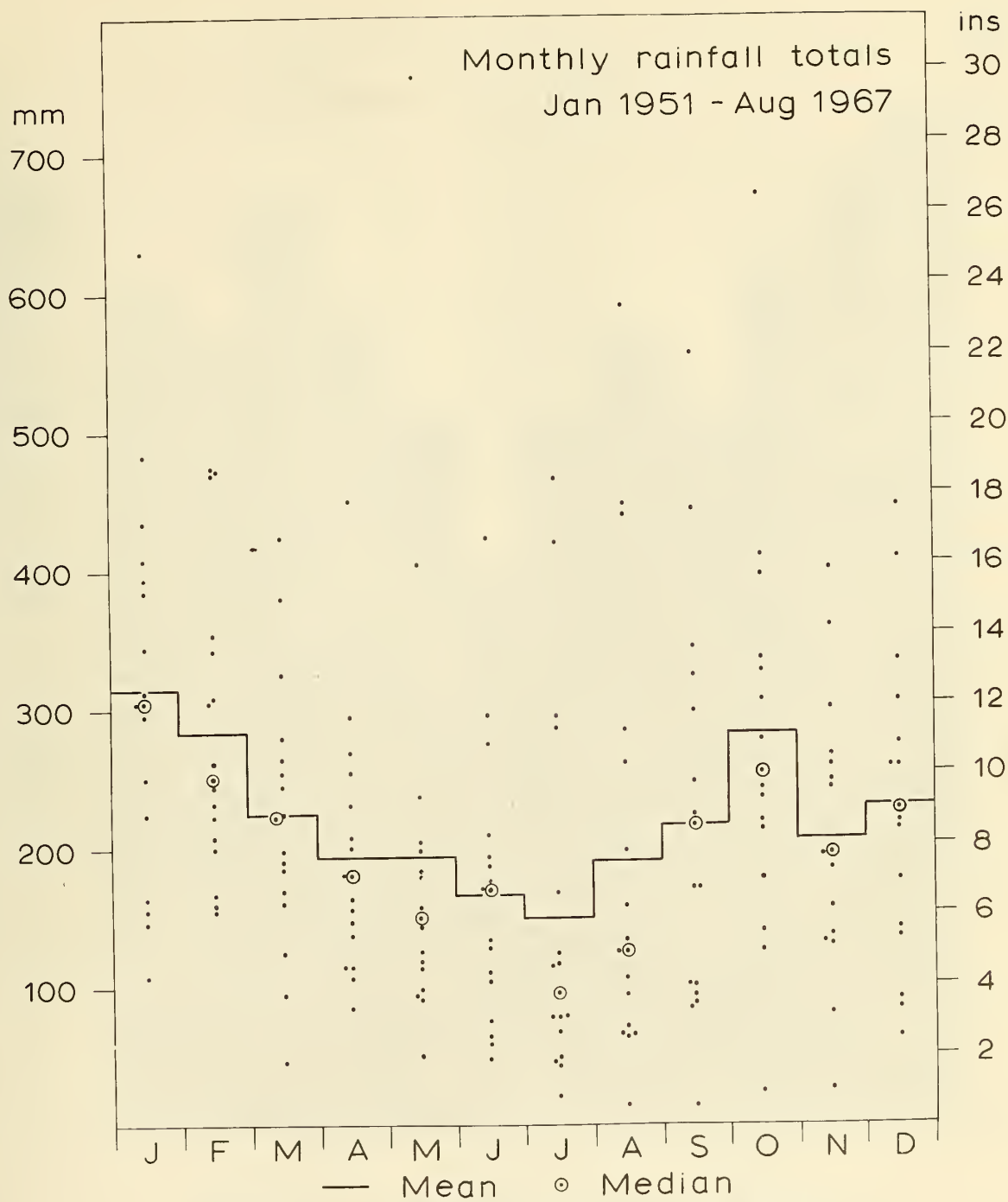


Fig. 23. Monthly rainfall 1937-1938, 1950-1966.

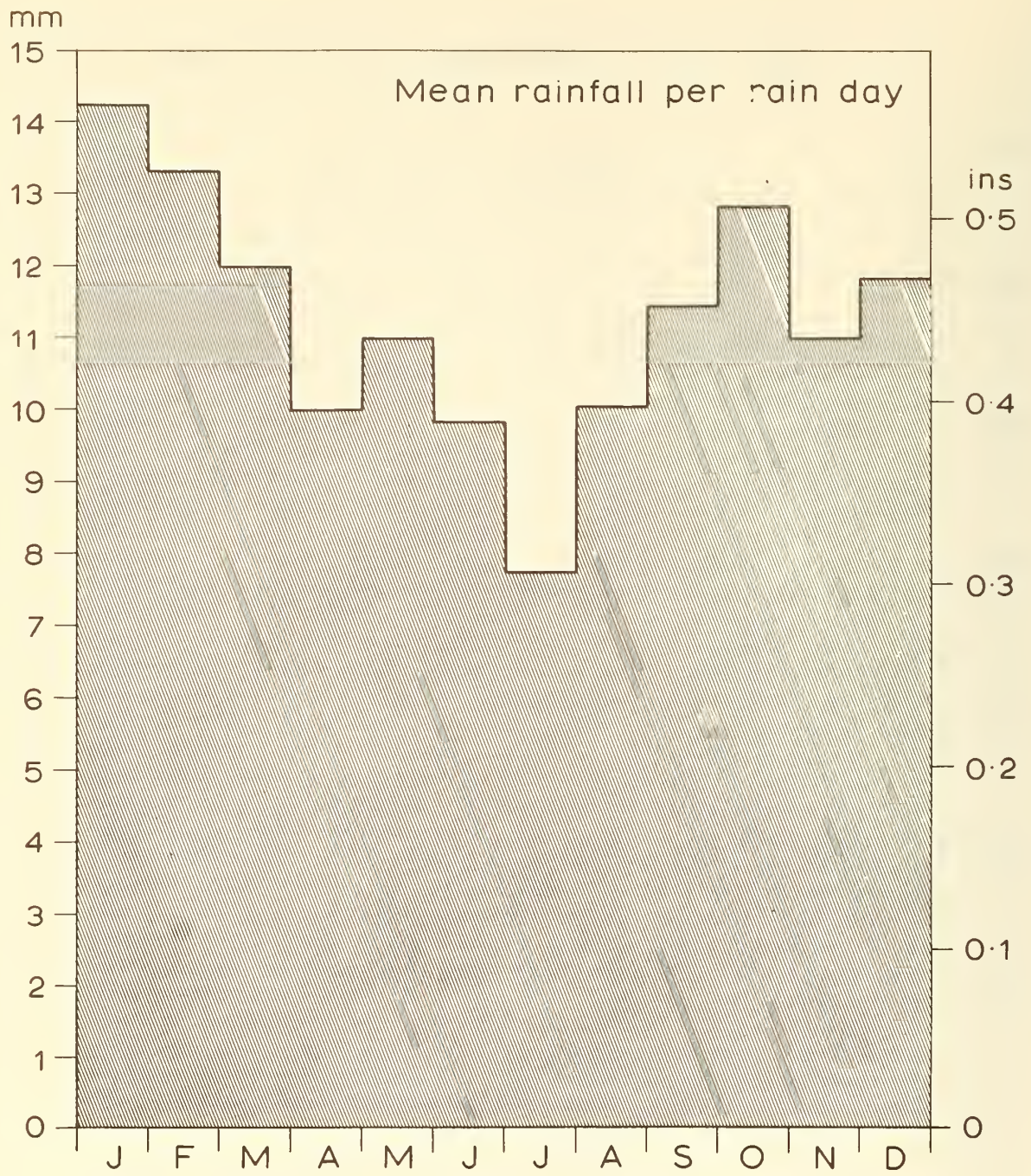


Fig. 24. Mean rainfall per rain day for each month.

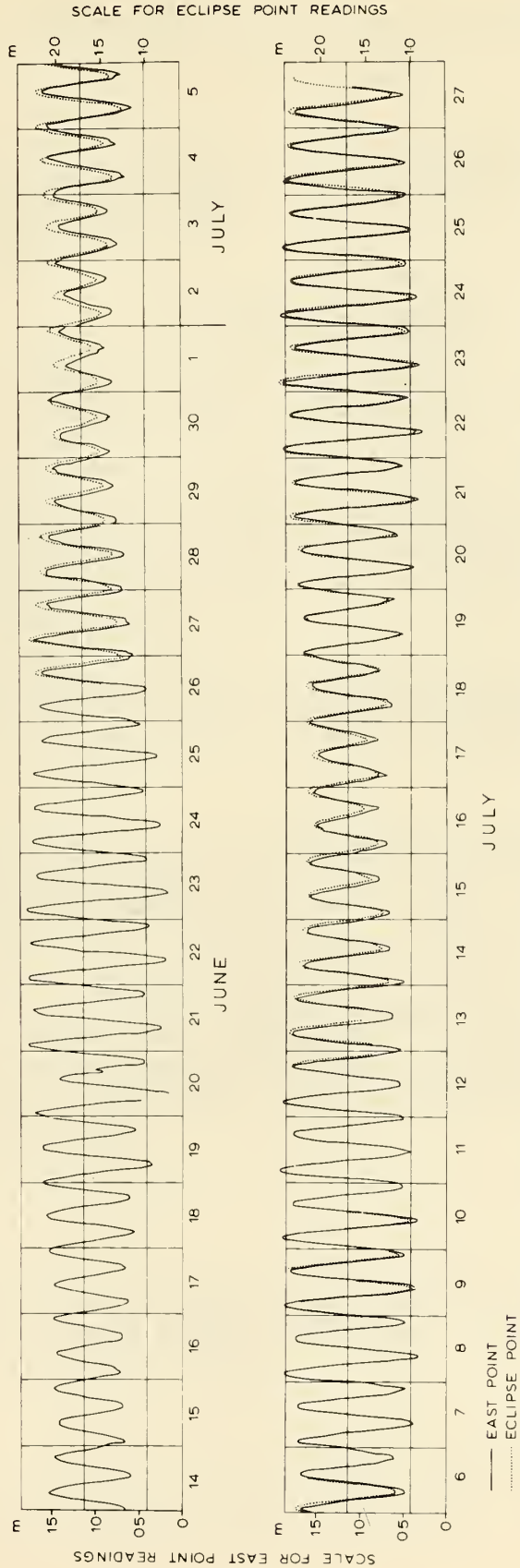


Fig. 25. Tidal records at East Point and Eclipse Point, June-July 1967. From observations by HMS Vidal and reproduced with the sanction of the Controller, Her Majesty's Stationery Office and of the Hydrographer of the Navy.

4. OBSERVATIONS ON THE SHALLOW-WATER MARINE FAUNA

John D. Taylor

The following observations on the zonation and distribution of marine invertebrates were made during the course of 18 days reconnaissance collecting in July 1967.

A. Intertidal zonation

Under this heading is discussed zonation on beachrock and on vegetation in the littoral fringe* and eulittoral zones.

On seaward shores beachrock exposures are common either as continuous units, broken blocks or both. On lagoon shores beachrock is not frequent but in the southern parts of the lagoon there are widespread exposures of horizontally bedded limestone associated with the barachois. Intertidal fauna may occur on tree trunks and vegetation overhanging the lagoon shores.

The most exposed seaward shore studied on Diego Garcia is at West Island. Here there is a raised limestone ramp with surge channels and potholes at the lower portions and loose boulders higher up the shore (Fig. 26).

The littoral fringe* is occupied by blue green algal encrustations on the limestone and a sparse colonisation by the gastropods Littorina glabrata and Nerita plicata. Below this there is a bare grey coloured zone about 5 m in width followed by a red algal turf, a green algal zone, and in the surf a crust of calcareous red algae. This lower eulittoral zone is characterised by many predatory gastropods such as Drupa, Morula, Strigatella litterata, Engina bonasina and Conus sponsalis. The only other common species is Nerita albicilla. Limpets and barnacles are conspicuously absent. Grapsus tenuicrustatus is common all over the shore and Clibanarius abundant in the lower parts of the eulittoral zone.

* For an explanation of zonation and terminology, see Lewis, J. R., 1964, The ecology of rocky shores, and Taylor, J. D., Phil. Trans. R. Soc. London B, 254: 129-206, 1968.

At South Point on a beachrock exposure (Fig. 27) the zonation is essentially similar to that of West Island but with fewer molluscan species in the eulittoral zone. The higher parts of the beachrock are occupied by blue green algae and the lower by calcareous red algae. Limpets and barnacles are again absent. The crab Eriphia laevimana is common in the mid-eulittoral.

At other beachrock sites the fauna is similar but usually less abundant and frequently the beachrock is colonised solely by blue green algae, Littorina glabrata and Nerita plicata.

In the lagoon a rather different fauna is seen. Nerita plicata and the usual predatory gastropods are uncommon and most of the fauna consists of algal grazers. The zonation on a gently shelving cobbled shore at Carcasse is shown in Figure 28. The cobbles on the lower shore are colonised by the green algal Enteromorpha and the higher portions by blue-greens which produce a blackening effect. Cerithium morum and Cerithium pretosum are both exceedingly abundant, replaced a little higher on the shore by Nerita albicilla and Planaxis sulcata.

At Mamzelle Adélie (Fig. 29) the beachrock is horizontally bedded and stepped. The most conspicuous element of the higher levels is a blue green algal crust which supports a few Littorina scabra. Lower on the shore Cerithium morum and Cerithium pretosum are common with occasional Morula granulata which feeds upon polychaetes.

B. Beaches

Both seaward and lagoon beaches are colonised by the crabs Ocypode ceratophthalma and Coenobita rugosa. The burrowing bivalve Atactodea glabrata is only found on lagoon shores.

C. Seaward platforms

Shallow water marine invertebrate collections and observations were made at a number of sites around the Atoll. These included Eclipse Point, West Island, South Point, Point Thomas, East Point, Cust Point and Barton Point. Because of a lack of mobility the most comprehensive collections were made at East Point.

The seaward platform is remarkably uniform in character around the atoll and the descriptions given below for East Point and Eclipse Point cover most of the variations found.

1. East Point

The reef platform here is about 120 m in width. It lies at a shallow sublittoral level and is not fully emersed at low spring tides, many boulders however project up into the eulittoral zone.

At the base of the beach there is a zone about 10 m in width of coral boulders up to 0.5 m in diameter. Outwards there is then a narrow (5-10 m) belt of rippled sand which is followed abruptly seawards by a crust consisting predominantly of the byssate bivalve Modiolus auriculatus and the calcareous red alga Jania. The bivalves are attached in some places to an irregular reef platform or in others to masses of coralgal cobbles and debris. The surface of the crust is fairly uniform but interrupted by depressions which may be floored by sand or bare reef rock.

Interspersed with the Modiolus crust are sporadic patches of Cymodocea ciliata (= Thalassodendron ciliatum) with the rhizomes and roots deeply embedded between the cobbles.

Small coral growths of Pocillopora demicornis, Porites lutea and Platygyra lamellina are common.

Toward the seaward edge of the platform, calcareous algae become much more common and form a low cavernous "algal ridge." Corals occur on the outer edge of the ridge and these are small, stumpy or encrusting growths and include Acropora disticha, Pocillopora danae, Favites yamanarii and Leptoria phrygia. In the surf zone the cavernous "algal ridge" becomes smoother and more solid and small surge channels develop which are lined with small growths of Pocillopora danae and Acropora disticha but dominantly by sheets of calcareous algae. The surface of the algal ridge is covered by growths of the soft algae Turbinaria, Dictyosphaeria, Caulerpa and Dictyurus.

The upper surface of the boulders at the base of the beach are bare except for growths of Enteromorpha. Beneath the boulders the gastropods Strigatella litterata, Cypraea annulus and Cerithium nesioticum are particularly common. The small xanthid crab Leptodius sanguineus and the porcelain crab Petrolisthes lamarckii are extremely abundant.

In the Modiolus/Cymodocea area of the mid-platform the fauna is much more diverse. Large boulders up to 1 m in diameter are common all across the platform and these are colonised by the algae Turbinaria and Dictyosphaeria. Beneath the boulders and cobbles the large encrusting Foraminifera Carpentaria, Homotrema and Sporadotrema and many sponges occur.

Apart from Modiolus only a few invertebrates are present on open surfaces. About 30 m from the shore there is a belt about 15-20 m width in which the echinoid Tripneustes pileolus is exceedingly common; Holothurians are also abundant and in particular Holothuria atra, Actinopyga mauritiana and Microthele nobilis. Other holothurians are found beneath the boulders in crevices or in sand pockets; these are Holothuria cinerascens, H. albiventer, and Bohadschia argus. Ophiuroids particularly Ophiocoma erinaceus and O. scolopendrina and O. brevipes,

live in the crevices of the platform and boulders. Echinoids are less common (excepting Tripneustes) and only Echinometra matthai and Echinosterphus molaris were found in crevices beneath the boulders and in the cavernous algal platform.

Gastropods are very common mostly occurring beneath the boulders or within crevices. Drupa morum occurs on the upper surfaces of boulders and Rissoina ambigua, R. plicata and Pyrene azora occur in the algal turf.

Predators such as Conus ebraeus, C. lividus, C. rattus, Vasum turbinellus, Cymatium pileare, C. nicobaricum and Bursa bufonia are found beneath the boulders.

On the leaves of Cymodocea, Cypraea annulus, C. moneta, Cerithium rostratum and Smaragdia rangiana are characteristic.

Crabs occurring in this belt are Percnon planissimum, Actaea rufopunctata, Xanthias lamarckii, Daira perlata, Dromiopsis dormia and Petrolisthes lamarckii.

2. Eclipse Point

At North West Point the seaward platform is about 250 meters in width. The platform is very shallow and almost dries at low spring tides. The major morphological zonation features are shown in Figure 30. At the base of the beach there is a narrow (5 m) belt of cobbles up to 10 cm in diameter resting on sand. These may be coated with green algae. Seawards there is then a belt of 130-150 m wide of Cymodocea ciliata beds resting upon a patchy cobble, sand and boulder substrate held together by thick rhizome growths. The seaward edge of the Cymodocea beds is irregular and passes into a belt about 30 m wide consisting of boulders up to 30 cm in diameter resting upon the hard substrate of the reef platform. The boulders are coated with encrusting growths of calcareous algae. Seaward from this boulder belt is an area of bare reef platform which, with the exception of isolated boulders and small pockets, is sediment-free and smooth in appearance. This also is coated with sheet-growth of calcareous red algae. This bare area passes transitionally into an area of much prolific calcareous algal growth accompanied by a rise in height of about a third of a meter. This area is a low "algal ridge" and consists of prolific growth of calcareous algae into branching heads and encrusting sheets. The resulting structure is cavernous and many boulders are cemented to the surface by the growth of the algae. Surf conditions did not permit observations further seawards but the heads of many small surge channels lined with calcareous algae were observed.

a) Cymodocea beds

The growth of the phanerogam Cymodocea at this site is more continuous and luxuriant than any other seaward site observed around the atoll. Algae such as Caulerpa, Laurencia and Halimeda grow amongst the phanerogam and Turbinaria and Dictyosphaeria occur attached to the boulders and cobbles. The leaves of the Cymodocea are encrusted by melobesioid red algae and many other small epiphytes. Only a few animals live on the open surface of the beds and these include Holothuria atra and the echinoid Tripneustes gratilla. Some species live upon the leaves of the Cymodocea, these include the crab Menaethius monoceros, the gastropods Cerithium rostratum and Smaragdia rangiana, and the foraminiferan Marginopora. Most of the fauna is found beneath the boulders and cobbles common throughout the beds. The molluscan fauna is prolific and gastropods particularly common. These include the herbivores Trochus flammulatus, Cerithium nesioticum and two species of Rissoina. Common predatory gastropods are Drupa ochrostoma, Morula margariticola, Vasum turbinellus, Strigatella litterata, Bursa granularis, Cantharus undosus and Conus lividus. General grazers are Cypraea annulus and five other species of Cypraea. Bivalves are uncommon and the only records are of the byssate Pinctada margaritifera, Barbatia helblingi and Lima fragilis, and a small Tridacna maxima.

Crabs, particularly Xanthias lamarckii and Acteus rufopunctata, are abundant beneath the boulders. The ophiuroid Ophiocoma brevipes is abundant in crevices within the blocks.

b) Boulder belt

The boulders rest upon a relatively smooth substrate coated with a crust of calcareous algae. Most of the fauna in this zone is found beneath the shelter of the boulders. Encrusting sponges, ascidians, bryozoa and hydroids are common. The boulders are extensively penetrated by boring polychaetes. The undersides support a very diverse molluscan fauna. Bivalves are limited to the cemented Chama aspersa, Ostrea numisma and the byssate Barbatia helblingi and small Pinctada margaritifera. Gastropods are much more common and include a large proportion of vermivorous predators such as six species of Conus (especially Conus ebraeus, C. lividus, C. rattus and C. sponsalis), Vasum turbinellus, Bursa granularis. Other predators include Thais armigera, Morula uva, Maculotriton digitalis, Cymatium poleare and Bursa bufonia. Grazers on the encrusting fauna and flora include four species of Cypraea, two species of Rissoina, Triphora monilifera, Modulus tectum, Cerithium nesioticum and Vanikoro.

The porcelain crab Petrolisthes lamarckii is exceedingly common upon and beneath the boulders. The rest of the crab species occurring here are very similar to those occurring on the algal ridge discussed below.

c) Algal ridge

Within the algal ridge are heads of branching Porolithon which become much more abundant seawards, as do the corals. The corals are all small with semi-encrusting or stubbily branching species and include Tubipora musica, Stylophora mordax, Pocillopora eydouxi and Acropora disticha. Species of Millepora were remarkable by their absence.

The species composition of the molluscan fauna is essentially similar to that found in the boulder zone but more abundant.

The ophiuroids Ophiocoma erinaceus and O. scolopendrina are abundant in crevices.

Crabs are common and include the Percnon planissimum, Zosimus aeneus, Daira perlata, Actaea rufopunctata, Liomera bellus, Liomera monticulosus, Pilumnus hirsutus and Eriphia scrabacula.

3. South Point

Here the seaward platform is about 200 m wide and has many of the features described for East Point. The reef here receives more wave action and the inshore area is covered by boulders. The platform has an algal ridge, a Modiolus crust and a turf of red algae. On the algal ridge corals are much more abundant than at East Point and include the additional species Millepora tenera and M. platyphylla. The invertebrate fauna is very similar to that described for the other sites. Some of the boulders are very large and project up into the eulittoral zone; they are penetrated by vast numbers of sipunculids and by the boring barnacle Lithotrya valentiae. Cypraea caputserpentis, a species tolerant of wave action, was found in small crevices in the boulders.

4. Barton Point

At Barton Point almost the entire width of the seaward platform is covered by boulders up to 0.5 m in diameter. Calcareous red algae are prolific cementing the boulders together. Other algae present are Dictyosphaeria, Caulerpa, Dictyurus, Halimeda and Turbinaria. The fauna on and beneath the boulders is very similar to that found on and beneath the boulders at the sites discussed previously.

D. Lagoon shores

On lagoon shores the beaches are shallowly dipping, consist of fine sand and are overhung by supralittoral vegetation.

At the base of the beach there is usually an accumulation of small cobbles. On the eastern lagoon shores the platform is variable in

width from 75 to 300 m and on the western side the widest point is at Pointe Marianne which is 950-1150 m wide. The depth of the platform varies between intertidal and 2-3 meters but in many places the lagoonward edge of the platform is not sharp and slopes more or less gradually into the deeper central lagoon. The platform margins on the western side appear rather sharper than those to the east.

On the eastern side the platform is covered by a thick accumulation of fine sand upon which sporadic patches of algae, Cymodocea and corals occur. The zonation on the lagoon platform seen 0.5 km north of East Point is fairly typical for the eastern side of the lagoon. The platform shelves gently from the beach lagoonwards with an average depth of 1-2 m. Nearshore the fine sandy substrate is colonised by patches of the algae Padina and Laurencia between which there is open sand colonised by several species of sponge embedded into the sediment. Further lagoonwards patches of Cymodocea ciliata occur with the Padina and Laurencia. In these patches are small colonies of the corals Porites lutea and Pocillopora damicornis. The holothurian Holothuria atra and the asteroid Culcita schmideliana are abundant. The Cymodocea is heavily infested with epiphytic algae.

Further from the shore corals appear, becoming more abundant lagoonwards. They occur in patches separated by areas of open sand with abundant polychaetes. The coral patches are not more than 1.5 m high and largely dead on the upper surfaces and centres of the patches. These patches are made up of quite a diverse coral fauna. Most common is the branching Porites nigrescens with a massive Porites, spray growths of Acropora reticulata, Lobophyllia costata, massive Favia pallida and Porites (Synaraea) iwayamaensis. Other species occurring are Goniopora cf. savignyi, Porites solida, Favia pallida, several species of Montipora, Astreopora ocellata, large colonies of Stylophora pistillata and Pocillopora damicornis. The free living species Fungia repanda and Halomitra philippensis occur on the sand between the coral colonies.

The corals form a substrate for a large number of epifaunal and boring molluscs. In crevices and on dead branches the byssate species Barbatia helblingi and Isognomon legumen, I. perna and Septifer bilocularis are very common. Other species are Lima lima, Gloripallium pallium. Pedum spondyloideum occurs solely in narrow crevices in massive Porites colonies. The coral colonies themselves are bored by Lithophaga teres, Botula cinnamomea and Gastrochaena cuneiformis. Tridacna maxima occurs byssate on upper surface of coral colonies and in crevices. The holothurian Stichopus chloronotus is common amongst the corals and on the sand surrounding the patches. The sand patches themselves support a sparse fauna of polychaetes, Rhinoclavis asper and the bivalve Fragum fragum.

The sponge colonies which occur nearer the shore support an individual fauna including many ophiuroids of the species Ophiactis savignyi, O. exigua, crangonid shrimps, and an erycinid bivalve.

At Carcasse the lagoon platform is 70 m wide and the patches of algae, Cymodocea and coral much more sparse than at East Point. The coral colonies at this site are particularly heavily colonised by the boring and epifaunal molluscs. The upper surfaces of the coral colonies are covered by growths of the algae Turbinaria, Padina, and Dictyosphaeria.

At Cust Point the lagoon platform is wider but the inshore areas for about 200 m are covered by luxuriant Cymodocea beds. Together with Cymodocea ciliata, algae are common particularly Halimeda, Laurencia, Hydroclathrus, Caulerpa and Codium. On cobbles and dead coral colonies Turbinaria and Dictyosphaeria are epilithically attached. The Cymodocea and Turbinaria are infected by abundant epiphytic algae and are coated with abundant marginoporous foraminifera. Brown sponges are common. Coral occurring in this bed are Porites lutea, Porites nigrescens and Pocillopora damicornis. The stems of the Cymodocea are frequently encrusted by bryozoan colonies.

The holothurians Holothuria atra and Stichopus chloronotus and the ophiuroids Ophiocoma scolopendrina and O. brevipes are abundant.

The molluscs occurring upon the Cymodocea leaves and stems include Cypraea moneta and C. annulus, Smaragdia rangiana, Cerithium rostratum, Strombus decorus decorus and Drupa margariticola. Burrowing into the sediment are Polynices mammilla, Pinna muricata, Anadara urypigmelana and Codakia tigrina.

On the western side of the lagoon at Pointe Marianne there is a wide intertidal sandy belt with isolated patches of Laurencia, Padina and some Cymodocea. Further from the shore the amount of Cymodocea progressively increases. In the open sandy areas there are large quantities of brown sponges buried in the sediment and small cobbles coated with Dictyosphaeria. Other sponges contain the commensal bivalve Vulsella spongiarum. The crab Calappa hepatica is very common in the sand and Thalamita amongst the algae. Holothuria atra is present in numbers up to 2-3 per square meter and Stichopus chloronotus rather less common. Further out in the Cymodocea the molluscs Strombus decorus decorus, S. labiatus, Cypraea moneta, Cerithium rostratum, Codakia tigrina, Ctena divergens and Pinna muricata are present.

The edge of the platform on this western side was not studied but observations from a boat indicate a platform front of massive coral colonies, probably Porites, 2-3 m in diameter.

Near the entrance to the lagoon, the lagoon shore supports a more prolific coral fauna. On the lagoon side of Eclipse Point there is a coral-dominated area with a large number of species. The dominant coral in terms of area occupied is Acropora reticulata which occurs in plate-like growths over a meter in diameter. Acropora palifera in

club-shaped branches is also abundant. There is some growth of staghorn Acropora. Lobophyllia costata occurs in large mound-like growth. Goniastrea pectinata, Favia halicora, Favia abdita and Porites australensis occur as small rounded heads. Delicate foliose growths of Echinopora lamellosa are also abundant. Other corals include Cyphastrea microphthalma, Platygyra lamellina, Porites (Synaraea) iwayamaensis, Herpolitha limax, Pavona varians and Stylophora pistillata. The alcyonaceans Sinularia and Lobophyton are common in masses up to 50 m in diameter.

E. The barachois

The barachois situated at the southern end of the lagoon have narrow entrances and represent areas of extremely restricted circulation opening on to an area of lagoon which also has restricted circulation. It is not surprising, therefore, that the fauna is rather peculiar.

The higher fringes of the barachois are occupied by the crab Cardisoma carnifex, causing extensive disturbance of the sediment. Lower in the true intertidal areas where the sediment is a fine lime mud it is colonised by vast numbers of the fiddler crab Uca tetragonon. Other Crustacea include alpheid prawns and the crab Thalamita crenata. Deposit-feeding bivalves are more common in the barachois than at other sites: species include Asaphis deflorata, Leptomya rostrata, Quidnipagus palatam and Scissulina dispar. Suspension feeders Gafrarium pectinatum and Atactodea glabrata occur in coarser sediments. The gastropods Cerithium morum and Rhinoclavis asper are abundant.

The beachrock surrounding the barachois is colonised by the ellobiid gastropod Melampus castareus and Littorina scabra and sometimes under overhangs Ostrea cucullata.

Stromatolithic-like masses of algally fixed sediment are common around the edges of the barachois. Amongst these masses two holothurians are found together with burrowing crangonid shrimps, and Thalamita.

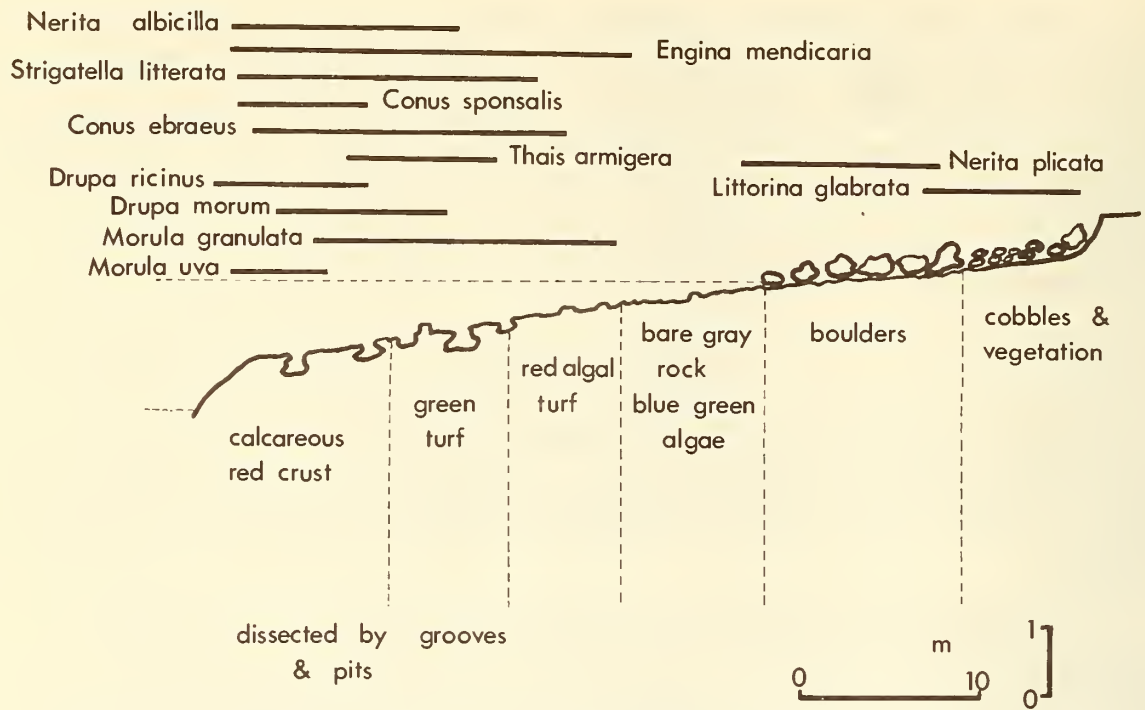


Fig. 26. Intertidal zonation on the seaward shore of West Island.

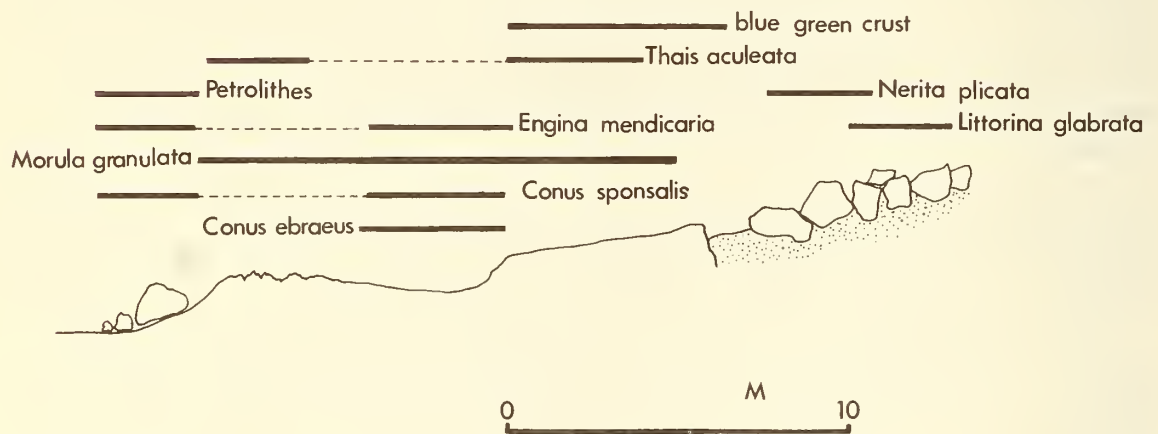


Fig. 27. Intertidal zonation on seaward beachrock at South Point.

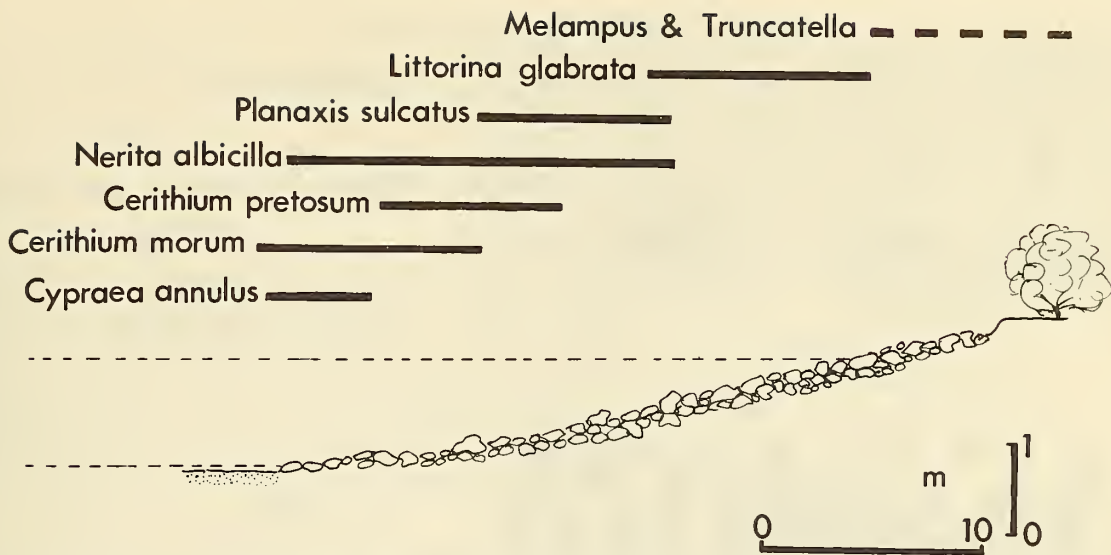


Fig. 28. Intertidal zonation on a cobbled lagoon shore, Carcasse.

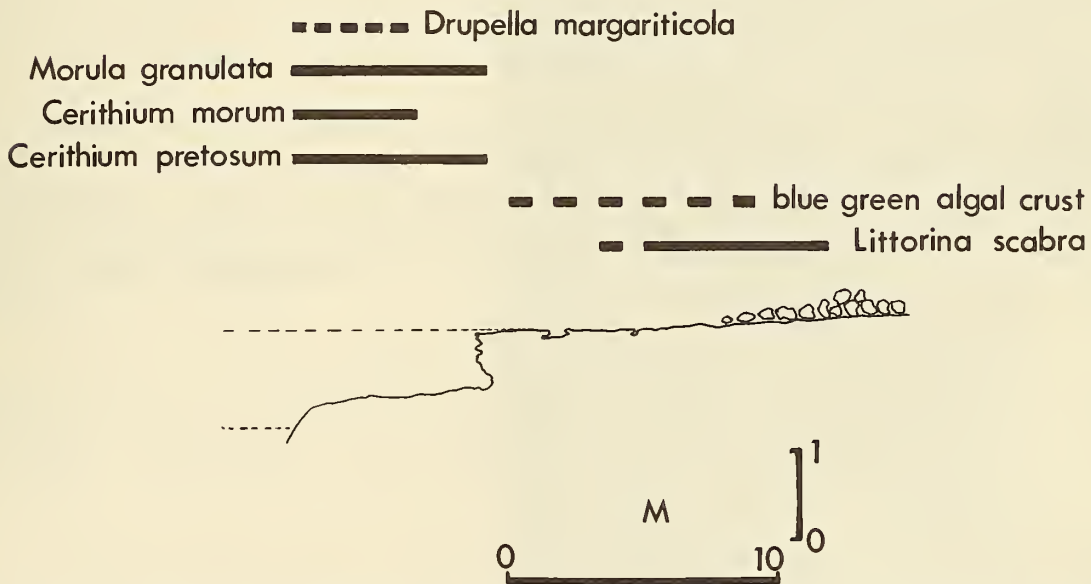
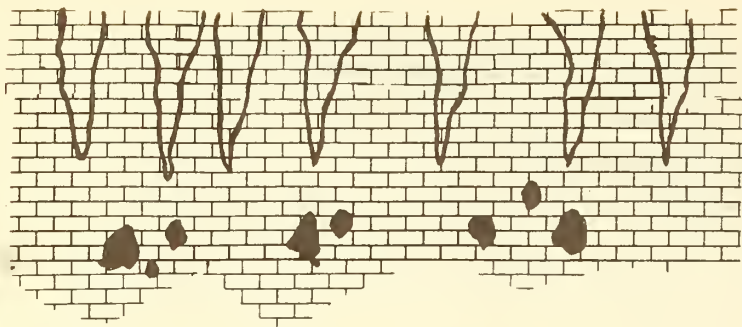


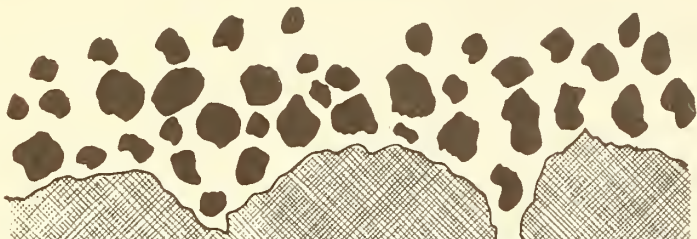
Fig. 29. Intertidal zonation on beach rock, entrance to Barachois Maurice.



surge channels

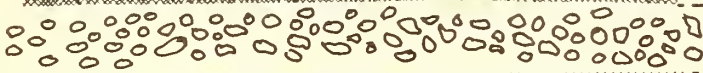
low ridge of calcareous
algae

bare pavement



boulders

Cymodocea beds



cobbles

beach

Fig. 30. Intertidal zonation on the reef platform at Northwest Point.

5. MARINE ALGAE OF DIEGO GARCIA

by Charles F. Rhyne

INTRODUCTION

The algal flora of Diego Garcia atoll seems after preliminary studies to compare closely with that found by earlier investigations (Hemsley, 1887; Gepp and Gepp, 1909; Weber-van Bosse, 1913; Reinbold, 1907) and with the floras of some adjacent islands and continental shores in the western Indian Ocean. Many new records of species on the atoll were established by the recent collection. Also, names of some entities in the 43 species collected around the turn of the century have been corrected when synonymy was noted by the author.

This list includes 115 known algal taxa from Diego Garcia. Seventy-one are new records for this central Indian Ocean atoll. These new records consist of 8 in the Myxophyceae, 30 in the Chlorophyceae, 9 in the Phaeophyceae and 25 in the Rhodophyceae. One new species of green alga is included, belonging to the new genus Struveopsis described elsewhere (Rhyne and Robinson, 1968). Earlier authors recorded 43 species, but only 14 of these were recollected by the writer. One terrestrial blue-green alga is included in this report.

Several entities have been purposely omitted for lack of sufficient data. Some groups, which are melobesioid corallines, Ceramium, Herposiphonia, Chondria, Sargassum, Turbinaria, Cladophora and Bryopsis, posed such taxonomic difficulty they are presently listed only by genera. Identifications of Halimeda are to be made later by Dr. Llewellyn H. Colinvaux.

I wish to thank Dr. Francis Drouet, Academy of Natural Sciences, Philadelphia, for identifying the Myxophyceae and Mr. Roy T. Tsuda, University of Guam, for the annotated determinations of the genus Caulerpa. I am grateful to Dr. Harold Robinson, Department of Botany, Smithsonian Institution, who critically read the manuscript.

The bibliography does not include citations of the original descriptions of the species unless pertinent data or figures are used in the discussion of the species. Original citations for many of the species can be found in Dawson (1954).

All numbered specimens are deposited in the herbarium of the Smithsonian Institution (US). CR collection numbers are those of the author.

HABITAT DESCRIPTIONS

Collections were almost wholly intertidal with occasional shallow sublittoral ones (to 3.3 m). There was a general lack of substantial growth in deeper waters of the lagoon and the extremely treacherous conditions along the "Porolithon" ridge area made collecting nearly impossible there. Despite the ubiquity of many species throughout the reef environment, a short summary of habitat descriptions will be given and a note of certain niches that contained distinctive species.

A. Lagoon shore, east and west sides

By far the most frequent ecological situation was a sloping sand beach consisting of occasional exposed rock reefs at low water spring (LWS) tide. Coral pebbles and cobbles, a few centimeters to 20 cm in diameter, were either embedded in intertidal sand or kept in continuous motion by the pounding surf driven by the SE winds. The surf was particularly evident along the western side of the lagoon.

The intertidal zone along the NW lagoon shore was largely devoid of attached algae except for Enteromorpha and Giffordia duchassaingiana. However, just below the turbulent intertidal area, a prevalent benthic flora appeared. As shallowly as 0.3-0.5 m, Dictyota, Pocockiella papenfussii, Hypnea, Halimeda, a melobesiod red and long skeins of Schizothrix were attached on dead and dying portions of erect corals. Here patches of Cymodocea ciliata in 0.3-1.0 m of water supported the barest epiphytic flora with occurrences of Bryopsis. Cymodocea and a melobesiod alga covered large areas of coral in 1.0-2.5 m of water. In deeper water, 2.4-4.0 m, Microcoleus lyngbyaceus appeared on loose coral cobbles while Padina produced thick scattered clumps over small isolated outcrops of coral. Otherwise the loose sandy bottom appeared as a rather desolate habitat for algal growth.

As one walked along the high intertidal zone at LWS tide a few species were found frequently in the drift. Among the drift Cymodocea ciliata, Hypnea pannosa and Pocockiella papenfussii were generally attached to small coral cobbles and Jania decussata-dichotoma was intimately associated with Dictyota. Sprigs of Turbinaria and Sargassum were occasional along the high intertidal zone. At Point Marianne occasional clumps of drift Hypnea pannosa were washed about in the shallow embayment.

Shallow water, limestone cliffs, high turbidity and high insolation characterized the seemingly desolate southern portion of the lagoon shore, but under the 0.8-1.7 m high cliffs, a distinct flora could be observed in the cavities. At LWS tide some of these depressions were completely shaded and although exposed for periods up to 6 hours the extreme dampness supported thick growth of Cryptonemia, Cladophora socialis, Botryocladia skottsbergii, Valonia utricularis, Caulerpa peltata and Avrainvillea. Long skeins of Schizothrix mexicana, Halimeda,

Chaetomorpha, Bryopsis pennata, Codium geppii, Galaxaura filamentosa and Gelidiopsis intricata were observed hanging from the ceiling of these cavities. Also under the ledges Halimeda was extremely abundant with Cladophoropsis sundanensis growing profusely over exposed coral flats at LWS tide. Schizothrix arenaria formed a large moss-like felt covering expanses of slightly raised coral ledges that were exposed even at HWS tides.

In the lower intertidal to 0.5 of water Hypnea pannosa was extremely abundant as scattered ball-like formations 20-45 cm in diameter. The cavity of these algal spheres afforded protection and a complete microenvironment for small fish, crab and shrimp.

Slightly NE of this southern tip of the lagoon Rhipidiphylon reticulatum was observed under ledges. In tide pools Schizothrix calcicola was locally common with the ever present Calothrix pilosa. In water to 1 m in depth Gelidiella acerosa, Boodlea composita, Galaxaura filamentosa and Herposiphonia were collected. Also Spyridia filamentosa was found extremely abundant as an epiphyte upon Cymodocea.

B. Islets

The Cymodocea beds surrounding three islets at the mouth of the lagoon yielded an abundant variety of algae. Dictyurus purpurescens, Valonia ventricosa, Dictyosphaeria cavernosa, Caulerpa peltata and Acetabularia moebii were found in a distinct environment beneath a thick canopy of the seagrass leaves. Epiphytes such as Sphacelaria furcigera, Amphiroa fragilissima, Fosliella farinosa, Enteromorpha flexuosa, Microdictyon pseudohapteron, Champia parvula, Hypnea, Jania tenella and Lophosiphonia were seemingly specific for certain portions of Cymodocea. Melobesioids appeared commonly scattered about the bottom near the extensive Cymodocea beds.

C. Lagoon floor

SCUBA and free diving allowed observation and collection of the flora on the lagoon floor. In the northern portion dives ranged from 3-10 m and to 2-3 m in the southern portion. The deeper dives revealed a paucity of fleshy forms with some Halimeda and melobesioid algae predominating. The bottom at 10 m was composed of 80 % soft coral sediments. Toward the southern end of the lagoon a survey of the bottom in 2-3 m of water revealed large areas of sand with sizable depressions filled with drift Padina to a depth of 0.5 m. Also, isolated coral heads rose within 1.0-1.5 m of the surface and supported luxuriant growths of Sargassum, Turbinaria, Padina, Jania, Galaxaura and Dictyota. These coral heads were the only observed sites for attached Sargassum.

D. Ocean shore, east and west sides

An intermediate area between the true lagoon environment and the ocean side was observed at Eclipse Point. The location of the area afforded protection from daily heavy wave action at high tide. At LWS tide the reef was almost totally exposed with occasional tidal pools with 1-15 cm of water and large coral-conglomerate rocks breaking the surface. Cymodocea patches were scattered about, but individual plants were only 7-20 cm tall in contrast to the deeper placed plants on the lagoon side which reached 18-28 cm in height. Very fine calcareous silt settled over the entire reef flat camouflaging much of Schizothrix mexicana, Dictospheria, Boodlea composita, Gelidiella acerosa, Turbinaria, Laurencia, Jania capillacea, Herposiphonia and Cladophoropsis sundanensis which were common as a felt over the coral rocks. Larger coral rocks supported a significant number of plants on the lower surfaces where they were protected from the extremely high insolation. Melobesioids were common members of this micro-environment. Schizothrix calcicola, Microcoleus lyngbyaceus and Rivularia polyotis formed extensive patches over sandy areas, while Halimeda was scattered commonly over the reef flat area and appeared to be the dominant large species.

A large cemented beach-rock formation south of the preceding location yielded a substantially different flora related to the change in habitat type. Rock shelving extended ca. 100 m outward from the high intertidal zone to the "Porolithon" ridge, ranging in depth from zero to 0.6 m of water at LWS tide. Rivularia polyotis was found as dark gelatinous clumps on tops of coral rubble. Jania decussata-dichotoma was frequent in crevices, while Dictyospheria intermedia covered the sandy bottom at times, and Halimeda, as stubby plants, commonly grew from larger crevices. Cladophora, attached to coral rocks was the main element in the algal felt.

Along the extremely turbulent ocean side near the southern end of the atoll melobesioids were common at the edge of the ridge and as cast-up material. Microdictyon pseudohapteron, Boodlea composita, Schizothrix calcicola and Microcoleus lyngbyaceus were common entities covering large areas over coral cobbles along with the ever present dwarfed Turbinaria.

At Horsburgh Point, Botryocladia skottsbergii, Ralfsia, Caulerpa peltata and C. urvilliana were under ledges and in deep crevices formed by small limestone cliffs. At extreme low tides this area was left dry for several hours at a time, with only the deepest portions of the crevices remaining damp enough to support their unique floras. In 0.5-1.0 m of water Pocockiella papenfussii and Laurencia nidifica were observed as common patches over a flat rock bottom swept essentially clean by an extremely fast current running parallel to the shore.

Approximately 1 mile north of this area a wide reef flat with ca. 100 m of exposed coral and reef rock formation was observed. The vegetation was predominantly Jania and Laurencia with abundant clumps of melobesioids up to 20 cm in diameter.

Adjacent to East Point village the reef floor consisted of pavement-like surface with scattered coral rocks and boulders. What could be seen of a well-formed "Porolithon" ridge enticed the author to sample it, but wave action forced him to "observe" only. Jania, a melobesioid, Boodlea composita and Turbinaria were all common in 0.7-1.3 m of water while Gelidiella acerosa was abundant in the intertidal zone.

At Minni-Minni ca. 2 miles north of East Point village a flat coral reef appeared quite representative for the ocean side environment. However, this particular area along the outer reef edge and "Porolithon" ridge supported a rich diversity of forms not seen earlier. Unfortunately collecting was nearly impossible because of the strong surge and dangerous waves. Well-formed surge channels extending almost from the ridge to the sloping sand shore allowed good water circulation even at LWS tide. The collected vegetation was of a matted habit with Jania capillacea, Laurencia, Boodlea composita, Microdictyon pseudohapteron, Caulerpa urvilliana, Halimeda and melobesioids predominating. An unidentified peltate red alga was also collected in the extremely turbulent area between the ridge and reef proper.

COLLECTING STATIONS

Station 1. Coral reef flat on oceanside at Eclipse Point. 11 June 1967.

Station 1a. Cemented beach rock ledge ca. 200 m S of Sta. 1. 14 June 1967.

Station 2. Drift material along coral cobble and sand lagoon shore in vicinity of Northwest Point. 12 June 1967.

Station 3. Coral reef in 0.6-1.3 m of water along lagoon shore in vicinity of Northwest Point. 12, 13, 15, 17 June 1967.

Station 3a. In 2.4-4.0 m of water on sand-coral bottom at Sta. 3. 15 June 1967.

Station 3b. Drift material from Sta. 3. 14 June 1967.

Station 4. Lagoon side of West Island in shallow but thick Cymodocea beds. 16, 22 June 1967.

Station 5. On spur reef at West Island in 0.3-1.0 m of water amid sand and coral pieces and in 1-2 m of water on coral reef. 21 June 1967.

- Station 6. Lagoon shore ca. 2 miles S of East Point village in shallow reef area. 23 June 1967.
- Station 6a. Beach rock and sand shoreline ca. 100 m S of Sta. 6. 18 July 1967.
- Station 7. Epiphytic material on various substrates in 0.5-1.0 m depths along lagoon shore at East Point village. 26 June 1967; drift - 5 July 1967.
- Station 8. Drift material along seaward sand and coral cobble beach at East Point village. 26 June; 1, 3 July 1967.
- Station 9. Seaward side of the "Porolithon" ridge in 1.7-4.0 m of water at East Island. 27 June 1967.
- Station 10. Drift along sandy shoreline at Point Marianne. 28 June 1967. Epiphytic material in shallow intertidal area. 25 July 1967.
- Station 11. In 1.3-2.0 m of water on lagoon floor ca. 4 miles S of East Point village in Cymodocea beds and scattered coral heads. 29 June 1967.
- Station 12. In shallow recessed tidal lagoon ca. 6 miles S of East Point village. 29 June 1967.
- Station 13. Sand and coral cobble lagoon shore ca. 1.5 miles N of East Point village. 1, 4 July 1967.
- Station 14. Shallow coral flat area along seaward side at East Point village. 1, 5, 10 July 1967.
- Station 15. Sand and eroded coral ledge, lagoon shore ca. 1 mile S of East Point village. 4 July 1967.
- Station 16. Oceanside of "Porolithon" ridge in 2.0-3.5 m of water at Observation Point. 6 July 1967.
- Station 16a. Over disturbed sand and coral rock bottom in 0.3-1.0 m depths at Observation Point. 6 July 1967.
- Station 17. Exposed oceanside coral reef flat at LWS tide ca. 1 mile N of Horsburgh Point. 7 July 1967.
- Station 17a. Beach-rock and eroded coral cliff habitat at Horsburgh Point (CR-575 - CR-578). In 0.3-1.0 m of water (CR-579 - CR-582). 7 July 1967.
- Station 18. Coral reef flat and sand area in vicinity of southern-most tip of lagoon. 8 July 1967.

- Station 19. Lagoon side of East Island in 0.3-0.7 m depths at LWS tide.
9 July 1967.
- Station 20. In temporarily dried fresh water pond ca. 0.75 miles S
of East Point village. 12 July 1967.
- Station 21. Southern-most tip of lagoon, physically similar to Sta. 18.
12 July 1967.
- Station 22. Vicinity of southern-most tip of lagoon, physically similar
to Sta. 18. 13 July 1967.
- Station 23. Ca. 1 mile S of East Point village along lagoon shore in
0.3-0.7 m of water on sand and coral cobble bottom. 18 July 1967.
- Station 24. In large shallow recessed tidal lagoon ca. 3 miles S of
East Point village. 18 July 1967.
- Station 25. Highly exposed oceanside reef flat ca. 3-4 miles N of
southern tip of atoll on W side. 19 July 1967.
- Station 26. Beach-rock and sand lagoon shore ca. 3 miles N of southern
tip on W side. 19 July 1967.
- Station 27. Seaward coral reef flat exposed at LWS tide ca. 1 mile N
of Cust Point. 20, 21 July 1967.
- Station 28. Thick Cymodocea beds and rich coral area in 0.7-2.7 m depths
on lagoon side ca. 1 mile N of Cust Point. 20, 21, 22 July 1967.
- Station 29. Seaward reef flat exposed at LWS tide at Minni-Minni. 24
July 1967.
- Station 30. In 10 m of water on lagoon floor ca. 1 mile due S of East
Island. 26 July 1967.
- Station 31. In 8.3 m of water on lagoon floor ca. 1500 m SSW of
Observation Point. 27 July 1967.
- Station 32. In 5 m of water on lagoon floor ca. 1500 m SE of Eclipse
Point. 27 July 1967.

SYSTEMATIC LIST

Myxophyceae

Calothrix crustacea Schousb. & Thur.

Stations: 12, locally common in tide pools, CR-515; 21,
consolidated over sand, CR-624a; 23, abundant on beach-rock
exposed at LWS tide, CR-697, CR-698.

Calothrix pilosa Harv.

Stations: 12, extensive growth over beach-rock, CR-516; 18, abundant on coral flat, CR-588; 23, over beach-rock, CR-697.

Microcoleus lyngbyaceus (Kütz.) Crouan

Earlier records: Reinbold 1907 (as Hydrocoleum lyngbyaceum Kütz.)

Stations: 1, CR-355; 3a, CR-410; 6, CR-468, CR-475; 13, CR-526; 14, CR-538, CR-558; 23, CR-698, CR-699; 6a, CR-701, CR-702; 25, CR-719; all common over sand or coral substrates.

Nostoc commune Vauch.

Stations: 3, terrestrial, abundant over sandy soil, CR-387.

Rivularia polyotis (J. Ag.) Born. & Flah.

Stations: 1, over sand, CR-356; 1a, common on coral rocks, CR-395; 14, common on coral rocks, CR-552.

Schizothrix arenaria (Berk.) Gom.

Stations: 18, abundant over coral flats exposed at LWS tide, CR-588; 20, on soil of temporary brackish pond, CR-623; 21, over sand, CR-624a; 25, common over coral rocks, CR-719.

Schizothrix calcicola (Ag.) Gom.

Stations: 1, CR-355; 1a, CR-395; 12, CR-515; 14, CR-552, CR-558; 20, CR-623; 21, CR-624a; 23, CR-697; CR-698; CR-699; 25, CR-719; all common over sand or coral substrates.

Schizothrix mexicana Gom.

Stations: 1, CR-339; 2, CR-361; 3, CR-377, CR-384; 17, CR-573; 21, CR-634; 22, CR-644; all common over coral rocks or under ledges.

Scytomena hofmannii Ag.

Stations: 20, locally abundant on soil of temporary brackish pond, CR-623.

ChlorophyceaeAcetabularia moebii Solms-Laubach

Stations: 4, rare, at base of Cymodocea bed mixed with larger algae, CR-431. Plants ca. 6-7 cm tall; disks ca. 2 mm in diameter with ca. 13 rays with rounded tips; rays calcified together.

Avrainvillea sp. cf. A. amadelpha Gepp & Gepp 1911: 42, pl. 14, figs. 112-115.

Stations: 12, CR-508; 21, CR-633; rare under ledges at both stations.

Seemingly dwarfed specimens of A. amadelpha but also rather close to A. lacerata (Harv.) J. Ag. Plants to 2.5 cm tall, of a spongy texture and somewhat zonate; frond filaments without tenaculae, ca. 15-25 μ in diameter.

Boodlea composita (Harvey) Brand; Dawson 1954: 390, fig. 9c, f.

Stations: 1, common over sandy area, CR-343; 12, common over coral and beach-rock, CR-510, CR-519; 14, common over coral reef, CR-564, CR-559; 25, common as tufts over coral rocks, CR-718; 29, common over reef flat exposed at LWS tide, CR-782.

Filaments ranging in size from 250-400 μ in diameter as a short felt over the substrate. The dry material appears to differ somewhat from other herbarium specimens; however, dimensions and habit of the wet material indicate B. composita.

Boodlea vanbossei Reinbold; Dawson 1956: 29, fig. 6.

Earlier records: Reinbold 1907.

Bryopsis pennata Lamx. var. leprieurii (Kütz.) Collins & Hervey; Taylor 1960: 132. Stations: 21, infrequent from ceiling of ledge, CR-635.

Almost identical with CR-700 except that numerous vacant spaces exist along main axis.

Bryopsis pennata Lamx. var. secunda (Harv.) Collins & Hervey; Taylor 1960: 132, pl. 9, fig. 12.

Stations: 6a, mixed with various other matted algal forms, CR-700.

Main axis 200-275 μ in diameter, pinnae ca. 60-80 μ in diameter, plants ca. 3-5 cm tall with strong secund branching in many areas.

Bryopsis sp. #1

Stations: 14, over coral rocks, CR-554, CR-606.

Main axis to 1 mm in diameter; with pinnae 40-60 μ in diameter and 2-3 mm long; plants 2-3 cm tall; material seems to indicate pinnae situated at random around branch. Possibly close to B. hypnoides.

Bryopsis sp. #2

Stations: 3, locally infrequent in sand in Cymodocea beds, CR-435.

Plumose habit with distichous branching; pinnae arranged as characteristic of B. indica, but generally only at lower portions of thallus, main axis ca. 300 μ in diameter, pinnae 50-75 μ in diameter.

Caulerpa antoensis Yamada 1944: 27, pl. 1, fig. 1; Dawson 1956: 36, fig. 20.

Stations: 4, rare over sand in Cymodocea beds, CR-430.

The cylindrical rhizome bears numerous short rhizoids which are firmly attached to fine sand particles. The simple or branched foliar branches, about 1 cm high, possess apiculate ramuli which are distinctly upcurved and arranged in a verticillate manner.

Caulerpa cupressoides (Vahl) Weber-van Bosse

Earlier records: Reinbold 1907.

Caulerpa cupressoides Weber-van Bosse var. mamillosa f. nuda Weber-van Bosse

Earlier records: Gepp and Gepp 1909, on reef exposed at dead low tide.

Caulerpa freycinetii Ag. var. typica f. spiralis Weber-van Bosse

Earlier records: Gepp and Gepp 1909, on reef exposed at dead low tide.

Caulerpa mamillosa Mont.

Earlier records: Hemsley 1887.

Caulerpa peltata Lamx. 1809: 145; Taylor 1950: 65.

Stations: 4, rare over sand in Cymodocea bed, CR-429; 14, infrequent under large coral rocks, CR-539; 17a, infrequent under ledges, CR-578; 21, frequent under ledges, CR-632.

The branched cylindrical rhizomes, about 0.5-1.0 mm in diameter, bear single entire peltate ramuli which are about 2-4 mm in height. Occasionally the ramuli may be branched.

Caulerpa racemosa var. peltata (Lamx.) Eubank 1946: 421, fig. 2r.

Stations: 14, infrequent, with other matted forms, CR-560.

The ramuli on this specimen consist of two morphological forms, the "turbinata" type and the "peltata" type. Past field observations in Hawaii and Guam have revealed that C. racemosa v. peltata and C. peltata are two different entities. The former can be differentiated from the latter by the presence of the peltate ramuli on an erect axis as opposed to the ramuli occurring directly on the rhizome in the latter species.

Caulerpa serrulata var. typica (Weber-van Bosse) Tseng 1936: 178, pl. 1; Eubank 1946: 418.

Stations: 1, CR-353; 3a, CR-412; 5, CR-438; 6, CR-469; 11, CR-504; 13, CR-532; 16a, CR-569; all over sand or coral rocks.

The twisted serrated flattened foliar branches, about 1.0-4.5 cm in height, may arise singly, dichotomously or irregularly.

Caulerpa urvilliana Montagne 1845: 21; Taylor 1950: 62, pl. 31, fig. 2.

Stations: 16a, locally frequent on coral rocks and on sand, CR-570; 17a, over coral rocks and abundant in drift, CR-579, 25, frequent in drift, CR-715; 29, frequent over reef flat, CR-786.

The specimens seem to be referable to v. typica f. tristicha (J. Ag.) Weber-van Bosse. The foliar portion branches near the base and reaches a height of 6 cm.

Chaetomorpha aerea (Dillw.) Kütz.

Earlier records: Reinbold 1907.

Chaetomorpha gracilis Kütz.; Taylor 1960: 70.

Stations: 12, locally abundant under tree exposed at LWS tide, CR-513; 21, infrequent under ledge, CR-638.

Filaments ca. 55-80 μ in diameter, cells 150-275 μ long, walls 5-15 μ thick.

Chaetomorpha sp. cf. C. brachygona Harvey; Taylor 1960: 70, pl. 2, fig. 9.

Stations: 6a, locally frequent over soft bottom in 0.3-0.7 m of water, CR-703.

Filaments ca. 110-135 μ in diameter, cells 115-225 μ long, cell walls 15-25 μ thick, no basal cell observed.

Chaetomorpha sp.

Stations: 6, common over intertidal coral cobbles, CR-462; 7, abundant over small coral rocks, CR-547.

Filaments ca. 140-200 μ in diameter, cells mostly shorter than broad or equal; basal cell in CR-462 ca. 350 μ long and ca. 100 μ in diameter.

Cladophora demissa J. Ag.

Earlier records: Hemsley 1887.

Cladophora socialis Kütz.; Børgesen 1946: 28; Dawson 1956: 24.

Stations: 12, common under ledges, CR-511; 21, abundant over various coral substrates, CR-624b; 21, abundant under ledges, CR-629.

Branches ca. 75-110 μ in diameter, with cells ca. 0.8-3.0 mm long, some rhizoidal processes observed; Børgesen used the name C. patentiramea f. longiarticulata for this plant in earlier works.

Cladophora sp. #1

Stations: 3b, one piece, CR-390; 6a, locally common over bottom in 0.3-0.7 m of water, CR-704.

Branches ca. 100-150 μ in diameter, cells 0.5-3.0 mm long. This may be a robust form of C. socialis.

Cladophora sp. #2

Stations: 24, very common in tufts over bottom, CR-708.

Cells ca. 75-125 μ in diameter and seemingly larger at one end than at the other, 250-400 μ long.

Cladophoropsis sundanensis Reinbold: Dawson 1956: 31.

Earlier records: Reinbold 1907.

Stations: 1, locally frequent over coral and sand substrates, CR-349; 6, common over sand and coral substrates, CR-470, CR-473, CR-476; 18, very common over reef flat exposed at LWS tide, CR-589; 21, frequent over reef flat exposed at LWS tide, CR-640.

All specimens but those of CR-349 seem to be rather robust forms of the species as branch size was 105-165 μ in diameter. At first C. limicola Setchell was thought to compare well by description. However, owing to previous collections on Diego Garcia and the fact that Dawson (1956) states that C. sundanensis can approach 175 μ in branch diameter, the specimens are placed here.

Codium geppii O. C. Schmidt; Børgesen 1946: 49, figs. 195-199.

Stations: 8, infrequent over coral cobbles, CR-489; 14 infrequent over large coral rocks, CR-534; 21, locally common under ledges, CR-637.

Utricles ca. 400-750 μ long, 150-325 μ in diameter; end wall ca. 1 μ thick; CR-489 and CR-534 branches to 2 mm in diameter; CR-637 with branches 2-4 mm in diameter, appearing as a much more robust and luxuriantly formed specimen, with gametangia ca. 250 μ long and 50-60 μ in diameter.

Dictyospheria cavernosa (Forsk.) Børg.; Taylor 1950: 43, pl. 27, fig. 2; Dawson 1954: 388, fig. 8i.

Earlier records: Reinbold 1907 [as Dictyospheria favulosa (Mert.?) Dcne.]

Stations: 1a, infrequent, CR-402; 4 infrequent in Cymodocea beds, CR-417; 6, locally infrequent, CR-465.

Dictyospheria intermedia Weber-van Bosse; Taylor 1950: 42.

Stations: 1, along sides and under surfaces of large coral rock, CR-342; 1a, frequent over sand bottom, CR-403; 6, locally infrequent, CR-464; 11, in Cymodocea bed, CR-499; 28, very common over coral rocks, CR-726; 31, on coral rock, CR-795.

It is difficult to be sure that internal spines were not present.

Enteromorpha flexuosa (Wulfen ex Roth) J. Ag. cf. subsp. flexuosa:

Bliding 1963: 73, figs. 38-41.

Stations: 4, infrequent on Cymodocea stems, CR-422; 6, common over coral cobbles in intertidal zone, CR-461; 14, distinct band over coral rocks at low water mark, CR-553.

Short tufted tubular thalli to 3 cm tall with dense branching generally from lower portion of main axis only; branches to 1 mm in diameter; cells in longitudinal order, 15-30 μ long, 12-22 μ in diameter; 2-4 pyrenoids.

Enteromorpha flexuosa (Wulfen ex Roth) J. Ag. cf. subsp. paradoxa
(Dillwyn) Bliding; Bliding 1963: 79, figs. 42-45.

Stations: 3b, one piece over coral rocks in intertidal zone,
CR-388; 21, epiphytic upon Cocos pinnae, CR-624; 23, epiphytic
upon Casuarina twigs in 0.3 m depths, CR-692.

Tufts to 3-4 cm tall; filaments thin, 125-300 μ in diameter; cells
in longitudinal order, sometimes in transverse order; cells ca. 15 μ
square to 12-20 μ in diameter, 18-30 μ long; 1-5 pyrenoids; a much more
finely branched and elongate form than subsp. flexuosa.

Enteromorpha lingulata J. A.

Earlier records: Reinbold 1907.

In discussing the determination of E. lingulata, Reinbold relates
these specimens closely to E. crinita.

Halimeda incrassata (Ell. & Sol.) Lamx.

Earlier records: Reinbold 1907.

Halimeda opuntia Lamx.

Earlier records: Hemsley, 1887; Gepp & Gepp 1909.

Halimeda opuntia f. typica E. S. Barton (verging towards f. cordata and
triloba)

Earlier records: Gepp & Gepp 1909.

Halimeda tuna (Ell. & Sol.) Lamx.

Earlier records: Reinbold 1907.

Microdictyon pseudohapteron Gepp & Gepp 1909: 165, pl. 22, figs. 1-4;

Dawson 1956: 36.

Stations: 4, locally common on Cymodocea stems, CR-423; 17a, drift,
CR-582; 25, CR-716; 27, CR-724; 29, CR-783; all common on or
under large coral rocks.

Segments to 260 μ in diameter, ca. to 400 μ long; ends of
anastomosing membranes crenulate in appearance.

Microdictyon pseudohapteron Gepp & Gepp cf. f. luciparense Setchell 1929:
549, figs. 72-75.

Stations: 4, locally infrequent on Cymodocea stems, CR-447.

Segments to 200 μ in diameter, to 500 μ long, with seemingly a wider
mesh than in the type.

Noemeris mucosa Howe 1909: 84, pl. 1, fig. 5 & pl. 5, figs. 1-14.

Stations: 1a, rare in sand, CR-396; 28, locally frequent over
coral rocks, CR-729.

Length of primary branches ca. 300-500 μ long; 50-75 μ in diameter; plants 6-13 mm tall.

Rhipidiphyllon reticulatum (Askenasy) Heydrich; Taylor 1950: 45;

Dawson 1956: 32, fig. 10.

Stations: 4, infrequent on Cymodocea stems, CR-424a; 12, infrequent under ledges, CR-509.

Lower cells to 175 μ in diameter with anastomosing branchlets.

Struvea anastomosans (Harv.) Piccone & Grunow; Egerod 1952: 359, pl. 31, fig. 4a-h.

Station: 22, on bivalve shell, CR-649.

With definite anastomosing habit and tenaculae; plants to 3 cm tall; stripe ca. 275-300 μ in diameter.

Struveopsis chagoensis Rhyne & H. Robinson 1968: 472, figs. 1-3.

Stations: 4, epiphytic upon Cymodocea, in 0.3-0.7 m of water, CR-421 (holotype-US); infrequent as epiphyte in Cymodocea bed, CR-450.

Valonia utricularis (Roth) C. Ag.

Earlier records: Reinbold 1907.

Stations: 12, associated with other larger algae, CR-505; 17a, infrequent on beach rock, CR-577; 21, very common under ledges, CR-631; 28, common as epiphyte on Cymodocea, CR-737.

The form of V. aegagropila was somewhat observed in CR-372, CR-505 and CR-577; however, these specimens are still probably dwarf forms of V. utricularis.

Valonia ventricosa J. Ag.

Stations: 4, infrequent in Cymodocea beds, CR-415, CR-445.

Spherical cells to 15 mm in diameter.

Valoniopsis pachynema (Martens) Børg.

Stations: 12, infrequent as epiphyte on larger algae, CR-520; 8, epiphytic on melobesioid alga, CR-545.

Highly contorted branching, branches up to 900 μ in diameter.

Phaeophyceae

Dictyota barteyresiana Lamx.

Earlier records: Reinbold 1907.

Dictyota sp. cf. D. divaricata Lamx.

Stations: 6, locally frequent under ledges, CR-456; 23, drift, CR-691.

Plants short to 5-6 cm tall; upper branches extremely narrow.

Dictyota sp. cf. D. friabilis Setchell 1926: 91, pl. 13, figs. 4-7, pl. 20, fig. 1; Dawson 1954: 401, 16a, b.

Stations: 2, common in drift, CR-370; 3, abundant on coral, CR-378; 11, frequent as epiphyte on Sargassum and Turbinaria, CR-503; 22, locally abundant patches, CR-642.

The low growing with concrescent thalli are as in D. friabilis Setch. Sporangia in our material measure ca. 80 μ in diameter, whereas in D. friabilis, Setchell indicates 160 μ .

Giffordia duchassaingiana (Grunow) Taylor; Dawson 1956: 43, fig. 32, (as Ectocarpus indicus Sonder in Zollinger).

Stations: 7, epiphytic upon Cymodocea, CR-494b; 23, over sand bottom in 0.3-0.7 m depths, CR-693; 10, locally frequent on various substrates in sand, CR-792.

Hydroclathrus clathratus (Bory) Howe

Earlier records: Reinbold 1907 (as Hydroclathrus cancellatus Bory)

Stations: 6, scattered in 0.3-0.7 m of water, CR-466; 13, locally abundant in drift, CR-528; 21, one clump in 0.3-0.7 m depths, CR-636.

Padina commersonii Bory

Earlier records: Reinbold 1907.

Stations: 2, drift, CR-368; 6, abundant over sand bottom, CR-457; 7, drift over sand bottom, CR-495; 11, abundant as drift over sand bottom, CR-498.

Padina sp. cf. P. tetrastomatica Hauck; Misra 1966: 158, fig. 84.

Stations: 13, very common in drift, CR-525.

Padina sp.

Stations: 3, scattered over small reef patches, CR-411.

Completely void of incrusting lime, but perhaps a form of P. commersonii.

Pocockiella papenfussii Taylor 1950: 98, pl. 54, fig. 2; Dawson 1956: 44.

Stations: 2, CR-359; 3, CR-375; 4, CR-416; 8, CR-546; 17a, CR-580; 19, CR-601; 28, CR-725. Most are common on coral or Cymodocea in 0.3-0.7 m depths.

Thalli to 325+ μ thick; ca. 8-9 cell tiers high.

Pocockiella variegata (Lamx.) Papenfuss

Earlier records: Gepp & Gepp 1909 (as Zonaria variegata Mart.)
in lagoon.

Stations: 11, epiphytic upon Dictyospheria, CR-500.

Thallus, 140-160 μ thick.

Ralfsia sp.

Stations: 17a, infrequently matting floors under ledges, CR-576.

The habit and internal structure agree with the genus Ralfsia;
however, without fertile material, a determination is not possible.

Rosenvingea intricata (J. Ag.) Børg.; Misra 1966: 125.

Stations: 6, infrequent under ledges, CR-467.

Hollow thallus with small superficial cells, 15-25 μ long; larger
cells beneath, (100)-175-200-(300) μ long, 75-125 μ in diameter.

Sargassum subrepandum (Forsk.) Kütz.

Earlier records: Reinbold 1907.

Sargassum spp.

Stations: 2, CR-366; 13, CR-530; 7, CR-550; all as drift; 11,
attached and locally abundant on scattered coral heads;
seemingly sterile, CR-496.

Sphacelaria furcigera Kütz.

Stations: 4, common as epiphyte on Cymodocea stems, CR-418.

Sphacelaria novae-hollandiae G. Sonder; Dawson 1954: 399, fig. 14g.

Stations: 3, epiphytic growth on coconut husks, CR-379.

Propagulum 90-110 μ long; 65-80 μ wide at tip with corner cells
divided as in Dawson's figure. Filaments however, are only 15-20 μ in
diameter rather than 50-70 μ as described by Børgesen 1941: 45.

Turbinaria conoides (J. Ag.) var. conoides f. laticuspidata Taylor;

Taylor 1966: 97.

Earlier records: Hemsley 1887 (as Turbinaria vulgaris var.
decurrens J. Ag.)

Turbinaria ornata J. Ag.

Earlier records: Gepp & Gepp 1909, on reefs exposed at dead low
tide.

Turbinaria trialata Kütz.

Earlier records: Reinbold 1907.

Turbinaria spp.

Stations: 1, CR-345; 2, CR-369; 6, CR-455; 11, CR-497; 14, CR-561; 6a, CR-705; 28, CR-734; most as stubby growth on various coral substrates.

All specimens are evesiculate and many seemingly dwarfed. Most are without dentate, lateral longitudinal ridges.

RhodophyceaeAmphiroa fragilissima (L.) Lamx.; Dawson 1954: 430, fig. 40g, h.

Stations: 4, in Cymodocea beds, CR-419.

Segments ca. 300 μ in diameter with evident nodal swellings.

Amphiroa sp. cf. A. anastomosans Weber-van Bosse; Dawson 1956: 50, fig. 45.

Stations: 6, locally abundant over beach rock, CR-459.

Segments ca. 250 μ in diameter, perhaps a little larger for this species, fertile.

Amphisbetema indica (J. Ag.) Weber-van Bosse 1913a: 133, pl. 13, fig. 24, pl. 14, fig. 34, and text fig.

Earlier records: Hemsley 1887 (as Dasya indica J. Ag.); Weber-van Bosse 1913a.

Stations: 14, drift, CR-541; 19, locally abundant on coral reef in 0.3-0.7 m depths, CR-600.

Botryocladia skottsbergii (Børg.) Levring

Stations: 12, CR-506; 17a, CR-575; 21, CR-630; all as infrequent tufts under limestone ledges.

Centroceras clavulatum (Ag.) Mont.

Stations: 13, CR-531, CR-548; common over coral rocks in 0.3-0.7 m of water.

Ceramium repens Harvey

Earlier records: Reinbold 1907.

Ceramium spp.

The collections have not yet been determined to species.

Champia compressa Harvey

Earlier records: Reinbold 1907.

Champia parvula (Ag.) Harvey

Stations: 4, locally frequent on Cymodocea stems, CR-424, rather dwarfed.

Champia sp.

Stations: 14, one piece, CR-563.

Cystocarps 475-525 μ in diameter, somewhat urceolate; wall with one layer of cells, these being 20-30 μ in diameter with smaller ones interspersed, 7-10 μ in diameter; branches concrescent here and there, to 1+ mm in diameter. This specimen has some characters of C salicornioides and compressa, but may be a rather robust form of C. parvula.

Chondria pumila Vickers; Weber-van Bosse 1913a: 125, pl. 12, fig. 8.

Earlier records: Weber-van Bosse 1913a.

Chondria spp.

Stations: 2, drift, CR-363; 18, frequent over coral cobbles, CR-587.

Cryptonemia sp. cf. C. crenulata J. Ag.

Stations: 21, locally frequent under limestone ledges, CR-628,
CR-628a.

Thallus ca. 200 μ thick, filamentous medulla and inner cortex.

Dictyurus purpurascens Bory

Earlier records: Weber-van Bosse 1913a.

Stations: 4, locally abundant in Cymodocea beds, CR-414; 5, infrequent under ledges, CR-442; 4, locally frequent in Cymodocea bed, CR-448.

Fosliella sp. cf. F. farinosa (Lamx.) Howe; Dawson 1954: 425, fig. 37c.

Stations: 2, CR-358; 4, CR-420; 19, CR-601a; all as epiphytes on Cymodocea blades and Pocockiella thalli.

Galaxaura filamentosa Chou; Chou 1945: 39, pl. 1, figs. 1-6, pl. 6, fig. 1; Dawson 1954: 419, fig. 30a.

Stations: 1, CR-360; 11, CR-502; 12, CR-512; 12, CR-521; 14, CR-535; 22, CR-643; epiphytes on other algae, Cymodocea or various coral substrates.

Gelidiella acerosa (Forsk.) Feldm. & Hamel

Earlier records: Weber-van Bosse 1928 (as Gelidiopsis rigida (Vahl) Weber-van Bosse) on reefs.

Stations: 1, CR-344; 6, CR-458; 8, CR-488; 12, CR-518; 10, CR-605; 21, CR-625; 28, CR-739; generally frequent to common over various coral and beach-rock substrates.

Gelidiella sp. cf. G. myrioclada (Børg.) Feldm. & Hamel; Dawson 1954: 473.

Stations: 21, abundant over coral cobbles, CR-625a; 21, abundant over sand flats, CR-627.

Branches ca. 150-200 μ in diameter; wiry texture; with apical cell; no rhizoids observed.

Gelidiopsis intricata (Ag.) Vickers; Dawson 1954: 423, fig. 34a-d.

Stations: 6, locally common over coral rocks, CR-471; 18, very common on beach-rock, exposed at LWS tide, CR-585; 28, frequent as wiry tufts under ledges, CR-647, CR-648; 23, frequent in 0.3-0.7 m of water, CR-694.

Branches 150-250 μ in diameter; with no apparent apical cell; tough wiry texture; tetrahedral tetraspores, ca. 30-40 μ in diameter; sporangia terminally placed, ca 430 μ wide, 700 μ long.

Gelidiopsis variabilis (Grev.) Schm.

Earlier records: Reinbold 1907.

Gelidium crinale (Turn.) Lamx.

Earlier records: Reinbold 1907; Weber-van Bosse 1913a.

Gelidium crinale var. perpusillum Picc. & Grun. in Piccone;

Earlier records: Reinbold 1907.

Stations: 26, locally common on beach-rock, exposed at LWS tide, CR-722.

Small tufts to 5 mm tall; branches 75-125 μ in diameter; with bilocular cystocarps.

Gelidium sp. cf. G. pusillum (Stackh.) Le Jolis; Dawson 1954: 420, fig. 31a-c.

Stations: 3b, one piece over coral rock, CR-389; 3, locally frequent on various coral substrates, CR-408; 6 locally common on coral rocks, CR-472.

Stubby growth to 1 cm tall; rhizoids seemingly concentrated in medulla; branches compressed to 1+ mm; with bilocular cystocarps in CR-408.

Herposiphonia tenella (Ag.) Ambronn; Børg. 1918; 286, figs. 287-289; Dawson 1954: 452, fig. 59a.

Stations: 3, epiphytic on Halimeda, CR-381.

Main axis ca. 100-125 μ in diameter, with ca. 8-10 pericentral cells that are 125-135 μ long; branching regular with a branch per cell over most of the plant; branches 50-75 μ in diameter.

Herposiphonia sp. #1

Stations: 13, on tree trunk in water, CR-527; 15, abundant over beach rock cobble, CR-549.

Herposiphonia sp. #2

Stations: 1, CR-348; 8, CR-491; 12, CR-522; frequent to common over various coral substrates.

Hypnea hamulosa (Turn.) Mont.

Earlier records: Reinbold 1907 (this may possibly be Hypnea valentiae (Turn.) Mont. as discussed in Dawson 1961: 239).

Hypnea pannosa J. Ag.; Tanaka 1941: 247, fig. 20; Dawson 1956: 51, fig. 46.

Earlier records: Reinbold 1907.

Stations: 2, drift, CR-365; 3, frequent in crevices of corals, CR-376; 10 infrequent in drift, CR-482; 7, on steel pilings, CR-492.

The following specimens seem referable to H. pannosa but with reservations. 4, locally frequent on Cymodocea stems, CR-425; 26, drift, CR-721: both as dwarfed material; 2, drift, CR-364; 6, entangled with other matted forms, CR-474; 12, infrequent over coral cobbles, CR-514; 18, abundant over coral cobbles, CR-583. The last four specimens were sterile.

Tetrasporic areas when found were only near lower portions of thallus near holdfast; sporangial areas were variable, being observed in some cases to encircle the branchlet, in other to form saddle-shaped sori as described for H. nidulans, or to be concentrated on one side as described for H. pannosa. Dawson 1961: 237, concludes that H. pannosa J. Ag. and H. nidulans Setchell are conspecific and should be known under the name H. pannosa.

Jania capillacea Harvey; Dawson 1954: 432, fig. 41a, b.

Stations: 1, frequent as epiphyte on Cymodocea and on various coral substrates, CR-347; 1, locally common on Halimeda, CR-350; 28, common Cymodocea, CR-736; 29 common over reef flat exposed at LWS tide, CR-780.

Segments ca. 100 μ in diameter, widely spreading branches at dichotomies.

Jania decussata-dichotoma (Yendo) Yendo; Dawson 1956: 49, fig. 44.

Stations: 2, drift, CR-367; 1a, frequent in crevices of coral rock, CR-398; 6, locally abundant as matted growth on beach-rock, CR-460; 8, abundant in drift, CR-490; 11, abundant on Cymodocea stems CR-501.

Fertile branches ca. 100-175 μ in diameter; segments generally 4-7 diameters long; with characteristic branching habit; conceptacles ca. 300 μ long, 400 μ in diameter.

Jania tenella Kütz.; Dawson 1956: 49, fig. 43.

Earlier records: Reinbold 1907 [as Corallina tenella (Kütz.) Heydr.]
Stations: 4, abundant on Cymodocea stems, CR-426.

Fertile segments terminal, ca. 100 μ in diameter.

Laurencia perforata Mont.

Earlier records: Reinbold 1907.

Laurencia pygmaea Weber-van Bosse 1913a: 122, pl. 12, fig. 6; Dawson 1954: 458, fig. 62k.

Earlier records: Weber-van Bosse 1913a.

Stations: 18, infrequent over coral cobbles, CR-592.

Repent, lax habit; branches 125-200 μ in diameter, somewhat constricted at their bases; surface cells ca. 20 μ in diameter, 30 μ long, other up to 80 μ long. Additional structures could not be seen clearly in cross sections.

Laurencia spinulifera Kütz.

Earlier records: Weber-van Bosse 1913a.

Laurencia sp. cf. L. nidifica J. Ag.; Yamada 1931: 202; Cribb 1958: 168, pl. 5, fig. 12; pl. 6, fig. 1-3.

Stations: 1, infrequent over various coral substrates, CR-346;

1a, drift, CR-397; 8, CR-487; 17, frequent over reef flat, CR-574; 17a, abundant over coral bottom in 0.3-0.7 m depths, CR-581; 29, on reef flat near "Porolithon" ridge, CR-784.

Branches ca. 450-750 μ in diameter; low matted entangled habit; with some lenticular thickening in a few specimens; tetraspores 60-100 μ in diameter.

Laurencia sp. cf. L. obtusa (Huds.) Lamx. var. ?; Yamada 1931: 222, pl. 16, figs. a-c; pl. 17, figs. a-c; Cribb 1958: 173, pl. 9, fig. 3.

Stations: 29, matted growth on reef flat near "Porolithon" ridge, CR-781.

Seemingly a member of the Cartilagineae; short stubby habit with branches to 3 mm in diameter, somewhat compressed in places, with tuberculate-like branchlets. See also L. corymbosa, L. parvipapillata & L. paniculata.

Liagora sp.

Stations: 29, frequent at edge of coral reef in 0.1-0.3 m depths, CR-779.

Possibly dwarfed L. ceranoides or L. rugosa.

Lithophyllum kaiseri Heydrich; Foslie 1907: 104.

Earlier records: Reinbold 1907.

Lithophyllum simulans Foslie

Earlier records: Reinbold 1907

cf. Lophosiphonia villum (J. Ag.) Setch. & Gardn.
Stations: 4, on Cymodocea stems, CR-432.

Main axis 50-60 μ in diameter; four pericentral cells 100-125 μ long; branches mostly simple but with some secondary branching, ca. 60 μ in diameter; branch pericentral cells ca 75 μ long; nonseptate rhizoids arising in many cases in middle of axis cells, irregularly placed in other cases; rhizoids do not seem to have a cross wall between themselves and main axis cells.

Neogoniolithon myriocarpum (Fosl.) Setch. & Mason; Dawson 1954: 428, fig. 39b.

Earlier records: Reinbold 1907 (as Goniolithon myriocarpon Foslie).

Peyssonelia calcea Heydrich; Weber-van Bosse 1921: 277, fig. 94; Dawson 1954: 425, fig. 37a.

Stations: 28, infrequent on coral reef in 1.3-2.3 m depths, CR-733.

Yellow-brown in color with very thick calcification.

Peyssonelia sp.

Stations: 22, infrequent on coral rocks, CR-646.

Large incrusting thalli but loosely adhering with septated rhizoids; thallus ca. 100-125 μ thick, seemingly closest to P. squammaria (Gmel.) Dcne. Sterile fragments.

Polysiphonia sp. cf. P. ferulacea Suhringar

Stations: 7, on Cymodocea stem, CR-493a.

Main axis ca. 175-200 μ in diameter with 4 pericentral cells; cells 150-170 μ long; tetraspores 45-50 μ in diameter

Porolithon oncodes (Heydrich) Foslie; Taylor 1950: 125, pls. 9, 61, 62 & 63.

Earlier records: Reinbold 1907 (as Lithophyllum onkodes Heydr.)

Spyridia filamentosa (Wulf.) Harvey

Stations: 7, CR-493; 12, CR-517; 13, CR-529; 21, CR-626; 23, CR-690; 10, CR-793: most as epiphytes on Cymodocea.

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6. ANNOTATED CHECK LIST AND BIBLIOGRAPHY OF CORALS OF THE CHAGOS
ARCHIPELAGO (INCLUDING THE RECENT COLLECTION FROM
DIEGO GARCIA), WITH REMARKS ON THEIR DISTRIBUTION

Brian R. Rosen

INTRODUCTION

The coral faunae of the Red Sea, Maldives, Southern India, Ceylon, Bay of Bengal, Cocos Keeling, Singapore and the Indonesian region are relatively well known. To the south and east, however, the central western Indian Ocean (which includes the Seychelles, Comoros, Mascarenes, Chagos, Madagascar and the East African coast) perhaps deserve further attention. No synthesis of coral records from Chagos has been published before, as far as is known, and the coral list which follows therefore fills this gap, and also provides further information about the region as a whole. The coral list is based on three collections:

1. That of G. C. Bourne from Diego Garcia, in 1885,
2. that of J. Stanley Gardiner et al., during the Percy Sladen Expedition to the Indian Ocean in 1905,
3. that of J. D. Taylor made during his recent visit to Diego Garcia, July, 1967. This consists of about 100 specimens identified for the present paper.

Publication of the first two collections has never been completed, but a reasonably representative picture of the Chagos coral fauna could hitherto be obtained by combining the two sets of appropriate publications. Only Bourne's Astrocoeniina and Poritidae are well covered by the literature, whereas these are precisely the groups in the Sladen collection which are still undescribed. Additional coral names are also to be found in general accounts of the islands, but these usually consist of generic names only (Bourne, 1888; Gardiner, 1936; Gardiner & Cooper, 1907). Knowledge of the Chagos corals is however rather uneven, since Diego Garcia is not really represented by Sladen material, while Bourne and Taylor only visited (as intended) Diego Garcia. With the completion of the present list, Diego Garcia is now best known of the four principal atolls with regard to its corals (see table 6).

The corals from all three visits are part of the collection in the British Museum (Natural History), London. A considerable number of specimens from the previous two visits have been examined by the author in the course of this and other work, but although some changes are in fact necessary, no attempt has been made here to revise names or synonymies. Names have only been changed where current usage requires this. Such instances will be clear from the list, which must, however, be regarded as provisional.

While other expeditions have visited the Chagos group, no coral collections appear to have been made by them.

REMARKS ON THE CORAL FAUNA

1. Genera

The total of 54 genera and subgenera, shown in Table 5, includes 42 hermatypic scleractinians. It is interesting to compare this figure with data given in Wells' map (1954, pl. 186). For the comparison to be valid however the subgenera of Fungia must be taken as a single genus (the map is earlier than Wells' 1966 subdivision of Fungia), and Agariciella disregarded. The adjusted figure then becomes 38, which is slightly lower than the figure interpolated from Wells' map (40-45). This anomaly is probably an indication of incomplete collecting, especially in deeper water. Relatively little dredging has been done in the course of the three principal visits to the archipelago. Hence deeper water sampling together with further surface reef collecting and examination of unpublished material in the British Museum (Natural History) may produce specimens of Psammocora (Plesioseris), P. (Stephanaria), Pavona (Polyastra), Merulina, and a number of widespread, though not abundant representatives of the Fungiidae and Pectiniidae. With regard to the first of these families, Wells' map (1966, Fig. 5) predicts a further three genera and one subgenus (see note in check list), whilst the second is noticeably not represented at all yet.

Of those genera recorded, Siderastrea, Agariciella and Ctenella are noteworthy. The first is unfortunately only a sight record and may possibly have referred to a Pavona, as explained in the check list. Siderastrea is one of the few genera known both from the West Indian and Indo-Pacific regions, though Indo-Pacific species are restricted to the western Indian Ocean. If Gardiner's record is confirmed, Chagos will be the easternmost limit of its known distribution in southern tropical waters. Ctenella is a very rare genus known only from Chagos and the Saya de Malha bank to the south of the Seychelles. Agariciella (usually as "Agaricia") is a third genus of rare occurrence. Its distribution may also be restricted, but confusion with Pavona (Polyastra) obscures any pattern that may exist. Other less common genera known from Chagos include Plerogyra and Oulophyllia.

Of the eight genera known only from sight records, four are hermatypic scleractinians: Seriatopora, Alveopora, Euphyllia and, as already mentioned, Siderastrea. Two are ahermatypic (Fungiacyathus and Madrepora) and the remaining two are non-scleractinians (Stylaster and Heliopora).

The scleractinian fauna is almost entirely hermatypic. This is in accord with the above conclusion that relatively little sampling has been done in deeper water. Of the four ahermatypic genera, two are only sight records (Fungiacyathus and Madrepora), and the other two are

Table 5. Genera and subgenera collected by expeditions to the Chagos Archipelago

Investigators	Genera for each visit		New records		Net total of different genera
	Sight records	specimens and sight records	sight records	specimens and sight records	
Bourne (in 1885)	5	11	5	11	11
Gardiner (in 1905)	15	48	10	38	49
Taylor (in 1967)	0	26	0	5	54

Table 6. Genera and species recorded from each atoll*

	Diego Garcia	Egmont	Peros Banhos	Salomon	Whole group
Total number of genera and sub-genera	28	19	21	40	54
Number of hermatypic Scleractinian genera and subgenera	25	16	16	29	42
ditto, adjusted for comparison with Wells (1954)	23	13	16	26	38
Total number of species (approx.)	64	23	24	56	107
Number of hermatypic Scleractinian species (approx.)	60	20	20	44	91.

* 1 genus (1 species?) was also recorded from banks to the southeast of the group, but this does not alter final column.

probably from shallow water (Balanophyllia and Dendrophyllia). Horst's (1926) descriptions give no depths for the latter.

The depth range of dredging (Percy Sladen Expedition only) is 0.1098 m. Dredging in waters deeper than about 20 m was mainly done in the vicinity of Salomon. Five out of eight non-scleractinian genera were dredged, all of them from this area, as were Fungiacyathus and Madrepora.

Non-scleractinian genera are mostly from deep water, however (five out of eight).

2. Species

The value of conclusions made on the basis of species-level consideration is open to doubt because of the severity of the species-problem in corals. Following Bourne's visit to Diego Garcia, there were about 20 species known from Chagos. Gardiner's Sladen Expedition visit to the group raised this figure to about 75, and Taylor's to Diego Garcia to about 105. Of these 91 are hermatypic Scleractinia, a figure which may be compared with some of the surface reef species figures given by Wells (1954, 395): 150 in the Marshalls, Palau Islands, and Fiji, 155 in the Philippines and 200 in the Great Barrier Reef region. The Chagos fauna thus appears small, as is also indicated by the number of genera present there. The difference however is in approximate proportion to the number of genera present, though this has been shown above to be somewhat lower than expected, probably on account of incomplete collecting. The true number of species should probably be about 120-140, assuming no radical differences in species definitions. Further species may be provided by the predicted but unrecorded genera mentioned above, together with further species of Psammocora, Seriatopora, Acropora, Montipora, Goniopora, Synaraea and Goniastrea. Noticeably absent are staghorn species of Acropora, A. humilis and Goniastrea retiformis. On the other hand, comparison and examination of existing Chagos specimens of Acropora, Montipora and Porites may well show some of those listed to be the same.

Other points relevant here have already been made in the preceding section.

3. Individual atolls

Table 6 shows that the coral faunae of Diego Garcia and Salomon are better known than those of Egmont and Peros Banhos. This is a more probable explanation of the different numbers of genera and species than an ecological one. The table shows that more genera have been recorded from Salomon than Diego Garcia, but more species from Diego Garcia. The difference in genera is largely made up of ahermatypic and non-scleractinian corals, most of which are from depths greater than 60 fms (109m). There is no record of dredging round Diego Garcia. A second factor originates with the published collection lists. Previous to Taylor's

visit, the Diego Garcia corals that had been described and published were mainly Astrocoeniina, i.e. few genera represented by a relatively high number of species. For Salomon, visited by Gardiner, the Faviina and Fungiina were the most important of the published groups, these consist of relatively few species within each genus. Gardiner apparently collected very few corals in Diego Garcia. Whilst Taylor's collection substantially balances the picture for Diego Garcia, Salomon (and the other two atolls) remain better known for their Faviina and Fungiina alone. Relevant material in fact awaits examination in the British Museum (Natural History).

Taylor's collection adds 19 genera and subgenera to the coral list from Diego Garcia, 17 of these being hermatypic Scleractinia. About 40 species have been added. Comparison of these figures with Table 6 shows that previous to his visit, this atoll was least well represented.

CORAL CHECK LIST

In the following list:

- * indicates new records for the Chagos Archipelago,
- (*) indicates species or genera whose only previous record from Chagos was a sight record, and
- sr indicates sight records.

The three principal collections are indicated under each species by the initials of the three investigators concerned; thus, B (Bourne), G (Gardiner) and T (Taylor), and localities given for each, followed by references and comments where applicable. When a genus has been recorded without a species name in a general, non-systematic work, this has been quoted under the generic name concerned. It is assumed that more than one species may have been covered by such references. References in systematic papers (e.g. Allopora sp.) are listed as species.

Classification from Wells, 1956.

Class ANTHOZOA
 Subclass ZOANTHARIA
 Order Scleractinia
 Suborder Astrocoeniina
 Family ASTROCOENIIDAE
 Subfamily Astrocoeniinae

* Stylocoeniella

- * Stylocoeniella armata (Ehrenberg)
 T: Diego Garcia - Lagoon, East Point.

Family THAMNASTERIIDAE

Psammocora

- sr G: "submerged banks to the south-east" of the Chagos group (Gardiner & Cooper, 1907: 54)

Psammocora planipora Edwards & Haime
G: Salomon (Horst, 1922: 425)

Family POCILLOPORIDAE

(*) Stylophora

- sr G: Diego Garcia (Gardiner, 1936: 420)
sr Egmont (Gardiner, 1936: 414, 415; Gardiner & Cooper, 1907: 53)
sr Peros Banhos - Coin 5-10fms (9-18m) (Gardiner & Cooper, 1907: 38)
sr Salomon (Gardiner & Cooper, 1907: 36) and down to 10fms (18m) (Gardiner, 1936: 406, 407, 409)

* Stylophora pistillata (Esper)

T: Diego Garcia - North Point Lagoon and Lagoon Reef East Point

* Stylophora mordax (Dana)

T: Diego Garcia - algal ridge North West Point.

Seriatopora

- sr G: Salomon (Gardiner, 1936: 408)

Seriatopora stricta Brueggemann

- sr B: Diego Garcia (Bourne, 1888: 450)

(*) Pocillopora

- sr B: Diego Garcia (Bourne, 1888: 450)
sr G: Salomon (Gardiner, 1936: 404, 407)
sr Peros Banhos - Ile du Coin, 5-10fms (9-18m) (Gardiner & Cooper, 1907: 38)

* Pocillopora eydouxi Edwards & Haime

T: Diego Garcia - algal ridge North West Point

* Pocillopora damicornis (Linnaeus)

T: Diego Garcia - windward reef South Point, North Point lagoon, Cust Point.

* Pocillopora danae Verrill

T: Diego Garcia - windward reef South Point.

Family ACROPORIDAE

Acropora

- sr B: Diego Garcia (Bourne, 1888: 450, as Madrepora)
sr G: Egmont (Gardiner, 1936: 414)
sr Peros Banhos - Ile du Coin, 5-10fms (9-18m) (Gardiner & Cooper, 1907: 38, as Madrepora)
sr Salomon, less than 10fms (18m) (Gardiner, 1936: 404-410; "Madrepora" dredged from less than 10fms, p. 409 is probably Acropora)

Acropora aspera (Dana)

sr B: Diego Garcia (Bourne, 1888: 454, as Madrepora aspera)

Acropora cytherea Dana ?

B: Diego Garcia (Brook, 1893: 99, as Madrepora ?cytherea)

* Acropora sp.cf. cymbicyathus (Brook)

T: Diego Garcia - windward reef South Point.

Acropora disticha Brook

B: Diego Garcia. TYPES (Brook, 1893: 84, pl. 33, fig. D, as M. disticha)

T: Diego Garcia - windward reef South Point, algal ridge East Point. These specimens are intergradational with A. murrayensis Vaughan

Acropora diversa (Brook)

B: Diego Garcia TYPE (Brook, 1891: 461, 1893: 141, pl. 16, fig. B, as M. diversa)

Acropora eurystoma (Klunzinger)

B: Diego Garcia (Brook, 1893: 137 as M. eurystoma and M. eurystoma var. parvula Brook)

* Acropora glochicladus (Brook)

T: Diego Garcia - North Point lagoon.

Acropora haimeii (Edwards & Haime) ?

B: Diego Garcia (Brook, 1893: 77, as Madrepora ?haimeii)

Acropora hyacinthus (Dana)

B: Diego Garcia (Brook, 1892: 452, 1893: 100, TYPES in part of Madrepora armata. See synonymy, Wells, 1954: 421)

* Acropora murrayensis Vaughan

T: Diego Garcia - windward reef South Point.

Acropora palifera (Lamarck)

B: Diego Garcia (Brook, 1893: 131)

T: Diego Garcia - North Point lagoon.

* Acropora reticulata (Brook)

T: Diego Garcia - North Point lagoon.

* Astreopora* Astreopora ocellata Bernard

T: Diego Garcia - lagoon flats immediately North of East Point, lagoon North Point, lagoon reef East Point.

Montipora

sr G: Salomon, down to 5fms (9m). (Gardiner, 1936: 406-410)
 sr Diego Garcia (Gardiner, 1936: 420)

* Montipora sp.cf. brueggemanni Bernard
 T: Diego Garcia - lagoon reef East Point.

* Montipora edwardsi Bernard
 T: Diego Garcia - lagoon East Point.

Montipora effusa (Dana)
 B: Diego Garcia (Bernard, 1897: 144)

* Montipora sp.cf. hispida (Dana)
 T: Diego Garcia - lagoon flats immediately north of East Point

Montipora lobulata Bernard
 B: Diego Garcia. TYPE. (Bernard, 1897: 76, pl. 16)

* Montipora sp.cf. tuberculosa (Lamarck)
 T: Diego Garcia - lagoon flats immediately north of East Point, lagoon North Point, lagoon reef East Point.

* Montipora sp.
 T: Diego Garcia - lagoon reef East Point. Coral has grown round stems of Cymodocea (= Thalassodendron) weed.

Suborder Fungiina
 Superfamily AGARICITICAE
 Family AGARICIIDAE

Pavona

sr G: Salomon, down to 10fms (18m) (Gardiner, 1936: 408, 409)
 "Siderastrea" (Gardiner & Cooper, 1907: 38), from Ile du Coin, Peros Banhos, less than 4fms (7m), may have referred to Pavona

Pavona explanulata (Lamarck)
 G: Salomon (Horst, 1922: 418); (sr - Gardiner, 1936: 405)

Pavona varians Verrill
 G: Egmont (Horst, 1922: 419)
 Peros Banhos (ibid.)
 Salomon (ibid.)
 T: Diego Garcia - lagoon North Point.

Pavona clavus Dana
 G: Egmont (Horst, 1922: 420)
 Salomon (ibid.)

AgariciellaAgariciella ponderosa (Gardiner)G: Salomon (Horst, 1922: 418, as Agaricia ponderosa)LeptoserisLeptoseris incrustans (Quelch)

G: Peros Banhos, 15-16 fms (27-29m) (Horst, 1922: 422)

PachyserisPachyseris levicollis (Dana)

G: Salomon (Horst, 1922: 427)

Family SIDERASTREIDAE

sr Siderastrea

(?) G: Peros Banhos - Ile du Coin, less than 4 fms (7m)
 (Gardiner & Cooper, 1907: 38. This may have been
Pavona; see for instance Gardiner, 1906: 934-936, for
 then current concept of Siderastrea.)

Superfamily FUNGIICAE
 Family FUNGIIDAE

In addition to those genera listed below, Wells' map (1966: fig. 5) indicates that the Chagos archipelago lies within the limits of the known geographical distribution of Cycloseris, Fungia (Ctenactis), Polyphyllia, and Podabacia.

Fungia

sr G: Salomon (Gardiner, 1936: 406)

Fungia sp. Authocaulus stage (ca. 5 mm diam.)

T: Diego Garcia

Fungia (Pleuractis) scutaria Lamarck

G: Egmont (Gardiner, 1909: 267, 272)

Peros Banhos (ibid.)

Salomon (ibid.)

T: Diego Garcia - windward reef South Point.

Fungia (Verrillofungia) concinna Verrill

G: Egmont (Gardiner, 1909: 267, 276)

Salomon (ibid.)

Fungia (Verrillofungia) fieldi Gardiner

G: Salomon, TYPE (Gardiner, 1909: 267, 277, pl. 33, figs. 3, 4, pl. 34, fig. 7)

- * Fungia (Verrillofungia) repanda Dana
T: Diego Garcia - lagoon flats immediately north of East Point.

Fungia (Danafungia) corona Döderlein
G: Egmont (Gardiner, 1909: 267, 278)

Fungia (Fungia) fungites (Linnaeus)
sr B: Diego Garcia (Bourne, 1888: 450, as Fungia dentata Dana. See Döderlein, 1902: 136)
G: Egmont (Gardiner, 1909: 267, 279)
Salomon (ibid.)

* Herpolitha

- * Herpolitha limax (Esper)
T: Diego Garcia - lagoon flats immediately north of East Point, lagoon North Point.

Halomitra Dana

Halomitra philippensis Studer
B: Diego Garcia (Gardiner, 1909: 281)
G: Salomon (ibid. "protected reefs of lagoon lying free in holes, between large fixed growths of massive corals.")
T: Diego Garcia - lagoon flats immediately north of East Point, lagoon East Point.

Fungiacyathus

sr G: off Salomon, 350-600fms. (640-1098m) (Gardiner & Cooper, 1907: 42), as Bathyactis.

Superfamily PORITICAE

Family PORITIDAE

(*) Goniopora

sr G: Salomon, less than 10fms (18m) (Gardiner 1936: 409)

- * Goniopora sp.cf. savignyi Dana
T: Diego Garcia - lagoon flats immediately north of East Point, lagoon reef East Point. The specimens are identical to Goniopora "xd" Bernard, 1903: 158, pl. 8, fig. 5. This was previously identified as G. savignyi Dana by Brueggemann (MS) but Bernard states that this is "out of the question."

Porites

sr B: Diego Garcia (Bourne, 1888: 450, 454)
sr G: Diego Garcia (Gardiner, 1936: 420; Gardiner & Cooper, 1907: 46)
sr Egmont (Gardiner, 1936: 414)

- sr Peros Banhos (Gardiner, 1936: 423) - Ile du Coin, less than 4fms (7m) (Gardiner & Cooper, 1907: 38)
 sr Salomon down to 10fms (18m) (Gardiner, 1936: 400-410)

Porites (Porites) "Diego Garcia (3) 1 Bernard"

B: Diego Garcia (Bernard, 1905: 216, pl. 32, fig. 1)

Porites (Porites) "Diego Garcia (3) 2 Bernard"

B: Diego Garcia (Bernard, 1905: 216, pl. 32, fig. 2)

Porites (Porites) "Diego Garcia (3) 3 Bernard"

B: Diego Garcia (Bernard, 1905: 217, pl. 32, fig. 3, pl. 34, fig. 4)

- * Porites (Porites) lutea Edwards & Haime
 T: Diego Garcia - lagoon flats immediately north of East Point, lagoon reef East Point, Cust Point. Wells (1954: 453) states that this species "does not appear to occur in the Red Sea or Indian Ocean." Preliminary examination suggested that this was the closest species, but further study may lead to an alternative identification.
- * Porites (Porites) solida (Forskål)
 T: Diego Garcia - lagoon reef East Point.
- * Porites (Porites) australensis Vaughan
 T: Diego Garcia - lagoon North Point.
- * Porites (Porites) lichen Dana
 T: Diego Garcia - windward reef South Point.
- * Porites (Porites) andrewsi Vaughan
 T: Diego Garcia - lagoon reef East Point, Cust Point.
- * Porites (Porites) nigrescens Dana
 T: Diego Garcia - Cust Point.
- * Porites (Synaraea) iwayamaensis Eguchi
 T: Diego Garcia - lagoon North Point, lagoon reef East Point, lagoon East Point.

Alveopora

- sr G: Peros Banhos - Ile Diamant, 15fms (27m) (Gardiner & Cooper, 1907: 28)
 sr Salomon (Gardiner, 1936: 409)

Suborder	<u>Faviina</u>
Superfamily	<u>FAVITICAE</u>
Family	<u>FAVIIDAE</u>
Subfamily	Faviinae

Gardiner & Cooper (1909: 28, 38) give sight records of Orbicella from Peros Banhos, but Gardiner's use of this generic name (e.g. see Gardiner, 1906: 774-778) makes it difficult to interpret which form(s) he was referring to. Orbicella sensu Gardiner might correspond in current usage to Diploastrea, Leptastrea, Plesiastrea, or Favia. It would therefore appear to be safer to omit it from the list. Caution is also required in interpreting Prionastrea, Favia and Goniastrea as given by Gardiner (1936) and Gardiner & Cooper (1907) but in general these may be taken to correspond to more recent concepts of Favites, Favia and Goniastrea respectively (but note Matthai's 1914 usage of Favia, which Gardiner might conceivably have adopted). Confusion of nomenclature has also surrounded the brain corals. Maeandra, Maeandrina, Coeloria, Platygyra and Leptoria have all been used to refer to representatives of the last two named genera. Thus Bourne's (1888) sight record of "Maeandrina" might have meant Platygyra, Leptoria or even a number of other genera. Like Orbicella above it would therefore be safer to omit it.

Plesiastrea

Plesiastrea versipora (Lamarck)

G: Salomon (sr - Gardiner, 1936: 407; Matthai, 1914: 103, both as Favia versipora. See synonymies in Yabe, Sugiyama & Eguchi, 1936: 23, Orbicella versipora, and Wells, 1954: 460)

Favia

sr G: Egmont (Gardiner, 1936: 414)
sr Salomon (ibid, 405, 409)

Favia stelligera (Dana)

sr B: Diego Garcia (Bourne, 1888: 450 as F. lobata.) See synonymy Vaughan 1918: 101)
G: Egmont (Matthai, 1914: 102, as F. acropora. See synonymy Vaughan, 1918: 101)
Salomon (Matthai, 1914: 102, pl. 25, fig. 3, pl. 33, fig. 1, as F. acropora).
T: Diego Garcia - lagoon North Point.

Favia favus (Forskål)

G: Salomon (Matthai, 1914: 79)
T: Diego Garcia - lagoon flats immediately North of East Point, lagoon reef East Point. Specimen from latter locality is intergradational with F. pallida.

Favia pallida (Dana)

G: Peros Banhos - Ile du Coin (Matthai, 1914: 84 as F. doreyensis)
Salomon (sr - Gardiner, 1936: 407; Matthai, 1914: 84. Both as F. doreyensis. See synonymy Vaughan, 1918: 105).
T: Diego Garcia - lagoon reef East Point.

Favia speciosa (Dana) facies "clouei"

- G: Egmont (Matthai, 1914: 89, as F. clouei. See synonymy Vaughan, 1918: 103)
 Salomon (ibid. Also pl. 25, fig. 2. As F. clouei)

Favites

- sr G: Peros Banhos - Ile Diamant, 15fms (27m) (Gardiner & Cooper, 1907: 28, as Prionastrea) and Ile du Coin, less than 4 fms (7m) (ibid. 38, as Prionastrea)

Favites abdita (Ellis & Solander)

- G: Egmont (Matthai, 1914: 91, as Favia abdita. See synonymy Vaughan, 1918: 109)
 Salomon (ibid. Also pl. 9, fig. 5, as F. abdita) Favia orbita (Gardiner, 1936: 405) from Salomon may be this species (sr)
 T: Diego Garcia - lagoon North Point.

Favites halicora (Ehrenberg)

- G: Egmont? (Matthai, 1914: 106, as Favia halicora. See synonymy Vaughan, 1918: 110)
 Peros Banhos - Ile Diamant, 15fms (27m) (ibid., as F. halicora)
 Salomon (ibid. Also pl. 26, figs. 5-7, as F. halicora)
 T: Diego Garcia - lagoon North Point.

Favites virens (Dana)

- G: Egmont (Matthai, 1914: 108, pl. 27, fig. 3, as Favia vasta. See synonymy Vaughan, 1918: 111)
 Salomon (Matthai, 1914: 108, pl. 27, fig. 5, as F. vasta)

Favites melicerum (Ehrenberg)

- G: Salomon (Matthai, 1914: 95, as Favia pentagona. See synonymy Vaughan, 1918: 112)

* Favites aspera (Verrill)

- T: Diego Garcia - windward reef South Point.

* Favites yamanarii Yabe & Sugiyama

- T: Diego Garcia - windward reef South Point, algal ridge East Point.

OulophylliaOulophyllia crispa (Lamarck)

- G: Salomon (Matthai, 1928: 257, pl. 19, fig. 2)

Goniastrea

- sr G: Peros Banhos - Ile du Coin, less than 4fms (7m) (Gardiner & Cooper, 1907: 38)

sr Salomon (Gardiner, 1936: 405)

Goniastrea? hombroni (Rousseau)

G: Salomon (Matthai, 1914: 107, pl. 26, figs. 1, 2, pl. 33, fig. 2, as Favia hombroni. See Vaughan, 1918: 100)
Professor John W. Wells kindly informs me that he has examined Rousseau's type and says that it is a specimen of Favia stelligera.

Goniastrea pectinata (Ehrenberg)

G: Egmont (Matthai, 1914: 121, pl. 31, fig. 8, as G. planulata. See synonymy Crossland, 1952: 135)
Salomon (sr - Gardiner, 1936: 407, as G. planulata; Matthai, 1914: 121, as G. planulata; Matthai, 1914: 120).
T: Diego Garcia - lagoon North Point.

Platygyra

sr G: Salomon (Gardiner, 1936: 404, 407, as Coeloria)

Platygyra lamellina (Ehrenberg)

* facies astreiformis (Edwards & Haime)

T: Diego Garcia - windward reef South Point, lagoon North Point.

facies sinensis (Edwards & Haime)

G: Salomon (Matthai, 1928: 24, pl. 5, fig. 1, as Coeloria daedalea. See Wells, 1954: 462 and Stephenson & Wells, 1955: 35-36)

* facies rustica (Dana)

G: Diego Garcia - lagoon flats immediately north of East Point, windward reef South Point, lagoon reef East Point.

facies lamellina Ehrenberg

G: Salomon (Matthai, 1928: 37, pl. 6, fig. 5, as Coeloria lamellina. See Stephenson & Wells, 1955: 35-36. Text gives locality as "Chagos"; plate caption gives "Salomon, Chagos".)

* Leptoria

* Leptoria phrygia (Ellis & Solander)

T: Diego Garcia - windward reef South Point.

Hydnophora

Hydnophora exesa (Pallas)

G: Egmont (Matthai, 1928: 140)
Salomon (ibid.)

Hydnophora microconos (Lamarck)

- G: Peros Banhos - Ile du Coin (Matthai, 1928: 144, pl. 17, fig. 4, pl. 49, fig. 5)
 *Salomon (Matthai, 1928: 144)

Subfamily Montastreinae

Leptastrea

- sr G: Salomon (Gardiner, 1936: 405, 409)

Leptastrea purpurea (Dana)

- G: Egmont (Matthai, 1914: 68, as L. ehrenbergana. See synonymy Vaughan, 1918: 91)
 Salomon (Matthai, 1914: 68, pl. 19, fig. 4, as L. ehrenbergana)

The next species may belong here also.

Leptastrea roissyana Edwards & Haime

- G: Salomon (Matthai, 1914: 67. Matthai's concept of this species appears to overlap with that of other authors' L. purpurea and L. transversa, e.g. see Vaughan's discussion of the genus, 1918: 90-97. Crossland, 1952: 114 states that all these intergrade.)

Leptastrea bottae (Edwards & Haime)

- G: Salomon (Matthai, 1914: 69, pl. 18, figs. 3 and 6, as L. solida. See synonymy Vaughan, 1918: 94)

Cyphastrea

- sr G: Salomon (Gardiner 1936: 405)

Cyphastrea chalcidicum Klunzinger

- G: Salomon (Matthai, 1914: 41)

Cyphastrea microphthalma (Lamarck)

- G: Egmont (Matthai, 1914: 43, pl. 12, fig. 6)
 Salomon (Matthai, 1914: 43)
 T: Diego Garcia - lagoon North Point

Echinopora

- sr G: Salomon, down to 10fms (18m) (Gardiner, 1936: 408-409)

Echinopora lamellosa (Esper)

- G: Peros Banhos - Ile du Coin (Matthai, 1914: 50, pl. 14, fig. 4)
 Salomon (Matthai, 1914: 50, pl. 14, fig. 6)
 T: Diego Garcia - lagoon North Point

Echinopora hirsutissima Edwards & Haime

- G: Peros Banhos - Ile du Coin (Matthai, 1914: 51, pl. 15, fig. 2)
 Salomon (Matthai, 1914: 51, pl. 15, fig. 3)

Family OCULINIDAE
Subfamily Oculininae

Madrepora

- sr G: off Salomon, 350-600fms (640-1098m) (Gardiner & Cooper, 1907: 42, as Amphihelia.)

Subfamily Galaxeinae

GalaxeaGalaxea clavus (Dana)

- G: Peros Banhos - Ile du Coin (Matthai, 1914: 62, as G. musicalis. See synonymy Vaughan, 1918: 99)

Galaxea lamarcki Edwards & Haime

- G: Peros Banhos - Ile du Coin, and Ile Diamant 16fms (29m) (Matthai, 1914: 64. This species is close to G. clavus and may only be a deeper water facies of it.)

Family MEANDRINIDAE
Subfamily Meandrininae

CtenellaCtenella chagius Matthai

- G: Egmont (Matthai, 1928: 172, pl. 54, fig. 2. TYPE)

Family MUSSIDAE

AcanthastreaAcanthastrea echinata (Dana)

- G: Salomon (Matthai, 1914: 110, as Favia hemprichii. See Wells, 1954: 467)

Lobophyllia

- sr G: Peros Banhos - Ile Diamant 15fms (27m), and Ile du Coin 5-10 fms (7-18m) (Gardiner & Cooper, 1907: 28 and 38 respectively, as Mussa)
sr Salomon, down to 10fms (18m) (Gardiner, 1936: 408-409)

Lobophyllia corymbosa (Forskål)

- sr B: Diego Garcia (Bourne, 1888: 450, as Mussa corymbosa. See synonymy Matthai, 1928: 210)
G: Diego Garcia (Matthai, 1928: 210)
Peros Banhos - Ile du Coin (ibid. Also pl. 60, fig. 6)
Salomon (sr - Gardiner, 1936: 407; Matthai, 1928: 210)

Lobophyllia costata (Dana)

- G: Peros Banhos - Ile du Coin (Matthai, 1928: 216, pl. 47, fig. 8). The caption to pl. 28, fig. 1 of this species gives "Chagos: Salomon" for the locality. This is not mentioned in text. The British Museum (Natural History)

register No. of the specimen indicates that it can be neither Bourne's nor Gardiner's material because it was registered before either expedition. It does however accord with Guppy's Salomon Is. material. Hence for "Salomon" read "Solomons".)

T: Diego Garcia - lagoon flats immediately north of East Point.

Symphyllia

Symphyllia nobilis

G: Egmont (Matthai, 1928: 227, pl. 31, fig. 1. For "Chagos: Salomon" in caption to pl. 30, fig. 4, read "Solomon Is." See note under Lobophyllia costata above.)

Suborder	<u>Caryophylliina</u>
Family	CARYOPHYLLITIDAE
Subfamily	Eusmiliinae

Euphyllia

sr G: Salomon, down to 10fms (19m) (Gardiner, 1936: 409)

Plerogyra

Plerogyra sinuosa (Dana)

G: Peros Banhos - Ile du Coin (Matthai, 1928: 184)

Suborder	<u>Dendrophylliina</u>
Family	DENDROPHYLLITIDAE

Balanophyllia

Balanophyllia regularis (Gardiner)

G: Peros Banhos - Ile du Coin (Horst, 1926: 50)
Salomon (ibid.)

Dendrophyllia

Dendrophyllia aurea (Quoy & Gaimard)

G: Salomon (Horst, 1926: 46)

Turbinaria

* Turbinaria sp.cf. irregularis Bernard

T: Diego Garcia - lagoon reef East Point

Turbinaria globularis Bernard

B: Diego Garcia (Bernard, 1896: 68, pl. 20, pl. 32, fig. 20. TYPE)

Subclass OCTOCORALLIA
 Order Stolonifera
 Family TUBIPORIDAE

(*) Tubipora

- sr G: Egmont (Gardiner, 1936: 414)
 sr Peros Banhos - Ile du Coin, less than 4fms (7m) (Gardiner & Cooper, 1907: 38)
 sr Salomon (Gardiner, 1936: 406, 408)

(*) Tubipora musica (Linnaeus)

T: Diego Garcia - algal ridge North West Point. There being only one known species of Tubipora, the references without species names above, may be taken to indicate T. musica, and the recording of the actual species from Chagos is not completely new.

Order Coenothecalia
 Family HELIOPORIDAE

Heliopora

- sr G: Peros Banhos (Gardiner, 1936: 423) - Ile du Coin, less than 4fms (7m) (Gardiner & Cooper, 1907: 38)
 sr Salomon (Gardiner, 1936: 406-409)

Heliopora coerulea (Pallas)

- sr G: Peros Banhos, Salomon (as above). There is only one known species of Heliopora, and the above references may be taken to be this species.

Class HYDROZOA
 Order Milleporina
 Family MILLEPORIDAE

Millepora

- sr B: Diego Garcia (Bourne, 1888: 454)
 sr G: Egmont (Gardiner, 1936: 414)
 Peros Banhos - Ile du Coin, less than 4 fms (7m) (Gardiner and Cooper, 1907: 38)
 sr Salomon (Gardiner, 1936: 400-409)

Millepora platyphylla Hemprich & Ehrenberg

- B: Diego Garcia (Boschma, 1949: 665)
 T: Diego Garcia - windward reef South Point

Millepora tenera Boschma

- B: Diego Garcia (Boschma, 1949: 669)
 T: Diego Garcia - windward reef South Point

Order Stylasterina
 Family STYLASTERIDAE
 Subfamily Stylasterinae

Stylaster

?sr G: Salomon, 60-337fms (109-612m) (Gardiner, 1936: 412. Boschma, 1957 quotes Gardiner on p. 18 and comments, "Hickson & England, 1909, do not record a species of Stylaster from this locality; they list a coral from Salomon Atoll as Allopora sp.?" Gardiner's record thus appears doubtful.)

Allopora

Allopora sp.?

G: off Salomon, 60-120fms (109-219m) (Hickson & England, 1909: 346; Boschma, 1957: 30)

Crypthelia

Crypthelia ramosa Hickson & England

G: off Salomon, 120-150fms (219-274m) (Hickson & England, 1909: 351; Boschma, 1957: 38)

Conopora

Conopora tenuis Moseley

G: off Salomon, 120-150fms (219-274m) (Hickson & England, 1909: 351; Boschma, 1957: 39)

Subfamily Distichoporinae

Distichopora

sr G: off Salomon, 60-337fms (109-612m) (Gardiner, 1936: 412. Boschma, 1957: 47 implies in his comment on Gardiner's record that this was D. violacea because Hickson & England 1909 record this species from shallow water, Egmont. However, these authors record D. profunda, from deep water off Salomon, and this appears to be a more likely interpretation.)

Distichopora violacea (Pallas)

G: Egmont - shallow water (Hickson & England, 1909: 346; Boschma, 1957: 49; Boschma, 1959: 134. Also see note above)

Distichopora profunda Hickson & England

G: off Salomon, 120-150fms (219-274m) (Hickson & England, 1909: 348, pl. 44, text-figs. 4-7, TYPE; Boschma, 1957: 46; Boschma, 1959: 162. Also see note above.)

Distichopora sp.

T: Diego Garcia - windward reef South Point.

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Hickson, S.J. & England, H.E., 1909. The Stylasterina of the Indian Ocean. Trans. Linn. Soc. Lond., Zool. (2)12: 345-354, pl. 44. (G, 4 genera, 5 species, Egmont but mostly Salomon).

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7. ECHINODERMS FROM DIEGO GARCIA

A. M. Clark and J. D. Taylor

This annotated list comprises specimens collected in 1967 by J. D. Taylor and identified by Miss A. M. Clark, British Museum (Natural History). The collection has B.M. reg. nos. 1969.5.27.1 to 1969.5.27.81.

Previous records of echinoderms from Diego Garcia are from the Deutsche Tiefsee-Expedition (Döderlein 1906, Hertz 1927, Heding 1940), and from the Percy Sladen Trust Expedition (Bell 1909). Records by these previous workers are also included in this list.

ECHINODERMATA

ECHINOIDEA

Eucidaris metularia (Lamarck)

Recorded by Döderlein (1906).

Tripneustes gratilla (Linnaeus)

East Point, seaward, sublittoral fringe* 20 m from shore.

Echinothrix diadema (Linnaeus)

Recorded by Döderlein (1906).

Echinothrix calamaris (Pallas)

Recorded by Döderlein (1906).

Echinostrephus molaris (de Blainville)

East Point, seaward, mid-reef flat, crevices, sublittoral fringe, 8 July, 1967.

Echinometra mathaei (de Blainville)

East Point, seaward, mid-reef flat beneath boulders, sublittoral fringe, 8 July, 1967. Carcasse, lagoon, coral colonies, in crevices, sublittoral 1 m, 9 July, 1967. Recorded by Döderlein (1906) as Mortensenia oblonga and by Bell (1909) as Echinometra lucunter.

Gymnechinus sp.

N. W. Point, seaward, Thalassia beds, beneath loose block, sublittoral fringe, 21 July, 1967.

* For an explanation of zonation and terminology, see Lewis, J. R., 1964, The ecology of rocky shores, and Taylor, J. D., Phil. Trans. R. Soc. London B, 254: 129-206, 1968.

Parasalenia gratiosa Agassiz
Recorded by Bell (1909).

Brissus latecarinatus (Leske)
Recorded by Döderlein (1906).

OPHIUROIDEA

Ophiactis savignyi Müller and Troschel
East Point, lagoon, sublittoral 1 m, on sponge, 7 July, 1967.
East Point, lagoon, sublittoral 1 m, on sponge, 12 July, 1967.

Ophiothrix savignyi Müller and Troschel
East Point, lagoon, sublittoral 2 m on coral patch, 12 July, 1967.

Ophiothrix exigua Lyman
East Point, lagoon, sublittoral 1 m on sponge, 7 July, 1967.

Macrophiothrix hirsuta (Müller and Troschel)
East Point, seaward, mid-reef flat, sublittoral fringe, cryptofauna, 6 July, 1967.

Ophiocoma erinaceus Müller and Troschel
East Point, seaward, mid-reef flat, sublittoral fringe, cryptofauna, 6 July, 1967. East Point, seaward, mid-reef flat, sublittoral fringe, cryptofauna, 8 July, 1967.

Ophiocoma scolopendrina (Lamarck)
North of Point Thomas, seaward, boulder zone, sublittoral fringe, cryptofauna, 13 July, 1967. North West Point, seaward, boulder zone, cryptofauna, 21 July, 1967. Also recorded by Hertz (1927) from the lagoon.

Ophiocoma brevipes Peters
North of Point Thomas, seaward, boulder zone, sublittoral fringe, cryptofauna, 13 July, 1967.

Ophiocoma brevipes Peters
South Point, seaward, beneath boulders, sublittoral fringe, 11 July 1967. East Point, seaward, beneath boulders, sublittoral fringe, 6 July, 1967. Also recorded by Hertz (1927) from the littoral.

Ophiocoma pica Müller and Troschel
South Point, seaward, mid-reef, beneath boulders, 11 July, 1967.

Ophiocomella sexradia (Duncan)
East Point, seaward, mid-reef flat, cryptofauna, 6 July, 1967.

Ophiolepis superba H. L. Clark

East Point, seaward, mid-reef flat, sublittoral fringe, crypto-fauna, 6 July, 1967.

ASTEROIDEA

Culcita schmideliana Retzius

East Point, lagoon, sand, sublittoral 1 m, 5 July, 1967.

HOLOTHUROIDEA

Holothuria (Semperathuria) cinerascens (Brandt)

South Point, seaward, beneath beach rock, sublittoral fringe, 11 July, 1967. East Point, seaward, mid-reef flat, beneath boulders, 6 July, 1967. East Point, seaward, beneath boulders at base of beach, 8 July, 1967. Also recorded by Heding (1940).

Holothuria (Thymiosycia) hilla (Lesson)

Barton Point, seaward, beneath boulders, sublittoral fringe, 7 July, 1967.

Holothuria (Thymiosycia) impatiens (Forskål)

Carcasse, lagoon, in crevices in coral colony, 9 July, 1967. Also recorded by Heding (1940).

Holothuria (Lessonothuria) pardalis Selenka

Barachois Maurice, burrowing in fine sediment, near beach rock, 16 July 1967.

Holothuria (Mertensiothuria) leucospilota (Brandt)

Barachois Maurice, burrowing in fine sediment, 15 July, 1967.

Holothuria (Halodeima) atra Jager

Pointe Marianne, lagoon, Thalassia beds, epifaunal, 22 July, 1967. East Point, lagoon, sublittoral 1 m, sand and algae, 7 July, 1967. Also recorded by Heding (1940) from the lagoon.

Holothuria (Metriatyla) albiventer Selenka

East Point, seaward, mid-reef flat, beneath boulders, sublittoral fringe, 6 July 1967.

Holothuria vagabunda Selenka

Recorded by Heding (1940).

Actinopyga mauritiana (Quoy and Gaimard)

Carcasse, lagoon, sand, sublittoral 1 m, 9 July 1967. East Point, seaward, mid-reef flat, epifaunal, 6 July 1967. Also recorded by Heding (1940).

Actinopyga echinites Jager

East Point, seaward, mid-reef flat, epifaunal, sublittoral fringe, 6 July 1967.

Bohadschia argus Jager

East Point, seaward, mid-reef flat, in crevices of boulders, sublittoral fringe, 6 July 1967.

Labidoemas rugosa (Ludwig)

East Point, seaward, mid-reef flat, in crevices of boulders, sublittoral fringe, 6 July 1970. Barton Point, seaward, beneath boulders, sublittoral fringe, 7 July 1967. East Point, lagoon, coral patch, in crevices, sublittoral 1 m, 19 July 1967.

Ohshimella ehrenbergi (Selenka)

East Point, lagoon, coral patch, sublittoral 1 m, in crevices, 9 July 1967.

Microthele nobilis (Selenka)

East Point, seaward, mid-reef flat, shallow sublittoral, 8 July 1967. Recorded by Heding (1940).

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8. CRUSTACEA: BRACHYURA AND ANOMURA FROM DIEGO GARCIA

J. D. Taylor

This list consists mainly of species collected in July 1967 by J. D. Taylor, who also made the identifications. The specimens are deposited in the British Museum (Natural History). Previous records are also included in the list; these are mainly small collections made by expeditions during short stops at the Atoll. The most notable of these are those of the Deutsche Tiefsee-Expedition (Doflein 1904, Doflein and Balss 1913, Balss 1912) and of the Percy Sladen Trust Expedition (Rathbun 1911, Laurie 1926, Borradaile 1907). The crabs in the Desjardins Museum of the Mauritius Institute were listed by Ward (1942), and amongst them were many species from Diego Garcia collected by J. Morin in 1936.

Brachyura

DIVISION OXYRHYNCA

Menaethius monoceros (Latreille)

North West Point seaward reef, Cymodocea beds, cryptofauna, sublittoral fringe*, 21 July 1967. East Point, seaward, cryptofauna reef flat, sublittoral fringe, 6 July 1967. East Point lagoon reef, Cymodocea beds, on leaves, sublittoral 1 m, 1 male, 1 female, 7 July 1967. Rathbun (1911) lagoon 14 fathoms.

Xenocarcinus tuberculatus White

Rathbun (1911) lagoon 14 fathoms.

Parthenopoides erosus Miers

Ward (1942).

Kraussia sp.

South Point, seaward, coral colonies, sublittoral fringe, 11 July 1967.

* For an explanation of zonation and terminology, see Lewis, J. R., 1964, The ecology of rocky shores, and Taylor, J. D., Phil. Trans. R. Soc. London B, 254: 129-206, 1968.

DIVISION BRACHYRHYNCHA

Cardisoma carnifex (Herbst)

Barachois Maurice, burrows around edge of barachois. Littoral fringe and supralittoral. Common around lagoon shores, and barachois.

Ocypode ceratophthalma (Pallas)

Barton Point, lagoon beach, supralittoral, 7 July 1967. Ward (1942). Doflein (1904).

Ocypode cordimana Desmarest

East Point seaward shore, sandy beach, supralittoral, 5 July 1967. North East Point, seaward beach. South Point, windward beach, 18 July 1967. Ward (1942).

Uca tetragonon (Herbst)

Barachois Maurice, white mud, intertidal, 15 July 1967. Barachois Maurice, base of barachois rock, 1 male, 16 July 1967. Carcasse, intertidal mud, 4 male, 3 female, 9 July 1967. Borradaile (1907) Barachois.

Grapsus tenuicrustatus (Herbst)

South Point, beachrock, intertidal, 11 July 1967. Cust Point, lagoon shore, beachrock, intertidal, 14 July 1967. Barton Point, on boulders, intertidal, 7 July 1967. East Point, seaward reef, beachrock, intertidal, 1 female, 8 July 1967.

Geograpsus grayi (Milne Edwards)

East Point, mid island, beneath vegetation, terrestrial, 7 July 1967. Doflein (1904).

Metopograpsus messor (Forskål)

Barachois Maurice, beneath rocks around margin, intertidal, 9 July 1967. Lagoon shore S. of Mamzelle Adélie, beachrock, intertidal, 17 July 1967.

Metopograpsus thukuhar (Owen)

Carcasse, tidal inlet, 9 July 1967.

Pachygrapsus minutus Milne Edwards

East Point, lagoon shore, coral cobbles, base of beach, intertidal, 5 July 1967.

Metasesarma rousseauxi Milne Edwards

Barton Point, terrestrial, beneath old coconut husks, 7 July 1967. Ward (1942).

Percnon abbreviatum (Dana)

East Point, seaward reef, algal ridge, cryptofauna, sublittoral fringe, 8 July 1967.

Percnon planissimum (Herbst)

Barton Point, beneath rocks at base of beach, eulittoral, 7 July 1967. East Point, seaward reef, mid-reef flat, cryptofauna, beneath block, sublittoral fringe, 8 July 1967. West Island, seaward platform, eulittoral, 23 July 1967. Doflein (1904).

Carupa laeviscula Heller

Ward (1942).

Portunus orbitosinus Rathbun

East Point, seaward reef, base of beach beneath boulders, eulittoral, 8 July 1967.

Thalamita admete (Herbst)

East Point, lagoon on coral colony, sublittoral, 1 m, 19 July 1967. Ward (1942).

Thalamita gloriensis Crosnier

South Point, seaward reef, in weed, sublittoral fringe, 11 July 1967.

Thalamita integra Dana

Pointe Marianne, lagoon shore, Cymodocea beds, 22 July 1967. Rathbun (1911) lagoon.

Thalamita picta Stimpson

East Point, seaward reef, reef flat, cryptofauna, sublittoral fringe, 6 July 1967. Ward (1942).

Thalamita poissoni (Audouin and Savigny) ?

Barachois Maurice, beneath rock at base of barachois rock, intertidal, 16 July 1967.

Thalamita prymna (Herbst)

Ward (1942).

Carpilius maculatus (Linnaeus)

Ward (1942) 1 female.

Zosimus aeneus (Linnaeus)

East Point, seaward shore, beneath boulders on reef flat, close inshore, sublittoral fringe, 8 July 1967. North West Point, seaward reef, algal ridge beneath boulders, sublittoral fringe, 21 July 1967.

Chlorodiella nigra (Forskål)

Carcasse, lagoon reef, from coral colony, 1 metre depth, 8 July 1967; East Point seaward reef, algal ridge cryptofauna, sublittoral fringe. Rathbun (1911) lagoon.

Xantho cf. voeltzkowii (Lenz)

East Point seaward reef, cryptofauna, 6 July 1967.

Xantho sp.

South Point, beach rock, cryptofauna, eulittoral, 11 July 1967.

Leptodius cavipes (Dana)

Ward (1942).

Leptodius quinquentatus Krauss

East Point, lagoon shore, cobbles at base of beach. Intertidal, 5 July 1967. East Point, seaward shore, boulders at base of beach, 8 July 1967.

Leptodius sanguineus (Milne Edwards)

South Point, in beach rock crevices, cryptofauna, eulittoral, 11 July 1967; South Point seaward reef flat, base of beach rock, eulittoral, 11 July 1967; East Point, seaward reef, base of beach, boulders, eulittoral, 8 July 1967; East Point, seaward reef, cryptofauna, sublittoral fringe, 6 July 1967; West Island seaward platform, eulittoral, 23 July 1967. Doflein (1904).

Actaea (Glyptoxanthus) cavipes (Dana)

East Point, seaward flats, midreef flat, cryptofauna. 3 specimens; Headland N. of Point Thomas, beneath boulders, sublittoral fringe, 13 July 1967. Ward (1942) under A. fossulata Girard.

Actaea banareias (Rathbun)

Ward (1942).

Actaea rufopunctata (Milne Edwards)

East Point, seaward reef, mid reef flat, cryptofauna, sublittoral fringe, 8 July 1967; 6 July 1967; North West Point, seaward reef Cymodocea beds, cryptofauna, sublittoral fringe, 21 July 1967. North West Point seaward reef algal ridge beneath boulders, sublittoral fringe. South Point; seaward reef, sublittoral fringe, 1 female, 11 July 1967; West Island, lagoon reef, Cymodocea beds, cryptofauna, sublittoral fringe, 23 July 1967.

Actaea speciosa Dana

South Point, seaward in coral, sublittoral fringe, 11 July 1967.

Actaea parvula (de Haan)

Doflein (1904).

Lachnopus subacutus (Stimpson)

South Point, seaward reefs, under cobbles, 1 male, 11 July 1967.

Platypodia cristata Milne Edwards

Rathbun (1911) lagoon.

Chlorodopsis spinipes Heller
Rathbun (1911) Lagoon, 10 fathoms.

Pseudoliomera natalensis Ward
Ward (1942).

Liomera bellus (Dana)
North West Point, seaward reef, algal ridge, boulders, sublittoral fringe, 21 July 1967.

Liomera monticulosus (Milne Edwards)
North West Point, seaward reef, algal ridge, boulders, sublittoral fringe, 21 July 1967; Barton Point, seaward shore, boulder zone, cryptofauna, intertidal, 7 July 1967; Headland immediately North of Point Thomas, beneath boulders, cryptofauna, sublittoral fringe, 13 July 1967; South Point, seaward reef, sublittoral fringe, 11 July 1967; East Point, seaward flats, cryptofauna, mid reef, sublittoral fringe, 6 July 1967.

Liomera tristis (Dana)
East Point, seaward reef, cryptofauna, mid reef flat, sublittoral fringe, 8 July 1967; West Island, lagoon reef, Cymodocea beds, sublittoral fringe, 23 July 1967.

Liomera sp.
North West Point, seaward reef, algal ridge, beneath boulders, sublittoral fringe, 21 July 1967.

Xanthias lamarckii (Milne Edwards)
East Point, seaward reef, cryptofauna, reef flat, sublittoral fringe, 6 July 1967, several collections. East Point, seaward reef, cryptofauna, mid reef flat, sublittoral fringe, 8 July 1967. East Point, seaward reef, algal ridge, cryptofauna, sublittoral fringe, 8 July 1967. South Point, seaward reef, coral colony, sublittoral fringe, 11 July 1967. North West Bay, seaward Cymodocea beds, cryptofauna, sublittoral fringe, 21 July 1967. Doflein (1904).

Xanthias latifrons (de Man)
Ward (1942).

Phymodius ungulatus Milne Edwards
Doflein (1904); Rathbun (1911) lagoon, 10 fathoms.

Etisodes armatus Ward
Ward (1942).

Etisus dentatus (Herbst)
Doflein (1904).

Etisus laevimanus Randall

Rathbun (1911) Barachois; Ward (1942).

Etisus electra (Herbst)North West Point, seaward Cymodocea beds, cryptofauna, sublittoral fringe, 21 July 1967; East Point, lagoon shore, cobbles at base of beach, intertidal, 5 July 1967.Etisus demani Odhner

East Point, seaward, 8 July 1967.

Menippe sp.

Barton Point, beneath rocks at base of beach, intertidal, 7 July 1967.

Juxtaxanthias livida (Lamarck)

Ward (1942).

Lioxantho subacutus (Stimpson)

Ward (1942).

Macromedaeus punctatus Ward

Ward (1942).

Medaeus simplex Milne Edwards

Ward (1942).

Platyozius laevis (Borradaile)

Ward (1942).

Ozius guttatus garciaensis Ward

Ward (1942).

Pseudozius caystrus (Adams and White)

Barton Point, seaward reef, beneath rocks at base of beach, intertidal, 7 July 1967. Rathbun (1911) Lagoon 10 fathoms. Ward (1942) (tentative identification).

Epixanthus frontalis (Milne Edwards)

Lagoon shore South of Mamzelle Adélie, beach rock, intertidal, 17 July 1967; South of Mamzelle Adélie lagoon, beach rock, cryptofauna, intertidal, 17 July 1967; Carcasse, lagoon shore, cobbles and sand, intertidal. Carcasse, tidal inlet, 9 July 1967.

Pilumnus longicornis Hilgendorf

Rathbun (1911) lagoon 14 fathoms.

Pilumnus cf. hirsutus Stimpson

North West Point, seaward reef algal ridge, boulders, sublittoral fringe, 21 July 1967.

Daira perlata (Herbst)

East Point, seaward reef, cryptofauna, algal ridge, sublittoral fringe, 8 July 1967; East Point, seaward reef, cryptofauna, mid reef flat, sublittoral fringe, 8 July 1967; North West Point, seaward, algal ridge, boulders, sublittoral fringe, 21 July 1967. South Point, seaward reef off coral colony, sublittoral fringe, 11 July 1967. Doflein (1904).

Eriphia laevimana Guérin

South Point, seaward shore, beach rock, intertidal, 11 July 1967; East Island, beach rock, intertidal, 26 July 1967.

Eriphia scabricula Dana

North West Point, seaward algal ridge, sublittoral fringe, 21 July 1967; East Point, seaward, cryptofauna, mid reef, sublittoral fringe, 6 July 1967, 8 July 1967.

Eriphia scabricula garciaensis Ward

Ward (1942), (not separable from above).

Trapezia cymodoce Herbst

East Point, seaward flats, mid reef, cryptofauna, sublittoral fringe, 6 July 1967. Rathbun (1911), lagoon 12 fathoms.

Trapezia digitalis Latreille

Eclipse Point, seaward flats, algal ridge, in coral sublittoral fringe, 21 July 1967.

Trapezia ferruginea Latreille

East Point, seaward reef, cryptofauna, reef flat, sublittoral fringe, 6 July 1967.

Trapezia speciosa Dana

South Point, seaward, coral colony, sublittoral fringe, 11 July 1967.

Tetralia glaberrima (Herbst)

South Point, seaward reef, coral colony, sublittoral fringe, 11 July 1967.

Euruppellia annulipes (Milne Edwards)

East Point, seaward reef, beach rock crevices, intertidal, 8 July 1967.

Dromidiopsis dormia (Linnaeus)

North West Point, seaward flats, Cymodocea beds, cryptofauna, sublittoral fringe, 21 July 1967; East Point, seaward reef, cryptofauna, reef flat, sublittoral fringe, 6 July 1967; East Point, Cymodocea beds, cryptofauna.

Calappa hepatica (Linnaeus)

Pointe Marianne, lagoon shore, Cymodocea beds, sublittoral fringe, 22 July 1967.

Cryptochirus marsupialis (Stimpson)

East Point, lagoon, in Stylophora colony, 1 m depth, 10 July 1967.

Anomura

PAGURIDEA

Calcinus elegans Milne Edwards

Balss (1912).

Calcinus laevimanus (Randall)

Headland immediately N. of Point Thomas, reef flat, beneath boulders, sublittoral fringe, 13 July 1967.

Calcinus terraereginae Haswell

Balss (1912).

Calcinus sp.

Barton Point, windward shore, beneath boulders, cryptofauna, intertidal, 7 July 1967.

Dardanus guttatus Olivier

Balss (1912).

Dardanus megistos (Herbst)

Pointe Marianne, lagoon flats, Cymodocea beds, intertidal, 22 July 1967; Cust Point, lagoon, Cymodocea beds, epifaunal, 1 m depth, 14 July 1967.

Coenobita clypeatus (Latreille)

North East Point, beach, July 1967; East Point, terrestrial, 26 July 1967; Minni Minni, in vegetation, terrestrial.

Coenobita perlatus (Milne Edwards)

South Point, beach, 11 July 1967.

Coenobita rugosus Milne Edwards

East Point, lagoon side, sandy beach, supralittoral, 26 July 1967; East Point, seaward beach, supralittoral, 5 July 1967. Balss (1912); Ward (1942).

Birgus latro (Linnaeus)

Common over much of atoll land rim.

GALATHEIDEA

Petrolisthes barbatus (Heller)

Ward (1942).

Petrolisthes lamarckii Leach

East Point, seaward flats, cryptofauna, mid reef, sublittoral fringe, 6 July 1967. Barton Point, beneath rocks at base of beach, intertidal, 7 July 1967; seaward reef, beneath boulders, intertidal, eulittoral, 7 July 1967. North West Point, seaward reef, algal ridge, boulders, sublittoral fringe, 21 July 1967. Doflein & Balss (1913).

Pachycheles cf. natalensis (Krauss)

South Point, seaward reef, coral colony, sublittoral fringe, 11 July 1967.

Polyonyx biunguiculatus Dana

Laurie (1926), lagoon 14 fathoms.

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9. CRUSTACEA: CIRRIPEDES FROM DIEGO GARCIA

W. A. Smith

Only two species were collected in July 1967. These were identified by W. A. Smith, British Museum (Natural History). A single species was recorded by Gruvel (Trans. Linn. Soc. London II, Zool., 13: 23-27, 1909), presumably from drift material.

Tetraclita wireni africana Nilsson-Cantell

West Island, on beach rock, eulittoral, 23 July 1967.

Lithotrya nicobarica Reinhardt

South Point, seaward reef, boring into boulders, 11 July 1967.

Lepas australis Darwin

Recorded by Gruvel (1909).



10. MARINE MOLLUSCA FROM DIEGO GARCIA

John D. Taylor

The marine mollusca of the atoll have been very incompletely collected and with the present collection number only 179 species compared with 504 species recorded from Cocos-Keeling (Maes 1967). Some of the paucity is due to dispersal phenomena associated with the isolation of the Chagos.

The first account of molluscs from the atoll is by Liénard (1877) who lists 39 species. Kohn & Robertson (1968) point out that for the genus Conus a good proportion of Liénard's records for the Chagos have not been confirmed by subsequent work. In addition it is difficult in many cases to decide to what species some of his names refer: all of Liénard's records have therefore been omitted from the present list.

Fischer (1891) lists in distribution records of species from Indo-China a number of species from the Chagos Archipelago including seven from Diego Garcia. The Deutsche Tiefsee Expedition of 1898-1899 called briefly at Diego Garcia and subsequent reports by von Martens (1903) and Thiele and Jaekel (1931) record six gastropods and one bivalve respectively. The Percy Sladen Expedition collected 32 species from the atoll which are described and listed in Melvill (1909).

Schilder and Schilder (1937) record 44 species of Cypraea from the Chagos Archipelago, but do not list species from individual atolls.

Since then the only molluscan record known to the author is a new genus and species of gastropod (Tomlinella miranda) from Diego Garcia by Viader (1938). Poisson (1954) listed a few molluscs from the Chagos Archipelago but none specifically from Diego Garcia. The species of Conus from the Maldive and Chagos groups are listed by Kohn and Robertson (1968) but they do not separate records from individual atolls although all Kohn's collections were made on Peros Banhos.

A list of molluscs collected in July 1967 is given below together with short habitat notes. Records by other workers are also included. The species are grouped by superfamilies.

GASTROPODA

FISSURELLACEA

Emarginula peasei Thiele

East Point, seaward, beneath loose block, sublittoral fringe*,
1 specimen, 6 July 1967.

Diodora singaporensis (Reeve)

East Point, lagoon, on coral colony, 1 m, 1 specimen, 10 July
1967. North West Point, seaward, algal ridge, cryptofauna,
sublittoral fringe, 1 specimen, 21 July 1967.

PATELLACEA

Cellana sp.

East Point, lagoon, coral. 1 m, 1 specimen, 12 July 1967.

TROCHACEA

Trochus flammulatus Lamarck

East Point, lagoon, on coral, sublittoral, 1 m, 1 specimen,
12 July 1967. Barton Point, seaward shore, on boulders at base
of beach, low eulittoral, 1 specimen, 7 July 1967. North West
Point, Cymodocea beds, cryptofauna, sublittoral fringe, 1 speci-
men, 21 July 1967.

Tectus mauritianus (Gould)

East Point, lagoon, epifaunal on coral, 1 m, 1 specimen, 12
July 1967.

Gena strigosa A. Adams

Melvill (1909), from Barachois.

Clanculus margaritarius Philippi

Melvill (1909), from Barachois.

* For an explanation of zonation and terminology, see Lewis, J. R., 1964,
The ecology of rocky shores, and Taylor, J. D., Phil. Trans. R. Soc.
London B, 254: 129-206, 1968.

Stomatella varia A. Adams

Cust Point, seaward, off bryozoan colony, Cymodocea beds, 14 July 1967.

Turbo argyrostomus Linnaeus

West Island, lagoon, Cymodocea beds, beneath dead blocks, 1 specimen, 23 July 1967.

Turbo intercostalis Menke

Pointe Marianne, lagoon, Cymodocea beds, beneath loose block, 1 specimen, 22 July 1967.

NERITACEA

Nerita albicilla Linnaeus

East Point, seaward, eulittoral, beneath boulders at base of beach, 1 specimen, 8 July 1967. East Point, lagoon, eulittoral, beneath cobbles at base of beach, 1 specimen, 5 July 1967. Barton Point, seaward, eulittoral, beneath boulders, 8 specimens, 7 July 1967. West Island, seaward, eulittoral, epifaunal open surface, 1 specimen, 23 July 1967. Headland N. of Point Thomas, seaward, eulittoral, beneath boulders, 27 specimens, 13 July 1967.

Nerita plicata Linnaeus

Barton Point, seaward, eulittoral, on open surfaces of boulders, 2 specimens, 13 July 1967.

Nerita polita Linnaeus

Headland N. of Point Thomas, seaward, eulittoral, beneath boulders at base of beach, 10 specimens, 13 July 1967. Carcasse, lagoon, eulittoral beneath cobbles at base of beach, 5 specimens, 9 July 1967. Barton Point, seaward, eulittoral, beneath boulders at base of beach, 1 specimen, 7 July 1967.

Nerita undata Linnaeus

Barton Point, seaward, eulittoral, on open surfaces of boulders, 20 specimens, 7 July 1967.

Smaragdia rangiana (Recluz)

North West Point, seaward, sublittoral fringe, in algae on reef flat, 1 specimen, 21 July 1967.

LITTORINACEA

Littorina scabra (Linnaeus)

South Point, lagoon, littoral fringe on beach rock, 1 specimen, 12 July 1967. Barachois Maurice, lagoon, littoral fringe, on beach rock, 20+ specimens, 16 July 1967, 15 July 1967. East Point, lagoon, littoral fringe, on tree trunks, 20+ specimens, 5 July 1967.

Littorina glabrata (Philippi)

East Point, lagoon, littoral fringe, on tree trunks, 8 specimens, 5 July 1967. Cust Point, lagoon, littoral fringe, on tree trunks, 4 specimens, 14 July 1967.

RISSEOACEA

Rissoina ambigua Gould

East Point, seaward, beneath loose blocks, 4 specimens, 6 July 1967; algal ridge, beneath block, sublittoral fringe, 1 specimen, 8 July 1967. North West Point, seaward, in algae, sublittoral fringe, 1 specimen, 21 July 1967. Headland N. of Point Thomas, seaward, 1 specimen, 13 July 1967.

Rissoina plicata A. Adams

East Point, seaward, beneath dead coral blocks, sublittoral fringe, 2 specimens, 6 July 1967. North West Point, seaward, in algae, 1 specimen, 21 July 1967. Headland N. of Point Thomas, seaward, beneath loose blocks, 1 specimen, 13 July 1967.

CERITHIACEA

Planaxis lineatus (Da Costa)

Barton Point, seaward, on sand and beneath boulders, base of beach, eulittoral, very common, 7 July 1967. Headland N. of Point Thomas, seaward, beneath boulders at base of beach, eulittoral, 100+ specimens, 13 July 1967.

Planaxis sulcatus Born

Mamzelle Adelle, lagoon, on beach rock, epifaunal, eulittoral, 20 specimens, 17 July 1967. Carcasse, lagoon, eulittoral, beneath cobble of beach, 20+ specimens, 9 July 1967. Melvill (1909) records it from Barachois.

Modulus tectum (Gmelin)

Barton Point, seaward, beneath boulders at base of beach, 1 specimen, 7 July 1967. North West Point, seaward, sublittoral fringe, algal ridge, 1 specimen, 21 July 1967.

Rhinoclavis asper (Linnaeus)

East Point, lagoon, sublittoral (1 m) sand burrowing, 1 specimen, 9 July 1967. Barachois Maurice, eulittoral, burrowing in fine sand with Uca. 20 specimens, 16 July 1967. Melvill (1909), in barachois; von Martens (1903).

Cerithium obeliscus Bruguière

East Point, seaward, reef flat, dead, 1 specimen, 6 July 1967.

Cerithium pretosum Wood

East Point, lagoon, eulittoral, beneath cobbles at base of beach, 50+ specimens, 5 July 1967. Carcasse, lagoon, beneath beach

cobbles, 20+ specimens, 9 July 1967. Mamzelle Adélie, lagoon, eulittoral, amongst green algae, 20+ specimens, 17 July 1967. Melvill (1909) in barachois.

Cerithium rostratum Sowerby

North West Point, seaward, Cymodocea beds, on leaves, 2 specimens, 21 July 1967. Pointe Marianne, lagoon, Cymodocea beds, on leaves, 2 specimens, 22 July 1967.

Cerithium (Conocerithium) atromarginatum Dautzenberg & Bouge

North West Point, seaward, algal ridge, beneath loose blocks, 3 specimens, 21 July 1967.

Cerithium cf. (Conocerithium) egenum Gould

East Point, seaward, algal ridge beneath blocks, 2 specimens, 8 July 1967.

Cerithium (Semivertagus) ianthinum Gould

North West Point, seaward, algal ridge, beneath loose blocks, 1 specimen, 21 July 1967; Cymodocea beds, 1 specimen, 21 July 1967. East Point, seaward reef, algal ridge, 1 specimen, 8 July 1967.

Cerithium (Semivertagus) nesioticum Pilsbry and Vanatta

East Point, seaward, inner reef flat, beneath boulders, 1 specimen, 8 July 1967. North West Point, seaward, Cymodocea beds, 1 specimen, 21 July 1967.

Cerithium sp.

Carcasse, lagoon, beneath cobbles, eulittoral, 20+ specimens, 9 July 1967. Barton Point, seaward, beneath boulders, eulittoral, 6 specimens, 7 July 1967.

Triphora aurea (Hervier)

East Point, lagoon, off coral, sublittoral, 1 specimen, 19 July 1967.

Triphora coetivensis Melvill

Barton Point, seaward beneath boulders at base of beach, 1 specimen, 7 July 1967.

Triphora monilifera (Hinds)

North West Point, seaward, in algae, 1 specimen, 21 July 1967.

Triphora sp.

East Point, lagoon, off coral, sublittoral, 1 specimen, 19 July 1967.

Tomlinella miranda Viader

Viader (1938).

HIPPONICACEA

Vanikoro cancellata Lamarck

North West Point, seaward, in algae, sublittoral fringe, 1 specimen, 8 July 1967. East Point, seaward, beneath loose blocks, 2 specimens, 6 July 1967; algal ridge beneath boulders, 4 specimens, 8 July 1967.

Hipponyx conica Schumacher

East Point, seaward, mid-reef flat on Conus, heavy infestation, July 1967. South Point, seaward, beach rock crevices, epifaunal mostly on species of Conus, 11 July 1967. North West Point, seaward, algal ridge, commensal on Conus, 21 July 1967. Von Martens (1903) as Hipponyx acutus Quoy and Gaimard, on Conus distans.

CALYPTRAEACEA

Cheilea equestris (Linnaeus)

East Point, seaward, cemented beneath loose blocks on algal ridge, 2 specimens, 8 July 1967. Headland N. of Point Thomas, seaward, cemented beneath blocks, 2 specimens, 13 July 1967.

STROMBACEA

Strombus decorus decorus Röding

Cust Point, lagoon flats, Cymodocea beds, epifaunal, 1 m, 2 specimens, 14 July 1967. Pointe Marianne, lagoon, Cymodocea beds, epifaunal, 3 specimens, 22 July 1967. East Point, lagoon, amongst algae, 1 m, 3 specimens, 14 July 1967.

Strombus labiatus (Röding)

Pointe Marianne, lagoon, Cymodocea beds, epifaunal, 1 specimen, 22 July 1967. East Point, lagoon, amongst algae, epifaunal, 1 m, 4 specimens, 14 July 1967.

Strombus mauritianus Lamarck

Melville (1909), Diego Lagoon.

Strombus mutabilis Swainson

East Point, lagoon, amongst weed, epifaunal, 1 m, 4 specimens, 14 July 1967.

Lambis crocata (Link)

Beach washed. 2 specimens.

NATICACEA

Polynices melanostoma (Gmelin)

Barachois Maurice, lagoon, burrowing in mud with Uca, 2 specimens, 16 July 1967. Cust Point, lagoon, Cymodocea beds.

TONNACEA

Bursa bufonia (Gmelin)

North West Point, seaward, algal ridge, beneath loose boulders, 1 specimen, 21 July 1967. East Point, seaward, beneath dead coral blocks, sublittoral fringe, 5 specimens, 6 July 1967. South Point, seaward, epifaunal mid-reef flat, 1 specimen, 11 July 1967. Headland N. of Point Thomas, seaward, epifaunal, reef flat, 1 specimen, 13 July 1967.

Bursa granularis Röding

East Point, seaward, epifaunal, sublittoral fringe, 10 specimens, 8 July 1967; 6 July 1967. North West Point, seaward, Cymodocea beds, epifaunal, 2 specimens, 21 July 1967; algal ridge, beneath loose blocks, 2 specimens, 21 July 1967.

Bursa rhodostoma (Sowerby)

North West Point, seaward, algal ridge, beneath boulders, 1 specimen, 21 July 1967.

Apollon bituberculare (Lamarck)

North West Point, seaward, Cymodocea beds, beneath cobble, 1 specimen, 21 July 1967.

Cymatium pileare (Linnaeus)

North West Point, seaward, algal ridge, 1 specimen, 21 July 1967. Pointe Marianne, lagoon, Cymodocea beds beneath dead coral blocks, 2 specimens, 22 July 1967. South Point, seaward, beach rock crevices, eulittoral, 1 specimen, 11 July 1967.

CYPRAEACEA

Cypraea annulus Linnaeus

East Point, seaward reef flat, cryptofauna, sublittoral fringe, 3 specimens, 6 July 1967; inner reef flat, seaward reef, beneath cobbles, sublittoral fringe, 2 specimens, 8 July 1967. North of Point Thomas, seaward, headland, cryptofauna, 2 specimens, 13 July 1967. North West Point, Cymodocea beds, cryptofauna, seaward, 2 specimens, 21 July 1967.

Cypraea carneola Linnaeus

West Island, lagoon shore, sublittoral fringe, Cymodocea beds, 1 specimen, 23 July 1967.

Cypraea childreni Gray

Fischer (1891).

Cypraea chinensis Gmelin

North West Bay, seaward flats, algal ridge, sublittoral fringe, 1 specimen, 21 July 1967.

Cypraea helvola Linnaeus

North West Point, Cymodocea beds, cryptofauna beneath cobbles, 4 specimens, 21 July 1967.

Cypraea histrio Gmelin

West Island, lagoon shore, Cymodocea beds, sublittoral fringe, 1 specimen, 23 July 1967. North East Point, seaward reef, Cymodocea beds beneath boulder, sublittoral fringe, 1 specimen, 21 July 1967. North West Point, seaward reef, algal ridge, cryptofauna, 3 specimens, 21 July 1967.

Cypraea isabella Linnaeus

Fischer (1891), beach washed.

Cypraea lynx Linnaeus

East Point, lagoon flats, beneath cobbles, 1 m. 2 specimens, 14 July 1967. North West Point, seaward reef, Cymodocea beds, cryptofauna, 1 specimen, 21 July 1967.

Cypraea depressa (Gray)

North West Point, seaward, algal ridge, cryptofauna sublittoral fringe, 2 specimens, 21 July 1967. East Point, seaward, mid-reef flat, 1 specimen, 7 July 1967.

Cypraea moneta Linnaeus

East Point, seaward reef, cryptofauna beneath dead coral blocks, sublittoral fringe, 1 specimen, 6 July 1967. Cust Point, lagoon shore, Cymodocea beds, on leaves, 1 m, 3 specimens, 14 July 1967; East Point, lagoon shore amongst algae, 1 m, 2 specimens, 14 July 1967. Pointe Marianne, lagoon flats, Cymodocea beds, 1 specimen, 22 July 1967. Carcasse, lagoon shore beneath cobbles, eulittoral, 2 specimens, 9 July 1967. Headland north of Point Thomas, seaward flats, sublittoral fringe, 2 specimens, 13 July 1967. North West Point, Cymodocea beds, cryptofauna, sublittoral fringe, 5 specimens, 21 July 1967. Melvill (1909) from barachois.

Cypraea kieneri Hidalgo

East Point, seaward, cryptofauna, 1 specimen, 7 July 1967. North West Point, seaward reef algal ridge, cryptofauna, 3 specimens, 21 July 1967.

Cypraea staphylaea Linnaeus

Melvill (1909).

Cypraea talpa Linnaeus

Beach washed.

Cypraea caputserpentis Linnaeus

South Point, seaward, mid-reef, crevice, 1 specimen, 11 July 1967.

Trivia insecta (Mighels)

South Point, seaward, in branching coral colony crevices, sublittoral fringe, 3 specimens, 11 July 1967.

MURICACEA

Murex adustus Lamarck

Melvill (1909), Barachois Maurice.

Drupa morum Röding

South Point, seaward, reef flat, eulittoral, 3 specimens, 11 July 1967, base of beach rock, 3 specimens, 11 July 1967. East Point, seaward, epifaunal on loose blocks, 3 specimens, 6 July 1967. West Island, seaward platform, epifaunal, 2 specimens, 23 July 1967. Barton Point, seaward, boulders at base of beach, eulittoral, 6 specimens, 7 July 1967.

Drupa ricinus (Linnaeus)

South Point, seaward, eulittoral, base of beach rock, 4 specimens, 11 July 1967. West Island, seaward, eulittoral, epifaunal, 1 specimen, 23 July 1967. North West Point, seaward, sublittoral fringe, algal ridge, 1 specimen, 21 July 1967; Cymodocea beds, 21 July 1967. Barton Point, seaward, eulittoral, boulders at base of beach, 6 specimens, 7 July 1967. East Point, seaward, eulittoral, on loose blocks, 8 July 1967. Headland North of Point Thomas, seaward, sublittoral fringe, beneath boulders, 2 specimens, 13 July 1967.

Drupa cornus Röding

East Point, lagoon, off Favia colony, sublittoral, 1 m, 2 specimens, 9 July 1967.

Drupella margariticola (Broderip)

East Point, lagoon, beneath cobbles at base of beach, eulittoral, 13 specimens, 5 July 1967. Cust Point, lagoon, Cymodocea beds on loose blocks, 3 specimens, 14 July 1967. Mamzelle Adélie, lagoon, on beach rock, eulittoral, 8 specimens, 17 July 1967. Carcasse, lagoon, beneath cobbles, eulittoral, 7 specimens, 9 July 1967. North West Point, seaward, Cymodocea beds, beneath cobbles, 1 specimen, 21 July 1967. Headland North of Point Thomas, seaward, beneath boulders at base of beach, eulittoral, 4 specimens, 13 July 1967. Melvill (1909) as Sistrum fiscellum Chemnitz.

Drupella ochrostoma (Blainville)

North West Point, seaward, Cymodocea beds, beneath loose blocks, 4 specimens, 21 July 1967.

Morulaanaxeres (Kiener)

Mamzelle Adélie, lagoon, beach rock, eulittoral, 4 specimens, 17 July 1967.

Morula granulata (Duclos)

Barton Point, seaward, eulittoral, boulders at base of beach, 10 specimens, 7 July 1967. West Island, seaward platform, eulittoral, 3 specimens, 23 July 1967. South Point, seaward, eulittoral, base of beach rock, 12 specimens, 11 July 1967. East Point, seaward, reef flat, 1 July 1967. Mamzelle Adelle, lagoon, eulittoral, beach rock, 5 specimens, 17 July 1967.

Morula spinosa (H. & A. Adams)

Listed by Melvill as Sistrum iostoma (Reeve).

Morula uva (Röding)

South Point, seaward, reef flat, 3 specimens, 11 July 1967. Barton Point, seaward, eulittoral, boulders at base of beach, 10 specimens, 7 July 1967. North West Point, seaward, sublittoral fringe, algal ridge, 1 specimen, 21 July 1967. West Island, seaward platform, eulittoral, 1 specimen, 23 July 1967.

Nassa francolina (Bruguière)

Headland North of Point Thomas, seaward, cryptofauna, 1 specimen, 13 July 1967.

Thais aculeata Deshayes

Mamzelle Adelle, lagoon, base of beach rock, eulittoral, 3 specimens, 17 July 1967. West Island, seaward, epifaunal, eulittoral, 1 specimen, 23 July 1967. South Point, seaward, base of beach rock, eulittoral, 3 specimens, 11 July 1967. Headland North of Point Thomas, seaward, beneath loose blocks, 1 specimen, 13 July 1967. Barton Point, seaward, beneath boulders at base of beach, 4 specimens, 7 July 1967.

Thais armigera (Link)

North West Point, seaward, algal ridge, beneath blocks, 1 specimen, 21 July 1967. South Point, seaward flat, epifaunal, 5 specimens, 11 July 1967. West Island, seaward, eulittoral, on platform, 2 specimens, 23 July 1967. East Point, seaward, mid-reef flat, epifaunal, sublittoral fringe, 2 specimens, July 1967.

Thais tuberosa (Röding)

Headland North of Point Thomas, seaward, epifaunal, reef flat, 1 specimen, 13 July 1967. East Point, seaward, inner reef flat, epifaunal on dead coral blocks, eulittoral, 1 specimen, 8 July 1967; 3 specimens, 6 July 1967. South Point, seaward reef, epifaunal, sublittoral fringe, 1 specimen, 11 July 1967.

Maculotriton digitalis (Reeve)

Barton Point, seaward, beneath boulders at base of beach, eulittoral, 4 specimens, 7 July 1967. East Point, seaward, algal ridge, beneath loose blocks, sublittoral fringe, 1 specimen, 8 July 1967. Headland North of Point Thomas, seaward, beneath boulders, 1 specimen, 13 July 1967. East Point, seaward, inner reef flat beneath boulders, 1 specimen, 8 July 1967. South

Point, seaward, in beach rock crevices, eulittoral, 1 specimen, 11 July 1967. Cust Point, lagoon, Cymodocea beds, beneath blocks, 1 specimen, 14 July 1967. North West Point, seaward, algal ridge, beneath blocks, 4 specimens, 21 July 1967.

Maculotriton serriale (Laborde and Deshayes)

Barton Point, seaward, beneath boulders at base of beach, 2 specimens, 7 July 1967. East Point, seaward, boulders at base of beach, 2 specimens, 8 July 1967.

Quoyala madreporarum (Sowerby)

East Point, lagoon, on Pocillopora, July 1967.

Coralliophila monodonta (Quoy and Gaimard)

Melvill (1909).

BUCCINACEA

Columbella turturina Lamarck

North West Point, seaward, Cymodocea beds, beneath loose blocks, 5 specimens, 21 July 1967. Fischer (1891).

Columbella varians Sowerby

East Point, seaward, algal ridge, beneath loose blocks, 2 specimens, 8 July 1967. Barton Point, seaward, beneath boulders at base of beach, 6 specimens, 7 July 1967.

Pyrene azora (Duclos)

Carcasse, lagoon, beneath cobbles on beach, eulittoral, 20+ specimens, 9 July 1967. North West Point, seaward, algal ridge, in crevices, 1 specimen, 21 July 1967.

Pyrene sp.

East Point, lagoon, on algae on Tridacna maxima, 9 July 1967. Cust Point, lagoon, Cymodocea beds, beneath loose blocks, 10 specimens, 14 July 1967.

Cantharus undosus Linnaeus

East Point, lagoon, sublittoral (1 m) on Favia colony, 4 specimens, 9 July 1967; 10 July 1967. Headland North of Point Thomas, seaward, reef flat, beneath blocks, 2 specimens, 13 July 1967. North West Point, seaward, Cymodocea beds, beneath blocks, 2 specimens, 21 July 1967; algal ridge beneath boulders, 1 specimen, 21 July 1967. Melvill (1909), from Barachois Maurice.

Engina bonasina (von Martens)

North West Point, seaward, algal ridge, beneath block, 1 specimen, 21 July 1967.

Engina lineata (Reeve)

North West Point, seaward, algal ridge, beneath blocks, 7 specimens, 21 July 1967; Cymodocea beds, beneath loose blocks, 7 specimens, 21 July 1967.

Engina mendicaria (Linnaeus)

East Point, seaward, eulittoral, beneath boulders at base of beach, 5 specimens, 8 July 1967; beneath coral blocks, mid-reef flat, 2 specimens, 6 July 1967. Headland North of Point Thomas, beneath loose blocks, 2 specimens, 18 July 1967; boulders at base of beach, 10 specimens, 13 July 1967. Barton Point, seaward, eulittoral, beneath boulders at base of beach, 20+ specimens, 7 July 1967. West Island, seaward, eulittoral, on platform, 5 specimens, 23 July 1967. North West Point, seaward, Cymodocea beds, sublittoral fringe, 1 specimen, 21 July 1967. South Point, seaward, eulittoral, in beach rock crevices, 20 specimens, 21 July 1967.

Nassarius arcularis (Linnaeus)

Fischer (1891).

Nassarius gaudiosus (Hinds)

North West Point, seaward, algal ridge, beneath loose block, 1 specimen, 21 July 1967.

Nassarius maldivensis (Smith)

Melvill (1909), lagoon.

Nassarius paupera (Gould)

Cust Point, lagoon, Cymodocea beds, epifaunal, sublittoral, 1 m, 1 specimen, 14 July 1967. East Point, lagoon, sand burrowing, sublittoral, 1 m, 1 specimen, 9 July 1967.

Latirus craticulatus (Linnaeus)

North West Point, seaward, algal ridge, beneath boulders, 1 specimen, 21 July 1967. West Island, lagoon, Cymodocea beds, crypto-fauna, 1 specimen, 23 July 1967.

Latirus polygonus (Linnaeus)

Melvill (1909), Barachois Maurice.

Peristernia sp.

Barton Point, seaward, beneath boulders, 1 specimen, 7 July 1967.

Latirolagena smaragdula (Linnaeus)

Barton Point, seaward, beneath boulders at base of beach, eulittoral, 1 specimen, 7 July 1967. North West Point, seaward, algal ridge, beneath blocks, 3 specimens, 21 July 1967.

Fusinus tuberculatus Lamarck

Melvill (1909), Barachois Maurice.

VOLUTACEA

Mitra cucumerina Lamarck

North West Point, seaward, algal ridge, 1 specimen, 21 July 1967.

Mitra stictica (Link)

East Point, seaward, in sand pockets, 1 specimen 6 July 1967.
South Point, seaward reef flat in sand pockets, 1 specimen,
11 July 1967.

Strigatella litterata (Lamarck)

Barton Point, seaward, eulittoral, beneath boulders at base of beach, 10 specimens, 7 July 1967. East Point, seaward, eulittoral, beneath boulders at base of beach, 2 specimens, 8 July 1967. South Point, seaward, eulittoral, in crevices in beach rock, 1 specimen, 11 July 1967. Headland North of Point Thomas, seaward, beneath boulders, 3 specimens, 13 July 1967. North West Point, Cymodocea beds, beneath loose block, 1 specimen, 21 July 1967.

Strigatella paupercula (Linnaeus)

South Point, seaward, cryptofauna, 1 specimen, 11 July 1967.

Vasum turbinellus (Linnaeus)

Headland north of Point Thomas, seaward, mid-reef flat, epifaunal, 1 specimen, 13 July 1967. North West Point, seaward, algal ridge, beneath blocks, 1 specimen, 21 July 1967.

Harpa amouretta Röding

North West Point, seaward, Cymodocea beds, beneath loose block, 1 specimen, 21 July 1967.

CONACEA

Conus catus Hwass

Barton Point, seaward reef, beneath boulders, 1 specimen, 7 July 1967. South Point, seaward reef, epifaunal, intertidal (lower eulittoral) on beachrock, 5 specimens, 11 July 1967.

Conus chaldeus (Röding)

South Point, seaward reef, epifaunal, mid-reef flat, sublittoral fringe, 6 specimens, 11 July 1967. North West Point, seaward reef, algal ridge, beneath boulders, sublittoral fringe, 1 specimen, 11 July 1967. East Point, seaward, mid-reef flat, 1 specimen, 7 July 1967.

Conus distans Hwass

Von Martens (1903).

Conus ebraeus Linnaeus

West Island, seaward platform, eulittoral, epifaunal, 1 specimen, 23 July 1967. South Point, on beachrock, intertidal (eulittoral),

11 July 1967. East Point, seaward reef, sublittoral fringe, 1 specimen, 6 July 1967. Headland North of Point Thomas, seaward reef, sublittoral fringe, 3 specimens, 13 July 1967. North West Point, Cymodocea beds, cryptofauna, sublittoral fringe, 2 specimens, 21 July 1967. Von Martens (1903).

Conus flavidus Lamarck

South Point, base of beach rock, intertidal, epifaunal, 1 specimen, 11 July 1967.

Conus fulgetrum Sowerby

Barton Point, seaward, eulittoral, beneath boulders at base of beach, 1 specimen, 7 July 1967.

Conus lividus Hwass

North West Point seaward reef, algal ridge, epifaunal, sublittoral fringe, 6 specimens, 21 July 1967. North West Point, seaward, Cymodocea beds, epifaunal, sublittoral fringe, 3 specimens, 21 July 1967. Headland North of Point Thomas, seaward reef, epifaunal, 5 specimens, 13 July 1967. South Point, seaward reef, epifaunal, sublittoral fringe, 3 specimens, 11 July 1967. East Point, seaward reef, epifaunal, open surfaces, sublittoral fringe, 1 specimen, 6 July 1967. East Point, seaward reef inner flat, intertidal (low eulittoral), 1 specimen, 8 July 1967.

Conus miles Linnaeus

North West Point, seaward reef, algal ridge, cryptofauna, sublittoral fringe, 5 specimens, 21 July 1967. North West Point, seaward reef Cymodocea beds, 1 specimen, 21 July 1967. Headland North of Point Thomas, seaward reef, cryptofauna, 3 specimens, 13 July 1967. East Point, seaward, mid-reef flat, 1 specimen, July 1967.

Conus musicus Hwass

South Point, seaward reef, epifaunal, sublittoral fringe, 1 specimen, 11 July 1967.

Conus nussatella Linnaeus

Headland North of Point Thomas, seaward reef, 1 dead specimen, 13 July 1967.

Conus rattus Hwass

South Point, seaward reef, epifaunal, outer reef flat, sublittoral fringe, 10 specimens, 11 July 1967. East Point, seaward, mid-reef flat, 1 specimen, July 1967.

Conus sponsalis Hwass

North West Point, seaward reef, algal ridge, epifaunal, 1 specimen, 21 July 1967; seaward reef, Cymodocea beds, cryptofauna, 1 specimen, 21 July 1967. Headland North of Point Thomas, seaward reef, epifaunal, 7 specimens, 13 July 1967. South Point,

seaward flats, cryptofauna, 4 specimens, 11 July 1967; seaward reef, intertidal (eulittoral), on beach rock, 30 specimens, 11 July 1967. West Island, seaward platform intertidal (eulittoral), 2 specimens, 23 July 1967. East Point, seaward, mid-reef flat, 1 specimen, July 1967. Barton Point, seaward, eulittoral, beneath boulders, 1 specimen, 7 July 1967.

Conus virgo Linnaeus

Headland North of Point Thomas, seaward reef, 1 specimen, 13 July 1967.

PYRAMIDELLACEA

Eulima sp.

South Point, seaward reef, off holothurians, in beach rock crevices, 1 specimen, 11 July 1967.

Balcis sp.

East Point, seaward, algal ridge, 1 specimen, 8 July 1967.

PERACLEACEA

Volvatella cincta (G. & H. Nevill)

North West Point, seaward, amongst algae, 1 specimen, 21 July 1967.

SCAPHOPODA

Dentalium gemmiparum Melvill

Melvill (1909), dredged from lagoon.

BIVALVIA

ARCACEA

Arca (Arca) avellana Lamarck

East Point, lagoon, sublittoral, 1 m, coral colony crevices, 2 specimens, 10 July 1967; 19 July 1967; seaward, mid-reef flat, crevice, 1 specimen, July 1967.

Arca plicata (Dillwyn)

East Point, lagoon, sublittoral, byssate on Tridacna maxima, 1 specimen, 9 July 1967.

Anadara urypigymelana (Bory)

Cust Point, lagoon, burrowing in Cymodocea beds, 1 m, 14 July 1967. Recorded by Melvill (1909) as A. holoserica Reeve, from lagoon (10 fathoms) and Barachois Maurice.

Striarca tenebrica (Reeve)

East Point, lagoon, sublittoral 1 m, byssate, in coral crevice, 3 specimens, 12 July 1967; 10 July 1967.

Barbatia decussata (Sowerby)

East Point, lagoon, sublittoral, 1 m, byssate in coral crevices, 10 specimens, 19 July 1967; 10 July 1967; 12 July 1967.

Barbatia helblingi Bruguière

East Point, lagoon, byssate beneath coral colonies, sublittoral 1 m, 30 specimens, 19 July 1967; 10 July 1967.

Barbatia tenella (Reeve)

North West Point, seaward, algal ridge, boulder zone, byssate, 1 specimen, 21 July 1967. Headland North of Point Thomas, seaward, byssate, beneath coral blocks, 2 specimens, 13 July 1967.

Barbatia fusca Bruguière

East Point, lagoon shore, byssate, on coral colony, 1 m, 19 July 1967.

MYTILACEA

Modiolus auriculatus Krauss

East Point, seaward, byssate groups, sublittoral fringe, 30 specimens, 6 July 1967. South Point, seaward, byssate, mid-reef flat, 1 specimen, 11 July 1967. North West Point, seaward, Cymodocea beds, byssate, around stems, 2 specimens, 21 July 1967.

Brachiodontes variabilis Krauss

Barachois Maurice, eulittoral, byssate, beneath cay rock, 1 specimen, 16 July 1967.

Septifer bilocularis (Linnaeus)

Carcasse, lagoon, sublittoral, byssate, beneath coral colony (Favia), 6 specimens, 9 July 1967. East Point, lagoon, byssate, beneath coral colony, 1 m, 2 specimens, 10 July 1967. Barachois Maurice, lagoon entrance, byssate, on beach rock, eulittoral, 6 specimens, 15 July 1967. Recorded by Melvill (1909) from 10-14 fathoms in lagoon. Also recorded by Thiele and Jaekel (1931), Station 224.

Leiosolenus nasuta (Philippi)

Carcasse, lagoon, sublittoral 1m, boring into Favia colony, 10 specimens, 9 July 1967.

Lithophaga teres (Philippi)

Carcasse, lagoon, sublittoral, 1 m, boring into Favia colony, 3 specimens, 12 July 1967. East Point, lagoon, sublittoral, 1 m, boring into massive coral, 3 specimens, 12 July 1967; 19 July 1967. Melvill (1909) records it from the lagoon.

Botula cinnamomea (Lamarck)

Carcasse, lagoon, sublittoral, 1 m, boring into Favia colony, 10 specimens, 9 July 1967.

PINNACEA

Pinna muricata Linnaeus

Cust Point, lagoon, Cymodocea beds, burrowing, 1 m, 1 specimen,
14 July 1967.

PTERIACEA

Electroma alacorvi (Dillwyn)

North West Point, seaward, Cymodocea beds, dead, 21 July 1967.
East Point, lagoon, byssate beneath coral colony, in crevices,
1 m, 3 specimens, 10 July 1967.

Pinctada margaritifera (Linnaeus)

Headland North of Point Thomas, seaward, byssate, beneath loose
blocks, 1 specimen, 13 July 1967. North West Point, seaward,
Cymodocea beds, byssate, beneath block, 1 juvenile, 21 July 1967.

Pinctada sp.

Headland North of Point Thomas, seaward, byssate, beneath dead
coral lumps, 2 specimens, 13 July 1967.

Isognomon legumen (Gmelin)

Carcasse, lagoon, sublittoral, byssate, beneath Favia colony,
10 specimens, 9 July 1967. East Point, lagoon, byssate, in cre-
vices beneath coral colony, 10 specimens, 10 July 1967; 19 July
1967.

Isognomon perna (Linnaeus)

East Point, seaward, byssate beneath dead coral blocks, 1 speci-
men, 6 July 1967; 8 July 1967.

Vulsella spongiarum (Lamarck)

Pointe Marianne, lagoon, in sponges in Cymodocea beds, 10 speci-
mens, 22 July 1967.

PECTINACEA

Gloripallium pallium (Linnaeus)

East Point, lagoon, sublittoral 1 m, in branches of coral colony,
2 specimens, 19 July 1967; 10 July 1967.

Chlamys reticulatus (Reeve)

Recorded by Melvill (1909) from lagoon at 28 m.

Chlamys lemniscatus (Reeve)

West Island, lagoon; Cymodocea beds, byssate, on stems, 1 speci-
men, 23 July 1967.

Pedum spondyloideum (Gmelin)

East Point, lagoon, byssate, in crevices of massive Porites
colonies, 4 specimens, 10 July 1967.

Plicatula chinensis Morch

North West Point, seaward, algal ridge, cemented beneath blocks, sublittoral fringe, 1 specimen, 21 July 1967.

Spondylus aurantius Lamarck

Carcasse, lagoon, sublittoral fringe, 1 m, cemented, 1 specimen, 9 July 1967.

LIMACEA

Lima fragilis (Gmelin)

North West Point, seaward, sublittoral fringe, Cymodocea beds, beneath loose block, 1 specimen, 21 July 1967.

Lima lima (Linnaeus)

East Point, lagoon, sublittoral, 1 m, byssate, in coral colony, 6 specimens, 10 July 1967; 19 July 1967. Carcasse, lagoon, sublittoral, 1 m, byssate, in crevices of Favia colony, 2 specimens, 9 July 1967.

OSTREACEA

Ostrea numisma Lamarck

North West Point, seaward, algal ridge, cemented beneath boulders, 2 specimens, 21 July 1967; Cymodocea beds beneath loose block, 1 specimen, 21 July 1967. Headland north of Point Thomas, seaward, mid-reef flat, cemented beneath block, 1 specimen, 13 July 1967.

CHAMACEA

Chama aspersa Reeve

East Point, seaward reef flat, cemented beneath dead coral blocks, 1 specimen, 8 July 1967; lagoon, cemented dead coral surface, 1 m, 1 specimen, 19 July 1967. West Island, lagoon, Cymodocea beds beneath loose blocks, 2 specimens, 23 July 1967. Headland, North of Point Thomas, seaward reef flat, cemented beneath loose blocks, 2 specimens, 13 July 1967. South Point, seaward, beneath blocks, 1 specimen, 11 July 1967. Barton Point, seaward reef flat. North West Point, seaward flats, algal ridge, cemented beneath blocks, 4 specimens, 21 July 1967; Cymodocea beds, 2 specimens, 21 July 1967.

Chama cf. imbricata Broderip

Carcasse, lagoon flats, cemented beneath coral colony, 1 m, 2 specimens, 9 July 1967.

LUCINACEA

Ctena divergens (Philippi)

Pointe Marianne, lagoon, Cymodocea beds, burrowing, 1 specimen, 22 July 1967.

Codakia tigerina (Linnaeus)

Pointe Marianne, lagoon, Cymodocea beds, burrowing, 1 specimen, 22 July 1967. Recorded by Melvill (1909) as Codakia exasperata Linnaeus from Barachois Maurice.

"Wallucina" sp.

Headland north of Point Thomas, seaward, beneath boulders, 1 specimen, 13 July 1967.

LEPTONACEA

"Erycina" sp.

North West Point, seaward, byssate, beneath loose blocks on algal ridge, 1 specimen, 21 July 1967. West Island, lagoon, Cymodocea beds, byssate, beneath loose blocks, 1 specimen, 23 July 1967. East Point, seaward, byssate, beneath loose blocks, 2 specimens, 6 July 1967.

CARDIACEA

Fragum fragum (Linnaeus)

East Point, lagoon, seaward, beach washed, in sand, juvenile, 6 July 1967.

Parvicardium sueziense (Issel)

East Point, lagoon, dead, 1 specimen.

TRIDACNACEA

Tridacna maxima (Röding)

Cust Point, lagoon, Cymodocea beds, byssate, sublittoral 1 m, 1 1/2 specimens, 14 July 1967. East Point, lagoon, on coral, byssate, sublittoral, 1 m, 2 specimens, 9 July 1967; 10 July 1967.

MACTRACEA

Atactodea glabrata (Gmelin)

Carcasse, lagoon, eulittoral, burrowing in sand amongst cobbles, 20+ specimens, 9 July 1967. Barachois Maurice, lagoon, in mud beneath cay rock, eulittoral, in beach, 1 specimen, 16 July 1967. East Point, lagoon, eulittoral, in beach, 2 specimens, 5 July 1967.

Ervilia bisculpta (Gould)

Carcasse, lagoon, in sand, 1 m, 2 specimens, 9 July 1967.

TELLINACEA

Asaphis violascens (Forskål)

Mamzelle Adélie, lagoon, eulittoral, beneath loose block of beach rock, 1 specimen, 17 July 1967. Recorded from Barachois

Maurice as A. dellorata (Linnaeus) by Melvill (1909).

Quidnipagus palatam Iredale

Barachois Maurice, lagoon, intertidal, base of beach at barachois entrance, 1 specimen, 15 July 1967; burrowing in mud with Uca, 6 specimens, 16 July 1967; burrowing in mud beneath cay rock overhang, 6 specimens, 16 July 1967. Recorded from Barachois by Melvill (1909) as Tellina rugosa Born.

Scutarcopagia scobinata (Linnaeus)

Headland north of Point Thomas, seaward, sublittoral fringe, burrowing in shallow sand pocket, 1 specimen, 13 July 1967.

Scissulina dispar (Conrad)

Barachois Maurice, burrowing in Uca mud, 6 specimens, 16 July 1967.

Leptomysa rostrata Hanley

Barachois Maurice, burrowing in Uca flats, 5 specimens, 16 July 1967.

VENERACEA

Gafrarium pectinatum (Linnaeus)

Cust Point, lagoon, Cymodocea beds, 1 dead specimen, 14 July 1967. Barachois Maurice, lagoon, intertidal, in fine sand beneath cay rock, 6 specimens, 16 July 1967; base of beach at entrance, 20 specimens, 15 July 1967; in mud with crab Uca, 3 specimens, 16 July 1967. Recorded as Crista pectinata by Melvill (1909) from Barachois Maurice.

Gafrarium tumidum (Röding)

Recorded by Melvill (1909) as Crista gibba from Barachois Maurice.

GASTROCHAENACEA

Gastrochaena cuneiformis (Spengler)

East Point, lagoon, boring into Favia colony, 1 m, 1 specimen, 10 July 1967.

Gastrochaena mytiloides (Lamarck)

Carcasse, lagoon, boring into Favia colony, 1 m, 3 specimens, 9 July 1967.

MYACEA

Corbula sp. (cf. Plate 26, fig. E, Orr Maes 1967)

East Point, seaward, byssate beneath loose blocks.

Corbula modesta Hinds

Headland north of Point Thomas, seaward, byssate, beneath loose blocks, 1 specimen, 13 July 1967.

PHOLADACEA

Teredo sp.

Barton Point, dead valves from drift wood.

AMPHINEURA

Schizochiton incisus (Sowerby)

East Point, lagoon, off coral, sublittoral, 19 July 1967.

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11. LAND VEGETATION OF DIEGO GARCIA

D. R. Stoddart

The land vegetation of Diego Garcia consists almost entirely of coconut-dominated woodland, with some small areas of shrubs and occasional relict broadleaf trees. All parts of the atoll have been subject to continuous human interference for almost two hundred years, and man now actively controls vegetation growth in coconut plantations in many areas. Only the beach-crest vegetation, particularly on seaward beaches, is relatively unaltered in form and composition. In spite of this high degree of interference, however, many of the introduced species in the Diego Garcia flora are found at or close to present or former settlement sites, and large parts of the atoll have a much more restricted flora including many species which are presumably indigenous.

Description of the vegetation is made more difficult by the great length, variable width, and physiographic diversity of the land rim. The existence of environmental gradients, especially from seaward to lagoonward shores, and the scale of human interference have combined to form patterns in the vegetation, including zonations and mosaics. We first consider the distribution of vegetation in each of six main sectors of the atoll rim, plus the three lagoon-mouth islands, and then summarise the main types of vegetation present. A final section deals with the vegetation of the human settlements at East Point, Minni Minni, Pointe Marianne and elsewhere. This account is based on field notes made while collecting plants which were subsequently named by the Royal Botanic Gardens, Kew, and by Dr F. R. Fosberg; these determinations, which are used in this paper, are listed in the following chapter. Additional information on vegetation distribution has been obtained from the air photograph cover flown in 1967.

A. Regional description

1. Northeast Point

Physiographically the Northeast Point area consists of a seaward beach, channel beach, and lagoon beach, with a low dune field on the lagoonward half of the land rim and a low-lying flat area between the dune field and the seaward beach ridge. The beach crest vegetation round the entire point is dominated by a zone of Scaevola taccada, in

in places replaced by Tournefortia argentea. On the seaward beach there are occasional specimens of Suriana maritima, and, on the landward side of the beach hedge, Guettarda speciosa. The dune area has been recently cleared and planted with coconut seedlings in circular depressions 2-3 m in diameter and up to 1 m deep. The dominant shrub is low and spindly Scaevola taccada, with, on the largely bare and scoured sand surface, Fimbristylis cymosa and Eragrostis tenella.

The low-lying seaward half of the land rim has a rather uneven surface covered with coconut woodland. The higher better-drained areas have a ground cover of Kalanchoe pinnata, Boerhavia repens, Cyperus dubius, Digitaria horizontalis and Eleusine indica. At slightly lower levels the Kalanchoe is replaced by the sedge Fimbristylis cymosa, and shallow pools in depressions are surrounded with the fern Thelypteris interrupta. The sedge Eleocharis geniculata grows in these pools in water a few inches deep. The common ferns Asplenium nidus and A. longissimum are found at higher levels in the Kalanchoe community, generally growing on the boles or fallen trunks of coconuts.

Further south, especially on the lagoon side, the coconut cover becomes less dense, and there are clumps of tall trees (Tournefortia argentea, Hernandia sonora) with Asplenium and Psilotum beneath.

2. Cust Point isthmus

At its narrowest the Cust Point isthmus is less than 45 m wide, and the seaward and lagoonward beach-crest communities are continuous across the land rim. Both are formed almost exclusively of Scaevola taccada, with occasional Tournefortia argentea and Suriana maritima on the seaward side. There are a few adventitious coconuts and Guettarda speciosa in the middle of the rim at its narrowest. Northward the land rim widens, the two beach-crest communities diverge, and the middle of the rim is covered with coconut woodland with many Hernandia trees and a ground cover of sedges, Kalanchoe and Passiflora. The ground is very damp, and fallen trees are thickly covered with ferns and creepers; one fallen tree was coated with the drab olive alga Lyngbya ceylanica (Myxophyceae). The lagoon beach crest, with its Scaevola hedge, is here topped by narrow dunes, with a pioneer vegetation of young Scaevola, Tournefortia and Calophyllum, and with mature Scaevola and Hernandia farther inland.

3. Minni Minni to East Point

The land rim in this sector consists of a zone of seaward dunes, a zone of dry sand, a zone of low-lying ground with standing water after rains, and a lagoon beach ridge. The seaward dunes are covered with a hedge of Scaevola taccada, with infrequent Suriana on its seaward, and Tournefortia and Guettarda on its landward, sides. The Scaevola belt is 30-50 m wide, with trees up to 6 m tall, and is much overgrown with Cassytha filiformis. The main part of the land rim

is planted with coconuts with very variable undergrowth. On the higher dry areas on the seaward side this generally consists of low trees (Morinda citrifolia, Scaevola taccada, Pipturus argenteus) less than 6 m tall; where this tree layer has been cleared Kalanchoe is dominant. The lower wetter areas in the middle of the land rim are covered with sedges, the fern Asplenium longissimum, and tall Alocasia, mainly A. macrorrhiza but also A. plumbea. The dry sand area on the lagoon side is planted with coconuts in regular rows, with Morinda, Kalanchoe, and many introduced weeds. The lagoon shore has a fringe of Scaevola only 10 m wide (Suriana is absent and Tournefortia almost so), with, in places, very tall Calophyllum and more frequent Hernandia sonora. Near East Point settlement there are many juvenile Casuarina in the open coconut woodland.

4. East Point to Barachois Maurice

South of East Point the land rim vegetation is similar to that to the north, except (a) the seaward Scaevola hedge is lower and narrower, and (b) the lagoonward clumps of Calophyllum and Hernandia in the Scaevola hedge are replaced by Cordia subcordata, Hibiscus tiliaceus and Scaevola. The coconut woodland is lower, with less Morinda, and has an undergrowth of Kalanchoe and Rivina humilis. The small Barachois Carcasse has many young Casuarina round its edges, together with Cordia, and its margins and the surrounding marshy areas are covered with the sedge Cyperus ligularis.

5. Southeast rim

The Southeast rim is topographically more complex than other sectors of the Diego Garcia land rim, with the major lagoon indentations of Barachois Maurice and Barachois Sylvain and a more exposed seaward beach. The seaward beach-crest vegetation is again dominated by Scaevola taccada, but this is much lower than elsewhere (often less than 2 m) and it is often markedly wind-sheared. There are considerable stretches where Scaevola is replaced by Tournefortia argentea (e.g. immediately south of Horsburgh Point), which is unusual elsewhere round the atoll rim; and also patches of Suriana maritima, which is considerably affected by salt-spray and wind and in places is dead. The width of the Scaevola belt is very variable, and may reach 80 m. Inland from the seaward Scaevola hedge the vegetation consists of a mosaic of coconut woodland (mainly towards the lagoon) and pure stands of Scaevola and Suriana. The coconut woodland, except where actively cleared, has an intermediate tree storey with Guettarda and Morinda, and a ground cover of Kalanchoe, Ipomoea, sedges and grasses. The Scaevola and Suriana stands have a fairly uniform height of 3-4 m, and are patchily overgrown with Cassytha; the sand surface under these stands is largely bare, with trailing Cassytha, scattered clumps of Fimbristylis, and patches of a moss (Bryum sp.). The lagoon shore has a discontinuous fringe of Scaevola and some Suriana and Tournefortia, with a ground cover of Ipomoea and Paspalum distichum. The barachois

themselves are unvegetated, except for patches of a sterile grass, probably Paspalum distichum, which are almost submerged at high water. Portulaca colonises the higher gravelly margins of the barachois on the landward side. Landward of the narrow Scaevola zone is coconut woodland with Guettarda: the littoral trees common elsewhere (Calophyllum, Cordia, Hibiscus) are not found along this shore.

6. West rim: southern sector

The southernmost sector of the west rim is flat-lying, with a narrow and low seaward beach ridge. The seaward hedge of Scaevola taccada is here invaded by "inland" species, with frequent Guettarda speciosa close to the shore, and even coconuts in places seaward of Scaevola where the beach is retreating. Tournefortia is found at the southernmost point, and northwards, in places replacing Scaevola.

The land area is dominated by coconuts, in places planted and with ground vegetation cleared, elsewhere forming dense thickets ("Cocos Bon-Dieu"). There is usually a shrub or small tree understorey up to 8 m tall, with Guettarda speciosa, Pipturus argenteus and Morinda citrifolia, and a ground layer of Rivina humilis, Kalanchoe pinnata, Achyranthes canescens, grasses, sedges, and Passiflora suberosa. One or two thickets of Scaevola taccada and Suriana maritima toward the lagoon shore are in the process of being cleared. The denser coconut thicket is quite difficult to penetrate: the fern Asplenium longissimum (Plate 41) is common in the damp undergrowth, together with fungi, particularly the large brown bracket fungus Trametes cingulata on tree trunks. The large and less common fern Asplenium macrophyllum is also found in deep shade in Tournefortia thickets. There are some tall broadleaf trees in addition to the coconuts, generally as scattered individuals and only rarely grouped together. They include large Ficus benghalensis near the occasional settlements, Hernandia sonora, and Ochrosia oppositifolia. Hernandia becomes more common further north, with trees reaching 30 m in height. Cordia subcordata and Calophyllum inophyllum are also seen inland, but are absent from the lagoon shore in this southern sector. The lagoon beach crest has an open hedge of Scaevola, Suriana and Tournefortia, generally only a single plant in width and very different to the tall, dense exclusive Scaevola hedge of the eastern lagoon shore. Small dry barachois have scattered low trees of Casuarina, Cordia and Hernandia.

7. West rim: central sector

Between Mamzelle Adélie and Pointe Marianne the land rim varies in width and topography. Immediately south of Pointe Marianne it consists of a seaward dune ridge, a flat zone of sand and cobbles, a low zone with standing water, and a narrow lagoon beach ridge. The dunes are covered with a community of pure Scaevola taccada, 150-200 m wide. The zone of high sand and cobbles supports coconut woodland

with the undergrowth partially cleared. The low-tree storey in this woodland consists of Guettarda speciosa, Morinda citrifolia and Pipturus argenteus, and the ground cover of Achyranthes canescens, Rivina humilis, some Kalanchoe pinnata, and species of Asplenium. The lagoon beach has a thin growth of Suriana maritima and Scaevola.

As the land rim narrows southwards, Scaevola still tops the seaward ridge, but the coconuts are less numerous and the coconut woodland is in places replaced by an open woodland of Guettarda speciosa, with some tall trees (not shrubs) of Tournefortia argentea and a ground cover of Ipomoea macrantha, Passiflora suberosa and grasses. The lagoon shore along this sector is irregular in plan and lacks a well-developed beach ridge. Most of the headlands are marked by groves of tall Ficus, with a littoral vegetation of Cordia subcordata, Hernandia sonora and straggling Scaevola in the intervening bays.

8. West rim: northern sector

North of Pointe Marianne the land rim is fairly uniform in both topography and vegetation for about 8 km. The high seaward beach ridge is covered with a tall hedge of Scaevola taccada for this whole distance, with very occasional coconuts at the beach crest where retreat is taking place, and some Guettarda close to the shore. The lagoon beach has only a narrow zone of Scaevola, a single shrub wide, except close to Pointe Marianne, where the beach is higher, forms a bar enclosing standing water, and is covered with Scaevola, Tournefortia and Hernandia. The land vegetation in this sector consists of coconut plantation interspersed with medium-sized trees of Hernandia sonora and unusually abundant immature Casuarina. The low tree storey is largely absent, though there is some Morinda citrifolia; the ground cover consists of Kalanchoe pinnata, Achyranthes canescens, and grasses.

At the northwest point itself the land rim broadens to form a wide triangle of land which was only briefly investigated. A traverse was made due east from Simpson Point. The seaward beach-crest Scaevola zone is here succeeded inland by a zone of high coconut-dominated forest with a dense undergrowth of the ferns Asplenium nidus and A. longissimum. A large section of the centre of the rim is formed of low dunes, with an open vegetation of Scaevola, Casuarina, and some coconuts and Hernandia. Wedelia biflora is locally dominant, with a ground cover of Stachytarpheta jamaicensis and Euphorbia cyathophora. Traverses further south also showed a woodland of tall Hernandia and coconuts, with an undergrowth of Scaevola and Wedelia. Other ground plants in this area include Kalanchoe pinnata, Lippia nodiflora, Triumfetta procumbens, Aerva lanata and Psilotum nudum. Many of the trees, particularly tall Hernandia, are densely blanketed at heights up to 25 m by exceptionally luxuriant growths of Cassytha filiformis, and epiphytic vines of introduced Vanilla planifolia were seen on several coconut and Hernandia trees. The lagoon shore is dominated by a woodland of tall Casuarina, with many juveniles, and an undergrowth of Scaevola.

9. West, Middle and East Islands

All three islands at the mouth of the lagoon are covered with a dense woodland in which coconuts are present but not dominant. West Island, the smallest, has a beach crest hedge of Tournefortia and Scaevola, and a poorly developed woodland with some coconuts, Hernandia, immature Cordia, and a single Guettarda. The ground cover in the woodland consists of patches of the grass Stenotaphrum micranthum, forming a carpet 15-20 cm thick, together with Cyperus ligularis, Achyranthes canescens, Passiflora suberosa, Boerhavia repens and Sida parvifolia. There is one species of fern, Asplenium nidus, on coconut boles.

Middle Island is larger, with a shingle rampart enclosing a small lagoon on the south side. The shingle rampart is colonised mainly by Scaevola, together with Tournefortia, Guettarda and Suriana. On the seaward side of the island the beach-crest hedge is dominated by Tournefortia argentea, with subsidiary Scaevola. Tall broadleaf trees in the central woodland include Hernandia sonora, Cordia subcordata and Guettarda speciosa; wild Carica papaya is also present.

East Island is considerably larger than the other two. Its eastern half is covered with a belt of Scaevola taccada up to 5 m tall, with occasional Tournefortia, Guettarda and coconuts, and with small patches of sedges and grasses forming an outpost vegetation on the higher portions of the rock promenade. The western half of the island is covered either with coconut thicket, with an understory of Pipturus argenteus and Carica papaya 6-8 m tall, or with a tall dense woodland of massive Hernandia sonora. This Hernandia woodland has an understorey of Guettarda, and a ground cover of Rivina humilis, Asplenium nidus, Achyranthes canescens, Boerhavia repens, Passiflora suberosa, Stachytarpheta jamaicensis, Cyperus ligularis and Stenotaphrum micranthum.

Bourne (in Hemsley 1887, 334) noted the absence of coconut palms on all these islands.

10. Present and former settlements

(a) Minni Minni

The vegetation on the site of the former settlement at Minni Minni is dominated by tall broadleaf trees, notably a line of Calophyllum inophyllum along the shore; a double line of massive Ficus religiosa extending from the lagoon shore to what was presumably the old manager's office, with other Ficus scattered amongst the remains of buildings; and, most massive of all, Barringtonia asiatica, the mature trees being surrounded by saplings 3-4 m tall. Hernandia sonora is common, and coconuts are largely absent from the settlement area proper. Terminalia catappa is represented by several large trees. The dense canopy and dark foliage of these trees form a dark, damp environment for ground cover. Alocasia macrorrhiza grows luxuriantly to heights of 3-4 m in

and around the old building sites, with abundant ferns (Asplenium spp., Thelypteris opulenta) and a moss (Syrrhopodon revolutus) on tree boles, logs and masonry. The ground vegetation includes weeds (Euphorbia cyathophora, Stachytarpheta jamaicensis) and relics of cultivation (decoratives such as Haemanthus multiflorus, a conspicuous red-flowering lily, Asclepias curassavica, Hemigraphis alternata).

A number of common cultivated trees are absent at Minni Minni, particularly Artocarpus and Mangifera, the decorative shrub Hibiscus, and also Casuarina. The first three may have been introduced to the atoll after the Minni Minni settlement had been abandoned.

The clump of trees south of Minni Minni, marked on charts as Minni Minni Knob, near the lagoon shore, consists of tall Calophyllum and Hernandia trees, and may be a former settlement site.

(b) East Point

The vegetation at the present main settlement at East Point is floristically the most diverse on the atoll. Many of the species are clearly deliberate introductions, and are found only in gardens under cultivation. Thus the manager's garden includes such trees as Albizia lebbeck, the Norfolk Island pine Araucaria columnaris (one tree only), Averrhoa bilimbi, Eugenia javanica, the kapok Ceiba pentandra, and the exotic palms Phoenix sp. and Hyphaene sp. There is an introduced bamboo Bambusa vulgaris. Introduced decoratives found planted round houses and along roadsides in the village include Asclepias curassavica, Catharanthus roseus, Crinum latifolium, Haemanthus multiflorus, Hibiscus rosa-sinensis, Hymenocallis littoralis, Pentas lanceolata, Pithecellobium dulce, and Zephyranthes rosea; Bidens sulphurea is also growing in the small cemetery. Species introduced for economic reasons (including food plants) include cotton Gossypium hirsutum, banana Musa sp., a mint Mentha sp., the taros Alocasia macrorrhiza and A. plumbea, and limes and oranges, Citrus spp. A number of vegetables, including eggplant and lettuce, are under cultivation. Massive trees of Ficus benghalensis are found to the north of the settlement, and tall Casuarina in the quadrangle between the manager's house and the jetty.

Many weedy species are found at and near East Point, some of which (such as Ipomoea pes-caprae and I. macrantha) may be indigenous, though rare elsewhere on Diego Garcia, whereas others are certainly introduced (Mimosa pudica, for example, is found only at the head of the East Point jetty). Common weeds include Achyranthes canescens, Boerhavia repens, Cassia occidentalis, Spermacoce suffrutescens, Euphorbia cyathophora, Hippobroma longiflora, Mikania micrantha, Passiflora suberosa, Sida parvifolia, Stachytarpheta jamaicensis, Striga asiatica, Tridax procumbens, Triumfetta procumbens and Vernonia cinerea. Pathways are lined with sedges and grasses, some of which have not been recorded elsewhere on the atoll (Cyperus compressus, Cyperus dubius, Cyperus ligularis, Cyperus

sphacelatus, Eleusine indica, Fimbristylis cymosa, Paspalum distichum, Stenotaphrum dimidiatum).

In 1885 Bourne (in Hemsley 1887, 334) found "bananas, sweet potatoes, bitter oranges, citrons and a few other tropical fruits. ... Maize is cultivated at Minny Minny." Bourne also collected Capsicum frutescens (Hemsley 1887, 339).

(c) Pointe Marianne

The settlement at Pointe Marianne is located on a lagoon beach ridge which encloses a wide area of standing fresh water, with dead and decapitated coconuts and Casuarina. The water contains a pondweed Bacopa monnieri, and the drying margins are being colonised by Paspalum disticum (?). The landward margins of the pool are covered with tall Casuarina and coconuts.

The lagoon beach at the settlement is fringed with massive trees of Calophyllum inophyllum, Hibiscus tiliaceus and Cordia subcordata, with Scaevola shrubs appearing only to the north and south. Between the houses of the settlement there are massive buttressed trees of Hernandia and Calophyllum, three tall trees of Artocarpus altilis, numerous Carica papaya, and some Musa sp., Terminalia catappa, and Mangifera indica. The ground cover consists of Wedelia biflora, Stachytarpheta jamaicensis, Euphorbia cyathophora, Hippobroma longiflora and Ageratum conyzoides. Near the manager's house there is a clump of sterile Pandanus, two trees of Leucaena leucocephala, and such flowering plants as Sida acuta, Pentas lanceolata and Ocimum gratissimum. Catharanthus roseus and Zephyranthes rosa are planted as decoratives round the houses. There is a long-disused cemetery south of Pointe Marianne, with tall Ficus and a number of relict cultivated plants, including Codiaeum variegatum.

B. Vegetation types

Wiehe (1939), in his general account of the Chagos atolls, discusses the vegetation in terms of (a) beach vegetation, (b) coconut groves, and (c) marshes. The following classification of the vegetation of Diego Garcia into eight categories is proposed largely as a means of organising the available information. The atoll land rim is so long and narrow, and the mosaic of vegetation types so intricate, that it must be regarded as highly approximate. The distribution of the main vegetation types has been mapped from air photographs in Figure 31, but though the photographs are of exceptional quality the small scale of the map means that it too is very generalised. Some comparisons are drawn in the following account with the vegetation of the other Chagos atolls, particularly Salomon and Peros Banhos, and of the southern Maldives.

1. Shoreline vegetation

(a) Scrub community of seaward beach

The scrub community of the seaward beach forms the most continuous and widespread vegetation unit on the atoll. Scaevola taccada forms a beach-crest hedge along almost the entire seaward coast (about 64 km) (Plate 5). Along the east coast, overlooking a wide beach, the Scaevola is tall (up to 6 m high) and bushy, forming a zone up to 50 m wide. Along the southeast, windward coast the Scaevola is much lower, wind-trimmed, and in places replaced by Tournefortia argentea. Along the west coast the Scaevola is again bushy, but in places the inland vegetation extends almost to the beach, especially in the south. Tournefortia argentea and Suriana maritima (Plate 35) occasionally replace Scaevola as the dominant species, and scattered bushes of Suriana are in places found to seaward of a continuous Scaevola hedge. On the inland side trees of Guettarda speciosa and Cocos nucifera are frequently found along the margin of or within the Scaevola belt.

Pemphis acidula has not been collected at Diego Garcia, though Wiehe (1939, 11) states that it is of more frequent occurrence than Suriana; Sophora tomentosa is likewise apparently absent, though both species are recorded from Addu Atoll, southern Maldives. No native Pandanus is found on Diego Garcia beaches, nor is the genus recorded from the Chagos Archipelago though present in the Maldives. A pioneer strand vegetation of vines, herbs and grasses is notably absent from seaward beaches of Diego Garcia: shrubs of Scaevola and associated species invariably form the outermost vegetation on Diego Garcia seaward shores.

(b) Lagoon-shore Scaevola community

Scaevola taccada is also the most widespread species on lagoon shores. It is dominant on the lagoon beach between Eclipse Point and Pointe Marianne, though forming only a narrow zone; from Pointe Marianne to Barachois Maurice, though limited over much of this tract by barachois development inland from the coast and the presence of a rock platform beneath a thin superficial cover of sand; and from Cust Point to Observatory Point, where the growth is more luxuriant on dune sands. Generally the plants are less bushy and more open in growth-form than on the seaward shore, and the zone may be only a few meters (a single plant) in width. Tournefortia occasionally replaces Scaevola, but Suriana is only found in place of Scaevola at the mouths of barachois, where it takes the place that Pemphis might be expected to occupy were it present. Coconuts crowd close to the lagoon beach. Where the Scaevola is more open there is a ground vegetation of grasses and sedges, but such vegetation is sparse and Ipomoea is almost completely absent.

(c) Lagoon-shore Calophyllum-Barringtonia community

Large shoreline trees of Calophyllum inophyllum and Barringtonia asiatica, with massive branches extending horizontally over the water

and lower trunks and roots washed by waves, are common only on the lagoon shore between Cust Point and East Point, especially around Minni Minni. A few are found at Pointe Marianne and near Eclipse Point, but otherwise they are confined to a lee shore. The beach here is narrow, steep and cliffed, held up by tree roots. Consequently there is no pioneer strand vegetation. Of the two common species, Calophyllum is more numerous though less massive than Barringtonia.

(d) Lagoon-shore mixed woodland

A lagoon shore woodland of Cordia subcordata, Guettarda speciosa and Hibiscus tiliaceus is uncommon on Diego Garcia, being restricted to the shore between East Point and Barachois Maurice and again south of Pointe Marianne, where it is interspersed with Scaevola. H. tiliaceus is quite common though Hemsley (1887, 336) stated that this species was absent from Diego Garcia.

(e) Dune scrub communities

Where the shoreline is backed by low dunes, either on the seaward or lagoon coasts, shrubby species are dominant. These old dune tracts may be extensive on the inland parts of the land rim, as between Northwest Point and Barton Point, and along most of the southeast coast of the atoll. Scaevola taccada is the most common shrub species, reaching a maximum height on the southeast rim of 5-8 m, and with a much more open growth-form on the coast. Other species locally dominant are Suriana maritima and Wedelia biflora. The sand surface under the shrubs is generally bare, with clumps of Fimbristylis cymosa, round which sand may be eroding, some Portulaca, and grasses. On the southeast rim this zone may reach a width of almost 1 km. Parts of the dune scrub here and near Barton Point and Eclipse Point have been cleared for coconuts.

2. Broadleaf woodland

Before the spread of planted coconuts, broadleaf woodland must have been much more extensive at Diego Garcia than now, but few remnants of this woodland now remain. La Fontaine in 1770 is said to have found a vegetation of "fatamaka [sic, Calophyllum inophyllum], bois blanc bon pour pirogues [Hernandia sonora?], bois à brûler [Pemphis acidula?]" (Unienville 1838, 182). Hemsley (1887, 333) quotes Findlay's (1870, 459) general statement concerning the Chagos: "On nearly every part of these islands there grow at intervals great clumps of gigantic trees, the Bois Mapou or Rose Tree, which attains an enormous size and height, even to 200 feet [60 m]. Their fallen and decayed trunks form a large portion of the vegetable world of the Archipelago". Bourne (1886, 387) suggests that the large tree is Pisonia inermis, and Hemsley (1887, 335-336) either Pisonia or Afzelia (=Intsia) bijuga.

Apart from exceptionally large nearshore Calophyllum inophyllum and Barringtonia asiatica, and occasional Ficus benghalensis at settlements, the only common large tree now present on Diego Garcia is Hernandia

sonora. In places, for example on the southern part of the west rim, this forms an open Hernandia woodland, elsewhere a mixed Hernandia-cocunut woodland (Plate 36). Bourne (1886, 386) noted that Hernandia was "common, and may attain a considerable size; the natives use an infusion of the flowers as a medicine in gonorrhoeal complaints". Wiehe (1939) found Hernandia to be common and sometimes dominant.

Other species which may in the past have composed a native broad-leaf woodland are now rare or apparently absent. These include Intsia bijuga, Ochrosia oppositifolia, Pisonia grandis, and Cerbera odollam. Wiehe (1939, 13) described a forest of Intsia bijuga on Salomon Atoll, which was cut down in 1825; the largest tree had a trunk diameter of 2.8 m. Bourne (1886, 387) found "a single group of larger trees confined to a single spot on the northeast of the main island" on Diego Garcia, and Hemsley (1887, 336) states that there were then only four or five trees left. Because of depredation by rats, Bourne doubted that the species was replacing itself. Rhyne collected Intsia at East Point in 1967, but otherwise it was not seen. Ochrosia oppositifolia was recorded without comment (as O. borbonica) by Hemsley (1887, 1919) and Willis and Gardiner (1930) at Diego Garcia. A single tree was seen at the southern end of the west rim in 1967, height 12 m. Pisonia inermis (P. grandis) was recorded at Diego Garcia by Bourne (Hemsley 1887, 1919) and Willis and Gardiner (1930); and was noted in the Chagos generally by Wiehe (1939) as "a common tree, sometimes reaching heights of over 125 feet [38 m]". A single tree was seen on the atoll in 1967, on the seaward shore on the west rim, opposite Mamzelle Adélie. Wiehe (1939, 14) also noted Cerbera odollam as "a common tree in all the islands", but it has apparently not been specifically recorded from Diego Garcia and was not seen there in 1967.

Wiehe also mentions Guettarda speciosa and Thespesia populnea as common smaller trees, particularly near the shore, with the latter forming a dense thicket at the northwest point. This may be an error (? for Hibiscus tiliaceus) for the species has not otherwise been recorded from Diego Garcia, and was not found in 1967.

3. Coconut woodland

Cocos nucifera is clearly the dominant tree species in the land vegetation of Diego Garcia, and has been so since at least the middle of the seventeenth century (Horsburgh 1809, 131; Unieville 1838). Though at present coconut plantations are actively maintained near East Point and Pointe Marianne, coconut thicket with greater or lesser amounts of low trees and ground vegetation covers most of the atoll. Sauer (1967, 42-49) has argued from historical evidence and from propensity of Indian Ocean coconut palms to volunteer from drift nuts that the species is indigenous in the western Indian Ocean islands, and may have spread from there eastwards into the Pacific. At Diego Garcia, germinating drift seeds are particularly common on the lagoon shores of the northern islets, especially Middle Island, but are rare elsewhere; however, it is

these islands which alone on the atoll had no coconuts at the time of Bourne's visit in 1885. Without further historical evidence we can say little on the antiquity of coconuts on Diego Garcia, though it is probable that if they were introduced they were brought by pre-European sailors, a conclusion which applies to Cocos-Keeling, the rest of the Chagos, and other Indian Ocean reef islands.

Three types of coconut woodland can be distinguished on Diego Garcia:

(a) Coconut plantation

Intensively managed coconut plantations are found between East Point and Minni Minni, at Pointe Marianne, and southwest of Barachois Maurice (Plate 37). In these plantations the coconuts are planted in regular rows and the ground vegetation is usually not more than 0.5 m tall, though taller shrubs may grow between periods of clearing. Kalanchoe pinnata is one of the taller plants beneath the coconuts, replacing on Diego Garcia the Polynesian arrowroot Tacca leontopetaloides which is found in the Maldives and on many Pacific atolls. Kalanchoe is also recorded from Addu Atoll, southern Maldives, where, however, it is not common. Other widespread species in the ground layer include Achyranthes canescens, Rivina humilis, Passiflora suberosa, and the ferns Asplenium nidus and A. longissimum. On more open ground two small inconspicuous herbs are extremely common but may be overlooked: Pilea microphylla and Phyllanthus amarus. Striga asiatica is also common, especially on the east rim, where it grows to a height of 15 cm, compared with less than 5 cm on the drier atolls of the southwest Indian Ocean. The composition of the ground layer is rather restricted by comparison with similar habitats on other atolls: notably absent are certain members of the Euphorbiaceae such as Euphorbia chamissonis and E. atoto, common in other parts of the world. Epiphytes including ferns, Psilotum nudum and certain mosses are common, though less so in the more actively managed plantations, and the numerous piles of coconut husks, as well as tree trunks, are colonised by the moss Calymperes garciae.

(b) "Cocos Bon-Dieu"

More widespread than the managed plantations is a coconut woodland in which the coconuts themselves are irregularly distributed and largely self-sown, with intermediate storeys of small trees and tall shrubs 6-8 m tall and a luxuriant ground layer (Plate 38). In order of abundance the small tree layer consists of Morinda citrifolia, Pipturus argenteus, Guettarda speciosa and Scaevola taccada. Wiehe (1939) mentions Pipturus species as being common at Diego Garcia, and Premna obtusifolia as being present, though the latter was not collected in 1967. Examples of this woodland are found north of East Point, southwest of Barachois Maurice, and between Barachois Maurice and Carcasse. It is well developed between Barachois Sylvain and Mamzelle Adelle. The ground cover under Cocos Bon-Dieu consists of the species mentioned in the previous paragraph, except that Kalanchoe pinnata is absent.

(c) Mixed Coconut Woodland

Open coconut woodland is found in a few places mixed with Hernandia sonora and with a ground vegetation similar to that in actively managed coconut plantations. In places, as between Pointe Marianne and Mamzelle Adelle, a mixed woodland of coconuts with Guettarda speciosa and even trees of Tournefortia argentea is found. Tree density in such mixed woodland is generally low: there is no closed canopy and the vegetation is more open and park-like.

4. Casuarina Woodland

The status of Casuarina in the western Indian Ocean is uncertain. Often introduced in recent times, there is uncertain historical evidence for its pre-European occurrence on the Seychelles and Mascarene Islands, and Sauer (1967) considers it aboriginal in the former. It was first recorded from Diego Garcia by Bourne (1886, 386), who found "several clumps ... on the east side of the island ... [which] form conspicuous landmarks". Except at East Point, mature Casuarina is uncommon on the eastern rim today, though juveniles are common on Carcasse. The species is concentrated on the lagoon shore of the west rim, particularly from Pointe Marianne northwards (Plate 40), with juveniles invading coconut woodland. An extensive grove of pure Casuarina is found 1 km south of Eclipse Point on the lagoon shore, and the largest areas are near the seaward shore southwest of Eclipse Point.

5. Inland Marsh

At certain points on the land rim there is a depression between the lagoon and seaward ridges low enough to contain standing water or at least waterlogged soil. Near East Point, such depressions have a vegetation dominated by tall Alocasia macrorrhiza (Plate 42), the fern Asplenium longissimum, and sedges, but Alocasia is absent elsewhere on the land rim. Asplenium longissimum is common throughout the atoll in such situations. At the northeast point Thelypteris interrupta is found at the edge of standing water, and the sedge Eleocharis geniculata grows in the shallow water.

6. Barachois vegetation

The most striking feature of the barachois vegetation is its absence: no mangroves or associated species such as Acrostichum aureum are found on Diego Garcia, and in this respect the Chagos as a whole may be compared with the mangrove-free Tuamotus in the eastern Pacific. Mangroves are also absent from Cocos-Keeling Atoll in the eastern Indian Ocean, which in other respects also resembles Diego Garcia.

Six species of mangroves have been recorded from the Maldive Islands, of which only three are known from the southernmost atoll, Addu. These are (Fosberg 1957, Fosberg, Groves and Sigeo 1966):

<u>Sonneratia acida</u> L.	Malé, Miladumadulu, Addu
<u>Bruguiera cylindrica</u> (L.) Bl.	Malé, Goifurfehendu, Kolumadulu, Miladumadulu
<u>Bruguiera gymnorhiza</u> Lam.	Addu
<u>Rhizophora mucronata</u> Lam.	Suvadiva, Addu
<u>Lumnitzera littorea</u> (Jack.) Voight	Malé
<u>Lumnitzera racemosa</u> Willd.	Suvadiva

The mangrove-associated leather fern Acrostichum aureum has not been recorded from the Maldives. At Addu Atoll, none of the three recorded mangrove species form a woodland or "swamp," at least in the areas visited in 1964, and all are inconspicuous or rare.

Three mangrove species are recorded from the Chagos Archipelago, of which one is introduced. The two native species are Sonneratia acida L. (Ile Moresby, Peros Banhos) and Xylocarpus moluccensis (Lam.) Roemer, the latter an exclusive dominant in the marsh at Ile Boddam, Salomon Atoll (Wiehe 1939). Wiehe also noted the introduction of Rhizophora mucronata from Mauritius to Ile Boddam, Salomon, in 1935, but there is no information on the present status of this species.

This paucity in mangroves on atolls of the eastern and central Indian Ocean contrasts with their considerable development on atolls of the western Indian Ocean, for example in the high mangrove woodland at Aldabra Atoll, where eight species of mangroves are recorded. While the regional problem of absence of mangroves must result from ocean-wide dispersal patterns, it is likely that, at Diego Garcia itself, mangrove colonisation on lagoon shores and especially in barachois would have been limited by the elevation of the barachois floor, considerable tidal range, and distance from open water: even in mangrove areas such tracts are often either bare or sparsely colonised by Lumnitzera.

In the absence of mangroves, the barachois are relatively unvegetated. The sandy and muddy areas are devoid of vegetation except in patches which reach the approximate level of high spring tides. These are colonised by a wiry sterile grass (probably Paspalum distichum) and no other plants (Plates 12-15). In some of the barachois, especially at Mamzelle Adélie, these vegetated patches are more extensive and have the appearance, intersected by a branching creek system, of a salt marsh. Salt-marsh species, including primary colonisers, such as Arthrocnemum, are, however, absent. Most of the barachois are surrounded by rock ledges, again almost unvegetated except for patches of Portulaca. The transition to terrestrial vegetation, by a hedge of Scaevola, Suriana or Tournefortia, is usually sharp. Macroscopic algae are rare in the barachois, though a Schizothrix-like alga forms pink crusts on the higher areas, and another forms stromatolithic mounds at intermediate levels.

7. Settlement vegetation

Apart from the larger settlements at Pointe Marianne, Minni Minni, and particularly at East Point, there are numerous isolated houses round the atoll rim, which probably mark the centres of former land holdings. These are characteristically marked by one or two tall trees of Ficus benghalensis, often Terminalia catappa, and frequently a number of Carica papaya and Musa sp. Weeds such as Stachytarpheta, decorative plants, and food plants are also found near the houses.

Massive trees of Ficus benghalensis are found at all three main settlements, but particularly at Minni Minni (Plate 46). East Point and Pointe Marianne also have a number of introduced decorative and food species, some of great size, including Artocarpus altilis, Mangifera indica, Terminalia catappa, Albizia lebbeck, Averrhoa bilimbi, Ceiba pentandra, Eugenia javanica and Araucaria columnaris. Cultivated decorative plants include Catharanthus roseus, Hibiscus rosa-sinensis, and several lilies (Crinum sp., Haemanthus multiflorus, Hymenocallis littoralis, Zephyranthes rosea). Gossypium hirsutum is common at East Point but has not spread elsewhere, and the taros, Alocasia species, are also so restricted.

Many weedy species are restricted to East Point, clearly their point of introduction, or, if found elsewhere on the atoll, are especially abundant at settlements. Several have been noted in Section A.10 and will not be repeated here. It is of interest that most of these species were apparently absent in the collections made by Hume (Hemsley 1884) and Bourne (Hemsley 1887), and though these were admittedly incomplete it is probable that many introduced species were not present eighty years ago. Wiehe (1939), however, records many exotics, and the 1967 collections added about thirty new records. These are documented in the list by Fosberg and Bullock in Chapter 12. In spite of the continual human interference with the vegetation of the atoll, it is remarkable that many of the introduced species are still so localised.

C. Summary

In summary, the most striking features of the vegetation of Diego Garcia are as follows:

1. The dominance of Scaevola taccada on both seaward and lagoon coasts, especially on the former. Tournefortia and Suriana are also present, but not Pemphis.
2. The dominance of coconut woodland inland, either in the form of actively managed and cleared plantations with a ground cover of Kalanchoe pinnata (but no Tacca), herbs and grasses, or a more irregular, denser woodland ("Cocos Bon-Dieu") of coconuts with a small layer of Guettarda, Morinda, Pipturus and Scaevola.

3. The widespread distribution of Hernandia sonora among the indigenous broadleaf trees, and the rarity of other species.
4. The limited distribution of very large littoral trees such as Calophyllum and Barringtonia.
5. The presence of massive trees of Ficus benghalensis and other cultivated trees at settlements.
6. The absence of Pandanus, except for two cultivated individuals.
7. The luxuriance of the fern flora (six species, dominated by Asplenium longissimum and A. nidus), of the bryophytes (especially Calymperes garciae on tree trunks and coconut husks), and to a lesser extent of the fungi, both on the ground and on rotting logs.
8. The absence of mangroves and associated vegetation.
9. The large number of recently introduced species, mainly at East Point, contrasting with the simplicity of the vegetation and restricted flora over most of the atoll.

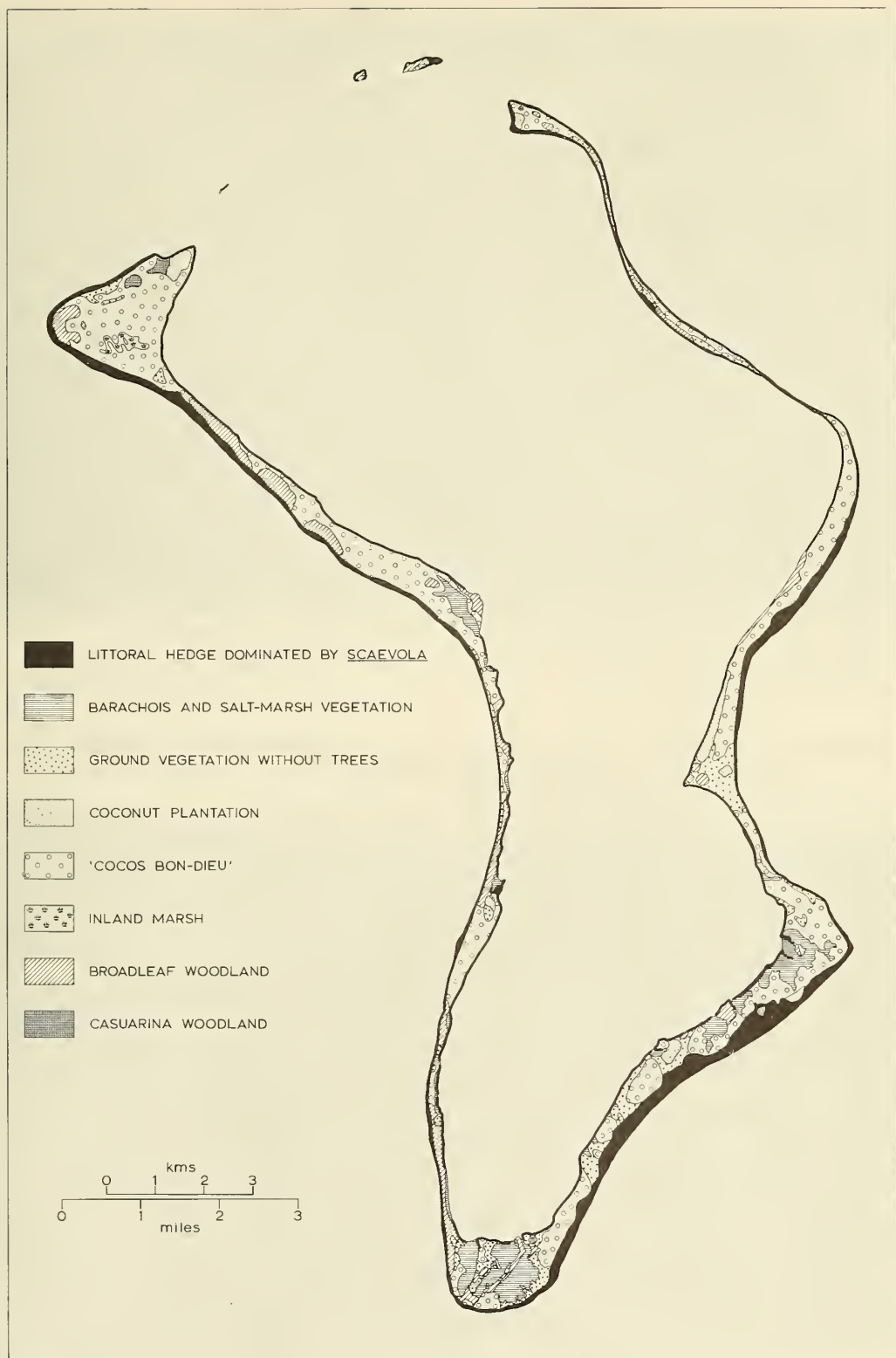


Fig. 31. Distribution of vegetation. Based largely on air photographs made available by the Ministry of Defence.



35. Suriana maritima largely killed by wave-spray in coastal scrub on the beach crest, southeast coast northeast of Barachois Sylvain

36. Broadleaf woodland of Hernandia, with coconuts and Scaevola scrub, northwest coast of East Island





37. Well-managed coconut plantations, southeast rim, southwest of Barachois Maurice

38. "Cocos Bon-Dieu" with Pipturus and other undergrowth species between Carcasse and Horsburgh Point





39. Germinating beach-drift coconuts on the southern beach ridge of Middle Island

40. Casuarina woodland on the lagoon coast south of Eclipse Point





41. Asplenium longissimum in dense woodland, western rim between Barachois Sylvain and Mamzelle Adélie

42. Alocasia species growing on low-lying ground in coconut woodland, centre of the east rim, north of East Point





12. LIST OF DIEGO GARCIA VASCULAR PLANTS

F.R. Fosberg and A.A. Bullock

This list does not pretend to be more than an account of the specimens from Diego Garcia Atoll examined by the authors, plus records from the Willis and Gardiner (1931) list, for those species of which they have seen no Diego Garcia specimens. Those from other Chagos atolls, or indicated by Willis and Gardiner as from all islands, or the whole group, without specific Diego Garcia records, have not been included. Except in one or two cases where very recent changes have been made, synonymy has not been included, though frequently earlier published records have been under names not accepted here.

It is planned that such taxonomic and nomenclatural details will be elaborated in a flora of the western Indian Ocean atolls that is being prepared.

A small collection of plant specimens made by Mr. Jack Frazier in 1970 has not been included, as the material is not yet available for determination. These specimens will also be cited in the flora mentioned above.

Fosberg accepts responsibility for the plant names used, as Bullock has not had an opportunity to see the list in its final form.

The symbols US, K and MAU in the specimen citations indicate the herbaria where the specimens are deposited, the U.S. National Herbarium, that of Kew Gardens, and that of the Sugar Research Institute, Mauritius, respectively.

PSILOACEAE

Psilotum Sw.

Psilotum nudum (L.) Beauv.

East Point, Stoddart 791 (K); near ocean side at North-West Point, Rhyne 432 (US); East Point village near ocean, Rhyne 679 (US); s.l. Morin in 1939 (MAU); Wiehe in 1939 (MAU).

POLYPODIACEAE

Asplenium L.Asplenium longissimum Bl.

East Point Settlement, Stoddart 767 (K); between Observation Point and Barton Point, Stoddart 799 (K); West Rim, Southern Point, Stoddart 851 (K); near ocean side at North-West Point, Rhyne 429 (US); East Point village, ocean side, Rhyne 671 (US). Chemin Long, Wiehe in 1939 (MAU); Carcasse, Wiehe 1617 (MAU).

Asplenium macrophyllum Sw.

s. l. Bourne 7 (K); West rim, south end, Stoddart 850 (K); ocean side North-West Point, Rhyne 436 (US); Chemin Long, Wiehe in 1939 (MAU); Carcasse, Wiehe in 1939 (MAU); Pointe Noroit, Wiehe 1621 (MAU).

Asplenium nidus L.

Between Observatory Point and Barton Point, Stoddart 796 (K); East Island, Stoddart 882 (K); West Island, Stoddart 867 (K); near ocean side at North-West Point, Rhyne 430 (US); Carcasse, Wiehe 1618 (MAU).

Asplenium tenerum Forst. (A. aequabile Baker)

S. l. Lady Barkly 6 (K, type of A. aequabile).

Pteris L.Pteris tripartita Sw.

Carcasse, Wiehe in 1939 (MAU), Wiehe 1619 (MAU).

Pteris biaurita L. (sens. lat.)

Carcasse, Wiehe 1620 (MAU) (a large very open frond, broadly ovate, lobes well-separated, stipes with linear scales below).

Thelypteris Schmid.Thelypteris opulenta (Kaulf.) Fosb.

Minni Minni, Stoddart 832 (K); ocean side at North-West Point, Rhyne 434 (US); East Point village vicinity ocean side, Rhyne 670 (US) (possibly this, but immature).

Thelypteris interrupta (Willd.) Iwatsuki (Dryopteris goggilodus (Schkuhr) O. Ktze.).

Between Observatory Point and Barton Point, Stoddart 801 (K); Pointe Noroit, Wiehe in 1939 (MAU).

ARAUCARIACEAE

Araucaria Juss.Araucaria columnaris (Forst. f.) Hook.?

East Point Settlement, one tree in garden, Stoddart 837 (K, US); East Point village, Rhyne 689 (US).

PANDANACEAE

Pandanus L.Pandanus sp.Point Marianne, Rhyne 778 (US) (sterile).

POTAMOGETONACEAE

Thalassodendron den Hart.Thalassodendron ciliatum (Forsk.) den Hart. (Cymodocea ciliata Ehrenb. ex Aschers.)1-1/4 mi. south of Leconte Point, on lagoon side, Rhyne 735 (US); lagoon side near North-West Point, Rhyne 385 (US); ocean side near North-West Point, Rhyne 354 (US); southernmost end of lagoon, Rhyne 590 (US).

GRAMINEAE

Bambusa Schreb.Bambusa vulgaris Wendl.East Point, cult., Stoddart 888 (K).Digitaria Fabr.Digitaria horizontalis Willd.Between Observatory Point and Barton Point, Stoddart 797 (K); West rim of atoll, South end, Stoddart 846 (K, US).Digitaria timorensis (Kunth) Bal.?Minni Minni, Wiehe in 1939 (MAU).Eleusine Gaertn.Eleusine indica (L.) Gaertn.Between Observatory Point and Barton Point, Stoddart 806 (K, US); East Point village, cemetery, Rhyne 678 (US).Eragrostis Host.Eragrostis tenella var. insularis Hubb.Between Observatory Point and Barton Point, Stoddart 798 (K, US); Stoddart 803 (K).Lepturus R. Br.Lepturus repens R. Br.S. 1., Wiehe in 1939 (MAU).Paspalum L.Paspalum distichum L.East Point village vicinity, Rhyne 608 (US) (sterile); near

Dumoulon and Barachois Sylvain, Wiehe in 1939 (MAU). (With very short thick spikes).

Pennisetum Rich.

Pennisetum polystachion (L.) Schult.

North-West Point, Stoddart 856 (K, US); Pointe Marianne, Wiehe 1623 (MAU).

Stenotaphrum Trin.

Stenotaphrum dimidiatum (L.) Brongn.

East Point Settlement, Stoddart 818 (K, US); East Point village vicinity, Rhyne 609 (US) ? (sterile).

Stenotaphrum micranthum (Desv.) C. E. Hubb.

East Island, Stoddart 876 (K, US); West Island, Stoddart 869 (K, US). S. l., Wiehe in 1939 (MAU).

Zea L.

Zea mays L.

Minni Minni, cultivated, recorded by Bourne (Hemsley 1884, p. 334).

CYPERACEAE

Cyperus L.

Cyperus compressus L.

East Point Settlement, Stoddart 820b (K).

Cyperus dubius Rottb.

East Point Settlement, Stoddart 776 (K, US); between Observatory Point and Barton Point, Stoddart 805 (K, US).

Cyperus kyllingia Endl.

S. l., Willis & Gardiner 35 (K).

Cyperus ligularis L.

S. l., Bourne 19 (K); East Point Settlement, Stoddart 785 (K, US); East Island, Stoddart 878 (K, US); East Point village vicinity, Rhyne 661 (US).

Cyperus rotundus L.

East Point Settlement, Stoddart 819 (K, US).

Cyperus sphacelatus Rottb.

East Point Settlement, Stoddart 820a (K, US). (Young, atypical, scarcely showing brown on scales, inflorescence compact).

Eleocharis R. Br.

Eleocharis geniculata (L.) R. & S.

Between Observatory Point and Barton Point, Stoddart 800 (K, US).

Fimbristylis Vahl

Fimbristylis cymosa R. Br.

East Point village, Rhyne 658 (US, K); East Point Settlement, seaward coast, Stoddart 781 (K, US) (style branches 3); between Observatory Point and Barton Point, Stoddart 802 (K, US) (nut examined trigonous, smooth).

PALMAE

Cocos L.

Cocos nucifera L.

General on atoll, comprising plantations.

Hyphaene Gaertn.

Hyphaene sp. ?

East Point, Stoddart 897 (K). (This is a juvenile fan palm leaf from beneath a 60 ft. tree, summit of petiole with no spines, leaf must have been about 70 cm diameter.) (This determination made at Kew, not signed.)

Phoenix L.

Phoenix sp. (P. dactylifera ?)

East Point, Stoddart 895 (K, US). (Leaves rather delicate, greyish-green).

ARACEAE

Alocasia G. Don

Alocasia macrorrhiza (L.) Schott

East Point, Stoddart 827 (K, US); vicinity of Minni Minni, Rhyne 745 (US).

Alocasia plumbea van Houtte

East Point village near cemetery, Rhyne 620 (US); East Point, Stoddart 828 (K, US) (young leaves, only, base contracted, sinus narrow, basal lobes wide subtruncate leaves purplish beneath, dark green above, 3-4 ft. tall.).

COMMELINACEAE

Commelina L.

Commelina benghalensis L.

S. I., Wiehe in 1939.

AMARYLLIDACEAE

Crinum L.

Crinum latifolium var. zeylanicum (L.) Hook. f. ex Trim.
East Point Settlement, Stoddart 821 (K).

Haemanthus L.

Haemanthus multiflorus Martyn
East Point Settlement, Stoddart 771 (K, US); East Point village
near cemetery, Rhyne 619 (US).

Hymenocallis Salisb.

Hymenocallis littoralis (Jacq.) Salisb.
East Point, in garden, Stoddart 855 (K).

Zephyranthes Herb.

Zephyranthes rosea (Spr.) Lindl.
East Point village near hospital, Rhyne 613 (US); Stoddart 772 (K,
US).

MUSACEAE

Musa L.

Musa sapientum L.
Bananas recorded by Bourne (Hemsley 1884, p. 334).

CASUARINACEAE

Casuarina Adans.

Casuarina equisetifolia L.
Lagoon shore south of East Point, Stoddart 814 (K); North West
Point, Rhyne 440 (US).

URTICACEAE

Pilea Lindl.

Pilea microphylla (L.) Liebm.
Pointe Marianne, Stoddart 893 (K, US).

Pipturus Wedd.

Pipturus argenteus (Forst.) Wedd.
East Island, Stoddart 874 (K, US); East Point Settlement, Stoddart
789 (K, US). S. I., Wiehe in 1939 (MAU); Pointe Noroit, Wiehe 1622
(MAU).

MORACEAE

Artocarpus Forst.

Artocarpus altilis (Park.) Fosb.
Pointe Marianne, Rhyne 770 (US).

Ficus L.

Ficus benghalensis L.
S. l., Willis & Gardiner s.n. (K); East Point village, Rhyne 654
(US); Stoddart 807 (K, US).

Ficus religiosa L.
Vicinity of Minni Minni, Rhyne 744 (US).

Ficus sp.
S. l., Morin in 1937 (MAU). (Leaves only, large, like F. nautarum
Bak.).

NYCTAGINACEAE

Boerhavia L.

Boerhavia repens L.
S. l., Bourne in 1885 (K); Morin in 1937 (MAU); Wiehe in 1939 (MAU).

Boerhavia repens L. (white flowered form)
West Island, Stoddart 870 (K); East Island, Stoddart 879 (K, US);
East Point Settlement, seaward coast, Stoddart 782 (K, US), 777
(K, US); between Observatory Point and Barton Point, Stoddart 804
(K, US).

Pisonia L.

Pisonia grandis R. Br.
S. l., Morin in 1937 (MAU); Wiehe in 1939 (MAU).

AMARANTHACEAE

Achyranthes L.

Achyranthes canescens R. Br.
S. l., Hume in 1883 (K); s.l., Bourne (?) in 1885; East Island,
Stoddart 875 (K, US); East Point Settlement, Stoddart 764 (K, US);
West Island, Stoddart 871 (K, US); East Point village near ocean,
Rhyne 683 (US).

Aerva Forsk.

Aerva lanata Juss.
North-West Point, Stoddart 859 (K, US).

Amaranthus L.Amaranthus viridis L.

Seen by Wiehe in 1939.

PHYTOLACCACEAE

Rivina L.Rivina humilis L.East Point Settlement, Stoddart 769 (K, US), 766 (K); East Island, Stoddart 877 (K, US); west rim of atoll, south end, Stoddart 848 (K, US); Pointe Marianne, Rhyne 775 (US).

PORTULACACEAE

Portulaca L.Portulaca sp. (aff. P. australis Endl.)Pointe Marianne, Stoddart 891 (K, US); East Point Settlement, seaward coast to north of Settlement, Stoddart 787 (K, US); South Point, Stoddart 825 (K, US); East Point village, ocean side, Rhyne 675 (US).Portulaca oleracea L.Pointe Marianne, Stoddart 890 (K, US).

LAURACEAE

Cassytha L.Cassytha filiformis L.East Point Settlement, Stoddart 823 (K).

HERNANDIACEAE

Gyrocarpus Jacq.Gyrocarpus americanus Jacq.

Seen by Wiehe in 1939.

Hernandia L.Hernandia sonora L.East Point, lagoon shore, Stoddart 792 (K, US); Minni Minni, lagoon shore, Stoddart 809 (K, US); East Point village near cemetery, Rhyne 618 (US); East Point village near ocean, Rhyne 688 (US); northwest, Wiehe in 1939 (MAU).

CRASSULACEAE

Kalanchoe AdansKalanchoe pinnata (Lam.) Pers.East Point Settlement, seaward coast, Stoddart 763 (K, US); ocean side North-West Point, Rhyne 439 (US); East Point village vicinity, Rhyne 660 (US).

ROSACEAE

Photinia Lindl.

Photinia japonica Lindl.

Recorded by Willis and Gardiner (1931) but seems rather unlikely.

LEGUMINOSAE

Albizia Durazz.

Albizia lebbeck (L.) Benth.

East Point Settlement, Stoddart 831 (K, US) "seed pods also seen at Minni Minni".

Canavalia Adans.

Canavalia cathartica Thou.

East Point, lagoon shore, Stoddart 842 (K, US).

Cassia L.

Cassia occidentalis L.

East Point, Stoddart 844 (K, US); East Point Settlement, Stoddart 824 (K); East Point village, Rhyne 749 (US).

Intsia Thou.

Intsia bijuga (Colebr.) O. Ktze.

S. 1., Bourne 45 (K); East Point village vicinity, Rhyne 655 (US).

Leucaena Benth.

Leucaena leucocephala (Lam.) de Wit

Pointe Marianne, lagoon beach ridge, Stoddart 861 (K, US).

Mimosa L.

Mimosa pudica L.

East Point, Stoddart 884 (K, US), 841 (K, US).

Pithecellobium Mart.

Pithecellobium dulce (Roxb.) Benth.

East Point Settlement, cultivated, Stoddart 817 (K, US).

OXALIDACEAE

Averrhoa L.

Averrhoa bilimbi L.

East Point, Stoddart 887 (K, US); East Point village, ocean side, Rhyne 672 (US); Pointe Marianne, Rhyne 771 (US).

RUTACEAE

Citrus L.Citrus aurantium L.

Bitter oranges recorded by Bourne (Hemsley 1884, p. 334).

Citrus medica L. ?

Pointe Marianne, Rhyne 774 (US) (sterile).

SURIANACEAE

Suriana L.Suriana maritima L.

East Point Settlement, seaward coast, Stoddart 788 (K, US).

ANACARDIACEAE

Mangifera L.Mangifera indica L.

Pointe Marianne, Rhyne 772 (US).

EUPHORBIACEAE

Acalypha L.Acalypha indica L.

S. 1., Bourne 34 (K).

Acalypha sp. ?

North-West Point, Rhyne 437 (US) (seedlings).

Breynia Forst.Breynia nivosa (Bull) Small

East Point village near cemetery, Rhyne 617 (US).

Codiaeum A. Juss.Codiaeum variegatum (L.) Bl.

Pointe Marianne, old cemetery, Stoddart 892 (K, US).

Euphorbia L.Euphorbia cyathophora Murr.

North of East Point village, lagoon side, Stoddart 808 (K, US).

Euphorbia hirta L.

S. 1., Bourne 12 (K); s.l., Rhyne 663 (US).

Euphorbia prostrata Ait.

Seen by Wiehe in 1939.

Phyllanthus L.Phyllanthus amarus Sch. & Th.

S. l., Bourne 42 (K); Pointe Marianne, Stoddart 894 (K); East Point village, ocean side, Rhyne 674 (US).

Phyllanthus maderaspatensis L.

S. l., Herb. Justice Blackburn (K); East Point Settlement, seaward coast, Stoddart 779 (K, US).

Phyllanthus tenellus Roxb.?

S. l., Wiehe s.n. (MAU) (possibly from Diego Garcia, very lax, with large oblong leaves, a pistillate and a smaller staminate flower in an axil).

BALSAMINACEAE

Impatiens L.Impatiens balsamina L.

"Near the old coal dump," recorded by Willis and Gardiner (1931).

TILIACEAE

Triumfetta L.Triumfetta procumbens Forst.

East Point Settlement, seaward coast, Stoddart 780 (K, US); ocean side North-West Point, Rhyne 438 (US); East Point village near hospital, Rhyne 614 (US); s.l., Morin in 1937 (MAU).

MALVACEAE

Abutilon Mill.Abutilon indicum (L.) Sweet

East Point, Wiehe in 1939 (MAU).

Gossypium L.Gossypium hirsutum L. (glabrate form)

East Point Settlement, seaward coast, Stoddart 773 (K).

Hibiscus L.Hibiscus manihot L.

S. l., Justice Blackburn (K) (leaf large, cordate, unlobed, crenate-serrate).

Hibiscus rosa-sinensis L.

East Point village, cultivated, Stoddart 816 (K, US); East Point village vicinity, Rhyne 662 (US)?

Hibiscus tiliaceus L.

East Point Settlement; Stoddart 794 (K, US); East Point village vicinity, Rhyne 664 (US), 665 (US); Pointe Marianne, Rhyne 773 (US).

Malvastrum A. GrayMalvastrum coromandelianum (L.) Garcke

East Point, Wiehe in 1939 (MAU).

Sida L.Sida acuta Burm. f.

Pointe Marianne, village, Stoddart 863 (K, US); Pointe Marianne, Rhyne 776 (US). (Showing some introgression from S. rhombifolia, indicated by rather long, articulate fruiting pedicels. Leaves are typical S. acuta).

Sida parvifolia DC.

West Island, Stoddart 872 (K, US); East Point Settlement, seaward coast, Stoddart 778 (K, US); s.l., Morin in 1937 (MAU).

BOMBACACEAE

Ceiba Mill.Ceiba pentandra (L.) Gaertn.

East Point, cultivated, Stoddart 896 (K).

STERCULIACEAE

Melochia Rottb.Melochia pyramidata L.

East Point Settlement, Stoddart 795 (K, US).

GUTTIFERAE

Calophyllum L.Calophyllum inophyllum L.

East Point, shore line, Stoddart 790 (K, US); East Point village, Rhyne 607 (US); s.l., Morin in 1937 (MAU).

TURNERACEAE

Turnera L.Turnera ulmifolia var. elegans Urb.

Recorded by Willis and Gardiner (1931).

CARICACEAE

Carica L.Carica papaya L.

East Island, Stoddart 873 (K).

PASSIFLORACEAE

Passiflora L.Passiflora suberosa L.

East Point Settlement, seaward coast, Stoddart 768 (K), Stoddart 765 (K); West Island, Stoddart 868 (K, US); East Island, Stoddart 881 (K); ocean side North-West Point, Rhyne 439a (US)? (sterile); west rim of atoll, southern end, Stoddart 847 (K, US).

CUCURBITACEAE

Cucumis L.Cucumis melo L.

West rim of atoll, Stoddart 849 (K, US). (Fruits about 6-7 cm diameter globose).

Cucurbita L.Cucurbita maxima Duch.

Recorded, as cultivated, by Willis and Gardiner (1931).

LYTHRACEAE

Pemphis Forst.Pemphis acidula Forst.

Seen by Wiehe in 1939.

COMBRETACEAE

Terminalia L.Terminalia catappa L.

S. l., Bourne 32 (K); East Point Settlement, Stoddart 830 (K).

LECYTHIDACEAE

Barringtonia J.R. & G. Forst.Barringtonia asiatica (L.) Kurz

S. l., Hume in 1883 (K); Minni Minni, Stoddart 812 (K, US); East Point village vicinity, Rhyne 656 (US); s.l., Morin in 1937 (MAU).

MYRTACEAE

Eugenia L.Eugenia javanica Lam.

East Point, Stoddart 886 (K, US).

SAPOTACEAE

Mimusops L.Mimusops bojeri A. DC.

Reported by Lambrecht, m.s. WHO Rept., 1969.

APOCYNACEAE

Catharanthus G. Don

Catharanthus roseus (L.) G. Don

East Point Settlement, Stoddart 835 (K, US) (pink flowers); East Point, Stoddart 834 (K) (white flowers); East Point village vicinity, Rhyne 659 (US).

Cerbera L.

Cerbera odollam Gaertn.

Reported by Lambrecht, m.s. WHO Rept., 1969.

Ochrosia Juss.

Ochrosia oppositifolia (Lam.) K. Schum.

S. I., G. C. Bourne 39 (K); Wiehe in 1939 (MAU); West rim, South end, Stoddart 845 (K, US).

ASCLEPIADACEAE

Asclepias L.

Asclepias curassavica L.

Minni Minni, Stoddart 810 (K, US); East Point Settlement, Stoddart 762 (K); East Point village near hospital, Rhyne 612 (US); s.l., Wiehe in 1939 (MAU).

CONVOLVULACEAE

Ipomoea L.

Ipomoea batatas (L.) Lam.

Sweet potatoes recorded by Bourne (Hemsley 1884, p. 334).

Ipomoea pes-caprae L. ssp. pes-caprae

East Point Settlement, uncommon elsewhere, Stoddart 829 (K, US); Main island, Bourne 28 (K) (leaf shape better for ssp. brasiliensis); East Point village near hospital, Rhyne 611 (US).

Ipomoea macrantha R. & S (I. tuba (Schlecht.) G. Don)

S. I., Bourne 27 (K); Pointe Marianne and southwards, Stoddart 889 (K, US); East Point Settlement, seaward coast North of Settlement, Stoddart 786 (K, US).

BORAGINACEAE

Cordia L.

Cordia subcordata Lam.

S. I., Bourne 23 (K); lagoon shore south of East Point, Stoddart 815 (K, US); East Point village vicinity, Rhyne 666 (US); Pointe Noroit, Wiehe in 1939 (MAU).

Tournefortia L.

Tournefortia argentea L. f.

S. l., Bourne 6-(K); beach zone, Rhyne 393 (US); East Point Settlement, seaward side, Stoddart 822 (K); East Point village near ocean, Rhyne 687 (US).

VERBENACEAE

Lippia L.

Lippia nodiflora L.

North-West Point, Stoddart 858 (K, US).

Premna L.

Premna obtusifolia R. Br.

S. l., Bourne 4 (K) (a form with large oblong leaves with long petioles and unusually broad, complex panicle, flowers with some pubescence in throat, calyx only slightly dentate); Wiehe in 1939 (MAU).

Stachytarpheta Vahl

Stachytarpheta jamaicensis (L.) Vahl

S. l., Bourne 18 (K); s.l., Hume in 1883 (K); East Point Settlement, seaward coast, Stoddart 775 (K, US); East Island, Stoddart 880 (K, US); vicinity of Minni Minni, Rhyne 748 (US).

LABIATAE

Mentha L.

Mentha sp.

East Point, garden, Stoddart 843 (K, US) (almost glabrous, leaves abruptly contracted at base, petioles short; sterile).

Ocimum L.

Ocimum americanum L.

Pointe "Mardannes", Wiehe in 1939 (MAU).

Ocimum gratissimum L.

Pointe Marianne, in village, Stoddart 964 (K, US).

SOLANACEAE

Capsicum L.

Capsicum frutescens L.

S. l., Bourne 13 (K).

Solanum L.

Solanum nigrum L.

Seen by Wiehe in 1939.

SCROPHULARIACEAE

Bacopa Aubl.Bacopa monnieri (L.) Wettst.

Pointe Marianne, in water to 2 ft deep, freshwater barachois,
Stoddart 860 (K, US) (fruit 4-4.5 mm long, plant elongate); Pointe
 Marianne, Rhyne 777 (US); Pointe "Ramanne", Wiehe in 1939 (MAU).

Striga Lour.Striga asiatica (L.) Kuntze

East Point, Settlement, seaward coast, Stoddart 784 (K, US).

ACANTHACEAE

Hemigraphis NeesHemigraphis alternata (Burm. f.) T. Anders.

Minni Minni, Stoddart 811 (K, US); Wiehe 1615 (MAU); vicinity Minni
 Minni, Rhyne 746 (US).

RUBIACEAE

Guettarda L.Guettarda speciosa L.

S. l., Hume in 1883 (K); Morin in 1937 (MAU); East Point, Stoddart
770 (K, US); North-West Point, Rhyne 443 (US); East Point village
 near ocean, Rhyne 685 (US).

Morinda L.Morinda citrifolia L.

South of East Point, lagoon side, Stoddart 813 (K, US); East Point
 village near ocean, Rhyne 686 (US).

Pentas Benth.Pentas lanceolata ssp. cymosa (Klotzsch) Verdc.

Pointe Marianne, Stoddart 865 (K, US); East Point village near
 cemetery, Rhyne 622 (US).

Spermacoce L.Spermacoce suffrutescens Jacq.

East Point Settlement, Stoddart 836 (K, US); East Point village near
 hospital, Rhyne 615 (US).

CAMPANULACEAE

Hippobroma G. DonHippobroma longiflora (L.) G. Don

Pointe Marianne, Stoddart 866 (K, US); East Point village, cemetery,
Rhyne 677 (US).

GOODENIACEAE

Scaevola L.Scaevola taccada (Gaertn.) Roxb.

East Point, Stoddart 887 (K), 883 (US) (glabrous form, sterile shoot with very large leaves and very little axillary hair); beach zone, Rhyne 392 (US).

COMPOSITAE

Ageratum L.Ageratum conyzoides L.

Pointe Marianne, Stoddart 862 (K, US); vicinity of Minni Minni, Rhyne 747 (US).

Bidens L.Bidens sulphurea (Cav.) Sch. Bip.

East Point Settlement, Stoddart 833 (K, US).

Cosmos Cav. (see Bidens L.)Eupatorium L.Eupatorium triplinerve Vahl

Recorded, as cultivated, by Willis and Gardiner (1931).

Mikania Willd.Mikania scandens (L.) Willd.

East Point village near hospital, Rhyne 616 (US); East Point Stoddart 885 (K), 793 (K, US).

Synedrella Gaertn.Synedrella nodiflora (L.) Gaertn.

East Point village, ocean side, Rhyne 676 (US).

Tridax L.Tridax procumbens L.

East Point, Stoddart 783 (K, US).

Vernonia Schreb.Vernonia cinerea (L.) Less.

S. 1., Bourne 2 & 3 (K); East Point village, ocean side, Rhyne 673 (US); East Point, Stoddart 774 (K, US); "Pte. N.E.", Wiehe 1616 (MAU).

Wedelia Jacq.

Wedelia biflora (L.) DC (Melanthera biflora (L.) Wild.)
North-West Point, Stoddart 857 (K, US).

13. LIST OF DIEGO GARCIA BRYOPHYTA

C. C. Townsend

The mosses collected by Mr. Rhyne were entrusted to Harold Robinson (Smithsonian Institution) for determination, and those collected by Dr. Stoddart to C. C. Townsend (Twickenham, Middlesex, England); subsequent consultation took place and material of all gatherings is preserved at the Smithsonian Institution and in Townsend's private herbarium. Stoddart's material is also represented at the British Museum (Natural History).

Only one moss appears to have been previously recorded from Diego Garcia. Mitten described Calymperes garciae as new to science in Hemsley (1887, 239). This paper was apparently unknown to the compilers of the "Index Muscorum", as C. garciae is listed therein as a nomen nudum. The type of this species is at Kew.

CALYMPERACEAE

Calymperes garciae Mitt.

Northwest Point, camp area, damp area with dim light. Common over fallen Cocos trees, 15 July 1967, Rhyne 435; Cust Point, on old coconut husks, Stoddart 839, and on the lower trunk of a living coconut, Stoddart 840.

C. garciae is very close to C. tenerum, but differs in the denticulate margin of the expanded leaf base, and in the form of the cells between the cancellinae and the leaf margin. In C. garciae these are longer, with the corners scarcely thickened; in C. tenerum they are rather short, with corners very much more incrassate than those of the upper cells of the leaf.

Calymperes tenerum C. M.

Northwest Point, camp area, 13 June 1967, Rhyne 386.

Syrrhopodon revolutus Doz. and Molk. (incl. S. microbolaceus C.M. ex Kindb.)

Minni Minni, moss two inches thick on rotten tree trunk, 12 July 1967, Stoddart 826.

BRYACEAE

Bryum coronatum Schwaegr.

South rim of atoll, east side, moss on dry sand surface, 18 July 1967, Stoddart 852.

Without capsules, but female flowers present. The excurrent nerve, apparently dioicous inflorescence and long perichaetium, as well as the areolation, all seem to indicate this pantropical moss. Brachymenium indicum is excluded by its synoicous inflorescence.

REFERENCE

- Hemsley, W. B. 1887. Report on the vegetation of Diego Garcia. J. Linn. Soc. Bot. 22: 332-340.

14. TERRESTRIAL FAUNA OF DIEGO GARCIA AND OTHER CHAGOS ATOLLS

D. R. Stoddart

The terrestrial fauna of Diego Garcia, and indeed of all the Chagos atolls, is less well known than either the land flora or the marine fauna and flora. Apart from the collections made by G. C. Bourne and Bourne's brief discussions of the fauna of Diego Garcia itself (Bourne 1886a, 1886b), knowledge of the terrestrial fauna of the group derives almost entirely from the collections made by J. S. Gardiner and his colleagues, notably T. B. Fletcher, during five weeks in the Chagos Archipelago in 1905. Some further collections have been made since, for example of land mollusca and crustacea, and these are noted below. The collections of terrestrial fauna made in 1967 were very partial, and in some groups, especially the insects, were very small indeed.

In any discussion of the terrestrial fauna of the Chagos islands, therefore, two points must be stressed. First, the collections, which are few in number, have all been made rapidly, and can hardly be considered representative of the complete fauna. This is, however, also true of collections from most of the other western Indian Ocean islands, and comparisons are thus not entirely meaningless. It is probable that the collections adequately reflect the general character of the land faunas of such small and isolated islands. Second, because of the smallness of the collections from individual islands in the Chagos group, it would be unwise to place too great an emphasis on records for particular islands: a better impression of the land fauna is certainly obtained in the case of the Chagos by grouping the records from all the constituent islands.

Gardiner (1936b) has compared the fauna and flora of the Chagos atolls as a group with those of the Maldives and other western Indian Ocean coral islands, and Scott (1933) has made similar comparisons in greater detail for the Insects. Peake (1971) has recently discussed faunal sizes of many western Indian Ocean islands, including the Chagos, for a variety of taxa. In this chapter, attention is drawn particularly to those groups not treated elsewhere in this volume and for which data are available, mainly in the reports of the Percy Sladen Expedition. Special comparisons are made between the faunas of the Chagos atolls and those of the southern Maldives, though too little is known of individual Maldivian atolls, other than Male and Addu, to discuss faunal gradients with any confidence. The main introduced birds and mammals are also noted.

A. Annelida

Four species of megascolecid earthworms are described in this volume by R. Sims, from Diego Garcia; no earthworms are known from the other Chagos atolls. Of these species, Lampito mauritii has also been recorded from the Maldives (as Megascolex mauritii), where Gardiner collected a total of three species (Beddard 1903).

B. Mollusca

Gardiner (1936b) noted only three species of land mollusca from the Chagos, compared with 40 species from the Seychelles. Madge (1946) listed many additional species from Diego Garcia, and Peake in this volume increases the recorded number of Diego Garcia species to 24, all of them small and inconspicuous. Madge's list also includes species from Salomon. It is of interest that the Giant African land snail Achatina fulica is not present on Diego Garcia or the other Chagos atolls, though it was numerous on Addu Atoll by 1964.

C. Arthropoda

1. Crustacea

Borradaile (1907) has listed the Percy Sladen Expedition land Brachyura, and Table 7 shows the distribution of these and other Crustacea, mainly marine, on the various Chagos atolls visited by this expedition. J. Morin collected at Diego Garcia in 1936, and his specimens are listed by Ward (1942). In this volume, Taylor includes these and also the Valdivia collections with those made in 1967. Budde-Lund (1912) lists six species of terrestrial isopods from the Chagos, two of which are recorded from Diego Garcia.

Among the land Crustacea, particular mention may be made of the coconut crab Birgus latro, which extends across the Indian Ocean to the Aldabra group and Zanzibar but is absent from the Maldivian Islands. Other conspicuous "crabs" include Cardisoma carnifex and hermit crabs.

2. Arachnida

Hirst (1911) lists nine species of spiders from the Chagos (two from Egmont, three from Diego Garcia, five from Peros Banhos and six from Salomon). This compares with 23 species from the Maldivian Islands (Pocock 1906). There is a widespread species of scorpion, Isometrus maculatus, on Diego Garcia and also in the Maldives.

Table 7. Crustacea recorded by the Percy Sladen Expedition in the Chagos Archipelago

Order	Reference	Peros Banhos	Salomon	Egmont	Diego Garcia	Total for Chagos Archipelago
ISOPODA	Budde-Lund 1912	5*	3	5	2	6
DECAPODA						
Anomura	Laurie 1926	6	12	4	1	15
	Borradaile 1910	-	2	-	-	2
Reptantia	Borradaile 1910	-	-	-	-	1
Natantia	Borradaile 1910	-	1	-	-	1
Brachyura	Rathbun 1911	27	58	34	13	85
STOMATOPODA	Borradaile 1907	2	3	-	1	5

* Figures indicate number of species.

3. Insecta

89 species of insects in eight orders were recorded by the Percy Sladen Expedition in the Chagos Archipelago as a whole; of these, 28 species were in Lepidoptera, 14 each in Orthoptera and Diptera, and 13 each in Coleoptera and Hymenoptera. The systematic papers on the Chagos insects collected on each atoll are keyed in Table 8. Scott (1933) has made general comments on the fauna, which is mainly of Oriental character and thus similar to the insect faunas of the Maldives and the Seychelles. Bourne (1886b, 391) considered the insect fauna to be poor in species but rich in individuals: flies, cockroaches (the common cockroach Pycnoscelus surinamensis (L.)), mosquitoes and ants were then, and now, conspicuous to the visitor. Of the orders present, the Coleoptera are poorly represented, though this may possibly be the result of inadequate collecting. The rhinoceros beetle Oryctes rhinoceros has been present on Diego Garcia for some decades and is a major pest in the coconut plantations. Mamet (1941) has also listed coccids of economic importance from Diego Garcia and other Chagos islands. A small collection of insects was made in 1967 by H. A. Fehlmann, and this is being worked up by Dr R. E. Crabill of the U. S. National Museum.

Gardiner (1936b, 453) gives the following comparison of the insect faunas of the Chagos and Maldivian archipelagoes in terms of number of genera in each order:

	<u>Chagos</u>	<u>Maldives</u>
Orthoptera	12	24
Odonata	3	6
Hemiptera	3	20
Lepidoptera	26	67
Coleoptera	15	61
Hymenoptera	12	25

Table 8. Insects recorded by the Percy Sladen Expedition in the Chagos Archipelago.

Order	Reference	Peros Bahos	Salomon	Egmont	Diego Garcia	"Chagos"	Total for group	Total species per order	
HEMIPTERA	Distant 1913	-	-	-	-	1*	1	2	
	Green 1907	-	-	-	1	1	1		
ORTHOPTERA	Bolivar 1912	4	5	2	3	-	7	14	
	Bolivar 1924	2	3	-	2	-	5		
	Burr 1910	-	-	1	-	1	2		
	Arrow 1922	-	-	1	-	-	1	13	
COLEOPTERA	Aurivillius 1922	-	1	-	1	-	1		
	Bernhauer 1922	-	-	-	1	-	1		
	Champion 1914	1	1	1	-	1	2		
	Fleutiaux 1922	1	-	1	-	-	2		
	Grouvelle 1913	-	-	-	1	-	1		
	Scott 1912	1	-	2	1	-	4		
	Sicard 1912	1	1	-	1	-	1		
	Esben-Petersen 1927	1	1	-	-	-	1	1	
	LEPIDOPTERA	Fletcher 1910a	12	17	5	8	-	26	28
		Fletcher 1910b	-	-	-	-	1	1	
Meyrick 1911		-	-	-	-	1	1		
ODONATA	Campion 1913 and Laidlaw 1907	2	1	-	3	-	4	4	
	DIPTERA	Bezzi 1923	2	2	-	-	1	5	14
Lamb 1912		-	1	-	-	-	1		
Lamb 1914		-	2	-	1	-	2		
Lamb 1922		3	2	-	2	-	4		
Stein 1910		-	-	-	-	1	1		
Theobald 1912		1	-	-	-	-	1		

HYMENOPTERA

Cameron 1907, Meade
Waldo 1912, Marley
1912
Forel 1907
Turner 1911

5	4	3	3	-	8	13
-	-	-	-	3	3	
-	-	-	-	2	2	

TOTALS

36	41	16	28	13	89	
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* Figures indicate number of species

(In the original Gardiner quotes 22 genera for Chagos Hymenoptera, but this must be in error). This comparison clearly indicates the smaller size of the Chagos fauna, with particularly low relative representation in the Hemiptera and the Coleoptera. The insect faunas of both archipelagoes are, however, very inadequately known.

1. Pisces

One semi-freshwater fish was collected on Peros Banhos by Gardiner and was listed by Boulanger (1909) as Chanos salmoneus. This species, together with one species of true freshwater fish and four other species of semi-freshwater fish, is also recorded from the Maldive Islands (Regan 1903).

2. Amphibia

No amphibians are known on Diego Garcia or on other Chagos islands. The toad Bufo melanostictus is, however, common on Addu Atoll in the Maldives and was collected by Gardiner on this atoll and on Malé (Laidlaw 1903, Phillips, 1958b).

3. Reptilia

Two chelonians have been previously recorded from Diego Garcia. The side-necked turtle Pelusios subniger was collected by Gardiner in 1905 "in one swamp near East Point" (Gardiner and Cooper 1907, 48). Two specimens are in the British Museum (Natural History), and the species was listed by Boulenger (1909) as Sternothaerus nigricans (= Pelusios subniger). This is a widespread species of Africa and Madagascar and is also present in the Seychelles; it was probably introduced to Diego Garcia. G. C. Bourne in 1886 collected a terrapin Geoemyda trijuga thermalis (Lesson). Bourne (1886a, 333) referred to it only as "a mud-tortoise ... abundant in some of the marshy pools" though the specimen in the British Museum was identified by Boulenger. This species is native to Ceylon, India and Burma; it is also present in the Maldives, at many localities (Laidlaw 1903, Phillips 1958b). Both Pelusios subniger and Geoemyda trijuga were presumably introduced, though there is no direct evidence for this, and neither were found on Diego Garcia in 1967. According to local inhabitants, neither has been seen since at least 1945, and it is likely that the Geoemyda had become extinct by the time of Gardiner's visit in 1905.* Rothschild (1915) refers to the pre-

* According to J. Frazier, who visited Diego Garcia in 1970, and Jean-Michel Vinson, the Meteorological Station staff on the atoll report that one or both of these reptiles are still extant though difficult to find during the dry season.

sence in the past of the Giant Land Tortoise Geochelone gigantea in the Chagos Archipelago, but there is apparently no evidence for this: if this tortoise did occur in the Chagos, it was presumably as an introduction which became extinct.

House geckoes are common in the settlements on Diego Garcia. Boulenger (1909) records the widespread species Hemidactylus frenatus Dum. and Beb. and the Malesian species Lepidodactylus lugubris Dum. and Beb. Fehlmann collected 91 specimens of the Hemidactylus in 1967, and these were identified by G. R. Zumi of the Smithsonian Institution. The common gecko noted by Bourne (1886b, 391) was presumably these species. Gardiner also collected the same two species on Salomon, and the Lepidodactylus on Peros Banhos. Three lizards (including H. frenatus) and one skink are recorded from the Maldives (Laidlaw 1903).

There are no snakes recorded from the Chagos Archipelago. By comparison, two snakes (other than sea-snakes), a Typhlops and a colubrid, are recorded from the Maldivian Islands (Phillips 1958b).

Marine turtles are no longer very common at Diego Garcia, though there is no evidence of their past status. According to Bourne (1886b, 392), Green Turtles Chelonia mydas are most numerous during the South-east Trades and Hawksbill Eretmochelys imbricata during the northwesterlies, when three or four of the latter were taken each week. Hawksbill were seen in the lagoon in July 1967.

4. Aves

Loustau-Lalanne (1962) has given a general survey of the Chagos birds, and Bourne in this volume thoroughly reviews existing information on the birds of the whole archipelago. Whereas when the islands were first described colonies of breeding seabirds, particularly terns, noddies and shearwaters, were important, these have now virtually disappeared on Diego Garcia and possibly on the other larger atolls also. The most conspicuous birds on Diego Garcia are now all introduced land birds: Foudia madagascariensis, introduced before 1844; Streptopelia picturata, described as a subspecies chuni and introduced either from the Seychelles or Mauritius at an early date (Benson 1970); Francolinus pondicerianus; Geopelia striata, introduced from the Seychelles in 1960; and the now very common Mynah Acridotheres tristis, probably introduced between 1960 and 1964. Passer domesticus was also recorded by Gardiner from Salomon and Peros Banhos. There are thus no native land birds. Of the wading birds the Green Heron Butorides striatus is most distinctive (Ripley 1969); the Cattle Egret Ardeola ibis was introduced from the Seychelles in 1955. Bourne lists all the seabird records from the archipelago, but at least at Diego Garcia the seabirds are now inconspicuous, and are practically confined to the lagoon-mouth islets, where noddies, fairy terns and occasional frigatebirds were seen in 1967. Bourne stresses the total lack of ornithological information from the smaller Chagos islands, where there is greater likelihood of survival of seabird colonies and least of the introduction of land birds.

5. Mammalia

There are no native mammals in the Chagos Archipelago, and no records of either insectivorous or frugivorous bats. Pteropus in particular is absent, though the Indian P. giganteus is present in the Maldives (P. g. ariel Allen at Malé and North Malé atolls) and P. hypomelanus maris Allen is numerous at Addu Atoll. Species of Pteropus are also found in the Seychelles and at Aldabra (P. seychellensis), in the Andamans and Nicobars (P. melanotus) and in the Mascarenes (P. niger). Insectivorous bats are also found in the Maldives, at Aldabra, and on the high islands, but not in the Chagos.

Introduced mammals and other domestic animals are now numerous. Bourne (1886a, 332) found the following present in 1885: donkeys, hogs, fowls, rats. Cattle and sheep had also been introduced to Diego Garcia by that time, and Bourne noted that "cattle do not thrive, but sheep have been imported and appear to do well on the herbage which covers the more open spaces; the first consignment was unfortunately destroyed by the donkeys, to whom sheep were utter strangers" (1886a, 332). Bourne also refers (1886b, 387) to goats being destroyed by donkeys. Donkeys, chickens, cats and dogs are now present, and noted in Chapter 18. The common rat on Diego Garcia is Rattus rattus L. All of these introduced mammals are common on other Indian Ocean coral islands (Stoddart, in preparation). The shrew Suncus murinus, common in the Maldives at Malé and Addu, does not appear to have reached the Chagos.

15. EARTHWORMS OF DIEGO GARCIA

R. Sims

Four species of earthworm were collected on Diego Garcia by J. D. Taylor in July 1967. These were identified by R. Sims of the British Museum (Natural History) and are incorporated in the collections.

MEGASCOLECIDAE

Lampito mauritii Kinberg 1867

Litter sand and stones beneath Scaevola, East Point, 2 specimens,
18 July 1967.

Pheretima morrisi (Beddard 1892)

Litter beneath Cocos, East Point, 1 specimen, 13 July 1967.

Pheretima rodericensis (Grube 1879)

Litter beneath Cocos, Minni Minni, 1 specimen, 5 July 1967.

OCTOCHAETIDAE

Dichogaster sp.

Litter beneath Cocos, Minni Minni, 4 immature specimens, 5 July
1967.



16. NON-MARINE MOLLUSCA OF DIEGO GARCIA

J. F. Peake

This list includes all previous records for the atoll; those species collected in 1967 by J. D. Taylor are marked with an asterisk. A further account of the non-marine Mollusca of the Islands of the western Indian Ocean is in preparation.

*Assiminea parvula Morelet

Beneath cobbles, supra-littoral zone, lagoon shore, Carcasse;
beneath stones, supra-littoral zone, Barachois Sylvain.

*Blauneria exsilium Preston

Beneath rotten wood, Carcasse barachois.

Ellobium henleyanum (Gassies)

Recorded by Madge (1946).

Enterodonta conica (Pease)

Recorded by Madge (1946).

*Gastrocopta microscopica Nevill

In litter beneath coconuts, East Point.

Gulella bicolor (Hutton)

Madge (1946).

*Lamellaxis gracilis (Hutton)

In litter beneath coconuts, East Point.

*Louisia bardayi (Benson)

Litter beneath trees, Minni Minni; litter, Eclipse Point.

Melampus caffer (Küster)

Madge (1946).

Melampus kusteri (Krauss)

Madge (1946).

Melampus lividus (Deshayes)

Madge (1946).

Melampus luteus (Quoy and Gaimard)

Nevill (1878), Lienard (1887) and Madge (1946).

Melampus parvulus Pfeiffer

Madge (1946).

*Melampus semiplicatus Pease

Rotten wood, supra-littoral, Carcasse; beneath stones, Barachois Sylvain.

Nesopupa peilei Madge

Madge (1946).

*Opeas goodalli Miller

Litter beneath trees, Minni Minni.

Opeas javanicum (Reeve)

Madge (1946).

Opeas clavulinum (Poties and Michaud)

Madge (1946).

Pedipes affinis Fenussac

Madge (1946).

Plecotrema bellum H. and A. Adams

Madge (1946).

Plecotrema clausa H. and A. Adams

Madge (1946).

*Subulina octona (Bruguière)

Litter beneath trees, Minni Minni; litter, Eclipse Point.

*Succinea concisa Morelet

Litter beneath trees, Minni Minni; beneath coconuts, East Point; freshwater pool, Barton Point; leaves on shore, Carcasse.

*Truncatella guerinii A. and J. B. Villa

On rotten wood at the edge of tidal pool, Carcasse; litter beneath coconuts, East Point; beneath stones, Barachois Sylvain; beneath beach cobbles, supra-littoral, Carcasse.

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17. THE BIRDS OF THE CHAGOS GROUP, INDIAN OCEAN

W. R. P. Bourne

Introduction

The Chagos Archipelago (Fig. 3) consists of five island groups and one small outlier scattered over an area 240 km from north to south and 130 km from east to west, around the largely submerged Chagos Bank between 5°20' to 7°35' S and 71°20' to 72°40' E in the centre of the Indian Ocean. They lie 390 km south of Addu Atoll at the southern end of the physically rather similar Laccadive-Maldivé atoll chain, 1580 km east of the Seychelles, 1400 km SSW of Ceylon, 1930 km WSW of the East Indies, and 1610 km NNE of Mauritius, nearly as far from land as it is possible to be in this area. This is the region where the presence of inter-tropical fronts leads to an increased productivity in the sea and precipitation on land associated with the development in other oceans of particularly interesting natural communities. These are of even greater interest in this one, because of the occurrence of the monsoons associated with a seasonal reversal of the winds and ocean currents immediately to the north. Unfortunately there is little information on the birds, and that mostly for the largest island, Diego Garcia, which is now largely devastated from an ornithological point of view by nearly two centuries of the activities of man and other introduced animals. Because it seems possible that some of the comparatively unspoilt outlying islands and surrounding seas may still be of exceptional interest, and moreover in urgent need of conservation in view of current proposals for further development of the area, it may be useful to review what is known of the birds of the group as a whole and the waters close to it. The area is taken to include for convenience the seas lying between the equator and 15° S, and between 65° and 80° E.

A. Description and history of the group

The central Chagos Bank, 120 km across from east to west and approximately 80 km from north to south, is now entirely submerged except for half a dozen uninhabited islets along its western rim and one in the north. The main land area is now found in four outlying atolls, Diego Garcia and Egmont in the south, and Salomon and Peros Banhos in the north. According to Wiehe (1939) the soil of at least Iles du Coin, Peros Banhos, and Boddam Island, Salomon group, consists of layers of sand, organic matter, and old guano. Gardiner (1907) also reports that it is phosphatised on Egmont, so this is doubtless general. Guano has been exported

from Diego Garcia in recent years, indicating the presence of important seabird colonies in the past, though they are now much reduced on the inhabited islands. It appears from early reports (summarized by Scott, 1961, and in accompanying papers in this volume) that all the islands were originally heavily forested, apparently mainly with huge specimens of Intsia bijuga, the natural vegetation being of cosmopolitan or Asiatic origin.

The islands were apparently discovered by the Portuguese during their first exploration of the Indian Ocean at the end of the fifteenth century, and were subsequently visited deliberately or accidentally by a variety of people. But they were not settled for nearly three centuries, when they were very rapidly and successfully colonized in the 1780's by the French, who with the assistance of slave labour probably derived directly from West Africa (where they were major participants in the slave trade in this time: Ingham, 1962) soon felled the majority of the native woodland and replaced it with exceptionally productive coconut plantations wherever there was room for them. Timber continued to be exported to Mauritius from the last and most luxuriant forest on Boddam Island in the Salomon group, well into the nineteenth century, and tree stumps could still be seen there very recently.

The British retained Mauritius and its dependencies after the peace treaty of 1810. By the time they had reallocated the French leases and taken the first steps to control the slave trade in the islands to the north in 1813, there existed well-organised plantations with a large population and a wide variety of imported domestic animals and plants and doubtless also pests (notably rats) and weeds. There is little precise information on the state of affairs over the next few decades i.e. the period leading up to the final termination of slavery in British possessions in 1839, although it seems likely that a good deal of surreptitious communication with the slave-markets in East Africa took place for some years, bypassing the seat of government in Mauritius via such staging-posts as the Seychelles, Aldabra, Madagascar and Comoros. However, by the time a commission was sent to investigate the situation in 1859 the numerous human population was found to have been largely freed from restraint, although not encouraged to leave, and thereafter the main traffic was with Mauritius.

There was a considerable amount of whaling based on Diego Garcia in the middle of the nineteenth century. The main species sought was the sperm whale caught in January, February and April with a few in May and September (Townsend 1931, 1935). The island also served briefly as a coaling station during the early phase of the development of the steamship route between Aden and Australia in 1882-1888, with a consequent increase in the human population and amount of disturbance to the environment. The main seabird colonies appear to have been wiped out there about that time, despite attempts at conservation by the manager, James Spurs (not a totally enlightened individual, however, since he later introduced cats to Aldabra in the face of some opposition). Otherwise conditions appear to have remained fairly stable throughout the group for

over a century after the plantations were fully developed, until the smaller eastern islands which had always undergone vicissitudes finally had to be evacuated after their supply-ship the "Diego" was wrecked in 1935. Diego Garcia itself was further developed as a military base in the 1940s, and this is now under consideration again.

The description of the climate and local conditions on Diego Garcia in the accompanying chapters can probably be considered as typical for the group as a whole, and they will not be repeated here except in so far as they bear on the discussion of the ornithological findings.

B. The individual islands

1. Diego Garcia

This is the most southerly and largest of the islands. It consists of a bowed V convex to the east 19 km long, 10 km wide, and 50 km in circumference, with three small islets (West, Middle, and East Islands) spread across the mouth of the V. The birds have been investigated by a number of visitors, as follows:

Finsch (1887) made a brief excursion ashore while his ship was coaling on 8 July 1884. He remarks that this is the best atoll in the Indian Ocean, with more luxuriant vegetation but less wildlife and people than comparable sites in the Pacific, where he had vast comparative experience. He was most impressed by the number of terns, of which he took some eggs (Finsch and Blasius, 1887). They included possibly 100,000 Sooty Terns (scientific names are given in the systematic list in Section D), a tenth as many Common Noddies nesting on the ground inland, and a few White Terns nesting in the trees. He had seen boobies at sea offshore, but did not see them nesting (but he did not have time to visit the south end of the island). He only saw one frigate and no tropic-birds although he was told they occurred in small numbers. He remarks on the scarcity of heron and waders, though he saw a species of curlew. He only noticed one landbird, the fody, with a few males coming into breeding plumage, though the captain of the ship later reported that he saw doves at Pointe Marianne.

Bourne (1886) arrived for four months on 15 September the following year, 1885, and largely confirms this account. He reports that the inhabitants were taking many of the terns' eggs and he found boobies hatching chicks at the south end of the island, while he was told that frigates bred there at another season and shearwaters on the Ile des Oiseaux, though he did not see them himself. He made a useful collection, described at the time by Saunders (1886), and now mainly in the British Museum (Natural History), and including specimens of the Little Green Heron and Red-footed Booby, but apparently also failed to find the dove. Vanhoffen (1901) also made a small collection, now mainly in the Berlin Museum, during a brief stay by the research vessel Valdivia on 23 February 1899.

It includes specimens of the Madagascar Turtle Dove and Little Green Heron which were subsequently described by Reichenow (1900) as endemic forms, and also of the Lesser Noddy. The early phase of exploration of the group was brought to an end with the visit of the Percy Sladen Trust Expedition during an extensive tour of the whole archipelago on 7-13 July 1905. Unfortunately their notes on birds were always casual and particularly so here (Gardiner, 1907; Gadow and Gardiner, 1907), while none of the specimens that they took can be traced. They reported that terns, waders and herons were abundant, and that they saw a pair of White-tailed Tropic-birds nesting in a Pisonia tree said to have been in use for some years.

Thereafter there appears to have been a gap of half a century during which no important bird observations were made until Messrs. D. M. Neale and J. Branegan noticed ten species of seabird offshore during a brief visit by H.M.S. Gambia in July 1958 (Bourne, 1959). Two years later (December 1960) Loustaau-Lalanne (1962) toured the inhabited islands of the archipelago briefly and made the most detailed survey yet reported. He recorded several new introductions to Diego Garcia, including the Grey Francolin at an unknown date, Cattle Egrets from the Seychelles in 1955, and the Barred Ground-dove in 1960. He also noted the occurrence of an unidentified moorhen and the reduction of the seabirds to a few hundred noddies on the outlying islands and a handful of White Terns in the trees. Lt. P. G. Odling-Smee added the Mynah to the list of recent introductions during a ten-day visit in July-August 1964 (Bourne, 1966), and Pocklington and Stoddart (Pocklington 1967a) found the introduced species still flourishing in May 1965 and July-August 1966 (when H. A. Fehlmann made a small collection for the Smithsonian Institution), so that it appears that if the seabirds are now largely lost a growing land-bird fauna is becoming established.

2. The western islands: Egmont Atoll, Danger and Eagle Islands, and the Brothers

These are a series of small islands or groups scattered at intervals of 15 to 30 km along the western margin of the Chagos Bank. In recent times they were served from a plantation on Eagle Island, and were deserted with it when the barque "Diego" which provided communication with the larger atolls was wrecked in 1935.

Egmont is a small atoll with its main axis inclined WNW-ESE 120 km north-west of Diego Garcia and 30 km SSE of Danger Island on the South-west aspect of the Chagos Bank. It was described by Bergne (undated) as a string of islands forming an oval 9 km long by 3 km wide around a shallow central lagoon with a good anchorage. It was formerly entirely planted with coconuts, and had a population of about fifty people at the beginning of the century. Scott (1961) reports that a concession for development was first given to Victor Duparrel in 1808, and that conditions were very poor in the 1840s, when it was overrun by 600 pigs as well as dogs, cats, and rats; contemporary sailing directions (Horsburgh, 1852; Findlay, 1882) also mention poultry and pigeons among the supplies

available. The only ornithological observations were made by the Percy Sladen Trust Expedition during 14-23 July 1905 (Gardiner, 1907), who reported that Mynahs had also been introduced and that the "larger grey-headed tern" (presumably the Common Noddy?) had there taken to nesting in the trees, where Curlew and Whimbrel also took refuge when disturbed, and that there was a reed-marsh in the centre of Lubine Island.

Danger Island is about 2.4 km long by 1.2 km wide, and is described by Scott (1961) as inaccessible with palms and forest on the crown. Eagle Island itself, some 24 km to the north, is about 4 km long by 1.2 km across and was colonised by 1813. It held about sixty people and numerous donkeys by the beginning of this century, and is covered with palms. There is also a low outlier, the Ile aux Vaches Marines, two miles to the south. The Trois Frères lie along a NW-SE axis 8 km long 16 km farther to the ENE; the largest is 1.2 km long and also covered in palms; it was also inhabited for a time in the nineteenth century, but was apparently the first inhabited island to be abandoned. None of these islands ever appears to have been visited by an ornithologist, but Pocklington (1967a) reports that many birds can be seen at sea in the area, including numbers of Wedge-tailed and Audubon's Shearwaters, adult and immature Red-footed Boobies, and Sooty and Noddy Terns west of Eagle Island at 6°15'S, 71°10.5' E on 22 October 1963, and a male Lesser Frigate-bird and more boobies between Danger Island and Egmont Atoll in May 1965. Thus it seems likely that since they were deserted they have become important seabird colonies.

3. Nelson or Legonne

This is a small island 2.4 km long by a 0.5 km wide on the north side of the Chagos Bank nearly 80 km ENE of the Brothers and 32 km south of Peros Banhos and Salomon atolls. It appears never to have been inhabited, cultivated, or even visited at all frequently. Gardiner (1907) reports that boats used to visit it from Salomon and Peros Banhos to take the eggs and young of the frigate-birds, which breed there in December and January, and Loustau-Lalanne (1962) was informed that Brown Boobies and both shearwaters also breed there at much the same season. Otherwise nothing was known about the birds until J. Frazier (pers. comm.) visited it for an hour in July 1970 and found a clump of palms, a hut, and colonies of Red-footed and Brown Boobies, the two noddies, White Terns, and Great Frigate-birds displaying, although he did not notice any Lesser Frigates. Its status is therefore probably much the same as that of the western islands, which are of course now even less accessible.

4. Peros Banhos

This is a large atoll including some thirty islands and islets distributed in a rectangle around a lagoon about 24 km across from east to west and 21 km north to south, with a total land area just over 11.5 square km. It lies some 160 km north-west of Diego Garcia and 32 beyond Nelson Island at the northern extremity of the Chagos bank. The western islands are larger, and have long been cleared and planted with coconuts;

they include from south to north the headquarters on the Ile du Coin, Poule, which has feral chickens, Petite and Grande Soeur, Pierre and Diamante. Considerable seabird colonies survive on the many smaller eastern islands. Bourne (in Saunders, 1886) was informed that shearwaters bred on the Ile aux Vaches Marines in the south, while in June 1905 the Percy Sladen Trust Expedition (Gardiner 1907; Gadow and Gardiner, 1907) found Black-naped Terns nesting in trees on Yéyé and White Terns nesting on the shores on Petite Ile Coquillage, where noddies also had eggs and some chicks, preyed upon by Little Green Herons. At various places around the atoll they also recorded a party of House Sparrows and a variety of Palaearctic waders, and they were informed that Crab Plovers bred locally in holes in December and that a variety of landbird migrants including raptors, crows and hirundines also occurred with north winds at that season.

More recently Hartman collected four Fodies on the Ile du Coin on 23 October 1967 and two Little Green Herons, two Black-naped and a Sooty Tern and a Lesser Noddy there two days later, now all in the Peabody Museum, Yale University (N.P. Ashmole, in litt.). Loustau-Lalanne (1962) confirmed the presence of the Fody and Sparrow and saw or heard of a number of breeding seabirds among the eastern islands in December 1960, including from south to north Wedge-tailed and Audubon's Shearwaters and Brown Boobies on the Coin du Mire; both shearwaters, Sooty and White Terns on Grande Ile Coquillage; Sooty, Black-naped and White Terns and both noddies on Petite Ile Coquillage; both shearwaters and all five terns on Yéyé; and all the terns on Longue. Scott (1961) also reports that myriads of seabirds breed on Moresby Island in the north. Nobody has confirmed that Crab Plovers breed on the central Indian Ocean atolls and it seems possible that the report really referred to the shearwaters and that the Crab Plovers are really migrants from the north.

5. Salomon

This is a small atoll lying 32 km north of the Chagos Bank and 20 km east of Peros Banhos. According to Bergne (undated) it was once called the Twelve Islands, though there are now only eleven, distributed around an irregular oval 18 km long in a NE-SW axis by 8 km across, with a total land area of 5 square km, now all planted with coconuts except the Ile Diable. The main island, Boddam, is apparently the most fertile in the Archipelago, and originally supported a dense forest of huge trees up to 40 m high, probably mainly Intsia bijuga. According to Scott (1961) five islands were forested at least until 1838, supplying timber for Mauritius, and Takamaka still is. The Percy Sladen Trust Expedition noted the presence of House Sparrows imported from Mauritius, Little Green Herons, Guinea Fowl on Takamaka, Fouquet, and Anglaise Islands, and various seabirds and waders. Loustau-Lalanne (1962) reports the presence of Fodies and moorhens as well. However, the coconut plantations on this atoll always appear to have been particularly prosperous and the numerous human population in association with its small size does not appear to have been compatible with a rich avifauna.

C. Birds at sea

Finsch (1887) saw boobies shortly before arriving at Diego Garcia from the NW on 9 July 1884 and Vanhoffen (1901) also records that large flocks of Common Noddies were seen fishing low over the water in an area which produced a large catch of the blue copepod Poulellida one day before the Valdivia reached the same atoll from the north on 22 February 1899. Otherwise few notes appear to have been made on the occurrence of birds at sea in the area until very recently. However, following the development of the Royal Naval Bird-watching Society's sea report programme since the last war, a growing number of notes have become available from naval personnel visiting the area or sailors crossing it along the trade-routes between Aden and Western Australia or between South Africa and Singapore. It was also traversed by several of the lines of stations along meridians of longitude investigated systematically by ornithologists participating in the International Indian Ocean Expedition of 1962-1965. Taken together these observations now cover with varying accuracy and completeness some 30 voyages across the area in all months of the year except February, as seen in table 9. This is sufficient to provide at least an indication of the general character of the seabird population if not its detailed distribution, especially when compared with other surveys of the areas to the west by Bailey (1966) and Gill (1967) and the east by Japanese and Russian observers (Ozawa and Seno 1966; Shuntov 1968). The implications of these findings will be discussed later in Section E.

D. Notes on species

The order and nomenclature of the following systematic list of bird species are modified from those of the Smithsonian Institution Preliminary Field Guide to the Birds of the Indian Ocean (Watson et al. 1963), which also contains maps and a description of the archipelago and descriptions and figures of most birds species normally occurring in the area except for some of the dark petrels, discussed by Bourne (1960) and Bailey et al. (1968). In order to avoid continual repetition of a limited number of key references the origin of routine observations for each island is indicated by the date when this can be done without ambiguity, and the appropriate reference can be located in section B. In some groups identifications are uncertain, in which case species are dealt with collectively under generic or family headings.

Macronectes sp. Giant Petrel

J. Frazier (in litt.) bought a Giant Petrel in Diego Garcia in July 1970, currently deposited at the Ministry of Agriculture in the Seychelles. If as seems probable it is immature it may be difficult to determine which it is of two sibling species Macronectes giganteus and M. halli breeding in the subantarctic islands to the south (Bourne and Warham, 1966).

Table 9: Observations of birds at sea between 0-15°S, 65-80°E

(Observations taken from records of the Royal Naval Bird-watching Society deposited in the British Museum (Natural History) and published sources).

January: C. B. Thomson passed NE of the Chagos group in 1954, P. P. O. Harrison to the SE in 1960, and J. B. Mitchell to the north in 1961.

March: G. S. Willis passed to the NE in 1956, and F. E. Greaves in 1957.

April: Elkington (1929) passed to the SW in 1929, F. W. Greaves in 1957, and R. S. Bailey (1968 and in litt.) and F. B. Gill (1967) investigated stations along the 67 1/2°E and 75°E meridians in 1964.

May: R. Pocklington (1967a) sailed between Danger Island and Egmont Atoll in 1965.

June: P. P. O. Harrison passed to the NE in 1955, and R. S. Bailey (1968 and in litt.) repeated investigations along the 67 1/2°E meridian in 1964.

July: J. Branegan and D. M. Neale crossed the area from north to south calling at Diego Garcia in 1958, P. P. O. Harrison passed to the SW in 1958 and T. B. Scott in 1959, P. G. Odling-Smee spent ten days on Diego Garcia during the course of the cruise through the area in 1964 (Bourne, 1966), and A. J. Palmer passed to the SE in 1968.

August: P. G. Odling-Smee completed his 1964 cruise.

September: P. P. O. Harrison passed to the SE in 1957, and A. J. Palmer in 1968.

October: Elkington (1930) passed to the NE in 1929 and P. P. O. Harrison in 1954 and to the SW in 1955, R. Pocklington and R. Risebrough (1964) passed west of Eagle Island in 1963, and K. Salwegter to the SE in 1963.

November: C. B. Thomson passed to the NE in 1952, J. B. Mitchell to the SE in 1960, and K. Salwegter returned in 1969.

December: Ozawa and Seno (1966) completed the majority of repeated surveys along the 78°E meridian in 1962 and 1963.

Fulmarus glacialisoides Southern Fulmar

D. M. Neale provisionally identified as this species a large grey shearwater with a pale head, white underparts, a dark wing-tip and pale bill seen at 10°S 69°E on 11 July 1958.

Pachyptila sp. Prions

R. S. Bailey saw one at 12°42'S 67°18'E on 28 June 1964, and other possible examples at 13°40'S 67°24'E and 15°10'S 67°12'E over the next two days with water temperatures between 23-26°C; P. P. O. Harrison reported one and then two at 12°32'S 74°41'E with a water temperature of 27°C on 17 July 1958. They have been recorded even further north off East Africa (Bailey, 1968); it is debatable which of six similar species they may be.

Puffinus carneipes Flesh-footed Shearwater

Gill (1967) saw a possible bird at 4°11'S 75°00'E on 22 April 1964, and two at 2°14'S 75°14'E next day, Pocklington four at 8°30'S 66°50'E on 17 May 1965, P. G. Odling-Smee several between Diego Garcia and Gan in late July 1964, P. P. O. Harrison some ten large shearwaters, in three parties, at 2°13'S 71°30'E on 9 September 1957, and K. Salwegter one at 11°23'S 70°30'E on 10 Oct. 1969 and fifteen at 8°45'S 74°02'E next day. It appears that this species, which breeds in south-west Australia, must regularly pass the Chagos group on migration to its winter quarters around the northern periphery of the Indian Ocean, and some birds may winter in the area.

Puffinus pacificus Wedge-tailed Shearwater

Fouquets (the Creole name for shearwaters) were reported to breed on the Ile des Oiseaux, Diego Garcia, and the Ile des Vaches Marines at Peros Banhos, and it seems possible that the "Crab Plovers" reported in 1905 to breed in burrows in December on the latter atoll were really also shearwaters. Wedge-tailed Shearwaters were reported to breed on Coin de Mire, Grand Coquillage, and Yéyé islands, Peros Banhos, and Nelson Island in the period Nov.-Feb. (normal in the southern hemisphere) in 1960, and Bailey encountered them at sea along the 67 1/2°E meridian four times between 15°00'S and 0°50'S in April, and twice at 1°28'S in June; Neale saw them off Diego Garcia, Odling-Smee one at 3°04'S 73°11'E and Palmer one at 12°28'S 70°11'E in July; Odling-Smee saw several at 4°28'S 66°10'E in August, Harrison saw four at 6°04'S 76°18'S in September, and Salwegter saw two at 8°45'S 74°02'E and Pocklington (1967a) a number with other seabirds west of Eagle Island in October, so that they appear to occur both in the offshore waters and scattered widely at sea during most or all the year.

D. M. Neale identified ten white-breasted, wedge-tailed shearwaters seen on the equator at 78°E on 7 July 1958 as the pale phase of P. pacificus, previously only recorded in the Indian Ocean as breeding at Shark's Bay, Western Australia; he reported single individuals again the following day at 2°40'S 76°E and on 11 July at 10°S 69°E. What these birds may have been is questionable but it may be noted that white-breasted shearwaters of doubtful identity, thought on that occasion to be the Fluttering Shearwater, Puffinus gavia of New Zealand, have also recently been reported by Shuntov (1968) in the Indian Ocean off north-west Australia during the SE monsoon of 1967. They might possibly be the White-faced or Streaked Shearwater Calonectris leucomelas of the North Pacific, which visits the Malacca Strait and has reached Ceylon. It would be surprising to find them in the Indian Ocean in July, but the North Pacific storm-petrels also occur there then.

Puffinus l'herminieri Audubon's Shearwater

These were reported to breed with the Wedge-tailed Shearwaters at the same season in 1960, and were also seen with them off Diego Garcia on 9 July 1958 and west of Eagle Island on 22 Oct. 1963. There are fewer records of them at sea than with the last species, but these are also widely scattered. Mitchell saw one at 3°48'S 65°01'E on 12 Jan. 1961, and three with other birds over shoaling fish at 3°55'S 70°25'E next day; Bailey saw one at 15°00'S 67°29'E on 15 April 1964, and Harrison one at 6°00'S 76°15'E on 30 Oct. 1959. It may be remarked that in contradistinction to the Wedge-tailed Shearwater this species shows much geographical variation and often appears to have a prolonged or continuous breeding season elsewhere, so that both the characters of the Chagos population, which does not appear to have been collected yet, and its breeding behaviour particularly merit investigation.

Pterodroma sp. Gadfly petrels

A number of isolated records of dark or white-breasted petrels from widely separated parts of the tropical Indian Ocean appear to be referable to gadfly petrels of the genus Pterodroma. This includes numerous species known to breed or winter widely in the tropical parts of other oceans (Murphy and Pennoyer 1952). Their numbers are now often greatly reduced by predators introduced by man to their island breeding stations, and they may be elusive even where they have escaped them (Bourne, 1965). Three medium-sized petrels reported by Bailey from the Chagos area in June 1964 among other records appear to belong to this class:

1. A bird with dark upperparts and underwing but a white breast, seen at 0°06'S 65°13'E on 18 June, also thirty petrels brown above and white below with a dark underwing and bill seen by J. Branegan at 10°S 69°E on 11 July 1958, and possibly another slaty grey above with a dark underwing, a white breast, a short stubby tail, and a flapping, gliding flight low over the water, reported by P. P. O. Harrison further west (3°S 59°30'E, 28 July 1964) might all be the Soft-plumaged petrel, which has been recorded further south (Bailey 1968), or the pale phase of the Trinidade Petrel, Pterodroma arminjoniana. This is so far only

known to breed in very small numbers on Round Island off Mauritius in the Indian Ocean, although it is widespread along the southern border of the tropics in other oceans, but there usually has a mottled underwing. These birds could also have been the Phoenix Petrel Pterodroma alba or the Tahiti Petrel Pterodroma rostrata of the tropical Pacific, which are similar with dark underwings. Of these four species, it is notable that the Trinidade and especially the Phoenix Petrels breed on low islands very like the Chagos group in the tropical Pacific, whereas the Tahiti Petrel prefers the mountains of high islands like the Seychelles; the absence of these three species from the central Indian Ocean is frankly surprising, and it seems possible that colonies may have been exterminated in the past, or so seriously reduced that they have been overlooked.

2. Birds with dark upperparts and underwing margins but a white centre to the underwing and breast (3°43'S 67°24'E, 21 June) and also three seen by Harrison further west (3°S 54°E, 29 July) and another seen by Gill (1967) even further west beyond the Seychelles (5°23'S 48°08'E, 1 June) all described in much the same words except that Harrison mentions that they were the size of a Wedge-tailed Shearwater with a swooping, soaring type of flight, resemble Barau's Petrel Pterodroma barau although two of the observers apparently exclude the possibility. Barau's Petrel was recently discovered on Réunion, where it appears to be a summer breeder (Jouanin and Gill 1967); its very close ally, the Juan Fernandez Petrel Pterodroma externa, is a strong northward migrant in the Pacific (King, 1970), and it seems likely that Barau's Petrel migrates north in the Indian Ocean too, and is responsible for a number of confusing records there.
3. A uniformly dark bird with an erratic flight distinct from that of the next two species seen at 12°52'S 67°21'E on 28 June might be the Great-winged Petrel Pterodroma macroptera, which however is large and usually stays far south. It might also be the dark phase of the Trinidade Petrel, or the long lost Réunion Petrel Pterodroma aterrima recently rediscovered on that island and which may itself be a dark phase of the Tahiti Petrel (Jouanin, 1970).

Bulweria bulwerii and Bulweria fallax Bulwer's and Jouanin's Petrels

These are two closely-related medium to small dark brown petrels that differ mainly in size. Bulwer's Petrel, which is smaller and breeds in the summer in the northern subtropical Atlantic and Pacific, has been collected once in the Indian Ocean, immediately to the north of the Chagos group on Gan on 23 Aug. 1958. It seems possible that it is not uncommon among the smaller dark petrels that frequent the area (Bailey et al. 1968). Jouanin's Petrel, which is substantially larger and has not yet been found breeding, seems likely to do so somewhere along the south coast of Arabia in the summer. It has also been collected as far

south as Malindi, Kenya, in December, and reported at $8\ 1/2^{\circ}\text{S}\ 58^{\circ}\text{E}$ in July (Jouanin 1957; Bailey 1966, 1968). However, the full distribution of the two species remains somewhat obscure because they have to be distinguished not only from each other but also from the larger dark shearwaters and gadfly petrels and the smaller dark storm-petrels, and until very recently few observers realised that the majority of these species might occur anywhere near the area. In consequence, many records can only tentatively be allocated identifications, as follows:

Harrison identified a Jouanin's Petrel at $5^{\circ}23'\text{S}\ 66^{\circ}52'\text{E}$ on 26 Jan. 1960, and also reported some small-medium, chocolate brown petrels with a paler shade on the wing at $4^{\circ}56'\text{S}\ 66^{\circ}21'\text{E}$ the same day which may have been either Bulwer's Petrels or storm-petrels.

Bailey identified a Jouanin's Petrel at $0^{\circ}06'\text{S}\ 65^{\circ}13'\text{E}$ on 19 June 1964, other possible ones near the equator at 67°E next day and at $7\ 1/2^{\circ}\text{S}\ 67\ 1/2^{\circ}\text{E}$ on 22 April, and five dark petrels about ten inches long that could again have been either Bulwer's Petrels or storm-petrels at $10^{\circ}\text{S}\ 67\ 1/2^{\circ}\text{E}$ on 20 April. Pocklington saw three small all-dark petrels at $7^{\circ}54'\text{S}\ 70^{\circ}00'\text{E}$, on 18 May 1965 and another at $5^{\circ}04'\text{S}\ 66^{\circ}25'\text{E}$, three days later.

Harrison saw two medium-sized dark petrels at $15^{\circ}40'\text{S}\ 77^{\circ}20'\text{E}$ on 6 Oct. 1955, and two more with very pointed wings flying in a rather erratic way at $6^{\circ}49'\text{S}\ 67^{\circ}26'\text{E}$ two days later which might very well have been B. fallax.

Pocklington (in Bailey et al. 1968 and in litt.) saw dark petrels of two sizes in a mixed flock of birds feeding at $6^{\circ}15'\text{S}\ 71^{\circ}\text{E}$ west of Eagle Island on 22 Oct. 1963 which may have been the two species of Bulweria.

Oceanodroma matsudairae and O. (Leucorhoa) monorhis, Matsudaira's and Swinhoe's Storm-petrels.

These are another pair of medium to small brown storm-petrels with paler wing-coverts which differ from the last two mainly in having forked rather than wedge-shaped tails. They have both so far only been found breeding in the north-west Pacific, but wander into the Indian Ocean, where Matsudaira's Storm-petrel has been recorded mainly along the equator and Swinhoe's Storm-petrel in the Arabian Sea (Bailey et al. 1968). A closely allied form with a white rump, Leach's Storm-petrel O. leucorhoa has also been reported twice in the Indian Ocean area recently (Lapthorn et al. 1968), but not in the central part yet, though it is likely to occur there as well. As in the last case, identifications can only be tentative at present, as follows:

Gill (1967) saw a large bird at $11^{\circ}47'\text{S}\ 74^{\circ}43'\text{E}$ on 19 April 1964, and Bailey (Bailey et al. 1968) another at $1^{\circ}51'\text{S}\ 67^{\circ}47'\text{E}$ on the 25th when he also saw a smaller bird on the water at $0^{\circ}03'\text{S}\ 67^{\circ}37'\text{E}$; he had seen another at $0^{\circ}05'\text{S}\ 67^{\circ}40'\text{E}$ two days before. Pocklington recorded one at $5^{\circ}04'\text{S}\ 66^{\circ}46'\text{E}$ on 21 May 1965. Bailey saw three large birds at $0^{\circ}07'\text{S}\ 65^{\circ}41'\text{E}$ on 18 June 1964, and another with a smaller one near the equator at 67°E next day; Harrison also noted a small, all-dark storm-petrel at $6^{\circ}49'\text{S}\ 67^{\circ}26'\text{E}$ on 8 Nov. 1955.

Oceanites oceanicus Wilson's Storm-petrel

This species breeds in the far south and migrates north in all oceans. Bailey collected one at 13°39'S 67°41'E on 17 April 1964, and saw another at 7 1/2°S 67 1/2°E five days later, and again at 1°28'S 67°24'E on 20 June. Odling-Smee recorded a number of storm-petrels in the Chagos area in July and Aug. 1964. Harrison also reported several storm-petrels in July 1958 and Sept. 1957. Pocklington (1967a) saw the last in a mixed flock of seabirds feeding at 6°15'S 71°10.5'E west of Eagle Island on 22 Oct. 1963.

Pelagodroma marina White-faced Storm-petrel

In the Indian Ocean area, this species breeds off south-west Australia and at least in the past in the St. Paul-Amsterdam group, and also migrates north across the equator in winter. Greaves saw a doubtful bird at 6°S 70°E on 14 March 1957, Neale three six miles north of Diego Garcia on 9 July 1958, Harrison one at 12°32'S 74°41'E on 17 July 1958, and Odling-Smee two birds of this species or the next group at 0°25'S 76°08'E on 16 July 1964.

Fregetta tropica and F. grallaria Black- and White-bellied Storm-petrels

These are a complex closely-related group breeding on subantarctic islands and wintering in the tropical parts of all oceans. The Black-bellied Storm-petrel breeds relatively far south, on Kerguelen and the Crozets in the Indian Ocean area, and normally has a dark line down the centre of the white breast, though this may be entirely white, and proportionately long tarsi and toes. The White-bellied Storm-petrel breeds further north and has been collected at sea off the St. Paul-Amsterdam group in the Indian Ocean area, and normally has a white breast (though this may be dark in at least one Pacific population) and proportionately short tarsi and toes. What appears to be an intermediate, possibly hybrid, population occurs on Gough Island in the South Atlantic (Bourne, 1962). The breast markings are hard to see at sea, and which species occurs most commonly in the Indian Ocean has been disputed, though the Black-bellied Storm-petrel certainly occurs rather widely (Bailey, 1968). Pocklington saw two members of the group twice at 8°29'S 66°55'E and 7°54'S 70°00'E on 17 and 18 May 1965, and thought that the second two at least were white below. Two other possible records are listed under the preceding species. Bailey had a clear view of the dark line down the breast of a Black-bellied Storm-petrel at 5°43'S 67°26'E on 22 June 1964, and saw another member of the group at 11°04'S 67°18'E five days later.

Phaethon aethereus Red-billed Tropic-bird

This species breeds in the eastern Pacific and Atlantic with an isolated population in the Arabian Sea. It has been recorded several times in the Bay of Bengal and reported with inadequate evidence in the South China Sea, but its status in the last two areas is still obscure. Neale reported one on the equator at 78°E on 7 July 1958; he was

familiar with the species in the Arabian Sea, and mentions the red bill.

Phaethon rubricauda Red-tailed Tropic-bird

This species appears to be characteristic of the trade-wind areas of the central and western Pacific and southern Indian Ocean. Loustau-Lalanne (1962) writes that it was seen around the three inhabited atolls in late 1960, and that Gadov and Gardiner (1907) reported it breeding (in point of fact, this was the next species). However, Pocklington (1967a) was also informed by residents on Diego Garcia that it occurred fairly commonly in the north-west of that atoll, so that it seems likely it does breed. Harrison saw a tropic-bird "with a dark tail" at 5°23'S on 26 Jan. 1960, another at 2°12'S 72°12'E on 29 Oct. 1964, and Bailey a bird of this species at 12°52'S 67°21'E on 28 June 1964. However, it appears to be much less common at sea than the White-tailed Tropic-bird.

Phaethon lepturus White-tailed Tropic-bird

On Diego Garcia in July 1905, the Percy Sladen Trust Expedition were shown a pair nesting in a Pisonia tree which they had been using for some years. Loustau-Lalanne saw the species around the three inhabited atolls in Nov.-Dec. 1960, and Branegan saw it off Diego Garcia again on 9 July 1958. It appears to be the commonest of the tropic-birds found widely scattered over surrounding seas, but more to the north than the south, with a total of some twenty reports of birds identified as this species, two in March, three in April, four in June, ten in July (eight from Odling-Smee), and one in November. Taking all records of tropic birds from between 65-80°E together, 24 come from the area between 0-5°S, nine from between 5-10°S, and five from between 10-15°S with suggests that there is a definite concentration of records in the vicinity of the equator, though possibly more at the time when the southern equatorial current moves north with the development of the southerly monsoon than when the counter-current becomes established during the northern winter. So far there are no reports of the distinctive yellow race P. l. fulvus which breeds on Christmas Island and was recorded at sea north-west of Australia (Pocklington 1967b, Shuntov 1968) so that they likely must disperse to the east.

Sula abbotti Abbott's Booby

Mitchell reported two possible birds of this highly distinctive species, apparently never previously recognized at sea far from the breeding stations, at 3°55'S 70°25'E on 13 Jan. 1961. There is still a substantial population of about 5,000 birds nesting on Christmas Island to the east, although it is now threatened by phosphate mining which already led to the extermination of the other known colony on Assumption to the west (Nelson, 1971). It seems possible that the species may also once have bred on the Chagos group, which occupies an exactly intermediate position and was originally covered by the tall forests utilised by this species for breeding, but if so it was lost following the destruction of the forests. It might be useful if the subfossil deposits likely

to exist on some of the islands could be searched for evidence of its past occurrence, especially since consideration might be given to the reintroduction of the species to the Chagos group or Assumption if its position becomes more seriously threatened on Christmas Island.

Sula dactylatra Blue-faced Booby

Bailey recorded one immature bird at 1°42'S 67°38'E on 26 April 1964, another possible one at 6°20'S 67°26'E on 22 June 1964, and a third at 7°50'S 67°22'E next day, and Odling-Smee two at 4°30'S 73°12'E on 18 July 1964. While adults usually stay fairly close to the breeding colonies, young birds are sometimes found at sea far from land (Bailey 1968; King 1970) and the birds recorded may be wanderers from distant colonies to the east or west, although it will be surprising if this booby is not found to breed locally.

Sula sula Red-footed Booby

G. C. Bourne (1886) collected an adult in the white phase on Diego Garcia so that the "gannets" he reported to be hatching their eggs at the south end of the island in Sept. 1885 were likely this species. Pocklington (1967a) saw parties of up to fifty between Egmont Atoll and Eagle Island in October 1963 and May 1965, and J. Frazier found a colony on Nelson Island in July 1970, so that there are probably still a number of colonies in the uninhabited islands although this booby has not been reported from the inhabited ones in recent years. There are also five records of the occurrence of up to ten birds within 250 miles north-west of the islands, including a white individual seen by Mitchell (3°55'S 70°25'E, 13 Jan. 1961), five seen by Greaves (6°20'S 68°20'E, 2 April 1967), an immature examined on board by Bailey (5°03'S 67°25'E, 21 June 1964), four and then ten recorded by Salwegter (1°54'S 70°52'E, 8 Nov. 1968), one of which stayed on board overnight, and three and then ten which he saw at 6°17'S 67°19'E next day.

Measurements of the white adult male collected by Bourne and the brown bird examined by Bailey are: wing 377, 372 mm, tail 210, ca. 260 mm, culmen 78, 84.5 mm, tarsus 34, 36 mm; the brown bird weighed 1,000 g and had renewed the inner primaries, while the 5th was half grown, the outer four and two under wing coverts were old, and there were a mixture of old and new feathers in the tail. It vomited flying fish and an Ommastrephid squid, thought by Dr. Malcolm Clark to belong to the genus Symplectoteuthis. The feet were deep pink, the bill bluish-lilac, with the end of the lower mandible dark brown and the gape pink, and the iris was bluish. Dr J. B. Nelson informs me the appearance agrees with that of an immature bird of the white phase.

Sula leucogaster Brown Booby

This species was first recorded by Loustau-Lalanne who saw it around all three inhabited atolls in Nov.-Dec. 1960, and said that it was reported to breed from December to March on Coin de Mire island, Peros Banhos,

and Nelson Island. Frazier found a colony on the latter island in July 1970. Mitchell reports two or three from 3°55'S 70°25'E on 13 Jan. 1961, and Salvegter one which stayed on board overnight at 1°54'S 70°52'E on 8 Nov. 1968. It would appear that while the other boobies predominate out to sea, this is the common species among the islands, as it is among the Maldives and Laccadives to the north (Phillips 1963).

Fregata minor and F. ariel Greater and Lesser Frigate-birds

The precise status of the two frigate-birds is uncertain, but both certainly occur and probably breed in the Chagos area. Bourne was informed on Diego Garcia that they bred but not at the season when he was there; he collected an immature male on 29 Sept. 1885 which is almost exactly intermediate between the two species in appearance; measurements: wing 559 mm, tail 355 mm, culmen 92 mm long and 27 mm wide at base. The Percy Sladen Trust Expedition were informed that the birds breed on Nelson Island and have eggs and young in December and January, and Frazier saw Greater Frigate-birds displaying there in July 1970, while Loustau-Lalanne saw Lesser Frigates elsewhere throughout the inhabited islands, and especially at Yéyé Island, Peros Banhos, and West Island, Diego Garcia, in December 1960, though he did not find them breeding. Among a number of other records from among the islands, Branegan saw Greater Frigate-birds off Diego Garcia on 9 July 1958, Odling-Smee a male Lesser Frigate among a dozen birds over West Island there in July-Aug. 1964.

As with the boobies and to a lesser extent the tropic-birds, the frigates have been reported more frequently at sea between 65-80°E to the north than to the south, with twelve records between the equator and 5°S, five away from the islands between 5-10°S, and only one south of 10°S. Most pelagic records were not identified to species, and one is referred with confidence and two doubtfully to each of the two species. G. S. Willis saw two possible Greater Frigates at 4°26'S 73°18'E on 7 March 1950, Bailey one male Lesser and four birds with white breasts at 00°50'S 67°40'E on 27 April 1964, Pocklington a male Lesser at 7°54'S, 70°00'E on 18 May 1965, Odling-Smee a possible Lesser Frigate at 00°40'S 74°E on 17 July 1964, Harrison another at 2°29'S 63°30'E on 9 Oct. 1955, Palmer two Greater Frigates at 5°55'S 76°20'E on 13 Sept. 1968, and Mitchell two possible ones at 5°02'S 79°26'E on 6 Nov. 1960. Ozawa and Seno (1966) record that during transects along the 78°E meridian in Dec. 1962 and 1963 frigates were seen circling over flocks of Sooty Terns feeding above skipjack tuna shoals on four days while they were crossing the counter-current area.

Ardea cinerea (?) Grey Heron

Vanhoffen (1901) saw a large grey heron, presumably Ardea cinerea, feeding on the reef at Diego Garcia on 23 Feb. 1899.

Butorides striatus albolimbatus Little Green Heron

G. C. Bourne collected a pair on Diego Garcia on 22 Sept. and 28 Oct. 1885, now in the British Museum (Natural History), and Vanhoffen two more on 24 Feb. 1899, described by Reichenow (1900) as an endemic race, and now in the Berlin Museum. The Percy Sladen Trust Expedition found young birds on Petit Coquillage, Peros Banhos, in June 1905, where the birds were eating terns' eggs and young, and they collected four specimens which cannot be traced. Hartman also collected a pair on Coin du Mire there on 25 Oct. 1957, now in the Peabody Museum of Natural History, Yale University, and Fehlmann took three more on Diego Garcia in June 1967, which have been reassessed by Ripley (1969), who considers them very similar to B. s. javanicus of Ceylon and Java, but with more olive on the side of the throat, a character which becomes more pronounced in B. s. degens of the Seychelles. Loustau-Lalanne and other recent visitors confirm that on the inhabited atolls the species is still common both along the shore and inland.

Dr. G. Mauersberger has recently been good enough to examine the type and an immature male and reports that they are distinctly paler below than twelve adult B. s. javanicus, with the green gloss on the crown, back, and wings slightly weaker and less golden, the elongated back feathers paler and greyer rather than greenish, and the light rims to the wing feathers slightly wider than in freshly-moulted B. s. javanicus, not pure white though not as buff as some of the latter (though one from Malacca in 1853 also has white edges). This description agrees well with my own notes on the two specimens in the British Museum (Natural History), which I thought slightly paler and greyer with less green and more marked pale feather edges above and slightly paler below than B. s. javanicus. They show an early stage of the trend towards pale coloration found more markedly in B. s. albidula and especially semi-albinistic B. s. didi (Phillips and Sims 1958) in the Maldives to the north, and B. s. crawfordi and B. s. rhizophorae on Assumption and the Comoros to the west, as already pointed out by White (1951). I am inclined to wonder whether Dr. Ripley may have been misled by the heavier markings of the females already remarked by Benson (1960) in his evaluation of the Chagos birds. I find their wing measurements much the same, and they compare with those of the other races mentioned as follows:

<u>Race</u>	<u>Origin</u>	<u>Specimens</u>	<u>Wing: range and mean, mm</u>
<u>javanicus</u>	SE Asia	3 males, 3 females	175-193 (180)
<u>albolimbatus</u>	Chagos	type, immature male taken with it, male and female (?) in British Museum (Nat. Hist.)	174, 169 (174) 176, 171
<u>albidula</u>	S. Maldives	3 males, 3 females	164-176 (167)
<u>didi</u>	N. Maldives	3 males, 3 females	165-174 (170)
<u>crawfordi</u>	Assumption, Aldabra	3 males, 1 female (Benson, 1967)	157-161 (159)
<u>rhizophorae</u>	Comoros	range of 16 (Benson 1960)	170-180 ?

From the inadequate information available I conclude that B. s. albolimbatus is an intermediate form doubtfully distinguishable from B. s. javanicus of the mainland in one direction and B. s. albidula of the southern Maldives in the other, of mild interest because it shows a barely perceptible development of the trend towards pale coloration and small size found in the populations of a number of the smaller Indian Ocean islands.

Bubulcus ibis Cattle Egret

Saunders (1886) reports that G. C. Bourne found it a rare visitor during the north-west monsoon, and collected a male of the Asiatic form B. i. coromandas on Diego Garcia in September 1885. The species does not appear to have been reported again until Loustau-Lalanne (1962) recorded it as introduced to the same island from the Seychelles in 1955, and with an established colony of 27 nests at Point Est in December 1960. It has been reported in similar terms by most subsequent visitors while Pocklington found it breeding in May 1965. This population presumably belongs to the disputed race B. i. seychellarum (Salomonsen 1934, Vaurie 1963, Dawson 1966, Benson 1971), which is said to have a white throat like the nominate race from the west but reddish plumes in the breeding season like B. i. coromandas from the east, and to be somewhat small. The situation clearly deserves further investigation, but it seems possible that as with the more westerly Indian Ocean populations of the last species, the peculiar characters of the island populations may result from hybridisation between strays of both Asiatic and Ethiopian origin.

Francolinus pondicerianus Grey Francolin

The Chagos group may be covered by the general statement by Gadow and Gardiner (1907) that this species has been introduced to many Indian Ocean islands; otherwise it was first reported from Diego Garcia by Loustau-Lalanne in 1960. A species of francolin was encountered there again by Odling-Smee in 1964.

Numida (meleagris ?) Guinea Fowl

A species of guinea fowl was reported on Takamaka, Fouquet, and Anglaise Islands in the Salomon group by The Percy Sladen Trust Expedition in 1905, but Loustau-Lalanne failed to find it in 1960.

Gallus gallus Domestic fowl

Chickens have been reported to run wild on the Ile Poule in the Peros Banhos group, but the character of the population and its recent welfare do not appear to be recorded.

Gallinula sp.? Moorhen

Loustau-Lalanne was informed that a moorhen occurred on Diego Garcia and Salomon atolls in Dec. 1960, and it was reported again to Odling-Smee

on Diego Garcia in July-Aug. 1964, but it has not been identified yet. While the Common Moorhen Gallinula chloropus has colonised many islands throughout the world, the White-breasted Waterhen Amaurornis phoenicurus from the adjacent coast is widely resident in the Maldives to the north, with a local race which shows much white, A. p. maldivus, on North and South Malé atolls (Phillips and Sims 1958), so that it might be this species which occurs, and the population might moreover be a distinct one.

Arenaria interpres Turnstone

Collected on Diego Garcia by G. C. Bourne on 22 Oct. 1885, who reported that it occurred in flocks of twenty or thirty, and again in similar terms by visitors to all the islands at any time of year since then. Two were collected again on Diego Garcia by Fehlmann in June 1967. This species is even said to have been found breeding in the past (Farquhar, 1900).

Charadrius squatarola Grey Plover

The Percy Sladen Trust Expedition obtained an immature bird on Peros Banhos and saw others on Salomon atoll in June 1905, and Loustau-Lalanne saw several more on the Ile du Coin, Peros Banhos, in Nov.-Dec. 1960.

Numenius phaeopus Whimbrel

Collected on Diego Garcia by G. C. Bourne in 1885, who found it common but shy, and again by Vanhoffen in Feb. 1899. Loustau-Lalanne found it on all three inhabited atolls in Dec. 1960, feeding under the palms, Odling-Smee saw one on Middle Island, Diego Garcia, in July-Aug. 1964, and Fehlmann collected one there in June 1967.

Numenius arquata Common Curlew

Loustau-Lalanne reports one shot on Diego Garcia in Dec. 1960.

Crocethia alba Sanderling

Loustau-Lalanne saw two on Diego Garcia in Dec. 1960.

Calidris testacea Curlew Sandpiper

G. C. Bourne collected a male on Diego Garcia in Sept.-Oct. 1885, and reported it was "tolerably common." The specimen is in winter plumage and advanced wing moult, but still retaining the outer three old primaries. The Percy Sladen Trust Expedition obtained one on Salomon atoll in May 1905, and Pocklington saw one fly over the Atlantis II off Eagle Island on 22 Oct. 1963.

Dromas ardeola Crab Plover

G. C. Bourne shot one on Diego Garcia in Sept.-Oct. 1885, and reported it was common, but shy; the specimen is in moult, with new feathers in the mantle but still retaining the old outer three or four primaries. It was collected there again by Vanhoffen on 24 Feb. 1899. The Percy Sladen Trust Expedition were informed it bred in December in burrows on Peros Banhos: this species does nest in burrows but there could also have been some confusion with the shearwaters that nest there then. It was found to be common on Diego Garcia, and one was seen on Ile du Coin, Peros Banhos, by Loustau-Lalanne in Dec. 1960.

Catharacta skua Great Skua

Bailey saw a rather dark bird at 12°00'S 67°27'E on 19 April 1964, and Mitchell a possible bird in the distance at 3°48'S 65°01'E on 12 Jan. 1961. Occasional individuals are found considerably further north in the Indian Ocean.

Sterna sumatrana Black-naped Tern

G. C. Bourne found them common at Diego Garcia and collected one on 9 Oct. 1885. The Percy Sladen Trust Expedition found eggs on broken trunks of Tournefortia trees and the leaf bases of coconuts on Yéyé Island, Peros Banhos, in June 1905; where Hartman also collected a pair on the Ile du Coin on 25 Oct. 1957; Loustau-Lalanne found them present on Yéyé, Longue and Petit Coquillage Islands but not breeding in Dec. 1960. Odling-Smee found them numerous around Middle Island, Diego Garcia, in July-Aug. 1964, among other recent reports of their continued presence in the lagoon there.

Sterna fuscata Sooty Tern

Finsch (1887) found them breeding in vast numbers, estimated as of the order of 100,000, in a bare area in the centre of a thicket on Diego Garcia on 9 July 1884; they had eggs and were reported to start breeding about June and leave by November. The following year G. C. Bourne found eggs still present there on 17 September and took a female on 8 October; however, they were being severely persecuted at this time despite attempts by the Manager, Henry Spurs, to conserve them, and these may have been repeated layings. The birds appear to have deserted this atoll soon afterwards, though Branegan reported dark-backed terns (identified as Bridled Terns Sterna anaethetus, which are otherwise unrecorded, and possibly this species ?) offshore on 9 July 1958. The Percy Sladen Trust Expedition failed to find them anywhere in the group in May-July 1905, but Hartman collected a male on the Ile du Coin, Peros Banhos, on 25 Oct. 1957, and Loustau-Lalanne found several thousand with groups of hundreds starting to lay on Grand Coquillage, Yéyé and Longue Islands in December 1960. Pocklington (1967a) also saw many off Eagle Island on 22 Oct. 1963. Loustau-Lalanne reports that the main breeding season was considered

locally to start with the south-east monsoon in May and to last till July or August, with a second breeding season from November to February, but the available evidence is not entirely compatible with this, and it seems possible that the season may vary locally or from year to year, or that the birds may breed more often than once a year, as for example they do where they nest every 9.6 months on Ascension or twice a year in the central Pacific (Ashmole, 1963).

This species is very widespread at sea in flocks which often run into hundreds and exceptionally thousands, and as remarked by Bailey (1968) their distribution varies in a confusing way. They have been recorded somewhere in the area considered during most months of the year, though the numbers reported on individual voyages vary considerably, from reports of continuous views of flocks to complete blanks. When the records are considered as a whole, it is notable that few were reported in the area over the southern equatorial current south of 10°S and east of 70°E, notably by the Japanese expeditions which carried out transects along the 78° meridian in December 1962 and 1963. They found the birds concentrated over the equatorial counter-current further north where they were feeding over shoals of skipjack tuna (Ozawa and Seno 1966). Gill (1967) also saw few south of the Chagos group during a transect along the 75°E meridian in April 1964, whereas further west Bailey (1968) saw flocks scattered all along the 68°E meridian in April and June 1964, though the numbers seen in the central part of the area increased in June. Harrison, Palmer and others also have records of flocks on either side of the Chagos group in July, and they and other observers noted several more in September, October and November.

Because Bailey remarks on the absence of records of young birds in the well-populated breeding areas to the west, and none have been reported around the Chagos group either, it may be worth drawing attention to one bird moulting out of winter plumage photographed by Price when it came on board at 1°10'N 79°30'E far from land to the north-east on 14 Aug. 1966 (Bourne, 1970). This occurrence suggests the possibility that western Indian Ocean Sooty Terns may spend their immature period further east in the way that western Atlantic ones breeding on the Dry Tortugas off Florida have now been shown to spend their youth in the Gulf of Guinea to the south-east (Robertson, 1969).

Thalasseus bergii Crested Tern

G. C. Bourne collected an immature male in fresh plumage at Diego Garcia on 9 Oct. 1885, but did not find them common. Neale and Pocklington have seen them there again on 9 July 1968 and 19 May 1965, and Odling-Smee thought the Lesser Crested Tern T. bengalensis, otherwise unrecorded, might also have been present in July-Aug. 1964. The Percy Sladen Trust Expedition collected several birds at Peros Banhos in May-June 1905, and found two or three pairs occupying trees on Ile Lubine, Egmont Atoll, in June; Loustau-Lalanne saw a bird in Salomon lagoon in Dec. 1960, but breeding has not been proved yet.

Anous stolidus Brown or Common Noddy

Finsch found these nesting with Sooty Terns on Diego Garcia on 9 July 1884, and estimated that there were about a tenth as many, or perhaps 10,000. G. C. Bourne also found them nesting there on 15 Sept. the following year, and took a female on 2 October. He comments that many were nesting in trees so it seems possible he encountered Lesser Noddies as well. Vanhoffen observed flocks fishing over an area of sea swarming with the copepod Poulellida on 22 Feb. 1899, the day before arriving at Diego Garcia from the north, and also found the birds nesting in the palms there. Dr. G. Mauersberger reports that the two skins he collected on 24 February have fresh primaries, old central tail-feathers, and new growing outer ones. In June 1905 the Percy Sladen Trust Expedition found the birds nesting both on the ground and in trees and with eggs and young on Petit Coquillage, Peros Banhos, and nesting in trees on Egmont Atoll but they were informed that it was not the main breeding season on Peros Banhos. Loustau-Lalanne also found noddies nesting both on the ground and in the trees on West Island, Diego Garcia, and Grand and Petit Coquillage, Longue and Yéyé Islands, Peros Banhos, with both eggs and young in Nov.-Dec. 1960. He was informed that there are two main breeding seasons, the main one from May to August with another from December to February. A number of other visitors have also found the noddies breeding on the three small islands at the mouth of Diego Garcia lagoon in the period from May to August, while Pocklington saw many off Eagle Island on 22 Oct. 1963, and Mitchell a large flock at sea at 3°55'S 70°25'E on 13 Jan. 1961, in much the same area where they had been noted in February by Vanhoffen.

Anous tenuirostris Black or Lesser Noddy

This species was apparently overlooked among the Common Noddies by the earlier visitors, but Vanhoffen collected a male on Diego Garcia on 24 Feb. 1899, and the Percy Sladen Trust Expedition found it breeding in trees alongside the Common Noddies on Petit Coquillage, Peros Banhos, in June 1905, where Hartman also collected a male on the Ile du Coin on 25 Oct. 1957. Loustau-Lalanne found it breeding in trees alongside the Common Noddies on the lagoon islets of both Diego Garcia and Peros Banhos in Nov.-Dec. 1960, and several other visitors have recorded occasional birds or flocks at Diego Garcia since then. G. S. Willis also saw a possible bird at sea at 6°43'S 74°42'E on 8 March 1956, but like the Common Noddy it does not seem common far from land.

Gygis alba White or Fairy Tern

This species has been found breeding on Diego Garcia by most visitors, including Finsch in July 1884, G. C. Bourne in Sept.-Oct. 1885, Vanhoffen in Feb. 1899, the Percy Sladen Trust Expedition in July 1905, Loustau-Lalanne in December 1960, Pocklington in May 1965 and Stoddart in July 1967. It nests in trees on all the islands. The Percy Sladen Trust Expedition found it on Petit and Grand Coquillage, Yéyé and Longue Islands in June 1905, and Loustau-Lalanne on the Ile du Coin in December 1960 at

Peros Banhos, where it has also been found nesting on the ground. It has been reported to breed throughout the year. It does not appear to have been recorded far out at sea in this region.

Streptopelia picturata chuni Madagascar Turtle Dove*

The status of this species is uncertain. Pigeons are mentioned among the supplies available on Egmont Atoll in the first half of the 19th century (Horsburgh, 1842) though they do not appear to have been reported there since then. Neither Finsch (1887) nor G. C. Bourne (1886) found them on Diego Garcia, but the former mentions that when Captain Baudissin from his ship visited the island he saw a number of pigeons at Point Marianne, which seemed likely to have been introduced from Mauritius or Madagascar. Presumably this was the species eventually collected among some low bushes by Vanhoffen on 24 Feb. 1899, and described by Reichenow (1900) as a new race of the Madagascar Turtle-dove, a species already widely distributed by both natural and artificial means among the islands to the west of Chagos, and differing mainly from the nominate Madagascar form in its darker coloration. Thereafter it does not appear to have been noticed again until Loustau-Lalanne found it well distributed on Diego Garcia, and apparently largely parasitic on man, feeding at the copra driers, in December 1960, when he found a nest with one young. It has since been recorded by most visitors, and Fehlmann obtained two specimens, now in the Smithsonian Institution, on 13 June and 5 July 1967.

The three females so far available have recently been discussed by Benson (1970), who agrees that they are rather dark and concludes that they might be either a hybrid population combining characters of the races S. p. picturata of Madagascar and the darker form S. p. comorensis of the Comoros. The latter might have been introduced when the island was first colonized with slaves imported from East Africa in the late 18th and early 19th centuries. But possibly the Diego Garcia population

* The two specimens of Turtle Dove, Streptopelia picturata chuni (Reichenow) collected by Fehlmann and Payet on Diego Garcia in 1967 impress me on reexamination (Feb. 1971) as being a valid endemic race. In size they are identical to S. p. saturata (wing 160-162) from the Amirante group of islets south of the Seychelles and some 1300 miles west of the Chagos Archipelago. They differ, however, in lighter color, thus approaching typical picturata of Madagascar. The likelihood of this population being a hybrid one with the smaller rostrata of the Seychelles seems remote (contra Benson, 1970), and as the species is widely distributed in the western Indian Ocean islands and divided into some seven other subspecies, it seems credible to believe that chuni is indeed an endemic island population.--S. Dillon Ripley

might be the result of recent evolution of typical birds imported from Mauritius. Clearly the study of more specimens including males is still needed, as well as the investigation of their further evolution.

Geopelia striata Barred Ground-dove

Loustau-Lalanne reports that this species, already found feral on a number of other Indian Ocean islands, was first introduced to Diego Garcia from the Seychelles in 1960, and that 14 were present at Point Est by December that year. Pocklington saw one in May 1965, and wondered whether they were successful, but Fehlmann was still able to collect six in June 1967.

Acridotheres tristis Indian Mynah

This species, also introduced to many Indian Ocean islands, was found to be common on Egmont Atoll by the Percy Sladen Trust Expedition as early as 1905, but has apparently only reached Diego Garcia recently, according to one report in 1953. It was not noticed by Loustau-Lalanne in Dec. 1960, but was already considered to be the commonest land-bird by Odling-Smee in July-Aug. 1964, while Stoddart also found noisy flocks of forty to sixty everywhere in June 1967.

Passer domesticus House Sparrow

This is the only passerine mentioned by the Percy Sladen Trust Expedition as occurring on Peros Banhos and Salomon in 1905, and they were informed that it had been introduced from Mauritius. In December 1960, Loustau-Lalanne found that it was still the commonest land-bird on both atolls and was told that they breed throughout the year, but could not confirm this.

Foudia madagascariensis Madagascar Fody

This Madagascar species, also widely introduced to Indian Ocean islands and to St. Helena in the Atlantic from Madagascar, was first noticed on Diego Garcia by Finsch on 9 July 1884, who found it common, with most birds in the green eclipse plumage though a few cocks were beginning to show the scarlet breeding dress. G. C. Bourne obtained a male with a red head on 30 September the following year which closely resembles the allied species Foudia eminentissima in appearance, but the bill is short and the wing small for that species so it seems likely that it is actually F. madagascariensis in mid-moult. It was collected again on Diego Garcia by Vanhoffen in 1899, but does not appear to have been noticed by the Percy Sladen Trust Expedition in June-July 1905, possibly because birds in eclipse dress were mistaken for sparrows. Hartman next collected four males, three in breeding dress and one just starting to assume it, on the Ile du Coin, Peros Banhos, on 23 Oct. 1957, while Loustau-Lalanne found it the commonest land-bird on Diego Garcia but outnumbered by House Sparrows on Peros Banhos and Salomon in Nov. and Dec. 1960. He was informed that the males assume breeding dress from

Oct. to May, and found eggs, about two months later than in the Seychelles; he found 47 clutches of two, four of three and one of four eggs, an average clutch size of 2.1 compared to an average of 2.7 for sixteen clutches in the Seychelles (Crook, 1961). Subsequently, Odling-Smee and Stoddart have each noticed single males coming into breeding dress in July and August in 1964 and 1967.

Other migrants

Loustau-Lalanne saw flocks of ducks on the barachois Sylvain of Diego Garcia in Nov.-Dec. 1960. Seven species of duck have been recorded in the Maldives, and the Garganey Anas querquedula have even reached Rodriguez far to the south (Vinson, 1947).

The Percy Sladen Trust Expedition recorded a "snipe" on Diego Garcia in July 1905, and like Bourne twenty years before were informed that raptors, and also crows, pigeons and hirundines, occurred during the northerly monsoon. They saw at least two species of the latter, probably the Swallow Hirundo rustica and House Martin Delichon urbica in May-June 1905. Loustau-Lalanne also saw several hirundines, possible House Martins, on Peros Banhos and Salomon atolls in December 1960. At sea Elkington (1929) noticed a hawk seize a small white bird, and later two parrots Kakatoe tenuirostris escape from his ship and fly away towards the Chagos group 145 km away at 6°59'S 69°02'E on 15 April 1929. Later (Elkington 1930) he saw two small grey and white finch-like landbirds fly by his ship at 2°24'S 73°08'E on 23 Oct. 1929. There seems little doubt that with further study the islands would be found to receive much the same type of stray migrants as the Maldives to the north, which have a list of between ninety and a hundred species (Phillips, 1963), though the numbers would be smaller because of the greater distance from the mainland.

E. Discussion

The Chagos group occupy a strategic position, not only militarily but ornithologically. They are isolated in the remotest possible position in the tropical Indian Ocean, in a situation lying in the path of both landbird vagrants from three directions, the east, north and west, and seabird migrants from four, the north and south and dispersing east and west along the equatorial current systems. They provide a major breeding station for pelagic seabirds and an interesting potential site for colonisation by landbirds. It is one of the numerous unpublicized tragedies of insular ornithology that their natural history was not investigated before major changes had resulted from human colonisation of the larger islands, and another may result from further careless developments on the still comparatively unspoilt lesser islands if strict attention is not paid to conservation during the expansion of military facilities on Diego Garcia.

At the present time the information is insufficient to provide a full account of the ornithology of the group, and in the preceding attempt to assess the character of its avifauna there has had to be a strong speculative element. This is regrettable but necessary. The evidence is still inadequate to draw many general conclusions, but it may be useful to comment on some of the main points arising if only because they provide useful indications of the directions in which it might be desirable to carry out more work. The birds are probably best considered under two main headings, landbirds and seabirds.

1. The landbirds

It would be rather surprising if the original dense forests of the larger islands held no terrestrial landbirds, probably including at least one passerine, a dove, and perhaps a flightless rail. Since they were probably richly fertilized by seabird guano, and it is clear that at the present time the archipelago still receives a fair number of stray vagrants from the north during the northern monsoon, and quite likely others from the east when the south-east trades replace it, it seems possible that there was once quite a rich landbird community, comparable to that of Christmas Island further east (Gibson-Hill 1948). If so, it would appear to have been largely or entirely wiped out with the destruction of the native forests and the introduction of mammalian predators, with the possible exception of the "waterhen," which might still prove to be an interesting endemic form comparable to the flightless rail of Aldabra, and of course the weak local race of little Green Heron, perhaps the most widespread and locally variable of all Indian Ocean island birds.

Whatever the original landbird community may have been, it seems highly probable that with the exception of the waterhen and heron it now consists entirely of human introductions. At least two widespread Malagasy forms, the fody and turtle-dove, were apparently already present when the first ornithologist, Finsch (1887) arrived in 1884, and the second shows local peculiarities of a simple kind. However it seems rather less probable that these reached the islands naturally with the weak westerly winds that sometimes extend across the Indian Ocean in the vicinity of the equator during the northern winter than that they were imported by man together with the bulk of the first human colonists and such distinctive food-supplies as giant tortoises in the days of the slave-trade from East Africa (Ingham, 1962, and references quoted by Benson, 1970), possibly via Mauritius, the Comoros, or the Seychelles. Subsequently the next wave of introductions, notably the House Sparrow, appear to have come from the seat of government in Mauritius, while recently another group including the Ground-dove and Cattle Egret have been introduced from the Seychelles following the addition of the group to the British Indian Ocean Territory, administered from Mahé.

It is notable that whatever the fate of any original landbirds may have been they were confronted with the destruction of their habitat and the introduction of such predators as rats, cats, and hogs, all of which

appear to have been widespread by the middle of the 19th century (although Finsch noticed no rats on Diego Garcia in 1884, so that their introduction by vessels coaling there in the 1880s might explain the extermination of the terns at that time), the more recent introductions have often been extremely successful at least in the first instance. The fody is clearly extremely numerous on Diego Garcia although Loustau-Lalanne (1962) reports it is outnumbered by the House Sparrow where that species is also present as on Salomon and Peros Banhos. This is possibly an interesting example of the effects of competition between species with a similar ecology which deserves further study. The Mynah was also extremely common on Egmont in 1905, and has increased explosively following its introduction to Diego Garcia within the last twenty years. The doves are apparently also fairly successful in Diego Garcia, but there is unfortunately little information about the larger ground birds such as the moorhen, francolin, guinea fowl and feral chickens. The success of these introduced birds could also provide an interesting study, especially in comparison with the situation on the numerous other islands of the Indian Ocean area where they have also been introduced (Watson et al. 1963), and in relation to their effect on other elements in the island ecosystem including endemic plants and invertebrates.

Meanwhile, Loustau-Lalanne (1962) provides a few important indications of their ecology, including a list of plants whose flowers or seeds are eaten by the birds, and potential hazards, notably introduced mammals, Little Green Herons, which eat eggs and young birds, and sticky Pisonia seeds. It is notable that the fody and ground-dove, whose original area of origin presumably lies further south in the region of Madagascar, have so far been found breeding only in the southern summer, whereas the cosmopolitan House Sparrow is reputed to breed throughout the year, which might be one of the factors giving it an advantage over the fody where they occur together. So far the Little Green Heron, which is apparently of Asiatic origin, has only been found with young in the northern summer, while the cosmopolitan Cattle Egret has been seen at the nest sites in both December and June (Loustau-Lalanne 1962; Pocklington 1967), but it is notoriously unwise to draw conclusions about the breeding of water-birds from scanty evidence. However, as far as the evidence goes, it appears at the moment that local breeding seasons agree mainly with those found elsewhere, southern forms nesting in the southern summer, northern ones in the northern summer, and cosmopolitan ones continuously. It remains to be seen whether local factors also influence these breeding-seasons.

It may be noted that the two poorly-studied but clearly weak hypothetical endemic races show a simple type of geographical variation in conformity with trends widely established on other Indian Ocean islands, the Little Green Heron being slightly smaller and paler than the mainland population, and the Turtle Dove darker than the Madagascar one. The significance of these variations, if they exist, seems doubtful, and that of the Turtle Dove at least seems to have arisen very recently as the species was probably introduced within the last two hundred years only.

They deserve study in a wider context, and meanwhile it is satisfactory to be able to remark that both forms appear to be well established and unlikely to be harmed by any reasonable foreseeable developments.

2. The seabirds

The islands clearly have a rich seabird community, including both the breeding species and migrants from elsewhere. At the present time the breeding population is only known to include common pan-tropical species, but it has only been investigated superficially so far, and further examination of the outlying islands and subfossil deposits might yield evidence for the presence at least in the past of a variety of other more unusual species such as members of the protean gadfly petrel genus Pterodroma or the remarkable endemic tropical seabird community now only found further east on Christmas Island. Abbott's Booby Sula abbotti in particular may once have bred on the Chagos group. If it or any other scarce species does by any chance survive on outlying islands in the Chagos group, there is a very urgent need for conservation of the population in view of the many threats now arising to affect more accessible seabird colonies elsewhere.

Meanwhile, if we analyse the known breeding seabird community, it appears rather poor in species feeding inshore such as some of the terns, but rich in more pelagic species, some of which such as the Sooty Tern were clearly at one time extremely numerous, although they have now been either much reduced or driven to the less accessible outer islands. Observations during the International Indian Ocean Expedition, notably by the Japanese participants (Ozawa and Seno 1966) suggest that these pelagic species may feed largely to the north in the vicinity of the equatorial counter-current when it is well-developed at the end of the northern winter, which is also reported to be the main breeding season at least in the northern islands. Further south on Diego Garcia the terns were however found breeding at the opposite season of the year in the last century, and they may be exploiting instead the southern equatorial current when it extends north across the equator past the islands to become the monsoon drift during the period of onset of the SW monsoon in the Arabian Sea.

The precise oceanographic phenomena giving rise to the clearly substantial food-supply supporting these, at least originally, vast seabird communities are still unclear, but it could be as at other stations near the equator in the Pacific (Ashmole and Ashmole, 1967) and elsewhere, largely the descent of tropical water in regions of turbulence around the islands and in areas of convergence along the boundaries of the equatorial counter-current, resulting in an accumulation of floating food-organisms, in sharp contrast to the upwelling which results in a high marine productivity along the lee shores of the land-masses. In this connection, it is perhaps worthy of note that the rather distinct seabird community of Christmas Island, including two endemic species and a very well-marked race, Abbott's Booby Sula abbotti, the Christmas

Frigate-bird Fregata andrewsi and the Golden Tropic-bird Phaethon lepturus fulvus, may have evolved adaptations to exploit an equally distinct local phenomenon, a local area of upwelling to the east, south of Java and Sumbawa during the south-east monsoon (Wyrтки 1962, Cushing 1969) which appears to form the special feeding-area of the tropic-bird at least (Pocklington 1967b, Shuntov 1968). This might explain why these birds are not found further west, except for Abbott's Booby's occurrence in the past in a potentially similar area of upwelling north of Madagascar.

While the breeding seabird community of the Chagos islands may or may not be found to include additional species on further investigation, it seems extremely probable that more species are likely to be found as visitors offshore, either on migration between breeding and wintering areas in higher latitudes to the north and south, or passing the period of immaturity and between breeding-seasons in the high marine productivity regions in the vicinity of the equator. These may well include more northern skuas and terns (Stercorariidae and Sternidae) then have been suggested yet, and additional petrels such as the White-faced or Streaked Shearwater Calonectris leucomelas from the North Pacific, already known to winter commonly around the East Indies, and especially gadfly petrels of the genus Pterodroma, with strays of a wide variety of other species from the south. It is still unclear to what extent visitors already reported offshore, let alone any possible additions, occur there primarily as regular visitors over long periods, or merely as passing through on migration. It seems likely that the Chagos group may lie in the path of at least two important streams of migration, of Wilson's and "Fregetta" Storm-Petrels (Oceanites oceanicus and Fregetta spp.) north from the Southern Ocean to the northern coasts of the Indian Ocean, and of Flesh-footed Shearwaters (Puffinus carneipes) and White-faced Storm-petrels (Pelagodroma marina) which breed off south-west Australia and winter in the Arabian Sea. Other species such as the Oceanodroma storm-petrels which enter the Indian Ocean from the Pacific (Bailey et al. 1968) may also tend to pass through the area in numbers following the equatorial counter-current. Therefore the birds occurring at sea may also repay more detailed study in the future.

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18. SETTLEMENT AND DEVELOPMENT OF DIEGO GARCIA

D. R. Stoddart

A. Discovery

The islands of the Chagos Archipelago were probably discovered and named by Portuguese navigators sailing from the Cape of Good Hope to Goa in the first two decades after Vasco da Gama pioneered the route in 1498; but it was more than two hundred years from their discovery before the positions of the Chagos and other islands were reasonably determined. Clusters of islands probably representing the Chagos appear on Alberto Cantino's world map of 1502; but though Addu Atoll at the southern end of the Maldives was clearly marked on Joan Martines's chart of 1578, the islands to the south remained schematic (Bagrow 1964, Skelton 1958). Generally navigators sought to avoid the maze of islands and short steep seas of the Great Chagos Bank, which had no trading importance compared with the factories of India and, later, the colonies of the Mascarenes. The standard histories of the Indian Ocean contain little but conjecture for this early period (Toussaint 1961).

The Mascarene Islands, which had been discovered in 1505, were not permanently settled until the seventeenth century, and the Ile de France itself (Mauritius) was not formally annexed by France until 1717. During the century after 1734, when Mahé de la Bourdonnais became governor of the Ile de France and Bourbon (Réunion), the French systematically explored the islands to the north, from time to time clashing with the English. The first major voyage of discovery was that of Lazare Picault, who visited Peros Banhos Atoll in the Elisabeth in 1744. Picault's journals have not been published in full, though parts are available (Fauvel 1909). British ships visited the Chagos islands in 1719 (Stranger) and 1728 (Grantham), and Diego Garcia itself in 1745 and 1755 (Pelham and Mary, respectively). Growing rivalry between France and England led to a reappraisal of the value of these remote islands. In September 1769 a more thorough survey was made of Diego Garcia by the French ships L'Heure du Berger (Chevalier Grenier) and Vert Galant (Lt La Fontaine), and in 1770 La Fontaine made the first survey of the Diego Garcia lagoon. He reported that "a great number of vessels might anchor there in safety; but the principle object is wanting: for though it is covered with woods, it is not provided with fresh water" (quoted by Scott 1961, 68; Unienville 1838, 182). These observations, together with those of the Abbe Rochon (1793) and of the hydrographer D'Après de Manneville (1775), led to a much more detailed understanding of the topography of the

central and western Indian Ocean (Figure 33), which is reflected in charts from about 1780 onwards (e.g. Grant 1801).

The dangers associated with navigation in these seas are vividly illustrated by the fact that the hydrographer James Horsburgh was himself wrecked on Diego Garcia in the Atlas on 30 May 1786. "The charts on board were very erroneous in the delineation of the Chagos Islands and Banks," explained Horsburgh (1809, 132), "and the commander trusting too much to dead reckoning, was steering with confidence to make Ady or Candy (which do not exist) for a new departure, being in their longitude nearly, by account, and bound to Ceylon; but, unfortunately, a cloud over Diego Garcia prevented the helmsman from discerning it (the officer of the watch being asleep) till we were on the reef close to the shore; the masts, rudder, and everything above deck, went with the first surge; the second lifted the vessel over the outer rocks, and threw her in toward the beach."

B. Early Settlement

The French did not try to settle on Diego Garcia, and the first attempt to do so, in 1786, was by the English, who wished to use the atoll as a victualling station. Six shiploads of soil were sent from Bombay by the East India Company, in the hope of growing vegetables and cereals, but the experiment was a failure. Documents concerning the planning of this expedition by the Bombay Council, including a diary kept by the leader, R. Price, on Diego Garcia between 29 April and 24 September 1786, are preserved in the Bombay Secretariat Record Office (Secret Department, Vols. 33A, 1-77; 34, 532-890; 35, 10-11, 133-139, 195-215; 36, 395-7; 39, 177-208, 223-4, 327-47; 288, 1-185). By the time the French heard of the attempted settlement, and sent the frigate Minerve from Mauritius to deal with it, the English expedition has withdrawn. Magon de Médine on arrival formally reasserted the French claim to the atoll. The French made no settlement, and again the English returned, Lt Archibald Blair of the East India Company Marine making a survey in 1786.

French settlement began in the late 1780s, when a M. Le Normand was authorised by Deput de la Faye to settle at Diego Garcia and to supply coconuts to the Ile de France. In 1793 this was taken a step further, when M. Lapotaire was given permission to establish a factory at Diego Garcia to export copra and oil rather than whole nuts to the Ile de France. He began by taking two ships, each with 25-30 men, and slaves, to the atoll: and in 1794 he exported 900 veltes of oil (about 1350 gallons or 6100 litres). A few years later he was joined by brothers named Cayeux in the same business.

This profitable enterprise attracted others, however. Two new factors, Blevéc and Chépé, appeared, making oil in a very wasteful way. In 1808 Lapotaire petitioned the captain-general of the Ile de France

with new proposals. He suggested that the two sides of the atoll be allotted to him, and the southern part to Cayeux. No other factors would be allowed. He also proposed the prohibition of oil manufacture on the atoll, on the ground that it provided too great temptation to the English; instead, copra would be sent to mills in the Ile de France. On 26 April 1809, however, the captain-general gave Blévec and Chépé authority to exploit the eastern part of the atoll, while at the same time prohibiting oil manufacture. These grants were subject to cancellation on failure to replant coconuts, and the concessionaires were also to be responsible for the care of any lepers sent to Diego Garcia from the Ile de France. It had been intended that these lepers would live only on the small islets, but this was not adhered to. The population of the atoll at this time totalled 275, including 37 lepers (Moreau 1827).

C. The Plantations under the English

On 3 December 1810 the Ile de France capitulated to the English, and although at the treaty of Paris in 1814 several territories, including Bourbon, reverted to France, this did not apply to the Ile de France and its dependencies (including Diego Garcia), which remained under British Administration (Treaty of Paris, 30 May 1814, Article 8; proclamation in Mauritius 15 December 1814). The coconut concessions on Diego Garcia continued, but the English policy of ending the slave trade and finally (1839) of abolishing slavery led to problems in the plantations. Discontent at Diego Garcia among both slaves and lepers led to the appointment of the first government agent, M. Le Camus in 1824. In addition to administration, he was concerned to provide pilotage for visiting ships, and also with the construction of a lazarette on one of the small islands. New surveys were carried out at this time, by Col. E. A. Draper, who mapped Lapotaire's concession on the west side in detail (1824), and by W. and C. T. Hoart in 1824-5 (Figure 34). Camus served for five years, and in 1830 was given Lapotaire's concession as a reward. In 1837 Commander Moresby made the first full hydrographic survey of the atoll; some of his observations were used by Darwin (1842) and others were published anonymously (Anon. 1845).

In 1859 Commissioners (Lt H. Berkeley, Mr. J. Caldwell) were appointed by the Mauritius Government to report on conditions in the island dependencies, and in 1864 a district magistrate was appointed for the islands, visiting Diego Garcia the same year. Conditions must have been prosperous at this time, for the present plantation buildings, including the large manager's house, were being built at East Point. The population of Diego Garcia in 1851 totalled 334, and 1861 554 (males 417, females 137).

In 1865 the Government gave the concessionaires the opportunity to change their holdings from jouissance, essentially a right of usufruct subject to revocation, to a holding in perpetuity on cash payment of two shillings per velte of oil produced, based on the 1864 output: the production of oil had clearly been resumed at some time following the 1809

prohibition. In 1864, the output at Diego Garcia was as follows:

East Point	34 000 veltes	(51 000 gallons)	232 000 litres
Marianne	20 000 veltes	(30 000 gallons)	136 000 litres
Minni Minni	12 000 veltes	(18 000 gallons)	82 000 litres
Total	66 000 veltes	(99 000 gallons)	450 000 litres

These figures seem extremely high: at about 24 lbs of copra per velte of oil, representing about 75 nuts, it indicates a total yield of nearly five million nuts. Assuming 800 nuts to the acre, i.e. not particularly intensive or well-managed plantations, this would indicate that almost the whole area of the atoll (6250 out of 7488 acres) was being cropped for coconuts. These rough calculations simply indicate the order of magnitude of the operations at this time. Under the new administrative arrangements, the government retained the right to resume up to two acres in each property for any government purpose. The powers of magistrates for the island dependencies were defined in 1872, and in 1875 the first regular magistrate's tour was made by E. P. Brooks (Brooks 1876). The total Diego Garcia oil production of 66 000 veltes in 1864 compared with 13 500 on Salomon, 26 000 on Peros Banhos, 11 870 on Egmont, and 8 000 on Eagle (Lane 1956b, 671-3).

The three estates on Diego Garcia were amalgamated in 1883 under the Société Huilière de Diégo et Péros. James Spurs, the company manager at East Point, who later went to Aldabra, was a remarkably capable and enlightened man. He had strict regulations over liquor consumption, and ran his plantations in a benevolent if despotic manner. His labourers were expected to collect, dehusk and break 500 nuts a day, and the women to scoop out 1200 shells a day. There were hospital buildings on each of the estates.

D. The Coaling Stations

In 1881 the Orient Steam Navigation Company gave up its coaling station at Aden and surveyed Diego Garcia as an alternative. The Company operated twelve ships on the England to Australia run, and in 1882 it opened the first coaling station on Diego Garcia. The London company of G. Lund opened a second coaling station in the same year: it had only two cargo ships plying between England and Australia, but proposed to sell coal to any ship which called. Both Orient and Lund began at East Point. Orient employed James Spurs, who had resigned as manager for the Société Huilière, as their agent on the atoll, and imported both Somali and European labour. Lund appointed G. Worrell as local agent, and used local labour when required. The coal stocks were kept in hulks anchored off East Point and Minni Minni, and Orient also had yards on shore at East Point. At the time of the Magistrate's visit in 1883 there was a stock of 15,000 tons of coal at the atoll, two-thirds of it belonging to Orient. The target of the operators was to fuel 180 ships a year, each turning around in 24-68 hours; passengers were not allowed to go ashore.

The following year, 1884, Orient moved from East Point. Its hulks were anchored closer to the lagoon entrance, at Barton Point. The Company leased two of the small islets, Middle Island for Spurs as agent, and East Island for labour. Already there were considerable labour troubles, and also problems arising from the passage of large emigrant ships, many of whose passengers managed to get ashore. Ivanoff Dupont, the magistrate, was kept busy with incidents (Scott 1961). In November 1885 a police post had to be established at Minni Minni, consisting of two officers and six men, to keep order, but there was constant squabbling between the Mauritius Government and London over payment of the costs involved. With the British Government unwilling to pay, the Mauritius Government finally revoked the arrangement. G. C. Bourne gives an interesting insight into the nature of the labour problems during his visit in 1886: "Mr. Leconte told me that on his arrival on the island three years ago, he found the Negroes in a most insubordinate condition, and that within a month of his landing, his verandah was besieged by a body of thirty men, armed with knives and bludgeons, who declared that they would not leave the place until they had taken his life. Luckily for him they were as cowardly as they were insolent, and he was able to keep them at bay by presenting a revolver, until he had succeeded in reducing them to a more reasonable state of mind" (Bourne 1886b, 389-390).

The coaling stations again focussed attention on the strategic value of Diego Garcia, for the first time since the East India Company's foray in 1786. In February 1884 Lund made a proposal to the Mauritius Government for a mail service from Mauritius to Colombo, linking at Diego Garcia with the frequent Cape to Australia services, thus bringing mail to Mauritius much more rapidly than directly from the Cape. But the direct Cape-Mauritius service had just been renewed and Lund's proposal was not taken up. If it had, the strategic importance of the atoll would have been more apparent. The interest of the Imperial Government was great enough, however, for H.M.S. Rambler under Commander the Hon. F.C.P. Vereker, R.N., to make the first thorough hydrographic survey of the northern half of the lagoon in 1885. Vereker's survey, with Moresby's more general survey of the southern lagoon, remains the basis of the published charts.

In spite of its turbulence, the coaling station period was a brief one. In 1888, after only six years' operation, which had proved unprofitable, the Orient Company ceased using Diego Garcia and sold its facilities to Lund. James Spurs left the atoll and went to Aldabra. It is not known how long Lund continued working, but by 1900 Diego Garcia was once again simply a supplier of coconut products.

E. The Twentieth Century

After the withdrawal of the coaling stations, the atoll reverted to a plantation economy. The buildings at East Point were renewed, and a chapel added in 1895. Later a church and a jetty with light railway were added, and East Point emerged as the main commercial centre of the atoll.

The buildings at Minni Minni, Middle Island and East Island were abandoned and are now in ruins or have disappeared. Pointe Marianne is little more than an outstation of East Point, where all processing is carried out, and the large manager's house at Marianne has disappeared. Figures for oil production given by Bergne in an unpublished manuscript dated 1900 are remarkably similar to those of 1864:

<u>Plantation</u>	<u>Lessee</u>	<u>Oil production, galls.</u>	<u>Litres</u>
East Point	M. Liénard	50-60 000	227-273 000
Pointe Marianne	M. Levieux	30-35 000	136-164 000
	M. Liénard		
Minni Minni	M. Margery	16-20 000	73- 91 000

But in spite of this apparent stability, the industry was about to undergo a major technological change. In 1903 the Government of Seychelles introduced copra platforms into the islands to dry copra by a combination of sun and artificial heat, and by about 1910 copra was the main coconut product exported from the islands to Mauritius. The "Oil Islands", as the Chagos group had been known, were oil islands no longer. It is not known when exactly the change occurred at Diego Garcia, but presumably it was at about the same time as on other Indian Ocean islands (Dupont 1938). Wiehe (1939) gives a detailed account of the operation of the coconut plantations and of copra production on Diego Garcia, Peros Banhos and Salomon immediately before the Second World War: at this time the atoll was yielding about 5.3 million nuts a year. In 1967 the copra production was 707 tons, half the total for the British Indian Ocean Territory. This must represent a yield of at least 4.5 million nuts, and suggests that the annual production has not greatly changed over the last century.

Diego Garcia had brief notoriety during the early months of the First World War. In 1899 the German warships Bismarck and Marie had anchored in the lagoon, and two days after they left the British heavy cruiser Hampshire arrived with the Empress of Russia, which entered the lagoon (Hoyt 1967): the powers were clearly interested in oceanic anchorages. When war broke out the German cruiser Emden was in the Indian Ocean, and during its pursuit by English warships called at Diego Garcia on 9 October 1914 to coal and clean its bottom. At this time the local inhabitants were unaware that war had been declared. The Assistant Manager "came into the wardroom and made very good practice with the iced whisky and soda. For us the conversation became interesting from the moment that we recognised that this manager and the inhabitants had no idea that there was a war on in the world" (Hohenzollern 1928, 133). Battle damage to the ship was explained as having been caused by storms; the ship took on a large live pig, fish and fruit in return for wine and whisky, and it left on 10 September shortly before English warships arrived. The Emden was finally caught and destroyed at Cocos-Keeling on 9 November 1914.

The strategic value of the atoll again became apparent during the Second World War. Following the Japanese attack on Colombo in April 1942 and heavy British naval losses in the central Indian Ocean, it was decided to develop Addu Atoll in the Maldives, previously used as a refuelling

station and anchorage, as a military base (Roskill 1956, 25). Diego Garcia became one of a number of places used as fuelling and minor operational bases for naval craft and flying boats (Kirby 1958, 58; Roskill 1956, 33), and defended by six-inch guns. A wrecked Catalina still lies on the beach at East Point, but the military interest was short-lived and the installations were in decay at the time of Ommanney's visit in 1948 (Ommanney 1952, 233). Several books by Thompson (1946, 1949, 1956) give a largely fictional account of the atoll in war-time.

In 1965, Diego Garcia, together with the rest of the Chagos Archipelago, was detached from the administration of Mauritius and incorporated in the new British Indian Ocean Territory. An agreement was entered into between the United Kingdom and the United States in 1966, under which either party could have the use of any part of the Territory for military purposes for not less than fifty years. H.M.S. Vidal under Captain C. R. K. Roe, R.N., made a detailed hydrographic survey of the entire lagoon in 1967. Military use of the atoll had been contemplated for many years, and Bourne (1886b, 391) made the following comment after his visit eighty years ago: "I have even heard that it is proposed to protect the island by some sort of fortification, but how this is to be done, and of what use it would be to fortify an island 10 feet high, which might be completely commanded by a ship sailing outside of it, I am at a loss to know".

F. Introduction of animals and plants

There is little documentary evidence of the introduction of plants and animals to Diego Garcia, though from the beginning of the sixteenth century it was general practice to land sheep, goats, cattle, and even rabbits and hares on uninhabited islands in the Indian Ocean to provide a future food supply. Some introduction of plants probably took place in 1784 when the ship-loads of soil were brought from Bombay. By the end of the eighteenth century pigs and dogs were being bred in the islands for export, and bees and poultry had been introduced (Findlay 1882). Donkeys had been imported into the Chagos Archipelago and other islands by the 1840s to work the oil mills. There is an early description of these animals on Agalega (Leduc 1897-1906; Scott 1961, 145-146), where they "appear to thrive well ... and breed very fast" (Anon, 1845, 479).

Moresby in the late 1830s recorded maize, tobacco, cabbages, "greens", sweet potatoes, onions, carrots, turnips, "leaks", garlic, "and all the common vegetables cultivated in India, with limes and citrons" (Anon, 1845, 480). He also noted that "pompions and plantains grow wild and are of good flavour", and that cotton was widespread. Moresby was responsible for introducing Artocarpus to the Archipelago: "Of the bread-fruit tree, when Captain Moresby first visited these islands, they had none; but he brought about thirty young plants from Ceylon, which succeeded well, as also did the Malabar yam" (Anon, 1845, 480).

Bourne in 1886 found bananas, custard apples, bitter oranges and a few other tropical fruits in the gardens at East Point, Minni Minni and Pointe Marianne. According to him attempts to introduce potatoes and vegetables had been defeated by rats.

In addition to donkeys and rats, there were pigs and poultry in abundance in Moresby's time, together with feral cats (Anon, 1845). "Among the occupations of these Negroes was the feeding of swine, with which the dwellers on many of these islands lived in terms of considerable intimacy" (Anon. 1845, 483).

In 1967 donkeys were seen, generally in groups of 3-12, near the northwest point, south of East Point, along the southeast side, and south of Pointe Marianne. The population may number over one hundred, and individuals are occasionally shot for food. Rats are extremely numerous and are seen constantly during daylight running upon coconut trunks: There is a bounty of three cents a rat for each body produced. A similar bounty thirty years ago brought in more than thirty thousand rats a year (Wiehe 1939, 23). Chickens, cats and dogs are plentiful in the settlements.

Weeds and cultivated plants have been described in Chapters 11 and 12, and introduced insects, particularly the rhinoceros beetle Oryctes rhinoceros, in Chapter 14.

G. Conservation

Little attention has been paid at Diego Garcia to conservation: the atoll has simply been used as a supplier of coconut products, and to a lesser extent of dried fish and turtles, for Mauritius. Both the Green and Hawksbill turtle used to nest here in some numbers: the Hawksbill from December-March, and the Green at all seasons. The early settlers found the frigate birds, boobies, noddies, terns, herons and tropic birds to "breed on these islands. ... (They) are considered good eating; the feathers, too, make excellent bedding" (Anon. 1845, 483).

The first practical conservation measures were taken by James Spurs, when manager in the 1870s. He forbade the killing of sea birds, turtles and cipaye (Birgus) on his estate, to prevent any decline in numbers. As a dependency of Mauritius until 1965, the conservation legislation of that Colony applied to Diego Garcia, but in the absence of enforcing authority or of any clear need for conservation it is unlikely that much attention was paid to it. The main statutes affecting conservation in the Chagos islands were the Exportation of Plumage Birds Ordinances 1914 and the Wild Birds (Protection) Proclamation 1939, each with a schedule of birds. The Lesser Dependencies Importation of Animals statute 1933 prohibited the import of any mammal, bird, fish, reptile or living insect in the Chagos islands. Other Mauritius conservation legislation is relevant only to the Mascarenes proper (Lane 1946a, 1946b).

Following the creation of the British Indian Ocean Territory in 1965, its Commissioner took powers by Ordinance 2 of 1968 to make regulations for the protection and preservation of wild life in the Territory. These powers are intended not only to cover interference with animals but also "any change or alteration" in an animal's environment. Regulations under this Ordinance (S.I. No. 11 of 1968) have prohibited the taking of Green Turtle throughout the Territory, and also the possession or sale of any turtle products, from 13 August 1968.

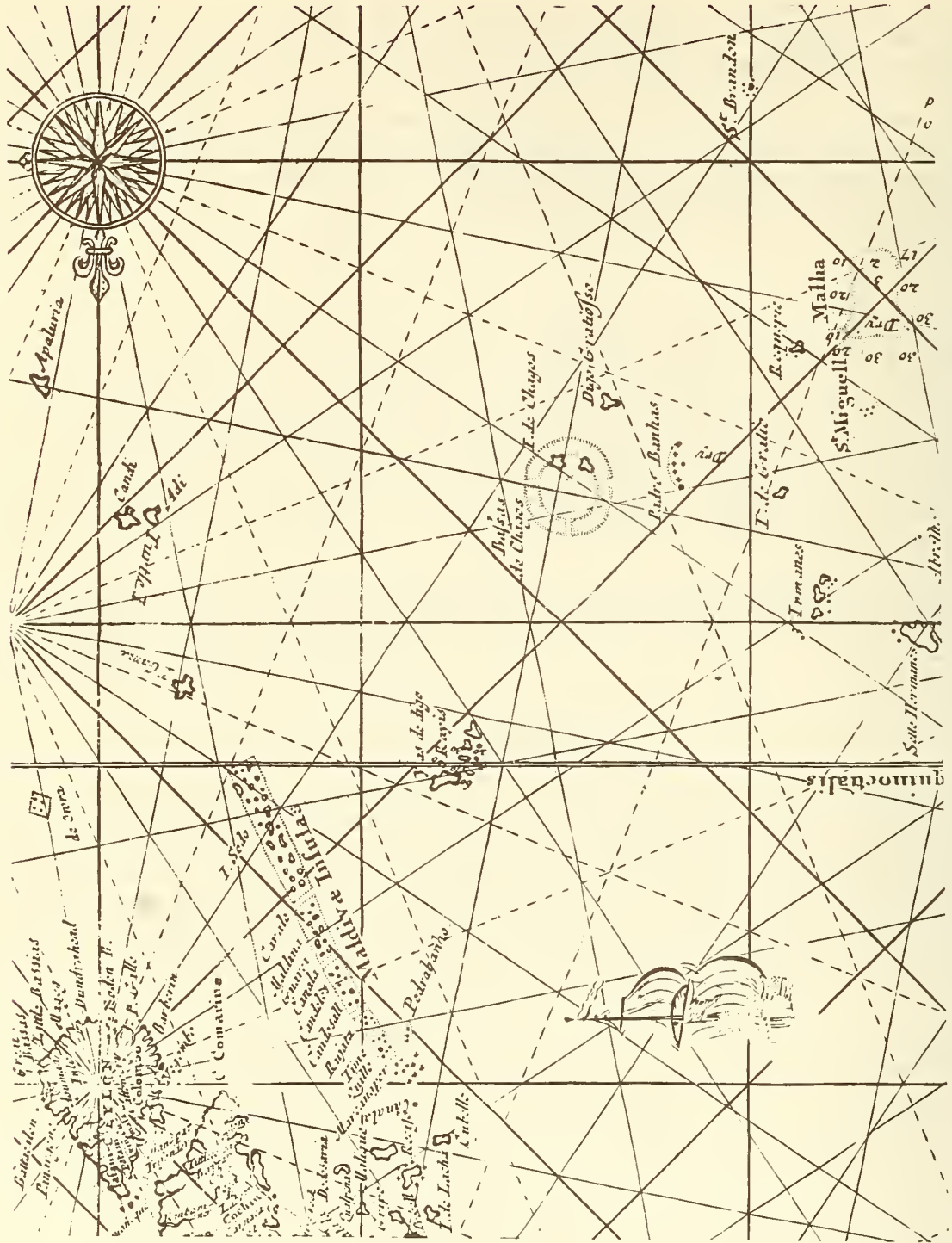


Fig. 32. The Chagos Archipelago and neighbouring islands, from The English Pilot (1755).

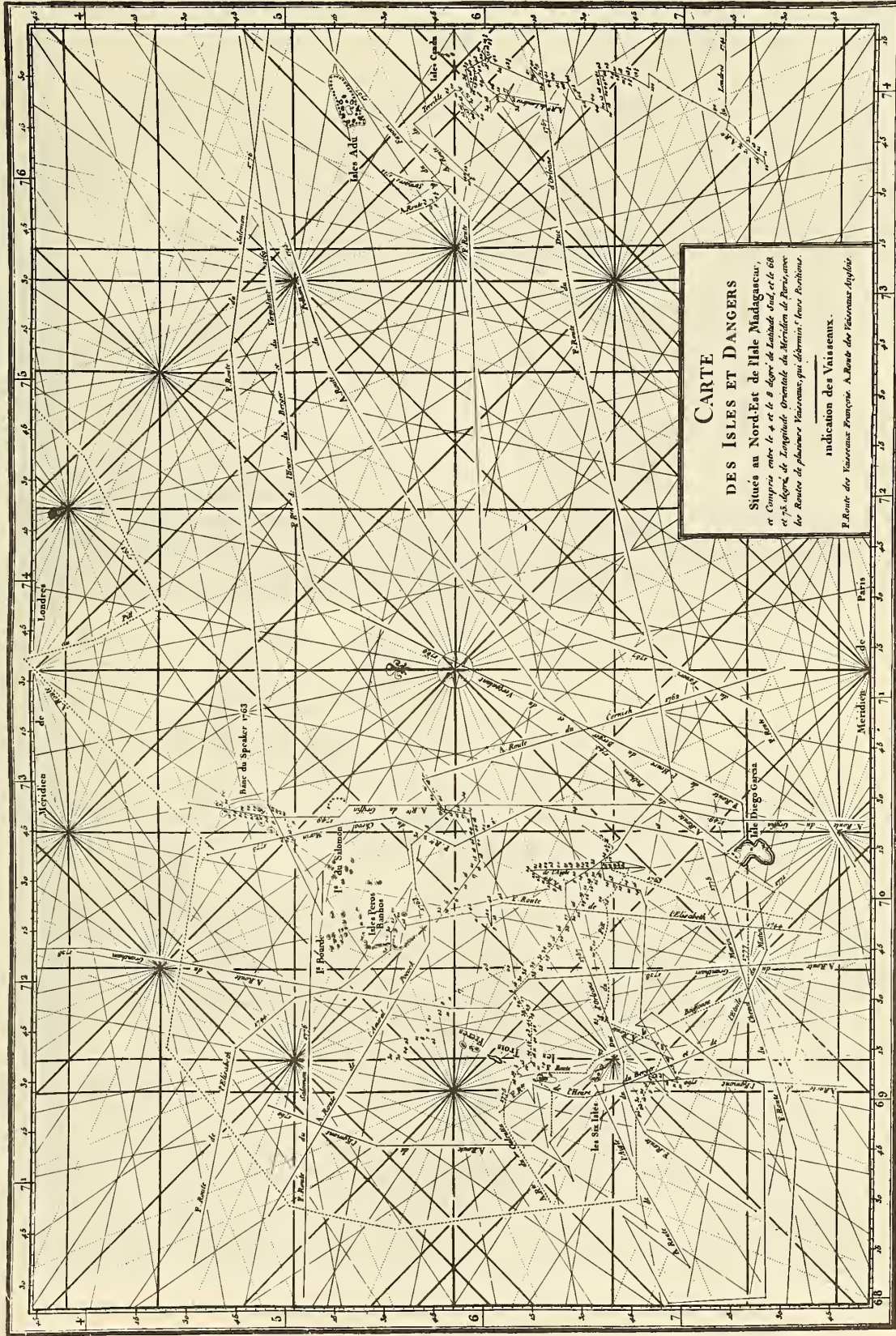


Fig. 33. The Chagos Archipelago and neighbouring islands, showing eighteenth century exploratory voyages, from the Neptune Oriental of Mannevillette (1775).

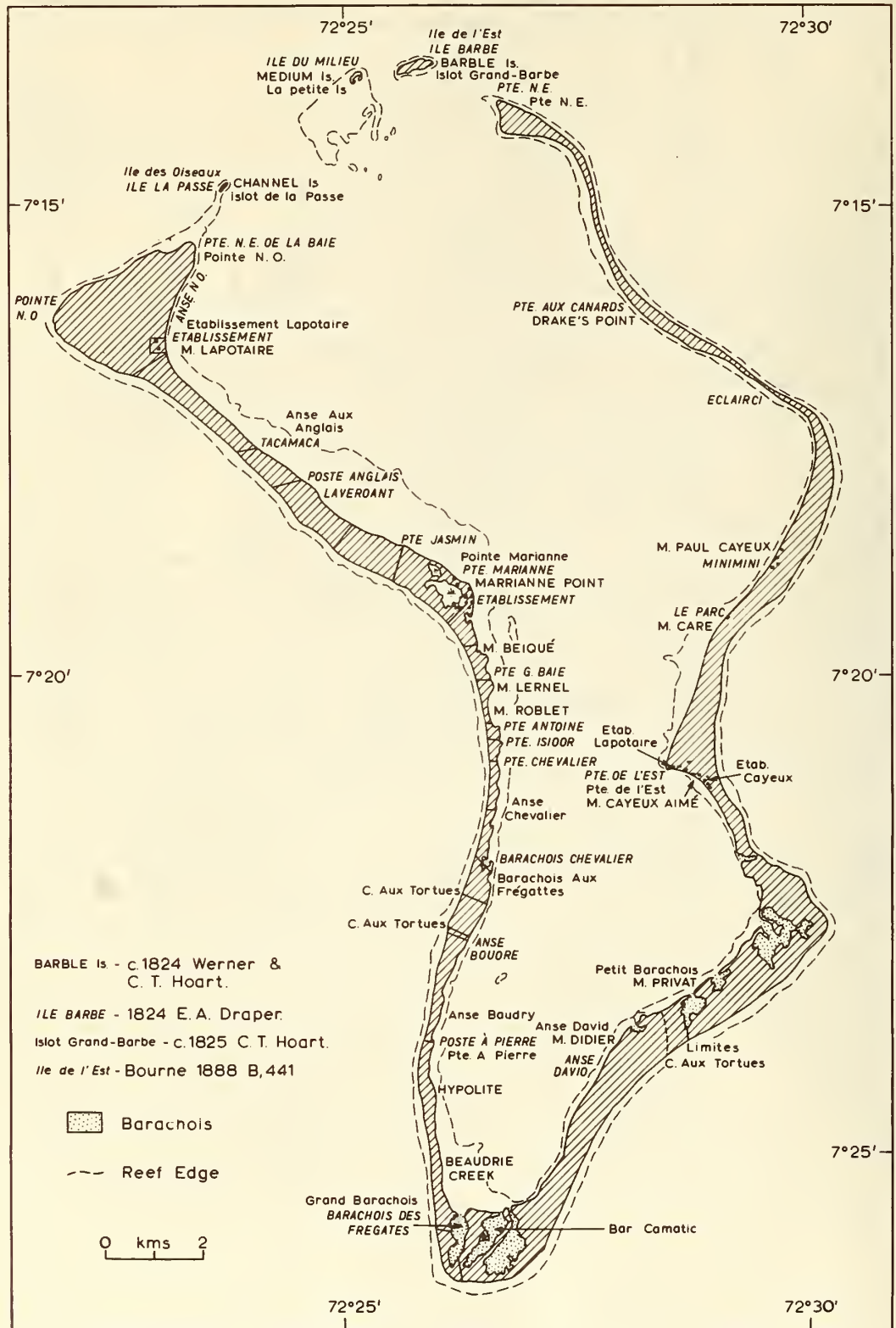


Fig. 34. Place names and topography of Diego Garcia on the maps of Draper (1824), Hoart and Hoart (c. 1824), and Hoart (c. 1825), and according to G. C. Bourne.



43. The Manager's house and other buildings at East Point: compare a similar photograph in Chun (1903). The railway leads to the jetty

44. Copra-drying sheds and the church at East Point





45. Motorable road through coconut plantations between East Point and Minni Minni

46. Ruined buildings seen through an avenue of old Ficus trees at Minni Minni





47. Labourer's houses at Pointe Marianne village

48. The cemetery at East Point





49. The disused cemetery, with a massive Ficus tree, at Pointe Marianne

50. Wild donkeys in coconut plantations southwest of Barachois Maurice



19. BIBLIOGRAPHY OF DIEGO GARCIA

D. R. Stoddart

Items in this bibliography containing specific references to Diego Garcia are marked with a single asterisk*. Items containing references to other Chagos islands or to the Chagos archipelago generally, without specific mention of Diego Garcia, are marked with a double asterisk**. The Bibliography also contains a number of items to which reference has been made in the text but which do not deal either with the Chagos islands or with Diego Garcia, and these are left unasterisked. The main bibliographic sources on the Chagos Archipelago are as follows: general, historical, public records, maps - Toussaint and Alphonse (1956); historical - Scott (1961); climate - Wallace (1963); geography and ecology - Sachet and Fosberg (1955). There is also much of relevance in my own bibliographies of the Maldives Islands (Stoddart, ed., 1966) and of Aldabra (Stoddart 1967). This bibliography is probably reasonably complete for items of geographical and ecological nature; only select historical items are included, however, and no attempt has been made to scan published official and unpublished archival records, a guide to which is included in the bibliography by Toussaint and Alphonse (1956).

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- * ----- 1877b. Report of the Acting Magistrate of the smaller Dependencies of Mauritius on the results of his visit to the Islands of Diego Garcia and Peros Banhos. Port Louis.
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ATOLL RESEARCH BULLETIN

150. THE NATURAL HISTORY OF FRENCH FRIGATE SHOALS,
NORTHWESTERN HAWAIIAN ISLANDS¹

by A. Binion Amerson, Jr.



Issued by
THE SMITHSONIAN INSTITUTION
Washington, D.C., U.S.A.





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THE NATURAL HISTORY OF FRENCH FRIGATE SHOALS, NORTHWESTERN HAWAIIAN ISLANDS¹

by A. Binion Amerson, Jr.²

INTRODUCTION

French Frigate Shoals is a coral atoll situated almost at the mid-point of the 1,600-mile-long Hawaiian archipelago (Figure 1). It is approximately 735 miles northwest of the eastern tip of Hawaii Island, and approximately 780 miles southeast of Kure Atoll. Of the 13 small named islands in the lagoon, 12 are low and sandy with sparse or no vegetation; the remaining island is of volcanic rock.

Forty-four bird species have been recorded from the atoll. Eighteen seabird species are known to breed and five migratory shorebird species have been regularly recorded. Humans inhabit one of the islands; excepting dogs and a gecko, there are presently no other terrestrial mammals or reptiles, but there are resident Hawaiian Monk Seals and Green Sea Turtles. Terrestrial invertebrate fauna is limited to a few insects and arachnids; marine life is, however, abundant. Wildlife is protected as French Frigate Shoals is part of the Hawaiian Islands National Wildlife Refuge administered by the Bureau of Sport Fisheries and Wildlife (hereafter referred to as BSWF) of the U.S. Department of the Interior.

In 1963 the Smithsonian Institution's Pacific Ocean Biological Survey Program (hereafter called POBSP) began an extensive biological research program in the central Pacific. Since June 1963 POBSP personnel have spent a total of 203

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Figure 1. The Hawaiian Islands.

days at French Frigate Shoals on 10 different survey trips. The initial results of BSFW and POBSP investigations, as well as previously published material, are discussed herein; special emphasis is focused on the vertebrate terrestrial fauna and the vascular flora.

DESCRIPTION

French Frigate Shoals, lying between the latitudes of $23^{\circ}37'18''$ and $23^{\circ}52'50''$ North and the longitudes $166^{\circ}03'14''$ and $166^{\circ}20'04''$ West (USCGS Chart 4172), is given an official location of $23^{\circ}45'N$ x $166^{\circ}10'W$ by the U.S. Department of the Interior (Office of Geography, 1956: 6). In 1786 La Perouse (1799) named this new atoll Basse des Frigates Françaises, or Shoal of the French Frigates, because it nearly proved to be the termination of his voyage. Several variations of the name have been used over the years--French Frigate Shoal, French Frigates Shoal, and French Frigate Shoals. On 1 October 1924 the U.S. Geographic Board of Names selected French Frigate Shoal as the official name. In July 1954, however, the Board changed its collective mind and adopted French Frigate Shoals.

The atoll consists of a crescent-shaped reef on a 20-fathom-deep oval platform,¹ whose long axis is 19 nautical miles in a northwest to southeast direction (Fig. 2). The crescentic reef is double; the almost continuous outer arc is 31 nautical miles long while the broken inner arc is 18 nautical miles; the resulting 140 square mile lagoon is seven nautical miles wide at its midpoint. The crescent tips point west and are 15 nautical miles apart. La Perouse Pinnacle lies on an imaginary line between these two tips; it is six miles southeast of the northern tip and nine miles northwest of the southern tip.

POBSP personnel found 12 sand islands, covering 111.3 acres, of which 33.3 acres are covered with vegetation² within the reef, and two exposed volcanic rocks near the center of the oval platform. Four of the islands--East, Tern, Trig, and Whale-Skate--have well established vegetation.

¹ Palmer (1927: 28-29) reported this platform to cover about 250 square miles at the 30 fathom mark.

² In 1923 Palmer (1927: 30) observed 46 acres of land of which 17 acres were covered with vegetation.

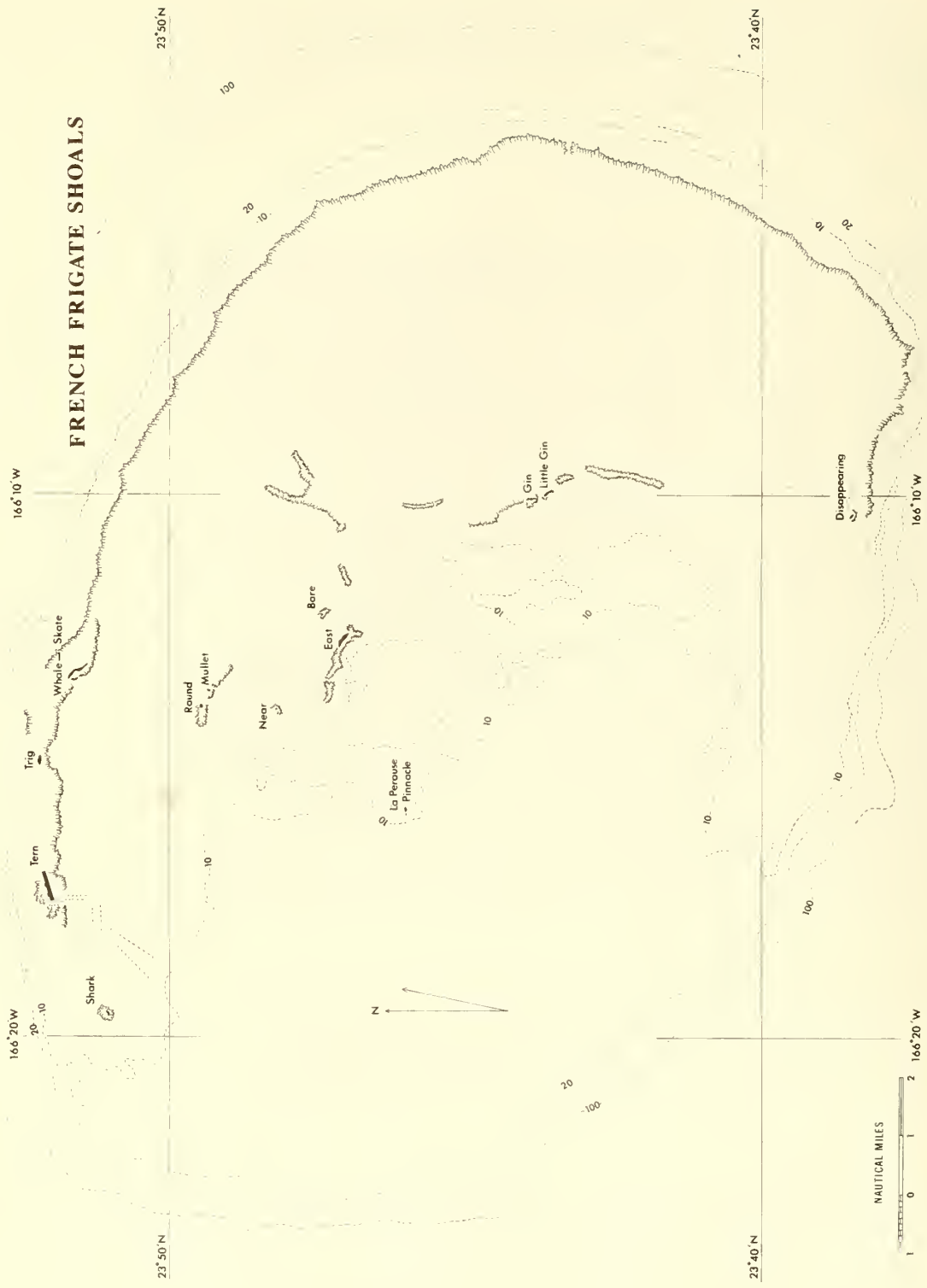


Figure 2. Map of French Frigate Shoals. Redrawn from USCGS Chart No. 4172.

Little Gin Island, although quite large in size, presently has a very limited flora; two other low but sizable islands, Gin and Disappearing, are without vegetation. All three are subject to occasional inundation. La Perouse Pinnacle also supports no vegetation in spite of its size and height. The remaining islands--Bare, Mullet, Near, Round, and Shark--are continually shifting sandbars. Three other nameless sandy islets are awash at high tide.

When La Perouse (1799) discovered the atoll on 6 November 1786, he only examined the southeastern half; he found four sand islands and the two rocks (Fig. 3). Five sand islets and the two rocks are indicated on Hydrographic Office Chart No. 2 (Fig. 4) which appeared in 1867; it was made by Brooke of the USS Fenimore Cooper during January 1859. Another chart (Fig. 5), made by Brooks of the bark Gambia in late April or early May 1859, shows 16 sand islets, as well as the two rocks.

During August and November 1914 personnel of the USS Rainbow conducted the first hydrographic survey of the atoll (Fig. 6); 12 sandspits were noted: East, Bob, Cud, Dim, Rat, Nun, Low, and Tom were more or less permanent though their shorelines continually shifted, and Ark, Mod, Ink, and Pup changed from day to day; the name¹ Hub was given to the rock islet (U.S. Nat. Arch., Mod. Mil. Hist. Div., R.G. 37, letter 1332-100666). In 1923 the Tanager Expedition mapped 16 sand islets (Palmer, 1927: 28-31). Of these 16, they named 12; all names are still used today. In 1928, personnel of the USS Guide surveyed the atoll; the current USCGS Charts 4171 and 4172 resulted from this and the 1913 surveys. The 1928 survey also located 16 sand islets. In 1942, with World War II raging in the Pacific, the U.S. Navy dredged coral from the lagoon to construct an air field on Tern Island; a small vessel channel 200 feet wide and 20 feet deep was cleared to the island.

These data suggest that topographical changes have occurred at French Frigate Shoals over the past 100 years, and that minor changes continue. Photographs from 1923 lent to the POBSP by Alexander Wetmore, and those U.S. Navy photographs taken in the 1930's and 1940's and obtained through the U.S. National Archives, support this hypothesis of change and provide additional material for the discussion of the vegetation in a following section.

¹ Although the name Lehua Island was used once in 1895 for one of the islets, these names are considered to be the first given to the islands, but were not listed on the ensuing unpublished map.

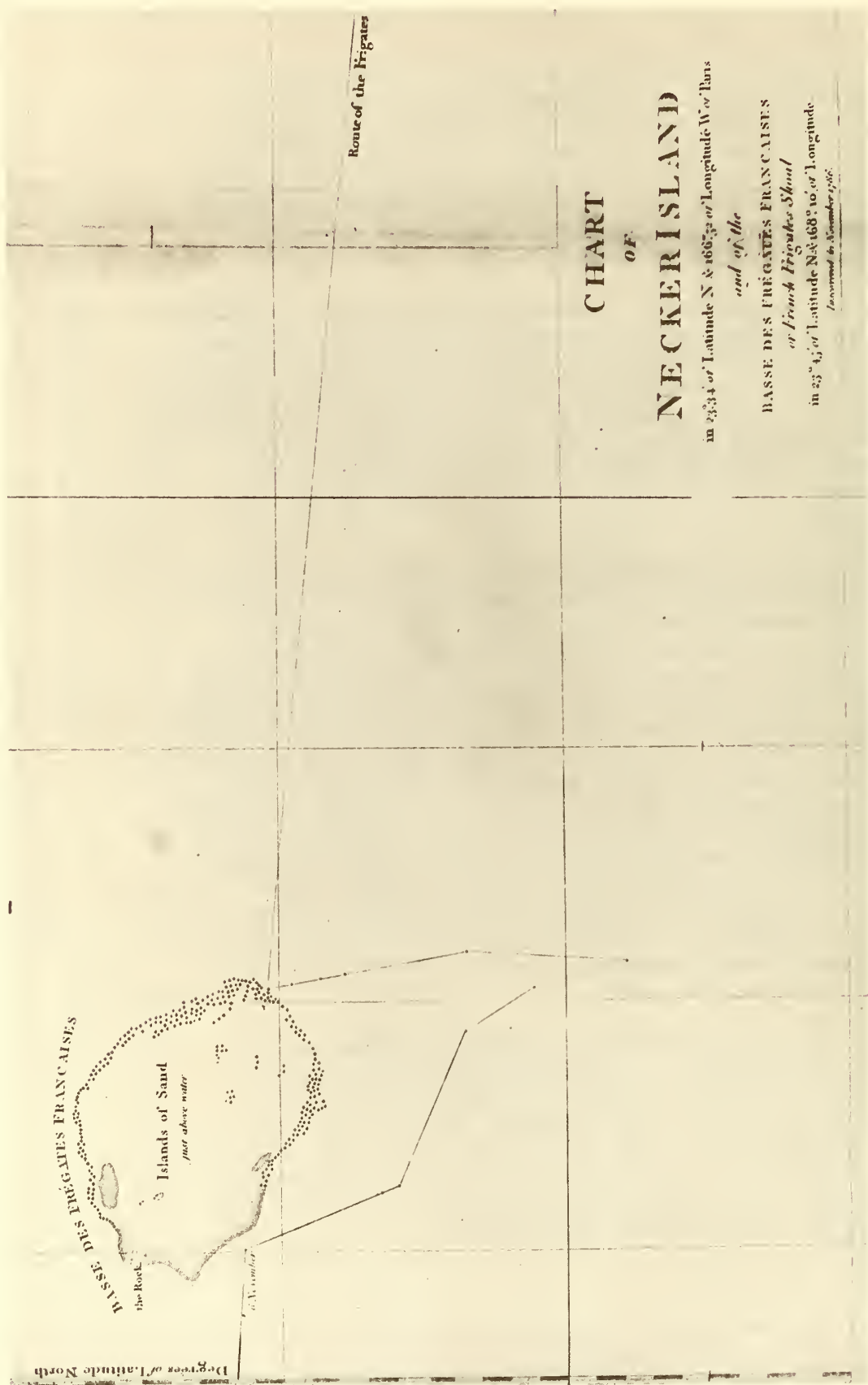


Figure 3. First map of French Frigate Shoals, published 1796 in Paris (French Hydrographic Office Map No. 556).

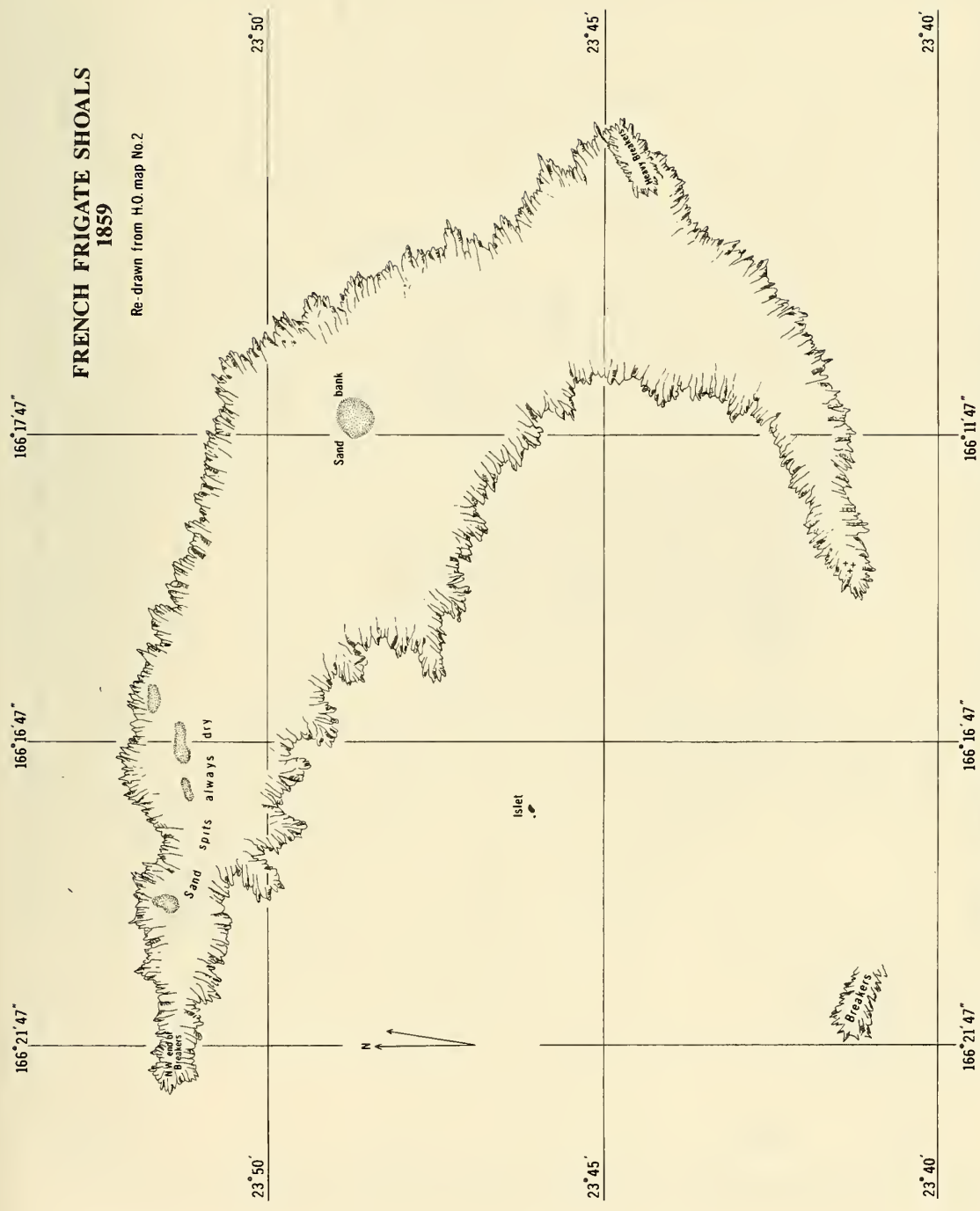


Figure 4. Map of French Frigate Shoals, drawn 1859, printed 1867.

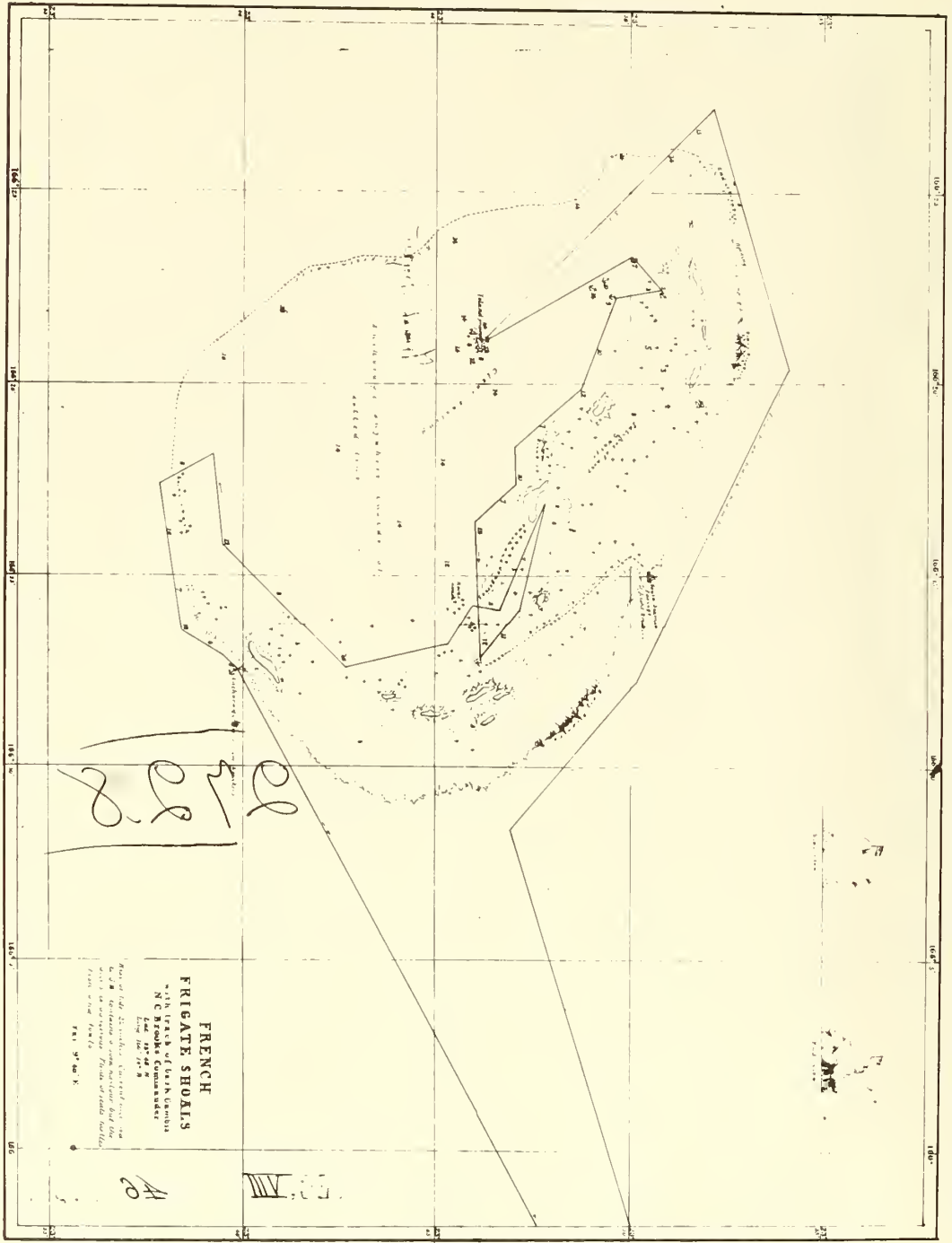


Figure 5. Map of French Frigate Shoals by N. C. Brooks showing track of Gambia and wreck of South Seaman, late April or early May 1859.

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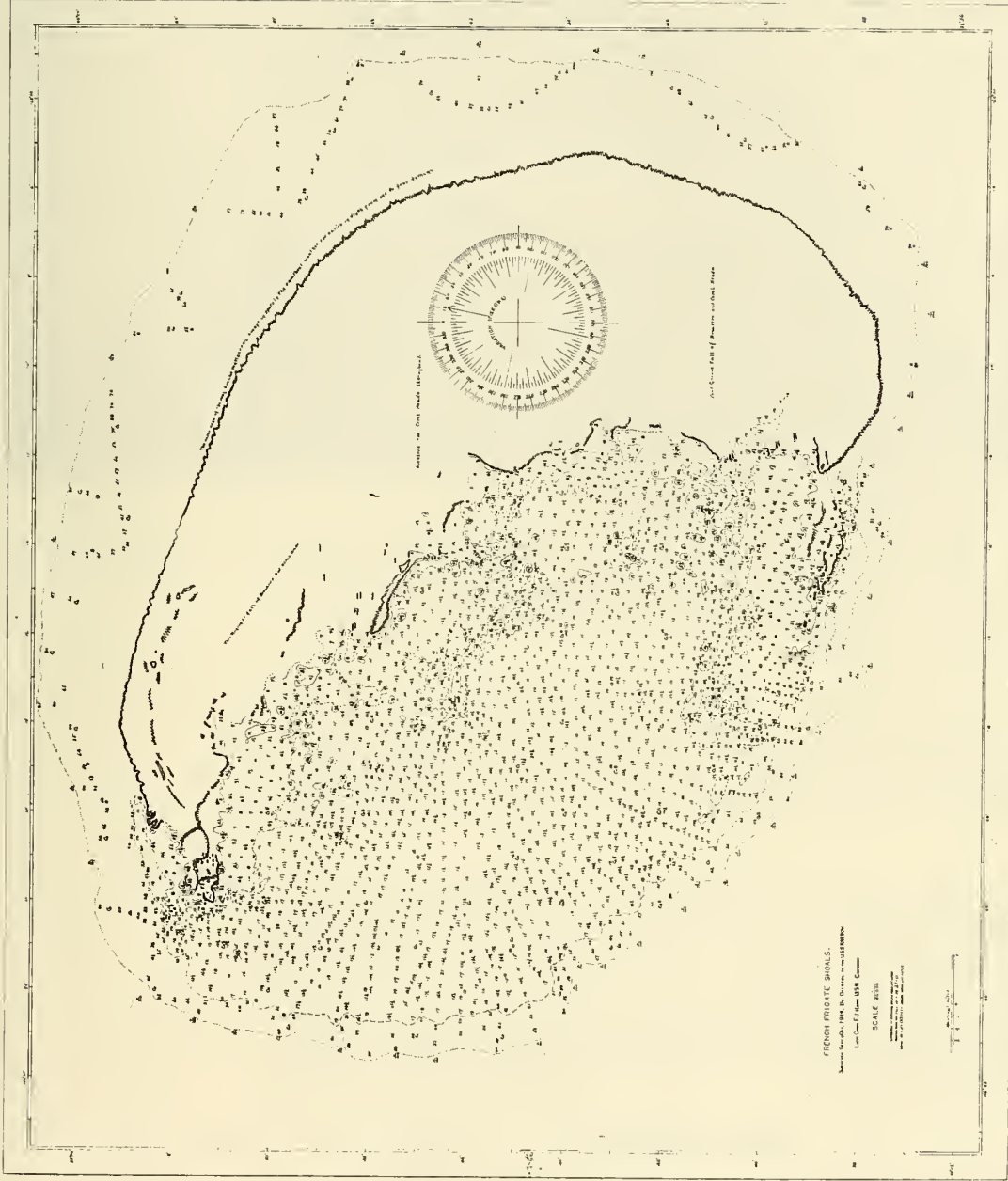


Figure 6. Original 1914 survey map of French Frigate Shoals surveyed by the officers of the U.S.S. Rainbow.

La Perouse Pinnacle

La Perouse Pinnacle (Fig. 7), at $23^{\circ}45'N$ x $166^{\circ}15'W$, is 6 miles south-southeast of Tern and 3 miles west-southwest of East. The main pinnacle rises 122 feet above sea level at its northwestern end and 120 feet at its southeastern end; it dips in the center to form a saddle. Sources differ, but the main rock is about 730 feet long northwest to southeast, and about 165 feet wide at its widest point. A second rock lies some 390 feet northwest of the main pinnacle; it rises about 9 feet above sea level and is about 200 feet long, northwest to southeast, and 65 feet wide at its widest.

The base of the main pinnacle is black while the upper portion has been whitened by guano deposits. A 5-foot-high, 25-foot-wide ledge is located at the midpoint of the southwest face; in calm seas, when swells are not coming from the southwest, this is an excellent landing. Attempts to climb the southwest face probably have succeeded but it is hazardous because of loose rock and guano. The northwest tip offers a better landing spot; from there one can work his way to the top using various ledges on the northeast face. The final 20 feet have to be traversed over the northwest end.

Loose rock is scattered about the top; guano deposits are primarily in the saddle area. Perhaps the loose rocks and guano were scattered and broken apart by the guano diggers in the late 1800's.

John M. Brooke of the USS Fenimore Cooper first noted guano in January 1859; his men found it on the surface and to a depth of four feet (Brooke, 1955: 619). Many ship captains noted its close resemblance to a full rigged sailing vessel.

Wetmore (ms.) in 1923 described it as "about 150 feet high by 150 yards long. A smaller rock 75 by 25 feet and 15 feet high lies 75 yards west of it. There are rock shelves on both north and south sides of the main islet." As to the guano, he noted that "in places it was encrusted with mineral matter, yellowish or whitish in color washed down from the guano above that at times formed small stalactites."

Tern Island

Tern Island (Fig. 8), the largest island in the atoll, is located near the northwest tip of the crescent at $23^{\circ}52'N$ x $166^{\circ}17'W$. This man-made island is 3,100 feet long east-northeast to west-southwest. Steel piling, driven to an approximate depth of 15 feet and standing 6-1/2 feet over the mean tide level, surrounds each end of the island and



Figure 7. Northeast face of La Perouse Pinnacle, 7 August 1965;
Little La Perouse at right. POBSP photograph by A. B. Amerson, Jr.

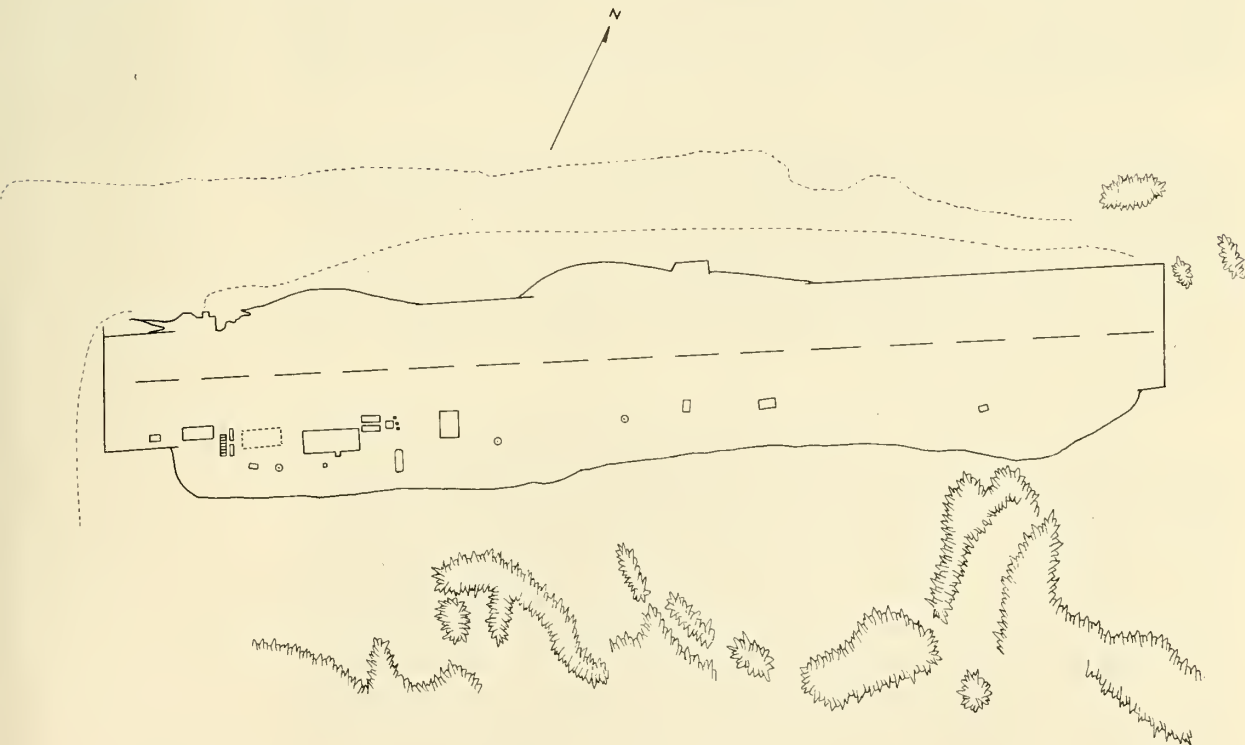


Figure 8. Tern Island, 10 January 1966. Redrawn from official
U. S. Navy photograph.

extends along the west-northwest side of the island, except for a 975-foot central sand beach section. When newly completed in late 1942, it was 350 feet wide (Fig. 9); the east-northeast end is still this wide, but the west-southwest end is now only 325 feet wide due to a break in the sea-wall in 1958. Along the east-southeast side, a 2,800-foot-long natural sandy section has now added 100 to 175 feet onto the island's width; the widest point is now about 600 feet. It has an area of 56.8 acres, of which vegetation covers 15.5 acres, and buildings cover 1.0 acre.

A runway 250 feet wide extends the length of the island and is composed of packed, fine-crushed coral; an area of fine-to-medium-crushed coral extends for 50 feet on either side. The newly added sand on both long sides ranges from fine- to medium-sized particles. Scattered grass, vines, and low bushes, as well as introduced trees and shrubs are to be found on both sides of the runway.

At least four buildings, several fuel and water tanks, a 129-foot antenna, a small-boat davit, and a tennis-basketball court are clumped on the western third of the east-southeast side; three other buildings are scattered along the western half of this side. Two wooden piers are located near the western end of the west-northwest side. Adjacent to these piers is a 20-foot deep, 400- by 650-foot turning basin which connects southward around the west end of the island to the 12,000-foot small vessel channel leading to the open ocean.

Tern Island is presently the site of a U.S. Coast Guard LORAN Station whose complement is normally one officer and 18 enlisted men. A tour of duty is for one year. The station is supplied by ship several times a year and by weekly air service. Electrical power is available as is fresh water; the latter is rainwater obtained from a roof-catchment system. After a rainstorm, fresh water stands about for days on the hard-packed coral runway.

On 28 June 1923, Wetmore (ms.) described the original Tern Island as "about 600 yards long by 150 yards wide. The eastern half is a long curving sandspit, from 6 to 8 feet above the sea. The western half which is the site of the bird colonies is from 10 to 12 feet above the sea and has a soil of fine coral sand." He found low vegetation covering most of the western half (Fig. 10). Palmer (1927: 30) computed the area to be 11 acres, of which 3 were vegetated. A U.S. Navy photograph taken June 1932 (Fig. 11) showed the island had changed very little (U.S. Nat. Archives, R.G. 80, CF-79783-1).

NAVAL AIR FACILITY
Proposed Building Locations
Drawing No. P.N.A.B.-N1-109
December 15, 1943

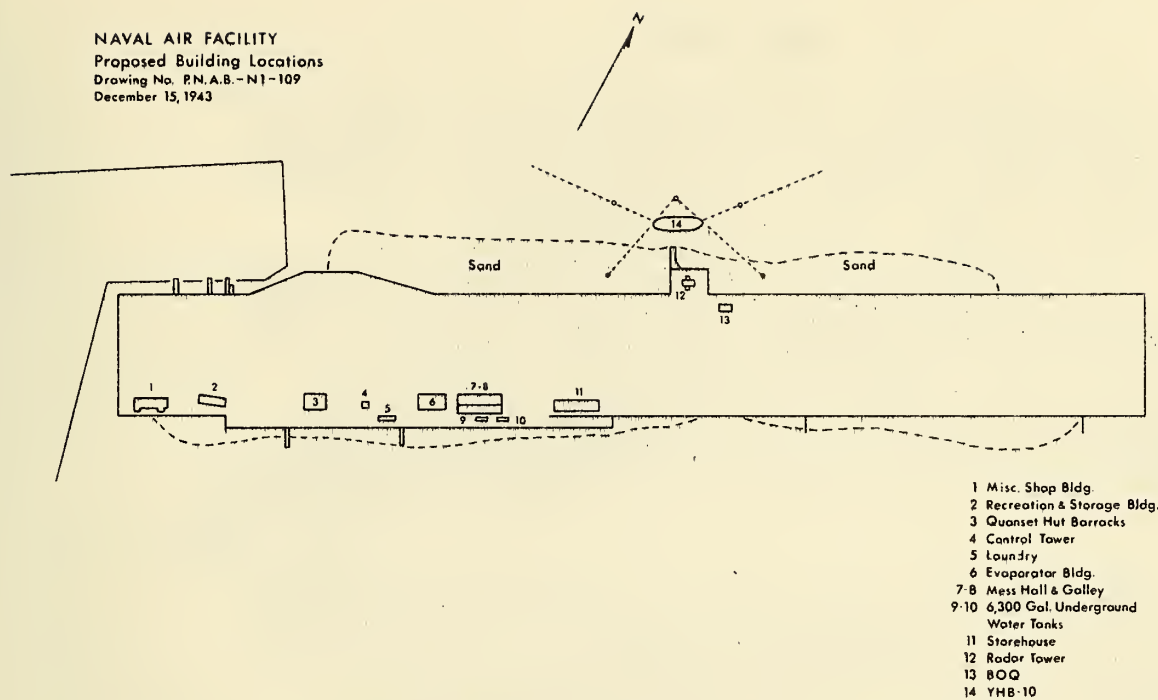


Figure 9. Tern Island Naval Air Facility, 15 December 1943.
Redrawn from official U. S. Navy blueprint map.

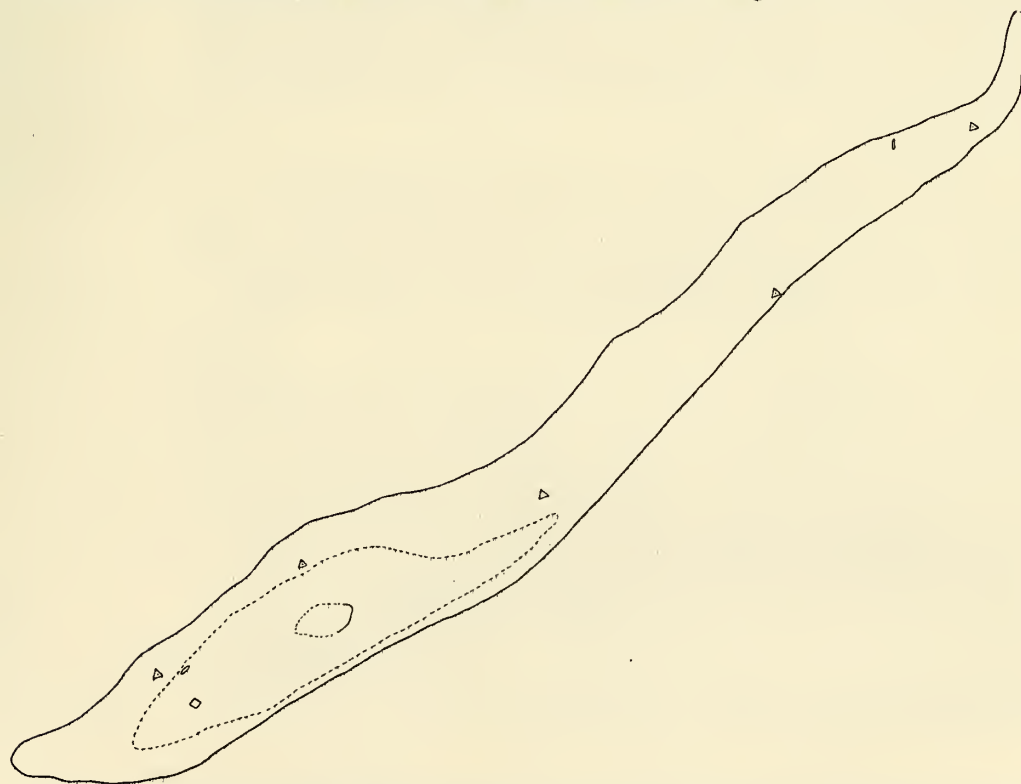


Figure 10. Map of Tern Island, 22-27 June 1923. Redrawn from
Tanager Expedition map by A. S. Chaney.

East Island

East Island (Fig. 12) lies almost midpoint along the inner reef of the crescent at $23^{\circ}47'N$ x $166^{\circ}13'W$, and is six miles southeast of Tern Island. It is irregular trapezium-shaped, with the southwest beach being the longest side. It has an area of 11.3 acres, of which 6.7 are vegetated.

The island is about 2,140 feet long northwest to southeast; the northeast beach is about 875 feet long. The widest part, 330 feet, is about midpoint of the island; the second widest part, 270 feet, is near the southeast end. The island is bluntly-pointed at the southeast tip. It is elongate and sharply-pointed at the northwest tip; the proximal sand portion is about 6 feet above sea level for some 580 feet, and its distal portion is a low shifting sandspit.

The main body of East is 8 to 10 feet above sea level, composed of fine coral sand, and covered with grasses, vines, and a few low bushes and shrubs. Scattered about the middle are the ruins of the U.S. Coast Guard Station which was abandoned in 1952. Rotting wood and rusting metal are strewn about. Five 100-foot wooden poles stand upright on the southeastern half; these provide excellent island markers when approaching by small boat. An overturned whaleboat and several pieces of rusting machinery are to be found near the southeast end. The larger seabirds utilize this debris for roosting, especially at night.

The entire northeast beach is narrow and steep and is composed of fine to medium-sized sand and broken shell. The southwest beach is wide and sloping with fine sand predominating. The best small boat landing area is along the western portion of the northeast beach.

In 1923 East Island's contours were similar to today's. Wetmore (ms.), 22 June 1923, wrote: "It is elongated, slightly curving in shape and according to an accurate map [Fig. 13] made by Judd 1,890 feet long by 400 feet wide at the widest part. The surface...is coarse coral sand with many fragments of large shells. The island rises from 8 to 10 feet above sea level. Vegetation is not continuous over the surface, but grows in mats with little gaps between. The beach is narrow and rather steep." He noted that the island had "been much larger but has been cut away by storm." Palmer (1927: 30), who was with Wetmore, found that East covered 9.6 acres, of which 6.0 acres were sparsely vegetated.

A U.S. Navy photograph taken in November 1935 and reproduced as a line drawing in Figure 14 shows very little



Figure 11. Tern Island, 24 June 1932. Redrawn from official U. S. Navy photograph.

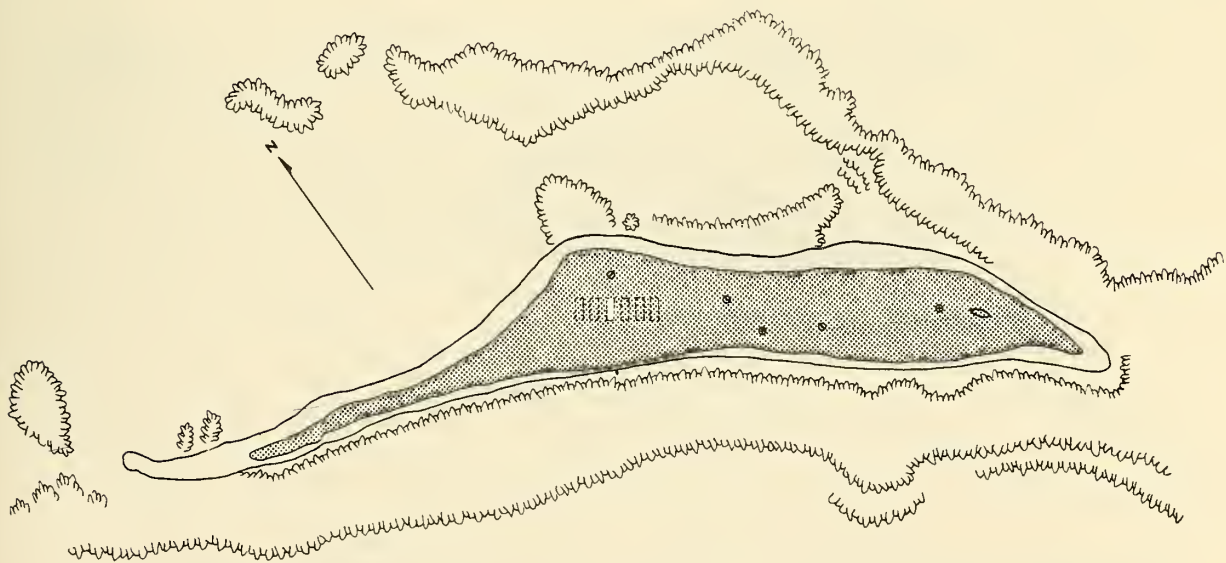


Figure 12. East Island, 10 January 1966. Redrawn from official U. S. Navy photograph.

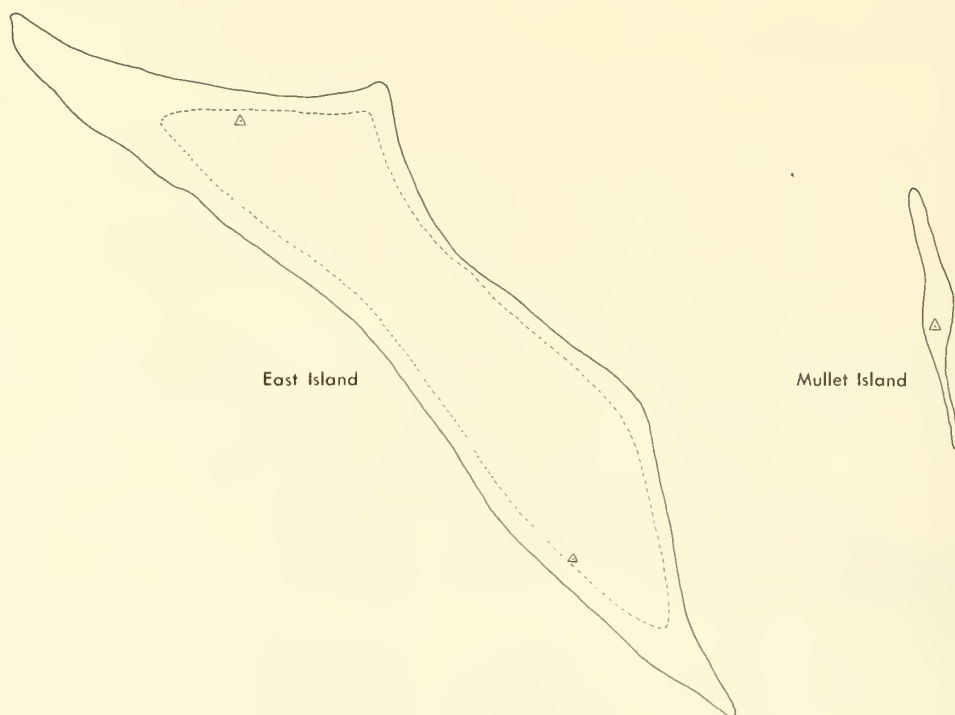


Figure 13. Map of East and Mullet Islands, 22-27 June 1923. Redrawn from Tanager Expedition map by A. S. Chaney.

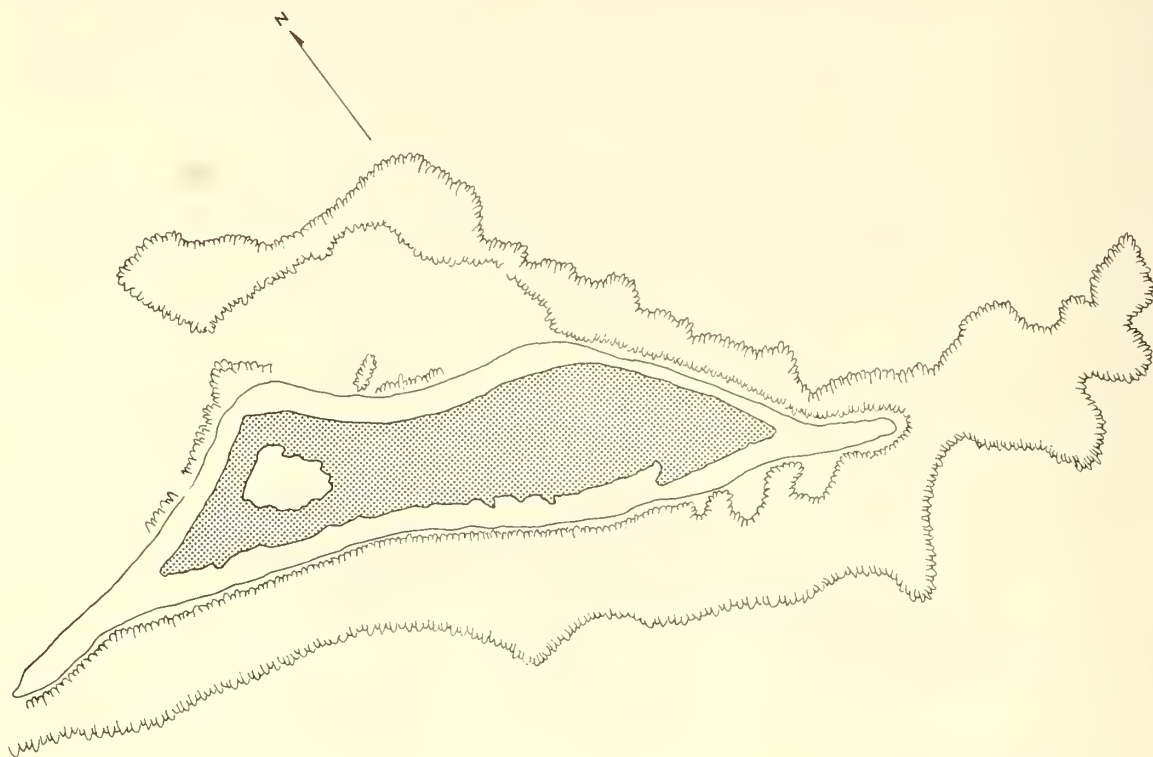


Figure 14. East Island, 11 November 1935. Redrawn from official U. S. Navy photograph.

change from 1923 (U.S. Nat. Archives, R.G. 80, CF-79793-10). When the U.S. Coast Guard built the LORAN station in 1944 the shape of the island was not altered, but various buildings and antennae were added as indicated in Figure 15 (Fed. Rec. Gen., Md., operational report, 1 Nov. 1948).

Whale-Skate Island

Whale-Skate Island (Fig. 16) is the easternmost of the northern islands and is situated at 23°51'N x 166°13'W; it is almost 3-1/2 miles east of Tern and 1-1/2 miles east-southeast of Trig. It is composed of two formerly discrete islands, Whale and Skate, which form a long, narrow, slightly curving island covering 16.8 acres. Vegetation covers 6.5 acres.

It is about 2,100 feet long with its axis lying in a northwest to southeast direction. The eastern (Whale) section is about 230 feet wide at its widest point and the western (Skate) section is about 270 feet wide; the connecting portion is approximately 165 feet wide at its narrowest point. The main body of this combined island is 8 to 10 feet above sea level. A short section, also 8 to 10 feet above sea level, at the east tip is separated from the main body by a low sandy strip. The soil ranges from fine to large-sized coral sand and broken shell, to small and medium-sized coral rock. Almost its entire length is vegetated with grass, creepers, low shrubs, and medium-sized bushes. The northeast beach is wide and sloping, while the southwest beach, although wide, is steep near the beach crest. A grounded, rusting barge is located 360 feet southwest of the midpoint of the eastern half of the island.

In June 1923 Wetmore (ms.) found Whale and Skate Islands "separated by a channel 150 yards wide;" he noted, however, that the two islands "are probably joined at times by the shifting sands as the water was not deep." Whale Island, so named by Wetmore because of a skeleton of a small whale on the beach, was "somewhat curved in form 400 yards long by 125 yards high and rose 10 to 12 feet above the sea. It appeared to be the oldest [sand] island in the entire group and had the upper surface covered with fine gray soil." Plant life was abundant. Wetmore observed that Skate Island "was 200 yards long by 100 yards wide and rose 8 to 10 feet above sea level. Its surface was...coral sand with scant vegetation of grass. Humus was slight and plants low and scattered." The islands were also mapped (Fig. 17) by King in June 1923; Palmer (1927: 30) noted the area of Whale to be 5.3 acres, of which 2.5 acres were covered by sparse grass; Skate Island measured 3 acres, half of which were covered by sparse grass.

LEGEND

No	Description
1	CO's Quarters & Rec. Hall
2	Barracks No. 1
3	Barracks No. 2
4	Mess Hall & Galley
5	Generator Hut No. 1 & GSK Storeroom
6	Generator Hut No. 2 & Machine Shop
7	Loran Hut & Radio Room
8	Aerology Office
9	Boatswain's Locker
10	Distiller Shed
11	Paint Locker
12	Vehicle Shed
13	Crew's Head

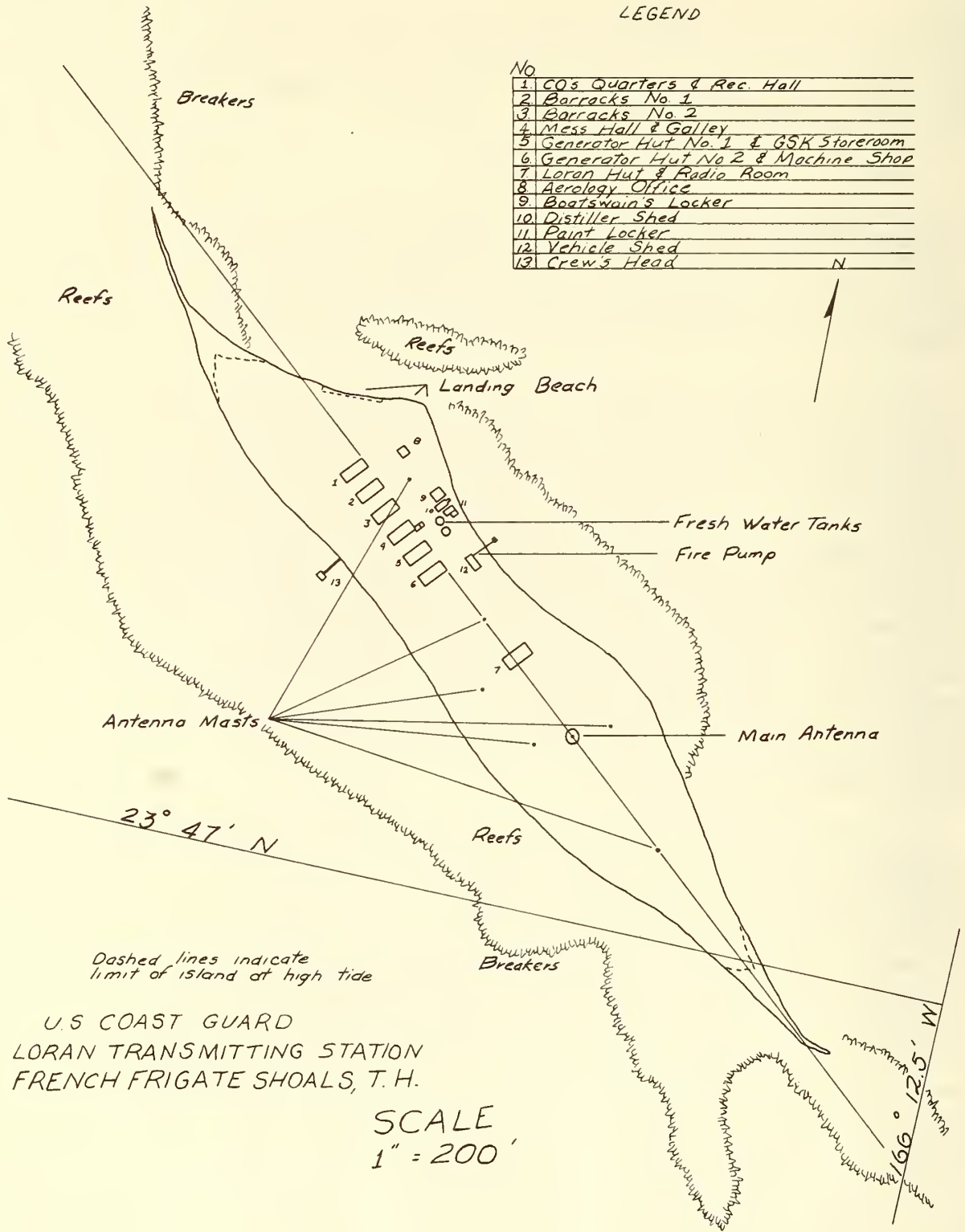


Figure 15. Map of East Island, 1 November 1948. Redrawn from official U. S. Coast Guard Operational Data Report.



Figure 16. Whale-Skate Island, 10 January 1966. Redrawn from official U. S. Navy photograph.

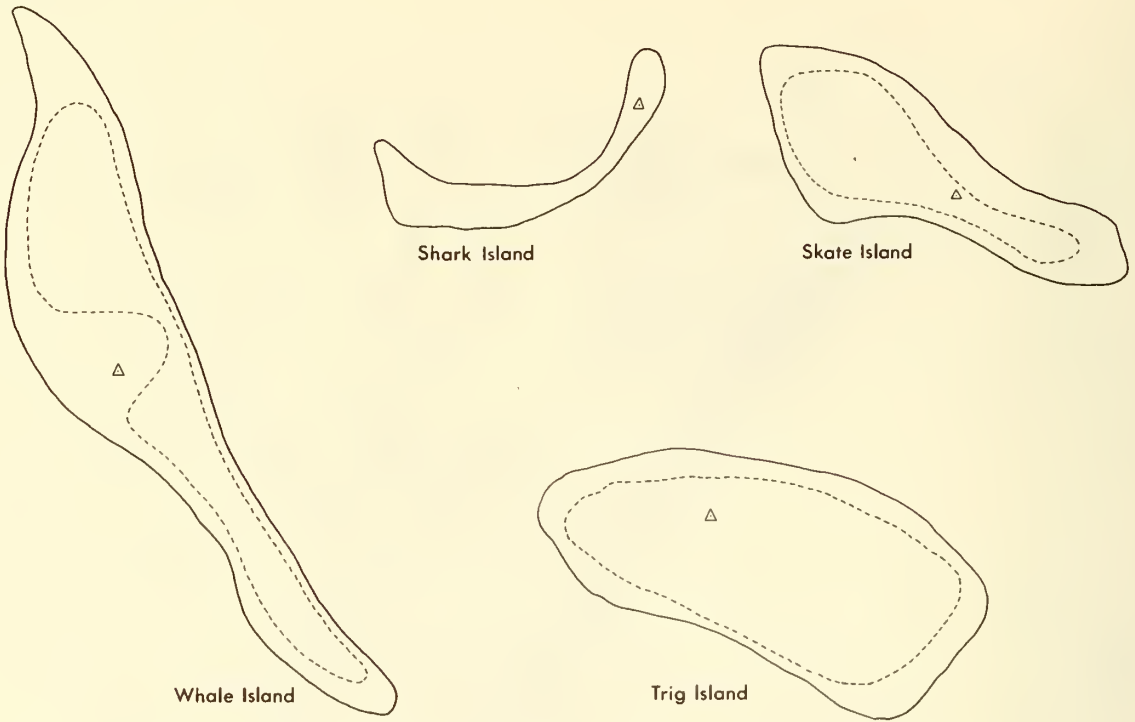


Figure 17. Map of Whale, Shark, Trig, and Skate Islands, 22-27 June 1923. Redrawn from Tanager Expedition map by A. S. Chaney.

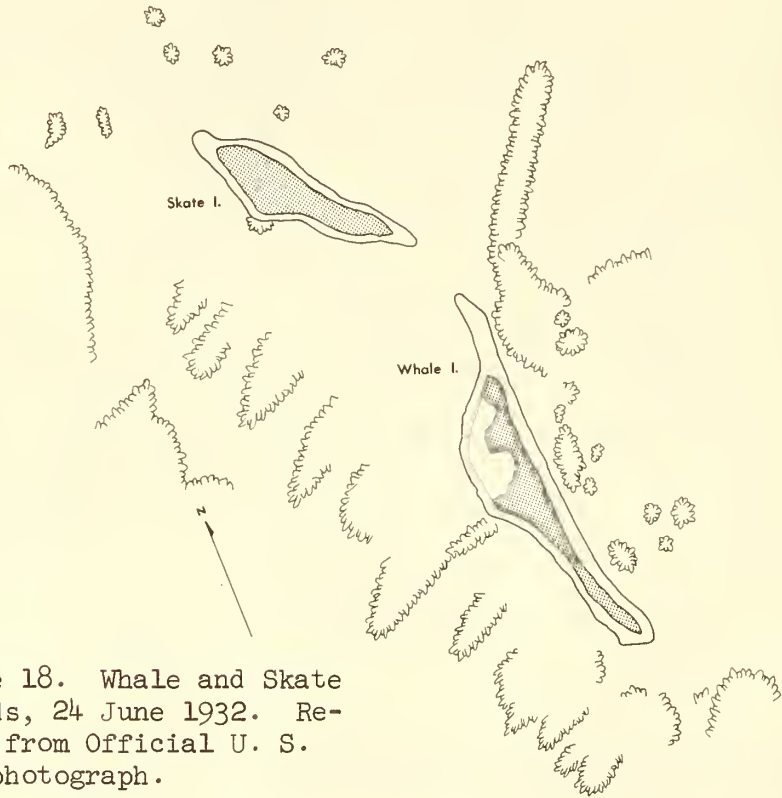


Figure 18. Whale and Skate Islands, 24 June 1932. Redrawn from Official U. S. Navy photograph.

Figure 18 shows the two islands on 24 June 1932 (U.S. Nat. Archives, R.G. 80, U.S. Navy photograph CF-79793-6). An extended sandspit had developed on the northwestern tip of Whale; otherwise there was little change from 1923.

POFI (ms.) personnel observed that Whale and Skate Islands were "joined by a sand bar 40 - 50' wide and 3 - 4' high" on 5 June 1956; they had been separate islands two months earlier when visited on 11 April. An aerial photograph taken 28 December 1957 by Rice and Kenyon also shows the sand connection; in addition, it shows that approximately 450 feet of the eastern section had been separated from the rest of the island by a shallow, narrow stretch of water. It is not known when this section rejoined the main body, but it was joined by June 1962 (HDFG photo).

Trig Island

Trig Island (Fig. 19), at 23°52'N x 166°15'W, is located just inside the northreef about 1-3/4 miles east of Tern and about 1-1/2 miles west-northwest of Whale-Skate. This dogleg-shaped island covers an area of 9.9 acres, of which 4.6 are vegetated.

It is approximately 1,170 feet long east to west; the eastern section is 215 feet wide at its widest point; it narrows to 195 feet before widening at its midpoint to 280 feet; the western half is 320 feet wide at its widest point. The north beach is concave and forms a cove about 600 feet long and 115 feet deep. The south beach is pointed at the island's midpoint; the east half is about 640 feet long and the west half is about 600 feet long.

Trig is the highest of the atoll's sand islands; it slopes from a low of 8 feet above sea level on the eastern half to a height of 20 feet above sea level at the edge of the vegetated west half. The west and south beaches are wide, but are steep next to the vegetated area. The entire north beach is sloping. The soil is fine to medium-sized coral sand. Grass and other low plants cover the west half; large bushes predominate on the southern side of the east half.

Wetmore (ms.) in June 1923 found Trig to be "225 yards long by 125 yards wide and...nearly circular in form. It rose from 8 to 19 feet above the water, had the summit covered with a fair growth" of vegetation. King mapped the island (Fig. 17), and Palmer (1927: 30) found the area to be 5.3 acres, of which 3.7 were covered with sparse grass.

Figure 20 illustrates its shape in June 1932 (U.S. Nat. Archives, R.G. 80, U.S. Navy photograph CF-79793-5). The island's shape changed considerably from 1932 to 1963; the north side eroded away and the southeast corner disappeared.

Gin Island

Gin Island (Fig. 21), situated at 23°44'N x 166°10'W along the inner southern reef, is 9-1/2 miles southeast of Tern and 4 miles south-southeast of East. This irregular, oval-shaped island has an area of 3.2 acres.

The island is 496 feet long from northwest to southeast and 351 feet wide. It is 6 to 8 feet above sea level with a steep eastern beach and a sloping western beach. It is composed of fine to large-sized coral sand and broken shell. A small tidal pool was found in 1969 near the center. The island is not vegetated.

In June 1923 Wetmore (ms.) described the island as "a curving sand spit, 1/3 of a mile long and from five to 150 feet wide. At the widest point there was a small area 19 feet above sea level and here were a few scattered plants. From this wider point a long curving spit ran out to the north." The island was given its name "by an empty Gordon gin bottle...found cast up by the waves." In June 1923 the island was also long and narrow, but irregular on the southwest side as shown in Figure 22 (U.S. Nat. Archives, R.G. 80, U.S. Navy photograph, CF-79793-3).

Little Gin Island

Little Gin Island (Fig. 21) is located less than half a mile southeast of Gin Island at 23°44'N x 166°10'W, and has an area of 5.1 acres. It is 1,170 feet long northwest to southeast; the northeast side is straight, but the southwest side is concave. It is 265 feet wide at the widest point of the northwest half and 6 to 8 feet high; the middle section is 90 feet wide at its narrowest point and 3 to 6 feet high; the southeast half's widest point is 380 feet and 10 to 12 feet wide. Fine to medium-sized sand covers the entire island. The central area of the southeast half is slightly depressed; a few sprigs of vegetation occur here. In June 1967, the northwest half was awash at high tide.

Wetmore (ms.) described the island in 1923 as "approximately 300 yards long by 100 yards wide in its main part and 10 feet high at the highest point. A slight depression at the summit 50 yards across was grown over with plants." Toward the north a long, narrow sand bar extended for 250 yards.

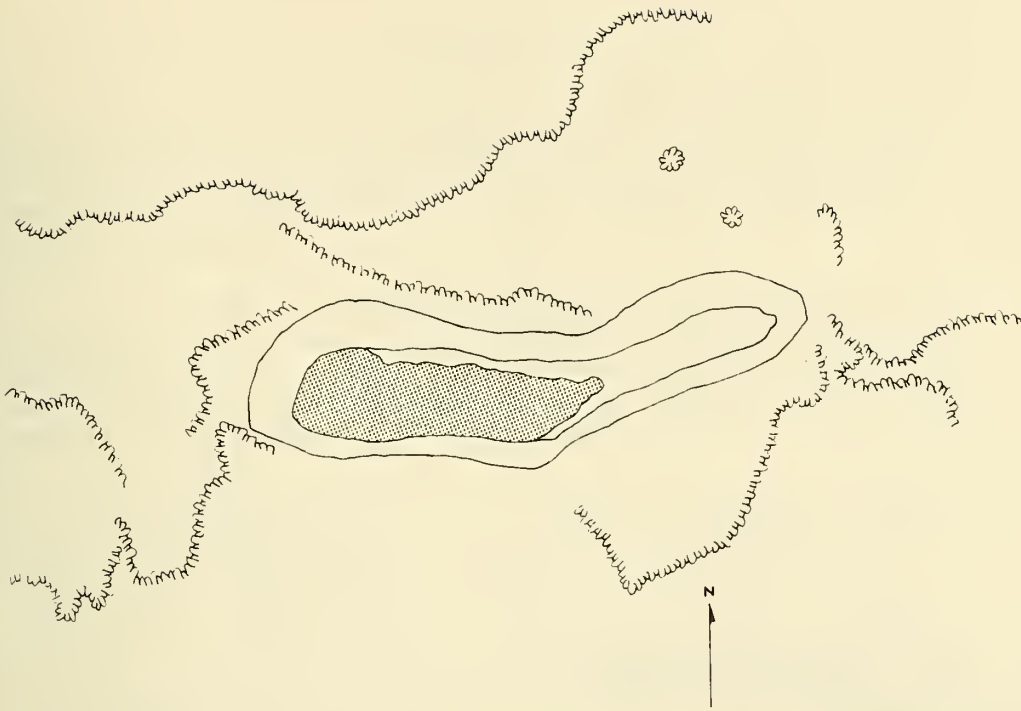


Figure 19. Trig Island, 10 January 1966. Redrawn from official U. S. Navy photograph.



Figure 20. Trig Island, 24 June 1932. Redrawn from official U. S. Navy photograph.



Figure 21. Gin and Little Gin Islands, 10 January 1966. Redrawn from official U. S. Navy photograph.

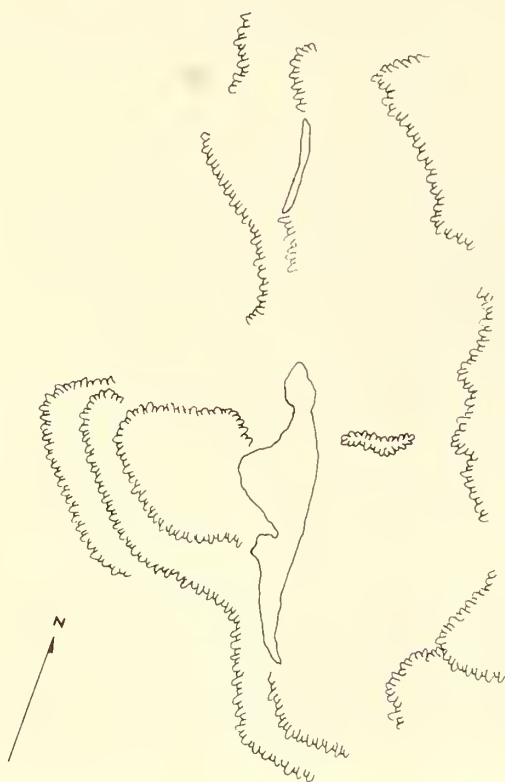


Figure 22. Gin Island and unnamed sandspit, 24 June 1932. Redrawn from official U. S. Navy photograph.

Round Island

Round Island (Fig. 23) is located near the north center of the lagoon at 23°49'N x 166°14'W. It is almost 4 miles southeast of Tern, slightly over 2 miles south-southwest of Whale-Skate, and 2-1/2 miles north-northwest of East. It covers an area of 0.5 acre.

As its name implies, the island is almost round; it is approximately 190 feet long north to south and 175 feet wide. The highest point is only about 4 feet above sea level; all beaches are sloping. The soil is fine to medium-sized coral sand and broken shell; no vegetation exists.

Wetmore (ms.) in June 1923 found "a circular island 100 yards in diameter rising 8 to 10 feet above the sea. The higher portion was covered with plants of four species." Palmer (1927: 30) computed its area at 1.6 acres. By June 1932 Round was an irregular, oval-shaped island (Fig. 24) and still partly covered by vegetation (U.S. Nat. Archives, R.G. 80, U.S. Navy photograph CF-79793-2). An aerial photograph taken by Rice and Kenyon 28 December 1957 shows no vegetation but the shape was still the same as in 1932.

Mullet Island

Mullet Island (Fig. 23) lies 0.04 miles east-southeast of Round Island at 23°49'N x 166°14'W. It is 260 feet long north to north and only 55 feet wide throughout its length. Its area is 0.5 acre. It is formed of fine coral sand, and is usually awash at high tide.

Wetmore (ms.) described this sand spit as "bare of vegetation being simply a ridge of coarse shell and coral" some "100 yards long by 30 or 40 feet wide." Chaney mapped it (Fig. 13); and Palmer gave its area as 0.4 acre.

Shark Island

Shark Island (Fig. 25), at 23°51'N x 166°20'W, is located at the northwest tip of the atoll's crescent reef. It is just over two miles west-southwest of Tern. In January 1966 it was 215 feet from east to west and 80 feet wide. It is 6 to 8 feet high, composed of fine sand, broken shell, and coarse coral rock, and has no vegetation. It covers 0.8 acre.

Wetmore (ms.) in June 1923 found Shark "of curving form, narrow, 200 yards long by 15 yards wide at the widest point. It supports no vegetation...and is made of much coarse coral and shell thrown up on the beach." King mapped the island (Fig. 17) and Palmer (1927: 30) noted its area as 1.1 acres.

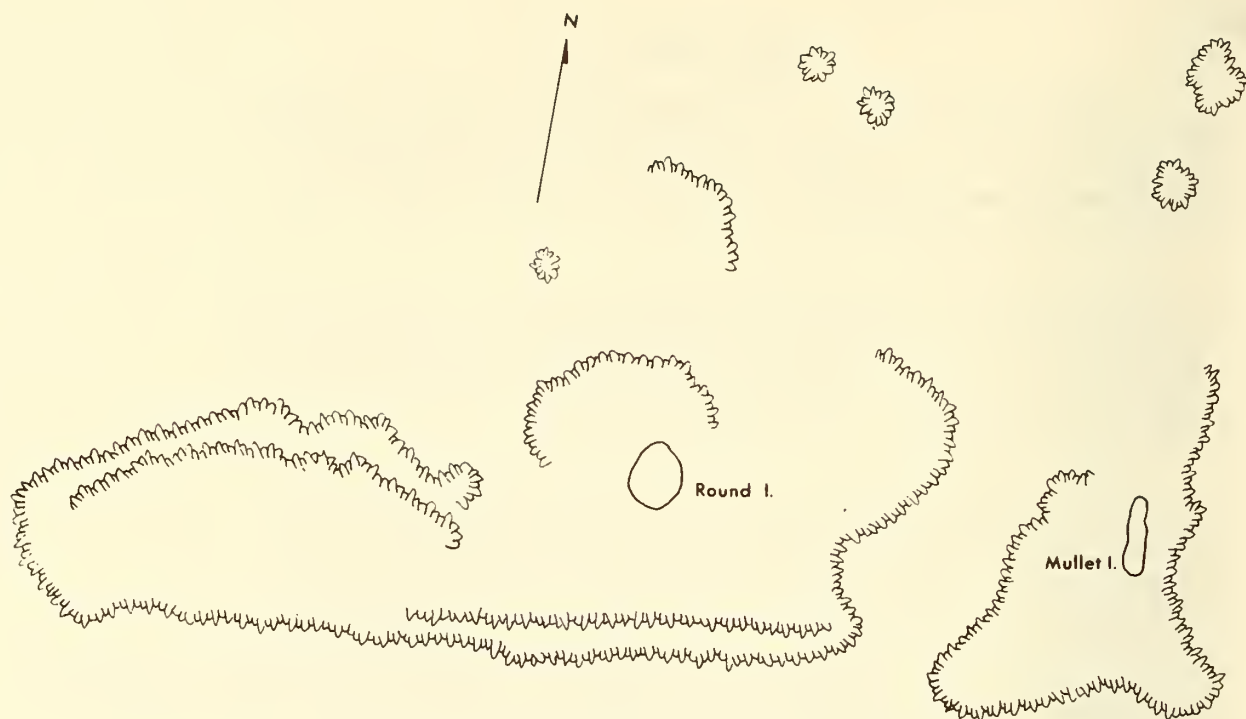


Figure 23. Round and Mullet Islands, 10 January 1966. Redrawn from official U. S. Navy photograph.

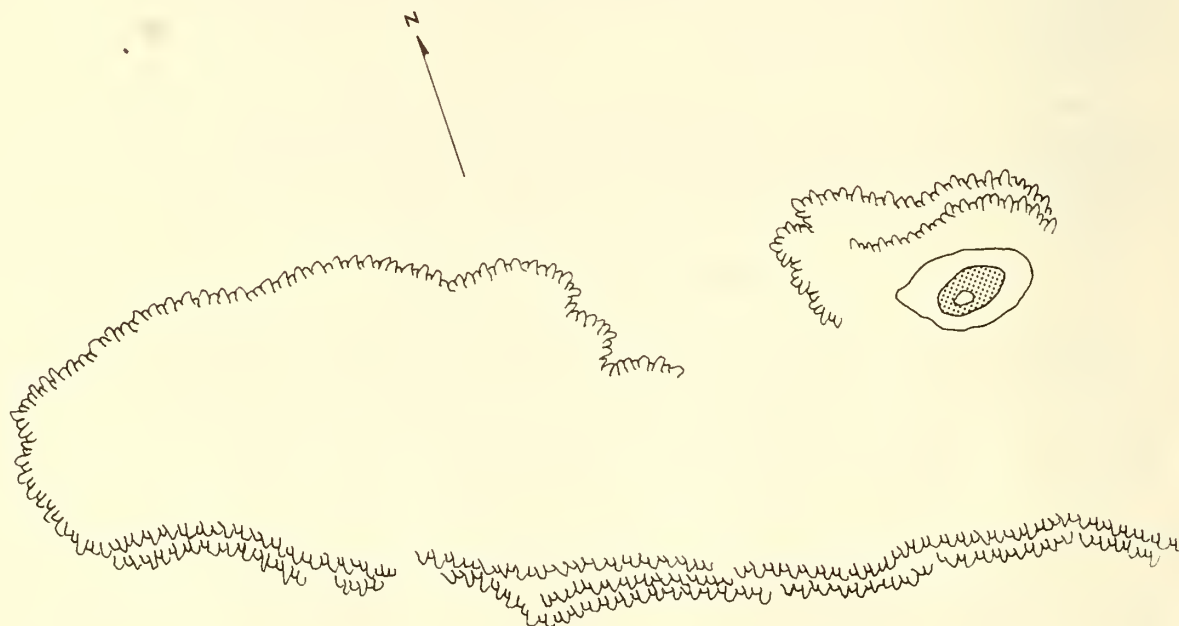


Figure 24. Round Island, 24 June 1932. Redrawn from official U. S. Navy photograph.

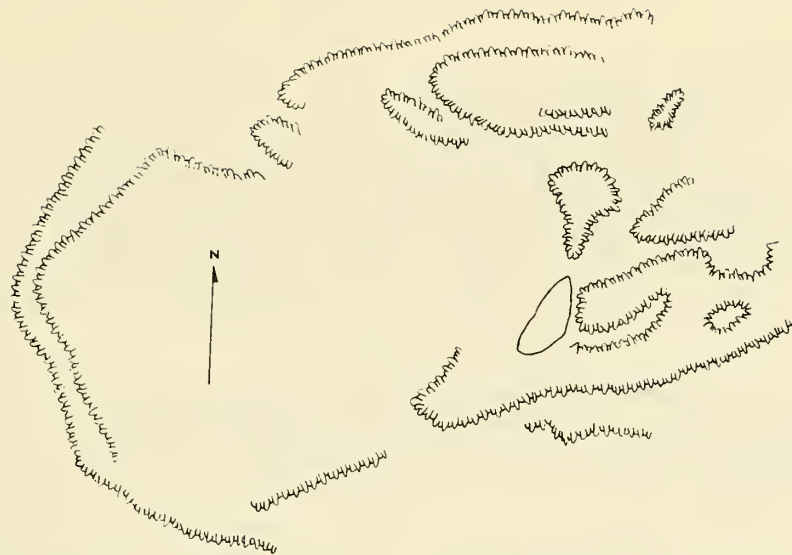


Figure 25. Shark Island, 10 January 1966. Redrawn from official U. S. Navy photograph.

Figure 26. Disappearing Island, 10 January 1966. Redrawn from official U. S. Navy photograph.



Disappearing Island

Disappearing Island (Fig. 26) is located at the southwestern tip of the atoll's crescent reef at 23°38'N x 166°10'W. The island is 8 to 10 feet high, 700 feet long from northwest to southeast and 505 feet at its widest point. Its composition is of fine to medium-sized coral sand and broken shell; no vegetation occurs. It covers an area of 6.2 acres.

The 1923 Tanager Expedition did not visit Disappearing but passed it in the ship on 28 June. Wetmore (ms.) noted that "it was apparently a bare sand spit 300 yards long with no indication of vegetation."

Bare Island

Bare Island is located half a mile northeast of East at 23°47'N x 166°12'W. It is awash at high tide and is usually about 100 feet long, 10 feet wide, and 4 feet high. It covers an area of 0.1 acre. Wetmore (ms.) in 1923 described it as "60 yards long by 10 wide, merely a ridge of sand rising 5 feet above the water and evidently swept" by waves. Palmer (1927: 30) found its area to be 0.1 acre.

Near Island

Near Island, at 23°48'N x 166°14'W, is located 1-1/2 miles northwest of East. It is a very small oval sandbar, covering only 0.1 acre, which is normally awash at high tide. The island was not present in 1923, but was noted in 1928 by USCGS personnel.

Three unnamed islets

Three unnamed islets, each very small and awash at high tide, presently exist. One is located 1/4 mile northwest of Trig; this islet was present in 1923 (Palmer, 1927: 29-30). A second islet, also present in 1923 (Palmer, 1927: 29-30), is located just north of Gin. The third islet is located about a mile south of Little Gin. Other islets at times have appeared about a mile north of Gin. In 1923 Palmer (1927: 29-30) noted two others just east of Trig.

GEOLOGY

French Frigate Shoals, like the rest of the Northwestern Hawaiian Islands, was produced by volcanic upheavals which formed a mountain ridge, rising some 2,500 fathoms above the ocean floor. The atoll was once an exposed top of a volcanic mountain, but all that remains are two small exposed volcanic

remnants and a coral reef, supporting sand islands, which has grown around them. The exposed coral reef, which is double and crescent shaped, rises from an 18-mile-long, shallow, oval platform. It sits atop an underwater cone which rises above a 155-mile-long ridge some 500 fathoms deep. This ridge drops off on all sides to a depth of 2,000 fathoms, and deeper.

Palmer (1927: 31), who visited the Shoals in June 1923 as a member of the Tanager Expedition, thought the reef and shallow platform were "the sea level extent of a former conical volcanic island." He suggested that "probably the original volcanic island was somewhat smaller than the area indicated, for the shoal may have been widened two or three miles by a terrace built of debris eroded from the volcano....Erosion by streams and waves leveled off the cone except for the residual La Perouse Rock, which, eventually, will also be removed." Palmer thought the leeward reef was older than the windward reef and stated that "the windward reef, lying in the direction from which the food-bearing currents come, has better nourished reef organisms and therefore has grown more vigorously." He pointed out that the extremities of the windward reef had joined those of the leeward reef, enclosing a lagoon. Finally, he predicted "that the leeward edge of the shoal will develop a reef making a nearly circular atoll or ring of a reef at some time in the future." Earlier Walker (1909) forecast the same thing; in 1891 he had found "that the N.W. horn of the crescent is rapidly extending, and in course of time will no doubt assume a circular form."

The most prominent feature of French Frigate Shoals is the centrally located volcanic remnant, La Perouse Pinnacle. Palmer (1927: 30-31) landed on this precipitous rock, noted that the lava flows dip one to two degrees to the northwest, collected two rock samples, and later described them, as follows:

One is a dark gray, vesicular olivine basalt. The vesicles are rather abundant, roundish, and 0.5 to 3 mm. in diameter. The olivine phenocrysts are somewhat rusty and range from 0.2 to 2 mm. in diameter. Under the microscope the olivine phenocrysts are seen to be fairly idiomorphic, and to contain small inclusions of magnetite. There are no other phenocrysts. The groundmass consists of feldspar laths with intersertal augite and glass [See Table 1, sample 1]. The other specimen is also an olivine basalt, medium gray in color, and with only a few vesicles. Under the microscope the olivine phenocrysts show resorption

rims and bays which indent the otherwise idiomorphic outlines. There are also a few phenocrysts of augite, some of which appear to have been granulated by movement of the lava. Magnetite inclusions are rather common in the olivine phenocrysts but rare in the augite phenocrysts. The groundmass is composed of feldspar laths with intersertal augite, and a little magnetite, but with no glass.

Washington and Keyes(1926: 348-350) analyzed these two rocks (Table 1) and found they were almost identical and noteworthy chiefly for their low SiO₂ and high MgO. This analysis was similar to that of the olivine basalts of Nihoa and Necker Islands, and like some of those in Hawaii.

Table 1. Chemical analysis of laval rock from La Perouse Pinnacle collected by Palmer in June 1923 and analyzed by Washington and Keyes(1926: 350).

Chemical	Sample 1	Sample 2
SiO ₂	44.58%	45.67%
Al ₂ O ₃	11.38	11.30
Fe ₂ O ₃	3.08	1.77
FeO	6.12	7.99
MgO	17.30	15.95
CaO	9.39	9.34
Na ₂ O	2.21	1.98
K ₂ O	0.41	0.52
H ₂ O+	0.49	0.76
H ₂ O-	1.52	0.56
CO ₂	0.00	0.00
TiO ₂	2.90	3.15
P ₂ O ₅	0.53	0.41
Cl	0.05	0.09
MnO	0.14	0.13
	<u>100.10%</u>	<u>99.62%</u>

Seventy-five percent of the land at French Frigate Shoals, excluding La Perouse, is located in the northern half of the atoll. This is the antithesis of land distribution in the three northwesternmost Hawaiian atolls--Kure, Midway, and Pearl and Hermes--which Standen (1967: 8) found to be 99 percent in the southern half of the atoll. He theorized (pp. 87-89) that land distribution is greatly affected by infrequent winter storms with high winds from the northwest, and not by the normal summer trade winds. He concluded that this land forms in the lee of such northwest winter winds, adjacent to and north of the south and southeast reef, and with its main axis perpendicular to these winds.

Although land distribution at French Frigate Shoals is different from the other three Hawaiian atolls, the location of the islands themselves follows Standen's theories of distribution. The differences can be attributed to different wind conditions and to the shape of the atolls.

At French Frigate Shoals winter storms with winds over 40 knots are infrequent and vary in direction; northern and eastern factors predominate, thus it can be said that winter storms are generally from the northeast. The normal trade-winds are from the east. French Frigate's crescent-shaped outer reef has tips pointing west; another irregular inner reef joins these two tips (Fig. 2). The two reefs thus form a convexo-concave atoll, which is skewed from northeast to southwest; the lagoon is open to the west.

Using Standen's theory, an island formed from infrequent winter high winds from the northeast should have its main axis running from northwest to southeast and should be located in the lee of such northeast winter wind. Five of the larger sand islands--Disappearing, East, Gin, Little Gin, and Whale-Skate--bear out Standen's theory. The other larger sand islands--Trig and the original Tern--have their axes running east to west. The other five sand islands--Bare, Mullet, Near, Round, and Shark--are just small islets, mostly awash at high tide. The four northernmost islands--Shark, Tern, Trig, and Whale-Skate--are situated between the double portions of the outer reef; in each case the island is in the lee of northeast winds and the inner portion of the double reef is adjacent to and just south of each island. Seven of the remaining eight sand islands are scattered along the northeast border of the irregular inner reef; each island is adjacent to and northeast of exposed reef. The twelfth sand island is located at the west tip of the south point; it too is adjacent to and northeast of the reef. Thus Standen's rules apply to the position of all sandy islands at French Frigate.

Palmer (1927: 30) noted that "the portion of the [sandy] islands above sea level consist of loose sand, with small bodies of indurated sand. Much of the sand at or below sea level is hardened into a sandstone." POBSP personnel found that the soils at French Frigate Shoals range from pure coral sand and gravel, including broken sea shells, through coarse coral rock rubble on the beaches, to a mixture of coral sand and some humus in the vegetated areas. Guano deposits are found only on La Perouse Pinnacle. No fresh water exists on any of the islands; perhaps brackish water can be obtained by digging shallow wells on the larger islands.

CLIMATE

The first climatic data from French Frigate Shoals were gathered in 1943 when the U.S. Naval Air Facility was established. When this unit was phased out after World War II, the data were taken by personnel of the U.S. Coast Guard LORAN Station. The information used in this section is from a summary of the years 1951 through 1962 (Air Weather Service [MATS] Climatic Center, USAF).

In this region of the Pacific, climate is marine and tropical in nature. French Frigate Shoals is influenced most of the year by the Pacific High, with easterly trade-winds prevailing. During winter this High is slightly affected by the Aleutian Low which moves south to the Kure-Midway-Pearl and Hermes area, bringing increased and variable winds and increased precipitation.

The mode of the mean monthly temperatures for the 12-year period from December 1950 to December 1962, and the range of the maximum and minimum modes are presented in Figure 27. The temperature variation shown is typical of a tropical marine environment. The mean annual temperature is 75.5°F; the mean annual range is 10°F. From December through April the means are between 71°F and 74°F, and during the rest of the year between 75°F and 80°F. The warmest months are August and September, and the coolest February and March. A 37-degree difference exists between the extreme high of 91°F and the extreme low of 54°F for this 12-year period.

Mean monthly precipitation in inches and the mean number of days with measurable precipitation are shown in Figures 28 and 29. The mean annual precipitation for June 1954 to January 1960 and for March 1960 to December 1962 was 45.29 inches. Rainfall was heaviest from December through March;

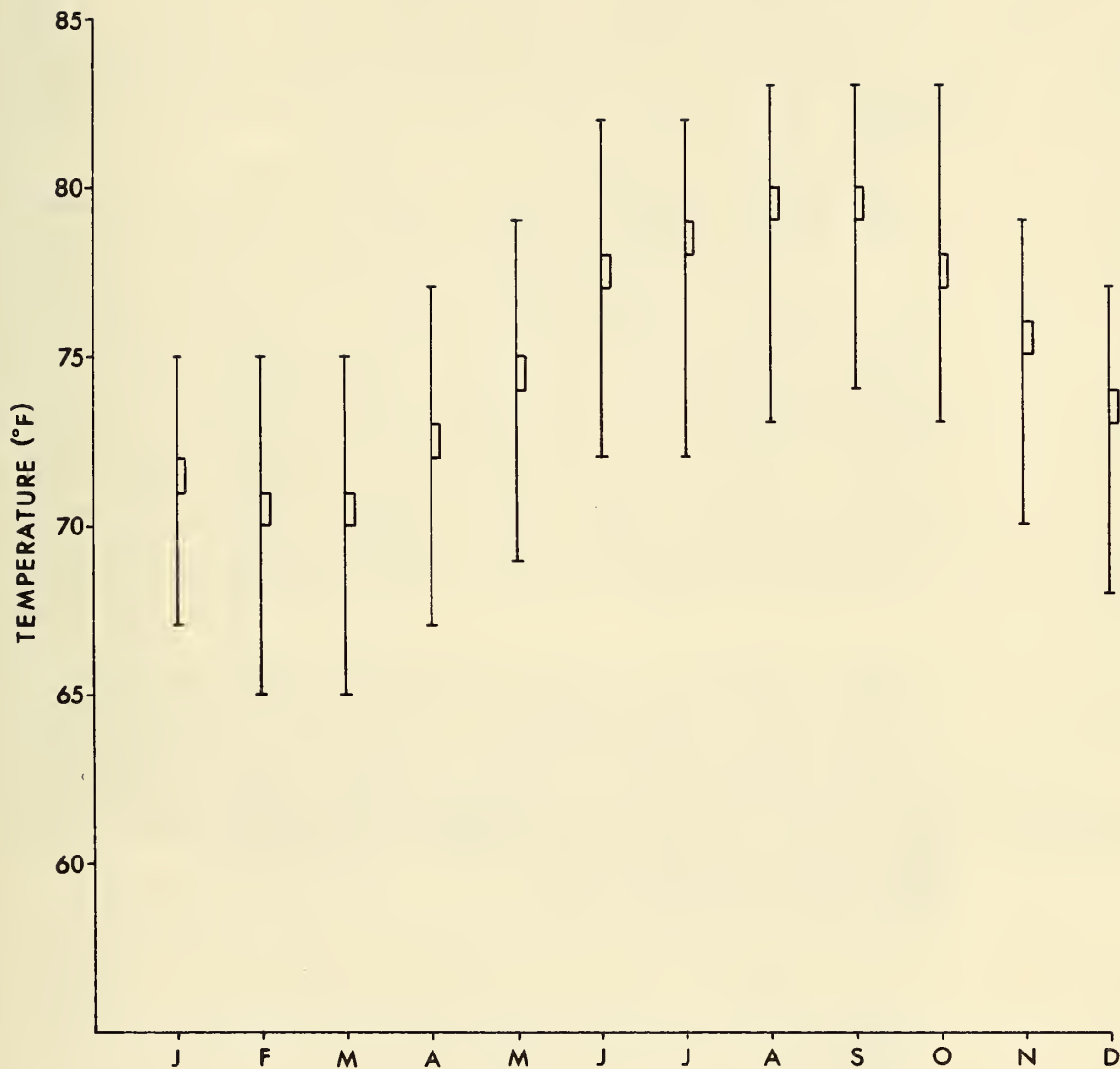


Figure 27. The mode of the monthly means for a 12-year period, December 1950 - December 1962, and the range of the maximum and minimum modes of temperature for French Frigate Shoals.

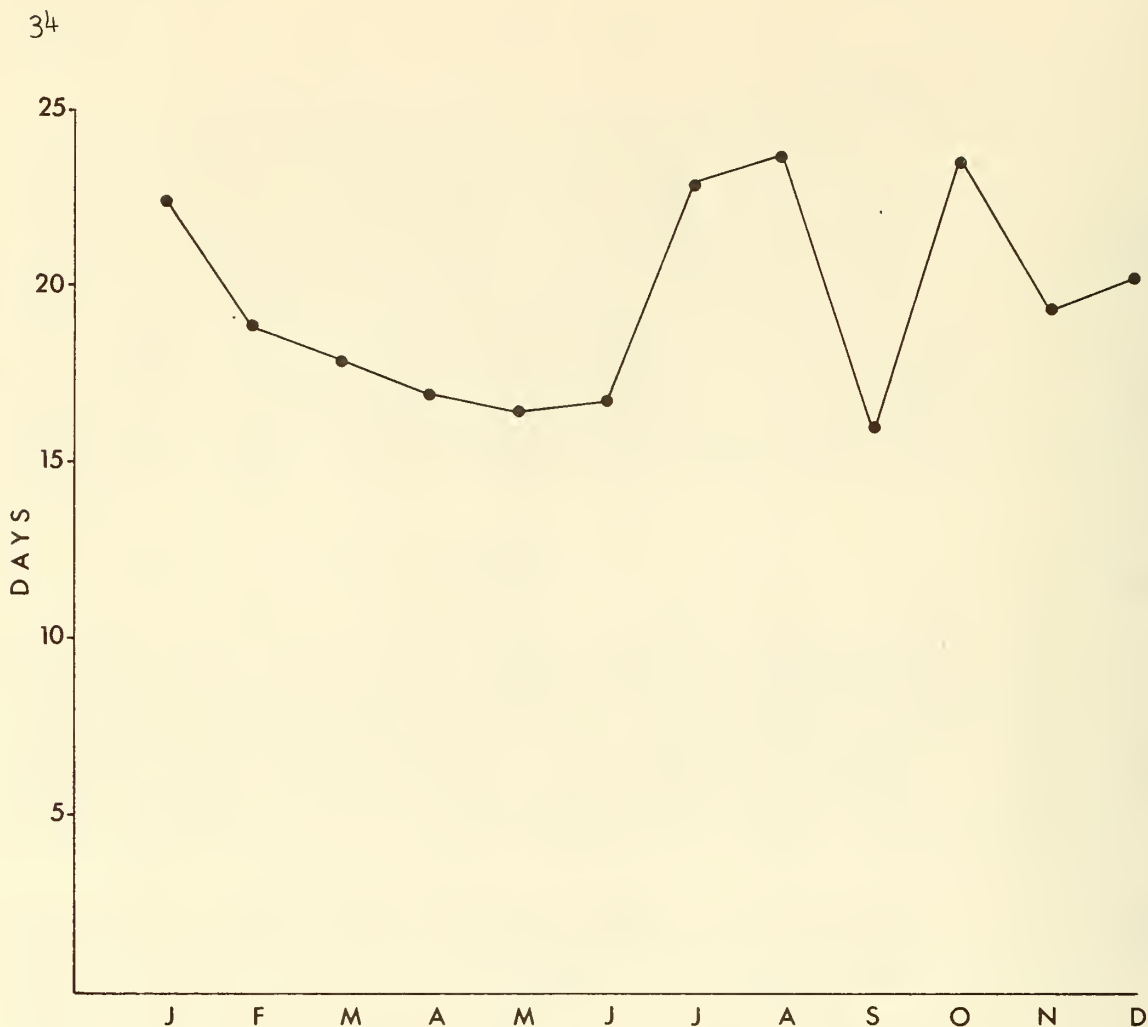


Figure 28. Mean number of days with measurable precipitation for French Frigate Shoals, June 1954 - January 1960, March 1960 - December 1962.

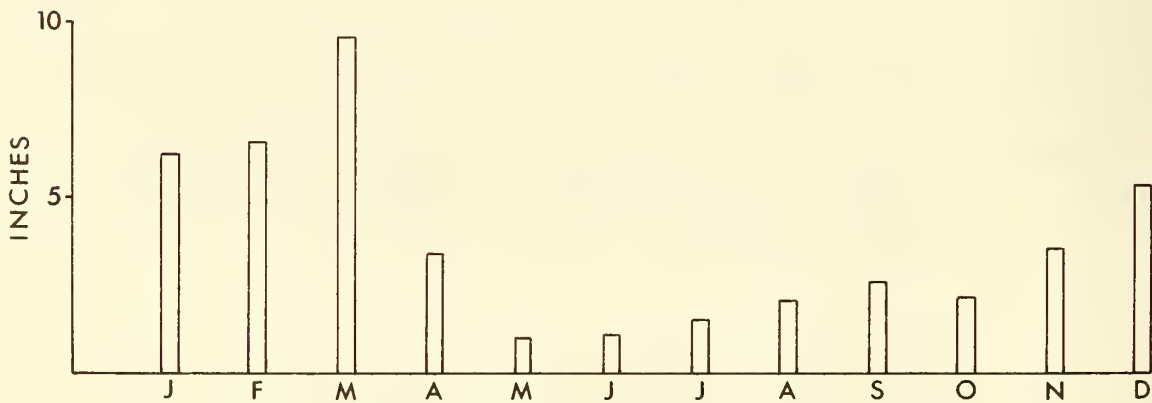


Figure 29. Mean monthly precipitation in inches for French Frigate Shoals, June 1954 - January 1960, March 1960 - December 1962.

a maximum mean of 9.55 inches occurred in March. It was lightest from April through November, with a minimum mean of 1.03 inches in May. Measurable precipitation occurred on at least 16 days each month; it was more frequent (20+ days), however, in July, August, October, and January, and least frequent from February through June, and September. Thunderstorms have been recorded only in April and December.

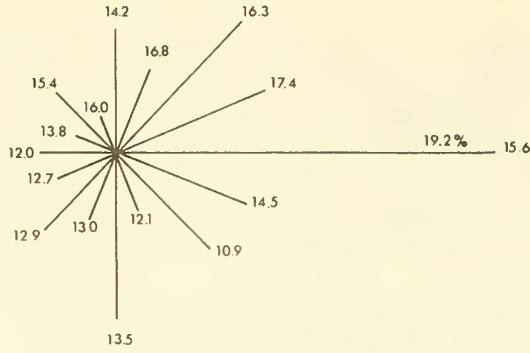
Severe tropical storms or typhoons are rare in the Hawaiian Islands. In August 1950, however, the area came under the influence of such a storm. "Able," "Hiki" in Hawaiian, the first Hawaiian typhoon in 45 years of records, passed just south of French Frigate Shoals. The closeness of this storm forced evacuation of the East Island USCGS LORAN Station from 16 to 24 August; damage to the station was negligible (U.S. Dept. of Commerce, 1950). Another typhoon, "Dot," forced evacuation of the Tern Island LORAN Station from 5 to 9 August 1959; there was no storm damage (Fed. Rec. Cen., Md., Log, 61A275, Box 111). Winter storms were common, causing a noticeable increase in precipitation, winds, and high seas. Such storms included those of October and November 1946, of January 1949, 1953 and 1954, and of September 1957.

The maximum sustained wind record for French Frigate Shoals for the period 1951 through 1962 was 52 knots from east-northeast in December. The annual mean windspeed was 12.6 knots, with a range of 5 knots. Mean monthly windspeeds were higher than the annual mean from November through April, and lower from March through October.

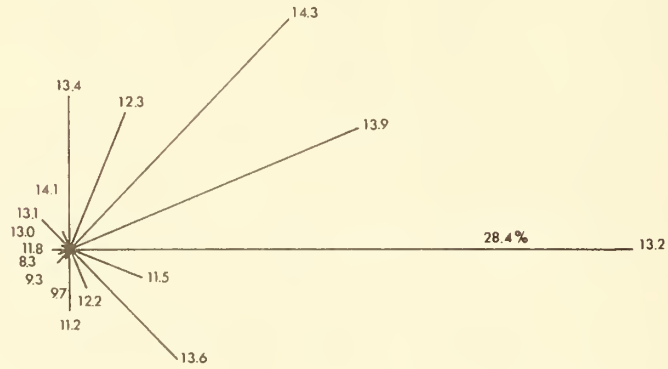
Surface windspeeds and directions for winter (December through February), spring, summer, and autumn are shown in Figure 30. The prevailing wind direction for each of these seasons, as well as for each month during the year, is easterly. During winter the mean windspeed is 14.3 knots; winds are high from all directions; the highest are from northwest to east-southeast, with a mean maximum from the east-northeast. The spring mean windspeed is 13.1 knots; winds are highest from west to south, with a mean maximum from the northeast. During summer the mean windspeed is 11.5 knots; winds are highest from northeast to east-southeast, with the mean maximum from the east. The mean autumn windspeed is 11.6 knots; the highest winds are from the west-northwest and northwest, and north through south-southeast, with the mean maximum being from the northeast.

The mean, in tenths, of total sky cover is almost uniform throughout the year, ranging from a low of 4.6 in February to a high of 5.2 in July and August; the annual mean is 4.9. The occurrence of fog and haze is negligible, but traces, due to heavy rain, are found from December through March.

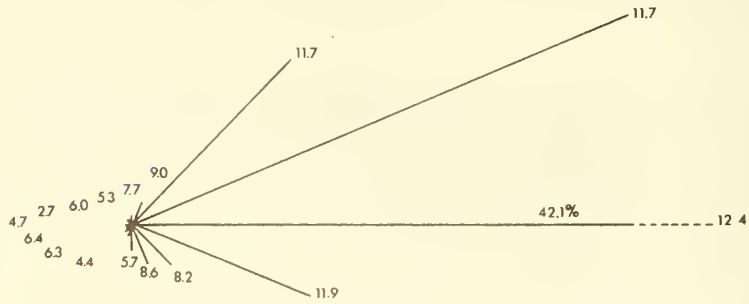
Winter



Spring



Summer



Autumn

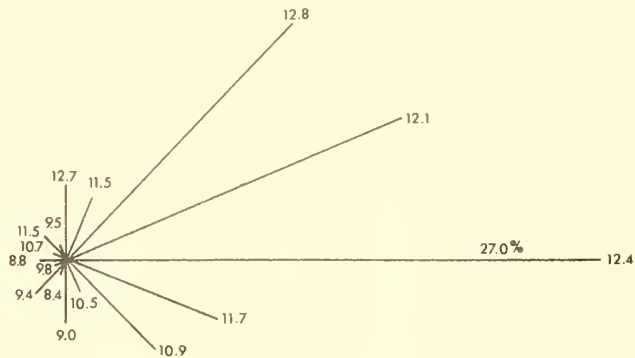


Figure 30. Wind direction and speed at French Frigate Shoals from December 1950 to December 1962. Length of directional line indicates percent of observations from that direction; figure at end of directional line is mean wind speed in knots.

Hydrographical surveys were conducted in 1859, 1914, and 1928 by the U.S. Navy and U.S. Coast and Geodetic Survey. K.T. Adams (USCGS Archives, Special Report, 1928), who headed the July to October 1928 survey, found the area inside the shoals to be very foul with coral heads; he felt that no anchorage should be recommended inside the reef for vessels not willing to pick their own way through the shoals. His chart (USCGS 4172) shows a lagoon depth of from 1/4 to 10 fathoms. The average depth appears to be about 3 fathoms and the bottom is covered with white coral sand.

To the west of the crescent-shaped reef and associated lagoon is an area of from 5 to 20 fathoms. There are numerous coral heads 1 to 5 fathoms below the surface at the intersection of the two areas. The bottom throughout this western area is coral and hard sand; this area provides good anchorage and offers excellent protection from the north, northeast, east, and southeast.

USCGS Chart 4172 reports a tidal range of 2.4 feet. Adams (USCGS Archives, Special Report, 1928) made no specific current observations in 1928, but noted some generalities.

A few miles inside of and north of the southwestern horn of the reef the current sets north-west and west, with quite a velocity. At the anchorage near East Island a slight current sets west. Just north and east of the northwestern horn of the reef the current sets west quite strongly. Outside the barrier reef and to the eastward the current sets north, and to the north-east of the reef the current sets northwestward. The current is strongest at about the hundred fathom curve and the steeper the slope of the bottom the stronger the current. In fact, outside the barrier reef the current seemed to flow counter clockwise and about parallel to the reef....On our deep sea sounding lines in the open ocean we have noticed a constant westerly set. This set varies from one or two tenths to four or five tenths of a knot and the direction is from west to west-north-west. This set differs over the shoals and appears to have no regular formula. For instance, over a small shoal area in the open sea which has recently been developed we encountered a set from NW to NNW with about an ENE wind.

Tidal waves from distant earthquakes and ground swells from distant storms infrequently affect French Frigate Shoals. A tidal wave on 1 April 1946 completely inundated the islands in the atoll; damage to the military stations was light; its effect on nesting wildlife was unknown. Another occurred on

4 November 1952; a wave 15 feet high was observed one-fourth mile offshore but broke up on the reefs. Still another caused a 3-foot rise in the water level on 27 March 1954. Ground swells, caused by a distant storm, severely damaged the Tern Island airstrip and Coast Guard facilities on 1 December 1969; nothing is known of its effect on the wild-life (Amerson, in prep.).

HISTORY

Although there are no records in historic Hawaiian lore, the earliest visitors to French Frigate Shoals probably came from the nearby Hawaiian Islands to the east which are known to have been settled by Polynesians between 1100 and 1300 A.D. (Emory, 1928). The Spanish and Portuguese began exploring the Pacific following Magellan's successful crossing in the 1520's. Early sailing vessels followed the Equatorial Current westward and the North Pacific Current eastward and the Hawaiian Islands were seldom, if ever, visited. Many writers believe that it was not until January 1778 that Captain James Cook, an Englishman, discovered the Sandwich (Hawaiian) Islands. Other Europeans soon visited the area.

A French Discovery

The discovery of French Frigate Shoals on 6 November 1786 was almost marred by disaster. The French explorer Jean François de Galaup, Comte de la Perouse, aboard his frigate, the Broussole, accompanied by the Astrolabe, was sailing westward on a tranquil sea from Monterey to Macao. At 0130 hours men on both ships sighted breakers directly ahead at a distance of only 2/10 mile. Both vessels were immediately brought about and headed south-southeast, passing as close as 1/10 mile to the breakers (La Perouse, 1799).

At daybreak, both ships reversed course, and at 0800 breakers were sighted north-northwest. Soon "a small island, or cleft rock, fifty toises [100 yards] at most in diameter, and about twenty or twenty-five [40 or 50 yards] in height" was sighted (La Perouse, 1799). Many years later this rock was named La Perouse Pinnacle after its discoverer.

La Perouse examined only the southeastern half of the atoll, as shown in his original 1786 map (Fig. 3) published in Paris in 1796 (French Hydrographic Office, Map. No. 556). He thought the rock was at the extreme northwest end of the reef and found only three sand-banks no more than four feet high. Before leaving he named his new discovery Basse des Frigates Françaises, or Shoal of the French Frigates.

Several variations of la Perouse's original name have been used over the years: French Frigate Shoal, French Frigates Shoal, and French Frigate Shoals. The most recent ruling was in July 1954 when the U.S. Board of Geographic Names adopted French Frigate Shoals.

United States Possession

During the late 1700's and early 1800's European and American traders called at the larger Hawaiian islands and by 1825 Honolulu had become the most important port in the entire Pacific. The United States became more and more interested in the Pacific and in August 1838 the United States Exploring Expedition put to sea under command of Lt. Charles Wilkes. This expedition spent some six months in the Hawaiian area; on 3 December 1841 they sighted French Frigate Shoals but were unable to land due to bad weather.

In early October 1858 the U.S. Schooner Fenimore Cooper, commanded by Lt. John M. Brooke, U.S. Navy, left San Francisco to sound out a route via Hawaii to Japan for a possible underwater telegraph cable. The Fenimore Cooper visited French Frigate Shoals from 3 to 7 January 1859; Brooke took depth soundings and charted the various islets for the first time. More importantly, however, Lt. Brooke took formal possession of French Frigate Shoals for the United States on 4 January in accordance with the U.S. Guano Act of August 1856 (U.S. Nat. Archives, R.G. 48).

The first complete published map of French Frigate Shoals resulted from the Fenimore Cooper's visit. Made under the direction of Lt. Brooke, it appeared in 1867 as H.O. Map No. 2.

Guano and Shipwrecks

Brooke also reported the discovery of guano at French Frigate Shoals, a fact which produced much excitement in Honolulu among guano investors. The bark Gambia sailed to the Shoals on 5 March 1859 and on the 23rd the American clipper ship Modern Times also set sail (Polynesian, 5 March 1859, 2: 3; Pacific Commercial Advertiser, 24 March 1859, 2: 1). Both ships returned with disappointing news concerning the size of the deposits and the cost of their removal.

The first wreck recorded on the Shoals was of the American whaling ship South Seaman, which wrecked on 13 March 1859. Fortunately the Hawaiian schooner Kamehameha IV was in the area and brought back to Honolulu 12 of the South Seaman's crew. The remaining 30 or so crewmen were left on one of the islands until the Kamehameha IV (chartered by the American consul) returned to pick them up. (Pacific Commercial Advertiser, 31 March 1859, 2: 1, 3).

The Gambia, under the command of Captain N.C. Brooks, again visited French Frigate Shoals in late April or early May 1859. While at the Shoals, Brooks noted an abundance of seals, turtle, fish, and birds and later described the atoll (Brooks, 1860).

A second ship, the brig Wanderer, bound from Honolulu for Japan, was totally lost on the night of 1 September the same year. The Wanderer's crew was also rescued by the schooner Kamehameha IV.

On 14 April 1867 French Frigate Shoals was the site of the shipwreck of the bark Daniel Wood. All of the crew managed to reach one of the islands. On the 16th Captain Richmond, the second mate, and 6 men embarked for Honolulu in one of the ship's whaleboats, leaving 27 shipmates behind. They landed at Honolulu on the 24th. The U.S.S. Lackawanna was dispatched by the American Consul to rescue the rest of the crew (The Friend, May 1867, 37: 1-3). On 20 May the schooner Malolo sailed for the Shoals in search of the wreck of the Daniel Wood. The Malolo returned to Honolulu on 22 June without finding a trace of the wrecked ship (Pacific Commercial Advertiser, 25 May 1867, 2: 1; 29 June 1867, 2: 1, 2: 2, 3: 5).

When U.S. Naval Hydrographic Office Maps 2, 3 and 4 showing the entire Northwestern Hawaiian Islands in detail were published in 1867, other countries became interested. The Japanese soon began to fish in the area.

The Japanese-owned American-chartered schooner Ada, working out of Yokohama, visited French Frigate Shoals from 3 February to 1 May 1882 (Hornell, 1934). It left the Shoals with a cargo of sharks' flesh, fins and oil, turtle shells and oil, dried bêche-de-mer and birds' down.

In early 1888 the schooner Wandering Minstrel, with Captain Walker, his wife and three sons aboard, spent a week at French Frigate. This was the first record of a woman visiting the Shoals (Farrell, 1928).

The first biological survey of French Frigate was made by Henry Palmer and George C. Munro aboard the Hawaiian bark Kaalokai 30 May to 5 June 1891 (Walker, 1909). During late spring 1894 the yacht Ebon, commanded by John Cameron, anchored at the Shoals. With him were his wife, daughter, a friend's child, servant, and crew (Farrell, 1928).

The North Pacific Phosphate and Fertilizer Company was interested in mining guano on the central Pacific islands. A letter from J.P. Hackfeld, secretary of the company, dated

6 January 1894, to James A. King, Minister of the Interior of the new Republic of Hawaii, requested that King order the lease by public auction of French Frigate Shoals, Kure, Midway, and Pearl and Hermes Reef for a term of 25 years and that the purchaser should have the exclusive right to mine guano, phosphate, fertilizers, and other materials.

The islands were leased on 15 February 1894 for a period of 25 years to the North Pacific Phosphate and Fertilizer Company.¹ This company was also granted exclusive rights to the guano deposits provided they would be worked within five years; otherwise, the rights would revert to the Hawaiian government. Since the Pacific Guano and Fertilizer Company never worked French Frigate Shoals, their guano rights presumably reverted in 1899; their lease, however, was probably valid.

Hawaiian Control

In order to obtain clear titles to the northwestern islands for the Republic of Hawaii, President Sanford B. Dole on 9 July 1895 appointed James A. King, Minister of the Interior, Republic of Hawaii, as Special Commissioner to take possession of French Frigate Shoals. On that same date, King sailed from Honolulu on the Revenue Cutter Lehua, commanded by Captain Berry, in pursuance of President Dole's commission. King (Hawaiian State Archives), in a subsequent letter to Dole on 22 July, noted that the Lehua sighted the rock islet of French Frigate Shoals on 13 July, that he landed and took possession; on a nearby sand island they planted the Hawaiian Flag.

On 22 February 1896 the sealing schooner Mattie E. Dyer wrecked. Captain Mockler and his 23 crewmen were able to get to the largest island in four whaleboats. Finding no water, they set out for Niihau; all arrived safely by March 2nd (Pacific Commercial Advertiser, 2 March 1896, 1: 5-6, 2: 1-2; and Hawaiian Gazette, 3 March 1896, 3: 1-3).

United States Territory

The U.S. Navy, as well as other U.S. Government agencies, became interested in the Northwestern Hawaiian Islands in the late 1890's and early 1900's. Hawaii became a United States

¹ This company changed its name to the Pacific Guano and Fertilizer Company on 3 April 1894.

Territory on 30 April 1900.¹ On 28 and 29 May 1902 the U.S. Fish Commission Steamer Albatross stopped at the Shoals; among their activities was wildlife survey.

A French ship, the Connetable de Richmond, wrecked at the Shoals on 10 October 1903. All hands escaped in three boats and arrived safely in the Main Hawaiian Islands by the 27th (Paradise of the Pacific, 8 November 1903, 8: 2; 9: 1).

Preservation of wildlife was of prime importance in the early 1900's and President Theodore Roosevelt signed an Executive Order on 3 February 1909 setting aside all the Northwestern Hawaiian Islands, except Midway, as a preserve and breeding ground for native birds. This preserve, to be known as the Hawaiian Island Reservation, was to be administered by the Department of Agriculture.²

Subsequently, U.S. Revenue Cutter Service vessels were used to patrol the area for bird poachers. The USRC Thetis made several trips to the islands. Her stops at French Frigate Shoals include 19 December 1912, 9 September 1914, 20-21 March 1915, and 28 January 1916³ (U.S. Nat. Archives, Thetis log, R.G. 26). The USS Hermes visited on 4-5 September 1918 on a similar inspection survey (U.S. Nat. Archives, Hermes log, R.G. 45).

From 25 August to 30 September and from 10 October to 4 November 1914 the USS Rainbow conducted a hydrographic survey outside of the reef. The subsequent map, first printed in June 1915, is considered to be the first modern map of French Frigate Shoals (U.S. Nat. Archives, Cartographic Div., R.G. 37).

¹ The City and County of Honolulu hold jurisdiction over French Frigate Shoals by virtue of Section 1717 of Chapter 118 in the Revised Laws of Hawaii dated 1925 (see also Morris, 1934). The atoll also became part of the State of Hawaii when the Territory of Hawaii was admitted as the 50th State in the Union on 21 August 1959 (Percy, 1959; U.S. Dept. of State, 1965).

² In 1940 the preserve was transferred to the Department of the Interior.

³ Other inspection trips included those by the USS Pelican on 8 May 1924, the USRC Itasca of 9-10 February 1931 and 20 June 1934, and the USCGC Reliance of 4 to 6 March 1936.

Despite the availability of such maps, another ship, the Churchill, ran aground and caught fire just before midnight on 25 October 1917. Fortunately the sampan Makiawa was fishing nearby and all crewmen were saved (Honolulu Star Bulletin, 30 October 1917, 1: 6-7, 2: 1-2). Eight persons returned aboard the J.A. Cummins to salvage whatever possible from the wreck; they stayed from 2 to 9 November but left with only 12 bags of wet and sand-covered copra. The ship was completely broken up as a result of a severe storm (Tucker, 1917).

As part of a biological survey of central Pacific islands, the Tanager Expedition, with 11 scientists, visited the atoll from 22 to 28 June 1923. Alexander Wetmore was the field director for this survey; his unpublished field notes (Wetmore, ms.) reveal details on the avifauna present as well as a description of each island. Many scientific collections were made. This survey was the first overall scientific survey of French Frigate Shoals.

The U.S. Coast and Geodetic Survey Steamer Guide conducted a complete hydrographic and topographic survey of French Frigate from 11 to 19 May, 5-23 July, 3-21 August, and 8-29 September 1928 (U.S. Nat. Archives, Guide log, R.G. 27). The current charts, numbers 2922, 4171, and 4172, were drawn from the combined 1914 and 1928 survey data.

While the Guide was conducting its survey of French Frigate Shoals, correspondence took place concerning publication of the final chart. On 8 June 1928--prior to the Guide's first return to Honolulu--J.H. Peters, Officer in Charge, U.S. Coast and Geodetic Survey, Honolulu Field Station, wrote a letter to the Commandant, U.S. Naval Station, Pearl Harbor, in which he pointed out "that French Frigate Shoals might be a very important point in case of a war between this nation and some power to the westward which would require troop movements in that direction. Preliminary descriptions indicate a long area suitable for anchorage of large vessels . . . which would be protected from prevailing winds as well as many smaller vessels such as submarines or destroyers . . . which would be protected from all winds. There appears to be sufficient land area for the construction of a landing field and any amount of shallow quiet water for the use of seaplanes." Peters noted that the results of this survey were to be published but suggested that, since the atoll was of so little commercial value and of such great military potential, it would be wise for the Navy Department to request the Commerce Department to keep the results of the survey confidential.

From a subsequent letter from R.S. Patton, Acting Director, U.S. Coast and Geodetic Survey, to the Hydrographer, U.S. Hydrographic Office, dated 14 July 1928 (U.S. Nat. Archives, Mod. Mil. Hist. Div., R.G. 37, QH 78/41-18, 95026), it is learned that the Secretary of the Navy requested the Secretary of Commerce to treat the chart for French Frigate Shoals as confidential. Patton pointed out that no chart had yet been constructed and that a large-scale chart would not be published without first consulting the Navy Hydrographic Office. The French Frigate Shoals survey was, however, "being performed for the purpose of safeguarding trans-Pacific commerce...[and] navigation."

On 22 June 1932 the U.S.S. Quail (AM 15) anchored at French Frigate Shoals; the ship's seaplane was hoisted into the calm waters near East Island on the 23rd; it took off and photographed the islands within the sprawling atoll. The next day it was up again, and on the 25th the ship departed for Pearl Harbor. The resulting photographs were the second set of aerial photographs to be taken of the shoals (U.S. Nat. Archives, Log of U.S.S. Quail for 1932, R.G. 24).

The June photographic mission paved the way for a coordinated plane-ship exercise by the U.S. Navy in August 1932 involving five ships and six seaplanes. Two ships anchored at the Shoals on the 17th; using the other three ships as guides, the planes arrived on the 18th. All departed for Pearl Harbor on the 20th. This exercise produced one of the first long-distance flights by U.S. Navy planes in the Central Pacific (U.S. Nat. Archives, Logs of U.S.S. Quail, Oglala, Breese, Gamble, and Montgomery for 1932, R.G. 24).

From 17 to 29 April 1933 a larger naval air maneuver took place. Thirty seaplanes, guided by seven ships, flew from Pearl Harbor to French Frigate Shoals, and on to Johnston Atoll; they returned by the same route (U.S. Nat. Archives, Mod. Mil. Hist. Div., R.G. 24, QU 78/41-18, 305598).

These 1932 and 1933 Naval air maneuvers were the forerunners of many such operations. From 7 to 28 May 1935 Phase Three of Fleet Problem Sixteen¹ utilized the Shoals as a training area; eight ships and 45 seaplanes took part in the exercise. The atoll provided the needed lagoon landing area for a mass flight to and from Midway; this was the first such long-distance flight by that many planes, which was even more significant since bombs were attached to their wings. Although two serious air

¹ The Annual Fleet Problem's purpose was to advance the training of the entire U.S. Fleet; conditions of war were to be simulated as nearly as practicable under peace-time training.

accidents occurred killing seven persons, the experience gained in this operation was of great benefit to naval aviation (U.S. Nat. Archives, R.G. 80, A 16-3--5-XVI; Grimes, ms.).

Other Naval training exercises utilized French Frigate Shoals in September and November 1935 and October and November 1936. A wooden cook shed and a "tent city" were constructed on East Island (Fig. 31). The Honolulu Advertiser reported portions of the November 1935 maneuver on the 11th (1: 6), 14th (5: 3), and 18th (1: 4); these were the first newspaper accounts of the usually secretive advanced base activities of the Navy's Pearl Harbor VP seaplane squadrons.

French Frigate Shoals was again used by the U.S. Fleet from 1 to 10 May 1937 for Fleet Problem Eighteen. East Island was used as a base camp and some nine ships and two seaplane squadrons participated. This fleet problem provided valuable data on aircraft anti-submarine activities, as well as important experiences in carrier tactics (Grimes, ms.).

Another U.S. Navy exercise, in which three ships and 33 seaplanes took part, was held in late October and early November 1937 (Fig. 32). The atoll's first recorded death, however, marred the exercise (U.S. Nat. Archives, Log of USS Langley for 1937, R.G. 24).

Part Five of Fleet Problem Nineteen, which took place from 25 to 30 March 1938 was also held at French Frigate Shoals. Some 25 ships, including five submarines, and numerous seaplanes, took part. Part Five demonstrated the possibilities of successful carrier-based air attacks on shore objectives (Grimes, ms.).

The Shoals was also involved in Part Six of Fleet Problem Twenty-One. From 13 to 21 April 1940 six ships and one VP squadron utilized the lagoon and surrounding ocean. This exercise also provided useful information and experience for naval aviators (Grimes, ms.).

World War II

When Japan attacked China in 1937 and increased its military activity in the Marshall and Gilbert Islands, tension mounted in the Pacific. Thus in February 1941 President Franklin D. Roosevelt issued Executive Order No. 8682 setting aside such islands as Midway, Wake, Johnston, and Palmyra as naval defensive areas (Bailey, 1956).

French Frigate Shoals was, however, not entirely forgotten. By 1940 it was considered so important to the United States

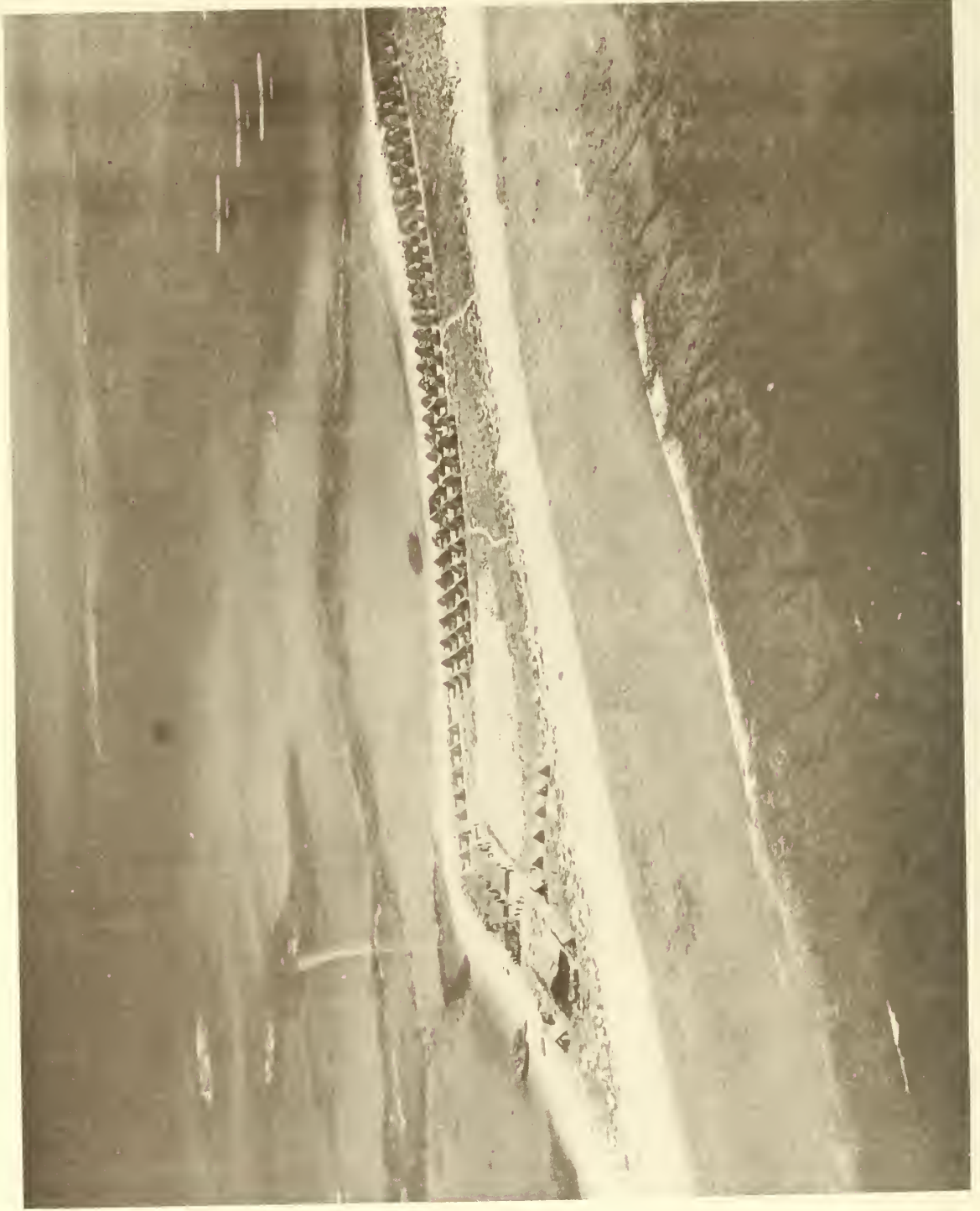


Figure 31. East Island "tent city," 11 November 1935. Official U. S. Navy photograph.

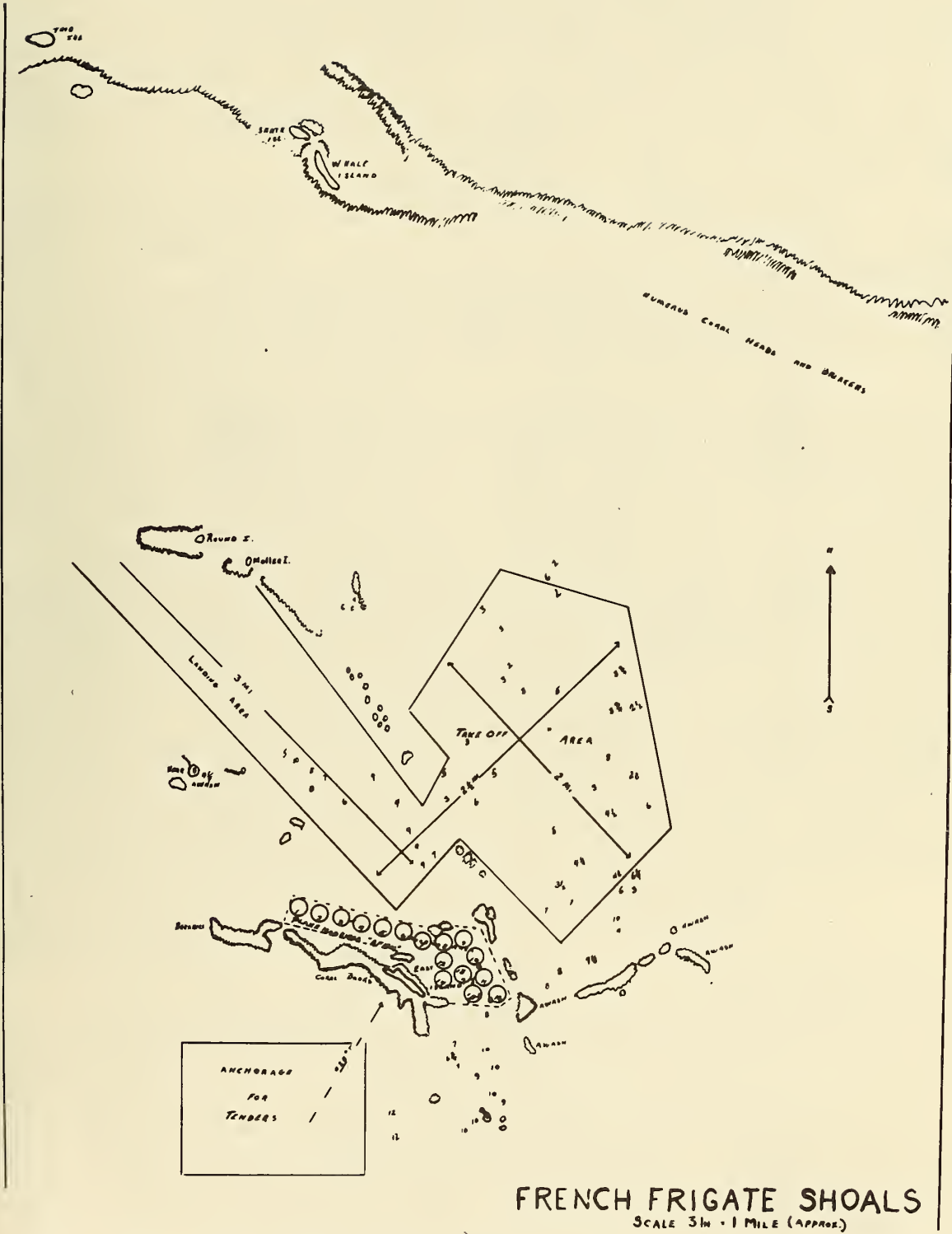


Figure 32. Map of East Island seaplane anchorage, 1 October, 1937. Official U. S. Navy photograph.

that only Hydrographic Chart No. 2, made from the 1859 survey, was issued to the public; the charts from the 1914 and 1928 surveys were classified (U.S. Nat. Archives, Mod. Mil: Hist. Div., R.G. 37, QH 78/41-18, 95026).

After the surprise carrier plane attack on Pearl Harbor 7 December 1941 by the Imperial Japanese Navy, the United States declared war on Japan on 8 December 1941.

The Japanese had not used French Frigate Shoals and it is doubtful that their warships had visited the atoll. When Japan captured Wake Island on 23 December 1941, however, they came into possession of a classified publication--"U.S. Naval Air Pilot, Pacific Islands, 1936"--from which they learned of the Shoals' excellent seaplane lagoon-landing capabilities.

On the night of 3 March 1942, the Japanese successfully used French Frigate's excellent lagoon as a rendezvous point for two submarines to refuel, as well as to load with bombs, two "Emilies" for a trial raid on Pearl Harbor. Suspecting the atoll's role in this raid, U.S. Navy experts mined the anchorage area on 3 and 8 April, placed a U.S. Marine detachment on East Island on 13 April, and ordered naval vessels to patrol the area beginning 13 May. Finding these deterrents on 26 to 31 May, three Japanese submarines called off a second Pearl Harbor reconnaissance. Thus the Japanese combined Fleet was forced to start its attack on Midway without knowledge of the whereabouts of the U.S. Fleet, which had secretly departed Pearl Harbor and headed north of the Hawaiian Chain for Midway. The stunning United States' victory at the Battle of Midway is now history. Had the Japanese captured Midway, however, they intended to seize French Frigate Shoals and use it as a staging area for raids on the main Hawaiian Islands (Layton, 1953; Lord, 1967; Shibuya, ms.; Amerson, in prep.).

Tern Island Naval Air Facility

Midway was still smoldering from the unsuccessful Japanese attack when one of the most secret projects in the Pacific Theatre was instituted. The Navy was determined that Midway be better protected (Woodbury, 1946) and decided on an air base at French Frigate Shoals as the means.

The idea of building a landing strip at French Frigate Shoals was considered prior to the Battle of Midway, but the decision to build was a direct result of the battle. The purpose of the airstrip was threefold. First, it would provide fueling and landing facilities for ferrying aircraft between Pearl Harbor and Midway. Fighter planes in 1942 did not have fuel capacity for the 1,300-mile trip to Midway and the Navy needed to get large numbers of planes to Midway in case the

Japanese struck again. Moreover, fighters could operate out of French Frigate Shoals to engage any enemy in the area. Second, it would serve as an emergency landing facility for either land or seaplanes. Third, it would be an outpost for the defense of Pearl Harbor; radio, radar, lookouts, and planes could detect and report any enemy activity in the area (R.M. Ricketts, ms.; Quaile, 1947; Anon., 1949).

Thus, Project "ME-36" (most often called "ME-6"), the Navy's code for the Naval Air Station Project at French Frigate Shoals, was born.

On 12 June 1942 a Navy vessel made a secret trip to the atoll to see if construction of a land base was feasible. The survey team, headed by Edward Brier, found very little land and thousands of seabirds, but decided a land base could be built by dredging and constructing a new island on the site of little Tern Island. The newly formed Seabees, along with the Hawaiian Dredging Company, were called upon to do the job. Men of Company B, Fifth Naval Construction Battalion, went to French Frigate in mid-July 1942 (Woodbury, 1946).

Dredging started on 13 August, and a 12,000 foot ship channel, 200 feet wide and 20 feet deep, was soon opened to Tern Island. Next, a seaplane landing area, 8,000 feet long and 1,000 feet wide, was cleared of coral heads adjacent to the island. Coral removed from these areas was dumped on Tern, covering the 1,800- by 450-foot original island. By November 1942, all dredging--660,000 cubic yards of coral fill--was complete; the island had been turned into a landing field 3,100 feet long and 350 feet wide, partially rimmed with 5,000 feet of steel sheet piling driven to a depth of 15 feet; it stood only 6-1/2 feet over the mean tide level (Fig. 33). By March 1943 ground facilities consisted of eight buildings, both above and below ground, 21 fuel tanks, and a 90 foot radar tower. The construction crew left on 21 March 1943; the new island had cost nearly \$2,000,000 (Beech, 1946b, Woodbury, 1946; Quaile, 1947; Anon., 1949).

To American naval pilots flying reconnaissance missions out of Honolulu in mid-1943, Tern Island suddenly took on a strange but familiar shape--that of an aircraft carrier. Although much larger than a regular carrier, the new island featured a "flight deck," with "storage decks" along its sides. Seen from a distance, the white water breaking over the extensive reef to the east gave a pilot the impression that the "coral carrier" was steaming to the west with its wake arching behind.

The new Naval Air Facility was commissioned on 17 March 1943 when the first draft of men arrived with Lt. W.S. Tenhagen in charge. The organization allowed for 118 men, who rotated



Figure 33. Newly constructed Tern Island Naval Air Facility, 9 September 1943.
Official U. S. Navy photograph.

every three months. Lt. A.B. Clarke was designated as officer-in-charge, but he did not arrive until 23 March. The facility at first was a department of the Naval Air Station, Pearl Harbor. In May 1943 it was transferred to the control of the Naval Air Center, Pearl Harbor¹ (Ricketts, ms.; Dater et al., ms.).

In November 1943 plans were initiated to add new barracks and galley facilities. Construction by a Seabee detachment didn't start, however, until 30 January 1944. By 24 September the original temporary base had been converted to a semi-permanent installation. In November 1944 there were four officers and 123 enlisted men. Land plane capacity was 18 VF's or small VB's, with 22 plane parking spaces available. The coral runway was in use as an emergency refueling strip, and certain aircraft repairs could be made (U.S. Naval Const. Bn. Cent., 99th NCB summary report, 1942-1944; U.S. Navy, Class. Oper. Archives, 14th Naval Dist., corresp., Op 441H).

During the war, daily reconnaissance flights were flown for a radius of 100 miles. Radar scanned a 40-mile radius. Weather data were constantly supplied to Fleet Weather Control, Pearl Harbor (U.S. Naval Const. Bn., 99th NCB summary report, 1942-1944).

Enemy action at or near the Shoals after the Battle of Midway was very light and the station was never attacked. The War Diary of the Commander Hawaiian Sea Frontier (U.S. Navy, Class. Oper. Archives, War Diary, 14th Naval Dist.) from October 1942 through 1945 reveals only seven instances of possible enemy ships in the area.

The war ended 2 September 1945 and the Navy no longer needed the Air Facility. On 7 October 1945 it was placed in a caretaker status; final disestablishment came on 9 June 1946 (U.S. Navy, Class. Oper. Archives, 14th Naval Dist., War Diary, 1945; U.S. Nat. Archives, R.G. 80, Op. 24-1jn. A 4-2/NA; Buchwach, 1946a).

¹ In January 1944, the Naval Air Facility at French Frigate Shoals was designated Task Group 97.2 and operated under the Commander Hawaiian Sea Frontier (Task Force 97). On 28 September 1944 this unit was designated a detached or separate command with authority to convene summary court martials, deck courts, and to administer punishments set forth in Article 24, Articles for the Government of the Navy (U.S. Navy, Class. Oper. Archives, War Diary, Jan. 1944, 14th Naval Dist. corresp., 1944).

Fishing Interests

The U.S. Navy, forgetting about French Frigate's status as a federal wildlife reservation and thinking they owned Tern Island, tried to hand over the disestablished base to the Territory of Hawaii. The Territory refused, but discussion on the issue continued. In early November 1948 the Territory's Hawaiian Aeronautics Commission notified the Commandant of the 14th Naval District, Pearl Harbor, that it was "in a position to take over the airstrip and other facilities...and...make them available...to the fishing industry" (Hawaiian State Archives, FFS file #1871).

As early as June 1946 Hawaiian commercial fishermen began to use the facilities. Early fishing boats enjoyed good fishing which prompted the Hawaiian Tuna Packers, Ltd. to send a vessel to the Shoals in mid-September 1946. Both Honolulu newspapers (Beech, 1946a, 1946b, 1946c, 1946d, 1946e; Buchwach, 1946a, 1946b) carried stories on the venture. Two shipments of fish were subsequently sent from Tern to Honolulu by chartered plane.

In a joint venture two companies, the Hawaiian-American Fisheries, headed by Louis K. Agard, Jr., and the Seaside Fishing Co., run by Frank Opperman and Warren Haines, established a fishing base on Tern Island early in November 1946. They chartered a DC-3 from Trans-Air Hawaii for transporting the fish. The companies obtained permission to use the air strip from the proper Territory offices; the Hawaiian Fish and Game Department gave them permission to use large fixed traps (Agard, in litt.).

During the first three years of operation, Hawaiian-American Fisheries grossed over \$73,000 at the Shoals; profits totaled almost \$20,000. Had the company owned its plane, profits would have been greater. Thus, a new corporation, Aero Fisheries, was formed and a plane purchased by Agard and his partners. In late July 1949 one flight was completed. Mechanical difficulties grounded the plane in mid-August and the corporation did not have the reserve finances to continue the plane operation (Agard, in litt.).

Various commercial fishing vessels visited the atoll in the 1950's with varying success. In 1959 Agard started another joint venture, and even purchased a refrigerated vessel and a plane. This too was short-lived (Agard, in litt.).

In August 1948 the Pacific Oceanic Fishery Investigation (POFI), with headquarters in Honolulu, was organized by the Bureau of Commercial Fisheries of the U.S. Fish and Wildlife Service. Since 1948, POFI vessels visited French Frigate Shoals on numerous occasions (POFI, ms.).

East Island LORAN Station

As early as January 1940, the Chief of the U.S. Navy Bureau of Aeronautics recommended to the Chief of Naval Operations that French Frigate Shoals be the site of a radio station. This was subsequently approved by the Civil Aeronautics Administration (CAA), and on 22 July 1940 the Secretary of Navy gave permission to the CAA and Department of Commerce to occupy East Island. Two days later the Judge Advocate General of the Navy informed the Chief of Naval Operations that, although East Island had been used by the Navy, it had not been placed under Navy control by Executive Order; furthermore, the island was under the jurisdiction of the Department of Interior. The Interior Department was contacted and they, in turn, consulted Governor J.B. Poindexter of Hawaii. On 9 September Poindexter signed Executive Order #893 which set aside East Island for government use by the United States. They were reminded, however, that French Frigate Shoals was a bird reservation (U.S. Nat. Archives, R.G. 80, NR EG 62--390603, and H 4-6/QG-400613; R.G. 48, 9-4-56).

The men, materials, and equipment for building the Radio Communications Station were in Honolulu by early June 1941, but due to the Pacific crisis the U.S. Navy was unable to provide the necessary transportation. Thus the proposed construction of the station was postponed and finally cancelled (U.S. Nat. Archives, R.G. 80, H 4-6/QG--400613-1).

On 16 December 1943 the Chief of Naval Operations directed the U.S. Coast Guard to establish and operate three Long Range Navigation (LORAN) transmitting stations in the Hawaiian Islands; ~~one of these~~--CG unit 204 or code GEORGE or GNAW--was to be located at East Island. Coast Guard Detachment C construction personnel and LORAN operating personnel, as well as material and equipment, were taken to the Shoals in early June 1944 (U.S. Coast Guard, 1946).

By the end of July the station was complete and contained 7 Quonset huts in which personnel lived and worked, 6 smaller buildings or sheds used for a weather station, distillation plant, and storage, a 96-foot dock, and a 7-pole antenna network (Fig. 34). On 15 July Lt. (jg) John J. Roshti, USCGR, was assigned as commanding officer with a crew of 26 enlisted men. The 3-station system went on the air on 23 July and was informally commissioned in August. The Commander, Coast Guard Construction Detachment, Pacific Area, officially turned over jurisdiction of the Hawaiian Chain of LORAN stations to the Commander, Coast Guard District, 14th Naval District, on 8 November 1944 (U.S. Coast Guard, 1946; Bragg and Cronk, ms.; Fed. Rec. Cen., Md., 14th CG corresp., 1944).



Figure 34. Newly constructed East Island Coast Guard LORAN Station, 24 April 1945.
Official U. S. Navy photograph.

Morale at first was high due to the newness of the station; by late October, however, the important question on the men's minds was: How long before rotation? By 1 January 1945 most men had been there six months and were getting tired of the isolated duty. The situation was aggravated by the fact that the entire crew at the nearby Tern Island Navy station was rotated every three months. In addition, requisitions for fresh food and routine station supplies went unfilled, and the station began to show the effects of heavy wind and salt air. Supplies began arriving with regularity in April and soon the station's appearance improved. During June a rotation plan took effect and by early July all personnel except the Commanding Officer had been rotated with the unit at Hawaii (Fed. Rec. Cen., Md., Summary Report, 1944-1945).

After the Japanese surrender in August 1945, the men at East Island immediately began thinking of returning home. In October 1945 flights to Tern Island were reduced to one per week. This further isolated the East Island station and morale dropped. To make matters worse, a tidal wave inundated the station on 1 April 1946. None of the personnel suffered injury and damage to the station was comparatively light (Fed. Rec. Cen., Md., Summary Report, 1945-1946).

When the Navy Air Facility at Tern closed on 9 June, the East LORAN station lost its weekly delivery of supplies and mail. Instead, a Coast Guard buoy tender serviced the island twice a month. This took care of station needs, but many times over the next six years the ship arrived without mail or movies, a fact which always greatly disappointed the isolated crew (Fed. Rec. Cen., Md., Summary Reports and Logs, 1946-1950).

By 1951 normal operation continued despite a reduction in logistics support to one supply vessel per month. Morale was good considering the isolated duty, reduced fresh food and mail service, and lack of variety in recreational activities. Storms and salt spray caused the buildings to be in need of almost constant repair (Fed. Rec. Cen., Md., Log for 1951).

In October 1951 the Coast Guard Commandant decided to renovate the East Island Station; Headquarters set aside \$200,000 for the job. A field survey in December suggested, however, that it would be better, and no more expensive, to renovate the old Navy buildings at Tern Island and on 17 January 1952 CG Headquarters tentatively approved the move. On 28 January the Hawaii Aeronautics Commission, which thought it had control over the island, granted a license to the Coast

Guard permitting them to use and occupy Tern Island.¹ On 6 March final approval for the Tern Island project was made and on 24 April 1952² a contract was awarded to C.W. Winstead, Ltd., of Honolulu. Construction began shortly thereafter (Fed. Rec. Cen., Md., corresp., 67A2057, Box 2).

On 24 October 1952 the East Island LORAN station secured transmission and on 3 November the station was formally de-commissioned. All personnel who had not been transferred to the new Tern Island facility were removed to the USCGC Kukui which was anchored offshore (Fed. Rec. Cen., Md., Log, 61A726, Box 1312).

Tern Island LORAN Station

On 14 October 1952 U.S. Coast Guard LORAN Transmitting Station Tern Island was placed in commission and command was assumed by Lt. (jg) Thomas E. Hawkins, USCG. The station consisted of a power and signal building, a barracks containing living areas, galley and mess deck, and a recreation building. There was also an antenna system, 5 water tanks, and 9 fuel tanks (Fed. Rec. Cen., Md., corresp., 67A2057, Box 2; Log, 61A726, Box 1312).

The isolated duty at Tern was similar to that on East. Tern, however, was larger and the biweekly plane service and bimonthly ship service brought fresh vegetables, supplies, and mail regularly. The monotony was occasionally interrupted by visitors, especially fishermen and scientists, and by winter storms and tidal wave alerts. The tour of duty was for one year (Fed. Rec. Cen., Md., Log 1952-1958).

In February 1959, material and equipment were transported to Tern Island for repairs on the seawall. That spring Naval air and surface operations were held in the area and several ships visited the Shoals. In late 1960 it was decided to place a Pacific Missile Range (PMR) team on French Frigate to track satellites and missiles and on 3 December the USS Skagit (AKA 105) anchored and commenced landing equipment, supplies, and personnel for the PMR Facility (Fed. Rec. Cen., Md., Log, 61A275 and 62A352).

¹ The Department of Interior in 1965 questioned the legality of the Coast Guard's occupation of Tern Island. A formal agreement was signed on 22 September 1966 between the U.S. Coast Guard and the Department of the Interior giving the Coast Guard permission to occupy Tern Island.

² The final cost totaled \$286,793.81 (Fed. Rec. Cen., Md., report, 67A2057, Box 2).

After the opening of the new facility, plane service in 1961 almost tripled: 109 planes and 13 helicopters landed in 1961 compared with 44 planes and 11 helicopters in 1960. During 1962, landings increased to 125 planes and 25 helicopters. The numbers of ship visits also increased as well as personnel (Fed. Rec. Cen., Md., Log 62A352, 64A319, Box 12 and 80; 65A593, Box 173).

By late August 1963 ships and planes had removed the PMR equipment and personnel. During early 1964 plans were drawn up for rehabilitation of the station facilities. On 8 April the first cement was poured for the foundation of a new cement block LORAN building (Fig. 35). Repairs were also made to the recreational building and barracks (Fig. 36); new pilings were placed seaward of the old seawall along the east and west ends of the runway. Two air-conditioned trailers left by the PMR were moved near the barracks for use by personnel. Construction and repairs were completed by 6 August (Fed. Rec. Cen., Md., Log 65A593, Box 173; and 66A761, Box 13).

The island's routine for the next several years was interrupted only by a few visiting ships and periodic visits by BSFW and POBSP personnel.

During the predawn darkness of 1 December 1969 the station was hit by tremendous waves which washed completely over the 8-foot-high island. The power equipment was flooded, forcing a shut-down of all electronic equipment. The men sought refuge on the roof of the LORAN building. A Coast Guard rescue plane arrived just after noon, but since it couldn't land dropped survival equipment (Kofron, in litt.).

No one was hurt, but the island's seawall was crushed in various places, soil was badly eroded along the north shore and around the base of the 129-foot LORAN tower, and the vegetation, especially on the northwest side, was washed away. The carpenter's shop and Quonset hut storage building were demolished. The double doors of the engine room were smashed; the equipment inside was wet and useless. The wooden barracks was in shambles; doors, windows, and some walls were destroyed. Furniture was broken and wet and many of the men's personal belongings were water damaged or washed away (Kofron, in litt.).¹

At dawn on the 2nd, the men and their three dogs were rescued by a helicopter from the New Zealand frigate HMS

¹ The damage was later placed at approximately \$142,000.

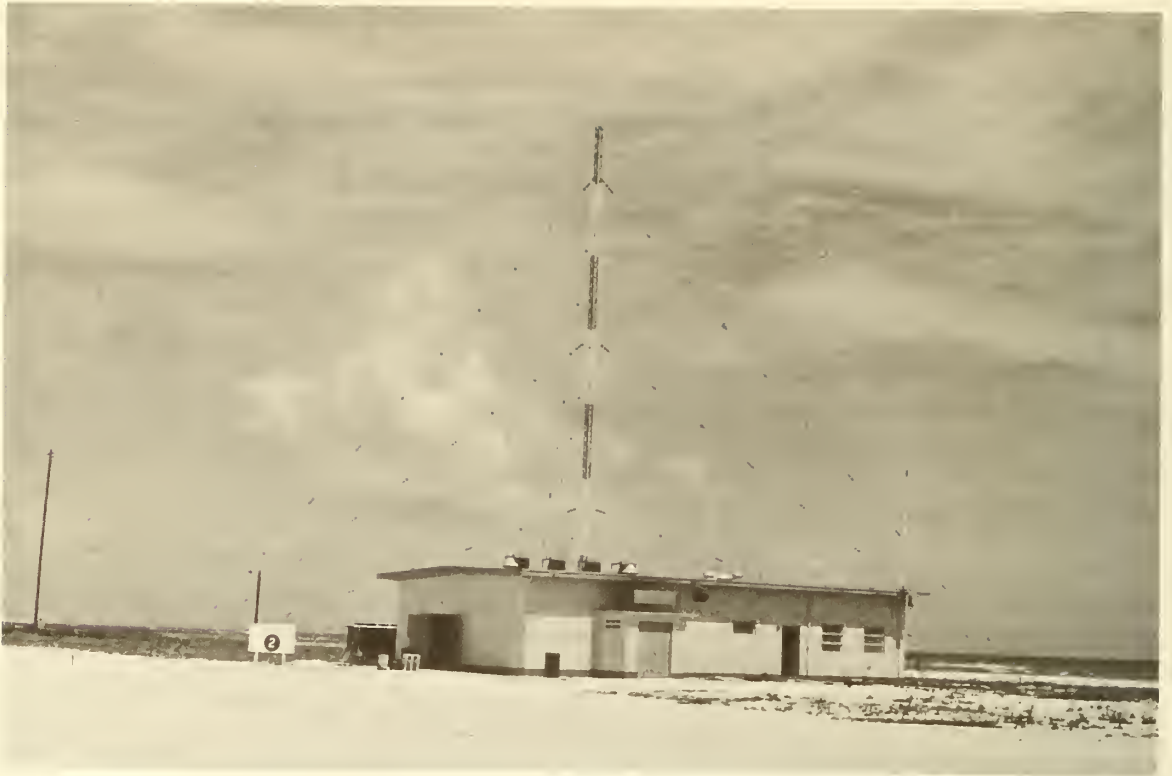


Figure 35. Tern Island Coast Guard LORAN and power building, 21 August 1965. POBSP photograph by A. B. Amerson, Jr.



Figure 36. Tern Island Coast Guard barracks, 21 August 1965. POBSP photograph by A. B. Amerson, Jr.

Waikato. They were taken to Midway and subsequently returned to Honolulu. The crew returned to Tern Island on the 12th aboard the USCGC Buttonwood and began the long, hard, messy job of cleaning up. The USCGC Mellon, USCGC Planetree, and USS Union had arrived earlier and had succeeded in getting the LORAN system into operation on the 6th. Repairs were begun in late December on the damaged barracks. The runway was operational by 15 January 1970 and the station was back to normal shortly thereafter (Kofron, in litt.; U.S. Coast Guard, Hdqtrs. files).

Although in the past the question of whether to continue the LORAN station has been much debated, the matter seems settled for the next 10 years. Funds have been allocated for improvement to the seawall, the runway, and the barracks. The station will probably be in operation until such time as a satellite-aids-to-navigation system is perfected.

Refuge Status

French Frigate Shoals' value as a wildlife sanctuary is generally acknowledged and it will continue as part of the Hawaiian Islands National Wildlife Refuge. The atoll offers a unique opportunity to terrestrial and marine biologists: there are few places where one can find isolated undisturbed islands and waters teeming with wildlife so close to an airport and lodging facilities.

Unquestionably the importance of French Frigate Shoals will continue, and probably will increase, over succeeding years.

SCIENTIFIC VISITS

The logs and reports from early ship captains sailing among the Northwestern Hawaiian Islands provide the first lists of scientific information about French Frigate Shoals. Among them were Lt. Brooke of the Fenimore Cooper (Brooke, 1955), and Capt. Brooks (1860) of the Gambia, both of whom visited the atoll in 1859, and Mate Mansbridge (Hornell, 1934) of the Ada who stopped in 1882.

The schooner Kaalakai, commanded by F.D. Walker, visited in late May and early June 1891 on the first biological survey of the atoll¹ (Walker, 1909). Aboard were two naturalists,

¹ On 3 December 1841 two ships of the United States Exploring Expedition sighted French Frigate Shoals, but were unable to stop due to bad weather.

Henry Palmer and George C. Munro, who had been sent by Walter Rothschild to collect birds. Later Rothschild (1893-1900) published on the birds and Munro (1941a, 1941b, 1944) published his notes on the atoll's wildlife. On 28 and 29 May 1902 the Albatross Expedition visited the Shoals; aboard were naturalists Charles H. Gilbert, Walter K. Fisher and John O. Snyder. Fisher (1903, 1906) published the ornithological results of this trip.

After the depredations by bird poachers in the late 1800's, the importance of the preservation of wildlife was recognized. President Theodore Roosevelt signed an Executive Order on 3 February 1909 setting aside French Frigate Shoals and most other Northwestern Hawaiian Islands as a preserve and breeding ground for birds, and thereafter the U.S. Revenue Cutter Thetis started periodical patrols of all the northwestern islands. These continued until the mid-1920's. Various scientists accompanied the Thetis on many of the trips. D.T. Fullaway, an entomologist, George Willett, an ornithologist, and Alfred M. Bailey, a naturalist, went there in December 1912; Bailey (1952, 1956) later published details about the wildlife. W.H. Munter (1915), the Thetis' First Lieutenant, filed a comprehensive biological report after a spring 1915 visit to the Shoals.

The Tanager Expedition, organized by the Biological Survey of the U.S. Department of Agriculture and the B.P. Bishop Museum of Honolulu, visited French Frigate Shoals from 22 through 28 June 1923. All islands except one were visited and the names given to them then are still in use. The scientific collections--birds, mammals, fish, insects, molluscs, plants and marine invertebrates--made by the Tanager Expedition were extensive and added a wealth of information on the ecology of the Northwestern Hawaiian Islands. Twenty bird species were recorded by Wetmore (ms.), the Expedition's leader; Wetmore (1925) later wrote a popular account of the field work. Fowler and Ball (1925) published an account of the fishes collected. In 1926, E.H. Bryan, Jr., and collaborators published a paper on the insects collected. Christophersen and Caum (1931) published on the vascular plants.

On 4 and 5 March 1928 Dr. Victor Pietschmann, Curator of Fishes, Museum of Natural History, Vienna, Austria, paid a scientific visit to French Frigate Shoals. He was on a five-weeks' cruise up the northwestern Hawaiian chain aboard the fishing schooner Lanikai, commanded by Captain William G. Anderson. Pietschmann collected 11 fish species (Pietschmann, 1938), 14 mollusc species (Schilder, 1933), and 5 polychaete species (Holly, 1935) from the lagoon off Tern and East Islands.

The U.S. Revenue Cutter Itasca, on an inspection trip, sighted the atoll on 18 and 27 June 1934, but seeing no poachers or other ships soon left. The U.S. Coast Guard Patrol Boat Reliance investigated the wildlife during March 1936; eight bird species were noted (U.S. Nat. Archives, Logs of Itasca and Reliance, R.G. 26).

Since 1948 various Pacific Ocean Fisheries Investigation (POFI) ships of the Bureau of Commercial Fisheries, U.S. Fish and Wildlife Service, have visited French Frigate Shoals. Published reports from these visits include those of Smith and Schaefer (1949), Eckles (1949), June and Reintjes (1953) and Ikehara (1953).

On 25 July 1952, C.R. Joyce, an Hawaiian entomologist, visited Tern Island and subsequently (Anon., 1953) it was revealed that he found a tick species that was biting military personnel. Joyce became the first non-marine biologist to visit the atoll since the end of World War II.

Frank Richardson (1954a, 1954b) visited the Shoals from 26 October to 2 November and 18-19 December 1953, and 20 March 1954; he recorded 15 bird species and a few seals on the first visit, 15 bird species on his second visit, and 11 species on his last. On the basis of his three visits to French Frigate and other Hawaiian Islands, Richardson (1957) later published an extensive paper on the breeding cycles of Hawaiian seabirds.

From 11 to 21 February 1956 Arthur Svihla (1957, 1959) of the B.P. Bishop Museum visited Tern Island to study the life habits and abundance of the Hawaiian monk seal. He recorded six plant, six insect, seven bird, three mammal (other than man), and one reptile species. On 3 August 1956 two zoologists, not identified in the station log, arrived at Tern Island by Coast Guard plane (Fed. Rec. Center, Md., Log, 58A602, Box 101); perhaps one of these was Archie F. Carr (1964), turtle specialist from the University of Florida. On 28 December 1957 Dale Rice and Karl Kenyon (1962) made a low-level photographic run over French Frigate Shoals to check the albatross population.

Richard E. Warner of the University of California and three other scientists accompanied the USCGC Matagorda on its brief 26 May 1958 supply stop at Tern Island. Before heading for Laysan, Warner (1958) observed seven bird species on Tern Island.

Dr. Hubert Casper from Hamburg University, Hamburg, Germany, visited Tern by a Coast Guard plane on 19 August 1959 (Fed. Rec. Center, Md., Log, 61A275, Box 111); his purpose for visiting the atoll is not known.

Chandler S. Robbins of the U.S. Fish and Wildlife Service (BSFW) visited the atoll via Coast Guard plane on 13 April 1960 to inspect the Refuge. He recorded 3 species of birds. Hawaiian Division of Fish and Game (HDFG) personnel made additional survey visits on 19 October 1960, March and September 1961, and June 1962. They recorded the bird species present, and (in 1961) collected algae (Tsuda, 1966).

On 2 September 1961, 10 scientists of the Coolidge Expedition spent an hour on Tern Island between disembarking from a Coast Guard plane and departing for the USCGC Ironwood, anchored offshore, which was to take them to Laysan. In subsequent publications, Udvardy (1961a) and Udvardy and Warner (1964) noted that they had observed six bird species, on, or flying over, the island but saw no signs of nesting birds. Lamoureux (1961) published notes on the plants he collected during his brief stopover.

POBSP personnel have spent 203 days at French Frigate Shoals on 11 separate trips since June 1963. BSFW personnel have been present on four of these trips. BSFW personnel spent an additional 73 days on 10 other trips. Dates and islands visited for each trip are listed in Table 2. Personnel for all surveys are listed in Appendix Table 1.

Papers resulting from POBSP activities at French Frigate Shoals were published by Amerson (1968), Amerson and Emerson (1971), Clapp and Woodward (1968), Gould and King (1967), Hendrickson (1969), Kohls (1966), Kohls and Clifford (1967), Maa (1968), Sibley and McFarlane (1968), and Tsuda (1966).

One hundred scientific publications have resulted from the various surveys to French Frigate Shoals. Some are specific; others cover several topics. The various topics and number of publications for each are: Coelenterata (2); Mollusca (3); Echinodermata (5); Annelida (3); Arthropoda: Crustacea (1), Arachnida (8); Insecta (15); Chordata: Pisces (11), Reptilia (10), Mammalia (18), Aves (26); Flora: Vascular Plants (4), Algae (2); Geophysical (2). These publications are listed in Appendix Table 2.

VEGETATION

Neither Brooke (1955: 618-620) nor Brooks (1860: 500) recorded vegetation when they visited French Frigate Shoals in 1859. The first mention of vegetation came from the shipwrecked crew of the Daniel Wood, who in April 1867 reported one "small sand bank, barren, with the exception of here and there a tuft of grass" (The Friend, May 1867, 37: 1-3). In July 1872

Table 2. Dates of POBSP and BSFW surveys of islands at French Frigate Shoals

Date of Visit	Survey Party	Fern	East	Whale-Skate	Trigs	La Perouse	Little Gin	Gin	Round	Disappearing	Shark	Mullet	Bare	Near
1963 7-15 June	POBSP	11	7-11	12-15	14-15	10	9	9	8	9	11	8	8	
1964 27 July	BSFW		27											
27-28 Sept.	BSFW POBSP	27	27	27	27	27								
1965 16 Mar.	BSFW POBSP		Did Not Go	Ashore										
4 Aug.- 2 Sept.	POBSP	4-5 10-12 17-23 28-29 31-2	5-10 23-28	11-17 1	16,29 31	7	25	25	10,23			10,23		
1966 21-24 Mar. 8 June- 9 July	BSFW POBSP	21 8-10 14-16 21-23 29-1 4-7	23 10-14 16-21	22 10,23- 29	22 10,23 1,3-4	23	23	23						
11 Aug.- 16 Sept.	POBSP	11-15 17-18 24-26 30-16	18-24 26-30	13,15- 17,4	13-14 4,12	4			26					
12-15 Sept.	BSFW	12-13	12-13	13			13**							
1967 11-14 Mar.	BSFW POBSP	11-14	11-12	14	13-14									

Table 2. (continued)

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Date of Visit	Survey Party	Islands	East	Whale-Skate	Trialg	Ta Perouse	Little Gin	Gin	Round	Disappearing	Shark	Mullet	Bare	Near
1967														
25 May-														
22 June	POBSP	25-26	26-31	2-7	2,8-9	12	9	9	13			13**	**	**
		31-2	9-13	15-19	19-20									
		7-9,13												
		15,18												
		20-22												
16-19 Sept.	BSFW	17-19	17	17	17									
7-11 Dec.	BSFW	7-11	9*	9*	9*	9*	9*	9*						
1968														
11-15 Mar.	BSFW POBSP	11-15												
29 May-														
27 June	POBSP	29-30	6-11	6,16	6,11		7	7	11,25			25		
		11-14	14-16	17-25	22,24-									
		16-17	25		25									
		19-20												
		22,23-												
		27												
6-27 June	BSFW	No Data												
1969														
22-24 Feb.	BSFW	22-24		23	22	24*								
23 Mar.	BSFW	23												
30-31 May	BSFW					30								
2-26 June	POBSP	2-4	5-10	3,16-	3,14	16,23	7,21	7,21	5					
		12	21	20,22	23-24									
		25-26												
21 Aug.-														
7 Sept.	BSFW	21-7	22,30	24	23,27	1	23,30	25	25	4**		2	25	

* Aerial survey

** Observed from nearby

Wood of the Kamehameha V also found very little vegetation (The Friend, October 1872, 81: 2-3). But by February 1882 the crew of the Ada found an island with "bushes growing on it" (Hornell, 1934). Walker (1909), who spent a week at French Frigate in mid-1891, pointed out that some of the sand islets were profusely covered with scrub.

The Tanager Expedition visited the atoll in June 1923 and found six species of plants--Lepturus repens, Chenopodium oahuensis, Boerhavia diffusa [=repens], Portulaca lutea, Tribulus cistoides, and Ipomoea pes-caprae (Christophersen and Caum, 1931: 8)--on nine of the islands. Wetmore (ms.) noted that another nine species were planted by expedition personnel. It is not known how long these introduced plants lived, but none apparently survived long. Some, however, have been reintroduced since.

During World War II, military activities completely altered one island and partially altered another. With this activity came plant introductions.

A plant collection of 10 species from various islands in the atoll was made by H. Ivan Rainwater in October 1953; these unnumbered specimens are deposited in the B.P. Bishop Museum in Honolulu. Svihla (1957: 1-2) published observations of vegetation after visiting Tern from 11 to 21 February 1956. He reported Ipomoea pes-caprae, Scaevola, Cocos nucifera, and Casuarina sp., and collected seven additional species. On 2 September 1961 Lamoureux (1961: 7-10) visited Tern Island and collected 21 of 22 species of vascular plants observed; 14 of these 22 were new records for the atoll.

POBSP and BSFW personnel have collected vascular plant specimens, or have taken notes and photographs, on most visits to the Shoals. In June 1963 POBSP personnel collected 15 specimens of 8 species and observed 2 other species on four islands. Twenty-one plant species were collected and four others were observed on four islands in September 1964 by C. Robert Long, a POBSP botanist from the University of Hawaii. The islands and their major vegetation associations were mapped in June 1967. Plant specimens collected by the POBSP, its cooperators, and past botanical collectors may be found in the herbaria of the National Museum of Natural History (USNM), the B.P. Bishop Museum (BPBM), and the University of Hawaii (UH).

Vascular Plants

Forty species of vascular plants, representing 24 families, have been observed or collected from eight islands at French Frigate Shoals (Table 3 and Appendix Table 3).

Table 3. Distribution of vascular plants at French Frigate Shoals

Species	Tern	East	Trig	Whale-		Little		Shark
				Skate	Round	Gin	Gin	
<u>Cenchrus echinatus</u>	x	x	x					
<u>Cynodon dactylon</u>	x							
<u>Eleusine indica</u>	x							
<u>Eragrostis whitneyi</u>	x							
<u>Lepturus repens</u>	x	x	x	x	x	x		
<u>Setaria verticillata</u>	x	x	x	x				
<u>Fimbristylis cymosa</u>	x							
<u>Cocos nucifera</u>	x	x						
<u>Livistona australis</u>		x						
<u>Pritchardia gaudichaudii</u>		x						
<u>Pritchardia pacifica</u>	x	x						
<u>Ficus sp.</u>	x							
<u>Casuarina equisetifolia</u>	x	x						
<u>Atriplex muelleri</u>	x							
<u>Chenopodium oahuensis</u>	x	x	x	x				
<u>Salicornia virginica</u>	x							
<u>Coccoloba uvifera</u>	x							
<u>Boerhavia repens</u>	x	x	x	x	x	x		x
<u>Portulaca lutea</u>	x	x	x	x	x	x	x	
<u>Portulaca oleracea</u>	x							
<u>Coronopus didymus</u>	x							
<u>Spergularia marina</u>	x							
<u>Haematoxylon compechianum</u>		x						
<u>Tribulus cistoides</u>	x	x	x	x	x			
<u>Euphorbia thymifolia</u>	x							
<u>Euphorbia prostrata</u>	x							
<u>Hibiscus tiliaceus</u>	x	x						
<u>Thespesia populnea</u>	x	x						
<u>Calophyllum inophyllum</u>	x	x						
<u>Frankenia grandifolia</u>	x							
<u>Barringtonia asiatica</u>	x							
<u>Plumeria obtusa</u>	x							
<u>Ipomoea pes-caprae</u>	x	x						
<u>Tournefortia argentea</u>	x	x	x	x				
<u>Solanum lycopersicum</u>	x							
<u>Scaevola taccada</u>	x	x	x	x				
<u>Conyza bonariensis</u>	x							
<u>Lactuca sp.</u>	x							
<u>Pluchea odorata</u>	x	x						
<u>Sonchus oleraceus</u>	x	x						

The following vegetation discussion, by island, is based on POBSP data, as well as all previous botanical accounts. Islands are listed in order of magnitude of occurrence of plant species. Whenever plant associations are discussed, the species are listed in order of decreasing abundance.

Tern Island

Thirty-seven vascular plants have been recorded from Tern Island (Table 3). Of these 37 species, 30 are exotic plants. The vegetation is presently dominated by 18 species.

Vegetation is limited to both sides of the airstrip (Fig. 37). The area southeast of the airstrip is covered with an herbaceous growth of Ipomoea pes-caprae, Boerhavia repens, Cenchrus echinatus, Setaria verticillata, Sonchus oleraceus, and Conyza bonariensis. Widely scattered shrubs of Tournefortia argentea and Pluchea odorata, as well as a few Scaevola taccada, are found throughout this side. Of less frequent occurrence here are Eleusine indica, Lepturus repens, Portulaca lutea, and P. oleracea. Spergularia marina and Fimbristylis cymosa are common along the margins of the packed-coral airstrip.

The narrow area along the northwest side of the airstrip is rather densely covered with shrubs of Pluchea, Tournefortia, and Casuarina equisetifolia. Tribulus cistoides and Cynodon dactylon were found, as well as the same herbaceous species found on the southeast side.

Introduced exotic plants around the U.S. Coast Guard buildings include several 50-foot-high Casuarina, and a few Coccoloba uvifera, Cocos nucifera, and Plumeria obtusa. From 1964 through 1969, Solanum lycopersicum was cultivated by USCGS personnel.

In June 1923 the Tanager Expedition recorded Lepturus repens, Chenopodium oahuensis, Boerhavia diffusa [=repens], Portulaca lutea, and Tribulus cistoides from Tern (Christophersen and Caum, 1931: 8). Wetmore (ms.) noted that on 26 June Judd (Fig. 38) planted sprouted Cocos nucifera, slips of Hibiscus tiliaceus, and seeds of Calophyllum inophyllum, Thespesia populnea, Casuarina equisetifolia, and Pritchardia pacifica on Tern. If any of these survived, they were destroyed in 1942.

From July to November 1942, U.S. Navy personnel and civilian workers dredged coral from the lagoon, covered the original Tern Island, and constructed a new island in its place.



Figure 37. Aerial view of Tern Island, 11 December 1966, showing vegetation growing along both sides of the airstrip. Official U. S. Coast Guard photograph.



Figure 38. C. S. Judd planting Hau trees west end of Tern Island, 26 June 1923. B. P. Bishop Museum photograph by E. H. Bryan, Jr.

This new Tern Island was devoid of vegetation (Fig. 33); furthermore, several of the first Commanding Officers would not allow even a blade of grass to grow. The first recorded vegetation, Tribulus cistoides, reappeared in late December 1943 or early January 1944. Dabagh, the new C.O., carefully watered it and shortly the plant produced a small, yellow blossom. He carefully picked the bloom and enclosed it in his next letter home; his wife Jean still has the pressed Tribulus in her possession (Dabagh, in litt.).

U.S. Navy photographs taken in April 1945, a year prior to disestablishment of the Navy station, show Tern as a white-coral expanse. Sparse vegetation probably did occur, however. U.S. Coast Guard photographs taken in 1949 show Ipomoea and Lepturus scattered around the abandoned Navy buildings, but overall (Fig. 39) the island was still bare.

Between June 1946 and March 1952 Tern Island was abandoned by the military. During this period, the Coast Guard personnel on East kept the airstrip usable, and an occasional plane landed. Commercial fishermen also used the island. Lamoureux (1964: 8) reported that "in 1948 Dr. Vernon E. Smith visited the island and did not find any higher plants growing there."

In April 1952 workers began renovating the old Navy buildings so that the Coast Guard could use Tern instead of East. The small amount of vegetation growing around the buildings was probably destroyed during this period; USCGS photographs show very sparse vegetation in June, July, and August 1952. The new LORAN station went into operation in October.

Photographs taken in January 1953 by Price (in litt.) show a narrow growth of low grass along the central portion of the northwest edge of the airstrip; scattered grass clumps grew around the old Quonset huts on the west half of the southeast side; the eastern portion of the southeast side was completely bare. Lamoureux (1964: 8) noted that "by October 1953 re-vegetation had progressed to the point where H.I. Rainwater was able to collect 9 [10] species."

A U.S. Coast Guard photograph (Fig. 40) taken in January 1956 shows little vegetation along the northwest side of the airstrip, but shows two large vegetated areas on the eastern half of the southeast side. Svihla (1957: 1-2), who visited Tern Island from 11 to 21 February 1956, collected seven plant species and reported four others. He noted that the island "consists largely of the barren landing strip but there is a small area of approximately three acres in extent which still retains some of the original flora." As for exotics, he



Figure 39. Abandoned Tern Island Naval Air Facility, 16 August 1949, showing its barren, white-coral expanse. Official U. S. Navy photograph.



Figure 40. Aerial view of Tern Island, 3 January 1956, showing little vegetation along the northwest side of the air-strip, but two large vegetated areas on the eastern half of the southeast side. Official U. S. Coast Guard photograph.

observed that around the buildings "the three coconut trees are about one foot high and seem to be established. The *Casuarina* [sic], planted in front of the mess hall are about 15 feet high."

On 2 September 1961, Lamoureux (1961: 7-10) visited Tern and found 22 species of plants. He noted that 6 of these were cultivated species, 5 were species which were part of the original vegetation, 1 was probably intentionally introduced but could be a native species, and 10 were probably unintentionally introduced weeds. Figure 41 shows an aerial view of Tern's vegetation in December 1961, three months after Lamoureux's visit.

Lamoureux (1961: 8) speculated on the modes of introduction of the weedy species. He noted that "it seems likely that the seeds of some of these came to the island in the soil which was reportedly brought there from Honolulu (Svihla, 1957)." Svihla, however, was in error, for no soil was barged or otherwise brought from Honolulu (Amerson, in prep.). Lamoureux (op. cit.) further noted that "other weedy species may have reached Tern ... accidentally via construction equipment, aircraft, or personnel." He also did not "discount the possibility of 'natural' dispersal by wind, birds, or ocean currents." He stressed that "most of the weedy species were present in the main Hawaiian Islands for many years before 1923, but the species were not found on French Frigate Shoal then. Thus, the weeds appeared there only after man began to make frequent visits."

East Island

Twenty-one species of vascular plants have been recorded from East Island. POBSP personnel recorded eight species in June 1963, and two additional species in September 1964.

East Island is covered throughout with Tribulus cistoides; an almost pure stand grows in the center of the length of the island. Towards the edges Tribulus is mixed with Boerhavia repens and Portulaca lutea. Lepturus repens is scattered along the lagoon side of the northwest half, as well as on the middle portion of the southwest side. Chenopodium oahuensis is scattered around the ruins of the LORAN station, as well as on the southeast portion of the southeast side. One low Scaevola taccada occurs near the lagoon beach about midpoint of the southeast half. A large, 4-foot-high Tournefortia argentea is situated at the southeast tip of the vegetated portion; a dead one occurs near the ocean beach at the midpoint of the northwest half. Sparse Sonchus oleraceus, Setaria verticillata, and Cenchrus echinatus grow among the building ruins.

In June 1923, Christophersen and Caum (1931: 8) reported Lepturus repens, Chenopodium oahuensis, Boerhavia diffusa

[=repens], Portulaca lutea, Tribulus cistoides, and Ipomoea pes-caprae from East. Wetmore (ms.) also noted that Judd planted nine species in June 1923. They were: 50 cuttings of Hibiscus tiliaceus, 8 sprouted Cocos nucifera, and seeds of Haematoxylon campechianum, Thespesia populnea, Casuarina equisetifolia, Pritchardia pacifica, P. gaudichaudii, Livistona australis, and Calophyllum inophyllum. Only Cocos nucifera has been recorded since, and that not from the original introduction.

Vegetation on the lagoon side of the island was partially destroyed in the mid-1930's due to military camp sites connected with various U.S. Naval fleet exercises. In 1944 the U.S. Coast Guard constructed a LORAN station on East. The eight main buildings and a few roads disrupted vegetation on the north-western half of the island (Fig. 42). In 1952 the station was abandoned. By 1962 the buildings were still present, but all evidence of the road had disappeared (Fig. 43). POBSP personnel burned the remains of the buildings in 1965.

Trig Island

Nine species of vascular plants have been recorded from Trig Island, all since 1963 (Table 3).

The western half is covered predominately with Tribulus cistoides and Lepturus repens. Scattered throughout this section are Portulaca lutea and Boerhavia repens. Chenopodium oahuensis occurs on the south and west portions of this half. Several low Scaevola taccada grow along the north border of this half. A large 15-foot-high, 30-foot-wide Tournefortia argentea grows in the center of the island. Smaller Tournefortia occur on the south and east side of the eastern half; two occur near the west end of the island. Sparse Setaria verticillata and Cenchrus echinatus¹ have been found on the island.

Christophersen and Caum (1931: 8) collected Lepturus repens, Boerhavia repens, Portulaca lutea, and Tribulus cistoides from Trig in June 1923. No seeds were planted on this island by Tanager personnel (Wetmore, ms.)

POBSP personnel have noted considerable vegetation changes at Trig since 1963. From 1963 through 1965 the eastern half was almost barren sand (Fig. 44). In subsequent years, Tournefortia grew so rapidly on the south crest (Fig. 45) that by 1969 the bushes were about five feet high; these now provide

¹ BSWF personnel eliminated this species in late 1969.



Figure 41. Aerial view of Tern Island's vegetation, 13 December 1961; Lamoureux (1961:7-10) found 22 plant species here on his September visit. Official U. S. Coast Guard photograph.



Figure 42. Aerial view of East Island Coast Guard LORAN Station, circa 1949, showing extent of vegetation. Official U. S. Coast Guard photograph.



Figure 43. East Island's vegetation, June 1962. Hawaiian Division of Fish and Game photograph by David B. Marshall.



Figure 44. West view from east end of Trig Island, 16 August 1965; dug-up area in foreground caused by turtles laying eggs; small Tournefortia plants on the left. POBSP photograph by A. B. Amerson, Jr.

added nesting and roosting space for Red-footed Boobies, as well as roosting space for Great Frigatebirds. The grassy western half underwent a drastic reduction in vegetation between June 1968 and February 1969; this reduction, which was still apparent in June 1969, was perhaps caused by excessive turtle nesting activity or by a drought. Storm damage was ruled out for this island was otherwise unaltered. This area undoubtedly will revegetate and should return to its prior status in a short time.

Whale-Skate Island

Eight vascular plant species have been recorded from Whale-Skate Island (Table 3); all still occur.

Except for the beaches and a short sandy stretch near the southeast end (Fig. 46), Whale-Skate is mainly covered by vegetation. Tribulus cistoides and Lepturus repens form the predominant ground cover over all vegetated portions. Scattered throughout are Portulaca lutea and Boerhavia repens. Two large areas of Chenopodium oahuensis occur in the central portion of the two halves. Scattered 4- to 5-foot-high Tournefortia argentea grow along the beach crests on both lagoon and ocean sides. Several small Scaevola taccada occur near the southeast tip. A few clumps of Setaria verticillata grow on the lagoon side in the middle portion of the southeast half.

In June 1923 during the Tanager Expedition, Whale and Skate were separate islands. Five plant species collected from both islands were identified by Christophersen and Caum (1931: 8) as Lepturus repens, Chenopodium oahuensis, Boerhavia repens, Portulaca lutea, and Tribulus cistoides. Wetmore (ms.) reported no introductions to either island in 1923.

With the exception of the addition of large Tournefortia and the two minor species, Whale-Skate Island's vegetation has changed little since 1923. The island has had very little human disturbance.

Round Island

Four plant species are known to have occurred on Round Island (Table 3); none presently grows there.

In 1923, Christophersen and Caum (1931: 8) reported Lepturus repens, Boerhavia diffusa [=repens], Portulaca lutea, and Tribulus cistoides. The island was considerably larger then. A U.S. Navy aerial photograph taken in June 1932 also shows considerable vegetation present. None exists, however, in Kenyon and Rice's aerial photographs taken in December 1957.



Figure 45. Southwest view from east end of Trig Island, 3 July 1966; Tournefortia along south crest has grown two feet in less than a year (see Figure 44). POBSP photograph by A. B. Amerson, Jr.



Figure 46. Vegetation covers all of Whale-Skate Island except the beaches and a short sandy stretch near the far southeast end, June 1962. Hawaiian Division of Fish and Game photograph by David B. Marshall.

The island's extremely low height and small size made it susceptible to wave and wind action, and its vegetation, and consequently four nesting bird species, was eliminated. POBSP personnel recorded no vegetation from 1963 through 1969.

Little Gin Island

Three plant species have been recorded from Little Gin Island (Table 3); only two have been recorded in recent years.

POBSP personnel observed and photographed (Fig. 47) Boerhavia repens and Portulaca lutea growing in small numbers in the central depression during August 1965. No plants were recorded during the June 1963 visit, and none has been found subsequent to 1965.

Christophersen and Caum (1931: 8) reported small clumps of Lepturus repens, Boerhavia diffusa [=repens], and Portulaca lutea from Little Gin in June 1923. None was subsequently observed until the 1965 POBSP records.

Little Gin's usual lack of vegetation despite its large size demonstrates the effect of wave action during winter storms. In years having violent storms, the plants are covered up or destroyed. In those years with few winter storms, the dormant vegetation has a chance to grow.

Gin Island

One plant species has been recorded from Gin Island (Table 3); no vegetation presently grows.

Christophersen and Caum (1931: 8) found sparse Portulaca lutea in June 1923. No vegetation has since been observed and the island is presently bare sand. This island, like Little Gin, is probably affected by winter storm wave action.

Shark Island

Table 3 shows that one plant species has been recorded at Shark Island. No plants presently grow there.

A small amount of Lepturus repens was recorded at Shark by Christophersen and Caum (1931: 8) in June 1923. None has been found since. This island's present lack of vegetation is undoubtedly due to wave action during winter storms.



Figure 47. Total vegetation (*Boerhavia repens* and *Portulaca lutea*) on Little Gin Island, 25 August 1965. POBSP photograph by A. B. Amerson, Jr.

Other Islands

The other sand islands--Bare, Disappearing, Mullet, and Near--have no records of vegetation because of their small size and low height. Salt water washes over them regularly, precluding growth of vegetation.

No vegetation has been recorded from La Perouse Pinnacle. Wetmore (ms.) found none when he climbed the rock in 1923. Richardson (1954a: 63) found no vegetation on the cliff faces around the west end on 31 October 1953. POBSP personnel found no vegetation on the northeast face or on the entire top of the main rock in June 1969. The nearby little rock is also barren.

REPTILES

Two reptiles--the Green Sea Turtle and the Mourning Gecko--are known from French Frigate Shoals. Both species breed on the atoll. The gecko is an introduced species, whereas the turtle species is a resident. Possibly the Pacific Hawksbill Turtle, Eretmochelys imbricata, an uncommon species in the Hawaiian Islands, has visited the atoll, but no records exist of its occurrence.

GREEN SEA TURTLE

Chelonia mydas

Status

Common resident breeder; occurs on all islands, except those awash at high tide; nests on the six major sand islands. Maximum recent population estimate 1,300 in August 1965.

Observations

Sea turtles were first recorded from the sand islands of French Frigate Shoals 3 to 7 January 1859 by Lt. John M. Brooke of the USS Fenimore Cooper (U.S. Nat. Archives, Old Mil. Hist., Log of USS Fenimore Cooper for 1859). In May (?) of the same year Captain N.C. Brooks of the Gambia also found the Shoals abounding with turtles.

From 3 February to 1 May 1882, the crew of the Japanese-owned American-chartered schooner Ada, with two sampans, visited French Frigate Shoals "to get anything they could sell in the way of fish, shark, [and] turtle" (Hornell, 1934). When the Ada departed on 1 May its cargo included 47 gallons of turtle oil and 1,543 pounds of turtle shell. The Ada's log gives some indication as to how much turtle was actually taken. Prior to

its arrival at the Shoals, 168 turtles had been collected. Assuming a single adult turtle yields three pounds of tortoise shell (Parsons, 1962), about 346 turtles were taken by the Ada's crew. Turtles were not eliminated, however, for great numbers were present in early 1888 when the Wandering Minstrel visited the atoll (Farrell, 1928), as well as in May and June 1891 when the Kaalokai surveyed the atoll (Walker, 1909; Munro, 1941a).

The USS Rainbow's hydrographic survey of French Frigate Shoals in the late summer and fall of 1914 found turtles plentiful (U.S. Nat. Archives, Mod. Mil. Hist. Div., Rainbow corresp., R.G. 37, 1132-100666). Turtles and turtle eggs, as well as evidence of previous turtle slaughter, were found by Wetmore (ms.) during the April 1923 visit of the Tanager Expedition.

Two commercial fishing companies, the Hawaiian-American Fisheries, headed by Louis K. Agard, Jr., and the Seaside Fishing Company, established a fishing base on Tern Island in November 1946. A great many turtles were captured and taken to the Honolulu market. Turtle meat became one of the mainstays of the crew's diet, supplanting beef. However, the turtle numbers dwindled, probably more as a result of human disturbance than actual killing, and soon turtle was not taken for the commercial market. Agard (in litt.) estimates taking about 200 turtles between 1946 and 1948. Commercial fishermen again took turtle from the atoll in the spring of 1957 (POFI, 1957).

HDFG, BSWF, AND POBSP personnel have recorded turtles on almost all visits during the 1960's. All turtle observations at French Frigate Shoals are presented in Tables 4-9.

Annual Cycle

French Frigate Shoals' Green Sea Turtle population is the largest in the Hawaiian Islands. Turtles have been recorded year-round. The adult population is lowest in the fall, winter, and early spring. The highest population occurs in the late spring and summer and coincides with breeding. Copulation has been observed in early May; nesting usually commences in late May. Infrequent egg-laying has been noted in August and September. Hatchlings probably appear in late July and are commonly seen in August and early fall.

Hendrickson (1969: 90) suggests that French Frigate Shoals' turtle hatchling production exceeds that of all the other Hawaiian nesting sites combined.

Table 4. Green Sea Turtle observations at East Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1955 May 5	2	Medium-sized (POFI, 1955).
1956 Apr. 11	2	Ca. 100 lbs. each (POFI, 1956a).
June 4	6	(POFI, 1956b).
1957 Apr. 24	10-15	(POFI, 1957).
May 11	12	(POFI, 1957).
1959 July 21	4	Dead, appeared to have been killed, but not butchered; 0 adults diurnally; 33 sets of fairly fresh haul-out tracks on beaches; nest pits (POFI, 1959).
1961 Feb. 9	1	In nearby water (POFI, 1961a).
Mar. 4	1	Dead newly hatched turtle (HDFG, 1961b).
July 13	3	(POFI, 1961c).
1962 June	present	Considerable number noted, nest pits (HDFG, 1962a).
1963 June 7-11	20+	Adults nightly; much egg laying (POBSP, 1963).
1964 Sept. 27	5	Dead: 2 adults, 3 hatchlings; 250 nest pits counted (BSFW, 1964b; POBSP, 1964).
1965 Aug. 5-10, 23-28	32+	Adults: 1♂, 31♀; numerous hatchlings; 5-20 adults daily; ♀♀ laying nightly (POBSP, 1965b).
1966 Mar. 23	4	Adults: 2♂, 2 unknown (BSFW, 1966a).
May 13	12-15	Copulation observed (POFI, 1966).
June 10-14, 16-21	5-24	Adults observed daily; 5+ ♀♀ laying nightly (POBSP, 1966a).
Aug. 18-24, 26-30	1-3+	Adults daily; some laying eggs; hatchlings present (POBSP, 1966b).
Sept. 13-14	86+	1 adult ♀ at night may have hauled up to lay eggs; 85 hatchlings seen on the 14th (BSFW, 1966b).

Table 4. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 Mar. 11-12	1	Offshore (BSFW, 1967a; POBSP, 1967b).
May 26-31, June 9-13	20-60	Adults daily, 5-21 ♀♀ laying nightly; 1 subadult (POBSP, 1967a).
Dec. 9	0	5 old nest pits at east end (BSFW, 1967c).
1968 June 6-11, present 14-16, 25		Adults laying (POBSP, 1968a).
1969 June 5-10, 21	15-40	Adults daily; ♀♀ laying nightly (POBSP, 1969).
Aug. 22, 30	6	Adults in nearby water; many nest pits, only a few appeared freshly dug (BSFW, 1969c).

Table 5. Green Sea Turtle observations at Gin Island.

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 24	3-4	1 with a front flipper missing (Wetmore, ms.)
1956 Apr. 11	9	Ca. 100 lbs. each (POFI, 1956a).
June 4	4	(POFI, 1956b).
1957 Apr. 25	10-15	(POFI, 1957).
May 12	10-12	(POFI, 1957).
1961 Feb. 18	2	(POFI, 1961a).
1963 June 9	10	Adults (POBSP, 1963).
1966 Mar. 23	2	♂ adults (BSFW, 1966a).
Sept. 14	0	20 nest pits, but no hatchlings (BSFW, 1967b).
1967 June 9	5	Adults, no nest pits (POBSP, 1967a).
1969 Aug. 23, 30	0	25 old nest pits counted (BSFW, 1969c).

Table 6. Green Sea Turtle observations at Little Gin Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1923 June 24	?	Nest of turtle eggs with developing embryos (Wetmore, ms.).
1950 June 19	4	(POFI, 1950c).
1956 Apr. 11	1	<u>ca.</u> 100 lbs. (POFI, 1956a).
June 4	6	(POFI, 1956b).
1957 Apr. 25	10-15	(POFI, 1957).
1961 Feb. 18	2	(POFI, 1961a).
1966 Mar. 23	0	25 old nest pits on higher ground (BSFW, 1966a).
1967 June 9	3	Adults; no nest pits (POBSP, 1967a).
1969 Aug. 23, 30	0	66 old nest pits counted (BSFW, 1969c).

Table 7. Green Sea Turtle observations at Tern Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1959 July 21	1	1-year old pet kept in salt-water pond; 1 haul-out track on beach; USCG C.O. revealed that 25-50 turtles had been taken by commercial fishermen from French Frigate Shoals by air during past few months (POFI, 1959).
1962 June 11-13, 21-22	?	Artificial turtle pond started (BSFW, 1962b).
1964 Sept. 27-28	0	Several nests reported to have hatched about 1 month prior (BSFW, 1964b; POBSP, 1964).
1966 June 8-10, 14-16, 21-23, 29 July 1, 4-7	0	Old nest pits on southeast beach (POBSP, 1966a).

Table 7. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1966 Aug. 11-15 17-18 24-26, 30- Sept. 16	75	Hatchlings, no adults (POBSP, 1966b).
1967 May 25-26, 31-June 2, 7-9, 13-15, 18, 20-22	3	Adults; some nest pits (POBSP, 1967a).
1968 Mar. 11-15	1	Adult ♂ (POBSP, 1968b).
May 29- June 6, 11-14, 16-17, 19-20, 22-27	present	Adults in nearby water (POBSP, 1968a).
1969 Mar. 23	1	Near pier (BSFW, 1969b).
June 2-4, 11-15 25-26	2	Adults: 1 on north beach, 1 in water (POBSP, 1969).
Aug. 21- Sept. 6	2	1 adult on beach, 1 subadult in water; 1 nest pit (BSFW, 1969c).

Table 8. Green Sea Turtle observations at Trig Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 26	?	Considerable turtle signs on beach (Wetmore, ms.).
1950 Jan. 19, 23-25	1	Caught on 23rd (POFI, 1950a).
1951 May 8-10	?	Breeding (POFI, 1951).
1953 Oct. 28	2	Large sea turtles sleeping on beach (Richardson, 1954a: 62).

Table 8. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1956 Apr. 11	2	Ca. 100 lbs. (POFI, 1956a).
June 5	1	(POFI, 1956b).
1957 May 10	12	(POFI, 1957).
1959 July 21	1	Recently-butchered parts of large turtle; no haul-out tracks (POFI, 1959).
1961 Feb. 18	12	(POFI, 1961a).
1963 June 14,15	20	Adults daily (POBSP, 1963).
1964 Sept. 27	23	5 adults; 1♂, 2♀, 2 unknown; 18 hatchlings: 1 alive, 17 petrified (BSFW, 1964b; POBSP, 1964).
1965 Aug. 16, 29, 31	28+	Adults: 13♂, 15♀; 5-20 adults daily; ♀♀ laying nightly (POBSP, 1965a).
1966 Mar. 22	12	Adults: 4♂, 3♀, 5 unknown (BSFW, 1966a).
June 10-23, July 1,3-4	5-24	Adults daily; 5+ ♀♀ laying eggs nightly (POBSP, 1966a).
Aug. 13-14, Sept. 4,12	27+	Adults on the 13th; some ♀♀ laying eggs; hatchlings present (POBSP, 1966b).
Sept. 12	5	Adults: 1♂, 1♀, 3 unknown (BSFW, 1966b).
1967 Mar. 13-14	29	Adults: 14♂, 15♀ (23 adults on 1st day count); another 15-20 adults sleeping on bottom between Trig and seaward reef (BSFW, 1967a; POBSP, 1967b).
June 2, 8-9, 19-20	10-25	Adults daily; 5± ♀♀ laying nightly; adult sex ratio on 20th: 3♂, 1♀ (POBSP, 1967a).
Sept. 17	1	Dead adult (BSFW, 1967b).
Dec. 7	2	Adults, sighted from plane (BSFW, 1967c).

Table 8. (continued)

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1968 June 6, 11, 22, 24-25	present	Adult ♀♀ laying (POBSP, 1968a).
1969 Feb. 22-23	8	Adults on 23rd; 1 on 22nd (BSFW, 1969a).
June 3, 14 23-24	5-20	Adults daily, ♀♀ laying nightly (POBSP, 1969).
Aug. 23, 27	1	Adult daily; west end literally torn up by turtle digging; some new digging; 12 eggs almost fully developed collected (BSFW, 1969c).

Table 9. Green Sea Turtle observations at Whale-Skate Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1923 June 26	?*	Turtle bones near a rock fireplace (Wetmore, ms.).
June 26	?**	Remains of a number of turtles lay scattered about (Wetmore, ms.).
1951 May 8-10	?*	Breeding (POFI, 1951).
May 8-10	?**	Breeding (POFI, 1951).
1953 Oct. 28	1*	Dead newly hatched young (Richardson, 1954a).
1956 Feb. 21	1*	(Svihla, 1957).
Feb. 21	2**	(Svihla, 1957).
Apr. 11	14*	100 to 150 lbs; a large 10' shark attacked a 100 lb. turtle just offshore, turtle later seen on beach minus its left front flipper (POFI, 1956a).
June 5	10-12	(POFI, 1956b).

Table 9. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1957 May 10	36	(POFI, 1957).
1959 July 21	12	Large shells: carapace and plastron cut apart, flippers and head lacking; slaughter appeared recent; few haul-out tracks (POFI, 1959).
1963 June 12-15	20	Adults daily; much egg laying (POBSP, 1963).
1964 Sept. 27	0	125 nest pits counted (BSFW, 1964b; POBSP, 1964).
1965 Aug. 17, 29-Sept. 1	27*	Adults: 1♂, 26♀; numerous hatchlings; 5-20 adults daily; ♀♀ laying nightly (POBSP, 1965a).
1966 Mar. 22	4	Adults (BSFW, 1966a).
June 10, 23-July 3	5-24	Adults counted daily; 5+ ♀♀ laying nightly (POBSP, 1966a).
Aug. 15-17, Sept. 4	2+	Adults; some ♀♀ laying eggs; hatchlings present (POBSP, 1966b).
1967 June 2-7, 15-19	20-45	Adults daily, 5-10 ♀♀ laying nightly; 3 subadults; adult sex ratio on 18th and 19th: 6♂, 24♀ (POBSP, 1967a).
1968 June 6, 16-25	present	Adult ♀♀ laying (POBSP, 1968a).
1969 June 3, 16-20, 22	10-35	Adults daily; ♀♀ laying nightly (POBSP, 1969).
Aug. 23, 27	6	1 adult, 5 subadults in nearby water; none on beach; some digging activity (BSFW, 1969c).

* Whale ** Skate

Estimating the Green Sea Turtles' population is complicated by several factors. Adult turtles of both sexes bask on the beaches during the day, perhaps, as Hendrickson (in litt.) has suggested, to aid in digestion of their food.¹ If disturbed by humans, these baskers leave. Adult females lay their eggs only at night and may relay after about a week. Tagging has shown that there is a large daily island population turnover, with new turtles being found each day. Few turtles are seen within the lagoon. This indicates that turtles return to the sea after basking in the sun or laying eggs on the island. In 1965, 86 adult turtles were tagged by POBSP on 3 islands during August; an average of 5 turtles was tagged on each of the 17 days tagging occurred. Thus, if new turtles arrived and departed each day, this would mean roughly 150 using each of the 3 islands during the month, or a total of 450 for these 3 islands for August. But this is a minimum figure for several were lost or missed each day and from 5 to 20 were actually observed each day. Using 10 as a more realistic average, the estimate for these 3 islands then becomes 900. If we consider those using the other 2 turtle islands in the atoll, the August population could range from 650 to as many as 1,300.

The June and July breeding populations are probably higher than in August for as many as 60 turtles have been counted on a single island at one time. The total population using the atoll may be very large. Hendrickson (1969: 90) discussed the POBSP August 1965 estimates and noted that they were "highly tentative," but suggests "that one might assume twice the August number to represent the month of July and take the same increment for the early part of the season. One would then obtain a figure of between 2,600 and 5,200 turtles as the Hawaiian breeding population (1 + 2 + 1 times 650 - 1,300, and ignoring all other island nestings)." He then states "flatly that this estimate has little basis and is not to be trusted," but then notes "that it does not appear to conflict violently with any other available information."

BSFW personnel, assisted by POBSP personnel, inaugurated a tagging operation throughout the Northwest Hawaiian Islands; present and future retrap data will provide more information on French Frigate Shoals' turtle population. These data are being analyzed by Kridler and Sincock.

¹ The surrounding water, being cooler than at other breeding areas, may hinder digestion; basking in the sun would aid the digestive process.

Ecological Distribution

Green Sea Turtles are known from Disappearing, East, Gin, Little Gin, Tern, Trig, Round, and Whale-Skate Islands. Nesting occurs on each of these islands, except Disappearing (?) and Round.

East Island: Although turtles were probably first observed at East Island in the mid-1800's, the first known record was by POFI personnel in May 1955. Since then, except for 1958 and 1960, turtles have been recorded each year (Table 4).

BSFW and POBSP personnel found the turtle population on East Island to be the highest in the atoll during the 1960's. Most likely, however, the breeding turtle population at East was eliminated, or discouraged, during the 1944 to 1952 Coast Guard tenure.

The sun-basking areas at East are the north lagoon beach, the southeast lagoon beach (Fig. 48), and the south seaward beach. The entire seaward 50-foot edge of the vegetated portion is preferred by turtles for digging their nest pits (Fig. 49). They also utilize the vegetated edge of the lagoon side. These nesting areas are subjected to much digging which destroys many seabird nests, especially those with eggs or small chicks. Species affected include Sooty Tern, Brown Noddy, Wedge-tailed Shearwater, and Blue-faced Booby.

Gin Island: Wetmore (ms.) first recorded turtles at Gin in June 1923. POFI personnel observed them there in the 1950's and BSFW and POBSP personnel found them breeding in the 1960's (Table 5).

The population is small, with from 2 to 15 basking on the beaches. Twenty-five nest pits were counted in August 1969. Turtles usually sun bask on Gin's leeward beaches. Nest pits are dug above the beach crest.

Little Gin Island: Turtles were first found at Little Gin Island by Wetmore (ms.) in June 1923. POFI personnel recorded them there in the 1950's, and BSFW and POBSP observed them there during the 1960's (Table 6).

Sixty-six nest pits were counted on Little Gin in August 1969. Turtles utilize the southwest leeward beach cove area for sun basking and the area just above the beach crest for digging their nest pits.

Tern Island: Although turtles probably utilized the original Tern Island for basking and nesting prior to the 1942 Navy construction, no such records exist. POFI personnel noted



Figure 48. Green Sea Turtles sun-basking on the southeast lagoon beach of East Island, 19 June 1966. POBSP photograph by A. B. Amerson, Jr.



Figure 49. South seaward 50-foot edge of East Island utilized by Green Sea Turtles for nest pits, 19 June 1966. POBSP photograph by A. B. Amerson, Jr.

one set of haul-out tracks on Tern's beach in July 1957. Since then, BSFW and POBSP personnel have seen a few adults, as well as several nest pits (Table 7). Nest pits are most common at the southeast lagoon edge. In June 1969 one frequently was found basking on the small sandy north beach.

Trig Island: Wetmore (ms.) noted "considerable turtle sign" in June 1923. POFI personnel found them breeding in the 1950's; BSFW and POBSP personnel frequently recorded them during the 1960's (Table 8).

At Trig, turtles sun bask primarily on the north seaward beach. Nest pits are placed above the beach crest of this same area. After June 1968 turtle nesting activity was so extensive in the western vegetated portion that by February very little vegetation remained.

Whale-Skate Island: Wetmore (ms.) found a few turtle bones on Whale-Skate Islands in June 1923. POFI personnel recorded them breeding in the 1950 s. BSFW and POBSP personnel found them to be numerous during the 1960's (Table 9).

Turtles most frequently utilize the north beach for sun basking. They prefer the sandy lagoon edge of the vegetated portion, however, for placing their nest pits.

Other Islands: Ten adult turtles were recorded basking at Disappearing Island on 9 June 1963 by POBSP personnel. An adult was seen swimming near La Perouse Pinnacle on both 6 and 13 June 1969 by POBSP personnel. POFI personnel noted a 100-pound adult at Round Island 11 April 1956 and another at Shark Island on 25 April 1957. POBSP personnel observed four adults at Shark 4 June 1969. No nest pits were seen on any of these islands.

Tagging and Movement

Since 1963 BSFW and POBSP personnel have tagged 288 Green Sea Turtles at French Frigate Shoals, as follows: 3 in 1964, 86 in 1965, 3 in 1966, 61 in 1967, 121 in 1968, and 13 in 1969. At least 18 turtle recaptures have been taken on the atoll. Of these, one tagged at Laysan Island was captured at East Island; another tagged at Southeast Island, Pearl and Hermes Reef, was captured at Whale-Skate Island. Two female turtles tagged at Whale-Skate Island were captured at Southeast Island, Pearl and Hermes Reef. In addition, two turtles tagged at French Frigate Shoals were taken in the main Hawaiian Islands (Hendrickson, 1969: 93). These data are being further analyzed by BSFW personnel.

Hendrickson (1969: 94) has theorized that "a double population nests at French Frigate Shoals, one group migrating eastward to feeding grounds around the inhabited islands, the other group moving westward to an equal distance for the same purpose."

Carr (1964: 51-52) found the French Frigate Shoals turtle population to be predominantly dark and high-shelled. When he visited the atoll in 1956, he noted a single light-colored, flat yearling. He was unable to determine whether this individual was a variant of the local dark stock or a visitor from some distant, genetically different, population.

Specimens

POBSP: USNM 161524, hatchling, collected 12 August 1966 at Tern Island by Harrington.

MOURNING GECKO

Lepidodactylus lugubris

Status

Common introduced breeder; occurs on East and Tern Islands.

Observations

It is not known when Mourning Geckos were introduced to the French Frigate Shoals. They were first recorded from the atoll by POBSP personnel, who found them prominent in and around the USCG LORAN station buildings on Tern Island during August 1965. Subsequently, POBSP personnel have observed them at both East and Tern Islands.

Annual Cycle

Mourning Geckos are present on the atoll year-round; nothing is known of their population fluctuation. Gravid females and partially grown young were collected in March 1968.

Ecological Distribution

At French Frigate Shoals, Mourning Geckos are known only from East and Tern Islands.

East Island: Mourning Geckos were first observed here by POBSP personnel during May and June 1967. They were seen again in June 1969. They frequent the ruins of the USCG LORAN station; they especially prefer the darkened interior of the two walk-in refrigerators.

Tern Island: Subsequent to the discovery of Mourning Geckos in August 1965, POBSP personnel observed them in June, August, and September 1966, May and June 1967, March and June 1968, and May and June 1969.

This gecko frequents all the buildings on the island, especially the old Quonset hut and the old "Ham" building. They also are found in the cement block storage area.

Specimens

POBSP: USNM 161517-519, collected 15 August 1966 on Tern Island by Harrington; USNM 161520-523, collected 12 August 1966 on Tern Island by Harrington. Two specimens collected August 1965 on Tern Island by B. Amerson and two specimens collected 12 March 1968 on Tern Island by Clapp have been misplaced or lost. This is a new specimen record for the atoll.

BIRDS

Several sources were used in assembling the common and scientific names of the birds occurring at French Frigate Shoals. The names used in the American Ornithologists' Union's Checklist of North American Birds, 1957, 5th edition, were followed for species occurring in North America. In the interest of consistency, seabird names agree with those which appear in Watson's Smithsonian Identification Manual: Seabirds of the Tropical Atlantic Ocean, and King's Smithsonian Identification Manual: Seabirds of the Tropical Pacific Ocean. Taxonomic order follows that of Peter's Checklist of Birds of the World, volumes I, II, and III, with the exception of the Procellariiformes, which follow Alexander et al. (1965), the Anseriformes, which follow Delacour (1954, 1959), and the Charadriiformes, which follow Bock (1958).

Introduction

The 44 species of birds recorded at French Frigate Shoals belong to 9 orders, 16 families, and 28 genera. In the following list, resident birds are unmarked, non-resident birds are marked with an *, and birds introduced by man are marked with a #.

Order Procellariiformes

Family Diomedidae

Diomedea nigripes

Black-footed Albatross

Diomedea immutabilis

Laysan Albatross

Family Procellariidae	
<u>Fulmarus glacialis*</u>	Northern Fulmar
<u>Pterodroma arminjoniana</u>	
<u>heraldica*</u>	Herald Petrel
<u>Pterodroma ultima*</u>	Murphy's Petrel
<u>Pterodroma hypoleuca</u>	Bonin Petrel
<u>Bulweria bulwerii</u>	Bulwer's Petrel
<u>Puffinus griseus*</u>	Sooty Shearwater
<u>Puffinus pacificus</u>	Wedge-tailed Shearwater
<u>Puffinus nativitatus</u>	Christmas Shearwater
Family Hydrobatidae	
<u>Oceanodroma tristrami</u>	Sooty Storm Petrel
Order Pelecaniformes	
Family Phaethontidae	
<u>Phaethon aethereus mesonauta*</u>	Red-billed Tropicbird
<u>Phaethon rubricauda</u>	Red-tailed Tropicbird
<u>Phaethon lepturus*</u>	White-tailed Tropicbird
Family Sulidae	
<u>Sula dactylatra</u>	Blue-faced Booby
<u>Sula sula</u>	Red-footed Booby
<u>Sula leucogaster</u>	Brown Booby
Family Fregatidae	
<u>Fregata minor</u>	Great Frigatebird
Order Circoniiformes	
Family Ardeidae	
<u>Bubulcus ibis*</u>	Cattle Egret
Order Anseriformes	
Family Anatidae	
<u>Anas platyrhynchos*</u>	Mallard
<u>Anas strepera*</u>	Gadwall
<u>Anas acuta*</u>	Pintail
Order Galliformes	
Family Phasianidae #	
<u>Gallus gallus</u> #	Domestic Chicken
<u>Phasianus colchicus</u> #	Ring-necked Pheasant
Order Gruiformes	
Family Rallidae	
<u>Fulica americana*</u>	American Coot
Order Charadriiformes	
Family Charadriidae	
<u>Pluvialis dominica*</u>	Golden Plover
<u>Charadrius semipalmatus*</u>	Semipalmated Plover

Family Scolopacidae

<u>Numenius tahitiensis</u> *	Bristle-thighed Curlew
<u>Heteroscelus incanum</u> *	Wandering Tattler
<u>Arenaria interpres</u> *	Ruddy Turnstone
<u>Crocethia alba</u> *	Sanderling

Family Laridae

<u>Larus delawarensis</u> *	Ring-billed Gull
<u>Larus occidentalis</u> *	Western Gull
<u>Larus glaucescens</u> *	Glaucous-winged Gull
<u>Larus pipixcan</u> *	Franklin's Gull
<u>Sterna lunata</u>	Gray-backed Tern
<u>Sterna fuscata</u>	Sooty Tern
<u>Procelsterna cerulea</u>	Blue-gray Noddy
<u>Anous stolidus</u>	Brown Noddy
<u>Anous tenuirostris</u>	Black Noddy
<u>Gygis alba</u>	White Tern

Order Strigiformes

Family Strigidae

<u>Asio flammeus</u> *	Short-eared Owl
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Order Passeriformes

Family Mimidae

<u>Mimus polyglottos</u> *	Mockingbird
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Family Drepaniidae

<u>Psittirostra cantans ultima</u> #	Nihoa Finch
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Of the 44 bird species recorded at French Frigate Shoals, 18 species are classed as resident seabirds, 5 species are regular migrant shorebirds, and 21 species are vagrant, accidental, and introduced.

Resident Seabirds

The 18 resident seabirds recorded at French Frigate Shoals belong to 7 families: Diomedidae, Procellariidae, Hydrobatidae, Phaethontidae, Sulidae, Fregatidae, and Laridae.

These 18 species all breed in the Hawaiian Islands. Only 1, the Laysan Albatross, breeds solely in the Hawaiian Islands. Three others--the Black-footed Albatross, Bonin Petrel, and Sooty Storm Petrel--breed only in the Hawaiian Islands and the Bonin-Volcano Islands area. The range of these 4 species is normally north of 10° N. The remaining 14 residents--Bulwer's Petrel, Wedge-tailed Shearwater, Christmas Shearwater, Red-tailed Tropicbird, Blue-faced Booby, Red-footed Booby, Brown Booby, Great Frigatebird, Gray-backed Tern, Sooty Tern, Blue-gray Noddy, Brown Noddy, Black Noddy and White Tern--all breed in both the north and south Pacific.

Migrant Shorebirds

Over 30 shorebird species have been recorded from the Northwestern Hawaiian Islands (Bryan, 1958; Udvardy, 1961b; Clapp, 1968; Clapp and Woodward, 1968); only 5 of these-- Golden Plover, Bristle-thighed Curlew, Wandering Tattler, Ruddy Turnstone, and Sanderling--are considered to be regular migrants and all 5 have been regularly recorded from French Frigate Shoals.

These 5 shorebird species breed during the summer in the northern hemisphere and migrate south during the fall. Some individuals use French Frigate as their regular "wintering ground." Others visit the atoll for a short period of time while migrating farther south, or while on their northward migration back to their breeding areas. Some, particularly first-year birds, spend the summer on central Pacific islands.

Vagrant, Accidental, and Introduced Birds

Twenty-one species, classed as vagrant, accidental, and introduced, have been recorded from French Frigate Shoals.

Six of these are seabirds, of which only the White-tailed Tropicbird breeds in the central Pacific. The Sooty Shearwater migrates through the central Pacific from its breeding grounds in the south Pacific to feeding areas in the north Pacific. Both are accidental visitors to French Frigate. The remaining 4 species--Herald Petrel and Murphy's Petrel which breed in the southeast and southwest Pacific, the Northern Fulmar which breeds in the far north Pacific, and the Red-billed Tropicbird which breeds in the eastern Pacific--are rare, vagrant species on land and sea in the Hawaiian Islands area, as well as the central Pacific.

Four gull species--Ring-billed, Western, Glaucous-winged, and Franklin's--have been recorded once each at French Frigate Shoals and are considered accidental. The Glaucous-winged Gull is Holarctic in origin, while the other three species are North American.

One shorebird species--Semipalmated Plover--is an accidental visitor to French Frigate. This species normally winters from the southern United States to South America. There are several possible explanations for the occurrence of only one accidental shorebird species from the Shoals. The atoll is located in the center of the Hawaiian Chain; accidental species coming from the east would reach the Main Hawaiians first and those coming from the west would reach the western Northwestern Hawaiians. There would be a tendency for them to stop on the outer ends of the chain instead of continuing to the middle islands. The

size of the island may also be important. Larger islands, such as Laysan and Lisianski, may attract more species because of the variety and extent of roosting space and food supplies. Certainly the lagoon and its food at Laysan is a factor in attracting shorebirds; French Frigate Shoals has no island-enclosed lagoon. Enough visits have been made in spring, summer, and fall that accidentals would likely have been seen had they been there.

French Frigate Shoals has no record of resident land or fresh-water bird species. An endemic finch, Psittirostra cantans, is found on both Laysan and Nihoa Islands, some 563 miles apart and approximately equidistant from French Frigate Shoals. It is probable that in the past the finch occurred at, or used as a stepping stone, French Frigate Shoals. Whether or not it survived at the Shoals for any significant period is not known. The recent introduction of Nihoa Finches, P.c. ultima, may or may not be successful.

Two other introduced species--Domestic Chicken and Ring-necked Pheasant--did not live on the atoll long after being introduced in the late 1940's.

Of the three duck species recorded from French Frigate, the Pintail and Mallard are fairly regular migrants to the Main Hawaiian Islands, but only occasional migrants to the Shoals. The third duck species, the Gadwall, is accidental to the Hawaiian area.

The American Coot, a straggler to French Frigate Shoals, breeds on all the Main Hawaiian Islands, where it is known as the Hawaiian Coot and is a recognized endemic subspecies, Fulica americana alai. The Cattle Egret, also a straggler to the Shoals, is a well-established introduction in the Main Hawaiian Islands. The Short-eared Owl, an occasional visitor, is probably from the Main Hawaiian Islands; there it is recognized as an endemic subspecies, Asio flammeus sandwichensis. The Mockingbird, also an occasional visitor, is also probably from the Main Hawaiian Islands where it was successfully introduced in 1928.

Offshore and Pelagic Birds

The exposed semicircular reef (Fig. 2) enclosing 12 sand islands at French Frigate Shoals sits on a slightly larger

irregular oval which rises abruptly out of the ocean's depths. The only offshore shallow area is just west of the exposed semicircular reef and offers an excellent feeding area for such seabirds as the Brown Booby, Gray-backed Tern, Blue-gray Noddy and White Tern.

In the surrounding ocean one may find both seabird species that use or breed at French Frigate and those that seldom occur at the Shoals. These include some species that breed only on the Main Hawaiian Islands: Dark-rumped Petrel (Pterodroma phaeopygia), Newell's Shearwater (Puffinus puffinus newelli), Harcourt's Storm Petrel (Oceanodroma castro), and White-tailed Tropicbird. Other pelagic birds breed in other areas of the Pacific and migrate into or through the waters of the Hawaiian Islands during their non-breeding season. Ten pelagic species (Table 10) occur with such frequency as to be called regular migrants. In addition, 40 other species are classified as either rare migrants or vagrants to the Hawaiian Islands area (King, 1967). Normally all of these species stay at sea but, due to sickness, storm, or accident, any could turn up on the islands of French Frigate Shoals. To date, 6 such species have been taken on the atoll.

Table 10. Pelagic birds which regularly migrate into the waters surrounding French Frigate Shoals

<u>Species</u>	<u>Breeding Area</u>	<u>Hawaiian Occurrence</u>
Juan Fernandez Petrel (<u>Pterodroma externa externa</u>)	Juan Fernandez Is.	All months; May-Dec. peak
White-necked Petrel (<u>Pterodroma externa cervicalis</u>)	Kermadec Is.	All months; May-Jan. peak
Mottled Petrel (<u>Pterodroma inexpectata</u>)	New Zealand	Apr.-May and Oct.- Nov.
Kermadec Petrel (<u>Pterodroma neglecta</u>)	South Pacific	All months; June-Jan. peak
Black-winged Petrel (<u>Pterodroma hypoleuca nigripennis</u>)	Kermadec Is.	May-Nov.
Sooty Shearwater (<u>Puffinus griseus</u>)	New Zealand and Australia	Mar.-May and Sept.- Nov.
Slender-billed Shearwater (<u>Puffinus tenuirostris</u>)	Australia	Oct.-Dec.

Table 10. (continued)

<u>Species</u>	<u>Breeding Area</u>	<u>Hawaiian Occurrence</u>
Leach's Storm Petrel (<u>Oceanodroma leucorhoa</u>)	Asia and North America	All months; Oct.-May peak
Red Phalarope (<u>Phalaropus fulicarius</u>)	Arctic North America	Feb.-Apr.
Pomarine Jaeger (<u>Stercorarius pomarinus</u>)	Arctic Asia and No. America	Oct.-June

Annual Cycles

Breeding Cycles

The seabirds of French Frigate Shoals breed during all seasons of the year (Fig. 50). Some have short, distinct breeding periods, while others have extended breeding cycles. If one considers maximum breeding periods (Table 11), these birds may be grouped as: winter and spring breeders (4 species); spring and summer breeders (11 species); summer and fall breeders (2 species); and fall and winter breeders (1 species).

Table 11. Maximum breeding periods of French Frigate Shoals birds

<u>Winter-Spring</u>	<u>Spring-Summer</u>	<u>Summer-Fall</u>	<u>Fall-Winter</u>
Black-footed Albatross	Christmas Shearwater	Bulwer's Petrel	Black Noddy
Laysan Albatross	Red-tailed Tropicbird	Wedge-tailed Shearwater	
Bonin Petrel	Blue-faced Booby		
Sooty Storm Petrel	Red-footed Booby		
	Brown Booby		
	Great Frigatebird		
	Gray-backed Tern		
	Sooty Tern		
	Blue-gray Noddy		
	Brown Noddy		
	White Tern		

Winter and Spring Breeders: All 4 of the breeding species having a winter and spring maximum breeding period are procellariiforms. There is variation in the start of egg laying, with the Black-footed and Laysan Albatrosses beginning to nest

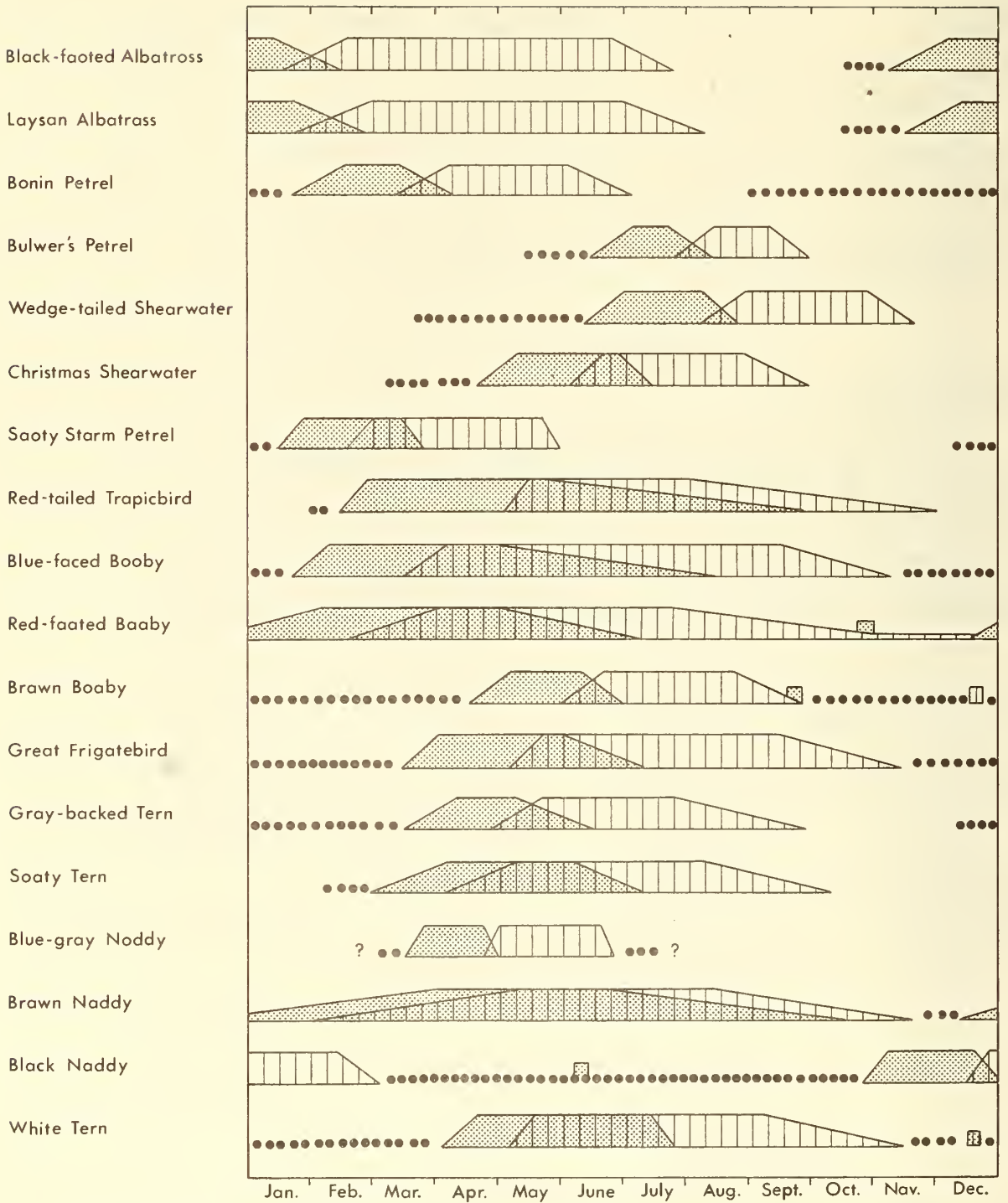


Figure 50. Breeding cycles of seabirds at French Frigate Shoals; stippled areas represent eggs, barred areas young, and black dots nonbreeding birds.

in late fall, and the Bonin Petrels and Sooty Storm Petrels beginning in midwinter. Albatrosses do not begin to fledge until early summer, but fledging is usually completed by late July. Bonin Petrels and Sooty Storm Petrels fledge in late spring, and some individuals may remain into June.

Spring and Summer Breeders: Of all the 11 species which have a spring and summer maximum breeding period, 1 is a procellariiform, 5 are pelecaniforms, and 5 are charadriiforms. Egg laying within this group varies. Seven species (64 percent) lay during the spring months: Christmas Shearwater, Brown Booby, Great Frigatebird, Gray-backed Tern, Sooty Tern, Blue-gray Noddy, and White Tern. Of the remaining 4 species (36 percent), individual birds commence laying during the winter months--the Brown Noddy and Red-footed Booby as early as December, the Blue-faced Booby in mid-January, and the Red-tailed Tropicbird in mid-February. Of the 11 spring-summer breeders, only the young of one species (Blue-gray Noddy) completely fledge during the summer months. The young of the other ten species usually commence fledging in the summer and fledging extends into the fall. Fledging of 4 species (Christmas Shearwater, Brown Booby, Gray-backed Tern, and Sooty Tern) continues into early fall; the remaining 6 species (Red-tailed Tropicbird, Blue-faced Booby, Red-footed Booby, Great Frigatebird, Brown Noddy, and White Tern) extend into late fall.

Summer and Fall Breeders: The two breeding species having a summer and fall period are procellariiforms: Bulwer's Petrel and Wedge-tailed Shearwater. Both commence laying in early summer and usually complete fledging by mid- or late fall.

Fall and Winter Breeders: The Black Noddy has a fall-winter maximum breeding period at French Frigate Shoals. Eggs are laid in late fall and fledging is usually completed by late winter or early spring.

Although all 18 breeding species have a maximum breeding period, four have an extended breeding season. These are the Red-tailed Tropicbird, Blue-faced Booby, Red-footed Booby, and Brown Noddy. In all of these species the egg laying period either extends over a three-season period or is non-continuous (Fig. 50).

Population Cycles

Inspection of Figure 50 and Table 12, as well as subsequent species accounts, shows that many of both resident and non-resident species leave French Frigate Shoals during part of each year. Others stay year-round, but, even so, all have a population buildup sometime during the year.

Table 12. Monthly occurrence of non-resident birds at French Frigate Shoals*

Species	Feb.	Mar.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Northern Fulmar				x						
Herald Petrel		x								
Murphy's Petrel								x		
Sooty Shearwater				x						
Red-billed Tropicbird				x						
White-tailed Tropicbird			x	x						
Cattle Egret				x						
Mallard								x	x	
Gadwall										x
Pintail		x					x	x	x	x
American Coot						x				
Golden Plover	x	x	x	x	x	x	x	x	x	x
Semipalmated Plover										x
Bristle-thighed Curlew	x	x	x	x	x	x	x			x
Wandering Tattler	x	x	x	x	x	x	x	x		x
Ruddy Turnstone	x	x	x	x	x	x	x	x		x
Sanderling	x	x	x	x	x	x	x	x	x	x
Ring-billed Gull		x								
Western Gull								x	x	
Glaucous-winged Gull		x								
Franklin's Gull						x				
Short-Eared Owl										x
Mockingbird		x				x		x		x?

* No observations in January and April

Resident Species: Of the 18 resident seabird breeding species, individuals of 7 remain on the atoll year-round: Blue-faced Booby, Red-footed Booby, Brown Booby, Great Frigatebird, Brown Noddy, Black Noddy, and White Tern. Populations of all except the Black Noddy decrease during their non-breeding seasons in the late fall; the Black Noddy population increases during its non-breeding season due to an influx of adult and subadult birds from other Hawaiian Islands and Johnston Atoll.

The 11 resident seabird breeding species which do not stay on the atoll throughout the year leave after breeding and just before or just after their young fledge. Some remain at sea in the general area of the Hawaiian Islands; others leave the

central Pacific and migrate to distant areas. The Black-footed Albatross, Laysan Albatross, Bonin Petrel, Red-tailed Tropicbird, and Gray-backed Tern are only away from the atoll for two to three months. All except the Gray-backed Tern and Bonin Petrel nest about a month after returning to the atoll; the Bonin Petrel spends about four months, mainly during nocturnal hours, on the atoll before nesting. The other six species--Bulwer's Petrel, Wedge-tailed Shearwater, Christmas Shearwater, Sooty Storm Petrel, Sooty Tern, and Blue-gray Noddy--spend from four to seven months away from the atoll (Fig. 50).

Non-resident Species: The monthly occurrence of the 23 non-residents--regular migrant shorebirds, and vagrant and accidental birds--is shown in Table 12. Some species occur throughout the year while others occur infrequently.

The 10 non-resident seabird and gull species show an irregular pattern of occurrence; none, however, has been recorded in winter months. The Herald Petrel, Ring-billed and Glaucous-winged Gull are each known from a single spring record, and the Northern Fulmar, Sooty Shearwater, Red-billed Tropicbird, and Franklin's Gull are each known from a single summer record. The Murphy's Petrel is a fall record. The White-tailed Tropicbird is known from March and June; and the Western Gull from one bird seen in October and November.

Five of the 6 shorebird species are known from most of the year. Only two species, the Golden Plover and Sanderling, are recorded for all months during which observations were made (no observations were made in January and April). The Ruddy Turnstone has been recorded for nine of the ten months of observation and the Wandering Tattler and Bristle-thighed Curlew for eight. Additional observations in the late fall and winter would probably increase the known occurrence of these five common species. The Semipalmated Plover, an accidental, is known only from December. The population of the regular migrants is highest during late summer and fall.

Of the 5 fresh-water birds, the Cattle Egret, Gadwall, and American Coot have each been recorded during one month; the Mallard has been recorded during two months; the Pintail has been recorded during five months. The occurrence of the three duck species is in the fall and winter; the Pintail record in March represents a recovery of a long-dead bird.

Of the 2 non-resident landbirds, the Short-eared Owl has been seen only in winter; the Mockingbird has been observed or reported during all four seasons.

Ecological Distribution Within the Atoll

Some islands at French Frigate Shoals are more suitable habitat than others for the 44 species of birds recorded from the atoll. The 13 named islands all differ in size, height, soil, vegetation, fresh-water supply, and human disturbance. The avifaunal distribution on these islands is presented in Table 13. The major distinctions are between vegetated and non-vegetated islands, and those that have or have not been disturbed by human habitation.

The major islands--East, Tern, Trig, and Whale-Skate--are all fairly large and well-vegetated.

All species have been recorded from at least one of these major islands: 39 from Tern, 26 from East, 24 from Whale-Skate, and 23 from Trig. Tern Island, with the greatest number of recorded species and the present highest number of species, is, nonetheless, the one island that is currently human-inhabited. The effect of human habitation has apparently not appreciably affected the total species number, but it has affected the population size of most species (see Tern Island Avifauna section). East Island is not currently inhabited by man; the number of species and population sizes have increased by almost one-third since man departed (see East Island Avifauna section). Trig and Whale-Skate Islands have never been disturbed by human habitation; the number of species and population sizes have varied little over the years.

The remaining islands support little or no vegetation; only 20 of the 44 species have been recorded there. These islands can be divided into two types: high, rocky (La Perouse Pinnacle) and low, sandy (all the others). La Perouse Pinnacle is bare but because of its high rocky terrain offers excellent habitat for certain species; 17 species have been recorded there. The low sandy islands have records of from 1 to 10 species per island.

Resident Seabirds

Table 14 compares the breeding status of the 18 resident seabird species nesting on vegetated islands to those nesting on non-vegetated islands. Vegetated and non-vegetated islands have 9 nesting species that are presently common to both; an additional species formerly was common to both but is now absent from the non-vegetated group.

Twice as many species presently nest on the uninhabited vegetated islands as on the inhabited one; the number of species presently nesting on the previously inhabited island falls almost halfway between these two extremes. The history

Table 13. Status of birds on French Frigate Shoals

Species	Tern	East	Trig	Whale-Skate	La Perouse	Gin	Little Gin	Round	Disappearing	Mullet	Shark	Bare	Near
Black-footed Albatross	B	B	B	B		b	B	b	b				
Laysan Albatross	B	B	B	B		b							
Northern Fulmar	a												
Herald Petrel	A												
Murphy's Petrel	A												
Bonin Petrel	B	P											
Bulwer's Petrel	B	b	p	B	B								
Sooty Shearwater				A									
Wedge-tailed Shearwater	B	B	B	B	B		b	b					
Christmas Shearwater	O	P	B	P									
Sooty Storm Petrel	P	p		B	P								
Red-billed Tropicbird		A											
Red-tailed Tropicbird	B	B	B	B	B								
White-tailed Tropicbird	O												
Blue-faced Booby	bO	B	B	B	P	B	B	B	P		P		
Red-footed Booby	P	B	B	B	P								
Brown Booby	O	P	O	B	B		P	o	P		P		
Great Frigatebird	P	P	P	B	P		P	O	P		p		
Cattle Egret	A												
Mallard	a												
Gadwall	A												
Pintail	A		A										
Chicken		i											
Pheasant		i											
American Coot	A												
Golden Plover	P	P	P	P	P	P	P	p					
Semipalmated Plover	A												
Bristle-thighed Curlew	P	P	P	P									
Wandering Tattler	P	P	P	P	P				P				
Ruddy Turnstone	P	P	P	P	P	P	P	p	P				
Sanderling	P	P	P	P				p	P				
Ring-billed Gull			o	P									
Western Gull	a												
Glaucous-winged Gull	a		A										
Franklin's Gull	A												
Gray-backed Tern	O	B	B	B	B				P				
Sooty Tern	bO	B	B	B	P								
Blue-gray Noddy	P				B								
Brown Noddy	bP	B	B	B	B	P	B	bP	P	P	p	P	P
Black Noddy	P	P	P	P	B	P	P	P	P	P	p		

Table 13. (continued)

Species	Tern	East	Trig	Whale-Skate	La Perouse	Gin	Little Gin	Round	Disappearing	Mullet	Shark	Bare	Near
White Tern	B	P	O	O	B								
Short-eared Owl	P												
Mockingbird	A												
Nihoa Finch	I	I		I									

B=Breeding; P=Present; O=Overflier; A=Accidental; I=Introduced.
Capital letters indicate status 1960-1969; lower case letters
indicate status 1891-1959, if different than present.

Table 14. Breeding status of species on vegetated and non-vegetated islands, some of which have been inhabited by man

Species	Vegetated			Non-Vegetated	
	Inhabited at Present: Tern	Inhabited in Past: East	Uninhabited: Whale-Skate and Trig	Uninhabited: La Perouse	All Other Islands
Black-footed					
Albatross	x	x	x		x
Laysan Albatross	x	x	x		*
Bonin Petrel	x				
Bulwer's Petrel	x	*	x	x	
Wedge-tailed					
Shearwater	x	x	x	x	*
Christmas					
Shearwater			x		
Sooty Storm					
Petrel			x		
Red-tailed					
Tropicbird	x	x	x	x	
Blue-faced Booby	*	x	x		x
Red-footed Booby		x	x		
Brown Booby			x	x	
Great Frigatebird			x		
Gray-backed Tern		x	x	x	
Sooty Tern	*	x	x		
Blue-gray Noddy				x	
Brown Noddy	*	x	x	x	x
Black Noddy				x	
White Tern	x			x	

x=Present Breeders; *=Past Breeders

of the two islands that have been inhabited by man shows that the number of breeding species decreased with the advent of man and the destruction of vegetation during initial military construction. Breeding species increased with the re-establishment of vegetation, and returned to or above pre-disturbance status with the departure of man. The non-vegetated islands have had a total of 12 breeding species, 2 of which presently nest exclusively on this group. Almost three times as many species presently nest on high, rocky La Perouse as on the low, sandy islands.

The influence of vegetation and human disturbance is discussed further under the Island and Species Accounts.

Migrant Shorebirds

The 5 regular migrant shorebirds to French Frigate Shoals are all recorded from all four major islands in the atoll. In addition, all except the Bristle-thighed Curlew have been found on two or more of the nine lesser islands (Table 13).

Vagrant, Accidental, and Introduced Birds

Thirteen of the 21 vagrant, accidental, and introduced species are known only from Tern Island (Table 13); the remaining 8 species are known variously only from the four major islands.

Four of the 6 seabird species are known only from Tern Island. Three of the 4 gull species are apparently attracted to Tern because of its garbage dump and frequent fresh-water puddles which occur on the runway after rainstorms. All 5 non-resident fresh-water species have also been recorded from Tern; only the Pintail has been recorded from Trig as well. The accidental shorebird, the Semipalmated Plover, was observed on Tern.

The two non-resident land birds have both been recorded solely from Tern Island. The thick vegetation and buildings would attract both species. The owl, however, probably goes to the other major islands in search of food. Of the three introduced land birds, only the Nihoa Finch remains. It has not survived at East Island and has decreased on Tern; one was observed at Whale-Skate.

Island Accounts

The following island accounts are listed in alphabetical order. All island names are official names adopted by the U.S. Board of Geographic Names.

Bare Island

Only the Brown Noddy has been recorded at Bare Island; it was recorded roosting in June 1923 and again in June 1967.

This small island, although located inside the lagoon and just east of East Island, is so low that it is awash at high tide. No vegetation exists; thus, birds are only attracted to it for roosting purposes. Few scientists have taken the time to visit it.

Disappearing Island

Ten bird species have been recorded from Disappearing Island (Table 15). The only scientific visits were made by POBSP personnel in June 1963 and 1969. Rice and Kenyon flew low over the island in December 1957 and made aerial photographs; these reveal the presence of 2 species, 1 of which was definitely nesting. Nine species, none of which was nesting, were observed during the 1963 and 1969 visits.

The location and sea conditions of Disappearing Island have severely limited the number of scientific visits. The island is located at the southwest tip of the atoll and is about nine miles from East. It is bounded by open ocean on two sides with resultant rough seas. Because of its small size, narrow width, and low height, the island is probably awash during rough seas. This, coupled with a lack of vegetation, has limited its use by birds.

Recent total daytime populations are very low: only 53 non-breeders were present in June 1963 and 66 in June 1969. Night populations may be higher.

Very small numbers of Black-footed Albatross were nesting in the middle of the widest portion in December 1957; Blue-faced Boobies, as singles and pairs, were also present and could have been nesting--the photograph is not clear enough to determine this. Blue-faced Booby, Brown Booby, Great Frigatebird, Gray-backed Tern, Brown Noddy, and Black Noddy roost on the island.

Wandering Tattler, Ruddy Turnstone, and Sanderling are known from the island. No accidentals have been recorded.

East Island

Twenty-six bird species have been recorded from East (Table 16); 18 were observed prior to 1935, 15 were recorded from 1935 through 1959 (1935-1949: 8; 1950-1959: 12), and

Table 15. Status and recent population of Disappearing Island birds

Species	Status		Recent Maximum Population	
	pre 1935	1935-1960-1969	Breeding	Non-breeding
Black-footed Albatross		B		
Blue-faced Booby		P	P	30
Brown Booby			P	few
Great Frigatebird			P	10
Wandering Tattler			P	1
Ruddy Turnstone			P	1
Sanderling			P	1
Gray-backed Tern			O	2
Brown Noddy			P	50
Black Noddy			P	15

B=Breeding; P=Present; O=Overflier

23 have been recorded since then. Of the breeding species, 9 were known prior to 1935, 6 from 1935 through 1959 (1935-1950: 4; 1950-1959: 5), and 9 since. One species that nested prior to 1935 no longer does so, and one present nester did not nest prior to 1960.

The decline, and subsequent increase, in the number of species, both recorded and breeding, reflects the U.S. Navy and Coast Guard occupation between 1935 and 1952, as well as the increased observations during scientific visits in recent times (post-1952). Unlike Tern, East did not lose its vegetation. With the exception of the west half of the island where the buildings were constructed, the island's vegetation was not greatly disturbed except for a reduction in Chenopodium. Photographs show no Chenopodium during this period, and the Red-footed Booby and the Red-tailed Tropicbird, both dependent on Chenopodium, stopped nesting during the occupation. Vegetation today is very similar to that seen in photographs taken in June 1923; Chenopodium is again present and so are the two species that temporarily left.

Recent total populations (breeders 131,402; non-breeders, 80,194) on East are the highest in the atoll. Populations of all present species are higher than during the pre-1960 period. The Sooty Tern, when present, is by far the most numerous of the island's avifauna. Other species with high populations are, in order, the Wedge-tailed Shearwater, Brown Noddy, and Black-footed Albatross.

Table 16. Status, recent population, and habitat of East Island birds

Species	Status		Recent Maximum Population		Habitat
	pre 1935	1935-1960- 1959 1969	Breeding	Non- breeding	
Black-footed Albatross	B	B	1,544	184	Nests around entire outer edge; concentrated at east end.
Laysan Albatross	B	B	678	83	Nests scattered in interior; concentrated at east end.
Bonin Petrel		P		1	Found dead.
Red-billed Tropicbird		A		1	Sitting on ground during day.
Bulwer's Petrel	B			1	Nests under old turtle shells, June 1891.
Wedge-tailed Shearwater	B	B	8,000	5,000	Burrows over entire vegetated portion.
Christmas Shearwater	P	P		1	Possibly bred in June 1923.
Sooty Storm Petrel	P				Possibly bred in June 1891.
Red-tailed Tropicbird	B	B	40	10	Nests under <u>Tournefortia</u> and rubble.
Blue-faced Booby	B	P	18	6	Nests on southeast upper beach and west tip.
Red-footed Booby	B	B	120	320	Nests on <u>Chenopodium</u> , <u>Tournefortia</u> , and rubble.
Brown Booby	P	P		1	Occasional visitor.
Great Frigatebird	P	P		375	Roosts on all rubble.
Chicken		I		?	Unsuccessful introduction in 1949.
Pheasant		I			Unsuccessful introduction in 1949.

Table 16. (continued)

Species	Status		Recent Maximum Population		Habitat
	pre 1935	1935-1960- 1959 1969	Breeding	Non- breeding	
Golden Plover	P	P	47		Beaches, sometimes in vegetated areas.
Bristle-thighed Curlew	P	P	3		Beaches and vegetated areas.
Wandering Tattler	P	P	5		Beaches.
Ruddy Turnstone	P	P	130		Beaches.
Sanderling	P	P	3		Beaches.
Gray-backed Tern		B	2	3	Nest near edge of vegetated part, lagoon side.
Sooty Tern	B	B	120,000	70,000	Nests over entire vegetated portion.
Brown Noddy	B	B	1,000	4,000	Nests mainly at east and west end of vegetated area.
Black Noddy		P		5	Occasional roosting bird.
White Tern	P	P		5	Occasional visitor.
Nihoa Finch		I		10	Introduced 10 March 1967; none present June 1967.

B=Breeding; P=Present; I=Introduced; A=Accidental

All areas of East are utilized by the nine present nesters (Figs. 51-52). Eight nest on or under the ground; the ninth nests in bushes or on rubble. Black-footed Albatross nest on the entire periphery (including the sandy ends) of the vegetated portion of the island, as well as on the sparse areas of the interior. Laysan Albatross nest only on the sparse areas of the island's interior. Both albatrosses concentrate their nests on the eastern half of the island which was the area of least disturbance during the military occupation. Wedge-tailed Shearwaters dig burrows over most of the vegetated portion of the island except the west tip; they also nest under rubble left from the period of military occupation which is scattered over the center of the island. Red-tailed Tropicbirds also nest under this rubble, as well as under the Tournefortia bush at the east tip. Blue-faced Boobies nest just above the beach crest on both the east and west tips, and a short distance inland along the vegetated edge on the ocean side. The Gray-backed Tern pair usually nest on the north-central edge of the vegetated portion near piles of building rubble. Sooty Terns nest over the entire vegetated portion, at times even onto the upper beach crest. Brown Noddies nest in two large colonies-- in the extreme west tip of the vegetated area, and on the ocean side of the east tip in the vegetated portion. This species has also been recorded nesting in scattered pairs or small groups around the edge of the entire island. Red-footed Boobies nest above ground on the live Tournefortia bush at the eastern tip and the dead one on the ocean side of the west-central area, on scattered Chenopodium bushes in the central area, and on scattered rubble in the center of the island.

Roosting individuals of these breeding species usually utilize the same general areas as the nesters. Brown Noddies roost on the old pier on the ocean side. Red-footed Boobies, Great Frigatebirds and Black Noddies roost on the various piles of rubble.

Brown Boobies from La Perouse Pinnacle occasionally fly over the island and sometimes alight on the old pier or on the extended sand arm at the extreme west tip. White Terns have been known to alight on the high portions of the rubble.

Shorebirds are found over most of East Island, especially on the beaches (most notably the Wandering Tattler, Ruddy Turnstone, and Sanderling). The Bristle-thighed Curlew and Golden Plover frequent the vegetated areas.

The Nihoa Finches introduced in March 1967 did not survive, probably due to a lack of a continual fresh water supply.

One accidental seabird, a Red-billed Tropicbird, was found on East in June 1968. No accidental shore-, fresh-water, or land bird has been observed on the island.



Figure 51. Sooty Terns nesting over most of East Island, 12 June 1966. POBSP photograph by A. B. Amerson, Jr.



Figure 52. Laysan Albatross young in foreground, Black-footed Albatross young in background, and Sooty Terns flying over east portion of East Island, 19 June 1966. POBSP photograph by A. B. Amerson, Jr.

Gin Island

Seven bird species have been recorded from Gin Island (Table 17); none were recorded prior to 1935, 4 were recorded from 1935 through 1959, and 5 have been recorded since. Of the nesting species, 2 are known to have nested from 1935 to 1960, and 1 from 1960 to the present. The other 2 previous nesters do not presently nest on the island.

The absence of species records prior to 1935, and the low population and breeding numbers recorded since, is due mainly to the small size of the island and the lack of vegetation. This sandy island is low and during extremely bad weather its location is such that wave action would destroy bird nests and vegetation. In 1923 a small amount of Portulaca was recorded, but no vegetation has been recorded since. However, scientific visits to Gin, especially prior to 1960, have been few.

Recent total daytime populations (breeders 70, non-breeders 100) are small, but rank second highest among the low, sandy non-vegetated islands. No nocturnal population estimates are available. Present population estimates of breeding species are lower than estimates made prior to 1960.

Presently only the Blue-faced Booby nests at Gin Island. It nests around the upper beach crest in the central depressed area. During the 1950's, the two albatross species nested in the central area. Both the Brown Noddy and Black Noddy roost in small numbers on the beaches during the daytime. Additional numbers of these species probably roost at night.

Low numbers of the Golden Plover and Ruddy Turnstone have been observed on the beaches.

La Perouse Pinnacle

Seventeen species of birds are known from La Perouse Pinnacle: 11 were known prior to 1935; 9 were recorded from 1935 through 1959; all 17 have been recorded since (Table 18). Two species are known to have nested prior to 1935, 5 from 1935 through 1959, and 9 have been known to nest since the beginning of 1960. Three of the present nesters did not nest prior to 1960.

The slight decrease and subsequent increase in the number of species recorded, as well as the increase in the number of breeding species recorded, is due, no doubt, to infrequent and brief scientific visits. Due to its inaccessibility except during very calm sea conditions, visits necessarily have been few.

Table 17. Status, recent population, and habitat of Gin Island birds

Species	Status		Recent Maximum Population		Habitat
	pre 1935	1935-1960- 1959 1969	Breeding	Non- breeding	
Black-footed Albatross		B			
Laysan Albatross		B			
Blue-faced Booby		P B	70	45	Nests in center of island.
Golden Plover		P P		5	Beach.
Ruddy Turnstone		P P		5	Beach.
Brown Noddy		P		40	Roosting on beach.
Black Noddy		P		5	Roosting on beach.

B=Breeding; P=Present

Table 18. Status, recent population, and habitat of La Perouse Pinnacle birds

Species	Status		Recent Maximum Population		Habitat
	pre 1935	1935-1960- 1959 1969	Breeding	Non- breeding	
	Bulwer's Petrel	P	B	500	
Wedge-tailed Shearwater	B	B	200	few	Nests in crevices of cliffs.
Sooty Storm Petrel		P		1	
Red-tailed Tropicbird	P	B	2+	9+	Nests on ledges and in crevices of cliffs.
Blue-faced Booby	P	P		10	Roosts on top of main rock.
Red-footed Booby	P	P		6	Roosts on top of main rock.
Brown Booby	P	B	100	30	Nests on ledges and top of main pinnacle.
Great Frigatebird		P		100	Roosting on top of main rock.
Golden Plover		P		10	Present on both rocks.
Wandering Tattler	P	P		1	Little rock.
Ruddy Turnstone		P		5	Little rock.
Gray-backed Tern		P	1,000	500	Nests on ledge of north cliff.
Sooty Tern		P		few	
Blue-gray Noddy	B	B	2	4	Nests in low crevices of north cliff.

Table 18. (continued)

Species	Status		Recent Maximum Population		Habitat
	pre 1935	1935-1960- 1969	Breeding	Non- breeding	
	Brown Noddy	P	B	1,000 [±]	
Black Noddy	P	B	600	2,000	Nests on ledges of cliffs.
White Tern	P	B	1,000	2,500 ⁺	Nests on ledges of both cliffs.

B=Breeding; P=Present

Isolation has resulted in almost unchanged conditions for at least the last 55 years. Vegetation is lacking and none is thought to have ever existed on the island. The many ledges and crevices on the cliffs, however, provide a variety of nesting habitats.

In recent years, maximum population estimates for La Perouse Pinnacle total 4,404 breeders and 5,676 non-breeders. Although this rock is not considered one of the four main islands due to its lower species complement, it does rank third in total population. The White Tern population is the highest of all 17 species on the island; this colony also represents the greatest concentration of White Terns in the atoll. The Black Noddy population is second highest on the island.

Although the Brown Booby is known from several of the other islands, it nests almost exclusively at La Perouse Pinnacle. The exception was a single nest found at Whale-Skate Island in the fall of 1967. The La Perouse population may have originally come from the rock-nesting populations of Necker and Nihoa Islands, rather than from the sandy-ground nesting populations of the low islands in the Northwestern Hawaiian Chain.

The nine presently known breeders nest in the rocks from just above high-water mark to the top of the 122' peak. Red-tailed Tropicbirds nest on the sheltered ledges and crevices of the north and south cliffs. The Brown Booby population nests on various ledges from halfway up the north and south cliffs to the very top of the peak. Gray-backed Terns nest on a wide ledge halfway up the north cliff. The few Blue-gray Noddies nest in the low crevices of the north cliff, just above the extreme high-water mark. The Brown and Black Noddies nest on the ledges on the north and south sides of the pinnacle, but predominantly on the south. The Wedge-tailed Shearwater and Bulwer's Petrel nest in the crevices of the cliffs.

Blue-faced Boobies, Red-footed Boobies, and Great Frigatebirds roost on the top of the high rock; no records of nesting exist although the habitat is favorable. It is possible that Christmas Shearwater, Sooty Storm Petrel, and White-tailed Tropicbird nest in the crevices of the cliffs. No birds nest on the small rock east of the main pinnacle.

Three shorebird species, Golden Plover, Wandering Tattler, and Ruddy Turnstone, have been observed on the low and middle ledges of the main pinnacle, as well as on top of the small rock. No accidental species have been recorded from La Perouse Pinnacle.

Little Gin Island

Nine bird species have been recorded from Little Gin (Table 19); 4 species were recorded prior to 1935, 3 from 1935 through 1959, and 8 since 1959. Of the 4 nesting species, 4 nested there prior to 1935, 1 from 1935 to 1960 and 3 since.

The low number of bird species recorded and breeding at Little Gin over the years reflects the small size of the island and the almost complete lack of vegetation. This sandy, desert-like island is high in places (20'), but, during extreme weather conditions, its location is such that wave action changes the island's shape and size. This action could destroy bird nests and probably has been the main factor in reducing the species number and the amount of vegetation on the island. In June 1923 Tanager Expedition botanists found a small amount of Lepturus, Boerhavia, and Portulaca (Christophersen and Caum, 1931). Lepturus is presently absent from the island and the other two species number only a few small plants each. Few scientific visits have been made to this island, especially prior to 1960.

Recent total daytime populations (breeding 536, non-breeding 135) are low when compared to La Perouse Pinnacle or one of the major islands, but the population on Little Gin is higher than on the other low, sandy islands. The population probably increases at night.

The three species presently nesting at Little Gin use primarily the middle portion of the island. When the island's sandy peninsula exists, as in 1963, 1965, and 1969, some nest there. Black-footed Albatross nest on the high western ridge as well as in the center portion. Blue-faced Booby and Brown Noddy nests are scattered over the central portion; some of the latter are placed among the few low plants. Wedge-tailed Shearwaters nested on this island in June 1923 and built burrows at the base of the Lepturus. With the disappearance of Lepturus (between 1923 and 1953), the Wedge-tailed Shearwater also disappeared. The Brown Booby and Great Frigatebird are occasional visitors, either flying over or roosting on rubble.

Low numbers of Golden Plover and Ruddy Turnstone have been observed on the beaches. No additional shorebird species have been recorded.

Mullet Island

Two bird species have been recorded from Mullet Island. Tanager Expedition personnel visited the island in June 1923 and found no birds. No scientific visits were made again

Table 19. Status, recent population, and habitat of Little Gin Island birds

Species	Status		Recent		Habitat
	pre 1935	1935-1969	Maximum Breeding	Population Non-breeding	
Black-footed Albatross	B	B	504	?	Nests in center of island.
Wedge-tailed Shearwater	B				
Blue-faced Booby	B	P	10	50	Nests in center of island.
Brown Booby		P		1	
Great Frigatebird		P		1	Roosting on rubble.
Golden Plover		P		10	Beach.
Ruddy Turnstone		P		5	Beach.
Brown Noddy	B	B	22	43	Nests on sand in central area.
Black Noddy		P		25	Roosting on beach.

B=Breeding; P=Present

until August 1965 and June 1967 when POBSP personnel viewed it from a short distance; POBSP and BSWF personnel landed in June 1968. Two seabird species were observed, neither of which was nesting.

This island is located just southeast of Round. No vegetation has been noted there. Because of its position in the center of the lagoon, it is protected from direct wave action from the open ocean, but, due to its low elevation, waves wash over it during extreme sea conditions. In June 1963 the island washed away but reappeared by August 1965, and was still there, although awash at high tide, in June 1967, 1968, and 1969. The island's lack of vegetation and low profile has limited its use by birds.

Brown and Black Noddies have been recorded roosting, although other seabird species may occasionally do so. No shorebird species have been recorded.

Near Island

Only the Brown Noddy has been recorded from Near Island. The island was not present in 1923 but is shown on recent maps. It is presently awash at high tide, and thus can only be used at low tide by roosting birds.

Round Island

Ten bird species have been recorded from Round Island (Table 20); 7 were observed prior to 1935, 6 were recorded from 1935 through 1959, and 3 have been recorded since. Of the 4 known nesting species, 4 are known to have nested prior to 1935, 1 from 1935 to 1960, and 1 from 1960 to the present.

The decrease in the number of bird species recorded and breeding over the years reflects the decline in island height and vegetation. The position of this island in the center of the lagoon and among coral is such that it is protected from excessive wave action except during extreme weather and sea conditions. In 1923 Lepturus, Boerhavia, Portulaca, and Tribulus were found by Christophersen and Caum (1931). However, wave action since 1923 has apparently affected the island. No vegetation has been found since. From photographs the island appears to be lower today than in 1923. Few scientific visits were made between 1923 and 1960 and recent visits have been infrequent and of short duration.

Recent total daytime population estimates (breeding 50, non-breeding 23) are very low; even so, Round Island ranks third highest in population among the low non-vegetated islands. The population probably increases at night. Present populations are much lower than before 1960.

Table 20. Status, recent population, and habitat of Round Island birds

Species	Status		Recent Maximum Population		Habitat
	pre 1935	1935-1960- 1959 1969	Breeding	Non- breeding	
Black-footed Albatross	B	B			
Wedge-tailed Shearwater	B				
Blue-faced Booby	B	P B	50	10	Nests in center of island.
Brown Booby		P			
Great Frigatebird		O			
Golden Plover		P			
Ruddy Turnstone	P	P			
Sanderling		P			
Brown Noddy	B	P	10		Roosts on beach.
Black Noddy	O	P	3		Roosts on beach.

B=Breeding; P=Present; O=Overflieger

Presently, only the Blue-faced Booby nests on Round Island (Fig. 53). Its nests are placed on the sand throughout the center portion. In recent years there is evidence that wave action has destroyed all or most of the nests. Black-footed Albatross nested as late as December 1957 over most of the north half of the island.

A small Wedge-tailed Shearwater population existed here in 1923; burrows were found at the base of scattered vegetation, especially Lepturus. Brown Noddies also nested in among the scattered vegetation in 1923.

The Brown Booby, Great Frigatebird, and Black Noddy have been recorded either flying over or roosting on the island. Small numbers of Golden Plover, Ruddy Turnstone, and Sanderling have been recorded.

Shark Island

Five bird species have been recorded from Shark Island (Table 21). The first scientific visit was by personnel of the Tanager Expedition in June 1923; they recorded 3 seabird species, none of which was nesting. POBSP personnel attempted a visit in June 1963 but, due to rough seas, could only view the island from about 100 yards. A second POBSP visit in June 1969 was successful; 2 bird species were recorded.

Shark Island's location, height, and present lack of vegetation have probably played a major role in limiting the number of bird species using the island. It is located at the northwest tip of the atoll and is struck by ocean waves on two sides. Its low height and sandy composition enable waves to change its shape during severe weather and sea conditions. In June 1923 a small amount of Boerhavia was recorded (Christophersen and Caum, 1931); no vegetation occurs today.

Only two birds, a Blue-faced and a Brown Booby, were recorded on Shark in 1969; others probably roost there. No birds have been known to nest there. In June 1923 the Great Frigatebird, Brown Noddy, and Black Noddy were observed roosting. U.S. Coast Guard personnel have visited the island in recent years; they report small black birds--probably Brown or Black Noddies--roosting on the beach.

No shorebirds have been recorded.

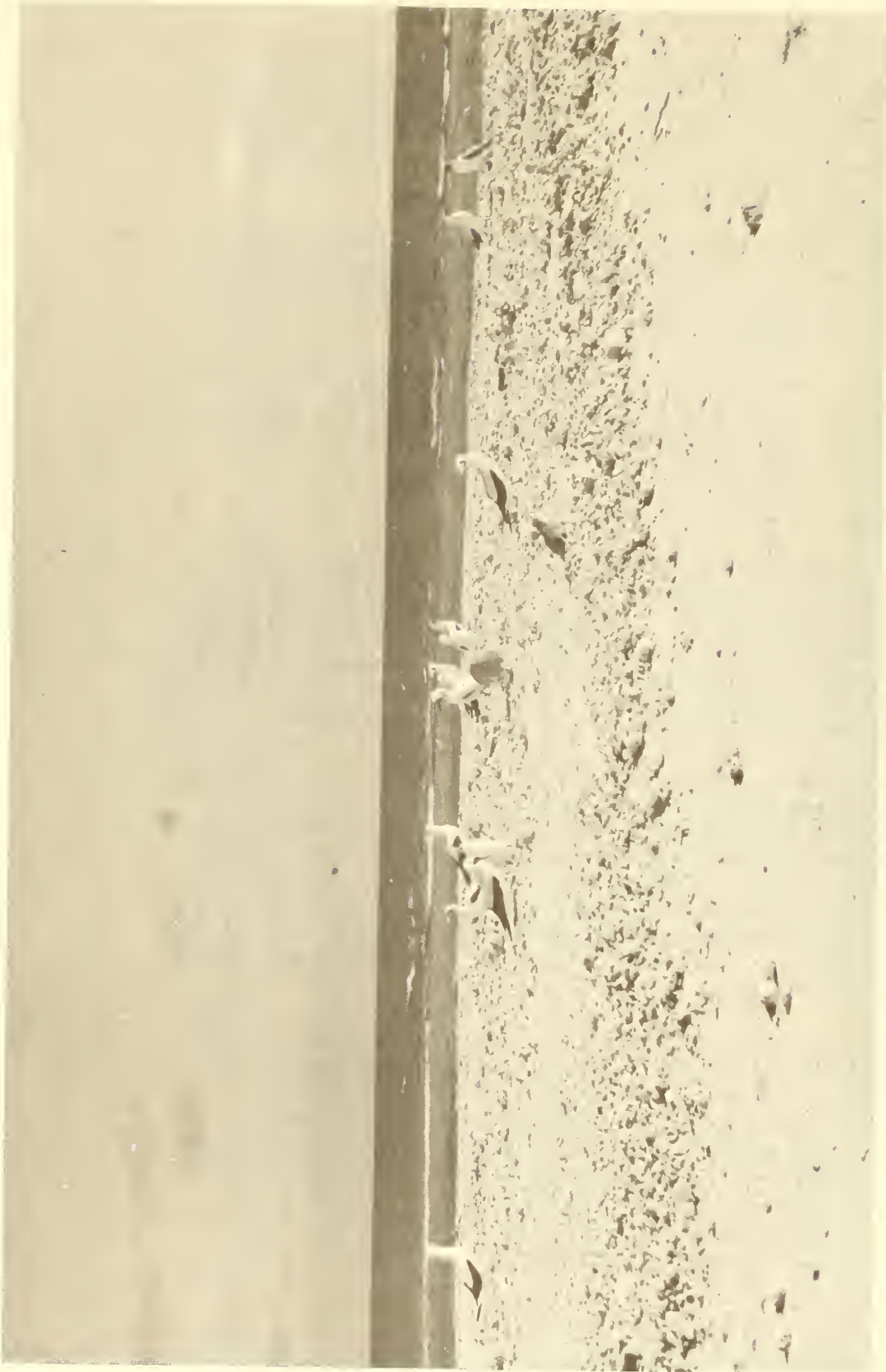


Figure 53. Blue-faced Boobies nesting on low Round Island, 10 August 1965; no vegetation present. POBSP photograph by A. B. Amerson, Jr.

Table 21. Status, recent population, and habitat of Shark Island birds

Species	Status		Recent Maximum Population		Habitat
	pre 1935	1935- 1959	1960- 1969	Non- Breeding	
Blue-faced Booby			P	1	Roosting on crest of island.
Brown Booby			P	1	Roosting on rubble.
Great Frigatebird			P		
Brown Noddy			P		
Black Noddy			P		

 P=Present

Tern Island

Of the 44 bird species that occur at French Frigate Shoals, 39 species have been recorded from Tern Island (Table 22). Fifteen species were recorded prior to 1935, 20 between 1935 and 1959 and 35 have been recorded since. Of the 10 recorded nesting species, 6 are known to have nested on the island prior to 1935, 3 from 1935 to 1959, and 7 since 1960. Three species that nested prior to 1935 no longer nest on the island; 4 present nesters did not nest prior to 1960.

The sharp increase in the number of species recorded possibly reflects the increased number of scientific visits to the island since 1950; it also reflects the increased amount of vegetation available to the avifauna. The decrease, and subsequent increase, in breeding species reflects the vegetational history of the island. With the advent of military construction in 1942, all vegetation was destroyed. Photographs from various sources reveal that both natural and introduced vegetation reestablished itself slowly until the late 1950's, after which a rapid increase took place in both ground cover (grass and weeds) and larger plants (Tournefortia, Casuarina, and Pluchea).

Recent total populations (breeders 1,586, non-breeders 480) on Tern are low compared to those on the other three major islands and La Perouse Pinnacle. Species that nest in large colonies (Sooty Tern, Brown Noddy, and Blue-faced Booby) are now all absent except for occasional visitors. Although the total Tern Island bird population is now lower, present breeding and non-breeding populations are higher than in the pre-1935 era.

The three species which formerly nested on Tern have probably joined established colonies on other islands within the atoll. Conversely, Bulwer's Petrel, Red-tailed Tropicbird, and White Tern--species which did not nest on the island prior to 1960--undoubtedly have come from other islands within the atoll. The Bonin Petrel has been recorded only at Tern Island, first in 1953 (Richardson, 1954b), and as nesting in 1967. The nearest Bonin Petrel population is 281 miles to the northwest at Laysan Island.

Seven breeding seabird species presently utilize the narrow vegetated strip on either side of the runway (Fig. 37). The runway was utilized by the Sooty Tern during the period between its abandonment by the U.S. Navy in 1945 and its reoccupation by the U.S. Coast Guard in 1951. The albatrosses nest primarily on the grass-covered areas in, and east of,

Table 22. Status, recent population, and habitat of Tern Island birds

Species	Status		Recent Maximum Population		Habitat
	pre 1935	1935-1960- 1959 1969	Breeding	Non- breeding	
Black-footed Albatross	B	B	14	?	Nests mainly on south side of runway.
Laysan Albatross	B	B	400	?	Nests on both sides of runway.
Northern Fulmar	P				One on beach, 1923.
Herald Petrel		A	1		Runway.
Murphy's Petrel		A	1		East end of runway.
Bonin Petrel	P	B	1,000	?	Burrows on south side of runway.
Bullwer's Petrel		B	2?	?	Possible nest under Quonset hut.
Wedge-tailed Shearwater	B	B	60	40	Burrows on both sides of runway and under buildings.
Christmas Shearwater		O		occasional	
Sooty Storm Petrel		P		1	Runway.
Red-tailed Tropicbird	P	B	90	10	Nests under <u>Plu</u> chea and <u>Tournefortia</u> .
White-tailed Tropicbird		O		2	
Blue-faced Booby	B	O		occasional	
Red-footed Booby	P	P		occasional	Roosting.

Species	Status		Recent Maximum Population		Habitat
	pre 1935	1935-1960- 1969	Breeding	Non- breeding	
	P	O	occasional	occasional	
Brown Booby	P	O	occasional		Offshore.
Great Frigatebird	P	P	occasional		Roosting.
Cattle Egret		A	1		<u>Lepturus</u> area, south side.
Mallard		A	6		
Gadwall		A	1		Runway near garbage dump.
Pintail		A	19		Runway (?).
American Coot		A	1		Low <u>Tournefortia</u> and <u>Pluchea</u> .
Golden Plover	P	P	50		Runway, vegetated area, and beaches.
Semipalmated Plover		A	1		East end of runway.
Bristle-thighed Curlew	P	P	5		Runway and vegetated portion.
Wandering Tattler		P	4		Runway and beaches.
Ruddy Turnstone	P	P	80		Runway, vegetated areas, and beaches.
Sanderling	P	P	9		Runway and beaches.
Western Gull		A	1		
Glaucous-winged Gull		A	1		

Table 22. (continued)

Species	Status		Recent Maximum Population		Habitat
	pre 1935	1935- 1969	Breeding	Non- breeding	
Franklin's Gull		A	1		Dead under <u>Pluche</u> a.
Gray-backed Tern		O	occasional		
Sooty Tern	B	O	occasional		
Blue-gray Noddy		O	occasional		
Brown Noddy	B	P	5		Roosting adult in <u>Casuarina</u> .
Black Noddy		P	5		Nests in <u>Casuarina</u> , <u>Tournefortia</u> , etc.
White Tern	P	B	18	200	Vegetation. <u>Tournefortia</u> and <u>Pluche</u> a.
Short-eared Owl		P	1		In vegetation and around buildings.
Mockingbird		P	2		
Nihoa Finch		IB	2	32	

B=Breeding; P=Present; O=Overflier; A=Accidental; I=Introduced

the antenna field; some nest on the grassy portions of the north edge of the island, particularly on the east side. The Bonin Petrel nests only on the south side of the runway; its burrows are mainly in the sandy portions in, and east of, the antenna field. The Bulwer's Petrel nests under the old Quonset hut and other building material scattered about the south side. The Wedge-tailed Shearwater nests primarily in burrows in the grass-covered, sandy south portions, from the antenna field to the east tip; it also nests under various buildings on the south side, including the old Quonset hut and the wooden water tanks next to the main barracks, and under the dense Pluchea on the north side. The Red-tailed Tropicbird nests on both sides of the runway; on the north side it nests under the dense Pluchea and scattered Tournefortia, on the south side under Tournefortia, building materials, and the Quonset hut. The White Tern nests in the Casuarina trees in front of the barracks, in the larger Tournefortia bushes, on the concrete supports of the metal fuel tanks and the rubber water tank, on the concrete survey marker, on various wooden posts around the docks, and on the larger coral rocks located in the north-central portion.

Breeding seabirds from other islands in the atoll that occasionally visit Tern roost on various objects: a Black Noddy consistently roosts in the Casuarina in front of the barracks; the occasional Red-footed Booby roosts in the large Tournefortia at the east end; while the Great Frigatebird prefers tall structures such as the wooden posts near the docks, and the pole and other objects near the east-end.

Six of the atoll's ten non-resident seabird and gull species have occurred exclusively on Tern. Another is known from Trig and Tern. Tern is located at the northern edge of the atoll, the closest major island to the open ocean. Dead birds from the sea can, thus, more easily wash up on Tern's lengthy beach, and birds passing close to the atoll may accidentally, or in taking a short cut, fly over the island. Water puddles on the runway and the garbage dump are probably the major attractions to the gulls.

All five regular migrant shorebird species frequent the runway, vegetated areas, and the beaches. Ruddy Turnstones and Golden Plovers are most common in the grassy areas around the buildings; Bristle-thighed Curlews in the thicker vegetated areas, and Wandering Tattlers on the beaches.

Tern Island's attraction for accidental land- and fresh-water birds is also due to its size and favorable habitat. Vegetation and fresh-water puddles are the main attractions.

The single Cattle Egret was found in the Lepturus area on the south side of the runway; when collected it was feeding on insects. The Mockingbirds have been found in the vegetated areas along both sides of the island.

The introduced Nihoa Finch searches all vegetated portions of the island for food.

Trig Island

Twenty-three bird species have been recorded from Trig Island (Table 23). Of these, 12 were recorded prior to 1935, 14 from 1935 through 1959, and 22 since 1959. Ten species are presently known to nest; of these, 7 were recorded nesting between 1935 and 1960, and 6 were known to nest prior to 1935.

The increase in the number of recorded species, as well as in the number of species recorded nesting, is probably due both to the increased number of scientific visits since 1950, which has resulted in an increase in number of observations, and to the increase in certain types of vegetation which has made the island a more attractive habitat. The increased number of scientific visits has resulted in observations in almost all months of the year, thus increasing knowledge of seasonal breeders. Vegetation changes have been marked since 1923. Wetmore reported no tall vegetation on the island in June 1923; likewise, Richardson reported no high vegetation during his three visits between October 1953 and March 1954. However, photos taken by Rice and Kenyon in their 1957 altatross work reveal tall vegetation which was identified in 1963 as Tournefortia. The Christmas Shearwater and Red-tailed Tropicbird, both of which began nesting here in recent years, require such cover. The Red-footed Booby, which built tall ground nests of sticks in 1923, presently nests in the Tournefortia.

Recent total populations (breeders 2,815, non-breeders 3,652) on Trig are much greater than on Tern, but are not as large as on East and Whale-Skate Islands and La Perouse Pinnacle. The reason that populations are greater than on Tern is that Trig has 2 colonial nesters (Sooty Tern and Brown Noddy) and large numbers of nocturnal roosting birds (Great Frigatebird and Black Noddy). This reflects the absence of human disturbance on Trig, as well as the existence of suitable roosting and nesting habitat.

Although the Christmas Shearwater is known from four islands in the atoll, it only nests at Trig. An adequate explanation for this restricted breeding distribution cannot be given. Similar habitat can be found on the other three

Table 23. Status, recent population, and habitat of Trig Island birds

Species	Status		Recent Maximum Population		Habitat
	pre 1935	1935-1960- 1969	Breeding	Non- breeding	
Black-footed Albatross	B	B	102	?	Nests around the island's periphery.
Laysan Albatross	B	B	88	?	Nests in vegetated area, west portion.
Bulwer's Petrel	P				Few present in June 1891.
Wedge-tailed Shearwater	B	B	500	few	Burrows placed in <u>Lepturus</u> area.
Christmas Shearwater	P	P	20	5	Shallow burrows under <u>Scaevola</u> and <u>Chenopodium</u> .
Red-tailed Tropicbird		B	10		Nests under <u>Tournefortia</u> .
Blue-faced Booby	B	B	137	14	Nests on upper beach, particularly lagoon side.
Red-footed Booby	B	B	106	94	Nests and roosts on <u>Tournefortia</u> .
Brown Booby		O		occasional	
Great Frigatebird		P		300	Roosting on <u>Tournefortia</u> , etc.
Pintail		O		1	
Golden Plover	P	P		20	Beaches and inland areas.
Bristle-thighed Curlew		P		3	Beaches and vegetated areas.
Wandering Tattler	P	P		5	Beaches only.

Table 23. (continued)

Species	Status		Recent Maximum Population		Habitat
	pre 1935	1935- 1959	1960- 1969	Non- breeding	
Ruddy Turnstone	P	P	P	102	Beaches only.
Sanderling		P	P	3	Beaches only.
Ring-billed Gull		O	O	1	
Glaucous-winged Gull		O	A	1	Beach and just west of the island.
Gray-backed Tern		B	B	12	Nests associated with <u>Lepturus</u> , west and south portion.
Sooty Tern	B	B	B	1,400	Nests associated with <u>Boerhavia</u> , center and west portion.
Brown Noddy	P	P	B	440	Nests associated with <u>Boerhavia</u> and <u>Tribulus</u> .
Black Noddy		P	P	3,000	Roosts in <u>Chenopodium</u> and <u>Tournefortia</u> .
White Tern		O	O	occasional	

B=Breeding; P=Present; O=Overflier; A=Accidental

main islands. The small numbers in which this species occur on the atoll may provide the answer. In order to breed they must congregate. Moreover, since there are few Wedge-tailed Shearwaters on Trig, there is no competition between the two species for nesting space. The human habitation of Tern may be a factor, but on other atolls (e.g., Johnston) this has not been important.

The 10 species that nest on Trig Island make maximum use of all available habitat. Black-footed Albatross and Blue-faced Boobies nest on the upper beach, particularly on the lagoon side, as well as on the open sandy areas in the interior of the island and in the east portion. Laysan Albatross nest on the open areas in the vegetated interior of the west portion. Sooty Terns usually nest in two small colonies--one just west of the large Tournefortia bush located in the center of the island, the other on the northwest crest of the island--in areas of sand and low Boerhavia. Single Brown Noddy nests are scattered about the vegetated portion, particularly in association with Tribulus and Boerhavia; one small colony exists on the west crest. Gray-backed Terns nest as single pairs or in small groups on the ground in association with Tribulus and Lepturus in the west and south areas. Red-tailed Tropicbirds nest under the large, thick Tournefortia bushes scattered about the island. Christmas Shearwaters also nest in shallow burrows under the very large Tournefortia bush located in the center of the island, under low, thick Scaevola bushes on the north crest, and under scattered Chenopodium bushes in the west and south portions. Wedge-tailed Shearwaters dig their burrows at the base of the Lepturus-covered west half of the island. The only bush-nester on Trig Island, the Red-footed Booby, utilizes the many scattered Tournefortia bushes, as well as the low Chenopodium bushes. Roosting individuals of these 10 species can be found in the same habitat as the nesters.

Breeding seabirds from other islands in the atoll occasionally visit Trig; these either fly around or roost on various portions of the island. The Great Frigatebird roosts on Tournefortia and Chenopodium, as well as on the Fish and Wildlife sign and other posts, standing or on the ground. The Black Noddy, mainly nocturnal, roosts on Tournefortia, Chenopodium, and Scaevola.

Shorebirds frequent both the vegetated and beach areas of Trig Island. All species can be found on the beaches. The Golden Plover and Bristle-thighed Curlew can often be found in grassy areas. No accidental shorebirds have been recorded.

Two non-resident gull and fresh-water species--Pintail and Ring-billed Gull--have been observed flying over the island; a third, Glaucous-winged Gull, was collected there.

Whale-Skate Island

Of the 44 species recorded from the atoll, 24 have been observed at Whale-Skate Island (Table 24); 10 were recorded prior to 1935, 11 were recorded from 1935 through 1959, and all 24 have been recorded since then. Nine of the 13 breeding species are known to have nested prior to 1935; 5 nested from 1935 through 1959; all 13 have nested since.

The sudden increase in the number of species recorded after 1959 again reflects an increase in number of observations made by visiting scientists and, to a lesser extent, an increase in amount and kind of vegetation. The drop in nesting species during the 1935 to 1959 period cannot be explained by lack of vegetation; Chenopodium and Tournefortia did, however, increase after 1957. As far as can be determined, there has been no human disturbance of Whale-Skate.

Recent total populations (breeders 8,870, non-breeders 13,167) are low compared to those of East Island, but they are the second highest in the atoll. Post-1959 individual populations are higher than pre-1935 populations, and, with the exception of the two albatrosses, are higher than they were from 1935 to 1959. The Sooty Tern, Wedge-tailed Shearwater, Brown Noddy, and Black-footed Albatross, in this order, are the most numerous breeding species. The Sooty Storm Petrel and Great Frigatebird nest only on Whale-Skate Island; the next nearest nesting colony for each is Necker Island, some 138 miles east of the atoll. The Black Noddy population is the largest of the non-breeding species.

The 13 breeding species presently utilize all portions of Whale-Skate for nesting (Figs. 54-55). Most species are concentrated toward the central portion of both halves, thus showing the influence of the two original islands. The Black-footed Albatross are found mainly along the sandy edges of the beach crest (especially on the lagoon side); the Laysan Albatross nest mainly on the bare spots in the Lepturus and Tribulus-covered areas of the island. The small Bulwer's Petrel population nests in the Lepturus-Tribulus area on the west half of the island; occasional individuals have been found under Tournefortia. The Wedge-tailed Shearwater population digs its burrows at the base of the Lepturus and Chenopodium which grow over most of the island. The Sooty Storm Petrel population is small and may have been overlooked for years. It digs shallow burrows in the Lepturus and Chenopodium near the middle of the east half of the island. Red-tailed Tropicbirds nest under the rapidly spreading Tournefortia. The abundant Blue-faced Booby nests on the upper portion of the beaches, the beach crests, and edges of

Table 24. Status, recent population, and habitat of Whale-Skate Island birds

Species	Status		Recent Maximum Population		Habitat
	pre 1935	1935-1960- 1959 1969	1935-1960- 1959 1969	Non- Breeding breeding	
Black-footed Albatross	B	B	B	1,056 ?	Nests on upper beach periphery and inland.
Laysan Albatross	B	B	B	100 20	Nests interior portion, <u>Lepturus-Tribulus</u> area.
Bulwer's Petrel		B	B	2	Nests in shallow burrow under <u>Chenopodium</u> .
Sooty Shearwater		A		1	
Wedge-tailed Shearwater	B	B	B	2,400 600	Burrows in <u>Lepturus-Tribulus</u> area.
Christmas Shearwater		P		3	Roosts occasionally on east central area.
Sooty Storm Petrel		B	B	4	Burrows in <u>Chenopodium-Lepturus</u> area.
Red-tailed Tropicbird	P	B	B	16	Nests under <u>Tournefortia</u> .
Blue-faced Booby	B	B	B	280 295	Nests on upper beach periphery and inland.
Red-footed Booby	B	P	B	28 72	Nests on <u>Tournefortia</u> and <u>Chenopodium</u> .
Brown Booby		B	B	2 occasional	Nests on ground in central portion.
Great Frigatebird	B	B	B	442 58	Nests on <u>Chenopodium</u> and <u>Tournefortia</u> .

Table 24. (continued)

Species	Status		Recent Maximum Population	Habitat
	pre 1935	1935-1960- 1959 1969		
Golden Plover	P	P	50	Beaches and vegetated areas.
Bristle-thighed Curlew	P	P	3	Vegetated areas.
Wandering Tattler	P	P	5	Beaches only.
Ruddy Turnstone	P	P	150	Beaches only.
Sanderling	P	P	3	Beaches only.
Ring-billed Gull	A		1	Beach.
Gray-backed Tern	B	B	240	Nests in small groups under <u>Chenopodium</u> and <u>Tournefortia</u> .
Sooty Tern	B	B	2,600	Nests in two colonies, east and west central portions.
Brown Noddy	B	B	1,700	Nests in association with <u>Boerhavia</u> and <u>Tribulus</u> .
Black Noddy	P	P	10,000	Roosts on <u>Chenopodium</u> and <u>Tournefortia</u> .
White Tern	P	P	5	Occasional visitor.
Nihoa Finch	I	I	1	Seen entering <u>Tournefortia</u> bush.

B=Breeding; P=Present; A=Accidental; I=Introduced



Figure 54. Nesting birds on east portion of Whale-Skate Island, 24 June 1966. POBSP photograph by A. B. Amerson, Jr.



Figure 55. Great Frigatebirds and Red-footed Boobies nesting on Tournefortia bush, Whale-Skate Island, 24 June 1966. POBSP photograph by A. B. Amerson, Jr.

the vegetated portions and the sparsely vegetated portions of the island's interior. It is especially prevalent on the lagoon side of the island. One Brown Booby pair nested in the sandy central portion of the island in September 1967. Red-footed Boobies prefer to nest in the tops of Tournefortia bushes, but a few still nest on low-growing Chenopodium as they did prior to the appearance of Tournefortia. Most of the Great Frigatebirds nest in the two Chenopodium areas; a few nest in the tops of Tournefortia. Gray-backed Terns nest in single pairs or in small groups over the entire island under the edges of Tournefortia, Chenopodium, Lepturus, and Tribulus. The Sooty Terns nest in two colonies near the center of each original island. They nest on the ground in the sparse Tribulus. Brown Noddies nest in small colonies and in single pairs in Boerhavia and Tribulus; nests are scattered throughout the vegetated portion of the island.

Most non-nesting individuals of the above breeding species roost very close to their nesting counterparts. Some Blue-faced and Red-footed Boobies and Great Frigatebirds roost on the old barge located offshore on the lagoon side of the island. Some non-nesting Brown Noddies, as well as visiting Black Noddies, roost in large flocks on the beaches. Most Black Noddies appear at dusk and roost in the Chenopodium and Tournefortia. Visiting Christmas Shearwaters are occasionally found at night under the Chenopodium in the east central area. White Terns are daytime visitors and usually fly around the island; an occasional individual may roost on the barge.

When present, the five species of regular, migrant shorebirds can be found over most of the island. The Wandering Tattler, Ruddy Turnstone, and Sanderling are most frequently found on the beaches. The Bristle-thighed Curlew is more often seen in vegetated areas.

One Nihoa Finch, being chased by a Great Frigatebird, was seen on the island in June 1967. The Finch undoubtedly flew to this island from either Tern or East Islands, where it was introduced in March 1967. One Ring-billed Gull, one of two accidental seabird and gull species found on the island, was observed on the beach. The other, a Sooty Shearwater mummy, was found on the beach crest.

Banding and Movements

Banding

Birds totaling 67,027 of 19 species were banded at French Frigate Shoals by POBSP personnel from mid-1963 through 1969 (Table 25).— Over 22,000 birds were banded in 1966 when two

Table 25. Yearly banding totals of French Frigate Shoals birds

	1963	1964	1965	1966	1967	1968	1969	Total
Black-footed Albatross	866			500	434	742	1,507	4,049
Laysan Albatross	329			198	103	314	398	1,342
Bonin Petrel				1	100		9	110
Bulwer's Petrel			6	2		2	141	151
Wedge-tailed Shearwater	200		3,336	1,579	106	15	36	5,272
Christmas Shearwater			6	20		28	5	59
Red-tailed Tropicbird	28		70	107	139	112	169	625
Blue-faced Booby	728		304	222	373	268	369	2,264
Red-footed Booby	144		480	532	347	281	286	2,070
Brown Booby				1	2		21	24
Great Frigatebird	254		415	408	737	298	147	2,259
Golden Plover	1		2	1				4
Wandering Tattler				1				1
Ruddy Turnstone	1		7	5				13
Gray-backed Tern	23		20	50	194	12	90	389
Sooty Tern	1,100		5,793	16,911	8,500	5,400	191	37,895
Brown Noddy	751	26	1,250	921	2,500	100		5,548
Black Noddy			2,358	926	500	371	633	4,788
White Tern			63	76	1	4	20	164
Totals	4,425	26	14,110	22,461	14,036	7,947	4,022	67,027

month-long trips were made during summer and early fall. Slightly over 14,000 birds were banded in 1965 and again in 1967; smaller numbers were banded in the other years.

These birds were banded on the eight islands within the atoll on which breeding occurs. The majority was banded on the four major islands--East, Whale-Skate, Trig and Tern, in that order. Over 40,000 have been banded on East Island alone.

Of the total banded there were: 37,895 Sooty Tern adults and nestlings; 5,548 Brown Noddies; 5,272 Wedge-tailed Shearwaters; 4,788 Black Noddies; and 4,049 Black-footed Albatross.

Movements

Sixteen species have been recaptured at French Frigate since 1963, totaling 8,238 birds (Table 26). Of this total, 7,958 were originally banded on the atoll, while 280 were banded on other atolls.

The 7,958 recaptured birds banded on the atoll involve: 378 (7 species) in 1965; 2,222 (13 species) in 1966; 2,550 (16 species) in 1967; 1,466 (11 species) in 1968; and 1,342 (13 species) in 1969. None would be expected to be recaptured in 1963. In 1964 only one short visit was made which limited banding and recapture activities.

The 280 captures of birds from other atolls involve 12 species: 2 in 1963; 65 in 1965; 92 in 1966; 74 in 1967; 27 in 1968; and 20 in 1969. These 280 recaptures represent only 269 birds, for some have been captured more than once. These birds were originally banded on all the Northwestern Hawaiian Islands except Nihoa, and on Oahu, Kauai, Johnston, Wake, Palmyra, and Alaska (Table 27). Most came from Johnston Atoll (128 birds, or 48 percent) with Laysan second (35, or 13 percent), and Kure third (25, or 9 percent).

In addition to birds coming to the atoll, 246 birds of 12 species originating at French Frigate Shoals have been captured on other central Pacific Islands (Oahu, Kauai, Nihoa, Laysan, Lisianski, Pearl and Hermes, Midway, Kure, Johnston, Wake, Eniwetok, the Philippines, and New Guinea) and from several at-sea localities in the north Pacific (Table 27). More birds (121, or 49 percent) have traveled to Johnston Atoll than to any other island, and secondly to Kure (43, or 17 percent).

The number of individual banded birds involved in inter-island movement, both to and from the atoll, totals 515. Johnston, Kure, Laysan, and Lisianski, in that order, are the islands most frequently involved.

Table 26. Yearly band return total for French Frigate Shoals*

Banded on:	1963		1965		1966		1967		1968		1969		Subtotal		Total
	FFS	Other	FFS	Other	FFS	Other	FFS	Other	FFS	Other	FFS	Other	FFS	Other	
Black-footed Albatross				1	1	1	11				4	1	16	2	18
Laysan Albatross			1		1		9				12		21	2	23
Bonin Petrel						1	1		2				3		3
Bulwer's Petrel				3	3		1				3		7		7
Wedge-tailed Shearwater			39	4	398	1	141	1	33		4		615	6	621
Christmas Shearwater						6	6		3		5		14		14
Red-tailed Tropicbird			3		16		38		80	1	124	2	261	3	264
Blue-faced Booby			220	5	340	1	516	4	510	2	593	3	2,179	15	2,194
Red-footed Booby	2		61	24	263	42	297	50	220	16	198	10	1,039	144	1,183
Great Frigatebird			17	1	67	10	127	4	49	2	94	4	354	21	375
Ruddy Turnstone			2		1	6	1	1					2	8	10
Gray-backed Tern					1		1				1		3		3
Sooty Tern			8	17	907	22	838	8	488	4	159		2,400	51	2,451
Brown Noddy			30	1	131	4	423	4	51		35		670	9	679
Black Noddy				10	89	3	139	3	29	2	110		367	18	385
White Tern					5	1	1		1				7	1	8
Totals	0	2	378	65	2,222	92	2,550	74	1,466	27	1,342	20	7,958	280	8,238

* No band returns in 1964

Table 27. Interisland movement of banded birds involving French Frigate Shoals

To French Frigate from:	Oahu	Kauai	Nihoa	Necker	Gardner Pinnacles	Laysan	Lisianski	P & H Reef	Midway	Kure	Wake	Eniwetok	Johnston	Palmyra	At Sea	New Guinea	Philippines	Alaska	Total
Black-footed Albatross								2											2
Laysan Albatross									1	1									2
Wedge-tailed Shearwater													5						5
Red-tailed Tropicbird									1										1
Blue-faced Booby						1	3	1		1	1								13
Red-footed Booby	10	6			24	14	2	2	6	14	4	61	9						141
Great Frigatebird					2	1	1			8	1		8						21
Ruddy Turnstone																		8	8
Sooty Tern	1				5	1	5		5			35		1					48
Brown Noddy				1								9							10
Black Noddy					1	3	5	3	1	1		3							17
White Tern												1							1
Total (To)	11	6	1	1	1	35	24	9	14	25	6	128	1	1	8	269			

From French Frigate to:

Black-footed Albatross						2	1			2					12				17
Laysan Albatross															1				1
Bonin Petrel										1									1
Wedge-tailed Shearwater										2									2
Red-tailed Tropicbird										1									1
Blue-faced Booby		1	1		3	1	2			5		14			3				30
Red-footed Booby	1				12	10	3	2	2	19	1	60			2				110
Great Frigatebird					3	2	3		1	10		1	23				1		38
Sooty Tern						2	2		1		1	14							21
Brown Noddy						1	1					4			1	1			7
Black Noddy					6	2	1			3		5							17
White Tern												1							1
Total (From)	1	1	1	1	26	19	7	3	43	2	1	121	19	1	1	1	1	1	246
Grand Total	12	7	1	1	61	43	16	17	68	8	1	249	1	19	1	1	1	8	515

Species Accounts

Prior to the first POBSP survey in June 1963, 85 specimens of 22 bird species were known from French Frigate Shoals. They are in the collections of the U.S. National Museum, Washington, D.C. (USNM), American Museum of Natural History, New York (AMNH), Bernice P. Bishop Museum, Honolulu (BPBM), and British Museum of Natural History, London (BMNH). POBSP personnel collected 55 specimens of 26 species from French Frigate; all are in the U.S. National Museum collection. Eleven of these represent new specimen records for the atoll. An additional eight species represent new sight records.

For descriptions and illustrations of the 44 bird species recorded herein, the reader is referred to the ornithological sources cited previously, especially King (1967).

Tables are in alphabetical order by island; when few observations have been made on some islands, they are grouped in the final table following each species account.

BLACK-FOOTED ALBATROSS

Diomedea nigripes

Status

Abundant breeding species; present from early November through mid-July with peak populations during winter and early spring; absent during remainder of the year. Nests on the ground around the periphery and in the interior of East, Little Gin, Tern, Trig and Whale-Skate Islands. Previously nested on Disappearing, Gin and Round Islands. Maximum POBSP population estimate 4,700 in June of 1969.

Observations

The Black-footed Albatross was first reported from French Frigate Shoals during early June 1891 by Rothschild (1893-1900) and Munro (1941b). Recent observations indicate a population increase. Populations vary among the islands and differ from earlier observations (see Ecological Distribution).

Annual Cycle

Figure 56 presents the Black-footed Albatross local breeding cycle as determined by actual observations and interpolation of incubation and fledging periods. The atoll is completely deserted by this species from mid-summer to mid-fall, a period of about three and a half months. Adults begin to arrive during mid-October, egg laying starts in early November, and most eggs are probably laid within a short period. Hatching probably commences

in mid-January, with the peak in late January. Most young begin to fledge during the latter part of June; all fledglings have gone by mid-July. The adult population diminishes in late spring and by early June only a few adults remain, usually only for long enough to feed their young.

Figure 56. Annual cycle of Black-footed Albatross

+++	++++	++++	++++	++++	++++	++++				*****	*****
***										—	
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = dependent young present; ___ = non-breeding birds present

Ecological Distribution

Breeding Distribution: Presently breeds on East, Little Gin, Tern, Trig and Whale-Skate Islands. In previous years nesting has occurred on Disappearing, Gin and Round Islands.

Disappearing Island: At present Black-footed Albatross do not nest. Rice and Kenyon (1962) found two pair nesting on 28 December 1957 (Table 33). POBSP personnel found the island awash in June 1963; although it was no longer awash in June 1969, no birds were nesting.

East Island: At French Frigate Shoals, East Island is presently the major breeding island for Black-footed Albatross (Table 28). Numbers have increased since Munter found 400 nesting in March 1915 (see March 1966 [Kridler, BSFW, 1966a] and March 1967, Table 28). Substantiating this apparent increase are figures for several years for June when fledging was at its peak: 100+ were recorded (Wetmore, ms.) in 1923, 450 in 1963, 1,800+ in 1968, and 2,400+ in June 1969. When the Coast Guard LORAN Station was in operation, numbers apparently fell off drastically. Photographs by the U.S. Coast Guard (#30154912) and Henry (photo, 1949) show only 60+ and 80+, respectively, for spring 1949.

Gin Island: Black-footed Albatross do not nest at present. In December 1953 (Table 33), Richardson (1954b) observed 300 to 400 with nests and eggs. He could, however, have reversed the populations for Gin and Little Gin Islands, as he only found 14 on the latter which normally has a high population. Rice and Kenyon (1962) counted only three nests in December 1957.

Little Gin Island: Wetmore (ms.) observed about 150 young in January 1923 (Table 29). In June 1963 there were only 17 fledglings present; numbers increased to 125+ young in 1969. Black-footed Albatross nest on the high sandy ridges.

Round Island: No Black-footed Albatross have been known to nest here since 1957 (Table 33), presumably because the island has no vegetation and may be awash at extreme high tide or during severe storms. (Blue-faced Boobies still nest on the island, however.) In June 1923 when Wetmore (ms.) observed 90 young, Round was vegetated; by 1957 when Rice and Kenyon (1962) noted 30 birds and 12 nests, the island had little or no vegetation but may still have been above high tide.

Tern Island: Black-footed Albatross occur presently in small numbers (Table 30). Rothschild (1893-1900) and Munro (1941b), Bailey (1956) and Wetmore (ms.) all observed small numbers. Nothing is known of their status during the time, and shortly after, the Navy constructed the present-day Tern Island in 1942. Photographs taken during April 1945 and March 1949 show none. In December 1953 Richardson (1954b) found six nests with eggs, but these were destroyed during January by high waves. A few were observed dancing but not nesting during February 1956 by Svihla (1957). The maximum number observed was 14 on 7 nests in December 1967.

Trig Island: Wetmore (ms.) reported 50 young Black-footed Albatross in June 1923. The numbers dropped by June 1966 and 1967 and increased sharply in 1968 and 1969 (Table 31).

Whale-Skate Island: Only East has a larger Black-footed Albatross population at French Frigate Shoals (Table 32). Ten years ago, however, the Whale-Skate population was the larger. If one goes further back, this population was much lower and about the same as the population of East; in June 1923 when Whale and Skate were still separate islands, Wetmore (ms.) found only 120 young. By June 1963 the number of young was ca. 400 and by June 1969 it had reached 550+ (POBSP, 1969).

Although today's nesting population is equal to that of ten years ago, there appears to be a sharp egg loss, with only about 37 percent fledging. Kridler (pers. corr.) suggests, however, that his 1967 population figure "might be just a little high because these birds were mixed up with the frigatebirds and I was unable to segregate the two in the short time...over the island...." Rice and Kenyon (1962) could have over-counted in 1957 as well, since one can see and distinguish flying Great Frigatebirds in their photographs, but one cannot distinguish those on the ground from Black-footed Albatross. The 1957 photographs also reveal an absence of the two large masses of knee-

high Chenopodium now growing. Many Black-footed Albatross which nested in the area in 1957 are presently unable to do so due to the thick vegetation. Possibly this displacement has caused many albatross to nest in unfavorable areas where their nests may be destroyed by wave action, etc.

Banding and Movements

The POBSP has banded a total of 4,049 young--866 in June 1963, 500 in June 1966, 434 in May and June 1967, 742 in June 1968, and 1,507 in June 1969. No adults have been banded.

Sixteen returns have been recorded by POBSP personnel. All were banded as locals in June 1963 and were captured as follows: June 1966 (1), March 1967 (10), June 1967 (1), and June 1969 (4). Two originally banded as young at Pearl and Hermes Reef have been captured at French Frigate Shoals; 17 that were banded on French Frigate as locals have been captured elsewhere--2 at Laysan Island, 1 at Pearl and Hermes Reef, 2 at Kure Atoll, and 12 at sea (Appendix Tables 4a and 4b).

Specimens

POBSP: USNM 497920, unsexed skeleton, collected 10 June 1963 on East by Sibley and Amerson.

Non-POBSP: USNM 300816, ♀, collected 22 June 1923 by Wetmore; AMNH 526842, unsexed, collected 5 June 1891 by Palmer.

Table 28. Observations of Black-footed Albatross at East Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1891 June 4-5	plentiful	Young present; more plentiful than on Tern (Rothschild, 1893-1900).
1915 Mar.	400	Nesting (Munter, 1915).
1923 June 22-23	100+	75 young, majority almost fledged; adults few (Wetmore, ms.).
1935 Nov. 11	many	Along center of island (Rec. Group 80, U.S. Nat. Arch.).
1949 Spring	60+	Few adults, many half-grown young (USCG Hqtrs. Photo 30154912).
Spring	80+	Large downy chicks, few adults (Henry, photo 1949).

Table 28. (continued)

Date of Survey		Population Estimate	Breeding Status, Remarks, and References
1949	Fall	100+	100+ nests in less than that many feet, confined to one end of island (Wilder, 1949).
1953	Oct. 31	30	(Richardson, 1954a, 1957).
	Dec. 19	200	Nests with eggs (Richardson, 1954b, 1957).
1957	Dec. 28	425	170 nests, aerial survey (Rice & Kenyon, 1962).
1960	Apr. 13	150	No count of chicks possible; count taken from plane (HDFG, 1960a).
1962	June	numerous	Many young (HDFG Photo R1-308).
1963	June 7-11	450	Mostly fledglings present (420), few adults (POBSP, 1963).
1964	July 27	0	None reported (BSFW, 1964a).
1966	Mar. 23	1,400-1,500	661 adults, 547 chicks (BSFW, 1966a).
	June 10-14, 16-21	575+	25+ adults, 550 young; fledging mid-June (POBSP, 1966a).
1967	Mar. 11-12	2,500	772 chicks, all stages; no eggs (BSFW, 1967a; POBSP, 1967b).
	May 26-31 June 9-13	550	50 adults, 500 young; young almost fledged by late June (POBSP, 1967a).
	Dec. 9	?	Lesser number nesting than Laysan Albatross (BSFW, 1967c).
1968	June 6-11, 14-16, 25	1,800+	1,200+ adults, 600+ young; many young flying by early June (POBSP, 1968a).
1969	June 5-10, 21	2,400+	1,600+ adults, 800 young; young fledging late June (POBSP, 1969).

Table 29. Observations of Black-footed Albatross at Little Gin Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 24	160+	150 young, several adults noted and a number of dead young (Wetmore, ms.).
1953 Dec. 19	14	Nests with eggs (Richardson, 1954b; pers. comm.).
1957 Dec. 28	850	340 nests, aerial survey (Rice & Kenyon, 1962).
1963 June 9	17	Fledglings (POBSP, 1963).
1965 Aug. 25	2	Two dead locals (POBSP, 1965a).
1966 Mar. 23	600	78 adults, 252 chicks; low mortality (BSFW, 1966a).
1967 June 9	100	25 adults, 75 young; young very large (POBSP, 1967a).
Dec. 9	several hundred	Nesting; seen from helicopter (BSFW, 1967c).
1968 June 7	109	86 adults, 23 young (POBSP, 1968a).
1969 June 7, 21	375	25 adults, 125+ young; fledging late June (POBSP, 1969).

Table 30. Observations of Black-footed Albatross at Tern Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1891 June 1-3	?	Number present, young half-fledged; on the sand above beach (Rothschild, 1893-1900; Munro, 1941b).
1912 Dec. 19	?	Nesting; in small colonies along the shore (Bailey, 1956).
1923 June 24-28	10+	8 young almost fledged; adults few (Wetmore, ms.).
1953 Dec. 18	12	6 nests with eggs (Richardson, 1954b; pers. comm.).

Table 30. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1954 Mar. 20	?	Nests present in December destroyed during January by very high waves (Richardson, 1954b).
1956 Feb. 11-21	few	Present, but not nesting; dancing observed (Svihla, 1957).
1957 Dec. 28	5	Aerial survey, 2 nests (Rice & Kenyon, 1962).
1960 Apr. 13	0	1 pair reported nesting earlier that winter (HDFG, 1960a).
1965 Nov. 5	1	First arrival on Tern Island, (Park, pers. corr.).
Nov. 19	6	No nests (Park, pers. corr.).
1966 Mar. 21	10	Chicks (BSFW, 1966a).
1967 Dec. 7	14	7 nests with eggs, mainly on south side of runway (BSFW, 1967c).
1968 May 29-30 June 11-14, 16-17, 19-20, 22, 23-27	10	6 adults, 4 young (POBSP, 1968a).
1969 Feb. 22-24	6	4 adults, 2 young; all on west end (BSFW, 1969a).
June 2-4, 12, 25-26	3	2 adults, 1 young (POBSP, 1969).

Table 31. Observations of Black-footed Albatross at Trig Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 26	50	50 young (Wetmore, ms.).
1953 Oct. 28	8	(Richardson, 1954a; pers. comm.).
Dec. 19	200	Nests with eggs (Richardson, 1954b; pers. comm.).

Table 31. (continued)

Date of Survey		Population Estimate	Breeding Status, Remarks, and References
1954	Mar. 20	200-300	Adults and young (Richardson, 1954b).
1957	Dec. 28	325	130 nests; aerial survey (Rice & Kenyon, 1962).
1963	June 14, 15	50	Mostly fledglings (39), few adults (POBSP, 1963).
1966	Mar. 22	33	Adults ??, chicks 11 (BSFW, 1966a).
	June 10, 23 July 1, 3-4	22	2 adults, 20 young; fledged late June (POBSP, 1966a).
1967	Mar. 13	125	51 chicks, 38 adults (BSFW, 1967a; POBSP, 1967b).
	June 2, 8-9, 19-20	44	10 adults, 34 young; young fledging by late June (POBSP, 1967a).
	Dec. 9	large number	Nesting; seen from helicopter (BSFW, 1967c).
1968	June 6, 11, 22, 24-25	90	60 adults, 30 young (POBSP, 1968a).
1969	Feb. 22	168	112 adults, 56 young (BSFW, 1969a).
	June 3, 14, 23-24	240	160 adults, 80 young (POBSP, 1969).

Table 32. Observations of Black-footed Albatross at Whale-Skate Island

Date of Survey		Population Estimate	Breeding Status, Remarks, and References
1923	June 26	90*	90 young (Wetmore, ms.).
	June 26	30**	30 young (Wetmore, ms.).
1953	Oct. 28	40-50*	(Richardson, 1954a; pers. corr.).
	Oct. 28	20**	(Richardson, 1954a; pers. corr.).
	Dec. 19	400*	Nests with eggs (Richardson, 1954b; pers. corr.).

Table 32. (continued)

Date of Survey		Population Estimate	Breeding Status, Remarks, and References
1953	Dec. 19	400**	Nests with eggs (Richardson, 1954b; pers. corr.).
1954	Mar. 20	500-600	Adults and young (Richardson, 1954b).
1957	Dec. 28	2,240	840 nests; aerial survey (Rice & Kenyon, 1962).
1963	June 12-15	400+	Mostly fledglings present (390), few adults (POBSP, 1963).
1965	Oct. 24	5	First fall arrival date 1965 (Park, pers. corr.).
1966	Mar. 22	747	219 adults, 528 chicks (BSFW, 1966a).
	June 10, 23-29, July 1-3	325	25 adults, 300 young; fledging late June (POBSP, 1966a).
1967	Mar. 14	1,500	431 chicks (BSFW, 1967a; POBSP, 1967b).
	June 2-7, 15-19	330	30 adults, 300 young; fledging late June (POBSP, 1967a).
	Dec. 9	800-1,000	Adults nesting, seen from helicopter (BSFW, 1967c).
1968	June 6, 16, 17-25	900+	600+ adults, 300+ young (POBSP, 1968a).
1969	Feb. 23	1,294	700-800 adults, 494 young (BSFW, 1969a).
	June 3, 16-20, 22	1,650+	1,100+ adults, 550+ young (POBSP, 1969).

* Whale Island

** Skate Island

Table 33. Observations of Black-footed Albatross on other islands at French Frigate Shoals

Date of Survey		Island	Population Estimate	Breeding Status, Remarks, and References
1902	May 28-29	FFS	?	Present (Fisher, 1903).
1917	Nov. 6	FFS	numerous	No other data (Tucker, 1917).

Table 33. (continued)

Date of Survey	Island	Population Estimate	Breeding Status, Remarks, and References
1923 June 22	Round	90	All young, no adults seen (Wetmore, ms.).
1953 Oct. 31	Round	20	Present (Richardson, pers. corr.).
Dec. 19	Gin	300-400	Nests with eggs (Richardson, 1954b; pers. corr.).
1957 Dec. 28	Gin	8	3 nests, aerial survey (Rice & Kenyon, 1962).
Dec. 28	Disappearing	5	2 nests, aerial survey (Rice & Kenyon, 1962).
Dec. 28	Round	30	12 nests, aerial survey (Rice & Kenyon, 1962).

LAYSAN ALBATROSSDiomedea immutabilisStatus

Abundant breeding species; present from mid-October to late July, a few stragglers into early August; absent during rest of year. Nests on the ground in shallow scrapes usually placed in vegetated portions of East, Tern, Trig and Whale-Skate Islands. Previously nested on Gin Island. Maximum POBSP population estimate 1,550+ in June 1968.

Observations

Laysan Albatross were first reported by Rothschild (1893-1900) and Munro (1941b), who visited the atoll in June 1891. Wetmore (ms.) made the first population census and observed almost-fledged young at East, Trig, Whale and Skate Islands in June 1923.

The total nesting population was slightly smaller in 1969 than in 1957; the population on some islands within the atoll increased while on others it decreased. Tables 34 to 38 list all known observations by island.

Annual Cycle

The annual breeding cycle is presented in Figure 57. In general, the cycle commences in October and ends in late July or early August.

Birds arrive in mid-October and egg-laying commences about mid-November. Hatching occurs mid- and late January. Young begin to fledge in late June and early July. All young leave by early August. Adults start leaving in early June and stay at sea during August, September and the first half of October. Usually the young fledge slightly later than Black-footed Albatross young.

Figure 57. Annual cycle of Laysan Albatross

*****	****									***	*****
+++	++++	++++	++++	++++	++++	++++	++++	++++	+++		
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = dependent young present; ___ = non-breeding birds present

Ecological Distribution

Breeding Distribution: Laysan Albatross presently breed on East, Tern, Trig and Whale-Skate Islands. Previously they nested on Gin Island.

East Island: At present more Laysan Albatross are utilizing East Island than in previous years (Table 34). In 1915 Munter (1915) found 15 birds nesting. Wetmore (ms.) found 100 nests containing almost fledged young in June 1923. Little is known of the Laysan Albatross on East in the 1930's and 1940's. Richardson (1954b) found 200 adults with nests in 1953, a year after the U.S. Coast Guard moved to Tern Island. In 1957 Rice and Kenyon (1962) recorded 200 nests and 500 adults.

POBSP personnel visited periodically from 1963 to 1969 and recorded Laysan Albatross as a major species. Nests were scattered throughout the interior with the great majority at the east end. The maximum recorded population was 1,100.

Gin Island: Richardson (1954b, per. corr.) reported two nests with eggs in 1953 (Table 38). None has been recorded in recent years.

Tern Island: Bailey (1956) recorded a few hundred nesting in 1912 (Table 35). Wetmore (ms.) did not list Laysan Albatross during 1923, nor do photographs taken by him and others on the Tanager Expedition reveal this species. During June 1942 Tern Island was covered with coral fill and enlarged, thus eliminating all nesting sites and possibly killing any young on the island. U.S. Navy photographs taken in April 1945 and March 1949 show none. During the 1950's a maximum of 28 nests was observed.

Since June 1963 populations have fluctuated with the highest count being 112 young in March 1968. All fledglings were in the sparsely vegetated areas along the runway, mostly on the south side. Although the breeding success has varied, the breeding population now is as high as, or higher than, the pre-1942 period.

Trig Island: In 1923 Wetmore (ms.) found only one young, possibly as a result of activities of feather poachers (Table 36). In December 1953 Richardson (1954b, 1967, pers. corr.) found 100 with nests containing eggs, but by March 1954 only 15 to 20 adults with young remained. Rice and Kenyon (1962) counted 100 nests in 1957. All of these were located in the vegetated (Lepturus, Tribulus) area on the western two-thirds of the island.

Recent fledgling counts have varied from 8 to 24.

Whale-Skate Island: Over the years there has been a considerable variation in the size of the population (Table 37). In 1923, when the two islands were separate, Wetmore (ms.) found 25 young on Whale and only one on Skate. In 1953, with the islands still separate, Richardson (1954b and pers. corr.) observed 200 on Whale and 100 on Skate, both populations with nests containing eggs. When Rice and Kenyon (1962) in December 1957 counted 260 nests, the two islands were connected by a sandy strip.

Since 1963 June fledgling populations have varied from a low of 33 to a high of 100. Laysan Albatross presently nest in the interior in the areas covered by Lepturus and Tribulus. They are scattered throughout but seem to prefer the grassy east portion. The great masses of Chenopodium now growing on the island may limit available nesting sites.

Banding and Movements

Since June 1963 POBSP personnel have banded 1,342 young: 329 in June 1963, 198 in June 1966, 103 in June 1967, 314 in June 1968, and 398 in June 1969.

Nine banded as young in 1963 were recaptured in March, May and June 1967; 12 were recaptured in June 1969. Another 1963-banded bird (737-35537) was recovered in February 1966 by a Japanese fishing vessel from Nakushima, Japan. The recovery location and date are unknown; the letter telling of the recovery was sent from Palau, in the western Caroline Islands.

One (597-88548) banded as a local at Sand Island, Midway Atoll, by R.F. Stockstad on 14 April 1961, was captured as an adult at Tern Island on 22 April 1965.

A bird (737-93378) banded by POBSP as an adult, sex unknown, on Kure Atoll 10 February 1965, was captured at East Island, French Frigate Shoals, on 19 June 1966.

Specimens

Non-POBSP: USNM 465210, ♂, collected 23 June 1923 by Wetmore; AMNH 526866, ♀, collected 6 May 1891 by Palmer; AMNH 526867, ♀, collected 2 June 1891 by Palmer.

Table 34. Observations of Laysan Albatross at East Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks and References</u>
1915 Mar.	30	Nesting (Munter, 1915).
1923 June 22-24	300	100 nests with young almost fledged (Wetmore, ms.).
1936 Oct. 25	few	Adults (Navy Dept. Photo 80 G 410123).
1949 Spring	1	1 adult (Henry, photo 1949).
Spring	25+	Adults with half-grown young (USCG Photo 30154912).
1953 Dec. 19	200	Nests with eggs (Richardson, 1954b; pers. corr.).
1957 Dec. 28	500	200 nests, aerial survey (Rice and Kenyon, 1962).
1960 Apr. 13	1	1 seen in flight but others may have been concealed by vegetation; count taken from plane (HDFG, 1960a).
1961 Mar. 4	few	Adults with a few young (HDFG, 1961b).
1962 June	?	Present (HDFG photo #R1-309).
1963 June 7-11	275	Mostly fledglings (247), few adults (POBSP, 1963).
1964 July 27	20	All immatures, unable to fly (BSFW, 1964a).
1966 Mar. 23	850-900	462 adults, 274 chicks; low mortality noted (BSFW, 1966a).

Table 34. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1966 June 10-14, 16-21	225	200 young very large, almost fledged (POBSP, 1966a).
1967 Mar. 11-12	1,100	339 chicks, all stages, no eggs (POBSP, 1967b; BSFW, 1967a).
May 26-31, June 9-13	225	25 adults, 200 young; young pre-fledging late June (POBSP, 1967a).
Dec. 9	large number	Adults nesting, seen from helicopter (BSFW, 1967c).
1968 June 6-11, 14-16, 25	975 [±]	650 [±] adults, 325 [±] young (POBSP, 1968a).
1969 June 5-10, 21	900	600 adults, 300 young (POBSP, 1969).

Table 35. Observations of Laysan Albatross at Tern Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1891 June 1-3	?	Present (Rothschild, 1893-1900; Munro, 1941b).
1912 Dec. 19	few hundred	Nesting in the shelter of bunch grass (Bailey, 1956).
1953 Dec. 18	35-40	28 nests with eggs (Richardson, 1954b).
1954 Mar. 20	7	5 adults, 2 young; very high waves destroyed the other eggs during mid-January (Richardson, 1954b).
1956 Feb. 11-21	?	Nests with month-old chicks (Svihla, 1957).
1957 Dec. 28	60	24 nests, aerial survey (Rice & Kenyon, 1962).
1958 May 26	<12	Less than a dozen present (Warner, 1958).
1960 Apr. 13	?	28 chicks present; 33 pairs reported nesting earlier that winter (HDFG, 1960a).

Table 35. (continued)

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1961 Mar. 3, 5	40	30 adults, 10 young; 23-25 young reportedly hatched (HDFG, 1961b).
1962 June 11-12, 21-22	36	2 adults, 34 young counted (HDFG, 1962a; see also Beardsley, 1966).
1963 June 11	50	41 fledglings, few adults (POBSP, 1963).
1965 Aug. 4-5, 10-11, 12, 17-23, 28- 29, 31-Sept. 2	3	3 young fledged and left by mid-August (POBSP, 1965a).
Nov. 5	1	First arrival (Park, pers. corr.).
18	77	First egg (Park, pers. corr.).
21	81	5 nests with eggs (Parks, pers. corr.).
1966 Mar. 21-24	400	200 chicks, adults not counted; chicks large and downy (BSFW, 1966a).
June 8-10, 14- 16, 21-23, 29- July 1, 4-7	101	Ca. 25 adults, with 76 young fledging early July (POBSP, 1966a).
Aug. 11-15, 17- 18, 24-26, 30-Sept 16	1	1 large local present on 11 August; apparently fledged on the 12th; none seen thereafter (POBSP, 1966b).
1967 Mar. 11-14	200	Young (BSFW, 1967a; POBSP, 1967b).
May 25-26, 31- June 2, 7-9, 13-15, 18, 20-22	50	Ca. 45 almost fledged young present; only 5-10 adults present (POBSP, 1967a).
Dec. 7-11	206+	156 nests observed (all with eggs except 2), 120 on south side of runway, 34 on north side; 50 adults non-nesting (BSFW, 1967c).
1968 Mar. 11-15	336+	224 adults (plus 50+ additional walkers), 112 young (POBSP, 1968b).

Table 35. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1968 May 29- June 6, 11-14, 16- 17, 19-20, 22-27	308	206 adults, 102 young (POBSP, 1968a).
1969 Feb. 22-24	105	70 adults, 35 young (BSFW, 1969a).
Mar. 23	105	70 adults, 35 young (BSFW, 1969b).
June 2-4, 11- 15, 25-26	111	74 adults, 37 young (POBSP, 1969).

Table 36. Observations of Laysan Albatross at Trig Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 26	3	1 young (Wetmore, ms.).
1953 Dec. 19	100	Nests with eggs (Richardson, 1954b, 1957).
1954 Mar. 20	15-20	Adults and young (Richardson, 1954b).
1957 Dec. 28	250	100 nests, aerial survey (Rice & Kenyon, 1962).
1963 June 14, 15	10	8 fledglings 2(?) adults (POBSP, 1963).
1966 Mar. 22	50+	44 large downy chicks, adults?? (BSFW, 1966a).
June 10, 23, July 1, 3-4	29	Young fledging early July, 5 adults (POBSP, 1966a).
1967 Mar. 13, 14	30	10 chicks, 7 adults (BSFW, 1967a; POBSP, 1967b).
June 2, 8-9, 19-20	12	2 adults, 10 young; young almost fledged (POBSP, 1967a).
Dec. 9	large number	Observed nesting from helicopter (BSFW, 1967c).

Table 36. (continued)

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1968 June 6, 11, 22, 24-25	48	32 adults, 16 young (POBSP, 1968a).
1969 Feb. 22	42	28 adults, 14 young (BSFW, 1969a).
June 3, 14, 23-24	51	34 adults, 17 young (POBSP, 1969).

Table 37. Observations of Laysan Albatross at Whale-Skate Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1923 June 26	75*	25 young (Wetmore, ms.).
June 26	3**	1 young (Wetmore, ms.).
1953 Dec. 19	200*	Nests with eggs (Richardson, 1954b; pers. corr.).
Dec. 19	100**	Nests with eggs (Richardson, 1954b; pers. corr.).
1954 Mar. 20	50-70	Adults and young present (Richardson, 1954b).
1957 Dec. 28	650	260 nests, aerial survey (Rice & Kenyon, 1962).
1963 June 12-15	50	Mostly fledglings (33), few adults (POBSP, 1963).
1966 Mar. 22	145	50 adults, 95 large chicks (BSFW, 1966a).
June 10, 23- 29, July 1-3	120	100 young fledging early July (POBSP, 1966a).
Aug. 15-17, Sept. 4	2	2 large locals present on 16 August had left by 4 September (POBSP, 1966b).
1967 Mar. 14	107	70 chicks, 37 adults. (BSFW, 1967a; POBSP, 1967b).
June 2-7, 15-19	95	20 adults, 75 young; young almost fledged (POBSP, 1967a).

Table 37. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 Dec. 9	800-1,000	Adults nesting, helicopter survey (BSFW, 1967c).
1968 June 6, 16-25	225 [±]	150 adults, 75 young (POBSP, 1968a).
1969 Feb. 23	138	92 adults, 46 young (BSFW, 1969a).
June 3, 16-20, 22	210 [±]	140 [±] adults; 70 [±] young (POBSP, 1969).

* Whale Island ** Skate Island

Table 38. Observations of Laysan Albatross on other islands at French Frigate Shoals

Date of Survey	Island	Population Estimate	Breeding Status, Remarks, and References
1902 May 28-29	FFS	?	Present (Fisher, 1903).
1917 Nov. 6	FFS	?	Numerous (Tucker, 1917).
1953 Dec. 19	Gin	2	Nests with eggs (Richardson, 1954b; pers. corr.).

NORTHERN FULMAR

Fulmarus glacialis rogersiiStatus

Accidental visitor; one specimen record.

Observations

A beach-dried mummy was found on Tern Island on 24 June 1923 by Grant and Wetmore (ms.; see also Clapp and Woodward, 1968). This bird probably died at sea and washed ashore. This species has also been recorded from Oahu, Midway Atoll, and Kure Atoll. It annually migrates over the ocean surrounding the Northwestern Hawaiian Islands, but does not normally occur on the islands in the area.

Specimens

Non-POBSP: USNM 489327, collected on Tern, 25 June 1967, by Wetmore.

BONIN PETREL

Pterodroma hypoleucaStatus

Relatively uncommon breeding species; present from early September to late June; absent during rest of year. Nests only at Tern Island; most abundant in the antenna field. Maximum POBSP population estimate 500-1,000 in March 1967.

Observations

The Bonin Petrel was not recorded in the 19th century. Bailey's (1956) record is the first; he found them common in burrows on Tern Island in December 1912. Richardson (1954b) found one in December 1953. In early March 1961 Woodside and Kramer (HDFG, 1961b) found only one pair although they examined 20 burrows. In recent years this species has been found nesting in fair numbers (Table 39).

Annual Cycle

Figure 58 presents the annual cycle. Adults are thought to arrive in early September; egg-laying possibly starts as early as January. All young fledge by early July. Eggs have been recorded as late as March; large young have been present in late May and June. Adults are absent from the atoll in July and August.

In late March 1966 Kridler and Walker (BSFW, 1966a) observed adults, but noted no evidence of egg laying. On 6 September 1966 one adult was caught, banded and released. This apparently was one of the first adults to return for the new breeding season. In mid-March 1967, 500 to 1,000 adults were actively courting and digging burrows in the antenna field on the southeast side of the runway. No eggs were found in checking 25 burrows. By June 1967, only 3 adults and 3 almost-fledged young were found (POBSP, 1967a,b; BSFW, 1967a). The breeding cycle was similar in 1968 and 1969.

Figure 58. Annual cycle of Bonin Petrel

	*****	*****									
		+++++	+++++	+++++	+++++						
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = dependent young present; ___ = non-breeding birds present

Ecological Distribution

Bonin Petrels nest only on Tern Island and only one has been recorded on the other islands in the atoll. They dig deep (5⁺ feet) curved nest-burrows in the sandy, grass-covered soil along the southeast side of the runway. The main colony is in the antenna field adjacent to the USCG transmitter building; some burrows are scattered from the antenna field to the northeast tip of the island. One dead adult was found on East in June 1968.

Possibly this population is just returning to normal after the long disturbance of building the island in the 1940's and the gradual buildup of proper soil and vegetation since then.

Banding and Movements

Since June 1963 only 110 Bonin Petrels have been banded. One adult was banded in September 1966, 100 were banded in March 1967, and 9 young were banded in June 1969. One of the March 1967 birds was recaptured in June 1967 and 2 others were recaptured in March 1968. No interisland records exist for this species to French Frigate Shoals.

One Bonin Petrel (712-55161), banded as an adult at Tern on 12 March 1967, was captured at Kure Atoll on 27 August 1968 by POBSP personnel.

Specimens

POBSP: USNM 544597, ♂, collected 21 June 1967 on Tern by Lewis.

Table 39. Observations of Bonin Petrel at Tern Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1912 Dec. 19	-	Common in burrows (Bailey, 1956).
1953 Dec. 18	1	Dead, killed by a cat (Richardson, 1954b).
1961 Mar. 3, 5	2+	1 of some 20 burrows examined contained a pair (HDFG, 1961b).
1966 Mar. 21-24	12	Adults only, no evidence of egg bearing (BSFW, 1966a).

Table 39. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1966 June 8-10, 14-16 21- 23, 29-July 1, 4-7	-	2 "mummies" found under guywires in antenna field (POBSP, 1966a).
Aug. 11-15, 17-18, 24- 26, 30- Sept. 16	1	1 adult caught, banded and released on 6 Sept. (POBSP, 1966b).
1967 Mar. 11-14	500-1,000	Adults actively courting and digging burrows (some 3' long); no eggs in 25 burrows checked; colony located on SE side of island in antenna field (POBSP, 1967b; BSFW, 1967a).
May 25-26, 31- June 2, 7-9, 13-15, 18, 20-22	6	3 adults, 3 young, young almost fledged by late June; most old burrows empty (POBSP, 1967a).
Dec. 7-11	18	Adults only (no evidence of eggs in 10 individuals handled) seen on night of 7th between the two main antennas; none seen during day (BSFW, 1967c).
1968 Mar. 11-15	200	Adults with burrows: 50% empty, 45% containing eggs, 5% containing small downy young (POBSP, 1968b).
May 29-30 June 1-6, 11-14, 16- 17, 19-20, 22-27	14+	10 ⁺ adults, 4+ chicks (POBSP, 1968a).
1969 Feb. 22-24	50	Adults digging burrows at night only; of 10 examined 1 contained an egg (BSFW, 1969a).
June 2-4, 12, 25-26	75	50 adults, 25 young (POBSP, 1969).

MURPHY'S PETREL

Pterodroma ultimaStatus

Straggler; one specimen record.

Observations

Observed flying around and landing on eastern end of Tern Island; collected by Harrington at sunset on 9 September 1966. This species has also been recorded from Kure Atoll (Gould and King, 1967; Clapp and Woodward, 1968), but it is not normally found in the Hawaiian Islands area.

Specimens

POBSP: USNM 497224, ♀, collected on Tern, 9 September 1966, by Harrington.

HERALD PETREL

Pterodroma arminjoniana heraldicaStatus

Straggler; one specimen record.

Observations

Late in the afternoon of 14 March 1968 Clapp collected a Herald Petrel as it flew about the airstrip on Tern Island. This species wanders occasionally into the north central Pacific (King, 1967); only 3 specimens have been collected at sea in the area. This constitutes the northernmost specimen record, 950 miles north of the previous record.

Specimens

POBSP: USNM 543342, immature¹ ♂, inactive testes 5 x 2.5 mm., 374 grams (of this 59 grams were fat); collected 14 March 1968 on Tern Island by Clapp.

BULWER'S PETREL

Bulweria bulweriiStatus

Uncommon breeder; present from probably late spring to early fall; absent during rest of the year. Nests in shallow burrows

¹ Huber and Bridge (pers. comm.) thought the bird had recently fledged since a number of crown feathers looked as if they showed the remains of down feathers.

(sometimes abandoned Wedge-tailed Shearwater burrows) on Tern and Whale-Skate Islands, and La Perouse Pinnacle. Previously nested on East Island; observed on Trig Island. Maximum POBSP population 518 in June 1969.

Observations

Rothschild (1893-1900) and Munro (1941a) recorded the first Bulwer's Petrels in 1891 (see also Munro, 1944). In 1923 Wetmore (ms.) observed low numbers on Tern Island and La Perouse Pinnacle. POBSP personnel next recorded Bulwer's Petrels in August 1965 and in subsequent summers through 1969. Numbers are still low (Table 40).

Annual Cycle

The probable annual cycle is presented in Figure 59. Due to the small population size, this species has presumably been overlooked by many observers with the result that there are too few observations to get a clear picture of the annual cycle. Adults probably arrive in mid-May, with egg laying beginning in mid-June. Young probably hatch during late July, with fledging in September.

Figure 59. Annual cycle of Bulwer's Petrel

				—	****	*****	***	+++++	+++++			
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	

** = eggs present; ++ = dependent young present; ___ = non-breeding birds present

Ecological Distribution

The Bulwer's Petrel has been recorded from East, Tern, Trig, Whale-Skate Islands and La Perouse Pinnacle.

East Island: Rothschild (1893-1900) and Munro (1941a) recorded nests, each with a single egg, and pairs of birds sitting beneath old turtle shells on East (?) on 4 June 1891. With the exception of two seen in June 1969, none has been recorded in recent years.

Tern Island: Wetmore (ms.) recorded a pair in 1923 under a flat board in a nest burrow containing an egg. In August 1965 POBSP personnel found two partial wings and other feathers,

indicating that the bird(s) had possibly been killed by the feral cat. It was not until June 1966, after the cat had died, that a live Bulwer's Petrel was observed. In 1966 a pair was believed to be nesting under the Quonset hut but the area could not be reached because the structure was too low. During May and June 1967 and 1968 adults were seen constantly at night near the barracks. They seem attracted to the lights and would even fly or wander into the building itself. In June 1969, 10 adults were recorded; one pair had a nest containing an egg under a pile of cement blocks.

Trig Island: A few were present on Trig (?) in June 1891 according to Munro (1941a). None, however, has been recorded since then.

Whale-Skate Island: Bulwer's Petrel was first recorded by POBSP personnel in August 1965 when six roosting adults were observed. They were present only at night and under large Tournefortia bushes or dense Chenopodium. They were observed in this area again in early June and early July 1966, but no nests were found until mid-August when a large chick was discovered in an unused Wedge-tailed Shearwater burrow located under Chenopodium. In 1967, 1968 and 1969 few adults were observed, all under Tournefortia.

La Perouse Pinnacle: Wetmore (ms.) listed Bulwer's Petrels as common on his 1923 visit, but gave no indication as to breeding status or habitat. POBSP personnel in June 1969 found an estimated 500 with nests, each containing a single egg. Nests were on open rock ledges, in rock crevices, or in crevices under the hardened guano. Most nests were lined with small feathers, probably from Bulwer's Petrels.

Banding and Movements

Since June 1963, POBSP personnel have banded 151 adults: 6 in August 1965, 1 in June 1966, 1 in August 1966, 2 in June 1968, and 141 in June 1969.

Seven of these have been recaptured at French Frigate Shoals. None has been recaptured on other islands and none banded on other islands has been recaptured at French Frigate Shoals.

Specimens

POBSP: USNM 495898, ♀, collected 13 August 1965 on Whale-Skate by Amerson and Huber.

Non-POBSP: USNM 300806, ♀, collected 25 June 1923 by Wetmore; AMNH 528377-80, ♂, ♂, ♀, ♀, collected 5 June 1891 by Palmer; BPBM 789-90, ♂, collected 5 June 1891 by Palmer; BPBM no number, egg, collected 1891 (?) by Munro.

Table 40. Observations of Bulwer's Petrel at French Frigate Shoals

Date of Survey	Island	Population Estimate	Breeding Status, Remarks, and References
1891 June 1-3	Trig?	few	Present (Munro, 1941a).
June 4	East?	?	Nests with single egg or paired birds sitting beneath old turtle shells (Rothschild, 1893-1900; Munro, 1941a).
	FFS	numerous	On largest island (Munro, 1944).
1923 June 24-28	Tern	2	1 pair with egg under a board (Wetmore, ms.).
June 27	La Perouse	common	Present (Wetmore, ms.)
1965 Aug. 4-5, 10-12, 17-23, 28-29, 31, Sept. 1-2	Tern	0	2 partial wings found (POBSP, 1965a).
Aug. 11-17, 29-Sept. 1	Whale-Skate	6	Roosting adults only (POBSP, 1965a).
1966 June 8-10, 14-16, 21-23, 29-July 1, 4-7	Tern	1	1 seen frequently at dusk near barracks (POBSP, 1966a).
June 10, 23-29, July 1-3	Whale-Skate	3	Adults present nightly; no nests seen (POBSP, 1966a).
Aug. 11-15, 17-18, 24-26, 30-Sept. 16	Tern	2	Although no nest was found, a pair was believed to nest under the Quonset hut (POBSP, 1966b).
Aug. 15-17, Sept. 4	Whale-Skate	3	1 nest with a large chick in unused Wedge-tailed Shearwater burrow under <u>Chenopodium</u> (POBSP, 1966b).
1967 May 25-26, 31-June 2, 7-9, 13-15, 18, 20-22	Tern	1	Frequently seen at night near barracks (POBSP, 1967a).

Table 40. (continued)

Date of Survey	Island	Population Estimate	Breeding Status, Remarks, and References
1967 June 2-7, 15-19	Whale-Skate	2	Adults only, no nests (POBSP, 1967a).
1968 May 29-30, June 1-6, 11-14, 16- 17, 19-20, 22-27	Tern	4	Adults only, courtship behavior observed (POBSP, 1968a).
June 6, 16,17-25	Whale-Skate	1	Adults only (POBSP, 1968a).
1969 June 2-4, 12,25-26	Tern	10	Adults; 1 egg (POBSP, 1969).
June 3, 16-20,22	Whale-Skate	6	Adults; no eggs (POBSP, 1969).
June 5-10, 21	East	2	Adults (POBSP, 1969).
June 6,13	La Perouse	500	Adults with nests containing single eggs (POBSP, 1969).

SOOTY SHEARWATER

Puffinus griseusStatus

Accidental; one specimen record.

Observations

Kleen and Amerson found a dried mummy of a large shearwater, tentatively identified as a Sooty Shearwater, on the beach of Whale-Skate Island on 3 June 1969. If identification is correct, this is a new species and specimen record for the atoll. It has been recorded previously from Kure, Midway, Laysan and Oahu (Clapp and Woodward, 1968) and is a common at-sea migrant in the Hawaiian area (King, 1967).

Specimens

POBSP: Mummy collected 3 June 1969 on Whale-Skate Island by Kleen and Amerson; specimen lost.

WEDGE-TAILED SHEARWATER

Puffinus pacificusStatus

Abundant breeding species; presently breeds on East, Tern, Trig and Whale-Skate Islands and La Perouse Pinnacle. It previously bred on Little Gin and Round Islands. Maximum POBSP population estimate 13,000 in August 1965.

Observations

The Wedge-tailed Shearwater was first recorded by Rothschild (1893-1900) and Munro (1941b), who found this species on Tern and East Islands in 1891. Munter (1915) observed this species, presumably at East Island, in 1915. In 1923, Wetmore (ms.) found nesting Wedge-tailed Shearwaters on several islands as well as on La Perouse Pinnacle. Little further information was available until the 1960's when HDFG, BSFW and POBSP visits occurred.

POBSP personnel have visited the Shoals ten times since June 1963 and each time found Wedge-tailed Shearwaters (Tables 41 to 45). Peak numbers, possibly due to better sampling methods, were noted during these visits.

Annual Cycle

The Wedge-tailed Shearwater is a summer-fall breeder (Fig. 60). Small numbers of adult birds arrive during mid-March, but are present only at night. By late March the number of night arrivals increases and some may be present in the daytime. The earliest known egg date is early June; by mid- and late June most eggs have been laid. Hatching starts in early August; most eggs are hatched by late August. Young birds remain on the island until late October and a few into early November. Adults start leaving in early October, prior to departure of their young. There is little difference in the cycle of this species on the several islands.

Figure 60. Annual cycle of Wedge-tailed Shearwater

					*****	*****	*****				
		_____	_____	_____	_____		+++++	+++++	+++++	+++	
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = dependent young present; _____ = non-breeding birds present

Ecological Distribution

The Wedge-tailed Shearwater presently breeds on East, Tern, Trig and Whale-Skate Islands, as well as on La Perouse Pinnacle. In previous years it has bred on Little Gin and Round Islands.

East Island: East Island (Table 41) is today the prime breeding island for Wedge-tailed Shearwaters. Rothschild (1893-1900) recorded them as plentiful, sitting on the sand, and in pairs. Munter (1915) observed 100 in 1915. Wetmore (ms.) observed 1,750 pairs preparing to breed in 1923. At dusk great numbers came in from the sea and formed little groups over the entire land surface. Mating was observed and a few burrows contained eggs. Very little is known of this species during the next three decades.

POBSP personnel first visited East Island in June 1963. Then and on the nine subsequent summer-fall trips the species was quite abundant. A maximum population of 13,000 was estimated in August 1965; the June population averaged 5,000. This species builds burrows over almost all the vegetated portion of the island except for the extreme west end. Many nest under the rubble (boards, metal sheeting, etc.) left on the island by the U.S. Coast Guard when it moved to Tern Island in 1952.

Little Gin Island: Wetmore (ms.) found 20 pairs in June 1923 (Table 45). There has been no record since.

Round Island: The Wedge-tailed Shearwater presently does not nest on this vegetation-less, sandy islet. Wetmore (ms.) found 50 pairs in June 1923 when vegetation was present (Table 45). It is not known when the colony was forced to leave, but as late as 1957 the Black-footed Albatross, which no longer nests, nested on the island (Rice and Kenyon, 1962).

Tern Island: Rothschild (1893-1900) and Munro (1941b) first recorded this species in 1891 (Table 42). In 1923 Wetmore (ms.) recorded the maximum number (500) ever observed. Photographs (B.P. Bishop #9813, 9814) taken by Bryan during the Tanager Expedition show nest burrows in association with Lepturus, Tribulus and Boerhavia.

During the 1940's the population was eliminated by the construction of the "new" island. Nothing is known of the initial attempts to reestablish a colony after construction was completed. Four Wedge-tails were recorded in late October to early November 1953 and the following March 1 live adult and the remains of 15 or more which had been killed by cats were seen. By 1960, when 100 burrows were found, numbers had increased greatly.

A few burrows with eggs were found on a brief daytime visit in June 1963 and 50 to 300 on subsequent June visits. This species presently digs nest burrows in the grassy area in and east of the

antenna field, under the water tanks, and under the thick Pluchea along the north side of the runway.

Although still not up to 1923 numbers, the population has increased drastically during the last 15 years. The continued growth of bunch grass and other ground cover on both sides of the runway, as well as the absence of cats, should ensure a further increase in population size in the future.

Trig Island: Wedge-tailed Shearwaters were first recorded by Wetmore (ms.) in 1923 (Table 43). Richardson (1954a, 1954b, pers. corr.) observed only young in late October 1953 and adults in late March 1954. The maximum population (2,000) was recorded by POBSP personnel in June 1963. Wedge-tails burrow in the Lepturus-covered west portion of the island. In June 1969 this portion was almost denuded of Lepturus, forcing many nesters to lay eggs on the surface; nesting success was probably low.

Whale-Skate Island: Wetmore (ms.) first recorded this species in 1923 when Whale and Skate were separate islands (Table 44). The next observations were those of Richardson (1954a, 1954b) in October 1953 and March 1954; the birds had left and returned during his absence. POBSP personnel found them on all summer-fall visits.

Wedge-tailed Shearwaters nest in two colonies--corresponding to nesting patterns on the two original islands. Their burrows are placed in association with Lepturus and Chenopodium. June population estimates have remained constant since 1966.

La Perouse Pinnacle: Wedge-tailed Shearwaters nest in the abundant holes on the steep cliffs (Table 45). Numbers apparently doubled from June 1923 to June 1969.

Banding and Movements

Since June 1963 POBSP personnel have banded 5,272 as follows: 200 in June 1963, 3,336 in August 1965, 500 in June 1966, 1,079 in August-September 1966, 106 in May-June 1967, 15 in May-June 1968, and 36 in June 1969. Of these, 615 have been recaptured at French Frigate.

Two adult Wedge-tailed Shearwaters, both banded at East Island, French Frigate Shoals, were captured at Green Island, Kure Atoll--some 711 miles away. One (635-12521) was banded 8 August 1965 and was recaptured 19 November 1965; the other (645-04865) was banded 19 June 1966 and recaptured 29 August 1966.

Five banded as adults at Sand Island, Johnston Atoll, have been recaptured (one twice) at French Frigate Shoals: 615-01347, banded 5 May 1964, captured Whale-Skate 18 June 1967; 535-13625, banded 6 October 1964, captured East 23 August 1965; 615-01494,

banded 24 October 1964, captured Whale-Skate 29 August 1965, recaptured East 18 June 1966; 615-01600, banded 26 October 1964, captured East 26 August 1965; and 615-01603, banded 26 October 1964, captured Whale-Skate 30 August 1965.

Specimens

POBSP: USNM 495832-33, ♂ and ♀, collected 21 August 1965 on Tern by Amerson; USNM 495834-35, ♂, collected 22 August 1965 on Tern by Huber.

Non-POBSP: USNM, ♂, collected 22 June 1923 by Wetmore; USNM 300744-45, ♀, collected 22 and 23 June 1923 by Wetmore; AMNH 527575-77, ♂, collected 2 June 1891 by Palmer.

Table 41. Observations of Wedge-tailed Shearwater at East Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1891 June 4-5	plentiful	Sitting on sand in pairs; copulation observed; burrows present (Rothschild, 1893-1900).
1915 Mar.	100	(Munter, 1915).
1923 June 22-23	3,500	Many nest burrows with eggs, some courting (Wetmore, ms.).
1936 Oct. 25	numerous	Burrows very numerous (U.S. Navy Photo 80 G 410123).
1949 Spring	numerous	Burrows present, adults sitting during daytime (USCG Photo #30154912).
1949? Spring	abundant	Young present (Wilder, 1949).
1953 Oct. 31	40-60	Young only (Richardson, 1954a; pers. corr.).
1963 June 7-11	3,500-5,000	Courtship observed; 1,750 breeding pairs, few burrows with eggs (POBSP, 1963).
1964 July 27	numerous	Burrows present, no eggs (BSFW, 1964a).
Sept. 27	present	Downy chicks present (BSFW, 1964b; POBSP, 1964).
1965 Aug. 5-10, 23-28	13,000	4,000 nests, 3,000 young; eggs began hatching early August (POBSP, 1965a).

Table 41. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1966 Mar. 23	300-350	291 counted at night; no evidence of egg bearing (BSFW, 1966a).
June 10-14, 16-21	5,000+	Ca. 2,500 nests with eggs laid beginning early June; burrows all over island (POBSP, 1966a).
Aug. 18-24, 26-30	7,500 (±1,000)	On 19 August 75% of nests had young 1-3 weeks old, 25% eggs (POBSP, 1966b).
1967 Mar. 11-12	6	Adults on open ground, apparently not breeding, not paired (BSFW, 1967a; POBSP, 1967b).
May 26-31, June 9-13	5,000	Adults only, 1,000 eggs laid beginning early June, courtship occurring (POBSP, 1967a).
1968 June 6-11, 14-16, 25	5,000	2,000 breeders, 3,000 non-breeders, 1,000 eggs (POBSP, 1968a).
1969 June 5-10, 21	5,000	2,000 breeders, 3,000 non-breeders, 1,000 eggs (POBSP, 1969).
Aug. 22, 30	45	Young; seen 30 Aug. (BSFW, 1969c).

Table 42. Observations of Wedge-tailed Shearwater at Tern Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1891 June 1-3	few	No eggs but paired and getting ready to lay; shallow burrows present (Rothschild, 1893-1900; Munro, 1941b).
1923 June 24-29	500	In pairs, many eggs in burrows or on the ground (Wetmore, ms.).
1953 Oct. 26-Nov. 2	4	(Richardson, 1954a).
Dec. 18	0	Not present (Richardson, 1954b).
1954 Mar. 20	16+	1 alive, 15+ killed by cats (Richardson, 1954b).

Table 42. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1958 May 26	few	Occasionally seen (Warner, 1958).
1960 Oct. 19	few	Ca. 100 burrows on southeast side of runway, most empty but a few nearly grown young present (HDFG, 1960b).
1961 Mar. 3, 5	0	None observed during day (HDFG, 1961b).
1963 June 11	few	Burrows with eggs present (POBSP, 1963).
1964 Sept. 27-28	1	1 downy chick (BSFW, 1964b; POBSP, 1964).
1965 Aug. 4-5, 10-12, 17- 23, 28-29, 31-Sept. 2	125	30 nests with 25 young; eggs hatched by late August (POBSP, 1965a).
1966 June 8-10, 14- 16, 21-23, 29-July 1, 4- 7	50	10 nests, eggs laid mid-June (POBSP, 1966a).
Aug. 11-15, 17- 18, 24-26, 30- Sept. 16	90	30 pairs; nests with eggs (75%) and downy chicks (25%) 12 August; 15 nests examined 8 September had chicks varying from 1-4 weeks (POBSP, 1966b).
1967 Mar. 11, 12- 14	0	None observed, no fresh diggings (POBSP, 1967b; BSFW, 1967a).
May 25-26, 31- June 2, 7-9, 13-15, 18, 20-22	50	Adults present, 10 eggs laid late June (POBSP, 1967a).
Sept. 16	1	Chick observed (BSFW, 1967b).
Dec. 7-11	0	Not reported (BSFW, 1967c).
1968 Mar. 11-15	0	Not observed (POBSP, 1968b).
May 29-30 June 1-6, 11-14, 16- 17, 19-20, 22-27	300	200 breeders, 100 non-breeders, 100 eggs (POBSP, 1968a).

Table 42. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1969 Feb. 22-24	0	(BSFW, 1969a).
Mar. 23	0	(BSFW, 1969b).
June 2-4, 12, 25-26	200+	Adults only, no eggs (POBSP, 1969).
Aug. 21- 6 Sept.	2	Young; seen 26 August (BSFW, 1969c).

Table 43. Observations of Wedge-tailed Shearwater at Trig Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 26	100	Nests with eggs (Wetmore, ms.).
1953 Oct. 28	30-50	Young only (Richardson, 1954a; pers. corr.).
1954 Mar. 20	125-150	(Richardson, 1954b).
1963 June 14-15	2,000	Large area of burrows, few with eggs (POBSP, 1963).
1964 Sept. 27	300	No additional data (BSFW, 1964b; POBSP, 1964).
1965 Aug. 16, 29, 31	700	250 nests with 200 young; most eggs hatched by late August (POBSP, 1965a).
1966 Mar. 22	numerous	2 found during day, many times that number during night; no evidence of egg bearing (BSFW, 1966a).
June 10, 23, July 1, 3-4	300	<u>Ca.</u> 50 nests, eggs laid late June (POBSP, 1966a).
Aug. 13-14, Sept. 4, 12	450	<u>Ca.</u> 300 adults nesting, 50% of nests with young from 1-3 weeks on 13 August (POBSP, 1966b).
1967 Mar. 13, 14	0	None observed, no fresh diggings (POBSP, 1967b; BSFW, 1967a).

Table 43. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 June 2, 8-9, 19- 20	300	Adults only, 50+ eggs laid by 20 June (POBSP, 1967a).
1968 June 6, 11, 22, 24-25	1,000	500 breeders, 500 non-breeders, 250 eggs (POBSP, 1968a).
1969 Feb. 22	0	Not observed (BSFW, 1969a).
June 3, 14, 23-24	300	200 breeders, 100 non-breeders, 100 eggs, many on open ground (POBSP, 1969).
Aug. 23, 27	1	Seen 23 August (BSFW, 1969c).

Table 44. Observations of Wedge-tailed Shearwater at Whale-Skate Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 26	1,000*	Nests with eggs (Wetmore, ms.).
June 26	60**	Nests with eggs (Wetmore, ms.).
1953 Oct. 28	30-40*	Young only (Richardson, 1954a; pers. corr.).
Oct. 28	10-15**	Young only (Richardson, 1954a; pers. corr.).
1954 Mar. 20	150-180	Present, no burrows (Richardson, 1954b).
1963 June 12- 15	1,000	Several seen on eggs (POBSP, 1963).
1964 Sept. 27	350	Maximum of 100 chicks (BSFW, 1964b; POBSP, 1964).
1965 Aug. 11- 17, 29- Sept. 1	4,000	1,200 nests with 1,000 young; most eggs hatched by late August (POBSP, 1965a).
1966 Mar. 22	250	6 in day, 250 at night; no evidence of egg bearing (BSFW, 1966a).

Table 44. (continued)

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1966 June 10, 23-29, July 1-3	2,000	Ca. 300 nests with eggs laid beginning late June; burrows in grassy portions (POBSP, 1966a).
Aug. 15-17, Sept. 4	1,500 (±500)	Nests with eggs and chicks (POBSP, 1966b).
1967 Mar. 14	0	None observed, no fresh diggings (POBSP, 1967b; BSFW, 1967a).
June 2-7, 15-19	2,000	Adults only, 200 eggs laid by 19 June (POBSP, 1967a).
1968 June 6, 16, 17-25	2,000	1,000 breeders, 1,000 non-breeders, 500 eggs (POBSP, 1968a).
1969 Feb. 23	0	(BSFW, 1969a).
June 3, 16-20, 22	2,000	1,000 breeders, 1,000 non-breeders, 500 eggs (POBSP, 1969).
Aug. 24	5	(BSFW, 1969c).

* Whale Island ** Skate Island

Table 45. Observations of Wedge-tailed Shearwater on other islands at French Frigate Shoals

<u>Date of Survey</u>	<u>Island</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1923 June 22	Round	100	In pairs (Wetmore, ms.).
June 24	Little Gin	40	Pairs (Wetmore, ms.).
June 27	La Perouse	100	In pairs (Wetmore, ms.).
1953 Oct. 31	La Perouse	6	Young only (Richardson, 1954a; pers. corr.).
1969 June 6, 13	La Perouse	200+	200 adults; 100 eggs (POBSP, 1969).

CHRISTMAS SHEARWATER

Puffinus nativitatusStatus

Uncommon breeding species; present from March until late August and possibly early September. Nests in shallow burrows under vegetation or wooden debris on Trig Island. May have nested previously on East Island. Maximum POBSP population estimate 50 during May-June 1968.

Observations

The first Christmas Shearwaters were recorded at Trig Island in June 1891 by Rothschild (1893-1900) and Munro (1941b). They were also seen by Fisher (1903), Wetmore (ms.) and Richardson (1954b). POBSP personnel observed this species nesting on Trig in 1963, and 1965 to 1969, and roosting on East and Whale-Skate (Tables 46 and 47). It may nest on La Perouse Pinnacle but was not observed there in June 1969.

Annual Cycle

The annual cycle for the Christmas Shearwater is presented in Figure 61. Adults begin arriving at least by early March; egg laying probably commences in late April. Young hatch early in June with some eggs remaining until early July. Young commence fledging by late August. None is on the atoll during fall and early winter.

Figure 61. Annual cycle of Christmas Shearwater

					+++++						
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = dependent young present; ___ = non-breeding birds present

Ecological Distribution

East Island: Wetmore (ms.) recorded the Christmas Shearwater only from East Island, where he observed two pairs, but did not indicate their breeding status. Christmas Shearwater have only been seen twice since (Table 47).

Trig Island: This is the only island on which the Christmas Shearwater presently nests (Table 46). It was recorded by Rothschild (1893-1900) and Munro (1941b), but Wetmore (ms.) did not note it in 1923. Richardson (1954b) found eight in March 1954, and it was seen on all POBSP visits except 1964.

From 1965 to 1969 this species was nesting in the late spring and summer in shallow depressions under Tournefortia, Scaevola and Chenopodium. The peak population (50) was observed in June 1968.

Whale-Skate Island: Roosting adult Christmas Shearwater were observed in June 1963, in August-September 1965, and in June 1967, 1968 and 1969 (Table 47).

Banding and Movements

POBSP personnel banded 59 Christmas Shearwater: 6 (4 adults, 2 nestlings) in August 1965; 20 (17 adults, 3 nestlings) in June 1966; 28 (27 adults, 1 nestling) in June 1968; and 5 (4 adults, 1 nestling) in June 1969.

Fourteen of these have been recaptured at French Frigate Shoals. There are no interisland returns.

Specimens

Non-POBSP: AMNH 527700, ♀, collected 5 June 1891 by Palmer; BPBM 791-92, ♀ and ♂, collected 5 June 1891 by Palmer.

Table 46 . Observations of Christmas Shearwater at Trig Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1891 June 1-3	?	Present (Rothschild, 1893-1900; Munro, 1941b).
1954 Mar. 20	8	(Richardson, 1954b).
1963 June 14, 15	12	Adults, 2 with large young under <u>Tournefortia</u> (POBSP, 1963).
1965 Aug. 16, 29, 31	6	Nests with 2 very large young (POBSP, 1965a).
1966 June 10, 23, July 1, 3-4	28+	10 nests with eggs and 3+ large downy chicks (POBSP, 1966a).
Aug. 13-14, Sept. 4, 12	15	Adults seen flying over island, probably landed but not seen; no nests observed (POBSP, 1966b).
1967 Mar. 13, 14	2	Adults found in shallow burrow under <u>Lepturus</u> (POBSP, 1967b; BSFW, 1967a).

Table 46. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 June 2, 8-9, 19- 20	22	20 adults, 2 young; 2 eggs to medium-sized young (POBSP, 1967a).
1968 June 6, 11, 22, 24-25	50	20 adults with 2+ eggs and 2+ large downy young (POBSP, 1968a).
1969 Feb. 22	0	None observed during day (BSFW, 1969a).
June 3, 14, 23-24	23	20 adults, 2 young; eggs to medium downy chicks (POBSP, 1969).
Aug. 23, 27	4	Seen 23 August (BSFW, 1969c).

Table 47. Observations of Christmas Shearwater on other islands at French Frigate Shoals

Date of Survey	Island	Population Estimate	Breeding Status, Remarks, and References
1902 May 28-29	FFS	?	Present (Fisher, 1903).
1923 June 22-23	East	4	2 pairs seen (Wetmore, ms.).
1963 June 12-15	Whale-Skate	3	Adults only (POBSP, 1963).
1965 Aug. 5-10, 23-28	East	1	Adult (POBSP, 1965a).
Aug. 11-27, 29-Sept. 1	Whale-Skate	2	Roosting adults (POBSP, 1965a).
1967 Mar. 14	Whale-Skate	0	None observed (BSFW, 1967a, POBSP, 1967b).
June 2-7, 15-19	Whale-Skate	1	Seen flying frequently at dusk, but not on ground (POBSP, 1967a).
1968 June 6, 16, 17- 25	Whale-Skate	1	On the ground (POBSP, 1968a).

Table 47. (continued)

<u>Date of Survey</u>	<u>Island</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1968 June 6-11, 14-16, 25	East	1	Flying over (POBSP, 1968a).
May 29-30, June 1-6, 11-14, 16- 17, 19-20, 22-27	Tern	1	Flying over (POBSP, 1968a).
1969 Feb. 23	Whale- Skate	0	None observed during day (BSFW, 1969a).
June 3, 16- 20, 22	Whale- Skate	1	Roosting adult (POBSP, 1969).
June 12	Tern	1	Flew over (POBSP, 1969).

SOOTY STORM PETREL

Oceanodroma tristramiStatus

Uncommon breeder; present possibly late fall, winter and spring; absent rest of year. Nests in shallow burrows under vegetation at Whale-Skate Island. Maximum POBSP estimated population 6 in March 1967.

Observations

The Sooty Storm Petrel was first recorded by Rothschild (1893-1900) in 1891 (Table 48). It was not recorded again until 1966 when three were found by Kridler and Walker (BSFW, 1966a). POBSP personnel recorded additional sightings in 1967 and 1969.

Annual Cycle

The Sooty Storm Petrel has a winter-spring breeding cycle (Fig. 62). Adults possibly arrive in late fall but more likely in December, with egg laying probably commencing in mid- or late January. Young hatch in late February or early March. Adults probably leave by mid-May, with young fledging in late May. This species is absent during the rest of the year.

Figure 62. Annual cycle of Sooty Storm Petrel

****	*****	***									
		+++++	+++++	+++++							
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = dependent young present; ___ = non-breeding birds present

Ecological Distribution

The Sooty Storm Petrel is presently known from Tern and Whale-Skate Islands and La Perouse Pinnacle, and previously from East Island.

East Island: Rothschild (1893-1900) observed a few pair in 1891 but none has been seen since.

Tern Island: Kridler (BSFW, 1969a) recorded an adult at night outside the barracks in 1969.

Whale-Skate Island: Nests are placed in shallow burrows under Chenopodium and Lepturus. No more than six birds have been recorded on any visit.

La Perouse Pinnacle: Amerson found a dead mummified adult near the Pinnacle's summit in 1969. This species probably nests in the many crevices of this rock.

Banding and Movement

BSFW personnel banded one individual on Tern Island. No returns or recaptures have been made.

Specimens

POBSP: Mummy collected 13 June 1969 on La Perouse Pinnacle by Amerson; specimen lost.

Non-POBSP: Rothschild collection, 2 specimens, East Island, 4 to 5 June 1891.

Table 48. Observations of Sooty Storm Petrel at French Frigate Shoals

<u>Date of Survey</u>	<u>Island</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1891 June 4-5	East	few	Pairs observed sitting on the sand; at least 2 collected (Rothschild, 1893-1900).

Table 48. (continued)

Date of Survey	Island	Population		Breeding
		Estimate	Status,	Remarks, and References
1966 Mar. 22	Whale-Skate	3		2 adults, 1 several-weeks-old dead downy chick found (BSFW, 1966a).
1967 Mar. 14	Whale-Skate	6		2 chicks (1 very small, 1 3/4 grown) in shallow burrows (BSFW, 1967a; POBSP, 1967b).
June 2-7, 15-19	Whale-Skate	1		1 fledgling handled (POBSP, 1967a).
1969 Feb. 22	Tern	1		Adult captured and released (BSFW, 1969a).
Feb. 23	Whale-Skate	6		1 adult and 2 very small, downy chicks found in searching <u>ca.</u> 40 nests (BSFW, 1969a).
June 13	La Perouse	1		Adult mummy found on top of pinnacle (POBSP, 1969).

RED-BILLED TROPICBIRD

Phaethon aethereus mesonautaStatus

Accidental; one specimen record.

Observations

An adult Red-billed Tropicbird was collected at East Island 15 June 1968. The bird was sitting on the ground in the shade of an old machine near the east end of the island. This is a new species and specimen record for French Frigate Shoals and is the first specimen collected by the POBSP from the central Pacific. It is the second specimen record from the Hawaiian Islands. The first was collected as it flew over Nihoa Island by Wetmore in 1923 (Clapp and Woodward, 1968). This species has also been observed at Johnston Atoll (Moynihan, 1957; Shelton, in prep.). Red-billed Tropicbirds breed on islands off the coast of Central and South America; the species is a rare straggler in the central Pacific.

Specimens

POBSP: USNM 544878, adult ♀, collected 15 June 1968 on East by A.B. Amerson, Jr.

RED-TAILED TROPICBIRD

Phaethon rubricaudaStatus

Common breeding species; present from early spring through probably late fall; possible straggler rest of year. Nests under vegetation or debris on East, Tern, Trig and Whale-Skate Islands, as well as in crevices on La Perouse Pinnacle. Maximum POBSP population 444 in June 1969.

Observations

Munter (1915) recorded the first Red-tailed Tropicbird in March 1915. In 1923 Wetmore (ms.) found this species nesting on East, Tern and Whale-Skate Islands, as well as La Perouse Pinnacle. Nothing is known of its status during the 1930's and 1940's. Since 1963 POBSP personnel have recorded this species nesting on East, Tern, Trig and Whale-Skate Islands, and La Perouse Pinnacle. Populations are presently decidedly greater than in 1923--the earliest year when all islands were examined (Tables 49 to 53).

Annual Cycle

The annual breeding cycle is presented in Figure 63. Adults start returning in February, with eggs appearing as early as mid-February. Peak egg laying probably occurs in April and by early June most young have hatched. (In June 1963, however, there were still more eggs than young.) Eggs have been found as late as 28 September. Young generally start hatching in late May, with peak fledging in July. Young leave the atoll as soon as they fledge. Probably few adults are around in the winter months.

Figure 63. Annual cycle of Red-tailed Tropicbird

	***	*****	*****	*****	*****	*****	*****	*****	*****			
	—			+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	

** = eggs present; ++ = dependent young present; — = non-breeding birds present

Ecological Distribution

The Red-tailed Tropicbird is presently found on more islands than in the past. It nests on East, Tern, Trig and Whale-Skate Islands and on La Perouse Pinnacle.

East Island: The population is presently higher than in the past (Table 49). Munter (1915) in March 1915 and Wetmore (ms.) in June 1923 observed few. U.S. Navy photographs taken in 1935 show no evidence of suitable tropicbird habitat. The same applies to photographs taken by the U.S. Coast Guard and W.O. Henry (pers. comm.) in 1949.

Since 1963 Red-tailed Tropicbirds have nested under the one large Tournefortia bush and the ruins of the USCG Quonset huts. Although this rubble is unsightly, it provides nesting habitat and probably has directly influenced the increase in population.

Tern Island: In recent years more Red-tailed Tropicbirds have nested on Tern Island than on any other island in the atoll (Table 50). In June 1969, 250 were present compared with 2 in June 1923. Considering the construction work in 1942, the destruction of vegetation, and the military usage of the island, this population increase is phenomenal. Even by April 1949 (USCG photograph) very little was growing except Lepturus and Ipomoea, most of which appeared to be around the main buildings at the southwest tip of the island. By late 1952, the patchy grass area extended along the north side of the runway (Price photographs). A dense, but low, grassy area occupied the southeast tip at the runway's edge. Very little vegetation remained around the main barracks. If Red-tailed Tropicbirds attempted to nest under the taller bunch grass and rubble during the 1952-53 season, the storm that swept the island that year would probably have disrupted them. Photographs taken by R.T. Getman between August 1956 and August 1957 reveal quite an increase in vegetation. Several Tournefortia bushes (one quite large) and Pluchea, as well as low-growing Tribulus, Ipomoea, and Boerhavia, could be seen; thus, nesting habitat was present. Aerial photographs taken by Rice and Kenyon (1962) in December 1957 show the same increase. The first Red-tailed Tropicbirds reported from Tern Island after the rebuilding were reported in late May 1958 by Warner (1958).

From 1963 to 1969 POBSP personnel recorded many birds nesting under the dense Pluchea along the north side of the runway and under the many scattered Tournefortia bushes, scattered rubble, deserted buildings, etc., along the south side of the runway. Thus, the increased Tournefortia and Pluchea and other suitable habitat has undoubtedly influenced the population growth of Red-tailed Tropicbirds in recent years. The small amount of this type of habitat on other islands probably accounts for the fact that most Red-tails presently nest on Tern.

Trig Island: No Red-tailed Tropicbirds were recorded until POBSP personnel found 3 nests with eggs and 10 adults under the 5 Tournefortia bushes in June 1963 (Table 51). Since then, POBSP

personnel have found an increase in number of nests. This could be due to the growth of Tournefortia on the east portion of the island. In 1963 this area was bare sand, but by 1967 the lagoon side was covered with 4-foot-high bushes. A further increase of both bushes and birds is expected in the future.

Whale-Skate Island: Wetmore (ms.) observed one pair of Red-tailed Tropicbirds at Skate Island in June 1923 (Table 52). Subsequently, none was observed until June 1963. Since then they have been observed 11 times, but never in quantity as on East and Tern. The lack of suitable nesting habitat is undoubtedly the main factor which keeps numbers down. A large amount of Chenopodium occurs, but it is not thick enough to provide the necessary cover. Very little Scaevola grows here. About eight large Tournefortia bushes grow on this island; the only nest sites this species utilizes are under these.

La Perouse Pinnacle: Wetmore (ms.) reported six pairs at La Perouse Pinnacle in June 1923 (Table 53). Red-tails have been observed on each recent visit to the rock. Approximately 50 breeders were estimated nesting in holes, crevices, and on ledges during June 1969 when La Perouse was scaled twice by POBSP personnel.

Banding and Movement

Since June 1963 POBSP personnel have banded 625 of which 418 were adults and 207 were nestlings. The banding breakdown by years is as follows: 21 adults, 7 nestlings in June 1963; 38 adults, 32 nestlings in August 1965; 49 adults, 31 nestlings in June 1966; 13 adults, 14 nestlings in August 1966; 100 adults, 39 nestlings in June 1967; 10 adults in March 1968; 51 adults, 51 nestlings in June 1968; and 136 adults, 33 nestlings in June 1969.

Two hundred and sixty-one birds have been recaptured at French Frigate Shoals. None has ever been taken at other islands or at sea. Two from other islands have been captured at French Frigate Shoals. One (605-11135) banded as a nestling on Eastern Island, Midway Atoll, 26 June 1963, was captured on Tern Island with another adult (645-12575) sitting under a Scaevola bush on 13 March 1968. This bird was recaptured on Tern Island 15 June 1969; it was mated with the same individual and had a large feathered young. Another adult banded as a nestling on Green Island, Kure Atoll, 14 September 1964 (615-09065), was captured 7 June 1969 on Tern; it was on a nest containing an egg.

Specimens

POBSP: USNM 495861, ♀, collected 22 August 1965 on Tern by Huber.

Non-POBSP: USNM 301003, ♀, collected 26 June 1923 by Wetmore.

Table 49. Observations of Red-tailed Tropicbird at East Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1915 Mar.	2	1 nest with egg (Munter, 1915).
1923 June 22-23	9	4 pairs present, 1 young almost fledged in shelter of low <u>Chenopodium</u> (Wetmore, ms.).
1963 June 7-11	46	7 nests with eggs, 6 with young (POBSP, 1963).
1964 July 27	1	Adult (BSFW, 1964a).
Sept. 27	10	1 immature seen (BSFW, 1964b; POBSP, 1964).
1965 Aug. 5-10, 23-28	37	3 nests with eggs, 12 with young; most eggs hatched by late August (POBSP, 1965a).
1966 Mar. 23	40	4 nests with eggs (BSFW, 1966a).
June 10-14, 16-21	40	3 nests with fresh eggs, 10 with fledglings (POBSP, 1966a).
Aug. 18-24, 26-30	15	5 nests with large chicks (POBSP, 1966b).
Sept. 13	6	2 chicks seen (BSFW, 1966b).
1967 Mar. 11-12	6	3 on ground (2 under <u>Tournefortia</u> , 1 under corrugated metal), 1 with egg on 11th; 6 in flight on 12th (BSFW, 1967a; POBSP, 1967b).
May 26-31, June 9-13	65	50 adults, 15 young; fresh eggs (5) to fledglings present (POBSP, 1967a).
Sept. 17	1	Almost fully grown chick under <u>Tournefortia</u> (BSFW, 1967b).
Dec. 7-11	-	Not reported (BSFW, 1967c).
1968 June 6-11, 14-16, 25	69 [±]	46 breeders, 10 [±] non-breeders, nests with 13 chicks and 10 eggs (POBSP, 1968a).

Table 49. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1969 June 5-10, 21	70	50 breeders, 20 nests with young, 5 nests with eggs (POBSP, 1969).
Aug. 22, 30	2	Seen 30 August (BSFW, 1969c).

Table 50. Observations of Red-tailed Tropicbird at Tern Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 24-28	2	1 pair (Wetmore, ms.).
1958 May 26	few	(Warner, 1958).
1960 Apr. 13	6	3 nests with eggs (HDFG, 1960a).
1962 June 11-12, 21-22	2	1 nest with egg under <u>Pluchea</u> bush (HDFG, 1962a).
1963 June 11	16	5 nests with eggs, 1 chick (POBSP, 1963).
1964 Sept. 27- 28	20	1 nest with egg, 2 with large young (BSFW, 1964b; POBSP, 1964).
1965 Aug. 4-5, 10-12, 17-23, 28-29, 31-Sept. 2	100	25 nests with young; all eggs hatched by late August (POBSP, 1965a).
1966 Mar. 21-24	12	12 adults, 4 nests with eggs under <u>Pluchea</u> (BSFW, 1966a).
June 8-10, 14-16, 21-23, 29- July 1, 4- 7	100	5 nests with eggs to 25 very large chicks (POBSP, 1966a).
Aug. 11-15, 17-18, 24- 26, 30- Sept. 16	83	On 11 August 4 nests with eggs, 25 with chicks (5 < 10 days, 3 11-20 days, 17 > 21 days); 12 immatures fledged by 16 September (POBSP, 1966a).

Table 50. (continued)

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1967 Mar. 11-14	2-3	2 seen flying on 11th, 3 seen flying on 12th; none seen on ground (BSFW, 1967a; POBSP, 1967b).
May 25-26, 31-June 2, 7-9, 13-15, 18, 20-22	130	100 adults, 30 young; fresh eggs (15) to fledglings present (POBSP, 1967a).
Sept. 16	9	Feathered-out chicks (BSFW, 1967b).
1968 Mar. 11-15	30+	Adults, 6 nests with eggs: 5 fresh, 1 moderately to heavily incubated (POBSP, 1968b).
May 29- June 6, 11-14, 16- 17, 19-20, 22-27	212+	144 adult breeders, 20 [±] non-breeders, 24 nests with eggs, 48 nests with young (POBSP, 1968a).
1969 Feb. 22-24	13	February 22: 3 adults on ground (1 incubating an egg), none flying; February 24: 10 adults on ground (1 incubating), 3 flying (BSFW, 1969a).
Mar. 23	10	6 adults on eggs, 4 adults roosting (BSFW, 1969b).
June 2-4, 12, 25-26	250+	200 breeders, 50 nests with young; 50 nests with eggs (POBSP, 1969).

Table 51. Observations of Red-tailed Tropicbird at Trig Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1963 June 14, 15	10	3 nests with eggs (POBSP, 1963).
1965 Aug. 16, 29, 31	5	1 nest with egg and 1 with young (POBSP, 1965a).
1966 Mar. 22	0	None noted (BSFW, 1966a).

Table 51. (continued)

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1966 June 10, 23, July 1, 3-4	2	1 nest with fresh egg (POBSP, 1966a).
Aug. 13-14, Sept. 4, 12	3	1 large young under <u>Tournefortia</u> bush (POBSP, 1966b).
1967 Mar. 13, 14	3	3 flying around on both days, none on ground; none nesting (BSFW, 1967a; POBSP, 1967b).
June 2, 8-9, 19-20	10	10 adults, 5 eggs, no young (POBSP, 1967a).
1968 June 6, 11, 22, 24-25	13 [±]	10 breeders, 2 [±] non-breeders, 4 nests with eggs, 1 nest with young (POBSP, 1968a).
1969 Feb. 22	0	None recorded (BSFW, 1969a).
June 3, 14, 23-24	15	10 breeders, 5 nests with young (POBSP, 1969).
Aug. 23, 27	17	Seen 23 August (BSFW, 1969c).

Table 52. Observations of Red-tailed Tropicbird at Whale-Skate Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1923 June 26	2*	1 pair (Wetmore, ms.).
1963 June 12-15	4	1 nest with egg (POBSP, 1963).
1964 Sept. 27	10	1 immature (BSFW, 1964b; POBSP, 1964).
1965 Aug. 11-17, 29-Sept. 1	20	5 nests with young only (POBSP, 1965a).
1966 Mar. 22	2	1 adult on nest with egg (BSFW, 1966a).
June 10, 23- 29, July 1-3	23	1 nest with fresh eggs; 7 from hatchling to large young (POBSP, 1966a).
Aug. 15-17, Sept. 4	7	2 nests with eggs; 1 with medium-sized chick under <u>Tournefortia</u> (POBSP, 1966b).

Table 52. (continued)

Date of Survey		Population Estimate	Breeding Status, Remarks, and References
1967	Mar. 14	4	4 flying around; none on ground (POBSP, 1967b; BSFW, 1967a).
	June 2-7, 15-19	18	15 adults, 3 fresh eggs; 3 nests with medium-sized young (POBSP, 1967a).
	Sept. 17	2	Large chicks under <u>Tournefortia</u> (BSFW, 1967b).
1968	June 6, 16, 17-25	32 [±]	24 breeders, 6 [±] non-breeders, 6 nests with eggs, 6 nests with young (POBSP, 1968a).
1969	Feb. 23	0	Not recorded (BSFW, 1969a).
	June 3, 16-20, 22	34	24 breeders, 2 nests with eggs, 10 nests with young (POBSP, 1969).
	Aug. 24	128	(BSFW, 1969c).

* Skate Island

Table 53. Observations of Red-tailed Tropicbird at La Perouse Pinnacle

Date of Survey		Population Estimate	Breeding Status, Remarks, and References
1923	June 27	12	6 pairs (Wetmore, ms.).
1961	Mar. 4	few	Seen from launch on or near the rock (HDFG, 1961b).
1966	Sept. 4	11+	1 large local seen on ledge, 10 adults flying over island (POBSP, 1966b).
1967	June 12	2	Flying around; 1 alighted on side of cliff, probably nesting (POBSP, 1967a).
1969	June 6, 13	75+	50+ breeders, 25+ young (POBSP, 1969).

WHITE-TAILED TROPICBIRD

Phaethon lepturusStatus

Uncommon visitor; only seen twice in the summer. Possibly this species nests on La Perouse Pinnacle.

Observations

POBSP personnel observed one adult White-tailed Tropicbird, a first record for the atoll, on 26 May 1967 as it flew west over Tern Island. Another adult was sighted on 1 June 1967, again flying west over Tern. In each instance the bird was flying away from La Perouse Pinnacle.

Ecological Distribution

Although the White-tailed Tropicbird has not been recorded as breeding at French Frigate Shoals, it may nest on La Perouse Pinnacle, since its preferred habitat is holes or recesses of cliffs. On the few visits to La Perouse it may have been missed.

In the north central Pacific it breeds primarily in the Main Hawaiian Islands, nesting in rocky cliffs; it is known to have nested at Midway Atoll in Casuarina, and elsewhere in rubble.

BLUE-FACED BOOBY

Sula dactylatraStatus

Common breeding species; present year around but population decreases in fall and winter; breeding season begins late winter and lasts until mid-fall. Nests on East, Gin, Little Gin, Round, Trig and Whale-Skate Islands. Previously nested on La Perouse Pinnacle (?) and Tern Island. Known to roost on Disappearing Island and La Perouse Pinnacle. Maximum POBSP population estimate 1,190 in June 1969.

Observations

Blue-faced Boobies were first recorded in 1891 by Rothschild (1893-1900) and Munro (1941b). The Tanager Expedition in 1923 observed numerous Blue-faced Boobies on several sand islands, as well as on La Perouse Pinnacle; during his 1953 and 1954 visits, Richardson (1954a, 1954b, and pers. corr.) observed them on most of the sandy islands. POBSP and BSFW personnel since June 1963 have recorded it as nesting on East, Gin, Little Gin, Round, Trig and Whale-Skate, as well as roosting on Disappearing Island and La Perouse Pinnacle.

Annual Cycle

The annual breeding cycle is shown in Figure 64. It is found throughout the year, although during late fall and early winter the population is low. Egg laying probably commences in mid-January, with most eggs laid by late March. Some eggs, however, are present as late as mid-August. Some young hatch as early as mid-March; most probably hatch by mid-May. A few young have been known to fledge by late June but most fledge by mid-September; some fledge as late as October or November.

Figure 64. Annual cycle of Blue-faced Booby

++++											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = dependent young present; ___ = non-breeding birds present

Ecological Distribution

The Blue-faced Booby probably has either nested or roosted on all islands, including islets, at French Frigate Shoals. It presently nests on East, Gin, Little Gin, Round, Trig and Whale-Skate Islands, and has been known to nest on Tern Island and possibly on Disappearing Island, as well as La Perouse Pinnacle. It prefers to place its nest scrape on the sand of the upper beaches, but will nest inland on open sandy areas. No nest material is utilized.

Disappearing Island: The Blue-faced Booby probably uses Disappearing Island only for roosting purposes because it is so often awash (Table 60). In 1963 when POBSP personnel found two roosting adults in the daytime, the sandy island was awash almost its entire length. Aerial photographs taken in 1957 by Rice and Kenyon (1962) reveal nine Blue-faced Boobies. At that time the island was much longer, higher and wider than in 1963. In 1969 POBSP personnel observed 30 adults roosting; the island was then quite large and not awash.

East Island: In the past East Island was the major breeding island for the Blue-faced Booby (Table 54). In 1923 Wetmore (ms.) observed 150 pairs, all with large young, compared to 110 pairs on Whale and Skate Islands. As early as 1915, Munter (1915) had found this species nesting along the shores. It disappeared after the U.S. Navy began to utilize the island in 1935. U.S. Navy photographs (U.S. Nat. Archives RG 80 CF79793-9, G410122-23) taken

in November 1935 and October 1936 show none, nor can any be seen in a U.S. Coast Guard photograph (#30154912) taken in the spring of 1949. According to Henry (pers. comm.), none nested there during 1948 and 1949. A recently fledged Blue-faced Booby does, however, appear in a 1949 photograph taken by Henry, who said it arrived from elsewhere and had not hatched on East. Apparently birds began reappearing in the early 1950's as Richardson (pers. corr.) found 10 to 20 in 1953. Six can be discerned from the aerial photographs taken in 1957 by Rice and Kenyon.

POBSP personnel found roosting adults and subadults on their first visit in June 1963. The first nesting since 1923 was observed in 1966 by BSWF personnel. Boobies used the island in increasing numbers during the period of POBSP observations.

Thus, the population is on an upswing. The disturbance by military personnel in the 1930's and 1940's seemed to affect this species much more than some of the others. The green sea turtle may affect its breeding success here, especially if birds are late nesters. Two nests with eggs were destroyed in June 1967 by turtles digging their own nests.

Gin Island: Blue-faced Boobies have only recently been recorded using the island (Table 55). Richardson (1954b, pers. corr.) first recorded the species in 1953. Aerial photographs taken by Rice and Kenyon (1962) during December 1957 revealed pairs and singles. POBSP and BSWF personnel found the species on all visits since 1963.

Weather and seas undoubtedly have a big effect on the breeding success of Blue-faced Boobies here. This sandy, un-vegetated island is constantly changed in size and shape from year to year, and in some cases from season to season, by the action of waves and currents. All Blue-faced Boobies nest in the center--a shallow depressed area 100± feet in diameter--of the island.

Little Gin Island: Wetmore (ms.) recorded adults and young in 1923 (Table 56). Numbers have fluctuated but presently are higher.

Little Gin, having almost no vegetation and being in an area of constant wave and current action, is, like Gin Island, affected by the weather and seas. This undoubtedly affects the breeding success of the Blue-faced Boobies. This species has nested on the edge of the beach crest (1963) but the majority nests in the center portion which is about 20 feet above sea level.

Round Island: Wetmore (ms.) in 1923 found 30 pairs, all with large young (Table 57). POBSP personnel found 29 active nests in 1963. Since then, numbers have decreased sharply.

The avifauna of Round Island, like that of Gin and Little Gin Islands, is influenced by weather and ocean. Being quite low (5+ feet high) and sandy, Round is vulnerable to wave action. Vegetation was present in 1923 but is no longer there, and only the Blue-faced Booby, of the four bird species which nested there then (two as late as 1957), nests there now.

Tern Island: Tern Island previously was a breeding spot for the Blue-faced Booby (Table 60), but none now nests. In 1891 Rothschild (1893-1900) and Munro (1941b) observed a number of boobies with nests containing young. Wetmore (ms.) found eight pairs present in 1923. Richardson (1954a) observed two during his 1953 visit. POBSP personnel have seen adults close offshore on many occasions; on 12 September 1966 several immatures were seen flying over the island and one landed on the runway.

Although the present disturbance by U.S. Coast Guard personnel is minimal, the Blue-faced Booby has, as yet, failed to return to nest. Based on the record at East, this species probably will not return unless the island is vacated. The breeding population, however, is currently abundant on other islands in the atoll, and even without the use of Tern this species is flourishing better than before.

Trig Island: This is another prominent breeding island (Table 58). In 1969 a maximum population of 230± was found, of which 70 pairs successfully nested. Wetmore (ms.) had found only 20 nesting pairs in 1923. The population has almost doubled since 1963 when POBSP personnel began making regular visits.

As on Whale-Skate, the majority of Blue-faced Boobies nests on the upper beach and above the beach crest on the lagoon side. A few nest on the flat sandy east portion, and on the little open sandy ground that could be found in the interior of the island.

Whale-Skate Island: This is now the major breeding island for Blue-faced Boobies (Table 59). In June 1969 a maximum population of 650, of which 173 pairs were breeding, was encountered. Wetmore (ms.) first recorded this species in 1923 when he observed 70 nesting pairs on Whale and 40 pairs on Skate; it has been observed by every visitor since. The population increased slightly from 1963 to 1969.

The majority of nests on the lagoon side is placed either high on the beach or just above the beach crest. Other nests are

scattered throughout the interior where they are in open areas among the Tribulus and Lepturus. A few nests are on the upper beach along the ocean side of the island; only a shallow nest scrape is used.

La Perouse Pinnacle: In 1923 Wetmore (ms.) observed 20 pairs. None was seen subsequently until POBSP personnel observed 2 adults roosting on top of the Pinnacle, with 6 or 7 immatures flying around, in 1966. In 1967, 10 adults were seen on the top, but their breeding status could not be determined since no landing was made. A roosting adult was present in 1969 but no evidence of nests was found (Table 60).

Banding and Movements

Since June 1963 POBSP personnel have banded 2,264, of which 2,179 have been recaptured locally (Table 61). Thirteen from other atolls have been captured at the Shoals: 6 from Johnston, 3 from Lisianski, 1 from Laysan, 1 from Pearl and Hermes, 1 from Kure, and 1 from Wake. Thirty Blue-faced Boobies from French Frigate have been recaptured elsewhere: Johnston (14), Kure (5), Laysan (3), Pearl and Hermes (2), Lisianski (1), Kauai (1), Nihoa (1), and at-sea (3). Additional details on all these movements are given in Appendix Tables 5a and 5b.

Specimens

POBSP: USNM 496009, ♀, collected 17 August 1965 on Whale-Skate by Huber.

Non-POBSP: USNM 300950, ♀, collected 23 June 1923 by Wetmore; AMNH 729298, ♀, collected 2 June 1891 by Palmer; BPBM 7019, egg, collected in 1891 (?) by Munro.

Table 54. Observations of Blue-faced Booby at East Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1915 Mar.	?	Present along shores on edge of vegetation; nests with fresh eggs to well-grown young (Munter, 1915).
1923 June 22-23	450	150 pairs, all with large young (Wetmore, ms.).
1953 Oct. 31	10-20	(Richardson, pers. corr.).

Table 54. (continued)

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1957 Dec. 28	6	Singles and in pairs, aerial survey (Rice & Kenyon, 1957 photo).
1963 June 7-11	20	Only roosting adults and subadults (POBSP, 1963).
1964 July 27	10	Adults (BSFW, 1964a).
Sept. 27	0	None present (BSFW, 1964b; POBSP, 1964).
1965 Aug. 5-10, 23-28	12	Roosting adults and subadults (POBSP, 1965a).
1966 Mar. 23	10	1 nest with eggs (BSFW, 1966a).
June 10-14, 16-21	12	2 nests: 1 with eggs, 1 with small chick; 6-11 roosting birds present nightly (POBSP, 1966a).
Aug. 18-24, 26-30	11	2 large locals; as many as 6 adults and 3 subadults roosting nightly (POBSP, 1966b).
1967 Mar. 11-12	15	13 adults and 2 subadults roosting after dark, no nests (BSFW, 1967a; POBSP, 1967b).
May 26-31, June 9-13	33	28 adults, 5 young, 2 eggs; fresh eggs to 1 large downy chick; 2 additional nests destroyed by turtles (POBSP, 1967a).
Sept. 17	3	Flying immatures on beach (BSFW, 1967b).
1968 June 6-11, 14-16, 25	48 [±]	12 breeders, 30 [±] non-breeders, no eggs, 6 young (POBSP, 1968a).
1969 June 5-10, 21	80+	22 breeders, 47+ non-breeders, 11 young (POBSP, 1969).
Aug. 22, 30	8	2 adults, 6 young (BSFW, 1969c).

Table 55. Observations of Blue-faced Booby at Gin Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1953 Dec. 19	20-30	(Richardson, 1954b; pers. corr.).
1957 Dec. 28	21	Singles and in pairs, aerial survey (Rice & Kenyon, 1957 photo).
1963 June 9	52	3 nests with 1 egg, 12 young (POBSP, 1963).
1965 Aug. 25	69	10 nests with 1 egg, 19 young (POBSP, 1965a).
1966 Mar. 23	32	16 nests with eggs (BSFW, 1966a).
Sept. 13	12	(BSFW, 1966b).
1967 June 9	68	50 adults, 18 young, 3 eggs; eggs to large chicks (POBSP, 1967a).
Dec. 9	10-12	Adults, several immatures seen from helicopter (BSFW, 1967c).
1968 June 7	85±	52 breeders, 20± non-breeders, 13 nests with eggs, 13 young (POBSP, 1968a).
1969 June 7, 21	145±	70 breeders, 10± non-breeders, 35 young (POBSP, 1969).
Aug. 23, 30	31	Chicks; seen 30 August (BSFW, 1969c).

Table 56. Observations of Blue-faced Booby at Little Gin Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 24	24	8 pairs with well-grown young, 1 dead (Wetmore, ms.).
1953 Dec. 19	15-20	(Richardson, 1954b; pers. corr.).
1957 Dec. 28	6	Singles and in pairs, aerial survey (Rice & Kenyon, 1957 photo).
1963 June 9	12	2 nests with 1 egg, 2 with young (POBSP, 1963).
1965 Aug. 25	55	5 young (POBSP, 1965a).

Table 56. (continued)

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1966 Mar. 23	8	4 nests with eggs (BSFW, 1966a).
1967 June 9	33	25 adults, 2 eggs, 8 young; eggs to large chicks (POBSP, 1967a).
1968 June 7	26 [±]	12 breeders, 10 [±] non-breeders, 2 nests with eggs, 4 young (POBSP, 1968a).
1969 June 7, 21	33 [±]	14 breeders, 12 [±] non-breeders, 7 young (POBSP, 1969).

Table 57. Observations of Blue-faced Booby at Round Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1923 June 22	90	30 pairs, all with large young (Wetmore, ms.).
1953 Oct. 31	100	(Richardson, pers. corr.).
1957 Dec. 28	26	Singles and in pairs; aerial survey (Rice & Kenyon, 1957 photo).
1963 June 8	85	4 nests with eggs, 25 with young (POBSP, 1963).
1965 Aug. 10, 23	47	7 nestlings and 10 immatures, (POBSP, 1965a).
1966 Aug. 26	28	24 adults with 4 large locals (POBSP, 1966b).
1967 June 13	40	Adults only, 1 nest with 2 eggs; apparently high tides had destroyed all nests and birds were reneesting (POBSP, 1967a).
1968 June 11, 25	35+	12 breeders, 22+ non-breeders, 5 nests with eggs, 1 young (POBSP, 1968a).
1969 June 5	20 [±]	20 [±] adults, ? young; viewed from off-shore (POBSP, 1969).

Table 58. Observations of Blue-faced Booby at Trig Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 26	60	20 pairs, all with well-grown young (Wetmore, ms.).
1953 Oct. 28	30-50	(Richardson, 1954a; pers. corr.).
Dec. 19	25-30	(Richardson, 1954b; pers. corr.).
1954 Mar. 20	60-80	Adults, many with eggs (Richardson, 1954b).
1957 Dec. 28	65	Singles and in pairs, aerial survey (Rice & Kenyon, 1957 photo).
1963 June 14, 15	132	4 nests with eggs and 32 with young (POBSP, 1963).
1964 Sept. 27	75	1 local and 21 immatures (BSFW, 1964b; POBSP, 1964).
1965 Aug. 16, 29, 31	51	12 nests with eggs, 21 with young (POBSP, 1965a).
1966 Mar. 22	42	21 nests with eggs, no young (BSFW, 1966a).
June 10, 23, July 1, 3-4	118	38 young from small chicks to fledglings (POBSP, 1966a).
Aug. 13-14, Sept. 4, 12	90	25 large locals and 5 flying immatures (POBSP, 1966b).
1967 Mar. 13, 14	50	24 nests, 6 with 1 egg, 16 with 2 eggs, and 2 with 1 egg and 1 chick; adults on island during day (BSFW, 1967a; POBSP, 1967b).
June 2, 8-9, 19-20	215	150 adults, 2 eggs, 65 young; eggs to large-size chicks (POBSP, 1967a).
Dec. 9	12 ⁺	Seen from helicopter (BSFW, 1967c).
1968 June 6, 11, 22, 24-25	208 ⁺	122 breeders, 25 ⁺ non-breeders, no eggs, 61 young (POBSP, 1968a).

Table 58. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1969 Feb. 22	74	37 nests, most with eggs, no young (BSFW, 1969a).
June 3, 14, 23-24	230 [±]	140 breeders, 20 [±] non-breeders, few eggs, 70 young (POBSP, 1969).
Aug. 23, 27	36	Seen 23 August (BSFW, 1969c).

Table 59. Observations of Blue-faced Booby at Whale-Skate Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 26	210*	70 pairs, all with well-grown young (Wetmore, ms.).
June 26	120**	40 pairs, all with well-grown young (Wetmore, ms.).
1953 Oct. 28	20-30**	(Richardson, 1954a; pers. corr.).
Dec. 19	15-20*	(Richardson, 1954b; pers. corr.).
Dec. 19	6-10**	(Richardson, 1954b; pers. corr.).
1954 Mar. 20	80-100	Adults, many with eggs (Richardson, 1954b).
1957 Dec. 28	76	Singles and in pairs, aerial survey (Rice & Kenyon, 1957 photo).
1963 June 12-15	532	Nests with 5 eggs and 132 young (POBSP, 1963).
1964 Sept. 27	140	2 locals and 39 immatures (BSFW, 1964b; POBSP, 1964).
1965 Aug. 11-17, Sept. 1	489	Medium to large young (89) (POBSP, 1965a).
1966 Mar. 22	190-200	71 nests with eggs, 40-50 pairs with no nests (BSFW, 1966a).

Table 59. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1966 June 10, 23-29, July 1-3	467	8 nests with eggs, 67 with young at all stages (POBSP, 1966a).
Aug. 13, 15-17, Sept. 4	196	46 large locals and flying immatures; <u>ca.</u> 150 roosting adults nightly (POBSP, 1966b).
Sept. 13	few	Few flying immatures noted (BSFW, 1966b).
1967 Mar. 14	86+	43 nests, 14 with 1 egg, 29 with 2 eggs; 53 birds on island during day (POBSP, 1967b; BSFW, 1967a).
June 2-7, 15-19	610	475 adults, 5 eggs, 135 young; eggs to large downy chicks, 1 fledgling (POBSP, 1967a).
Dec. 9	27	1 adult, 10 chicks (1 dead) on beach, 17 immatures (BSFW, 1967c).
1968 June 6, 16, 17-25	559 [±]	292 breeders, 125 [±] non-breeders, 4 nests with eggs, 142 young (POBSP, 1968a).
1969 Feb. 23	232	116 nests containing eggs, no young seen (BSFW, 1969a).
June 3, 16-20, 22	650+	346+ breeders, 130+ non-breeders, few eggs, 173 young (POBSP, 1969).
Aug. 24	186	(BSFW, 1969c).

*Whale Island **Skate Island

Table 60. Observations of Blue-faced Booby on other islands at French Frigate Shoals

Date of Survey	Island	Population Estimate	Breeding Status, Remarks, and References
1891 June 1-3	Tern	?	A number close to beach with young of different stages (Rothschild, 1893-1900; Munro, 1941b).

Table 60. (continued)

Date of Survey		Island	Population Estimate	Breeding Status, Remarks, and References
1902	May 28-29	FFS	?	Present (Fisher, 1903).
1912	Dec. 19	FFS	80	40 nests with fresh eggs (Bailey, 1956).
1923	June 24-28	Tern	16	8 pairs (Wetmore, ms.).
	June 27	La Perouse	40	20 pairs (Wetmore, ms.).
1953	Oct. 26- Nov. 2	Tern	2	(Richardson, 1954a).
1957	Dec. 28	Disappearing	9	Singles and in pairs, aerial survey (Rice & Kenyon, 1957 photo).
1963	June 9	Disappearing	2	Roosting adults (POBSP, 1963).
1964	Sept. 27	La Perouse	0	None present (BSFW, 1964b; POBSP, 1964).
1966	Aug. 11- 15, 17- 18, 24- 26, 30- Sept. 16	Tern	occasional	Several immatures seen flying over island; 1 landed on runway 12 Sept. (POBSP, 1966a).
	Sept. 4	La Perouse	9	2 adults roosting on top, with 6 or 7 immatures flying around (POBSP, 1966b).
1967	June 12	La Perouse	10	Adults only, on top; breeding status unknown (POBSP, 1967a).
1969	June 4	Shark	1	Roosting adult (POBSP, 1969).
	June 7	Disappearing	30	Roosting adults (POBSP, 1969).
	June 13	La Perouse	1	Roosting adult (POBSP, 1969).

Table 61. Blue-faced Boobies banded at French Frigate Shoals

Date	Nestlings	Immature	Subadult	Adults	Unknown	Total
1963 June	205	0	7	516	0	728
1965 Aug.	96	46	10	150	2	304
1966 June	0	1	5	102	0	108
July	0	2	0	93	0	95
Aug.	0	0	0	18	1	19
1967 May	0	0	8	17	0	25
June	217	0	8	123	0	348
1968 June	213	0	1	54	0	268
1969 June	296	11	9	53	0	369
TOTALS	1,027	60	48	1,126	3	2,264

RED-FOOTED BOOBY

Sula sulaStatus

Common breeding species; present throughout the year; breeds from mid-winter to mid-fall with peak in spring and summer. Nests on East, Trig and Whale-Skate Islands. Maximum POBSP population estimate 757 in June 1967.

Observations

Rothschild (1893-1900) and Munro (1941b) first recorded the Red-footed Booby on East and Trig Islands in 1891. In 1902 Fisher (1903) observed it but mentioned no island. Wetmore (ms.) found this species in small numbers at East, Skate and Whale Islands, as well as at La Perouse Pinnacle in 1923. Very little is known of this species from the mid-1920's until 1963 when POBSP personnel began visiting the Shoals. Red-footed Boobies were observed then as well as in subsequent years on East, Tern, Trig and Whale-Skate Islands, and on La Perouse Pinnacle.

Annual Cycle

The annual breeding cycle is presented in Figure 65. Some Red-footed Boobies are present throughout the year. The population

is highest in spring and summer and lowest in fall and winter. This corresponds with the breeding cycle for it too is predominately in the spring and summer. Some eggs are undoubtedly present in January as small chicks occur in late February and March. Most eggs, however, are laid in March and April with some remaining into early July; some have even been recorded in October and December. Young begin to hatch in late March and most hatching is completed by June. Most young fledge by August but some fledge as early as June and as late as October. Locals have even been found as late as December.

Figure 65. Annual cycle of Red-footed Booby

*****	*****	*****	*****	*****	*****				***		****-
		++	++++	++++	++++	++++	++++	++++	++++	++++	++++
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = dependent young present

Ecological Distribution

The Red-footed Booby nests on East, Trig and Whale-Skate Islands. It is known to have nested, but presently only roosts, on La Perouse Pinnacle and, infrequently, on Tern Island. Possibly this species also roosts on the other islands.

East Island: Rothschild (1893-1900) found the Red-footed Booby nesting in June 1891 (Table 62). The nests, each containing an egg, were built of vines about six inches above the ground, thus compensating for the lack of high bushes on which to nest. In 1923 Wetmore (ms.) found this species only roosting. It is not known what happened to this species during the U.S. Navy and Coast Guard use of East Island; however, none of the photographs examined reveals any Red-footed Boobies. The U.S. Coast Guard left East Island in 1951. By 1953, Richardson (1954a, 1954b, pers. corr.) found nests containing eggs and young. In 1961 Woodside and Kramer (HDFG, 1961b) found this species using deserted buildings and other rubble as nesting sites. On all POBSP visits, Red-footed Boobies were utilizing rubble from the collapsed buildings, the one live and the one dead Tournefortia bush, as well as the scattered Chenopodium bushes, for nesting. Although the nesting population has remained fairly constant since 1963, the roosting non-breeding population has decreased. This is probably because building rubble was burned in August 1965 and major roosting sites were eliminated.

Tern Island: Red-footed Boobies have been observed flying over on many occasions, and have been known to roost (Table 65), but not to nest.

Trig Island: Munro (1941b) first observed the Red-footed Booby in 1891 (Table 63). Richardson (1954a, 1954b, pers. corr.) saw one in October 1953 and in March 1954 he found nesting birds. In 1963 POBSP personnel found ten nests in the large Tournefortia bush in the center of the island. As Tournefortia bushes have increased in number and size, so have the number of nesting Red-foots. In 1969 POBSP personnel found 85 nests, an eightfold increase since 1963. The population will probably increase further as suitable vegetation increases.

Whale-Skate Island: Wetmore (ms.) observed this species on both Skate and Whale in 1923 (Table 64). Only 1 pair was present on Skate but 15 pairs were nesting on Whale. Nests were placed in the tops of low-growing Chenopodium. POBSP personnel also found this species nesting in the tops of low-growing Chenopodium, as well as in the higher-growing Tournefortia bushes scattered about the edge of the vegetated portion of the island. The Tournefortia bushes have, as on Trig Island, multiplied since 1963. Thus, numbers of nesting Red-footed Boobies have also increased. In 1963 there was only 1 nest; by 1968 a peak of 33 nests was recorded with a decrease in 1969 to 18 nests. The population increased from 21 in 1963 to 160 in 1969, probably due to an influx of displaced East Island roosting birds.

La Perouse Pinnacle: Wetmore (ms.) observed 30 pairs in 1923 but did not give their status (Table 65). In 1966 a few sub-adults and adults were seen flying around, and roosting on top of, this rocky island. Only one roosting adult was seen on top in 1969. This species does not presently nest on the island. (If it did, it would have to bring nesting material from East or another vegetated island.) It probably utilizes the top and ledges as nocturnal roosting sites.

Banding and Movements

Since 1963 POBSP personnel have banded 2,070 Red-footed Boobies (Table 66). The maximum POBSP population estimate of 757 in June 1967 is close to one-third of the total number banded. Thus, more Red-footed Boobies than are present at any given time use the islands.

Of those, 1,039 have been recaptured on the atoll. An additional 141 have been captured that were originally from other atolls, indicating that over 11 percent were from elsewhere: Johnston (61), Laysan (24), Kure (14), Lisianski (14), Oahu (10), Kauai (6), Midway (6), Wake (4), and Pearl and Hermes (2). One-hundred-and-ten Red-footed Boobies from French Frigate have been captured in the north central Pacific: Johnston (60), Kure (19), Laysan (12), Lisianski (10), Pearl and Hermes (3), Midway (2), Wake (1), Oahu (1), and at-sea (2). Details are given in Appendix Tables 6a and 6b.

Specimens

POBSP: USNM 495794-5, ♀ and ♂, collected 24 and 26 August 1965 on East by Huber.

Non-POBSP: USNM 300914, ♂, collected 24 June 1923 by Wetmore; AMNH 729391, ♂, collected 5 June 1891 by Palmer; BPBM 711, ♂, collected 5 June 1891 by Palmer; BPBM 7020, egg, collected in 1891 (?) by Munro.

Table 62. Observations of Red-footed Booby at East Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1891 June 4-5	?	Nest, with egg, built of vines <u>ca.</u> 6 inches aboveground (Rothschild, 1893-1900).
1923 June 22-23	20	Roosting only (Wetmore, ms.).
1953 Oct. 31	15-18+	Adults with nests containing eggs and young (Richardson, 1954a; pers. corr.).
Dec. 19	8-10	Nests with eggs and young (Richardson, 1954b; pers. corr.).
1957 Dec. 28	6	Flying over the island, aerial survey (Rice & Kenyon, 1957 photo).
1961 Mar. 4	150	Buildings and other rubble used as nesting sites (HDFG, 1961b).
1962 June	???	Few on nests placed on old buildings, from photo (HDFG, #R1-309).
1963 June 7-11	4-500	18 nests with eggs, 11 with small young, 31 with large young; numerous roosting subadults (POBSP, 1963).
1964 July 27	16	3 adults, 13 immatures (BSFW, 1964a).
Sept. 27	10	2 nests containing 1 local and 1 immature (BSFW, 1964b; POBSP, 1964).
1965 Aug. 5-10, 23-28	513	1 nest with eggs, 13 with young (POBSP, 1965a).

Table 62. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1966 Mar. 23	125	49 nests, most with eggs; 51 adults and 2 flying immatures seen (BSFW, 1966a).
June 10-14 16-21	446	4 nests with eggs, 46 with young; roosting population 38% adults and 62% subadults (POBSP, 1966a).
Aug. 18-24, 26-30	50 (±10)	Nests with 15 nearly fledged chicks and 1 half-grown chick; roosting population 2/3 subadult (POBSP, 1966b).
1967 Mar. 11-12	114	Ca. 80 roosting birds; 17 nests, 2 with eggs (POBSP, 1967b; BSFW, 1967a).
May 26-31, June 9-13	395	116 adults nesting, 45 young, 13 eggs; roosting population ca. 234 (adults and subadults); possibly higher due to nightly change-over (POBSP, 1967a).
Sept. 17	14	5 adults, 1 immature, 8 chicks, in <u>Tournefortia</u> and scattered junk (BSFW, 1967b).
Dec. 9	?	Observed from helicopter (BSFW, 1967c).
1968 June 6-11, 14-16, 25	278±	128 breeders, 100± non-breeders, 64 nests with 14 eggs, and 50 chicks (POBSP, 1968a).
1969 June 5-10, 21	169+	68 breeders, 67 non-breeders, 34 nests with chicks (POBSP, 1969).
Aug. 22, 30	10	1 adult, 9 young; seen 30 August (BSFW, 1969c).

Table 63. Observations of Red-footed Booby at Trig Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1891 June 1-3	?	Present, nesting (Munro, 1941b).
1953 Oct. 28	1	(Richardson, 1954a; pers. corr.).
1954 Mar. 20	6	4 nests, 3 with eggs (Richardson, 1954b).

Table 63. (continued)

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1963 June 14, 15	40	Nests with 3 small and 7 large young (POBSP, 1963).
1964 Sept. 27	10	2 immatures seen (BSFW, 1964b; POBSP, 1964).
1965 Aug. 16, 19, 31	120	Nests with 20 young in <u>Tournefortia</u> (POBSP, 1965a).
1966 Mar. 22	34	17 nests with eggs, no young (BSFW, 1966a).
June 10, 23, July 1, 3-4	108	33 nests with medium to large downy chicks; some roosting birds (POBSP, 1966a).
Aug. 13-14, Sept. 4, 12	114 (± 25)	14 nests with large young; nocturnal roosting population of all ages (POBSP, 1966b).
1967 Mar. 13, 14	60	29 nests (14 under construction), 14 with eggs, 1 with hatchling; 32 adults observed (POBSP, 1967b; BSFW, 1967a).
June 2, 8-9, 19-20	250	106 nesting adults, 3 eggs, 50 young, eggs to very large young (POBSP, 1967a).
1968 June 6, 11, 22, 24-25	332 \pm	156 breeders, 100 \pm non-breeders, nests with 2 eggs and 76 young (POBSP, 1968a).
1969 Feb. 22	55+	52 breeders; nests in <u>Tournefortia</u> : 2 empty, 21 with eggs, 3 with hatchlings (BSFW, 1969a).
June 3, 14, 23-24	355 \pm	160 breeders, 100 \pm non-breeders, 80 nests with young, 5 nests with eggs (POBSP, 1969).
Aug. 23, 27	44	Seen 23 August (BSFW, 1969c).

Table 64. Observations of Red-footed Booby at Whale-Skate Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1923 June 26	30+*	15 pairs, nests placed in tops of <u>Chenopodium</u> , eggs to nearly grown young (Wetmore, ms.).

Table 64. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 26	2**	1 pair (Wetmore, ms.).
1957 Dec. 28	5	Flying over island, aerial survey (Rice & Kenyon, 1957 photo).
1963 June 12-15	21	1 nest with eggs, 1 with large young (POBSP, 1963).
1964 Sept. 27	20	4 immatures (BSFW, 1964b; POBSP, 1964).
1965 Aug. 11-17, 29-Sept. 1	65	Nests with 15 young in <u>Tournefortia</u> (POBSP, 1965a).
1966 Mar. 22	40-50	10 nests: 2 active (1 with egg, 1 with chick); 12 adults and 7 immatures (BSFW, 1966a).
June 10, 23-29, July 1-3	88	2 nests with eggs, 13 from hatchling to fledgling; some roosting birds nightly (POBSP, 1966a).
Aug. 15-17, Sept. 4	80 (±25)	5 nests with large young; nocturnal roosting population of mixed ages (POBSP, 1966b).
Sept. 13	several	1 downy young; a number fully feathered (BSFW, 1966b).
1967 Mar. 14	28	14 nests, 7 under construction (6 with eggs, 1 with hatchling); 22 adults observed (BSFW, 1967a; POBSP, 1967b).
June 2-7, 15-19	112	28 adults nesting, 2 eggs, 12 young; roosting population <u>ca.</u> 72 (POBSP, 1967a).
Sept. 17	6	1 adult, 2 half-grown young, 3 immatures in <u>Tournefortia</u> (BSFW, 1967b).
1968 June 6, 16-25	141 [±]	66 breeders, 50 non-breeders, 33 nests with 8 eggs and 25 chicks (POBSP, 1968a).
1969 Feb. 23	30+	30 breeders, 15 nests in <u>Chenopodium</u> : 4 newly built, 11 with eggs (BSFW, 1969a).

Table 64. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1969 June 3, 16-20, 22	160+	36 breeders, 67 non-breeders, 18 nests with chicks (POBSP, 1969).
Aug. 24	12	(BSFW, 1969c).

* Whale Island ** Skate Island

Table 65. Observations of Red-footed Booby on other islands at French Frigate Shoals

Date of Survey	Island	Population Estimate	Breeding Status, Remarks, and References
1902 May 28-29	FFS	?	Present (Fisher, 1903).
1923 June 27	La Perouse	60	30 pairs (Wetmore, ms.).
1953 Dec. 18	Tern	1	(Richardson, 1954b).
1961 Mar. 3, 5	Tern	1	Flying over island (HDFG, 1961b).
Sept. 2	Tern	1	Juvenile in the air around island; none nesting (Udvardy and Warner, 1964).
1965 Nov. 19	Tern	1	Adult roosting in bush on east end of island (Park, pers. corr.).
1966 Aug. 11-15, 17-18, 24- 26, 30- Sept. 16	Tern	occasional	Birds of all ages seen flying over the island (POBSP, 1966b).
Sept. 4	La Perouse	6	4 subadults flying around, 2 adults roosting on top (POBSP, 1966b).
1968 Mar. 11-15	Tern	1	Adult flew over on 11th; no others seen (POBSP, 1968b).

Table 65. (continued)

Date of Survey	Island	Population		Breeding
		Estimate	Status, Remarks, and References	
1968 May 29- June 6, 11-14, 16-17, 19-20, 22-27	Tern	1	Subadult roosted on telephone pole in daytime (POBSP, 1968a).	
1969 June 3	Tern	1	Subadult roosting in <u>Casuarina</u> (POBSP, 1969).	
June 13	La Perouse	1	Adult roosting on top (POBSP, 1969).	

Table 66. Red-footed Boobies banded at French Frigate Shoals

Date	Nestling	Immature-Subadult	Adult	Total
1963 June	40	35	69	144
1965 Aug.	20	246	214	480
1966 June	62	164	133	359
July	48	14	62	124
Aug.	0	36	13	49
1967 May	0	95	26	121
June	94	69	63	226
1968 June	132	112	37	281
1969 June	133	88	65	286
TOTALS	529	859	682	2,070

BROWN BOOBY

Sula leucogasterStatus

Uncommon breeding species; probably present year around with peak numbers in spring and summer. Nests on ledges of La Perouse Pinnacle. One nest known from Whale-Skate Island. Maximum POBSP population estimate 130+ in June 1969.

Observations

Rothschild (1893-1900) and Munro (1941b) first reported the Brown Booby in 1891. Wetmore (ms.) found pairs at La Perouse Pinnacle in 1923. Richardson (1954a, pers. corr.) found 20 to 30 Brown Boobies nesting on La Perouse Pinnacle in 1953.

POBSP personnel have recorded the Brown Booby nesting on La Perouse Pinnacle each year since 1963 and have observed it on Disappearing, East, Little Gin, Shark, Trig and Whale-Skate Islands.

Annual Cycle

The annual breeding cycle is shown in Figure 66. Some birds are probably present all year around, as they have been seen in all months except November, January and February when no observations have been made. Populations probably increase in March with egg laying commencing in April. Young start hatching in late May; most fledge by late summer. Eggs have been observed as late as September and young as late as December. The main breeding season, however, is in the spring and summer.

Figure 66. Annual cycle of Brown Booby

			****	****				**			++
			+++++								
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = dependent young present; ___ = non-breeding birds present

Ecological Distribution

The Brown Booby nests and roosts almost exclusively on La Perouse Pinnacle. It has only once been known to nest on one of the low sandy islands (Whale-Skate), although it probably occasionally roosts on the other islands in the atoll.

Since this species is known to nest on both low sandy islands and high rock islands in other parts of the northwestern Hawaiian chain, it is curious that here it should restrict itself to La Perouse. Single causative factors such as climate, vegetation and man's disturbance seem to be ruled out. Climate is ruled out since there is virtually no difference in the climate of any of the islands at French Frigate Shoals. (Wind, however, may be stronger on the higher portions of La Perouse.) There is no vegetation on La Perouse Pinnacle, but neither is there any on Gin or Round Islands; therefore, lack of vegetation is ruled out. Man certainly has affected the bird populations on East and Tern Islands but has not disturbed Trig or Whale-Skate Islands.

There is also a possibility that two Brown Booby subspecies exist in the Hawaiian Islands--one rock nesters, one low sandy-island nesters. If this is a fact, however, one would expect some of the "low nesters" to regularly nest on the sandy islands of this atoll.

Whale-Skate Island: Although Richardson (1954b, pers. corr.) found one Brown Booby on Skate Island in 1953 (Table 68), and POBSP personnel found it to be an occasional visitor in March and June 1967, it has only once been recorded nesting, in September 1967 when Kridler (BSFW, 1967b) observed one on a ground nest with one egg. None was seen nesting in 1968 or 1969.

La Perouse Pinnacle: The Brown Booby was first recorded in 1891 (Table 67); however, no details were given as to its habitat or breeding status (Rothschild, 1893-1900). Since then, with one exception, it has been recorded as breeding exclusively on the ledges and top of this 122-foot-high rock.

Other Islands: The Brown Booby has been known to roost or fly over East, Disappearing, Little Gin, Round, Shark, Tern and Trig Islands (Table 68). It probably visits the other islands and islets in the atoll as well.

Banding and Movements

Twenty-four Brown Boobies have been banded: 1 adult in June 1966, 2 adults in June 1967, and 21 young in June 1969. An adult, wearing a fresh orange streamer on its left leg, indicating it was from Johnston Atoll, was sighted on and flying around La Perouse Pinnacle on 12 June 1967 by POBSP personnel.

Specimens

Non-POBSP: USNM 300878, ♀, collected 22 June 1923 by Wetmore.

Table 67. Observations of Brown Booby at La Perouse Pinnacle

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1891 June 3	?	Present (Rothschild, 1893-1900).
1923 June 27	60	In pairs (Wetmore, ms.).
1953 Oct. 31	20-30	Nesting (Richardson, 1954a, pers. corr.).
Dec. 19	6-8	1 large young (Richardson, 1954b).
1961 Mar. 4	?	Some seen from launch on or near the rock (HDFG, 1961b).
1963 June 10	50	Young present (POBSP, 1963).
1964 Sept. 27	25	7 immatures seen (BSFW, 1964b; POBSP, 1964).
1965 Aug. 7	100	25 young (POBSP, 1965a).
1966 Mar. 23	20	No landing made (BSFW, 1966a).
Sept. 4	90	Ca. 75 adults and 10-15 flying immatures (POBSP, 1966b).
1967 June 12	125+	100 adults, 25 young; medium to large nestlings seen on ledges and on top of rocks (POBSP, 1967a).
Dec. 9	several	Observed from helicopter (BSFW, 1967c).
1969 June 6, 13	130+	100+ adults, 10 nests with eggs, 30 nests with hatchlings to fledglings (POBSP, 1969).

Table 68. Observations of Brown Booby on other islands at French Frigate Shoals

<u>Date of Survey</u>	<u>Island</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1891 June 1-3	Tern	?	Small flock seen evening (Munro, 1941b).
1902 May 28-29	FFS	?	Present (Fisher, 1903).
1923 June 22-23	East	2	Seen on 22nd (Wetmore, ms.).

Table 68. (continued)

Date of Survey	Island	Population Estimate	Breeding Status, Remarks, and References
1923 June 24	Round	1	On sand spit nearby (Wetmore, ms.).
1953 Dec. 19	Skate	1	(Richardson, 1954b; pers. corr.).
1961 Sept. 2	Tern	1	Flying over (Udvardy, 1961a).
1963 June 9	Disappearing	few	Roosting only (POBSP, 1963).
1965 Aug. 25	Little Gin	-	1 dead subadult found (POBSP, 1965a).
1966 June 10-14, 16-21	East	1	Occasional roosting bird, seen offshore (POBSP, 1966a).
Aug. 18-24, 26-30	East	-	Few adults seen flying over (POBSP, 1966b).
1967 Mar. 11-12	East	-	1 flying along west end of island during afternoon, none nesting, none roosting after dark (POBSP, 1967b; BSFW, 1967a).
Mar. 13, 14	Trig	-	1 flew over, none nesting (POBSP, 1967b; BSFW, 1967a).
Mar. 14	Whale-Skate	-	1 flew over, none nesting (POBSP, 1967b; BSFW, 1967a).
May 26-31, June 9-13	East	1	Occasionally roosted on northwest beach (POBSP, 1967a).
June 2-7, 15-19	Whale-Skate	2	Occasional bird roosting at night (POBSP, 1967a).
Sept. 17	Whale-Skate	2	1 adult observed with nest containing egg on ground in central part of island (BSFW, 1967b).
1968 June 6-11, 14-16, 25	East	1-2	Occasional visitor, adults and subadults flying over (POBSP, 1968a).

Table 68. (continued)

<u>Date of Survey</u>	<u>Island</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1968 June 6, 11, 22, 24-25	Trig	1-2	Occasional visitor (POBSP, 1968a).
June 6, 16-25	Whale-Skate	1-2	Occasional visitor (POBSP, 1968a).
1969 June 4	Shark	1	Adult ♀ roosting (POBSP, 1969).
June 7	Disappear- ing	1	Subadult ♀ roosting (POBSP, 1969).

GREAT FRIGATEBIRD

Fregata minorStatus

Common breeding species; present year around with possible population decrease in late fall and early winter; occurs on most islands in the atoll but nests only at Whale-Skate. Maximum POBSP population estimate 1,413 in June 1967.

Observations

The first record was made by Rothschild (1893-1900) and Munro (1941b) in 1891. Wetmore (ms.) found the Great Frigatebird nesting on Skate and Whale Islands, as well as roosting on East and Shark Islands during his 1923 visit. Nothing is known of its status during the 1930's or 1940's and none could be seen in any U.S. Navy and Coast Guard photographs taken on East and Tern Islands during those years. It nested in 1954 on Whale-Skate (Richardson, 1954b).

POBSP personnel recorded the Great Frigatebird from Disappearing, East, Little Gin, Tern, Trig and Whale-Skate Islands and La Perouse Pinnacle.

Annual Cycle

The annual breeding cycle is presented in Figure 67. Some remain all year-round; numbers increase in late winter and remain high until late fall. This high population coincides with breeding. Eggs may be laid as early as late February but most are laid during early March. Eggs may be present as late as early June. Young

hatch beginning in early May, with most hatched by early June. Fledging commences by mid-September but most, although capable of flight, sit on or around their nest sites until late fall; some even remain until the following spring. The number of active June nests in 1923 was 60. The number of active June nests in the 1960's has ranged from 124 to 250.

Figure 67. Annual cycle of Great Frigatebird

				+++++									
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		

** = eggs present; ++ = dependent young present; ___ = non-breeding birds present

Ecological Distribution

The Great Frigatebird nests only on Whale-Skate Island. It roosts on Disappearing, East, Little Gin, Shark, Tern and Trig Islands, and La Perouse Pinnacle. It has been recorded flying over Round Island; if enough time were spent on it and the other islets, one would probably observe the Great Frigatebird on them.

East Island: The Great Frigatebird utilizes East Island only for roosting (Table 69). In 1891 Rothschild (1893-1900) recorded a few, as did Wetmore (ms.) in 1923. This species was not recorded during the 1930's, 1940's and 1950's. POBSP and BSWF personnel have seen them in numbers varying from 3 to 375 since 1963.

The daytime roosting population varies, depending on season and weather. At night the population increases drastically due to an influx of birds which have been feeding at sea during the day. They utilize almost all possible raised sites. The rubble left from the deteriorating U.S. Coast Guard buildings is most popular. If additional Scaevola and Tournefortia were present, the roosting population on East Island would be higher. Only one plant each of these two species now grows on the island.

Tern Island: The Great Frigatebird only roosts here (Table 70). It was first recorded in 1891 by Munro (1941b), who observed it chasing Wedge-tailed Shearwaters. POBSP personnel have observed the species flying over or roosting on the island on several occasions. Favorite day and night roosting spots include a high post and some tall rubble on either side of the runway at the northeast end of the island.

Trig Island: Great Frigatebirds use Trig for roosting only (Table 71). Richardson (1954a, 1954b, pers. corr.) recorded 250 to 300 in 1953; numbers since have varied from 0 to 300.

The roosting population has greatly increased since 1965. Prior to 1966 there were only three large Tournefortia bushes, all on the mid- or western portion of the island. By fall 1966 many additional Tournefortia bushes had invaded the heretofore bare east portion and added much roosting space. Due to this, the roosting population rose sharply in June 1967 but tapered off in 1968 and 1969, possibly because Red-footed Boobies nest in the same bushes.

Whale-Skate Island: This is the only island on which nesting has been recorded (Table 72). The first record was in June 1923 when Wetmore (ms.) found 60 pairs with eggs or young at Whale Island--then separated from Skate. He noted that two had turret-like nests of sticks built up to a height of nearly three feet. In late 1953 Richardson (1954a, 1954b, pers. corr.) observed them on both islands and in March 1954 he found them nesting on both. Nests and eggs to large young have been recorded on all June visits.

This colony has always nested on very low vegetation, building large nests of Tribulus stems. Within the last 10+ years several Tournefortia bushes have appeared. Some Frigates now nest on these bushes, but the majority still nests on the low Chenopodium and Tribulus. Why this species only nests at Whale-Skate Island when the vegetation and climate on the other islands in the atoll are similar is not known.

La Perouse Pinnacle: The Great Frigatebird roosts here (Table 73). It was first recorded in 1953 by Richardson (1954a, 1954b, pers. corr.). POBSP personnel have recorded this species roosting on all their visits.

Other Islands: Small numbers have been recorded roosting at Shark Island, at Round, at Disappearing and Little Gin Islands (Table 74). Possibly larger numbers roost on these sandy islands at night.

Banding and Movements

Since June 1963 POBSP personnel have banded 2,259. Table 75 shows the age classes by month and year. Of the total banded, 354 have been recaptured by the POBSP at French Frigate. Twenty-one from other islands and atolls have been captured on French Frigate; 8 were from Johnston, 8 from Kure, 2 from Laysan, 1 from Lisianski, 1 from Pearl and Hermes, and 1 from Wake. Twenty-three Great Frigatebirds from French Frigate have been captured on Johnston, 10 on Kure, 3 on Laysan, 1 on Eniwetok, and 1 in the Philippines (Appendix Tables 7a and 7b).

Specimens

POBSP: USNM 495805, ♀, collected 17 August 1965 on Whale-Skate by Huber.

Non-POBSP: USNM 300964-66, ♂, ♀, ♀, collected 26, 26 and 23 June 1923 by Wetmore.

Table 69. Observations of Great Frigatebird at East Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1891 June 4-5	few	(Rothschild, 1893-1900).
1923 June 22-23	6	6 roosting on island; others passing during day (Wetmore, ms.).
1960 Apr. 13	75	In flight over island; count taken from plane (HDFG, 1960a).
1962 June	?	1 flying over (HDFG photo #R1-308).
1963 June 7-11	50-100	Common roosting in evening, mostly immature (POBSP, 1963).
1964 July 27	155	Roosting on posts, huts, etc. (BSFW, 1964a).
Sept. 27	3	Roosting, midday (BSFW, 1964b; POBSP, 1964).
1965 Aug. 5-10, 23-28	250	Roosting adults (70%) and subadults (30%), no nesting (POBSP, 1965a).
1966 Mar. 23	30-35	Present at night, no nesting (BSFW, 1966a).
June 10-14, 16-21	100-250	Roosting population of 60% adults and 40% subadults (POBSP, 1966a).
Aug. 18-24, 26-30	75	Roosting population usually <u>ca.</u> 25, but 75 present the night before a storm; most birds immature, ♀ - ♂ ratio 3:1 (POBSP, 1966b).
1967 Mar. 11-12	45	Roosting population, most ♀ and immatures (POBSP, 1967b; BSFW, 1967a).

Table 69. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 May 26-31, June 9-13	375	Roosting population of all ages (POBSP, 1967a).
Sept. 17	250 [±]	Soaring above island; no nests (BSFW, 1967b).
1968 June 6-11, 14-16, 26	100 [±]	Roosting population only (POBSP, 1968a).
1969 June 5-10, 21	200	Roosting adults and subadults (POBSP, 1969).
Aug. 22, 30	5	Adults; seen 30 August (BSFW, 1969c).

Table 70. Observations of Great Frigatebird at Tern Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1891 June 1-3	?	Present; chasing Wedge-tailed Shearwater (Munro, 1941b).
1953 Oct. 26- Nov. 2	2	(Richardson, 1954a).
1956 Feb. 11-21	occasional	Observed flying over island on several occasions (Svihla, 1957).
1960 Oct. 19	1-2	Flying over lagoon and island (HDFG, 1960b).
1961 Mar. 3, 5	1	Flew over island (HDFG, 1961b).
1965 Nov. 20	2	Roosting immatures (Park, pers. corr.).
1966 June 8-10, 14-16, 21- 23, 29- July 1, 4-7	1	1 occasionally roosted at northeast end (POBSP, 1966a).
Aug. 11-15, 17-18, 24- 26, 30- Sept. 16	occasional	All ages seen flying over island (POBSP, 1966b).

Table 70. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 May 25-26, 31-June 2, 7-9, 13- 15, 18, 20-22	1	1 adult occasionally roosted during day at northeast end of island (POBSP, 1967a).
1968 May 29- June 6, 11- 14, 16-17, 19-20, 22- 27	occa- sional	Flying over island infrequently (POBSP, 1968a).
1969 June 2-4, 11-15, 25- 26	1-2	Flying over periodically (POBSP, 1969).

Table 71. Observations of Great Frigatebird at Trig Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1953 Oct. 28	250-300	(Richardson, 1954a, pers. corr.).
Dec. 19	4-6	(Richardson, 1954b, pers. corr.).
1957 Dec. 28	19	Flying over island, aerial survey (Rice & Kenyon, 1957 photo).
1963 June 14-15	40	Roosting only (POBSP, 1963).
1964 Sept. 27	--	15 in air between Trig and Whale-Skate Island; none on Trig (BSFW, 1964b; POBSP, 1964).
1965 Aug. 16, 29, 31	12	Diurnal roosting population, not nesting (POBSP, 1965a).
1966 June 10, 23, July 1, 3-4	25	Roosting population only (POBSP, 1966a).
Aug. 13-14, Sept. 4, 12	200-300	Roosting only; 40% immatures and subadults, 50% adult ♀, 10% adult ♂ (POBSP, 1966b).
1967 Mar. 13-14	1	Flew over (BSFW, 1967a; POBSP, 1967b).

Table 71. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 June 2, 8-9, 19- 20	300	Roosting population only (POBSP, 1967a).
1968 June 6, 11, 22, 24-25	100 [±]	Roosting population only (POBSP, 1968a).
1969 June 3, 14, 23- 24	150	Roosting adults and subadults (POBSP, 1969).
Aug. 23, 27	17	Seen 23 August (BSFW, 1969c).

Table 72. Observations of Great Frigatebird at Whale-Skate Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 27	120*	60 pairs with eggs or young (Wetmore, ms.).
1953 Oct. 28	200-300*	(Richardson, 1954a, pers. corr.).
Oct. 28	40-60**	(Richardson, 1954a, pers. corr.).
Dec. 19	15-20*	(Richardson, 1954b, pers. corr.).
1954 Mar. 20	130-150	Nests, many with eggs (Richardson, 1954b).
1957 Dec. 28	117	Flying over island, aerial survey (Rice & Kenyon, 1957 photo).
1963 June 12-15	687	Nests with 34 eggs, 23 with small young, 164 with large young (POBSP, 1963).
1964 Sept. 27	700	22 nests with locals, 149 with immatures in <u>Chenopodium</u> (BSFW, 1964b; POBSP, 1964).
1965 Aug. 11-17, 29-Sept. 1	534	134 nests with medium to large young in <u>Chenopodium</u> (POBSP, 1965a).
1966 Mar. 22	450	204 active nests, 90% with eggs (BSFW, 1966a).

Table 72. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1966 June 10, 23-29, July 1-3	525	10 nests with eggs, 125 from hatchlings to fledglings (POBSP, 1966a).
Aug. 15-17	500+	201 large chicks (1/3 close to fledging), 300 adults; few roosted; ♀ - ♂ ratio 3:1 (POBSP, 1966b).
Sept. 13	3	Adults flying over island (BSFW, 1966b).
1967 Mar. 14	378	166 nests (59 new, 107 with 1 egg); 46 immatures sitting on old nests (BSFW, 1967a; POBSP, 1967b).
June 2-7	620	290 adults nesting; 25 eggs; 120 young to medium size; <u>ca.</u> 210 roosting population (POBSP, 1967a).
Sept. 17	169	85 adults; no eggs; 81 chicks 2/3 to 3/4 grown; 3 immatures; nests in <u>Chenopodium</u> (BSFW, 1967b).
1968 June 6, 16-25	785 [±]	402 breeders, 200 [±] non-breeders, 18 nests with eggs, and 183 with young (POBSP, 1968a).
1969 Feb. 23	266	6 adult ♀, 10 adult ♂ (6 with inflated gular pouches); 5 nests with eggs; 250 immatures (BSFW, 1969a).
June 3, 16-20, 22	975 [±]	500 breeders, 250 [±] non-breeders; nests with 25 eggs and 225 young (POBSP, 1969).
Aug. 24	128	(BSFW, 1969c).

* Whale Island ** Skate Island

Table 73. Observations of Great Frigatebird at La Perouse Pinnacle

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1953 Oct. 31	20-40	Not nesting (Richardson, 1954a, pers. corr.).
Dec. 19	40-50	(Richardson, 1954b).
1961 Mar. 4	?	Seen on or near the rock from launch (HDFG, 1961b).
1964 Sept. 27	15	Roosting adults (BSFW, 1967b; POBSP, 1964).
1965 Aug. 7	50	Breeding status unknown (POBSP, 1965a).
1966 Mar. 23	75-100	No landing (BSFW, 1966a).
Sept. 4	100	Flying over or roosting on the rock; no evidence of nesting (POBSP, 1966b).
1967 June 12	50	Appeared to be roosting only (POBSP, 1967a).
1969 June 6, 13	25	Roosting adults, no nesting (POBSP, 1969).

Table 74. Observations of Great Frigatebird on other islands at French Frigate Shoals

<u>Date of Survey</u>	<u>Island</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1902 May 28-29	FFS	?	Present (Fisher, 1903).
1915 Mar.	FFS	1	Seen hovering over ship while anchoring (Munter, 1915).
1923 June 25	Shark	1-2	Roosting only (Wetmore, ms.).
1953 Oct. 31	Round	few	Overhead (Richardson, pers. corr.).
1963 June 9	Disappearing	1	Roosting (POBSP, 1963).
1965 Aug. 25	Little Gin	1	Roosting adult ♀ (POBSP, 1965a).
1969 June 7	Disappearing	10	Roosting adults (POBSP, 1969).

Table 75. Great Frigatebirds banded at French Frigate Shoals

Date	Nestling	Immature	Subadult	Adult	Unknown	Total
1963 June	163	0	27	64	0	254
1965 Aug.	143	90	0	182	0	415
1966 June	0	73	29	246	0	348
July	10	9	0	10	0	29
Aug.	0	14	2	14	1	31
1967 May	0	32	13	118	0	163
June	0	213	19	339	3	574
1968 June	159	1	51	87	0	298
1969 June	0	0	100	47	0	147
TOTALS	475	432	241	1,107	4	2,259

CATTLE EGRET

Bubulcus ibisStatus

Straggler; one specimen record.

Observations

An adult Cattle Egret, which arrived at Tern Island on 16 June 1967 (D.A. Brashear, pers. comm.), was collected by Lewis on 20 June. When collected it was actively feeding in the Lepturus area just east of the main antenna field. Its stomach was filled to capacity with 15+ crickets and two grasshoppers. The Cattle Egret was introduced to all the Main Hawaiian Islands in July and August 1959 when 105 individuals were released on various ranches (Breese, 1959; Udvardy, 1961b). The species has become well established in the Main Hawaiians. This record is the first from the Northwestern Hawaiian Islands.

Specimens

POBSP: USNM 497550, adult ♀, ovary 12 x 6 mm., largest ova 1 mm., 303.5 gms., collected 20 June 1967 on Tern Island by Lewis.

MALLARD

Anas platyrhynchosStatus

Occasional migrant; one sight record.

Observations

Richardson (1954a) observed six Mallard ducks on Tern Island during his 26 October to 2 November 1953 visit. This species is also known from Laysan Island, Midway Atoll, and the Main Hawaiian Islands (Munro, 1944; Bailey, 1956).

GADWALL

Anas streperaStatus

Accidental; one sight record.

Observations

Kridler (BSFW, 1967c) found a male Gadwall on the runway near the garbage dump at Tern Island 7 December 1967. Although the bird was badly decomposed, the plumage was in fairly good condition, making identification certain. This is a new Northwestern Hawaiian Islands record.

This species was recorded from Oahu and Molokai in 1902 (Munro, 1944; Bryan, 1958) and Oahu in 1967 (Anon., 1967; Pyle, 1967) and in 1969 (Kaigler, 1969).

PINTAIL

Anas acutaStatus

Frequent migrant; at least four sight records.

Observations

Richardson (1954a) observed one Pintail duck on Tern Island during his 26 October to 2 November 1953 visit, and found a long-dead female on his 18 December 1953 visit to Tern (Richardson, 1954b). POBSP personnel and Kridler (BSFW, 1966b) observed one immature or adult female Pintail flying near Trig Island on 12 September 1966. It subsequently flew over the barrier reef and was not seen again. POBSP personnel found one battered carcass and a wing on 11 March 1967 at Tern Island. Coast Guard personnel said that 19 ducks, possibly Pintails, had arrived in early 1967 in a flock and a number had died shortly thereafter. This species has been reported from Midway, Laysan and Johnston Atolls, and there are many winter records from the Main Hawaiian Islands.

DOMESTIC CHICKEN

Gallus gallusStatus

Introduced; breed unknown; did not establish.

Observations

Henry (pers. corr.) recorded 10 chickens on East Island at the U.S. Coast Guard LORAN Station during September 1948. This is a new record for French Frigate Shoals.

RING-NECKED PHEASANT

Phasianus colchicusStatus

Introduced; did not establish.

Observations

Henry (pers. comm.) reported the introduction of a pheasant onto East Island in 1949. The bird lost its feathers, was sunburned, and subsequently died.

AMERICAN COOT

Fulica americanaStatus

Straggler; one specimen record.

Observations

A dead coot was found 11 August 1965 by POBSP personnel on Tern Island (Clapp and Woodward, 1968). The bird (dead for not over two days) was found in low Tournefortia and Pluchea on the north side of the runway over 100 feet from the beach, suggesting that it had not been washed up. The American Coot breeds on the Main Hawaiian Islands (Munro, 1944), but had not previously been recorded from the Northwestern Hawaiian Islands.

Specimens

POBSP: USNM 503194, alcoholic, adult, collected 11 August 1965 on Tern Island by Amerson.

GOLDEN PLOVER

Pluvialis dominicaStatus

Common migrant; usually recorded as singles or in small flocks on the beaches. Most abundant during late summer and fall; a few birds present throughout the year. POBSP maximum population count 160 in August 1965.

Observations

The Golden Plover was first recorded in June 1891 by Munro (1941b), who found a few at Trig Island in small flocks. From then until the early 1950's there are only three records for the atoll. POBSP personnel on ten visits from 1963 to 1969 observed this species on all islands except a few small sandy islets. Tables 76 to 80 summarize the data on Golden Plover for each island at French Frigate Shoals.

Annual Cycle

Golden Plovers are found throughout the year, even during their Northern Hemisphere summer breeding period. Observations are lacking for four months, but available data indicate a peak population in late summer and early fall. During this migration the daily population may vary from day to day due to the arrival and departure of new birds (Fig. 68).

Ecological Distribution

The Golden Plover is recorded from all major islands, including La Perouse Pinnacle, and most of the smaller sand islets except Bare, Disappearing, Mullet, Near and Shark Islands. Although it is commonly seen as singles, or in small flocks, on the beaches, it is occasionally seen in the vegetated areas. On Tern Island it frequents the runway, especially when rain puddles exist. On La Perouse Pinnacle it has been observed on the cliff ledges at various heights.

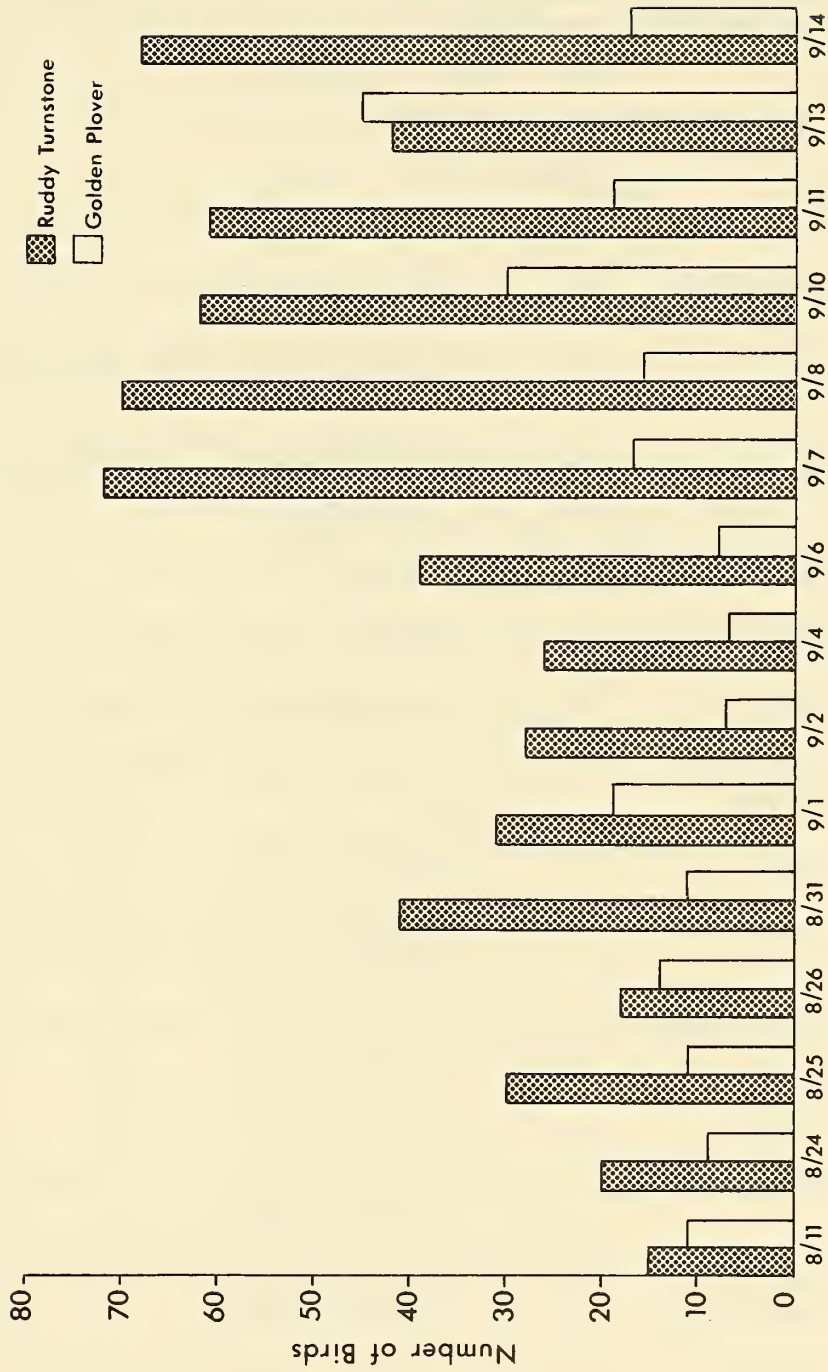


Figure 68. Daily shorebird population fluctuation at Tern Island, August - September 1966.

Banding and Movement

Four adult Golden Plovers have been banded by POBSP personnel: 1 in June 1963, 2 in August 1965, and 1 in August 1966. No inter-island movement has been noted.

Table 76. Observations of Golden Plover at East Island

Date of Survey	Population Estimate	Remarks and References
1923 June 22-23	20	<u>Ca.</u> 20 seen (Wetmore, ms.).
1936 Oct. 25-26	7	On beaches and inland (U.S. Navy Photo 80 G 410123 and 80 CF 79793-8).
1953 Oct. 31	few	(Richardson, pers. corr.).
Dec. 19	few	(Richardson, 1954b).
1954 Mar. 20	few	(Richardson, 1954b).
1963 June 7-11	10	Present daily (POBSP, 1963).
1964 Sept. 27	47	Actual count (POBSP, 1964).
1965 Aug. 5-10, 23-28	15	Present daily (POBSP, 1965a).
1966 Mar. 23	6	(BSFW, 1966a).
June 10-14, 16-21	5	Beaches and edge of vegetation (POBSP, 1966a).
Aug. 18-24	2-12	Population fluctuated daily (POBSP, 1966b).
Sept. 13, 26-30	6	On beach (BSFW, 1966b).
1967 Mar. 11-12	11	Actual count on 11th (BSFW, 1967a; POBSP, 1967b).
May 26-31, June 9-13	10	Frequented beaches and vegetated areas (POBSP, 1967a).
Sept. 17	16	Actual count (BSFW, 1967b).

Table 76. (continued)

Date of Survey	Population Estimate	Remarks and References
1968 June 6-11, 14-16, 25	5	On beaches (POBSP, 1968a).
1969 June 5-10, 21	10	On beach (POBSP, 1969).
Aug. 22, 30	3	Seen 30 August (BSFW, 1969c).

Table 77. Observations of Golden Plover at Tern Island

Date of Survey	Population Estimate	Remarks and References
1923 June 24	3	3 passed in northern flight; few in breeding plumage (Wetmore, ms.).
1953 Oct. 26- Nov. 2	14	Large accumulations of wings of birds killed by 4-5 cats (Richardson, 1954a).
Dec. 18	few	(Richardson, 1954b).
1954 Mar. 20	few	(Richardson, 1954b).
1958 May 26	few	Not abundant (Warner, 1958).
1960 Oct. 19	25 [±]	3 dead (HDFG, 1960b).
1961 Mar. 3, 5	10	(HDFG, 1961b).
Sept. 2	12	On airstrip (Udvardy and Warner, 1964; HDFG, 1961a).
1963 June 11	30	On runway (POBSP, 1963).
1964 Sept. 27-28	15	Actual count (POBSP, 1964).
1965 Aug. 4-5, 10-12, 17- 23, 28-29, 31-Sept. 2	50	Population increased during August (POBSP, 1965a).
1966 Mar. 21-24	3	(BSFW, 1966a).

Table 77. (continued)

Date of Survey	Population Estimate	Remarks and References
1966 June 8-10, 14-16, 21- 23, 29- July 1, 4-7	23	Population slightly increased late June (POBSP, 1966a).
Aug. 11-15, 17-18, 24- 26, 30- Sept. 16	12-45	Population increased in September (POBSP, 1966b).
1967 Mar. 11-14	3	Observed on runway and near barracks on 11th (BSFW, 1967a; POBSP, 1967b).
May 25-26, 31-June 2, 7-9, 13-15, 18, 20-22	25	Population showed slight increase during late June (POBSP, 1967a).
Sept. 16	3	Actual count (BSFW, 1967b).
Dec. 7-11	12	(BSFW, 1967c).
1968 Mar. 11-15	10	All in winter plumage; along edges of airstrip; at rear of mess hall feeding on food scraps (POBSP, 1968b).
May 29- June 6, 11- 14, 16-17, 19-20, 22- 27	5-16	Population fluctuated; frequented runway (POBSP, 1968a).
1969 Feb. 22-24	8	Actual count (BSFW, 1969a).
Mar. 23	20	Actual count (BSFW, 1969b).
June 2-4, 11-15, 25- 26	20	Frequented runway and lagoon beach (POBSP, 1969).
Aug. 21- Sept. 6	25	Seen 26 August (BSFW, 1969c).

Table 78. Observations of Golden Plover at Trig Island

Date of Survey	Population Estimate	Remarks and References
1891 June 1-3	few	In small flocks (Munro, 1941b).
1953 Oct. 28	-	Not reported (Richardson, 1954a).
Dec. 19	few	Small numbers (Richardson, 1954b).
1954 Mar. 20	few	Small numbers (Richardson, 1954b).
1964 Sept. 27	3	Actual count (POBSP, 1964).
1965 Aug. 16, 29, 31	20	Mainly on beaches (POBSP, 1965a).
1966 June 10-23, July 1, 3-4	3	Beaches and inland areas (POBSP, 1966a).
Aug. 13-14, Sept. 4, 12	present	No additional data (POBSP, 1966b).
1967 Mar. 13-14	2	On beach 13 March (BSFW, 1967a; POBSP, 1967b).
June 2, 8- 9, 19-20	5	Beaches and vegetated areas (POBSP, 1967a).
1968 June 6, 11, 22, 24-25	3	On beach (POBSP, 1968a).
1969 June 3, 14, 23-24	0	Not present (POBSP, 1969).
Aug. 23, 27	2	Seen 23 August (BSFW, 1969c).

Table 79. Observations of Golden Plover at Whale-Skate Island

Date of Survey	Population Estimate	Remarks and References
1953 Oct. 28	0	Not reported (Richardson, 1954a).
Dec. 19	few	Small numbers (Richardson, 1954b).
1954 Mar. 20	few	Small numbers (Richardson, 1954b).

Table 79. (continued)

Date of Survey	Population Estimate	Remarks and References
1963 June 12-15	3-5	Present daily (POBSP, 1963).
1964 Sept. 27	3	Actual count (POBSP, 1964).
1965 Aug. 17, 29-Sept. 1	50	Mainly on beaches (POBSP, 1965a).
1966 Mar. 22	14	(BSFW, 1966a).
June 10, 23-July 3	5-10	Beaches and vegetated areas (POBSP, 1966a).
Aug. 15-17, Sept. 4	present	No additional data (POBSP, 1966b).
Sept. 13	present	(BSFW, 1966b).
1967 Mar. 14	8	Foraging on beach (BSFW, 1967a; POBSP, 1967b).
June 2-7, 15-19	10	On beaches and vegetated areas (POBSP, 1967a).
Sept. 17	9	Actual count (BSFW, 1967b).
1968 June 6, 16-25	5	On beach with Ruddy Turnstone (POBSP, 1968a).
1969 Feb. 23	1	(BSFW, 1969a).
June 3, 16-20, 22	0	Not observed (POBSP, 1969).

Table 80. Observations of Golden Plover on other islands at French Frigate Shoals

Date of Survey	Island	Population Estimate	Remarks and References
1953 Oct. 31	Round	few	(Richardson, pers. corr.).
Oct. 31	La Perouse	6-12	On rocky ledges (Richardson, 1954a, pers. corr.).
Dec. 19	Gin	few	(Richardson, 1954b).

Table 80. (continued)

Date of Survey	Island	Population		Remarks and References
		Estimate		
1953	Dec. 19	Little Gin	few	(Richardson, 1954b).
1954	Mar. 20	Little Gin	few	(Richardson, 1954b).
	Mar. 20	Gin	few	(Richardson, 1954b).
1965	Aug. 7	La Perouse	5	On both rocks (POBSP, 1965a).
	Aug. 25	Little Gin	10	Actual count (POBSP, 1965a).
	Aug. 25	Gin	5	Actual count (POBSP, 1965a).
1966	Mar. 3	Gin	-	Not reported (BSFW, 1966a).
1967	June 9	Gin	1	On beach (POBSP, 1967a).
	June 9	Little Gin	2	On beach (POBSP, 1967a).
	June 12	La Perouse	2	On little rock (POBSP, 1967a).

SEMIPALMATED PLOVERCharadrius semipalmatusStatus

Accidental; one sight record.

Observations

Kridler (BSFW, 1967c) observed a Semipalmated Plover along the south beach at the east end of Tern Island on 7 December 1967. This is a first record for this species at French Frigate Shoals.

A Semipalmated Plover was collected at Midway Atoll on 26 August 1967 and another was seen on 30 April 1967 by POBSP personnel. Others have been seen in the Main Hawaiian Islands: Oahu, Maui, and Hawaii (Clapp and Woodward, 1968; Mull, 1969; and Donaghho, 1969).

BRISTLE-THIGHED CURLEWNumenius tahitiensisStatus

Common migrant; usually recorded as singles; frequents both beach and inland areas. Most abundant in summer. POBSP maximum count 5 in August and September 1966.

Observations

Wetmore (ms.) in June 1923 was the first to record the Bristle-thighed Curlew. He observed 1 to 2 on Tern Island and 8 on East Island. Thirty years later Richardson (1954a, 1954b, pers. corr.) found a few during October, December and March. Although there were several scientific visits in the late 1950's and early 1960's, none was observed.

POBSP personnel recorded this species on 8 of their 10 visits since June 1963. Tables 81 and 82 present all observations made on the atoll.

Annual Cycle

This species, which breeds in Alaska, has been recorded during eight of ten months of the year for which data are available. The population has always been low, with a maximum of 10 in June 1923 (Wetmore, ms.). Most observations have been of singles, but during summer and fall multiple sightings are common, especially on Tern Island. The population fluctuates from day to day, indicating the birds move from island to island in the atoll.

Ecological Distribution

The Bristle-thighed Curlew prefers Tern Island. It also frequents Trig and Whale-Skate Islands, and, to a lesser extent, East. Brown Noddies on the latter islands have been observed chasing curlews. This possibly accounts for the curlews' preference for Tern, where Brown Noddies no longer nest. Most records were for vegetated areas but on occasion it has been seen on the beaches. At times the Bristle-thighed Curlew has been associated with Golden Plovers and Ruddy Turnstones.

Specimens

POBSP: USNM 495888, ♂, collected 31 August 1965 on Whale-Skate by Huber.

Non-POBSP: USNM 301044-46, ♀, ♂, ♂, collected 22, 24 and 22 June 1923 by Wetmore.

Table 81. Observations of Bristle-thighed Curlew at Tern Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Remarks and References</u>
1923 June 24-28	1-2	Seen daily (Wetmore, ms.).
1953 Oct. 26- Nov. 2	0	Not observed (Richardson, 1954a, pers. corr.).

Table 81. (continued)

Date of Survey	Population Estimate	Remarks and References
1953 Dec. 18-19	few	(Richardson, 1954b).
1954 Mar. 20	few	(Richardson, 1954b).
1964 Sept. 27	0	Not observed (BSFW, 1964b; POBSP, 1964).
1965 Aug. 4-5, 10-12, 17- 23, 28-29, 31-Sept. 2	4	Appeared mid-August (POBSP, 1965a).
1966 Mar. 21	1	(BSFW, 1966a).
June 8-10, 14-16, 21- 23, 29- July 1, 4-7	2	Seen periodically (POBSP, 1966a).
Aug. 11-15, 17-18, 24- 26, 30- Sept. 16	1-5	Population fluctuated from 0 to 5 daily (POBSP, 1966b).
1967 May 25-26, 31-June 2, 7-9, 13-15, 18, 20-22	3	Population constant (POBSP, 1967a).
1968 May 29- June 6, 11- 14, 16-17, 19-20, 22- 27	3	On runway and beaches (POBSP, 1968a).
1969 June 2-4, 11- 15, 25-26	1	On runway (POBSP, 1969).
Aug. 21- Sept. 6	1	Seen 26 August (BSFW, 1969c).

Table 82. Observations of Bristle-thighed Curlew on other islands at French Frigate Shoals

Date of Survey	Island	Population Estimate	Remarks and References
1923 June 22-23	East	8	(Wetmore, ms.).
1953 Oct. 28	Whale	1	(Richardson, 1954a, pers. corr.).
Oct. 31	East	2	1 dying in tub of fresh water (Richardson, 1954a, pers. corr.).
Dec. 18-19	FFS	few	In small numbers on various islands (Richardson, 1954b).
1954 Mar. 20	FFS	few	In small numbers on various islands (Richardson, 1954b).
1963 June 12-15	Whale-Skate	1	Seen on 15th (POBSP, 1963).
1964 Sept. 27	FFS	0	Not observed (BSFW, 1964b; POBSP, 1964).
1965 Aug. 16, 29, 31	Trig	1	(POBSP, 1965a).
Aug. 11-17, 29-Sept. 1	Whale-Skate	2	Actual count (POBSP, 1965a).
1966 June 10, 23-29, July 1-3	Whale-Skate	1	Seen in vegetated areas (POBSP, 1966a).
Aug. 18-24, 26-30	East	1	Seen twice, on 26th and 29th (POBSP, 1966b).
Aug. 13-14	Trig	present	No additional data (POBSP, 1966b).
Aug. 15-17, Sept. 4	Whale-Skate	present	No additional data (POBSP, 1966b).
1967 Mar. 11-12	East	1	On 12th (BSFW, 1967a; POBSP, 1967b).
Mar. 13, 14	Trig	1	On 13th (BSFW, 1967a; POBSP, 1967b).
June 2, 8-9, 19-20	Trig	1	Beaches only (POBSP, 1967a).
Sept. 17	Whale-Skate	3	Actual count (BSFW, 1967a).

Table 82. (continued)

Date of Survey	Island	Population Estimate	Remarks and References
1967 Sept. 17	East	2	Actual count (BSFW, 1967b).
1968 June 6, 16-25	Whale-Skate	2	Inland and on beaches (POBSP, 1968a).
June 6, 11, 22, 24-25	Trig	1	Beach and inland areas (POBSP, 1968a).
1969 Feb. 22	Trig	3	Actual count (BSFW, 1969a).
Feb. 23	Whale-Skate	1	(BSFW, 1969a).
June 6, 16-25	Whale-Skate	2	On beach (POBSP, 1969).
June 6-11, 14-16, 25	East	1	Frequented beach area (POBSP, 1969).
Aug. 22, 30	East	1	Seen 30 August (BSFW, 1969c).
Aug. 24	Whale-Skate	1	(BSFW, 1969c).

WANDERING TATTLER

Heteroscelus incanumStatus

Common migrant; usually recorded singly, but may be in small flocks of 2 to 5 birds or associated with Golden Plovers and/or Ruddy Turnstones. On all major islands small numbers present throughout the year; slight increase in numbers during late summer. POBSP maximum count 15 in August 1965.

Observations

The Wandering Tattler was noted, probably on Trig Island, by Rothschild (1893-1900) and Munro (1941b) in 1891. Small numbers were recorded over the years on the four major sandy islands.

POBSP personnel recorded this tattler on East, Tern, Trig and Whale-Skate Islands and on La Perouse Pinnacle between 1963 and 1969. Tables 83 to 87 present all observations.

Annual Cycle

Small numbers are probably present throughout the year. Population estimates indicate a slight population increase during the summer. The POBSP maximum count was 15 in August 1965; 12 were seen in June 1967.

Ecological Distribution

The Wandering Tattler is known from Disappearing, East, Tern, Trig and Whale-Skate Islands, and La Perouse Pinnacle. It possibly visits the smaller sandy islets but has not been recorded. This species frequents the beaches where it prefers the surf-washed littoral zone. Occasionally it is found on the upper beach crest. On Tern Island it frequents the runway, while on La Perouse it occurs on the rocky ledges of the cliffs. This species may occur singly, in small flocks (2 to 5), or in association with other shorebirds (mainly Golden Plover and Ruddy Turnstone).

Banding and Movements

One adult Wandering Tattler was banded by POBSP personnel in September 1966. No interisland movement involving the atoll is known.

Specimens

Non-POBSP: USNM 301022-23, ♀, collected 26 and 25 June 1923 by Wetmore.

Table 83. Observations of Wandering Tattler at East Island

Date of Survey	Population Estimate	Remarks and References
1923 June 22-23	1	(Wetmore, ms.).
1953 Oct. 31	-	Not reported (Richardson, 1954a).
Dec. 19	few	(Richardson, 1954b).
1954 Mar. 20	few	(Richardson, 1954b).
1963 June 7-11	1	Present daily (POBSP, 1963).
1964 July 27	1	(BSFW, 1964a).
Sept. 27	1	(BSFW, 1964b; POBSP, 1964).

Table 83. (continued)

Date of Survey	Population Estimate	Remarks and References
1965 Aug. 5-10, 23-28	2	Actual count (POBSP, 1965a).
1966 Mar. 23	1	(BSFW, 1966a).
June 10-14, 16-21	1	Beaches only (POBSP, 1966a).
Aug. 18-24, 26-30	1-3	Population fluctuated from 1-3 daily (POBSP, 1966b).
Sept. 13	2	(BSFW, 1966b).
1967 May 26-31, June 9-13	5	Frequented beaches (POBSP, 1967a).
Sept. 17	-	Not reported (BSFW, 1967b).
1968 June 6-11, 14-16, 25	2	On beach (POBSP, 1968a).
1969 June 5-10. 21	2	On beach (POBSP, 1969).

Table 84. Observations of Wandering Tattler at Tern Island

Date of Survey	Population Estimate	Remarks and References
1953 Oct. 26- Nov. 2	-	Not reported (Richardson, 1954a).
Dec. 18-19	few	(Richardson, 1954b).
1954 Mar. 20	few	(Richardson, 1954b).
1958 May 26	few	Not abundant (Warner, 1958).
1960 Oct. 19	2-3	Seen on beaches (HDFG, 1960b).
1963 June 11	3	On runway (POBSP, 1963).
1965 Aug. 4-5, 10-12, 17-23, 28-29, 31-Sept. 2	5	Present entire period (POBSP, 1965a).

Table 84. (continued)

Date of Survey	Estimate	Remarks and References
1966 June 8-10, 14-16, 21-23, 29-July 1, 4-7	2	Population low all month (POBSP, 1966a).
Aug. 11-15, 17-18, 24-26, 30- Sept. 16	1-4	Population fluctuated from 1-4 daily (POBSP, 1966b).
1967 May 25-26, 31-June 2, 7-9, 13- 15, 18, 20- 22	3	Population constant (POBSP, 1967a).
Sept. 16-17	-	Not listed (BSFW, 1967b).
Dec. 7-11	-	Not reported (BSFW, 1967c).
1968 Mar. 11-15	1	Present on 12th and 13th at northern end (POBSP, 1968b).
May 29- June 6, 11- 14, 16-17, 19-20, 22- 27	3	Observed on beach and runway (POBSP, 1968a).
1969 Feb. 22-24	-	Not reported (BSFW, 1969a).
Mar. 23	-	Not reported (BSFW, 1969b).
June 2-4, 11-15, 25- 26	2	Observed on beach and runway (POBSP, 1969).

Table 85. Observations of Wandering Tattler at Trig Island

Date of Survey	Population Estimate	Remarks and References
1891 June 1-3	?	Present (Rothschild, 1893-1900; Munro, 1941b).
1953 Oct. 31	-	Not reported (Richardson, 1954a).

Table 85. (continued)

Date of Survey	Population Estimate	Remarks and References
1953 Dec. 19	few	(Richardson, 1954b).
1954 Mar. 20	few	(Richardson, 1954b).
1964 Sept. 27	-	Not reported (BSFW, 1964b; POBSP, 1964).
1965 Aug. 16, 29, 31	2	On beaches (POBSP, 1965a).
1966 Mar. 22	1	(BSFW, 1966a).
June 10, 23, July 1, 3-4	1	Beaches only (POBSP, 1966a).
Aug. 13-14, Sept. 4, 12	present	No additional data (POBSP, 1966b).
1967 Mar. 13-14	5	Actual count on 13th (BSFW, 1967a; POBSP, 1967b).
June 2, 6- 9, 19-20	2	Beaches only (POBSP, 1967a).
1968 June 6, 11, 22, 24-25	1	On beach (POBSP, 1968a).
1969 Feb. 22	-	Not reported (BSFW, 1969a).
June 3, 14, 23-24	2	On beach (POBSP, 1969).
Aug. 23, 27	1	Seen 23 August (BSFW, 1969c).

Table 86. Observations of Wandering Tattler at Whale-Skate Island

Date of Survey	Population Estimate	Remarks and References
1953 Oct. 28	-	Not reported (Richardson, 1954a).
Dec. 19	few	(Richardson, 1954b).
1954 Mar. 20	few	(Richardson, 1954b).

Table 86. (continued)

Date of Survey	Population Estimate	Remarks and References
1963 June 12-15	1	Present each day (POBSP, 1963).
1964 Sept. 27	-	Not reported (BSFW, 1964b; POBSP, 1964).
1965 Aug. 11-17, 29-Sept. 1	5	On beaches (POBSP, 1965a).
1966 Mar. 22	1	(BSFW, 1966a).
June 10, 23-29, July 1-3	2	Beaches only (POBSP, 1966a).
Aug. 15-17, Sept. 4	present	No additional data (POBSP, 1966b).
Sept. 13	1	(BSFW, 1966b).
1967 Mar. 14	2	Actual count (BSFW, 1967a; POBSP, 1967b).
June 2-7, 15-19	2	Beaches only (POBSP, 1967a).
Sept. 17	-	Not reported (BSFW, 1967b).
1968 June 6, 16-25	3	On beach (POBSP, 1968a).
1969 Feb. 24	-	None reported (BSFW, 1969a).
June 3, 16- 20, 22	2	On beach (POBSP, 1969).

Table 87. Observations of Wandering Tattler on other islands at French Frigate Shoals

Date of Survey	Island	Population Estimate	Remarks and References
1923 June 27	La Perouse	2	(Wetmore, ms.).
1965 Aug. 7	La Perouse	1	On little rock (POBSP, 1965a).
1969 June 6, 13	La Perouse	1	On ledge (POBSP, 1969).
June 7	Disappearing	1	With Ruddy Turnstones (POBSP, 1969).

RUDDY TURNSTONE

Arenaria interpresStatus

Common migrant; usually recorded in flocks on the beaches. Most abundant in spring and during late summer and fall; a few birds recorded during rest of the year. POBSP maximum population count 370 in August 1965.

Observations

Rothschild (1893-1900) and Munro (1941b) reported a few on Trig Island in small flocks in 1891. This species was seen in small numbers on almost all islands by all subsequent visitors.

POBSP personnel found that the number of Ruddy Turnstones varies considerably within the year and at similar times in different years, but that there is probably little change in the total number of birds using the atoll (Tables 88 to 92).

Annual Cycle

The Ruddy Turnstone is the most abundant shorebird on French Frigate Shoals at all seasons. Population estimates indicate a peak in September during the fall southward migration and a possible peak in March during the spring northward migration. During migration the turnover of birds from day to day is rapid. In August 1965 the population increased as the month progressed; however, in August to September 1966 the population did not increase until September (Fig. 68). Fluctuations in number are most likely due to birds arriving on and leaving the atoll, and not to movement within the atoll. A moderately-sized "summering" population uses the atoll each year; this number is fairly constant.

Ecological Distribution

Ruddy Turnstones have been recorded on almost all islands including La Perouse Pinnacle. They have not been found on small sandy islets such as Bare, Mullet, Near and Shark Islands.

Ruddy Turnstones usually are found in small flocks, alone, or associated with Golden Plovers. Although they prefer sandy beaches, they visit all parts of the islands. On Tern Island this species is frequently seen on the runway, especially around fresh water puddles. On La Perouse Pinnacle they have been observed on the narrow ledges of the main rock, as well as on the surface of the smaller rock.

Banding and Movements

Since June 1963, 13 adults have been banded: June 1963 - 1, August 1965 - 7, August and September 1966 - 5. Two of these were subsequently recaptured on the atoll.

Eight adult Ruddy Turnstones, all banded by POBSP personnel at St. George Island, Alaska, have been captured at French Frigate Shoals. One was taken just four days after being last handled some 1,800 miles to the north. Appendix Table 8 gives additional data on these movements.

Specimens

POBSP: USNM 495908, ♂, collected 31 August 1965 on Whale-Skate by Huber (USFW band no. 712-06593).

Table 88. Observations of Ruddy Turnstone at East Island

Date of Survey	Population Estimate	Remarks and References
1923 June 22-23	30	(Wetmore, ms.).
1953 Oct. 31	few	(Richardson, pers. corr.).
Dec. 19	few	(Richardson, 1954b).
1954 Mar. 20	few	(Richardson, 1954b).
1963 June 7-11	10	Present each day (POBSP, 1963).
1964 July 27	17	Actual count (BSFW, 1964a).
Sept. 27	130	Actual count (BSFW, 1964b; POBSP, 1964).
1965 Aug. 5-10, 23-28	25	Mainly on beaches (POBSP, 1965a).
1966 Mar. 23	94	Actual count (BSFW, 1966a).
June 10-14, 16-21	3	Beaches only (POBSP, 1966a).

Table 88. (continued)

Date of Survey	Population Estimate	Remarks and References
1966 Aug. 18-24, 26-30	44-94	Population fluctuated daily (POBSP, 1966b).
Sept. 13	43	On beach (BSFW, 1966b).
1967 Mar. 11-12	48	Actual count on 11th (POBSP, 1967b; BSFW, 1967a).
May 26-31, June 9-13	30	Frequented beaches (POBSP, 1967a).
Sept. 17	93	Actual count (BSFW, 1967b).
1968 June 6-11, 14-16, 25	8	On beach (POBSP, 1968a).
1969 June 5-10, 21	5	On beach (POBSP, 1969).
Aug. 22, 30	95	Seen 30 August (BSFW, 1969c).

Table 89. Observations of Ruddy Turnstone at Tern Island

Date of Survey	Population Estimate	Remarks and References
1923 June 24-28	1	Seen daily (Wetmore, ms.).
1953 Oct. 26- Nov. 2	8	Present on runway and areas of sparse vegetation above the beaches (Richardson, 1954a).
Dec. 18	few	(Richardson, 1954b).
1954 Mar. 20	few	(Richardson, 1954b).
1956 Feb. 11-21	15	Frequented vicinity of mess hall (Svihla, 1957).
1958 May 26	few	Not abundant (Warner, 1958).
1960 Oct. 19	100	Frequented area near main buildings (HDFG, 1960b).

Table 89. (continued)

Date of Survey	Population Estimate	Remarks and References .
1961 Mar. 3,5	50	(HDFG, 1961b).
Sept. 2	29	On margin of island (HDFG, 1961a; Udvardy and Warner, 1964).
1963 June 11	30	On runway (POBSP, 1963).
1964 Sept. 27-28	35	Actual count (BSFW, 1964b; POBSP, 1964).
1965 Aug. 4-5, 10-12, 17- 23, 28-29, 31-Sept. 2	75	Population increased during August (POBSP, 1965a).
1966 Mar. 21	80	(BSFW, 1966a).
June 8-10, 14-16, 21- 23, 29- July 1, 4-7	5	Population low all month (POBSP, 1966a).
Aug. 11-15, 17-18, 24- 26, 30- Sept. 16	15-72	Population increased in September (POBSP, 1966b).
1967 Mar. 11-14	48	On runway near barracks on 11th (POBSP, 1967b; BSFW, 1967a).
May 25-26, 31-June 2, 7-9, 13-15, 18, 20-22	10	Population fairly constant all month (POBSP, 1967a).
Sept. 16	3	(BSFW, 1967b).
Dec. 7-11	57	On 7th (BSFW, 1967c).
1968 Mar. 11-15	50	In flocks (up to 17) on airstrip, around barracks, and on beaches (POBSP, 1968b).
May 29- June 6, 11-14, 16- 17, 19-20, 22-27	12	On runway, beaches and vegetated areas (POBSP, 1968a).

Table 89. (continued)

Date of Survey	Population Estimate	Remarks and References
1969 Feb. 22-24	22	(BSFW, 1969a).
Mar. 23	15	Actual count (BSFW, 1969b).
June 2-4, 11-15, 25-26	10	On runways (POBSP, 1969).
Aug. 21- Sept. 6	9	Seen 26 August (BSFW, 1969c).

Table 90. Observations of Ruddy Turnstone at Trig Island

Date of Survey	Population Estimate	Remarks and References
1891 June 1-3	few	In small flocks (Rothschild, 1893-1900; Munro, 1941b).
1953 Oct. 28	few	(Richardson, 1954a, pers. corr.).
Dec. 19	few	(Richardson, 1954b).
1954 Mar. 20	few	(Richardson, 1954b).
1964 Sept. 27	45	Actual count (BSFW, 1964b; POBSP, 1964).
1965 Aug. 16, 29, 31	50	On beaches (POBSP, 1965a).
1966 June 10, 23, July 1, 3-4	5	Beaches only (POBSP, 1966a).
Aug. 13-14, Sept. 4, 12	present	No additional data (POBSP, 1966b).
Sept. 12	25	On beaches (BSFW, 1966b).
1967 Mar. 13-14	41	Actual count on 13th (BSFW, 1967a; POBSP, 1967b).
June 2, 8- 9, 19-20	5	Beaches only (POBSP, 1967a).

Table 90. (continued)

Date of Survey	Population Estimate	Remarks and References
1967 Sept. 17	102	(BSFW, 1967b).
1968 June 6, 11, 22, 24-25	5	On beach (POBSP, 1968a).
1969 Feb. 22	12	(BSFW, 1969a).
June 3, 14, 23-24	5	On beaches and inland (POBSP, 1969).
Aug. 23, 27	20	Seen 23 August (BSFW, 1969c).

Table 91. Observations of Ruddy Turnstone at Whale-Skate Island

Date of Survey	Population Estimate	Remarks and References
1953 Oct. 28	few	(Richardson, 1954a, pers. corr.).
Dec. 19	few	(Richardson, 1954b).
1954 Mar. 20	few	(Richardson, 1954b).
1963 June 12-15	15-20	Present each day (POBSP, 1963).
1964 Sept. 27	145	Actual count (BSFW, 1964b; POBSP, 1964).
1965 Aug. 11-17, 29-Sept. 1	150	Large flocks on beaches (POBSP, 1965a).
1966 Mar. 22	34	(BSFW, 1966a).
June 10, 23-29, July 1-3	5-10	Beaches only (POBSP, 1966a).
Aug. 15-17, Sept. 4	present	No additional data (POBSP, 1966b).
1967 Mar. 14	34	Actual count (BSFW, 1967a; POBSP, 1967b).
June 2-7, 15-19	15	Beaches only (POBSP, 1967a).

Table 91. (continued)

Date of Survey	Population Estimate	Remarks and References
1968 June 6, 16-25	10	On beaches (POBSP, 1968a).
1969 Feb. 23	10	(BSFW, 1969a).
June 3, 16-20, 22	9	On beaches (POBSP, 1969).
Aug. 24	19	(BSFW, 1969c).

Table 92. Observations of Ruddy Turnstone on other islands at French Frigate Shoals

Date of Survey	Island	Population Estimate	Remarks and References
1923 June 22	Round	1	Collected (Wetmore, ms.).
1953 Oct. 31	Round	few	(Richardson, pers. corr.).
Oct. 31	La Perouse	4-8	(Richardson, pers. corr.).
Dec. 19	Gin	few	(Richardson, 1954b).
Dec. 19	Little Gin	few	(Richardson, 1954b).
Dec. 19	La Perouse	few	(Richardson, 1954b).
1954 Mar. 20	Little Gin	few	(Richardson, 1954b).
Mar. 20	Gin	few	(Richardson, 1954b).
1964 Sept. 27	La Perouse	1	Actual count (POBSP, 1964).
1965 Aug. 7	La Perouse	10	On both rocks (POBSP, 1965a).
Aug. 25	Gin	10	On beaches (POBSP, 1965a).
Aug. 25	Little Gin	50	Large flocks (POBSP, 1965a).
1966 Mar. 23	Gin	1	(BSFW, 1966a).
Sept. 4	La Perouse	present	No additional data (POBSP, 1966b).

Table 92. (continued)

<u>Date of Survey</u>	<u>Island</u>	<u>Population Estimate</u>	<u>Remarks and References</u>
1967 June 9	Gin	5	On beach (POBSP, 1967a).
June 9	Little Gin	5	On beach (POBSP, 1967a).
June 12	La Perouse	5	On little rock (POBSP, 1967a).
1968 June 7	Gin	3	On beach (POBSP, 1968a).
1969 June 7, 21	Gin	1	On beach (POBSP, 1969).
June 7, 21	Little Gin	1	On beach (POBSP, 1969).
June 7	Disappear- ing	1	On beach (POBSP, 1969).

SANDERLINGCrocethia albaStatus

Common migrant; usually found along the beaches as singles, or in association with other shorebirds. A few birds recorded during all months (ten) for which data are available; slight population increase in spring and fall. POBSP maximum population count 9 in March 1967.

Observations

The first record was made by Wetmore (ms.) who collected one on 25 June 1923 at Tern Island. Thirty years elapsed before it was next recorded by Richardson (1954a, 1954b, pers. corr.), who found it on East, Round and Tern Islands in October 1953. Svihla (1957) saw one in mid-February 1956 and Woodside (HDFG, 1960b, 1961a) found Sanderlings in October 1960 and September 1961 (see also Udvardy and Warner, 1964).

Sanderlings have been recorded on eight of the ten POBSP visits since June 1963. BSFW personnel have also recorded them on most of their 1964 to 1969 visits. Tables 93 and 94 present all observations of this species at French Frigate Shoals.

Annual Cycle

This Northern Hemisphere circumpolar breeder is recorded on the atoll during all ten months for which data are available. Most observations are of singles or of less than four birds, but during fall 1953 and spring 1967 up to 9 in a flock were seen. The population on any island fluctuates daily; although some individuals seem to prefer certain islands, they may visit other nearby islands in the atoll.

Ecological Distribution

The Sanderling has been recorded from Disappearing, East, Round, Tern, Trig and Whale-Skate Islands and, in time, it probably will be recorded from all islands in the atoll. It frequents the beaches, but on Tern Island it also inhabits the runway, especially around rain puddles. It occurs singly, in small flocks, or associated with other shorebirds (mainly Ruddy Turnstone and Golden Plover, and sometimes Wandering Tattler).

Specimens

POBSP: USNM 543437, ♀, collected 20 June 1967 on Trig by Lewis.

Non-POBSP: USNM 301031, ♂, collected 25 June 1923 on Tern by Wetmore.

Table '93. Observations of Sanderling at Tern Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Remarks and References</u>
1923 June 24-28	1	Collected on 25th; alone on beach (Wetmore, ms.).
1953 Oct. 26- Nov. 2	10	(Richardson, 1954a).
Dec. 18-19	-	Not reported (Richardson, 1954b).
1954 Mar. 20	-	Not reported (Richardson, 1954b).
1956 Feb. 11-21	1	Only 1 observed (Svihla, 1957).
1960 Oct. 19	2	On south beach (HDFG, 1960b).
1961 Sept. 2	1	Present on margin of island (HDFG, 1961a; Udvardy and Warner, 1964).

Table 93. (continued)

Date of Survey	Population Estimate	Remarks and References
1965 Aug. 4-5, 10-12, 17-23, 28-29, 31-Sept. 2	1	Appeared late August (POBSP, 1965a).
1966 Mar. 21	1	(BSFW, 1966a).
June 8-10, 14-16, 21- 23, 29- July 1, 4-7	3	Observed on runway and beaches (POBSP, 1966a).
Aug. 11-15, 17-18, 24- 26, 30- Sept. 16	1-3	Population fluctuated from 0-3 daily (POBSP, 1966b).
1967 Mar. 11, 12-14	9	6 seen on runway feeding 11 March; 9 on runway and beaches 14 March (BSFW, 1967a; POBSP, 1967b).
May 25- June 2, 7-9, 13- 15, 18, 20-22	2	Population constant during period (POBSP, 1967a).
Sept. 16	1	(BSFW, 1967b).
Dec. 7-11	3	Observed on 7th (BSFW, 1967c).
1968 Mar. 11-15	1	On southeast beach (POBSP, 1968b).
May 29- June 6, 11-14, 16- 17, 19-20, 22-27	3	On runway and beach, often with Ruddy Turnstones (POBSP, 1968a).
1969 Feb. 22-24	2	(BSFW, 1969a).
Mar. 23	3	Actual count (BSFW, 1969b).
June 2-4, 11-15, 25-26	1	Present on 12th (POBSP, 1969).

Table 94. Observations of Sanderling on other islands at French Frigate Shoals

Date of Survey	Island	Population		Remarks and References
		Estimate		
1953	Oct. 31	East	few	(Richardson, pers. corr.).
	Oct. 31	Round	few	(Richardson, pers. corr.).
	Dec. 18-19	FFS	-	Not reported (Richardson, 1954b).
1954	Mar. 20	FFS	1	Not reported (Richardson, 1954b).
1963	June 12-15	Whale-Skate	3	Seen 13th-15th (POBSP, 1963).
1966	Mar. 22	Whale-Skate	1	(BSFW, 1966a).
	Aug. 15-17, Sept. 4	Whale-Skate	present	No additional data (POBSP, 1966b).
	Sept. 13	Whale-Skate	1	(BSFW, 1966b).
1967	Mar. 4	Whale-Skate	3	On beach (BSFW, 1967a; POBSP, 1967b).
	Mar. 11-12	East	1	Observed briefly on 11th; alighted for a few seconds before flying northeast (BSFW, 1967a; POBSP, 1967b).
	Mar. 13-14	Trig	3	Observed along beach (BSFW, 1967a; POBSP, 1967b).
	May 26-31 June 9-13	East	3.	Frequented beaches (POBSP, 1967a).
	June 2-7, 15-19	Whale-Skate	1	Beaches only (POBSP, 1967a).
	June 2, 8-9, 19-20	Trig	1	Beaches only (POBSP, 1967a).
	Sept. 17	Whale-Skate	3	Observed (BSFW, 1967b).
1968	June 6, 16-25	Whale-Skate	3	On beaches (POBSP, 1968a).
	June 6, 11, 22, 24-25	Trig	1	On beaches (POBSP, 1968a).
1969	June 7	Disappearing	1	On beach (POBSP, 1969).

RING-BILLED GULL

Larus delawarensisStatus

Straggler; one sight record.

Observations

Hackman (POBSP, 1967b) and Kridler (BSFW, 1967a) observed a Ring-billed Gull in first winter plumage flying around Trig Island and on the beach of Whale-Skate Island on 13 and 14 March 1967. Attempts to collect it failed. This is a new sight record for French Frigate Shoals. This species had previously been recorded from Kure Atoll and Pearl and Hermes Reef (Clapp and Woodward, 1968), as well as from the Main Hawaiian Islands (Munro, 1944).

WESTERN GULL

Larus occidentalisStatus

Straggler; one sight record.

Observations

Richardson (1954a) observed one Western Gull at Tern Island between 26 October and 2 November 1953 (see also Udvardy, 1961b). No other records exist for the Northwestern Hawaiian Islands. Although this species was introduced several times to Hawaii (Honolulu and Hilo), it never became established (Caum, 1933).

GLAUCOUS-WINGED GULL

Larus glaucescensStatus

Irregular winter visitor; two records.

Observations

A Glaucous-winged Gull in full adult plumage was observed repeatedly on the lagoon south of Tern Island and west of Trig Island on 19 and 20 March 1954 by Richardson (1954b). It later accompanied the USCGC Buttonwood south of the atoll for two days. An immature Glaucous-winged Gull, first observed 6 June 1968, was collected 11 June 1968 by Amerson at Trig Island. At one point the bird, which was in very worn plumage, was harassed by several Brown Noddies and an adult female Great Frigatebird to such an extent that it was forced to land on the water near the island. This is a new specimen record for French Frigate Shoals.

The Glaucous-winged Gull has been collected on most of the Main Hawaiian Islands, where it is a frequent visitor. Clapp and Woodward (1968) list all known records for the Northwestern Hawaiian Islands; Sibley and McFarlane (1968) discuss its distribution in the central Pacific.

Specimens

POBSP: USNM 544979, immature, collected 11 June 1968 on Trig Island by Amerson.

FRANKLIN'S GULL

Larus pipixcan

Status

Straggler; one specimen record.

Observations

The dried carcass of a Franklin's Gull was found by Amerson at Tern Island on 4 August 1965 (Clapp and Woodward, 1968; Sibley and McFarlane, 1968). It was on the north side of the runway under thick Pluchea, indicating that it had not washed up on the beach. The gull had been molting into adult plumage when it died. Only four other records exist for the Hawaiian Islands: a specimen from Maui, two sight records from Oahu, and an adult taken two miles off Kauai (King, 1959; Clapp and Woodward, 1968). The only other record from the central Pacific is from the Line Islands (Sibley and McFarlane, 1968).

Specimens

POBSP: USNM 496203, dried carcass, collected 4 August 1965 on Tern Island by Amerson.

SOOTY TERN

Sterna fuscata

Status

Abundant breeding species; present usually from mid-February through early October; absent during remainder of year. Nests on the ground, chiefly in association with Tribulus, at East, Trig and Whale-Skate Islands. Previously nested on Tern Island, and possibly on La Perouse Pinnacle. Maximum POBSP observations 250,000+ in May and June 1967.

Observations

The Sooty Tern is presently the most abundant species. It was first reported during 1891 by Rothschild (1893-1900) and

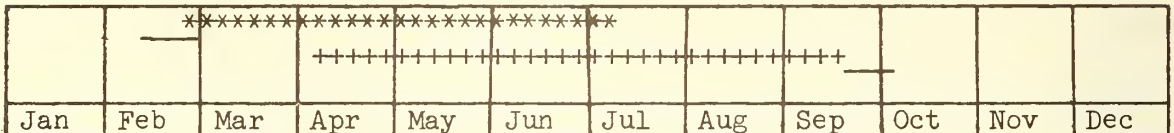
Munro (1941b), who reported thousands nesting at Tern Island. Rothschild also implied their presence on East Island. Fisher (1903) gave no estimate of numbers in late May 1902. In 1915 Munter (1915) reported a small nesting colony, probably at East Island. Wetmore (ms.) in late June 1923 reported many Sooty Terns on eggs, and young, at Tern, Trig, Skate and Whale Islands, and a few flying over East Island. Very little is known about the population between 1923 and the mid-1950's.

HDFG, BSFW, and POBSP personnel recorded the Sooty Tern in increased numbers from the major islands during the 1960's.

Annual Cycle

Figure 69 illustrates the Sooty Tern breeding period determined by observations and by interpolation of known incubation and fledging dates. The atoll is deserted from mid-fall to late winter. Adults begin to arrive during early February (Svihla, 1957), with egg-laying commencing in late February or early March. Peak egg-laying is during late April and early May, with some eggs through early July. Hatching probably commences in early April, with the peak in late May and early June. Peak populations occur during late spring and early summer. Most chicks fledge during late July and August, with a few stragglers remaining into early October. The majority of adults and immatures generally leaves by early September.

Figure 69. Annual cycle of Sooty Tern



** = eggs present; ++ = dependent young present; — = non-breeding birds present

Ecological Distribution

Although Sooty Terns have been seen over all islands at French Frigate Shoals, breeding has occurred only on East, Tern, Trig and Whale-Skate Islands, and possibly on La Perouse Pinnacle.

East Island: East is the major breeding island for Sooty Terns at French Frigate Shoals (Table 95). Their presence in June 1891 was implied by Rothschild (1893-1900). Fisher (1903) in late May 1902, Munter (1915) during March 1915, and Wetmore (ms.) in June 1923 each observed only a few. A low-level aerial photograph taken 28 April 1933 prior to disturbance of the island by military personnel shows no Sooty Terns. In November 1935 and

October 1936 after the "tent city" was built, U.S. Navy Department photographs (#CF 79793-8-10 and #80G 410122-410123, U.S. Nat. Archives, R.G. 80) reveal other seabird species nesting on the island but not Sooty Terns.

In 1944 the U.S. Coast Guard established a LORAN Transmitting Station and erected eight Quonset huts on the west and six antenna poles on the east portions. A photograph (Henry, pers. comm.) taken in the spring of 1949 shows 1,000+ Sooty Terns with nests containing eggs in the Lepturus and Tribulus on the east portion in spite of this disturbance. In 1952 the Coast Guard moved the LORAN Station to Tern Island and the Quonset huts, antenna poles, etc., were left. During March 1961 Woodside and Kramer (HDFG, 1961b) found two colonies nesting-- one southeast of the antenna pole area, and the other in the building area. In June 1962 thousands were on, and flying over, the island (HDFG photographs, R1-308 and 309).

In June 1963 POBSP personnel found 30,000 to 40,000 Sooty Terns which covered most of the vegetated part of the island. Since then, the colony has steadily increased in size but successful breeding occurred only in 1967 and 1968.

Tern Island: Sooty Terns presently do not breed here because of the U.S. Coast Guard activities (Table 96). In 1891 Munro (1941b) found them nesting on bare sand. Wetmore's photographs taken in 1923 show large numbers nesting on bare sand over most of the island and in association with Boerhavia and Lepturus. When the U.S. Navy started construction of the present-day island in mid-June 1942, the island was "populated by tens of thousands of terns" (Woodbury, 1946). The colony was dispersed when the original island was entirely covered by dredging operations. Until 1952, nothing is known of attempts, if any, by Sooty Terns to recolonize the island. Photographs taken September 1943, April 1945 and March 1949 show none. During the spring of 1952, however, there were many nests with eggs on the runway (Hawkins and Ensrud, pers. comm.). During 1952 and 1953 Price (pers. corr.) reports that birds "covered the island; it was impossible to walk without disturbing them." Apparently the Coast Guard took action and by late May 1958 Warner (1958) noted only the few old-looking carcasses. Since then, Sooty Terns have been known to alight only on a few occasions; the rest of the time they fly overhead going to and from their breeding colonies on other islands within the atoll.

Trig Island: Small numbers usually breed here (Table 97). Wetmore (ms.) reported 2,000 pairs in 1923. POBSP personnel found Sooties nesting during the breeding season each year except 1969. When nesting they utilize the Boerhavia and Lepturus area just west of the large Tournefortia bush, as well as the Boerhavia and Tribulus area on the west tip of the island.

Whale-Skate Island: Sooty Terns presently breed in small numbers (Table 98). In 1923 Wetmore (ms.) reported nesting on both Skate and Whale Islands, then separate. Richardson (1954b) found none in 1954. Only 200 were nesting, with eggs and young, among Tribulus and Lepturus when POBSP personnel visited in 1963. Nineteen sixty-seven and 1968 were the only really successful nesting years from then through 1969. From 1965 to 1968 there were two distinct Sooty Tern colonies on Whale-Skate Island, each seemingly located at the center of the original islands.

Other Islands: Sooty Terns fly over and possibly alight on the other islands. A swirl of 1,000 birds was reported by Kridler (BSFW, 1967a) over La Perouse Pinnacle on 15 March 1967, but, since it was seen from a distance, it may well have been of Gray-backed Terns. One adult Sooty Tern was recorded at La Perouse by POBSP in June 1969.

Banding and Movements

The POBSP banded 37,895 Sooty Terns (Table 99). Returns to French Frigate total 2,400. In addition, 48 Sooty Terns banded at other central Pacific localities have been captured at French Frigate Shoals: 35 from Johnston, 5 each from Laysan and Midway, and 1 each from Lisianski, Oahu and Palmyra. Twenty-one Sooty Terns banded at French Frigate have been captured at other islands and atolls: 14 at Johnston, 3 at Laysan, 2 at Lisianski, and 1 each at Midway and Wake. Additional data on these interisland birds are given in Appendix Tables 9a and 9b.

Specimens

POBSP: USNM 495874-75, unsexed, collected 23 August 1965 on East by Huber; USNM 495876-80, ♂, collected 27 August 1965 on East by Huber and Amerson; USNM 497938-40, unsexed, collected 10 June 1963 on East by Sibley; USNM 542922-24, ♂, ♀, ♂, collected 31 May 1967 on East by Lewis.

Non-POBSP: USNM 300587-89, ♂, ♂, ♀, collected 26 June 1923 by Wetmore; USNM 300590-91, ♀, ♂, collected 25 June 1923 by Wetmore; USNM 300592-94, ♀, ♀, ♂, collected 26 June 1923 by Wetmore; USNM 300595-98, ♀, ♂, ♀, ♀, collected 25 June 1923 by Wetmore; AMNH 746719, ♂, collected 2 June 1891 by Palmer; AMNH 746720-21, ♀, ♂, collected 2 June 1891 by Palmer; BPBM 780, no data; BPBM 7017, egg, collected June 1891 by Munro.

Table 95. Observations of Sooty Tern at East Island

Date of Survey	Population Estimate	Breeding Status, Remarks and References
1891 June 4-5	?	Presence implied (Rothschild, 1893-1900).
1902 May	?	Swarmed over islet (Fisher, 1903).
1915 Mar.	350	Nests with eggs (Munter, 1915).
1923 June 22-23	few	Pass occasionally (Wetmore, ms.).
1949 Spring	1,000+	Many nests with eggs (Henry, 1949 photo).
1961 Mar. 4	several thousand	2 colonies (southeast shore-antenna pole area, building area); eggs present, no young (HDFG, 1961b).
1962 June	thousands	On and flying over (HDFG Photos R1-308 and 309).
1963 June 7-11	30,000-40,000	Covered all of island; nests with 1,000's of eggs; young (100's) at all stages (POBSP, 1963).
1964 July 27	46,000	20,000 nests, young 2,000, some flying (BSFW, 1964a).
Sept. 27	3	Immatures, 2 with broken wings (POBSP, 1964; BSFW, 1964b).
1965 Aug. 5-10, 23-28	50,000	Only <u>ca.</u> 100 chicks present, majority of adult population roosting at night (POBSP, 1965a).
1966 Mar. 23	40,000	<u>Ca.</u> 19,000 nests, all with eggs; <u>ca.</u> 5-6 nests per sq. yard (BSFW, 1966a).
June 10-14, 16-21	50,500	Nests with 500 eggs and 500 with chicks of all ages scattered through colony (POBSP, 1966a).
Aug. 18-24, 26-30	20,125	100 chicks from hatchlings to fledglings, also <u>ca.</u> 25 flying immatures; adult roosting population doubled at night (POBSP, 1966b).
1967 Mar. 11-12	20,000	Breeding cycle just starting, only <u>ca.</u> 5,000 eggs present (BSFW, 1967a; POBSP, 1967b).

Table 95. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 May 26-31, June 9-13	250,000	200,000 adults, 50,000 young, 10,000 eggs; fresh eggs to fledglings (POBSP, 1967a).
Sept. 17	16	8 adults, 8 flying immatures (BSFW, 1967b).
1968 June 6-11	120,000	42,000 [±] breeders, 58,000 [±] non-breeders, 20,000 [±] young, 1,000 [±] nests with eggs; most young fledged by late June (POBSP, 1968a).
1969 June 5-10, 21	210,000	200,000 adults, 100 nests with eggs, 1,000 young hatchlings to fledglings (POBSP, 1969).
Aug. 22, 30	300	Adults; seen 30 August (BSFW, 1969c).

Table 96. Observations of Sooty Tern at Tern Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1891 June 1-3	thousands	Nesting on bare sand; eggs and young of all stages present, some fledglings (Rothschild, 1893-1900; Munro, 1941b).
1923 June 24-28	7,000	3,500 pairs; 1,000-1,500 dead young on beach of Trig on 26 June thought to have washed from Tern (Wetmore, ms.).
1942 June 14	thousands	"Populated by tens of thousands of terns" (Woodbury, 1946).
1952 Spring	numerous	Many nests with eggs on runway (Hawkins, Ensrud, pers. corr.).
1954 Mar. 20	1,000- 1,500	High circling flocks form over island in late afternoon and evening; none on ground (Richardson, 1954b).
1956 Feb. 11-21	most numerous	Appeared every evening just before or after sunset over shallow lagoon; disappeared about 0300 each morning (Svihla, 1957).

Table 96. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1958 May 26	few	"Old-looking carcasses remained of the once prolific colony...relicts undoubtedly of the successful campaign to frighten or drive this species from the island" (Warner, 1958).
1961 Mar. 3, 5	3	Flew over (HDFG, 1961b).
Sept. 2	1	Present in the air around island (Udvardy and Warner, 1964).
1965 Aug. 4-5, 10-12, 17- 23, 28-29, 31-Sept. 2	occasional	Observed over island and offshore (POBSP, 1965a).
1966 Mar. 23	10	Flying overhead (BSFW, 1966a).
June 8-10, 14-16, 21- 23, 29	occasional	Observed flying over island and offshore (POBSP, 1966a).
Aug. 1, 4- 7, 11-15, 17-18, 24- 26, 30- Sept. 16	occasional	Adults flying over (POBSP, 1966b).
1967 May 25-26, 31-June 2, 7-9, 13-15, 18, 20-22	occasional	Flying over island and offshore (POBSP, 1967a).
1968 Mar. 11-15	2+	Adults flew over island each day except 11th (POBSP, 1968b).
May 29- June 6, 11- 14, 16-17, 19-20, 22-27	occasional	Individual or small flock flew over island (POBSP, 1968a).
1969 June 2-4, 11-15, 25- 26	occasional	Adults flying over (POBSP, 1969).

Table 97. Observations of Sooty Tern at Trig Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 26	4,000	2,000 pairs, most on fresh eggs; see June 24-26, Table 96 (Wetmore, ms.).
1954 Mar. 20	1,500-2,000	Many on ground, no eggs (Richardson, 1954b).
1963 June 14, 15	200	Nests with eggs and young (POBSP, 1963).
1965 Aug. 16, 29, 31	25	Adults circling or flying over island only (POBSP, 1965a).
1966 Mar. 22	700	Adults on ground, no nests (BSFW, 1966a).
June 10, 23, July 1, 3-4	1,500	All adults, roosting only (POBSP, 1966a).
Aug. 13-14, Sept. 4, 12	occasional	Adults flying over (POBSP, 1966b).
1967 Mar. 13-14	50	No eggs on 13th, 15 fresh eggs on 14th; colony on west end (BSFW, 1967a; POBSP, 1967b).
June 2, 8-9, 19-20	2,200	1,500 adults, no eggs; 700 young, young almost fledged (POBSP, 1967a).
1968 June 6, 11, 22, 24-25	2,500	1,000 [±] non-breeders, no eggs, 500 [±] almost fledged young (POBSP, 1968a).
1969 Feb. 22	250 [±]	Flying overhead, none seen on 23rd (BSFW, 1969a).
June 3, 14, 23-24	occasional	Adults flying over, no evidence of previous colony (POBSP, 1969).

Table 98. Observations of Sooty Tern at Whale-Skate Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 26	250+*	125 pairs with eggs and young (Wetmore, ms.).
June 26	1,600**	800 pairs (Wetmore, ms.).

Table 98. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1954 Mar. 20	0	None (Richardson, 1954b).
1963 June 12-15	200	Nests with eggs and young (POBSP, 1963).
1964 Sept. 27	3	Adults only (POBSP, 1964; BSFW, 1964b).
1965 Aug. 11-17, 29-Sept. 1	2,000	10 young fledged by late August (POBSP, 1965a).
1966 Mar. 22	200	Most on ground, 1 egg found (BSFW, 1966a).
June 10, 23-29, July 1-3	5,000	Nests with 20 eggs and 5 chicks; egg laying increased late June (POBSP, 1966a).
Aug. 15-18, Sept. 4	3,000 ± 20%	15 chicks (10-21 days old), rest roosting adults just east of central portion (POBSP, 1966b).
1967 Mar. 14	150	No eggs, but birds were reluctant to fly and acted as if ready to lay; colony on north end (POBSP, 1967b; BSFW, 1967a).
June 2-7, 15-19	4,200	3,000 adults, 100 eggs, 1,200 young all ages (POBSP, 1967a).
Sept. 17	2	Adults overhead (BSFW, 1967b).
1968 June 6, 16-25	5,500	1,400± breeders, 3,600± non-breeders, 200± nests with eggs, 500± young (some fledglings) (POBSP, 1968a).
1969 Feb. 23	250±	Adults flying overhead; possibly same birds over Trig on 22nd (BSFW, 1969a).
June 3, 16-20, 22	2,200	2,000 adults, few eggs, 200 young (POBSP, 1969).

* Whale Island ** Skate Island

Table 99. Sooty Tern banded at French Frigate Shoals

Date	Adults	Young	Totals
1963 June	1,000	100	1,100
1965 Aug.	5,793		5,793
1966 June	8,519		8,519
Aug.-Sept.	8,345	47	8,392
1967 May-June	2,000	6,500	8,500
1968 May-June	100	5,300	5,400
1969 June	191		191
Totals	25,948	11,947	37,895

GRAY-BACKED TERN

Sterna lunataStatus

Uncommon breeding species; present during winter, spring and summer; usually absent during fall. Nests during spring and summer on East, Trig and Whale-Skate Islands, and on La Perouse Pinnacle; occasionally seen on other islands within the atoll. POBSP maximum population estimate 1,789⁺ in June 1969.

Observations

Gray-backed Terns first were recorded by Fisher (1903) in 1902. Wetmore (ms.) recorded this species with young from Skate and Whale Islands (then separate) in 1923. Nothing is known of its status during the 1930's and 1940's, but presumably it occurred at least on the uninhabited islands. Although Richardson (1954a, 1954b) visited all islands in 1953, he found Gray-backed Terns only once--at La Perouse Pinnacle in December. POBSP personnel found this species nesting at East, Trig and Whale-Skate Islands, and La Perouse Pinnacle. It has also been observed roosting on, or flying over, Disappearing and Tern Islands.

Annual Cycle

Gray-backed Terns at French Frigate Shoals have a spring-summer breeding cycle (Fig. 70). Adults probably return in early or mid-December after being absent during most of the fall. No

observations have been made during January and the February 1969 visit produced no record of this species; however, single eggs were found twice in March, so the species probably occurs in February. Eggs have been observed as late as early July. Peak egg laying probably occurs in April or early May. Hatching begins by late April, as fledglings have been observed in early June. Most young fledge by late July and August but some not until September.

Figure 70. Annual cycle of Gray-backed Tern

		*****	*****	*****	*****						
				+++++	+++++	+++++	+++++	+++++	+++++		
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = dependent young present; ___ = non-breeding birds present

The population cycle also coincides with the breeding cycle. No adults and few immatures are present in the fall. Adults return by mid-December and by March have numbered from 11 to 104. The population peak usually occurs in June, with numbers from 150 to 1,789[±] known. The population decreases in August and only immatures remain into late September.

Ecological Distribution

Although the Gray-backed Tern is an uncommon breeding species, it nonetheless can usually be seen on the major islands in the atoll. Small numbers breed on three islands--East, Trig and Whale-Skate--and La Perouse. In addition, this species has been known to roost on or fly over Disappearing and Tern Islands. It builds no nest, lays its single egg on the bare ground, and, depending on the island, usually nests in association with Lepturus, Chenopodium, Tournefortia, and sometimes Tribulus.

East Island: POBSP personnel recorded the first Gray-backed Terns in June 1963 (Table 100). They were near the lagoon on the north midpoint of the island near the old water tank. On succeeding visits one to four adults or fledglings were observed.

Trig Island: Richardson (1954b) observed Gray-backed Terns on nests with eggs during his March 1954 visit (Table 101). POBSP personnel annually observed 15 to 35 birds and nests on the lagoon side of the island in association with Lepturus.

Whale-Skate Island: In 1923 Wetmore (ms.) found Gray-backed Terns nesting on Skate and Whale Islands, then separate (Table 102).

Since 1963 POBSP and BSWF personnel observed up to 400 adults and young. In 1963 birds were found on the west end of the island, with nests in the Chenopodium-Lepturus area; roosting occurred on the upper beach area. In June 1966 nests were placed at the west end (in association with Lepturus and Chenopodium) and toward the center of the east half (in association with Chenopodium). As numbers of birds increased in 1967, nests and birds were found scattered about the island in small groups. Birds nested in association with Lepturus, Chenopodium and Tournefortia. Many nests were actually placed well under thick vegetation. At night adults and fledglings roosted in the nesting areas or on the adjoining beach areas.

La Perouse Pinnacle: Gray-backed Terns were first recorded in December 1953 by Richardson (1964b). POBSP personnel first observed it in 1963; upon scaling the rock in June 1969, 1,500 birds, including 500± nests, were found on top and on ledges (Table 103).

Other Islands: Although Gray-backed Terns probably fly over or roost on other islands, they have only been recorded on Disappearing and Tern (Table 104).

Banding and Movements

Since June 1963, 389 have been banded: 23 adults in June 1963; 5 adults, 15 nestlings in August 1965; 3 adults, 42 nestlings in June 1966; 5 nestlings in August-September 1966; 103 adults, 91 nestlings in June 1967; 3 adults, 9 nestlings in June 1968; and 5 adults, 85 nestlings in June 1969. Three returns have been taken on the atoll; no interisland movement is known.

Specimens

POBSP: USNM 495886, ♂, collected 17 August 1965 on Whale-Skate by Huber; USNM 543032-34, ♀, ♀, ♂, collected 6 June 1967 on Whale-Skate by Lewis.

Non-POBSP: USNM 300642-44, ♀, collected 26 June 1923 by Wetmore.

Table 100. Observations of Gray-backed Tern on East Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1963 June 7-11	6	1 fledgling (POBSP, 1963).
1965 Aug. 5-10, 23-28	3	1 pair with a chick which fledged during early August (POBSP, 1965a).
1966 Mar. 23	1	1 seen, no nests found (BSFW, 1966a).

Table 100. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1966 June 10-14, 16-21	1	1 fledgling, no adults seen (POBSP, 1966a).
Aug. 18-24, 26-30	occasional	Adults seen flying over (POBSP, 1966b).
1967 Mar. 11-12	4	Adults observed during afternoon (POBSP, 1967b; BSFW, 1967a).
May 26-31, June 9-13	2	Adults flew low over island daily (POBSP, 1967a).
1968 June 6-11, 14-16, 25	occasional	Adults flew low over island (POBSP, 1968a).
1969 June 5-10, 21	2	Adults occasionally flew over (POBSP, 1969).

Table 101. Observations of Gray-backed Tern at Trig Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1954 Mar. 20	24-30	8 nests with eggs (Richardson, 1954b).
1966 June 10, 23, July 1, 3-4	21	6 young from chicks to fledglings (POBSP, 1966a).
Aug. 13-14, Sept. 4, 12	occasional	Adults flying over (POBSP, 1966b).
1967 Mar. 13, 14	15	No nests observed (BSFW, 1967a; POBSP, 1967b).
June 2, 8-9, 19-20	20	15 adults; 3 nests with eggs, 5 with hatchlings to fledglings (POBSP, 1967a).
1968 June 6, 11, 22, 24-25	19 ⁺	6 breeders, 10 ⁺ non-breeders, no eggs, 3 young (all fledged by 24th) (POBSP, 1968a).
1969 Feb. 22	-	Not reported (BSFW, 1969a).
June 3, 14, 23-24	35	20 breeders, 5 non-breeders; no eggs; 10 young (POBSP, 1969).

Table 102. Observations of Gray-backed Tern at Whale-Skate Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 26	45*	15 pairs, with young full-grown or fledged (Wetmore, ms.).
June 26	45**	15 pairs, with young full-grown or fledged (Wetmore, ms.).
1963 June 12-15	100	10-15 nests with eggs (POBSP, 1963).
1964 Sept. 27	1	Immature (BSFW, 1964b; POBSP, 1964).
1965 Aug. 11-17, 29-Sept. 1	44	All 14 young fledged by late August (POBSP, 1965a).
1966 Mar. 22	10	1 nest with egg (BSFW, 1966a).
June 10, 23-29, July 1-3	235	Nests with 15 eggs and 35 young from hatchlings to fledglings (POBSP, 1966a).
Aug. 15-17, Sept. 4	25	15 adults, 10 immatures (POBSP, 1966b).
1967 Mar. 14	75-100	Scattered over island in groups of 2-10; only 1 egg found (BSFW, 1967a; POBSP, 1967b).
June 2-7, 15-19	400	300 adults, 20 eggs, 100 young; eggs to fledglings; scattered over island in small groups (POBSP, 1967a).
1968 June 3, 16- 20, 22	135 [±]	60 breeders, 50 [±] non-breeders, 5 eggs, 25 young (some flying); all nests among <u>Chenopodium</u> bushes (POBSP, 1968a).
1969 Feb. 23	-	Not reported (BSFW, 1969a).
June 3, 16- 20, 22	250 [±]	120 breeders, 80 [±] non-breeders, 10 eggs, 50 young (some fledged); nests under <u>Chenopodium</u> (POBSP, 1969).
Aug. 24	1	(BSFW, 1969c).

* Whale Island ** Skate Island

Table 103. Observations of Gray-backed Tern at La Perouse Pinnacle

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1953 Dec. 19	2-4	(Richardson, 1954b).
1963 June 10	50	Nesting? (POBSP, 1963).
1965 Aug. 7	50+	Breeding status not determined; probably nesting (POBSP, 1965a).
1967 June 12	350+	300 adults; ? eggs; 50+ young; colony located on north ledge (POBSP, 1967a).
1969 June 6, 13	1,500 [±]	1,000 adults, 500 nests with young and a few eggs (POBSP, 1969).

Table 104. Observations of Gray-backed Tern on other islands at French Frigate Shoals

<u>Date of Survey</u>	<u>Island</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1902 May 28-29	FFS	?	Present (Fisher, 1903).
1963 June 9	Disappearing	4	Roosting (POBSP, 1963).
1966 Aug. 11-15, 17-18, 24- 26, 30- Sept. 16	Tern	occasional	Adult flying over (POBSP, 1966b).
1967 May 25-26, 31-June 2, 7-9, 13-15, 18, 20-22	Tern	2	Adults frequently flew low over island in vicinity of docks (POBSP, 1967a).
1968 May 29- June 6, 11- 14, 16-17, 19-20, 22- 27	Tern	occasional	Adult flew low over north portion (POBSP, 1968a).
1969 June 7	Disappearing	2	Adults roosting (POBSP, 1969).

BLUE-GRAY NODDY

Procelsterna ceruleaStatus

Uncommon breeding species; may be present year-round, but has only been recorded during spring and summer. Nests on ledges and in holes on La Perouse Pinnacle during spring and summer. POBSP maximum population count 6 in June 1967.

Observations

Rothschild (1893-1900) saw a pair of odd terns, probably the Blue-gray Noddy, at La Perouse in 1891 (Table 105). Fisher (1903) observed this species in May 1902. He subsequently collected specimens at Necker Island from which he described the Hawaiian race. Wetmore (ms.) observed 20 on La Perouse Pinnacle in June 1923.

This species was not seen again until POBSP personnel saw one adult fly low over Tern Island on 2 June 1967. Others were subsequently observed by POBSP personnel at La Perouse in June 1967 and 1969. Five adults and one recently-fledged individual were seen on the north face of the tall rock in 1967; they were roosting on, and flying about, the small ledges and holes in the lower portion (10 to 15 feet above sea level) of the rock.

Annual Cycle

Very little is known about the annual breeding cycle of the Blue-gray Noddy at French Frigate Shoals. Fisher (1903) thought this species undoubtedly nested there. Wetmore (ms.) did not mention breeding. POBSP personnel observed a newly fledged bird on La Perouse Pinnacle on 12 June 1967; this fledgling probably hatched in mid-April and the egg was probably laid in mid-March. The assumed annual breeding cycle is shown in Figure 71.

Nothing is known of the annual population cycle of the Blue-gray Noddy. It has not, however, been observed on the atoll during fall and winter.

Figure 71. Probable annual cycle of Blue-gray Noddy

		—	+++++	+++++	+++++	—					
Jan	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = dependent young present; — = non-breeding birds present

Specimens

POBSP: USNM 503638, unsexed, collected 12 June 1967 on La Perouse by Amerson.

Non-POBSP: USNM 300431-33, ♀, collected 27 June 1923 by Wetmore.

Table 105. Observations of Blue-gray Noddy at La Perouse Pinnacle

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1891 June 3	2	Seen (Rothschild, 1893-1900).
1902 May 28	?	Undoubtedly nesting on the tall rock (Fisher, 1903).
1923 June 27	20	(Wetmore, ms.).
1953 Dec. 19	-	Not reported (Richardson, 1954b).
1966 Sept. 4	0	Not observed (POBSP, 1966b).
1967 June 12	6	5 adults, 1 recently fledged young (POBSP, 1967a).
1969 June 6,13	1	Adult on ledge on 6th (POBSP, 1969).

BROWN NODDY

Anous stolidusStatus

Common breeding species; present throughout the year, but lower numbers in autumn and winter months; breeding season may also extend throughout the year, but peak season is March through September. Nests at East, Little Gin, Trig and Whale-Skate Islands, and La Perouse Pinnacle; previously nested at Round and Tern Islands. Roosts on other islands. Maximum POBSP population 10,182 during June 1967.

Observations

Rothschild (1893-1900) recorded a few Brown Noddies on his 1891 visit but did not give island names. In June 1923 Wetmore (ms.) recorded large numbers nesting on East, Little Gin, Round, Tern, Trig and Whale-Skate Islands, as well as on La Perouse Pinnacle. POBSP personnel recorded the Brown Noddy on all visits from 1963 to 1969.

Annual Cycle

The annual breeding cycle is shown in Figure 72. Eggs and young are known from almost all months. Although a few nests with eggs and young are known from mid-December, most birds begin to lay by early March. Laying usually continues into June, then decreases by August and September. In 1966, however, egg production decreased to 16 eggs in June and then increased to 450 eggs in August and September. Although a few young have been recorded in December and March, most hatch by June. Most fledge by August and September, but some remain longer.

The population cycle follows a somewhat similar pattern for the Brown Noddy is present throughout the year. A low period exists during the fall months with an increase during late winter and early spring. The peak population is reached by early summer.

Figure 72. Annual cycle of Brown Noddy

	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	***
		++++	++++	++++	++++	++++	++++	++++	++++	++++	+++
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = dependent young present; ___ = non-breeding birds present

Ecological Distribution

The Brown Noddy has been recorded on almost all the islands. It now nests on East, Little Gin, Trig and Whale-Skate Islands, and La Perouse Pinnacle, and previously nested on Round and Tern Islands. Nests are placed directly on the ground in open sandy areas or in association with Boerhavia and Tribulus.

East Island: Although more Brown Noddies are usually recorded from here (Table 106) than from other islands, East has a smaller nesting population than Whale-Skate. Rothschild (1893-1900) recorded Brown Noddies on his 1891 visit. He did not list the islands on which he saw this species but probably observed it on East since the favored anchorage is nearby. In 1923 Wetmore (ms.) observed 400 pairs, some with eggs hatching. None can be seen in photographs taken during the 1930's and 1940's when military personnel occupied the island. However, this species probably nested as other species nested successfully. In October 1953, two years after the U.S. Coast Guard moved to Tern Island, Richardson (1954a,

pers. corr.) observed a few overhead and found several hundred dead, mostly fully grown young; two months later he (1954b, pers. corr.) found nests containing both eggs and young.

POBSP personnel observed Brown Noddies on all nine trips. Populations ranged from 300-350 in March to 5,300 in June to 1,000 in August. The Brown Noddy nests in two large colonies--one on each end of this east-west oriented island--as well as along the periphery of the lagoon side. Loosely constructed nests of dead grass, stems, feathers and shells are situated on the ground and/or in association with Boerhavia and Tribulus.

Little Gin Island: Only few, a remnant of a once much larger breeding population, now nest (Table 107). Wetmore (ms.) observed 125 pairs with eggs (one hatching). Richardson (pers. corr.) observed none in mid-December 1953. POBSP personnel have visited this sandy islet five times; nests were found during two out of three June visits.

Round Island: Wetmore (ms.) found 150 pairs in 1923 nesting in association with Boerhavia (Table 112). The island is apparently lower than in 1923; high tide during bad weather washes across it and, as a result, there is neither vegetation nor nesting except by the Blue-faced Booby.

Tern Island: Brown Noddies previously nested on Tern (Table 108) but, due to its use by military personnel since the early 1940's, none has nested recently. Wetmore (ms.) found 500 pairs in June 1923, a considerably smaller number than in 1891. POBSP personnel recorded this species infrequently on ten visits to Tern. An occasional bird flies over the island or just offshore on almost any day during spring and summer. Roosting birds are periodically observed at night.

Trig Island: Wetmore (ms.) observed 150 pairs in 1923 (Table 109). Richardson (1954a, 1954b, and pers. corr.) found only small numbers during his three 1953-1954 visits. POBSP personnel found this species nesting, with eggs and young, each year since 1963.

Brown Noddies nest only in the vegetated portion, mainly in a large colony on the open ground or in low Boerhavia and Tribulus located at the island's west end crest. Other nests are scattered throughout the interior. Eggs are placed on the ground and nests, if any, are loosely constructed of dead grass stems, shells, etc. Many birds roost in the Tournefortia and Chenopodium bushes, as well as on the sandy beaches.

Whale-Skate Island: Whale-Skate is the prime island for nesting Brown Noddies (Table 110). Wetmore (ms.) recorded 500 pairs on the then-separated islands in 1923. POBSP personnel observed them on all visits from 1963 to 1969. Recent populations range from 0 in February 1969 to 5,125 in August 1965.

The Brown Noddy nests throughout Whale-Skate in small colonies located in patches of Boerhavia and Tribulus or on the open ground. Eggs are laid either on the bare ground, or on a loosely constructed nest of grass stems, etc. When roosting, they prefer Tournefortia to Chenopodium; they also use the sandy beaches.

La Perouse Pinnacle: Wetmore (ms.) sighted 800 pairs in 1923 (Table 111). Richardson (1954b, pers. corr.) observed a few nesting in late October but saw only three in mid-December. In 1963 POBSP personnel found 2,000-5,000, many with young. Since then the species has been recorded on six or possibly seven visits.

Brown Noddies nest on the many narrow ledges on all sides and on the top. They use only feathers and bits of seaweed on this vegetation-less, isolated rock.

Other Islands: The Brown Noddy has been recorded roosting on all other islands (Table 112).

Banding and Movements

Since June 1923, 5,548 Brown Noddies have been banded. Table 113 presents these age-class groups by month and year. Locally, 670 have been recaptured. In addition, 10 from other central Pacific localities have been captured: 9 from Johnston and 1 from Necker. Seven birds banded at French Frigate have been captured elsewhere: 4 at Johnston, 1 at Lisianski, 1 at Cape Lambert, New Guinea, and 1 at sea. Appendix Tables 10a and 10b give complete details on Brown Noddies moving to and from French Frigate Shoals.

Specimens

POBSP: USNM 495902, ♂, collected 17 August 1965 on Whale-Skate by Huber; USNM 495903-04, ♀, collected 24 August 1965 on East by Huber; USNM 497612-14, ♂, ♀, ♂, collected 31 May 1967 on East by Lewis; USNM 497931-34, unsexed, collected 10 June 1963 on East by Sibley.

Non-POBSP: USNM 300522-23, ♂, collected 23 June 1923 by Wetmore; USNM 300524, ♀, collected 24 June 1923 by Wetmore;

USNM 300526-27, ♀, collected 26 and 25 June 1923 by Wetmore;
 USNM 300528-31, ♂, collected 26, 26, 26, and 23 June 1923 by Wetmore;
 USNM 300659, ♀, collected 22 June 1923 by Wetmore; USNM 300391-
 93, ♀, ♂, ♀, collected 23, 26, and 23 June 1923 by Wetmore;
 AMNH 747502 and 747504, ♀, collected 5 June 1891 by Palmer;
 AMNH 747503 and 747505-06, ♀, unsexed, unsexed, collected 2 June
 1891 by Palmer; BPBM 793, ♀, collected 5 June 1891 by Palmer;
 BPBM, egg, collected in 1891 (?) by Munro.

Table 106. Observations of Brown Noddy at East Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1891 June 4-5	?	Nesting, young much smaller than those on Tern (Rothschild, 1893-1900).
1915 Mar.	600	Nests with eggs only (Munter, 1915).
1923 June 22-23	800+	400 pairs, some eggs hatching (Wetmore, ms.).
1953 Oct. 31	few	A few overhead; several hundred dead, mostly full-grown young (Richardson, 1954a; pers. corr.).
Dec. 19	8-10	Nests with eggs and young (Richardson, 1954b, pers. corr.).
1963 June 7-11	600- 1,100	200 nests with eggs, 100 with young (POBSP, 1963).
1964 July 27	1,000- 1,100	300 nests, with eggs to almost grown young (BSFW, 1964a).
Sept. 27	300	Mostly locals, counted 25-30 eggs (BSFW, 1964b; POBSP, 1964).
1965 Aug. 5-10, 23-28	1,262	200 nests with eggs, egg laying continuing, 62 young (POBSP, 1965a).
1966 Mar. 23	300-350	122 nests, 2 new, 6 with chicks (2 fledglings), rest with eggs (BSFW, 1966a).
June 10-14, 16-21	5,025	3 nests with eggs, 25 with chicks; mostly roosting adults, some courtship (POBSP, 1966a).
Aug. 18-24, 26-30	1,000	400 nests counted 25 August; 200 with chicks less than 10 days, 25 chicks 10-21 days, 5 over 21 days; remainder with eggs (POBSP, 1966b).

Table 106. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 Mar. 11-12	390	45 nests, all but 7 with eggs; roosting population 300 (BSFW, 1967a; POBSP, 1967b).
May 26-31, June 9-13	5,300	5,000 adults, 200 eggs, 300 young; fresh eggs to fledglings, courtship (POBSP, 1967a).
Sept. 17	1,017	900 adults, 118 nests with eggs, 117 small downy chicks; nests placed among <u>Boerhavia</u> and <u>Tribulus</u> (BSFW, 1967b).
Dec. 9	present	A number observed (BSFW, 1967c).
1968 June 6-11, 14-16, 25	1,100±	600± breeders, 400± non-breeders, 200± eggs, 100± young; fresh eggs to fledglings (POBSP, 1968a).
1969 June 5-10, 21	2,050±	2,000± adults, few eggs, 50 young (POBSP, 1969).
Aug. 22, 30	775	Seen 30 August (BSFW, 1969c).

Table 107. Observations of Brown Noddy at Little Gin Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 24	250	125 pairs with eggs, 1 newly hatched young (Wetmore, ms.).
1953 Dec. 19	-	Not seen (Richardson, pers. corr.).
1963 June 9	54	5 nests with egg, 4 with young (POBSP, 1963).
1965 Aug. 25	100	Roosting only (POBSP, 1965a).
1966 Mar. 23	71	65 adults with 11 nests (6 with chicks) (BSFW, 1966a).
1967 June 9	27	25 young, no eggs, 2 young; small colony (POBSP, 1967a).
1968 June 7	20	Roosting adults (POBSP, 1968a).
1969 June 7, 21	0	Not observed (POBSP, 1969).

Table 108. Observations of Brown Noddy at Tern Island

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1891 June 1-3	thousands	Nests (slight depressions in grass bunches) with eggs and young of all stages (Munro, 1941b).
1923 June 24-28	1,000	500 pairs (Wetmore, ms.).
1953 Oct. 26- Nov. 2	2	(Richardson, 1954a).
Dec. 18	-	Not reported (Richardson, 1954b).
1960 Oct. 19	0	1 seen flying over lagoon; none on the island (HDFG, 1960b).
1965 Aug. 4-5, 10-12, 17- 23, 28-29, 31-Sept. 2	5	Occasionally visited island during day (POBSP, 1965a).
1966 Mar. 21-24	1	(BSFW, 1966a).
June 8-10, 14-16, 21- 23, 29- July 1, 4-7	occa- sional	Several observed flying over island and offshore (POBSP, 1966a).
Aug. 11-15, 17-18, 24- 26, 30- Sept. 16	occa- sional	Adult roosted nightly; no nesting (POBSP, 1966b).
1967 Sept. 16	1	Dead (BSFW, 1967b).
Dec. 7	3	Roosting on <u>Tournefortia</u> (BSFW, 1967c).
1968 May 29- June 6, 11- 14, 16-17, 19-20, 22-27	occa- sional	Adults flew over island (POBSP, 1968a).
1969 June 2-4, 11-15, 25- 26	occa- sional	Flying over (POBSP, 1969).

Table 109. Observations of Brown Noddy at Trig Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 26	300	150 pairs (Wetmore, ms.).
1953 Oct. 28	20-25	(Richardson, 1954a, pers. corr.).
Dec. 19	1	(Richardson, pers. corr.).
1954 Mar. 20	20-30	(Richardson, 1954b).
1963 June 14,15	1,000	Many nests with eggs and young (POBSP, 1963).
1964 Sept. 27	400	Nests with 100 chicks (POBSP, 1964; BSFW, 1964b).
1965 Aug. 16, 29, 31	210	Majority roosting only; 10 nests with young only (POBSP, 1965a).
1966 Mar. 22	443	220 nests, all with eggs except 3 with chicks (BSFW, 1966a).
June 10,23 July 1, 3-4	502	3 nests with eggs, 2 with small chicks (POBSP, 1966a).
Aug. 13-14, Sept. 4,12	125	Of 50 nests on 13 August, 50% had chicks less than 10 days old, 50% had eggs (POBSP, 1966b).
1967 Mar. 13-14	175	37 nests with eggs (BSFW, 1967a; POBSP, 1967b).
June 2, 8- 9, 19-20	600	500 adults, 75 eggs, 100 young; eggs to fledglings (POBSP, 1967a).
Dec. 9	300-400	Observed from helicopter (BSFW, 1967c).
1968 June 6,11, 22, 24-25	450±	100± breeders, 300± non-breeders, 50± eggs, 50± small young (POBSP, 1968a).
1969 Feb. 22	0	None observed (BSFW, 1969a).
June 3,14, 23-24	250±	200 adults, few eggs, 50± young (POBSP, 1969).
Aug. 23,27	220	Seen 23 August (BSFW, 1969c).

Table 110. Observations of Brown Noddy at Whale-Skate Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 26	600*	300 pairs (Wetmore, ms.).
June 26	400**	200 pairs (Wetmore, ms.).
1953 Oct. 28	200-300*	(Richardson, 1954a; pers. corr.).
Oct. 28	10-20**	(Richardson, 1954a; pers. corr.).
Dec. 19	-	Not recorded (Richardson, pers. corr.).
1954 Mar. 20	300-400	(Richardson, 1954b).
1963 June 12-15	3,500	800 nests with eggs, 500 with young (POBSP, 1963).
1964 Sept. 27	400	20 nests with eggs, 11 with small chicks (POBSP, 1964; BSFW, 1964b).
1965 Aug. 11-17, 29-Sept. 1	5,125	50 nests with eggs, 125 with young; majority roosting only (POBSP, 1965a).
1966 Mar. 22	1,300	650 nests, all with eggs except 5 with chicks (2 almost fledged) (BSFW, 1966a).
June 10, 23-29, July 1-3	4,010	10 nests with eggs, 2 with young; mostly roosting adults on beach, some courtship (POBSP, 1966a).
Aug. 15-17, Sept. 4	3,000	500 nests 16 August (50% small chicks, 50% eggs); nocturnal roosting population 2,000, of which 5% were immatures (POBSP, 1966b).
1967 Mar. 14	1,235	117 nests with eggs, 1 with 2/3rds grown chick; ca. 1,000 adults roosting on beach in 4 large groups (BSFW, 1967a; POBSP, 1967b).
June 2-7, 15-19	3,650	3,000 adults, 200 eggs, 650 young; fresh eggs to fledglings (POBSP, 1967a).
Sept. 17	581	563 adults, 126 eggs, 18 small downy chicks; nests scattered throughout island, most in central portion (BSFW, 1967b).

* Whale Island ** Skate Island

Table 110. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 Dec. 9	1,500-2,000	Flew off island on approach of helicopter (BSFW, 1967c).
1968 June 6, 16-25	3,100 [±]	800 [±] breeders, 2,200 [±] non-breeders, 300 [±] eggs, 100 [±] young; fresh eggs to fledglings (POBSP, 1968a).
1969 Feb. 23	0	None observed (BSFW, 1969a).
June 3, 16-20, 22	3,500 [±]	3,000 adults, 500 small to fledgling young, few eggs (POBSP, 1969).
Aug. 24	850	With eggs (BSFW, 1969c).

Table 111. Observations of Brown Noddy at La Perouse Pinnacle

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1923 June 27	1,600	800 pairs (Wetmore, ms.).
1953 Oct. 31	10-20	Nesting (Richardson, pers. corr.).
Dec. 19	3	(Richardson, 1954b).
1963 June 10	2,000-5,000	Many young (POBSP, 1963).
1964 Sept. 27	200	(BSFW, 1964b; POBSP, 1964).
1965 Aug. 7	300	Breeding status not determined (POBSP, 1965a).
1966 Mar. 23	800-900	No landing made (BSFW, 1966a).
Sept. 4	150+	Some chicks seen, but population composition not obtainable (POBSP, 1966b).
1967 June 12	600	500 adults, 100+ young, eggs?; small young to fledglings (POBSP, 1967a).
Dec. 9	?	Either this species or Black Noddy seen from helicopter (BSFW, 1967c).
1969 June 6, 13	2,500 [±]	2,000 [±] adults, few eggs, 500 [±] young; nests placed on ledges and on top (POBSP, 1969).

Table 112. Observations of Brown Noddy on other islands at French Frigate Shoals

Date of Survey	Island	Population Estimate	Breeding Status, Remarks, and References
1902 May 28-29	FFS	?	Present (Fisher, 1903).
1923 June 22	Bare	few	Roosting only (Wetmore, ms.).
June 22	Round	300	150 pairs, nesting (Wetmore, ms.).
June 25	Shark	few	Roosting only (Wetmore, ms.).
1963 June 9	Disappearing	50	Roosting (POBSP, 1963).
June 9	Gin	40	Roosting (POBSP, 1963).
1965 Aug. 10, 23	Mullet	few	Roosting only (POBSP, 1965a).
Aug. 25	Gin	25	Roosting only (POBSP, 1965a).
1967 May 26-31, June 9-13	Near, Bare	few	Few birds roosted on these two islets during low tide (POBSP, 1967a).
June 9	Gin	5	Roosting on beach (POBSP, 1967a).
1968 June 7	Gin	10	Roosting adults (POBSP, 1968a).
June 11, 25	Round	10	Roosting adults (POBSP, 1968a).
1969 June 7, 21	Gin	0	Not observed (POBSP, 1969).
June 7	Disappearing	5	Roosting adults (POBSP, 1969).

Table 113. Brown Noddy banded at French Frigate Shoals

Date	Nestlings	Subadults	Adults	Total
1963 June	251	0	500	751
1964 Sept.	26	0	0	26
1965 Aug.	84	302	864	1,250
1966 June	0	14	498	512
Sept.	0	0	409	409
1967 June	1,000	0	1,500	2,500
1968 June	98	0	2	100
Totals	1,459	316	3,773	5,548

BLACK NODDY

Anous tenuirostrisStatus

Common species but uncommon breeder; present throughout the year, with low population during autumn and winter. Nests only on La Perouse Pinnacle; roosts on most other islands, especially Trig and Whale-Skate. Maximum POBSP population estimate 11,000 in August 1965.

Observations

The first record was made by Wetmore (ms.), who observed 150 pairs at La Perouse Pinnacle in 1923. Although he visited all the islands in the atoll, he found this species on only two other islands. Richardson (1954a, 1954b, and pers. corr.) observed nesting during his 1953 visits to La Perouse Pinnacle; he did not observe this species on other islands he visited. During the first POBSP visit, the Black Noddy was not seen at La Perouse and was observed roosting in small numbers only on Little Gin and Whale-Skate Islands. On subsequent trips large numbers were found at La Perouse Pinnacle, Trig and Whale-Skate Islands, and small numbers at Disappearing, East, Gin, Little Gin, Mullet, Round and Tern Islands.

Annual Cycle

Very little is known about the breeding cycle here. Wetmore (ms.) recorded nothing about eggs or young. Richardson (1954a, 1954b, and pers. corr.) found this species nesting in October and December. Nests with eggs and young were found at La Perouse in June 1969. None has been known to nest on any of the sandy islands, but large numbers of adults and subadults roosted on Trig and Whale-Skate Islands during the summer and early fall.

Apparently the Black Noddy nests on La Perouse Pinnacle during the summer, late fall and early winter. The size of this breeding population is not known as no winter observations have been made on the Pinnacle since December 1953. The large summer roosting population on Trig and Whale-Skate Islands is possibly the fall-winter population which nests at La Perouse Pinnacle. Banding data have shown, however, that some of these birds are from other islands (see Banding and Movements). Figure 73 shows the probable breeding cycle of the Black Noddy on French Frigate Shoals.

Figure 73. Annual cycle of Black Noddy

+++++	+++++	+++			****				*****	*****	*****
+	+	+			+						+
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = young present; ___ = roosting adults present

Ecological Distribution

The Black Noddy nests only on rocky La Perouse Pinnacle. Large numbers roost on Trig and Whale-Skate Islands, a recent development thought to be due wholly to the increase in Chenopodium and Tournefortia which provide increased roosting sites. Small numbers also roost on almost all the other islands.

East Island: POBSP personnel recorded the first Black Noddy in 1965 (Table 114). Since then, only a few have been seen roosting or flying over.

The large amount of rubble is apparently unsuitable habitat for the Black Noddy. Another deterrent may be the large number of roosting Red-footed Boobies and Great Frigatebirds. When the buildings deteriorate further and Tournefortia and Chenopodium spread, the Black Noddy may utilize East Island.

Tern Island: POBSP personnel first recorded the Black Noddy in August 1965; one occasionally roosted at night in the Casuarina trees in front of the Coast Guard barracks (Table 115). On subsequent visits POBSP personnel also observed adults roosting at night in the few Casuarina trees. If the trees continue to increase in size and number, the Black Noddy population may increase and may even nest, as on Midway Atoll.

Trig Island: Numbers have increased dramatically since POBSP personnel's first record of ten roosting in Chenopodium at night in 1965 (Table 116). In 1966, 25 were seen; by 1967, 3,000 were observed roosting nightly. Only a few were present during the day. The increased roosting sites provided by the spread of Tournefortia probably accounts for the larger roosting numbers.

Whale-Skate Island: None had been recorded before POBSP personnel's 1963 visit (Table 117). In 1965, 10,000 were observed roosting nocturnally on Chenopodium and Tournefortia. Since then, numbers in June have varied from 3,000 to 8,000. A decline from the peak in 1966 coincided with increased numbers on Trig Island. An increase in Chenopodium and Tournefortia may eventually induce this species to nest here.

La Perouse Pinnacle: Wetmore (ms.) first recorded pairs in 1923, but gave no other data (Table 118). Richardson (1954a, 1954b, pers. corr.) observed nesting in October and December 1953; nests were on the various rock ledges of the cliff. POBSP personnel observed nesting only in June 1969. Birds roost on the ledges and can be seen flying about the rock. In June 1967 most of the roosting population was on the small rock south of the main pinnacle. Nests are constructed of feathers, seaweed and guano.

Other Islands: Wetmore (ms.) found a few roosting on Shark Island and saw a flock pass Round Island in 1923 (Table 119). From 1963 through 1969 POBSP personnel recorded from 1 to 25 roosting on Disappearing, Gin, Little Gin, Mullet and Round Islands.

Banding and Movements

Since 1963 POBSP personnel have banded 4,788 adult or sub-adult Black Noddies, all except three on Whale-Skate: 2,358 in August 1965, 581 in June 1966; 345 in August and September 1966; 500 in May and June 1967; 371 in May and June 1968; and 633 in June 1969.

Of these, 367 have been recaptured on the atoll. In addition, 17 birds banded on other atolls have been captured: 5 from Lisianski, 3 each from Johnston, Pearl and Hermes, and Laysan, and 1 each from Gardner Pinnacles, Midway and Kure. Seventeen banded at French Frigate have been captured elsewhere: 6 at Laysan, 5 at Johnston, 3 at Kure, 2 at Lisianski, and 1 at Pearl and Hermes. Details are given in Appendix Tables 11a and 11b.

Specimens

Non-POBSP: USNM 300461-63, ♀, ♂, ♂, collected 25, 25, and 22 June 1923 by Wetmore; AMNH 747656, unsexed, collected 2 June 1891 by Palmer.

Table 114. Observations of Black Noddy at East Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1953 Oct. 31	-	Not reported (Richardson, 1954a; pers. corr.).
Dec. 19	-	Not reported (Richardson, 1954b; pers. corr.).
1964 Sept. 27	0	Not seen (BSFW, 1964b; POBSP, 1964).

Table 114. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1965 Aug. 5-10, 23-28	5	Occasional roosting bird (POBSP, 1965a).
1966 Mar. 23	?	Present only at night (BSFW, 1966a).
Aug. 18-24, 26-30	few	Roosting on old pier daily (POBSP, 1966b).
1967 May 26-31, June 9-13	1-5	Occasional daytime visitor (POBSP, 1967a).
1968 June 6-11, 14-16, 25	few	Occasional visitor; none at night (POBSP, 1968a).
1969 June 5-10, 21	1	Occasional visitor (POBSP, 1969).
Aug. 22, 30	15	Seen 30 August (BSFW, 1969c).

Table 115. Observations of Black Noddy at Tern Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1965 Aug. 4-5, 10-12, 17- 23, 28-29, 31-Sept. 2	5	1 occasionally roosted in <u>Casuarina</u> (POBSP, 1965a).
Nov. 21	2	(Park, pers. corr.).
1966 June 8-10, 14-16, 21- 23, 29- July 1, 4-7	1	Roosted nightly in <u>Casuarina</u> (POBSP, 1966a).
Aug. 11-15, 17-18, 24- 26, 30- Sept. 16	few	Occasional adults roosted at night (POBSP, 1966b).

Table 115. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 May 25-26, 31-June 2, 7-9, 13-15, 18, 20-22	1	Adult roosted nightly in <u>Casuarina</u> tree (POBSP, 1967a).
Dec. 7-11	1	Roosting in <u>Casuarina</u> at night (BSFW, 1967c).
1968 Mar. 11-15	0	None observed (POBSP, 1968b).
May 29- June 6, 11- 14, 16-17, 19-20, 22- 27	few	1 roosted nightly in <u>Casuarina</u> tree in front of barracks (POBSP, 1968a).
1969 Feb. 22-24	0	Not present (BSFW, 1969a).
Mar. 23	0	Not present (BSFW, 1969b).
June 2-4, 11-15, 25- 26	few	Flying over occasionally (POBSP, 1969).

Table 116. Observations of Black Noddy at Trig Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1953 Oct. 28	-	Not reported (Richardson, 1954a; pers. corr.).
Dec. 19	-	Not reported (Richardson, pers. corr.).
1954 Mar. 20	-	Not reported (Richardson, 1954b).
1964 Sept. 27	0	Not present (BSFW, 1967b; POBSP, 1964).
1965 Aug. 16, 29, 31	10	Roosting only, in <u>Chenopodium</u> (POBSP, 1965a).
1966 June 10, 23, July 1, 3-4	25	Roosting only (POBSP, 1966a).
Aug. 13-14, Sept. 4, 12	few	Roosting in the <u>Tournefortia</u> (POBSP, 1966b).

Table 116. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 Mar. 13-14	0	Not observed (BSFW, 1967a; POBSP, 1967b).
June 2, 8-9, 19-20	3,000	Night roosting population of adults and subadults (POBSP, 1967a).
1968 June 6, 11, 22, 24-25	1,000 [±]	Roosting primarily in <u>Tournefortia</u> (POBSP, 1968a).
1969 Feb. 21-23	0	Not observed (BSFW, 1969a).
June 3, 14, 23-24	500 [±]	Roosting only (POBSP, 1969).
Aug. 23, 27	12	Seen 23 August (BSFW, 1969c).

Table 117. Observations of Black Noddy at Whale-Skate Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1953 Dec. 19	-	Not reported (Richardson, 1954b; pers. corr.).
1963 June 12-15	300	Nocturnal roosting population (POBSP, 1963).
1965 Aug. 11-17, 29-Sept. 1	10,000	Roosting population of adult and sub-adult birds (POBSP, 1965a).
1966 Mar. 22	250	Present only at night (BSFW, 1966a).
June 10, 23-29, July 1-3	8,000	Roosting population of adults and sub-adults (POBSP, 1966a).
Aug. 15-17, Sept. 4	2,000	Roosting in <u>Chenopodium</u> , 10% immatures (POBSP, 1966b).
1967 Mar. 14	200-300	Sitting on several <u>Tournefortia</u> bushes; no nest found (BSFW, 1967a; POBSP, 1967b).
June 2-7, 15-19	5,000	Roosting population of adults and sub-adults; bulk present during night only (POBSP, 1967a).

Table 117. (continued)

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1967 Sept. 17	270-280	Roosting on beach with Brown Noddy (BSFW, 1967b).
1968 June 6, 16-25	5,000 [±]	Roosting primarily in <u>Chenopodium</u> ; some in <u>Tournefortia</u> (POBSP, 1968a).
1969 Feb. 23	0	Not observed (BSFW, 1969a).
June 3, 16-20, 22	3,000 [±]	Roosting population (POBSP, 1969).
Aug. 24	640	(BSFW, 1969c).

Table 118. Observations of Black Noddy at La Perouse Pinnacle

<u>Date of Survey</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1923 June 27	300	150 pairs (Wetmore, ms.).
1953 Oct. 31	40-60	Nesting (Richardson, 1954a; pers. corr.).
Dec. 19	50-70	Nests with eggs (Richardson, 1954b).
1963 June 7-11	0	(POBSP, 1963).
1965 Aug. 7	1,000	Breeding status not determined (POBSP, 1965a).
1966 Mar. 23	0	Not observed (BSFW, 1966a).
Sept. 4	75	Roosting or flying about the rock (POBSP, 1966b).
1967 June 12	2,000	Roosting in daytime, mainly on small rock (POBSP, 1967a).
Dec. 9	?	Either this species or Brown Noddy seen from air (BSFW, 1967c).
1969 Feb. 24	?	Possibly this species observed from plane (BSFW, 1969a).
June 6, 13	2,300	2,000 adults, few eggs, 300 young (POBSP, 1969).

Table 119. Observations of Black Noddy on other islands at French Frigate Shoals

Date of Survey	Island	Population		Breeding
		Estimate	Status, Remarks, and References	Status, Remarks, and References
1923 June 25	Shark	few	Roosting only (Wetmore, ms.).	
June 22	Round	occasional	Flock of 12 passed (Wetmore, ms.).	
1963 June 9	Little Gin	5	Roosting (POBSP, 1963).	
1965 Aug. 10,23	Round	3	Roosting only (POBSP, 1965a).	
Aug. 10,23	Mullet	few	Roosting only (POBSP, 1965a).	
Aug. 25	Little Gin	25	Roosting only (POBSP, 1965a).	
Aug. 25	Gin	5	Roosting only (POBSP, 1965a).	
1967 June 9	Gin	1	Flying over (POBSP, 1967a).	
June 9	Little Gin	5	Roosting on beach during day (POBSP, 1967a).	
1968 June 7	Little Gin	few	Roosting (POBSP, 1968a).	
June 11,25	Round	few	Roosting (POBSP, 1968a).	
1969 June 7,21	Gin	0	Not observed (POBSP, 1969).	
June 7-21	Little Gin	0	Not observed; 100 roosting on sandbar east of island (POBSP, 1969).	
June 7	Disappearing	15	Roosting only (POBSP, 1969).	

WHITE TERN

Gygis albaStatus

Uncommon breeding species; present throughout the year with highest numbers in the summer. Nests on La Perouse Pinnacle and Tern Island; occasional bird seen on or over the other islands. POBSP maximum population estimate 3,700+ in August 1965.

Observations

Munro (1941b) found the White Tern on La Perouse Pinnacle and the sandy islands during his 1891 visit. Wetmore (ms.) recorded pairs on La Perouse Pinnacle in 1923.

POBSP personnel recorded nesting on La Perouse and their presence on Tern in 1963. Since 1965 they have been recorded nesting on Tern. They have occasionally been seen over, and roosting on, East, Trig and Whale-Skate.

Annual Cycle

The annual breeding cycle is shown in Figure 74. Birds are present throughout the year. White Terns have mainly a spring-summer cycle, with a few eggs possible as early as mid-December.

The population cycle coincides with that of the breeding cycle. Numbers are low during fall and winter and gradually increase during spring. By early summer the population has reached a high of 3,700+ and has been as low as 400 to 600. Numbers sharply decrease after the young fledge.

Possibly the Tern Island population is an overflow from the La Perouse population. In general, the Tern Island cycle appears to be slightly later than that of La Perouse (eggs as late as August).

Figure 74. Annual cycle of White Tern

			*****	*****	*****	*****	***				*
				+++++	+++++	+++++	+++++	+++++	+++++		+
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** = eggs present; ++ = dependent young present; ___ = non-breeding birds present

Ecological Distribution

The White Tern is common on Tern Island and La Perouse Pinnacle, the only two islands on which it nests. It is rare on the other islands in the atoll, but occasionally visits (flies over, rarely roosts on) them in small numbers.

Tern Island: Wetmore (ms.) may have seen White Terns over Tern Island in 1923. While on La Perouse he stated that "occasional pairs or little flocks pass the other islands en route to some feeding ground at sea." They were seen in 1956 and 1961;

in 1962 and 1963 they were observed in the Casuarina trees, but no nests were recorded (Table 120). During August 1965 POBSP personnel observed many adults flying about and roosting, and 2 nestlings in the Casuarina trees--the first breeding record for Tern Island. Nests were present as early as mid-March 1968.

White Terns nested also in Tournefortia near the barracks, on various cement and wooden posts, and on large coral rocks along the north side of the runway. They also roosted by day in these various habitats, but in the evening they usually preferred the Casuarina trees.

La Perouse Pinnacle: Munro (1941b) first reported this species in 1891 (Table 121). He gave no details of habitat or breeding status. Wetmore (ms.) observed "pairs," thus implying breeding. Richardson (1954a, 1954b, and pers. corr.) found the White Tern nesting in October and December 1953. POBSP personnel have observed it nesting on the cliffs. Eggs are placed directly on narrow ledges and in crevices on both faces of the main rock. Most nests are placed well up on the cliffs, none lower than 20 to 30 feet above the ocean.

Other Islands: White Terns probably visit, or at least fly over, all the other islands. They have been recorded occasionally at East, Trig and Whale-Skate (Table 122).

Banding and Movements

Since June 1963, 164 have been banded: 62 adults, 1 nestling in August 1965; 19 adults in June 1966; 57 adults in August and September 1966; 1 adult in June 1967; 4 nestlings in June 1968; and 4 adults, 16 nestlings in June 1969. All, except two which were banded on East and seven on La Perouse, were banded on Tern Island. Only seven returns have been taken.

An adult (712-01525), banded 4 August 1965 at Tern Island, was recovered dead on 14 February 1967 by POBSP personnel at Johnston Island, Johnston Atoll--a distance of 561 miles. An orange-streamered adult (642-01276), banded 29 May 1965 at Johnston Island, Johnston Atoll, was collected at Tern Island on 6 July 1966. This bird had been seen about the island for several days prior to being collected.

Specimens

POBSP: USNM 497581, ♀, collected 21 June 1967 on Tern by Lewis.

Non-POBSP: USNM 300394-95, ♀, ♂, collected 27 June 1923 by Wetmore.

Table 120. Observations of White Tern at Tern Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1953 Oct. 26- Sept. 2	2	(Richardson, 1954a).
1956 Feb. 11-21	6	Flew over island 1 day (Svihla, 1957).
1961 Sept. 2	1	Present in air around island (Udvardy and Warner, 1964).
1962 June 11-12, 21-22	6	"hovering about and landing in the ironwood trees near the Mess Hall... no eggs" (HDFG, 1962a).
1963 June 11	7	In <u>Casuarina</u> trees (POBSP, 1963).
1965 Aug. 4-5, 10-12, 17- 23, 28-29, 31-Sept. 2	200	2 young; adults roosting in <u>Casuarina</u> (POBSP, 1965a).
1966 Mar. 21	23	In <u>Casuarina</u> , reported to have arrived the previous week (BSFW, 1966a).
June 8-10, 14-16, 21- 23, 29- July 1, 4-7	54	Nests with 4 young (2 eggs hatched late June); population roosts in <u>Casuarina</u> (POBSP, 1966a).
Aug. 11-15, 17-18, 24- 26, 30- Sept. 16	55	1 nest with 2-week chick 14 September; adults roost primarily in <u>Casuarina</u> (POBSP, 1966b).
1967 Mar. 11-14	15	Present around Coast Guard barracks (POBSP, 1967b; BSFW, 1967a).
May 25-26, 31-June 2, 7-9, 13-15, 18, 20-22	81	75 adults, 6 young, 3 eggs; fresh eggs to fledglings (POBSP, 1967a).
Dec. 7	16	In <u>Casuarina</u> near headquarters (BSFW, 1967c).
1968 Mar. 11-15	20 [±]	Roosting population; 2 nests, each with a single slightly incubated egg (POBSP, 1968b).

Table 120. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1968 May 29- June 6, 11-14, 16- 17, 19-20, 22-27	112 [±]	20 breeders, 85 non-breeders, 7 young, 3 eggs (POBSP, 1968a).
1969 Feb. 22-24	13	Roosting adults (BSFW, 1969a).
Mar. 23	4	2 adults sitting on eggs (BSFW, 1969b).
June 2-4, 11-15, 25- 26	80 [±]	50 roosting adults, 25 breeders, 10 young, 2 eggs (POBSP, 1969).
Aug. 21- Sept. 6	32	1 egg; seen 26 August (BSFW, 1969c).

Table 121. Observations of White Tern at La Perouse Pinnacle

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1891 June 1-4	?	Present (Munro, 1941b).
1923 June 27	600	300 pairs (Wetmore, ms.).
1953 Oct. 31	60-80	Nesting on rocky ledges (Richardson, 1954a, pers. corr.).
Dec. 19	40-60	Nests with eggs and young (Richardson, 1954b).
1963 June 10	500-1,000	Many young present; nests placed on cliffs (POBSP, 1963).
1964 Sept. 27	100	(BSFW, 1964b; POBSP, 1964).
1965 Aug. 7	3,500+	500+ young (POBSP, 1965a).
1966 Mar. 23	300	No landing made (BSFW, 1966a).
Sept. 4	75	Adults flying around or roosting on rocks; no eggs or young seen but not all rock could be seen from ocean level (POBSP, 1966b).

Table 121. (continued)

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 June 12	3,500	3,000 adults, 500+ young, eggs present; eggs to large nestlings seen from raft (POBSP, 1967a).
1969 Feb. 24	?	Flying about; seen from airplane (BSFW, 1969a).
June 6,13	3,500	3,000 adults, 500 nests with eggs to almost fledged young (POBSP, 1969).

Table 122. Observations of White Tern on other islands at French Frigate Shoals

Date of Survey	Island	Population Estimate	Remarks and References
1891 June 1-4	FFS	?	On sandy islands (Munro, 1941b).
1902 May 28-29	FFS	?	Present (Fisher, 1903).
1923 June 22-23	East	occasional	Pass by island (Wetmore, ms.).
1965 Aug. 5-10, 23-28	East	2	Occasional roosting bird; usually only seen flying over island (POBSP, 1965a).
Aug. 11-17, 29-Sept. 1	Whale-Skate	2-5	Occasional roosting bird; usually only seen flying over island (POBSP, 1965a).
1966 June 10-14, 16-21	East	1-3	Occasional visitor (POBSP, 1966a).
June 10, 23-29, July 1-3	Whale-Skate	1-3	Observed flying over island occasionally (POBSP, 1966a).
Aug. 18-24, 26-30	East	occasional	Flying over (POBSP, 1966b).
Aug. 13-14, Sept. 4,12	Trig	occasional	Flying over (POBSP, 1966b).

Table 122. (continued)

Date of Survey	Island	Population Estimate	Remarks and References
1966 Aug. 15-17, Sept. 4	Whale-Skate	occasional	Flying over (POBSP, 1966b).
1967 May 26-31, June 9-13	East	1-5	Occasional daytime visitor (POBSP, 1967a).
June 2-7, 15-19	Whale-Skate	2	Occasional visitor; sometimes roosting on old barge located offshore (POBSP, 1967a).
June 2, 8-9, 19- 20	Trig	2	Occasional visitor (POBSP, 1967a).
1968 June 6, 11, 22, 24-25	Trig	occasional	Adult visitor (POBSP, 1968a).
June 6, 16-25	Whale-Skate	occasional	Adult visitor (POBSP, 1968a).
June 6-11, 14-16, 25	East	occasional	Adult visitor (POBSP, 1968a).
1969 June 5-10, 21	East	2	Adults occasionally flew over (POBSP, 1969).

NIHOA FINCH

Psittarostra cantans ultimaStatus

Introduced; spring-summer breeder; eight remained in September 1969.

Observations

On 11 March 1967 Kridler (BSFW, 1967a), accompanied by a member of the POBSP, released 27 banded Nihoa Finches (6 ♂, 20 ♀, and 1 unsexed immature) at Tern Island (Table 123) and 10 Nihoa Finches (4 ♂, 6 ♀) at East Island. All, with the exception of one male on Tern, began foraging for seeds of Casuarina, Chenopodium, Tribulus and Lepturus. A bad wind and rain storm occurred

that night. On 12 March only two females were seen on East Island; none has been seen since. Two birds were found dead on Tern, possibly killed by the storm. One had fallen into a bucket of water and another had apparently struck a window. On 13 March on Tern a male and a female were observed foraging near the mess hall, and on 14 March nine were seen feeding under the Casuarina.

From 25 May to 22 June 1967, 25 were estimated to be on Tern Island. They were observed in pairs or small groups foraging in almost all areas of the island. They seemed hard-pressed for food and water, for they moved about constantly in search of food, and frequently returned to two large water-filled 55-gallon drums at the end of the Commanding Officer's trailer. Coast Guard personnel reported that several drowned in these barrels. There was no positive evidence of breeding although the birds frequently appeared in pairs and were often heard singing. One was seen on 2 June 1967 on Whale-Skate (POBSP, 1967a) being chased by a female Great Frigatebird; it escaped into a Tournefortia bush. By September only 5 remained (BSFW, 1967b); only 3 could be found in December (BSFW, 1967c).

From 11 to 15 March 1968, 3 finches were observed on Tern Island. On the 14th a nest was found about 2 1/2 feet above the ground in a pile of unused concrete blocks; it was inside one of the blocks, some 14 to 16 inches deep. The sprawling, loose 9 x 5 inch nest was composed of twigs, grass and strips of paper (1/8 inch x 18 inches). In June 1968 three banded and two unbanded finches were observed at Tern. The two unbanded birds were in immature plumage and followed the others around the island.

In March 1969 Kridler (BSFW, 1969b) found 6 finches, including 1 unbanded nesting female; in June POBSP personnel observed 7 finches and a nest, and in August-September Kridler (BSFW, 1969c) found a total of 8 birds. Since the initial release, none has been banded.

Lack of food and the abrupt change in habitat from a high rocky island to a low sandy island may have caused the reduction in numbers of the originally released group. The few remaining birds have adapted to their new environment and have bred for two years. Perhaps there is enough food on Tern to support a small population of Nihoa Finches.

These Finch data are being further analyzed by BSFW personnel.

Table 123. Observations of Nihoa Finches at Tern Island

Date of Survey	Population Estimate	Breeding Status, Remarks, and References
1967 Mar. 11	27	Introduced from Nihoa Island by BSFW (BSFW, 1967a).
May 25- June 22	ca. 25	(POBSP, 1967a).
Sept. 16	5	(BSFW, 1967b).
Dec. 7	3	1 male, 2 females (BSFW, 1967c).
1968 Mar. 11-15	3	Nest in unused concrete blocks (POBSP, 1968b).
June	5	3 banded, 2 unbanded and in immature plumage (POBSP, 1968a).
1969 Mar. 23	6	1 unbanded nesting female (BSFW, 1969b).
June	7	1 male; 1 nest in concrete blocks (POBSP, 1969).
Aug. 21- Sept. 6	8	1 banded, 2 unbanded (BSFW, 1969c).

SHORT-EARED OWL

Asio flammeusStatus

Occasional visitor; two sight records.

Observations

Kridler (BSFW, 1967c) observed a Short-eared Owl, a new record for French Frigate Shoals, at Tern Island on 7 December 1967. He flushed this owl four different times. Coast Guard personnel reported seeing an owl, probably the same bird, in early 1968 (POBSP, 1968b).

The native Short-eared Owl (Asio flammeus sandwichensis) occurs in the Main Hawaiian Islands. The bird (or birds) observed at French Frigate Shoals was probably of this race. There are several sight records for Midway and Kure Atolls. The measurements of the one specimen collected at Kure were close to those of A. f. flammeus (Bailey, 1956; Kenyon and Rice, 1957; Udvardy, 1961b; and Clapp and Woodward, 1968).

MOCKINGBIRD

Mimus polyglottosStatus

Straggler; at least four birds have been recorded.

Observations

Woodside (HDFG, 1960b) made the first observation of Mockingbirds on 19 October 1960; he saw at least two near the buildings and vegetated area south of the runway on Tern Island. Only one Mockingbird was sighted at Tern on a subsequent visit by Woodside and Kramer (HDFG, 1961b) 3 to 5 March 1961.

On 4 August 1965 POBSP personnel saw two Mockingbirds in the Tournefortia and Pluchea along the edges of the runway on Tern. On 18 August 1965 one of these, in juvenal plumage and with fully grown flight feathers, was collected (Clapp and Woodward, 1968).

None was seen on subsequent POBSP visits. Kridler saw none on BSWF visits although he was informed by Coast Guard personnel that a bird similar to a Mockingbird was seen on 6 December 1967, the day before he arrived. He was unable to find it in spite of a thorough search of Tern Island.

Mockingbirds were first introduced into the Main Hawaiian Islands in 1928 (Munro, 1944) and are now established there (Udvardy, 1961b).

Specimens

POBSP: USNM 495887, juvenal ♂, collected 18 August 1965 on Tern Island by Huber.

MAMMALS

Beside human occupants, seven mammalian species occur at French Frigate Shoals. Two porpoises--the Bottle-nosed Dolphin, Tursiops truncatus, and the Hawaiian Spinner Dolphin, Stenella roseiventris--are visitors to the atoll's lagoon waters. A whale species is considered an accidental. The Hawaiian Monk Seal, Monachus schauinslandi, is a resident breeder on most of the islands. Three species have been introduced: the Domestic Dog, Canis familiaris, the House Cat, Felis catus, and the Pig, Sus scrofa, but only the former survives, at Tern Island.

Despite the presence of military facilities since 1942, no rats or mice have been recorded. This is extremely unusual, for most military establishments in the central Pacific (e.g. Johnston, Midway) are overrun by introduced rodents.

HAWAIIAN SPINNER DOLPHIN

Stenella roseiventris

Status

Visitor; known from one sight record.

Observations

POBSP personnel sighted two porpoises, tentatively identified by Amerson as Stenella roseiventris, between East Island and La Perouse Pinnacle and two between Disappearing and Little Gin Islands on 7 June 1969 (POBSP, 1969).

POBSP personnel saw two unidentified porpoises in the lagoon between Tern and Whale Islands on 17 August 1965 (POBSP, 1965a). As many as 10 porpoises were seen by the crew of the USCGC Ironwood as it lay anchored between La Perouse and Tern on 13 September 1966 (POBSP, 1966b).

POFI reports also contain sightings of unidentified porpoises. Ten were sighted on 23 January 1950 from the USFW F/V Hugh M. Smith (POFI, 1950a, 1950b); the same ship attracted 30 to 40 porpoises on 8 and 11 May 1951 (POFI, 1951).

Hawaiian Spinner Dolphins are uncommon visitors to the Hawaiian Islands (Brownell, pers. comm.). This is a new sight record for French Frigate Shoals.

BOTTLE-NOSED DOLPHIN

Tursiops truncatus

Status

Visitor; known from two sight records.

Observations

Rice (1960b) observed a single Bottle-nosed Dolphin ahead of his ship's bow 10 km. south of La Perouse Pinnacle 26 May 1958. In June 1958 he saw three gray dolphins with long snouts on the open ocean about 100 km. southeast of French Frigate; he noted that these could have also been Bottle-nosed Dolphins.

On the morning of 25 May 1967 POBSP personnel observed several porpoises which DeLong identified as Bottle-nosed Dolphins outside

the north reef as their ship approached Tern Island. None was seen inside the lagoon (POBSP, 1967a).

This species regularly occurs in shallow waters of the Northwestern Hawaiian Islands (Tomich, 1969).

WHALE species Cetacea sp.

Status

Accidental; known from one record.

Observations

Wetmore (ms.) recorded the "skeleton of a small whale...cast up on the beach" at the island he subsequently named Whale Island on 26 June 1923.

HAWAIIAN MONK SEAL Monachus schauinslandi

Status

Common resident breeder; present year-round on all islands. Maximum recent population estimate 171 in August and September 1967.

Observations

Seals were first recorded on 4 January 1859 by men of the USS Fenimore Cooper who obtained a seal skin on one of the atoll's sandspits¹ (U.S. Nat. Archives, Old. Mil. Hist., Log of USS Fenimore Cooper for 1859). Shortly thereafter the crew of the Gambia took seal from the atoll (Elschner, 1915). The Gambia revisited the shoals in late April or early May 1859 and noted it abounded in seals (Brooks, 1860). Seals were also present in fall 1886 (Farrell, 1928).

There was a notable absence of seal records from the atoll from then on. The Ada did not report any in 1882 (Hornell, 1934) and even the Tanager Expedition recorded none in June 1923 (Wetmore, ms.). No scientific visits were made during the 1930's and 1940's.

A POFI (1950a,b) survey in January 1950 recorded one seal on Little Gin Island; six were seen on Gin and Little Gin in June 1950 (POFI, 1950c). Using these sightings, Brock (Bailey, 1952)

¹ The Fenimore Cooper later wrecked in Japan (Brooke, 1955) and it is assumed that all scientific specimens were lost.

estimated an atoll population of 12. Two of the five seals sighted by POFI (1951) personnel in May 1951 were captured alive for zoos. Details are scant, but five more seals were taken (most by plane) for zoos in April and August 1955, September 1956, and July 1957. However, only two had survived by early 1958 (Kenyon and Rice, 1959). During the 1950's POFI personnel found increasing numbers at French Frigate.

HDFG, BSWF, and POBSP personnel recorded seals each year during the 1960's. All seal observations at French Frigate Shoals are presented in Tables 124 to 131.

Annual Cycle

Hawaiian Monk Seals are found year-round. Population estimates since Kenyon and Rice's (1959) 1957 estimate of 35 and Rice's (1960a) 1958 count of 39 adults and subadults and 4 pups have gradually increased. In June 1963 POBSP (1963) personnel estimated 55+ including a few pups; in June 1969 POBSP (1969) personnel estimated 99 adults and subadults and 13 pups; and in August and September 1969 BSWF (1969c) personnel found 150 adults and subadults and 21 pups. The average population from 1963 to 1969 was 75 seals; March counts averaged 59, June 85, and August and September 75. Pups have been born from as early as February, are usually more common in May and June, and normally are weaned by August and September.

Ecological Distribution

Hawaiian Monk Seals have been observed on all islands and islets. Adult females with pups have been recorded from almost all the islands. Seals move frequently from island to island within the atoll.

East Island: One seal was seen in February 1956 by Svihla (1957) (Table 124). POFI, HDFG, BSWF, and POBSP personnel have recorded them since; the island's seal population ranks third among the atoll's 13 islands.

Seals haul out on all beaches, but prefer the north and northeast lagoon beaches and the entire southwest beach. The latter is frequented by females with pups. A few adults make their way onto the edges of the vegetated area.

Gin Island: POFI personnel first recorded seals in June 1950 and continued to do so throughout the 1950's and early 1960's (Table 125). POBSP and BSWF personnel have observed them eight times since 1963. Seals normally utilize the leeward rather than the windward beaches; some haul up above the beach crest. Pups were seen on four occasions.

Little Gin Island: Seals were first noted by POFI personnel in January 1950 (Table 126). Since then POFI, BSWF, and POBSP personnel have recorded them 13 times. Pups were seen three times. Seals prefer to haul out on the leeward southwest beach; some lie above the beach crest.

Round Island: Svihla (1957) first found seals in February 1956 (Table 127). POFI, BSWF, and POBSP personnel have recorded them 10 times since. Pups have been observed on six occasions. Seals may be found over all portions of this small sandy island.

Tern Island: No seals were recorded prior to February 1956 when Svihla (1957) noted four (Table 128). Surely early visitors observed and collected seals here, but their records were either lost or concealed.

Since 1942 the almost continuous presence of humans and dogs has frightened the seals from hauling out on the beaches; however, they frequent the adjacent waters and haul out on several sections of the sheet pilings surrounding various portions of the island. No pups are known to have been born on the island (Kenyon, in prep.). Since the first record, there have been an additional nine. Seven of these have occurred since 1963 and were made by BSWF and POBSP personnel.

Trig Island: Richardson (1954b) first noted seals in March 1954 (Table 129). POFI personnel observed them from 1956 to 1961. POBSP and BSWF personnel recorded them 14 times between 1963 and 1969. An average of two pups has been seen per survey.

During the 1960's Trig's seal population ranked second among the islands. Seals are commonly found on all beaches, but prefer the protected north cove beach area. A few make their way over the beach crest and even into the vegetated areas.

Whale-Skate Island: In 1953 Richardson (1954a) first observed a seal on Skate Island (Table 130). Svihla (1957) found them on both Skate and Whale Islands in 1956. POFI (1956a,b) personnel recorded them in April and again in June 1956. POBSP and BSWF personnel observed seals on 15 surveys since 1963. During these surveys the Whale-Skate seal population has remained the highest in the atoll with an average population of 28 seals. An average of four pups was seen per survey.

Seals utilize all beaches, but prefer the sloping northeast beach. Some haul out above the beach crest and lie in the vegetated areas.

Other Islands: Seals have been recorded from Bare (3 times), Disappearing (4), Mullet (7), Near (2) and Shark (8) Islands, as well as La Perouse Pinnacle (5) (Table 131). Pups are known only from Mullet (1 time), Shark (3) and La Perouse (1). Seals, in small numbers, have also been observed on the various nameless sand islets that occasionally appear in the lagoon.

Tagging and Movements

Since 1965 BSFW and POBSP personnel have tagged at least 160 seals at French Frigate Shoals. Many have been recaptured on the Shoals. One seal originally tagged at Laysan Island has been captured at Trig Island. These seal data are being analyzed by BSFW personnel.

Table 124. Observations of Hawaiian Monk Seals at East Island

Date of Visit	Population Estimate	Breeding Status, Remarks, and References
1956 Feb. 21	1	Aerial count (Svihla, 1957).
Apr. 11	2	1 adult ♀; 1 pup (POFI, 1956a).
1957 Dec. 28	1	Aerial count (Rice & Kenyon photograph).
Apr. 24	3	(POFI, 1957).
May 11	1	(POFI, 1957).
1961 Feb. 9	4	3 adults; 1 pup (POFI, 1961a).
Feb. 18	4	Adults (POFI, 1961a).
Mar. 4	15	13 adults; 1 yearling; 1 pup (HDFG, 1961b).
July 13	7	Adults (POFI, 1961c).
1963 June 7-11	5	Uncommon (POBSP, 1963).
1964 July 27	9	2 adult ♀; 2 pups; 5 unclassified (BSFW, 1964a).
Sept. 27	7	4 adults: 2 ♂, 2 ♀, 2 unknown; 2 sub-adults: 1 ♂, 1 ♀, 1 ♂ pup (BSFW, 1964b; POBSP, 1964).
1965 Aug 5-10, 23-28	16	2-15 adults daily; 1 pup (POBSP, 1965a).

Table 124. (continued)

Date of Visit	Population Estimate	Breeding Status, Remarks, and References
1966 Mar. 23	9	5 adults: 4 ♀, 1 unknown; 1 ♂ subadult; 3 pups: 1 ♂, 2 unknown (BSFW, 1966a).
June 10-14, 16-21	16	2-5 adults daily; 2-10 subadults daily; 1 pup (POBSP, 1966a).
Aug. 18-24, 26-30	10	4-7 adults daily; 1-2 yearlings daily; 1 nursing pup (POBSP, 1966b).
Sept. 13-14	7	7 adults: 5 ♂, 2 ♀; 2 pups (BSFW, 1966b).
1967 Mar. 11-12	20	10 adults: 2 ♂, 4 ♀, 4 unknown; 5 subadults: 1 ♂, 4 unknown; 5 pups: 3 ♂, 2 ♀ (BSFW, 1967a).
May 26-31	15 [±]	10 [±] adults; 5 [±] subadults (POBSP, 1967a).
Sept. 17	10	7 ♀ adults; 2 subadults: 1 ♂, 1 ♀; 1 ♂ yearling (BSFW, 1967b).
Dec. 9		Data not available.
1968 June 6-11, 14-16, 25	5-25	(POBSP, 1968a).
1969 Mar. 22	?	4 pups (USCG via BSFW, 1969b).
June 5-10, 21	35	Adults, subadults, and pups (POBSP, 1969).
Aug. 22,30	20	4-5 adults; 4-9 subadults; 2-6 pups (BSFW, 1969c).

Table 125. Observations of Hawaiian Monk Seals at Gin Island

Date of Visit	Population Estimate	Breeding Status, Remarks, and References
1950 June 19	2	"Sea lions" (POFI, 1950c).
1951 May 8	3	Unclassified (POFI, 1951).
1956 Apr. 11	1	Adult (POFI, 1956a).

Table 125. (continued)

<u>Date of Visit</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1956 June 4	6	4 adults, 2 pups (POFI, 1956b).
1957 Apr. 25	7	6 on Gin; 1 on nearby islet (POFI, 1957).
May 12	3	2 adults, 1 young (POFI, 1957).
Dec. 28	8	3 others on nearby sandspit; aerial count (Rice and Kenyon photograph).
1961 Feb. 18	9*	8 adults; 1 pup (POFI, 1961a).
1963 June 9	present	(POBSP, 1963).
1965 Aug. 25	3	Adults (POBSP, 1965a).
1966 Mar. 23	1	Unclassified (BSFW, 1966a).
Sept. 14	5	3 adults: 2 ♂, 1 ♀; 1 ♀ subadult; 1 ♀ pup (BSFW, 1966b).
1967 June 9	4	1 adult; 3 subadults (POBSP, 1967a).
1968 June 7	5-25	(POBSP, 1968a).
1969 June 7, 21	present	(POBSP, 1969).
Aug. 30	16	7 adults; 6 subadults; 3 pups (BSFW, 1969c).

* Includes Little Gin Island

Table 126. Observations of Hawaiian Monk Seals at Little Gin Island

<u>Date of Visit</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1950 Jan. 19	1	"Sea lion" (POFI, 1950a,b).
June 19	4	(POFI, 1950c).
1951 May 8	2	Unclassified (POFI, 1951).

Table 126. (continued)

Date of Visit	Population Estimate	Breeding Status, Remarks, and References
1956 Apr. 11	2	Adults (POFI, 1956a).
June 4	8	6 adults; 2 pups (POFI, 1956b).
1957 Apr. 25	3	(POFI, 1957).
Dec. 28	4	Aerial count (Rice and Kenyon photograph).
1961 Feb. 18	9*	8 adults; 1 pup (POFI, 1961a).
1963 June 9	present	(POBSP, 1963).
1965 Aug. 25	5	Adults (POBSP, 1965a).
1966 Mar. 23	9	6 adults: 3 ♂, 3 ♀, 1 ♀ yearling; 2 pups (BSFW, 1966a).
1967 June 9	6	2 adults; 4 subadults (POBSP, 1967a).
1968 June 7	5-25	(POBSP, 1968a).
1969 June 7, 21	present	(POBSP, 1969).

* Includes Gin Island

Table 127. Observations of Hawaiian Monk Seals at Round Island

Date of Visit	Population Estimate	Breeding Status, Remarks, and References
1956 Feb. 21	2	Aerial count (Svihla, 1957).
Apr. 11	4	3 adults; 1 pup (POFI, 1956a).
1957 Dec. 28	4	3 adults, 1 pup; aerial count (Rice and Kenyon photograph).
1959 July 21	5	2 ♀ adults; 1 subadult; 2 pups (POFI, 1959).
1963 June 8	present	(POBSP, 1963).

Table 127. (continued)

Date of Visit	Population Estimate	Breeding Status, Remarks, and References
1965 Aug. 10, 23	7	6 adults; 1 pup (POBSP, 1965a).
1966 Aug. 26	2	Adults (POBSP, 1966b).
1967 June 13	6	3 ♀ adults; 3 pups (POBSP, 1967a).
1968 June 11, 25	few	(POBSP, 1968a).
1969 June 5	present	(POBSP, 1969).
Aug. 25	8*	5 adults; 2 subadults; 1 pup (BSFW, 1969c).

* Includes Mullet Island

Table 128. Observations of Hawaiian Monk Seals at Tern Island

Date of Visit	Population Estimate	Breeding Status, Remarks, and References
1956 Feb. 11-21	4	(Svihla, 1957).
1959 July 21	1	(POFI, 1959).
1965 Aug. 4-5, 10-12, 17- 23, 28-29, 31-Sept. 2	2	Adults (POBSP, 1965a).
1966 June 8-10, 14-16, 21- 23, 29- July 1, 4-7	4	1 adult, 3 subadults (POBSP, 1966a).
Aug. 11-15, 17-18, 24- 26, 30- Sept. 16	1	Yearling seen on 26th (POBSP, 1966b).

Table 128. (continued)

Date of Visit	Population Estimate	Breeding Status, Remarks, and References
1967 May 25-26, 31-June 2, 7-9, 13- 15, 18, 20-22	3	1 adult; 2 subadults (POBSP, 1967a).
1968 Mar. 11-15	1	Adult (POBSP, 1968b).
May 29- June 6, 11-14, 16- 17, 19-20, 22-27	few	(POBSP, 1968a).
1969 June 2-4, 11-15, 25- 26	2	1 adult; 1 yearling (POBSP, 1969).

Table 129. Observations of Hawaiian Monk Seals at Trig Island

Date of Visit	Population Estimate	Breeding Status, Remarks, and References
1954 Mar. 20	2	On beach; 1 a yearling (Richardson, 1954b).
1956 Feb. 21	4	Aerial survey; also 4 on nearby islet (Svihla, 1957).
Apr. 11	3	(POFI, 1956a).
June 5	1	Adult (POFI, 1956b).
1957 Dec. 28	2	Aerial count (Rice & Kenyon photograph).
May 10	6	(POFI, 1957).
1959 July 21	8	6 adults; 2 subadults (POFI, 1959).
1961 Feb. 18	7	6 adults; 1 pup (POFI, 1961a).
1963 June 14, 15	20+	Several with young (POBSP, 1963).
1964 Sept. 27	11	Adults: 5 ♂, 5 ♀, 1 unknown (BSFW, 1964b; POBSP, 1964).

Table 129. (continued)

Date of Visit	Population Estimate	Breeding Status, Remarks, and References
1965 Aug. 16, 29, 31	11	2-10 adults; 1 pup (POBSP, 1965a).
1966 Mar. 22	14	10 adults: 2 ♂, 7 ♀, 1 unknown; 1 ♀ yearling; 3 pups: 1 ♂, 2 unknown (BSFW, 1966a).
June 10-23, July 1, 3-4	11	2-3 adults daily; 2-7 subadults daily; 1 pup (POBSP, 1966a).
Aug. 13-14, Sept. 4, 12	17	12-13 adults; 2-3 subadults, 1 weaned pup (POBSP, 1966b).
Sept. 12	20	11 adults: 3 ♂, 8 ♀; 6 subadults: 1 ♂, 2 ♀, 3 unknown; 3 yearlings: 1 ♂, 2 unknown (BSFW, 1966b).
1967 Mar. 13-14	23	13 adults: 1 ♂, 12 ♀; 3 subadults: 2 ♂, 1 ♀; 7 pups: 2 ♂, 4 ♀, 1 unknown (BSFW, 1967a).
June 2, 8- 9, 19-20	16±	10± adults; 5± subadults; 1 pup (POBSP, 1967a).
Sept. 17	23	18 adults: 2 ♂, 7 ♀, 9 unknown; 4 subadults; 1 pup (BSFW, 1967b).
1968 June 6, 11, 22, 24-25	5-25	(POBSP, 1968a).
1969 Feb. 22	15	1 pup; 14 unclassified (BSFW, 1969a).
June 3, 14, 23-24	29	27 adults and subadults; 2 pups (POBSP, 1969).
Aug. 23, 27	29	6-12 adults; 3-7 subadults; 2 pups; 8 unclassified (BSFW, 1969c).

Table 130. Observations of Hawaiian Monk Seals at Whale-Skate Island

Date of Visit	Population Estimate	Breeding Status, Remarks, and References
1953 Oct. 28	1**	Large 7-8 foot seal sleeping on beach (Richardson, 1954a).

Table 130. (continued)

<u>Date of Visit</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1956 Feb. 21	7*	Aerial survey (Svihla, 1957).
Feb. 21	10**	Aerial survey (Svihla, 1957).
Apr. 11	5*	(POFI, 1956a).
Apr. 11	1**	(POFI, 1956a).
June 5	11	7 adults; 4 pups: 3 live, 1 dead (POFI, 1956b).
1957 Dec. 28	1	Aerial count (Rice and Kenyon photograph).
May 10	12	(POFI, 1957).
1959 July 21	10	(POFI, 1959).
1961 Feb. 18	18	16 adults: 15 live, 1 dead; 2 pups (POFI, 1961a).
1963 June 12-15	30+	(POBSP, 1963).
1964 Sept. 27	24	17 adults: 8 ♂, 2 ♀, 6 unknown; 6 sub- adults: 1 ♂, 2 ♀, 3 unknown; 1 pup (BSFW, 1964b; POBSP, 1964).
1965 Aug. 17, 29-Sept. 1	17	2-15 adults daily; 2 pups (POBSP, 1965a).
1966 Mar. 22	25	16 adults: 6 ♂, 7 ♀, 3 unknown; 4 sub- adults: 1 ♂, 2 ♀, 1 unknown; 5 pups: 2 ♂, 3 unknown (BSFW, 1964a).
June 10, 23-July 3	21	2-10 adults daily; 2-10 subadults daily; 1 pup (POBSP, 1966a).
Aug. 15-17, Sept. 4	33	8-21 adults; 8-9 yearlings; 3 weaned pups (POBSP, 1966b).
Sept. 13	23	8 adults: 5 ♂, 1 ♀, 2 unknown; 6 sub- adults: 4 ♂, 2 ♀; 9 pups: 2 ♂, 2 ♀, 5 unknown (BSFW, 1966b).

* Whale Island ** Skate Island

Table 130. (continued)

Date of Visit	Population Estimate	Breeding Status, Remarks, and References
1967 Mar. 14	16	7 adults: 6 ♀, 1 unknown; 4 ♂ subadults; 5 pups (BSFW, 1967a).
June 2-7, 15-19	27±	15± adults; 10± subadults; 2 pups (POBSP, 1967a).
Sept. 17	23	15 adults: 6 ♂, 4 ♀, 5 unknown; 6 subadults: 1 ♂, 1 ♀, 4 unknown; 2 yearlings: 1 ♀, 1 unknown (BSFW, 1967b).
1968 June 6, 16-25	5-25	(POBSP, 1968a).
1969 Feb. 23	48	1 pup; 47 unclassified (BSFW, 1969a).
Mar. 22	?	2 pups (USCG via BSFW, 1969b).
June 3, 16-20, 22	36	26 adults and subadults; 10 pups (POBSP, 1969).
Aug. 24	32	9 adults; 13 subadults; 8 pups; 2 unclassified (BSFW, 1969c).

Table 131. Observations of Hawaiian Monk Seals on other islands at French Frigate Shoals

Date of Visit	Island	Population Estimate	Breeding Status, Remarks, and References
1956 Feb. 21	Mullet	3	Aerial count (Svihla, 1957).
June 5	Mullet	6	4 adults; 2 pups (POFI, 1956b).
1957 May 10	Shark	1	(POFI, 1957).
May 11	Bare	1	(POFI, 1957).
Dec. 28	Shark	9	Aerial count (Rice and Kenyon photograph).
Dec. 28	Disappearing	4	Aerial count (Rice and Kenyon photograph).
1959 July 19	Shark	9	(USCG via POFI, 1959).

Table 131. (continued)

<u>Date of Visit</u>	<u>Island</u>	<u>Population Estimate</u>	<u>Breeding Status, Remarks, and References</u>
1959 July 21	Mullet	1	Adult (POFI, 1959).
1961 Apr. 22	Shark	11	10 adults and subadults; 1 pup (POFI, 1961b).
July 14	Shark	8	4 adults; 4 pups (POFI, 1961c).
1963 June 8	Bare	present	(POBSP, 1963).
June 8	Mullet	present	(POBSP, 1963).
June 8	Near	present	(POBSP, 1963).
June 9	Disappearing	present	(POBSP, 1963).
June 11	Shark	present	(POBSP, 1963).
1964 Sept. 28	La Perouse	1	Unclassified (BSFW, 1964b; POBSP, 1964).
1965 Aug. 10	Mullet	1	Adult (POBSP, 1965a).
1966 Sept. 5	La Perouse	1	Adult (POBSP, 1966b).
1967 June 9	Bare	1	Adult (POBSP, 1967a).
June 9	Near	1	Adult (POBSP, 1967a).
1968 June 25	Mullet	few	(POBSP, 1968a).
1969 May 30	La Perouse	1	Around base of pinnacles (BSFW, 1969d).
June 4	Shark	9	Adults and subadults (POBSP, 1969).
June 5	Mullet	present	(POBSP, 1969).
June 6,13	La Perouse	1	Unclassified (POBSP, 1969).
June 7	Disappearing	present	(POBSP, 1969).
Sept. 1	La Perouse	2	1 adult; 1 pup (BSFW, 1969c).

Table 131. (continued)

Date of Visit	Island	Population		Breeding
		Estimate	Status, Remarks, and References	Status, Remarks, and References
1969 Sept. 2	Shark	19	10 adults; 5 subadults; 1 pup; 3 unclassified (BSFW, 1969c).	
Sept. 4	Disappearing	37	Unclassified (FAA via BSFW, 1969c).	

DOMESTIC DOG

Canis familiarisStatus

Introduced; periodic breeder; kept as pets year-round on Tern Island. Maximum recent population 11 in June 1968.

Observations

In 1861 when the sloop Travis visited the atoll, its crew found a feral dog presumably left by the Gambia in 1859 (Dabagh, pers. corr.; Amerson, in prep.).

When the Tern Island Naval Air Facility started operations in 1942 and 1943, dogs were again introduced. The Station had a pet fox terrier in early 1944 (Dabagh, pers. corr.). At the East Island USCG LORAN Station, completed in July 1944, dogs were kept at least as early as October 1947 (Clinard, pers. corr.). On 1 September 1948 Henry (pers. corr.) found three.

Richardson (1954b) noted dogs on Tern Island on 18 December 1953. During February 1956 Svihla (1957) observed two pet dogs there. Robbins (HDFG, 1960a) also recorded two dogs in April 1960, as did Woodside (HDFG, 1960b) in October 1960. Woodside and Kramer (HDFG, 1961b) noted two in March 1961. They all reported that the dogs occasionally molested Tern Island's seals and birds; they discouraged seals from coming on the island, ran after the albatrosses, and dug up the shearwater and petrel burrows.

POBSP and BSFW personnel recorded three German Shepherds, a male dog and two bitches, on Tern Island in June 1963. In June 1967 one of the bitches gave birth to eight puppies; all pups were subsequently shipped to Honolulu.

These dogs chase birds only occasionally and apparently do them little harm; their chasing of seals hauled out on Tern's

beaches, however, has probably been a major factor in seals not pupping on the island. The three dogs are never taken to the other islands and, thus, do not greatly affect the bird, turtle, and seal populations on the atoll.

HOUSE CAT

Felis catus

Status

Introduced; last present in 1966.

Observations

Henry (pers. comm.) recorded the first House Cat on East Island on 1 September 1948. Richardson (1954a) noted four or five "well-fed house cats" which had supposedly "killed hundreds of Golden Plover" on his October 1953 Tern Island visit. Svihla (1957) recorded "two house cats (said to be of the same sex) which fed to a certain extent on the birds" during his February 1956 visit.

The Tern Island cats were not observed by Robbins (HDFG, 1960a) in April 1960, Woodside (HDFG, 1960b) in October 1960, or Woodside and Kramer (HDFG, 1961b) in March 1961. POBSP and BSWF personnel saw none in 1963 and 1964. Early in 1965 a feral cat, possibly one of the earlier two pets, appeared on Tern. The cat slipped into the barracks late at night and stole food from the galley for several months (Krauss, 1965) before being caught and tamed by Lt. (jg) George E. Archer, Jr. Archer kept the huge yellow male in his trailer but it died shortly after POBSP personnel departed the atoll in June 1966.

The Hawaiian Islands National Wildlife Refuge rules now prohibit cats on the atoll.

PIG

Sus scrofa

Status

Unsuccessful introduction.

Observations

Some pigs were left, on what is probably today East Island, on 29 April 1867 by the crew of the USS Lackawanna who had gone to the Shoals to rescue the crew of the wrecked bark Daniel Wood (U.S. Nat. Archives, Hydrographic Off. Corresp., Reynolds to Jenkins letter, R.G. 37, 272.7). Five years later the Kamehameha V visited the atoll. The crew "saw...two large hogs on a sand spit, a quarter of a mile in circumference. They have been there

since April 1867. There is no fresh water...and very little vegetation. As soon as the boat landed, the hogs took to the water and swam off to some rocks just awash, and seemed perfectly at home in the water" (The Friend, Oct. 1872, 81: 2-3). The pigs were never observed again.

SUMMARY

French Frigate Shoals, in the Northwestern Hawaiian Islands, has been the scene of many shipwrecks, the site of a U.S. Naval Air Facility during World War II, and a little-known commercial fishing area for Hawaiians throughout the years. Today the atoll is part of the Hawaiian Islands National Wildlife Refuge, with a U.S. Coast Guard LORAN Station on one of its 13 islands.

Personnel of the Pacific Ocean Biological Survey Program (POBSP), Smithsonian Institution, Washington, D.C., made 11 biological survey trips to the atoll from June, 1963, to June, 1969. Data from these visits, as well as from visits by Bureau of Sport Fisheries and Wildlife (BSFW) personnel, Hawaiian Division of Fish and Game personnel, Pacific Ocean Fisheries Investigations personnel, and from all previously published literature are summarized and discussed. Emphasis is placed on the vascular flora and the vertebrate terrestrial fauna.

In all, 40 species of vascular plants, representing 24 families, have been observed or collected from eight islands. Two species of reptiles, both breeders, are known. Since 1963, POBSP and BSFW personnel tagged 288 green sea turtles; 16 of these were recaptured on the atoll, and four were captured elsewhere in the Hawaiian Islands. In addition, two tagged elsewhere were captured on the atoll. Of the 44 species of birds recorded, 18 species are resident breeding seabirds, 5 are regular migrant shorebirds, and 21 are vagrant, accidental, or introduced. In all, 85 specimens of 22 species were known prior to the first POBSP survey. POBSP personnel collected 55 specimens of 26 species, 11 of which represent new specimen records for the atoll; an additional 8 species represent new sight records. Birds totaling 67,027, of 19 species, were banded with U.S. Fish and Wildlife bands by POBSP personnel; 7,958 of these (6 species) were recaptured on the atoll, and 246 (12 species) were captured at other Pacific localities. In addition, 280 birds of 12 species from other Pacific localities were captured on the atoll. Beside human occupants, seven mammalian species occur. Since 1965, POBSP and BSFW personnel tagged 160 Hawaiian monk seals; many recaptures are known, and one tagged elsewhere was captured.

French Frigate Shoals offers a unique opportunity to terrestrial and marine biologists: there are few places where isolated undisturbed islands and waters teeming with wildlife occur so close to an island with port, airport, and lodging facilities.

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Appendix Table 1. Scientific visits to French Frigate Shoals,
1859-1969 **

Date of Visit	Vessel	Personnel
1859 3-7 Jan.	USS <u>Fenimore Cooper</u>	Lt. John Mercer Brooke, John Kern and <u>Fenimore Cooper</u> personnel
Mar.	<u>Gambia</u>	N.C. Brooks
May or Apr.	<u>Gambia</u>	N.C. Brooks
1891 30 May- 5 June	<u>Kaalokai</u>	Rothschild Expedition: George C. Munro, Henry C. Palmer
1902 28-29 May	USS <u>Albatross</u>	Albatross Expedition: Charles H. Gilbert, Walter K. Fisher, John O. Snyder
1910 28 Jan.	USRC <u>Thetis</u>	CO W.V.E. Jacobs and <u>Thetis</u> personnel
Aug. or Sept.	USRC <u>Thetis</u>	CO W.V.E. Jacobs and <u>Thetis</u> personnel
1912 19 Dec.	USRC <u>Thetis</u>	Haw. Gov. Walter F. Frear, D.T. Fullaway, A.C. Lindsay; BBS: Alfred M. Bailey, Cmdr. G.R. Salisbury, William S. Wallace, George Willett

** Symbols and abbreviations: BBS - Bureau of Biological Survey; BPBM - B.P. Bishop Museum; BSFW - Bureau of Sport Fisheries and Wildlife; CC - Claremont College; FAA - Federal Aviation Administration; HU - Hamburg University; HDFG - Hawaiian Division of Fish and Game; HSPA - Hawaii Sugar Planters' Association; HSB - Honolulu Star Bulletin; HZ - Honolulu Zoo; NAS - National Audubon Society; NBC - National Broadcasting Company; OI - Oceanographic Institute; POBSP - Pacific Ocean Biological Survey Program; POFI - Pacific Ocean Fisheries Investigation; UA - University of Arizona; UBC - University of British Columbia; UC - University of California; UF - University of Florida; UH - University of Hawaii; USCG - U.S. Coast Guard; USDA - U.S. Department of Agriculture; USFW - U.S. Fish and Wildlife Service; USN - U.S. Navy; UW - University of Washington; VU - Vienna University; *Biologist-in-charge.

Appendix Table 1. (continued)

Date of Visit	Vessel	Personnel
1914 25 Aug.- 30 Sept., 10 Oct.- 4 Nov.	USS <u>Rainbow</u>	Lt. Cmdr. F.J. Horne and <u>Rainbow</u> personnel
9 Sept.	USRC <u>Thetis</u>	<u>Thetis</u> personnel
1915 20-21 Mar.	USRC <u>Thetis</u>	Capt. Joseph H. Brown, Lt. W.H. Munter and <u>Thetis</u> personnel
1916 28 Jan.	USRC <u>Thetis</u>	Capt. Joseph H. Brown, Lt. W.H. Munter and <u>Thetis</u> personnel
1918 4-5 Sept.	USS <u>Hermes</u>	Lt. J.T. Diggs and <u>Hermes</u> personnel
1919 24 Sept.	?	David T. Fullaway
1923 22-28 June	USS <u>Tanager</u>	Tanager Expedition: William G. Anderson, Edwin H. Bryan, Jr., Edward L. Caum, Erling Christophersen, Chapman Grant, George Higgs, C.S. Judd, H.S. Palmer, Eric L. Schlemmer, Ditlev Thaanum, Alexander Wetmore*
1924 8 May	USS <u>Pelican</u>	Lt. Doile Greenwell, Gerritt P. Wilder
1928 4-5 Mar.	Schooner <u>Lanikai</u>	William G. Anderson; VU: Victor Pietschmann
11-19 May, 5-23 July, 3-21 Aug., 8-29 Sept.	USCGSS <u>Guide</u>	Lt. Cmdr. Thomas J. Maher (May only); Lt. K.T. Adams, V.M. Gibbons, F.B. Quinn and <u>Guide</u> survey personnel
1930 1 May	USCGSS <u>Pioneer</u>	Capt. O.W. Swainson and sounding party
1931 9-10 Feb.	USRC <u>Itasca</u>	Capt. J. Pine and inspection party
4 Oct.	USCGSS <u>Pioneer</u>	Sounding team
1932 22-25 June	USS <u>Quail</u>	USN aerial reconnaissance survey party

Appendix Table 1. (continued)

<u>Date of Visit</u>	<u>Vessel</u>	<u>Personnel</u>
1934 20,27 June	USRC <u>Itasca</u>	Capt. J.S. Baylis and inspection party
1935 9 Dec.	USRC <u>Itasca</u>	Inspection party
1936 4-6 Mar.	USCGC <u>Reliance</u>	Boatswain B.L. Bassham; BBS: A.D. Trempe
1948 21 Jan.- 1 Feb.	USFW M/V <u>Oregon</u>	M.B. Schaefer; POFI: O.R. Smith
14-19 Aug.	USFW M/V <u>Oregon</u>	POFI: Howard H. Eckles
1950 19-26 Jan.	USFW M/V <u>Hugh M. Smith</u>	POFI: M.B. Schaefer
19 May	USFW M/V <u>Henry O'Malley</u>	POFI personnel
19-21 June	USFW M/V <u>Hugh M. Smith</u>	POFI: Ole J. Heggen
1951 8-10 May	USFW M/V <u>Hugh M. Smith</u>	POFI: Ralph Johnson
1952 25 July	USCG plane	UH: C.R. Joyce
1953 26 Oct.- 2 Nov.	F/V <u>Osprey</u>	UW: Frank Richardson; USDA: Ivan Rainwater
18-19 Dec.	USCGC <u>Buttonwood</u>	UW: Frank Richardson
1954 20 Mar.	USCGC <u>Buttonwood</u>	UW: Frank Richardson
1955 5-6 May	USFW M/V <u>J.R. Manning</u>	POFI personnel
1956 11-21 Feb.	USCG plane	BPBM: Arthur Svihla
9-11 Apr.	USFW M/V <u>J.R. Manning</u>	POFI: Herbert S. Shippen, Daniel Yamashita*
3-6 June	USFW M/V <u>J.R. Manning</u>	POFI: E.C. Jones*, T.S. Hida

Appendix Table 1. (continued)

<u>Date of Visit</u>	<u>Vessel</u>	<u>Personnel</u>
1956 3 Aug.	USCG plane	UF?: Archie F. Carr; 1 other zoologist
1957 31 Jan.	USCG plane	USFW: Vernon Brock; HZ: Paul Breeze
23-26 Apr., 10-13 May	USFW M/V <u>Hugh M. Smith</u>	POFI personnel
28 Dec.	USN plane	USFW: Karl W. Kenyon, Dale W. Rice (aerial photographic survey only)
1958 26 May	USCG <u>Matagorda</u>	UC: Richard E. Warner; UBC: Miklos D.F. Udvardy; UA: G.D. Butler, Charles W. Daniel
1959 21-22 July	USFW M/V <u>Charles H. Gilbert</u>	POFI: William Tanaka
19 Aug.	USCG plane	HU: Hubert Casper
1960 13 Apr.	USCG plane	USFW: Chandler S. Robbins
19 Oct.	USCG plane	HDFG: Joseph S. Medeiros, David H. Woodside
1961 9, 18-19 Feb.	USFW M/V <u>Charles H. Gilbert</u>	POFI personnel
3-5 Mar.	USCGC <u>Planetree</u>	HDFG: Raymond J. Kramer, R. Rodgers, David H. Woodside
8, 21-25 Apr.	USFW M/V <u>Charles H. Gilbert</u>	POFI personnel
2 Sept.	USCG plane and USCGC <u>Ironwood</u>	Coolidge Expedition: UA: George D. Butler; UH: Edward C. Jestes, Charles H. Lamoureux; UC: A. Starker Leopold; UBC: Miklos D.F. Udvardy; UC: William Usinger; UH: Martin J. Vitousek; HDFG: Ronald L. Walker; UC: Richard E. Warner; HDFG: David Woodside
1962 11-12, 21- 22 June	USS <u>Stone County</u>	HSPA: Jack W. Beardsley; HDFG: Raymond J. Kramer; USFW: David B. Marshall

Appendix Table 1. (continued)

Date of Visit	Vessel	Personnel
1962 13-14 July	USFW M/V <u>Charles H. Gilbert</u>	POFI personnel
1963 7-15 June	USS <u>Tawakoni</u>	POBSP: A. Binion Amerson, Jr., Fred C. Sibley*
1964 27 July	USFW M/V <u>Charles H. Gilbert</u>	BSFW: Eugene Kridler; POFI personnel
27-28 Sept.	USCGC <u>Basswood</u> and USCG plane	BSFW: Eugene Kridler*; HDFG: Ronald L. Walker; UH: John Beardsley; POBSP: Robert R. Fleet, Charles R. Long
1965 16 Mar.	USCGC <u>Blackhaw</u>	BSFW: Eugene Kridler*, Chandler S. Robbins; HDFG: Ronald L. Walker; POBSP: Winston E. Banko
4 Aug.- 2 Sept.	USNS <u>Shearwater</u> and USCG plane	POBSP: A. Binion Amerson, Jr* Lawrence N. Huber
1966 21-24 Mar.	USCGC <u>Button- wood</u>	BSFW: Eugene Kridler*; UH: Andrew J. Berger; HDFG: Nelson Rice, Ronald L. Walker
12-13, 16(?) May	USFW M/V <u>Charles H. Gilbert</u>	POFI personnel
8 June- 7 July	USNS <u>Shearwater</u> and USCG plane	POBSP: A. Binion Amerson, Jr.*, Jeffrey P. Tordoff
11 Aug.- 16 Sept.	USCG plane	POBSP: Brian A. Harrington*, Robert W. Tuxson
12-15 Sept.	USCGC <u>Ironwood</u>	BSFW: Karl W. Kenyon, Eugene Kridler*; CC: Sherwin Carlquist; HSB: Warren S. Roll
1967 11-14 Mar.	USCGC <u>Basswood</u>	BSFW: Eugene Kridler*; HDFG: Ernest F. Kosaka; UH: John Maciolek, Richard Wass; POBSP: C. Douglas Hackman
25 May- 22 June	USN light tugs	POBSP: A. Binion Amerson, Jr.*, T. James Lewis (25 May only: Robert L. DeLong, David L. Burck- halter, Dennis L. Stadel, F. Christian Thompson, Robert W. Tuxson)

Appendix Table 1. (continued)

<u>Date of Visit</u>	<u>Vessel</u>	<u>Personnel</u>
1967 16-19 Sept.	USCGC <u>Button-wood</u>	BSFW: Robert Ballou, Eugene Kridler*, John L. Sincock; HDFG: Ronald L. Walker
7-11 Dec.	USCG plane	BSFW: Eugene Kridler
1968 11-15 Mar.	USCGC <u>Ironwood</u>	BSFW: Karl W. Kenyon, Eugene Kridler*, John L. Sincock; HDFG: Ernest F. Kosaka; POBSP: Roger B. Clapp
29 May- 27 June	USCG plane	POBSP: A. Binion Amerson, Jr.*; USN: Ronald R. Amerson
6-27 June	USCG plane	BSFW: Eugene Kridler*; HDFG: Ernest F. Kosaka; OI: John R. Hendrickson
1969 22-24 Feb.	FAA plane	BSFW: Eugene Kridler*; NBC television camera crew
23 Mar.	USCGC <u>Button-wood</u>	BSFW: Karl W. Kenyon, Eugene Kridler*, David L. Olsen, John L. Sincock; NAS: George Laycock
30-31 May	USFW M/V <u>Mahi</u>	BSFW: David L. Olsen*, John L. Sincock; HDFG: Ernest F. Kosaka; UH: Karl Bathen, Tom Clark, Ronald Kent, James McVay, William Patzert, Douglas Yen
2-26 June	FAA plane	POBSP: A. Binion Amerson, Jr.*, Vernon M. Kleen
21 Aug.- 7 Sept.	USCGC <u>Button-wood</u>	BSFW: Eugene Kridler*, David L. Olsen, John L. Sincock; UH: George Losey, John Maciolek

Appendix Table 2. Publications and manuscripts on scientific collections and studies on French Frigate Shoals*

COELENTERATA

- | | |
|---------------|-------------------------------------------------------------------|
| Vaughan, 1907 | Lists 2 coral species |
| Nutting, 1908 | Records 4 coral species collected in 1904 by Albatross Expedition |

MOLLUSCA

- | | |
|--------------------------------|----------------------------------------------------------------------|
| Pilsbry, 1927 | Lists 1 barnacle species from Tanager collection |
| Schilder, 1933 | Reports 14 species of Cypraea collected by Pietschmann in March 1928 |
| Dall, Bartsch and Rehder, 1938 | Lists 7 mollusk species collected by Albatross Expedition |

ECHINODERMATA

- | | |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Agassiz and Clark, 1907 | Records 4 echinoderms from Albatross collection of 1902 |
| Agassiz and Clark, 1907-12 | Lists 1 sea urchin and 4 echinoderms |
| Clark, 1925 | Reports 7 sea urchin species and 2 sea cucumber species from Tanager collection |
| Fisher, 1925 | Reports 2 starfish species from Tanager collection |
| Clark, 1949 | Lists 11 brittle stars (Ophiuroidea) collected by Albatross and Tanager Expeditions; also lists 6 previously reported |

ANNELIDA

- | | |
|-------------|-------------------------------------------------------|
| Holly, 1935 | Lists 5 Polychaeta from Pietschmann's 1928 collection |
|-------------|-------------------------------------------------------|

* Authors are in chronological order

Appendix Table 2. (continued)

ANNELIDA (cont.)

- | | |
|----------------------------|-----------------------------------------------------------|
| Hartman and Schroder, 1965 | Describes a new polychaete |
| Hartman, 1966 | Summarizes earlier polychaetous annelids; lists 8 species |

ARTHROPODA

1. Crustacea

- | | |
|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| Edmondson <u>in</u> Edmondson <u>et</u>
<u>al.</u> , 1925 | Reports 48 species of decapods, including 2 new species, and 1 copepod species from Tanager collection |
|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|

2. Arachnida

- | | |
|--------------------------|-----------------------------------------------------------------------|
| Jacot, 1934 | Describes 1 oribatid mite from 1923 Tanager collection |
| Hardy, 1952 | Reports first record of Black-widow Spider |
| Anon., 1953 | Reports that C.R. Joyce found ticks biting humans on Tern |
| Suman, 1964 | Lists 1 spider |
| Beardsley, 1966 | Lists 4 spiders |
| Kohls, 1966 | Records an <u>Ixodes</u> species collected by POBSP |
| Kohls and Clifford, 1967 | Describes male and larvae of <u>Ixodes</u> species collected by POBSP |
| Amerson, 1968 | Reports distribution of ticks collected by POBSP |

INSECTA

- | | |
|-----------------------------------|-------------------------------------------------------------|
| Swezey, 1915 | Records 7 insect species collected by Kerr in 1914 |
| Swezey, 1920 | Describes new Lepidoptera species collected by Kerr in 1914 |
| Bryan <u>et</u> <u>al.</u> , 1926 | Reports <u>ca.</u> 26 insects from Tanager collection |

Appendix Table 2. (continued)

INSECTA (cont.)

Wheeler, 1934	Reports new listing of 3 ant species from former publication
Lopes, 1938	Provides description of new sarcophagid fly species from Tanager Expedition collection
Zimmerman, 1948a	Lists 2 Orthoptera and 2 Dermaptera
Zimmerman, 1948b	Lists 3 Hemiptera
Zimmerman, 1948c	Lists 2 Homoptera
Zimmerman, 1958a	Lists 3 Macrolepidoptera
Zimmerman, 1958b	Lists 1 Lepidoptera
Maa, 1962	Reports 2 Hippoboscidae species collected September 1919 and from 1923 Tanager collection
Hardy, 1964	Lists 1 Diptera
Beardsley, 1966	Lists 46 insect species
Maa, 1968	Records Hippoboscidae from POBSP collections
Amerson and Emerson, 1971	Records Mallophaga from POBSP collections

CHORDATA

1. Pisces

Snyder, 1904	Records 2 fish species collected by Albatross Expedition
Gilbert, 1905	Lists 5 deep-sea fishes from vicinity by Albatross Expedition
Fowler and Ball, 1925	Reports 53 fish species from 1923 Tanager Expedition collection
Fowler, 1927	Lists 4 fish species collected by Tanager Expedition

Appendix Table 2. (continued)

CHORDATA (cont.)

Gregory, 1929	Mentions Pietschmann's trip
Schindler, 1932	Discusses hemirhampids collected in 1928
Pietschmann, 1938	Reports fishes collected in 1927 or 1928
Ikehara, 1953	Reports on POFI visits
June and Reintjes, 1953	Lists tuna-bait fishes from POFI data
Strasberg, 1956	Records 3 blennioid fish species
Gosline and Brock, 1965	Includes fish from earlier records
2. Reptilia	
Walker, 1909	Records turtles present in 1891
Wetmore, ms.	Lists turtles seen in 1923
Hornell, 1934	Reports turtles slaughtered in 1882
Munro, 1941a	Reports turtles present in 1891
POFI (1948-1966) mss.	Consists of trip reports listing turtle observations
Svihla, 1957	Lists turtles seen in 1956
Parsons, 1962	Records occurrence of turtles
Carr, 1964	Records visit in 1956
Hendrickson, 1969	Presents population estimate and movement data from POBSP
Laycock, 1970b	Notes presence of turtles
3. Mammalia	
Brooks, 1860	Notes presence of seals in 1859
Elschner, 1915	Lists seals in 1859
Wetmore, ms.	Reports whale skeleton on beach in 1923

Appendix Table 2. (continued)

3. Mammalia (cont.)

Farrell, 1928	Records seals in 1886
POFI (1948-1966) mss.	Includes trip reports listing seal counts
Anon., 1951	Reports 1st Hawaiian Monk Seal to be kept in zoo
Bailey, 1952	Reports 1951 seal population
Richardson, 1954a	Presents seal records from October 1953
Richardson, 1954b	Presents seal records from December 1953 and March 1954
King, 1956	Summarizes seal information
Svihla, 1957	Reports dogs, cats and seals during 1956
Kenyon and Rice, 1959	Reports 1956 and 1957 seal observations by POFI personnel
Svihla, 1959	Reports 1956 observations on seals
Rice, 1960a	Reports results of 1957 and 1958 seal survey
Rice, 1960b	Reports observation of <u>Tursiops</u>
Krauss, 1965	Reports cat on Tern
Tomich, 1969	Reports cat, seal and porpoise
Laycock, 1970b	Notes presence of turtles
4. Aves	
Rothschild, 1893-1900	Notes birds of the atoll from 1891
Fisher, 1903	Records new species seen on 1902 Albatross Expedition
Fisher, 1906	Observes 12 species on 1902 Albatross Expedition

Appendix Table 2. (continued)

4. Aves (cont.)

Wetmore, ms.	Lists bird species observed in 1923
Hornell, 1934	Records taking of albatross down in 1882
Munro, 1941a	Lists birds seen in 1891
Munro, 1941b	Lists birds seen in 1891
Munro, 1944	Lists birds from atoll
POFI (1948-1966) mss.	Consists of trip reports listing birds observed
Wilder, 1949	Reports both albatrosses
Richardson, 1954a	Reports 17 species seen October 1953
Richardson, 1954b	Reports 15 species seen December 1953 and March 1954
Richardson, 1957	Lists birds that breed and/or occur
Svihla, 1957	Reports seeing 7 species during February 1956
Warner, 1958	Notes Sooty Tern carcasses
HDFG (1960-1961) mss.	Includes six trip reports of Refuge surveys
Udvardy, 1961b	Notes 6 species in September 1961
Rice and Kenyon, 1962	Reports 1957-1958 population of albatrosses
POBSP (1963-1969) mss.	Includes 11 trip reports from island surveys
BSFW (1964-1969) mss.	Includes 12 trip reports of Refuge surveys
Udvardy and Warner, 1964	Notes 6 species in September 1961
Gould and King, 1967	Reports 1 accidental species from POBSP data
Clapp and Woodward, 1968	Lists 11 species, including 7 new records from POBSP data

Appendix Table 2. (continued)

4. Aves (cont.)

- | | |
|----------------------------|---------------------------------------------|
| Sibley and McFarlane, 1968 | Lists 2 gulls from POBSP data |
| Berger, 1970 | Notes 12 species on various islands in 1966 |
| Laycock, 1970a | Notes presence of birds |

FLORA

1. Vascular plants

- | | |
|-------------------------------|------------------------------------------------------------------------------------|
| Christophersen and Caum, 1931 | Reports 6 plant species from 1923 Tanager Expedition |
| Lamoureux, 1961 | Presents historical review of atoll's plants; records 22 species in September 1961 |
| Lamoureux, 1964 | Presents historical review of atoll's plants |
| Force, 1965 | Mentions trip by Lamoureux and deposit of 23 herbarium specimens |

2. Algae

- | | |
|--------------|-------------------------------------------------------------------------------------------------------------------------------|
| Taylor, 1964 | Reports 1 algae species collected 18 December 1936 |
| Tsuda, 1966 | Reports 9 marine benthic algae species collected July 1924 and September 1964, and lists an earlier record of another species |

GEOPHYSICAL

- | | |
|----------------------------|-------------------------------------------------------|
| Washington and Keyes, 1926 | Analyzes La Perouse rock from 1923 Tanager collection |
| Palmer, 1927 | Observes geology of the atoll from 1923 observations |

Appendix Table 3. Annotated list of vascular plants from French Frigate Shoals found in the herbarium of the United States National Museum (USNM), the Bernice P. Bishop Museum (BPBM), and the University of Hawaii (UH)

Gramineae

- *Cenchrus echinatus L. Specimens only from Tern; known from East and Trig. Lamoureux 1661 (BPBM); Long 2506 (UH).
- *Cynodon dactylon (L.) Pers. Specimens only from Tern. Lamoureux 1673 (BPBM); Long (UH).
- *Eleusine indica (L.) Gaertn. Specimens only from Tern. Lamoureux 1662 (BPBM); Svihla (BPBM); Long 2512 (UH).
- Eragrostis whitneyi Fosb. Specimens only from Tern. Long 2504 (UH).
- Lepturus repens (Forst.) R. Br. Specimens from East, Tern, Trig and Whale-Skate; known from Little Gin and Round. Caum 88 (BPBM); Lamoureux 1668, 1674 (BPBM); Rainwater (BPBM); Svihla (BPBM); Amerson 1, 2 (USNM); Long 2465-68, 2479-80, 2490-91, 2502, 2513 (UH).
- *Setaria verticellata (L.) Beauv. Specimens from Tern and Trig. Lamoureux 1669, 1670 (BPBM); Rainwater (BPBM); Svihla (BPBM); Long 2469, 2476, 2499 (UH); and Amerson 3, 4 (USNM).

Cyperaceae

Fimbristylis cymosa R. Br. Specimen only from Tern. Long 2511 (UH).

Palmae

- *Cocos nucifera L. Sprouted nuts planted on East and Tern in 1923 by Tanager Expedition personnel (Wetmore, ms.); unsuccessful introduction. Reintroduced since 1942; known from East and Tern. No specimen records.
- *Livistona australis Mort. Seed planted on East by Tanager Expedition personnel in 1923 (Wetmore, ms.); unsuccessful introduction. No specimen records.
- *Pritchardia gaudichaudii Hbd. Seed planted on East in 1923 by Tanager Expedition personnel (Wetmore, ms.); unsuccessful introduction. No specimen records.

Appendix Table 3. (continued)

Palmae (cont.)

- *Pritchardia pacifica Wendl. Seed planted on East and Tern in 1923 by Tanager Expedition personnel (Wetmore, ms.); unsuccessful introduction. No specimen records.

Moraceae

- *Ficus sp. Specimen only from Tern. Lamoureux 1659 (BPBM).

Casuarinaceae

- *Casuarina equisetifolia L. Seed planted on East and Tern in 1923 by Tanager Expedition personnel (Wetmore, ms.); unsuccessful introduction. Reintroduced on Tern since 1942; specimens only from Tern. Lamoureux 1651 (BPBM).

Chenopodiaceae

- *Atriplex muelleri Benth. Specimens only from Tern. Lamoureux 1654 (BPBM); Rainwater (BPBM).

- Chenopodium oahuensis (Meyen) Aellen. Specimens from East, Tern, Trig and Whale-Skate. Caum 89 (BPBM); Long 2470, 2472, 2482, 2492 (UH); Amerson 5, 6 (USNM).

- *Salicornia virginica L. Specimen known only from Tern. Herbst 1213 (USNM).

Polygonaceae

- *Cocoloba uvifera (L.) Jacq. Specimens only from Tern. Svihla (BPBM); Lamoureux 1660 (BPBM).

Nyctaginaceae

- Boerhavia repens L. Specimens from East, Tern, Trig and Whale-Skate; known from Little Gin, Round and Shark. Caum 86, 87 (BPBM); Judd 9 (BPBM); Lamoureux 1671, 1675 (BPBM); Rainwater (BPBM); Svihla (BPBM); Long 2464, 2471, 2474, 2477, 2493, 2494, 2508 (UH); and Amerson 7, 8 (USNM).

Portulacaceae

- Portulaca lutea Sol. Specimens from East, Tern, Trig and Whale-Skate; known from Gin, Little Gin and Round. Caum 90 (BPBM); Lamoureux 1667 (BPBM); Rainwater (BPBM); Svihla (BPBM); Long 2473, 2483, 2495 (UH); and Amerson 9, 10 (USNM).

Appendix Table 3. (continued)

Portulacaceae (cont.)

Portulaca oleracea L. Specimens only from Tern. Lamoureux 1666
(BPBM); Long (UH); Rainwater (BPBM).

Cruciferae

*Coronopus didymus (L.) J.E. Smith. Specimen only from Tern. Long
(UH).

Caryophyllaceae

*Spergularia marina (L.) Griseb. Specimen only from Tern. Svihla
(BPBM); Lamoureux 1663 (BPBM).

Leguminosae

*Haematoxylon campichianum L. Seed planted on East in 1923 by
Tanager Expedition personnel (Wetmore, ms.); unsuccessful intro-
duction. No specimen records.

Zygophyllaceae

Tribulus cistoides L. Specimens from East, Tern, Trig and Whale-
Skate; known from Round. Caum 85 (BPBM); Lamoureux 1652 (BPBM);
Rainwater (BPBM); Svihla (BPBM); Long 2461, 2496, 2501 (UH); and
Amerson 11, 12 (USNM).

Euphorbiaceae

*Euphorbia thymifolia L. Specimens only from Tern. Long 2498 (UH).

*Euphorbia prostrata Ait. Specimens only from Tern. Long 2505 (UH).

Malvaceae

*Hibiscus tiliaceus L. Planted in 1923 on East and Tern by Tanager
Expedition personnel (Wetmore, ms.); unsuccessful introduction.
No specimen record.

*Thespesia populnea (L.) Sol. Seed planted on East and Tern by Tanager
Expedition personnel in 1923 (Wetmore, ms.); unsuccessful intro-
duction. No specimen records.

Guttiferae

*Calophyllum inophyllum L. Seed planted on East and Tern in 1923 by
Tanager Expedition personnel (Wetmore, ms.); unsuccessful intro-
duction. No specimen records.

Appendix Table 3. (continued)

Frankeniaceae

- *Frankenia grandifolia C. and S. Specimen known from Tern only.
Herbst 1217 (USNM).

Lecythidaceae

- *Barringtonia asiatica (L.) Kurn. Specimen from Tern only. Svihla
(BPBM). A single leaf only.

Apocynaceae

- *Plumeria obtusa L. Specimen only from Tern. Lamoureux 1650 (BPBM).

Convolvulaceae

- Ipomoea pes-caprae (L.) Sw. Specimens from East and Tern. Caum 91
(BPBM); Lamoureux 1658 (BPBM); Rainwater (BPBM); Long 2509 (UH).

Roraginaceae

- *Tournefortia argentea L. f. Specimens from East, Tern, Trig and
Whale-Skate. Lamoureux 1653 (BPBM); Rainwater (BPBM); Long 2463,
2487, 2489, 2503 (UH); and Amerson 13, 14 (USNM).

Solanaceae

- *Solanum lycopersicum L. Known only from Tern. No specimens collected.

Goodeniaceae

- Scaevola taccada (Gaertn.) Roxb. Specimens from East, Tern, Trig and
Whale-Skate. Lamoureux 1656 (BPBM); Rainwater (BPBM); Long 2462,
2475 (UH).

Compositae

- *Conyza bonariensis (L.) Cronq. Specimens only from Tern. Lamoureux
1655, 1665 (BPBM); Long 2497 (UH).
- *Lactuca sp. Known from Tern. Blooming plant observed by Richardson
(1954b: 73) on 18 December 1953. No specimen records.
- *Pluchea odorata (L.) Cass. Specimens only from Tern. Known from
East in 1953. Lamoureux 1657, 1672 (BPBM); Rainwater (BPBM);
Svihla (BPBM); Long 2510 (UH).
- *Sonchus oleraceus L. Specimens from Tern and East. Lamoureux 1664
(BPBM); Svihla (BPBM); Long 2500 (UH); and Amerson 15 (USNM).

Appendix Table 4a. Black-footed Albatross movement from French Frigate Shoals

<u>Band No.</u>	<u>Date</u>	<u>Age Sex*</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex*</u>
<u>East Island</u>					
737-30851	06-07-63	L - U	At Sea 41°2'N x 133°5'W	09-06-63	U - U
737-35732	06-08-63	L - U	Kure Atoll	12-08-68	A - U (on egg)
737-35772	06-08-63	L - U	At Sea 30°20'N x 119°50'W	07-12-64	U - U
737-35798	06-08-63	L - U	At Sea	07-25-65	U - U
737-35877	06-08-63	L - U	At Sea 37°50'N x 179°00'E	10-22-63	U - U
737-37004	06-08-63	L - U	Southeast, Pearl and Hermes Reef	03-21-67	A - U
757-26257	06-12-66	L - U	At Sea 33°23'N x 122°18'W	01-21-67	S - ♀
757-26297	06-12-66	L - U	Kure Atoll	05-09-69	A - U
757-26385	06-12-66	L - U	At Sea 42°11'N x 155°18'W	07-25-68	U - U
757-26931	06-19-66	L - U	At Sea 53°54'N x 162°38'W	08-15-67	U - U
757-26936	06-19-66	L - U	Hokkaido, Japan 43°00'N x 145°03'E	08-29-66	U - U
<u>Whale-Skate Island</u>					
737-38227	06-12-63	L - U	Cypress Point, Calif. 36°03'N x 121°05'W	06-26-64	U - U
737-38266	06-12-63	L - U	At Sea 48°30'N x 140°33'W	10-18-64	U - U

*A = adult; I = immature; L = local; N = nestling; S = subadult;
U = unknown

Appendix Table 4a. (continued)

Band No.	Date	Age Sex	Island Recaptured:	Date	Age Sex
<u>Whale-Skate Island</u>					
737-38344	06-12-63	L - U	At Sea 48°15'N x 126°30'W	04-29-65	U - U
737-38376	06-12-63	L - U	At Sea 47°00'N x 141°01'W	05-06-66	U - U
757-35913	06-05-67	L - U	Laysan	09-24-67	U - U
757-35955	06-05-67	L - U	Laysan	09-24-67	U - U

Appendix Table 4b. Black-footed Albatross movement to French Frigate Shoals

Band No.	Date	Age Sex	Island Recaptured:	Date	Age Sex
<u>Pearl and Hermes Reef</u>					
737-32806	03-08-63	N - U	East	06-10-69	A - U
737-25406	06-24-63	L - U	Trig	03-22-66	U - U

Appendix Table 5a. Blue-faced Booby movement from French Frigate Shoals

Band No.	Date	Age Sex	Island Recaptured:	Date	Age Sex
<u>East Island</u>					
737-37103	06-07-63	S - U	Sand, Johnston	02-13-64	A - U
737-37104	06-07-63	S - U	Sand, Johnston	02-28-65	A - U
737-37106	06-07-63	S - U	Laysan	03-18-68	A - ♂
737-37107	06-07-63	S - U	Laysan	03-09-65	U - U
757-26182	06-11-66	A - U	Pearl and Hermes Reef	05-28-67	A - U (found dead)
757-27685	08-23-66	A - U	East	05-26-67	A - ♂
			Laysan	09-06-67	A - U
568-71887	06-12-67	L - U	Sand, Johnston	08-09-68	S - U

Appendix Table 5a. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Gin Island</u>					
558-82649	06-09-63	N - U	Sand, Johnston	04-13-65	A - U (dead)
558-82653	06-09-63	N - U	At Sea 16°02'N x 171°01'E	04-18-65	A - ♂ (dead)
568-72322	08-25-65	L - U	Kure Atoll	05-20-66	S - U
<u>Trig Island</u>					
558-82962	06-14-63	N - U	Sand, Johnston	01-20-65	A - U (dead)
558-83427	06-15-63	A - U	Lisianski	03-12-65	U - U
			Trig	06-28-67	A - ♀ (on chick)
			Trig	06-24-68	A - ♀ (on chick)
			Trig	06-24-69	
568-72302	08-16-65	I - U	Sand, Johnston	05-05-67	A - ♀
568-70186	07-04-66	N - U	At Sea 36°00'N x 168°01'W	12-20-67	U - U
568-71818	06-09-67	N - U	Kure Atoll	07-16-68	S - U
568-71822	06-09-67	N - U	Kure Atoll	07-24-68	S - U
568-71825	06-09-67	L - U	Nihoa	08-24-68	U - U (dead)
568-70800	06-22-68	L - U	Sand, Johnston	04-22-69	S - U
<u>Whale-Skate Island</u>					
558-82809	06-12-63	N - U	Sand, Johnston	02-26-65	A - ♀
			Whale-Skate	06-06-67	A - ♀
558-82875	06-12-63	N - U	Sand, Johnston	02-26-65	A - U

Appendix Table 5a. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Whale-Skate Island</u>					
558-82880	06-12-63	N - U	Sand, Johnston	04-08-64	S - U
			Whale-Skate	06-21-68	A - U
			Whale-Skate	06-17-69	A - ♂ (on chick)
558-82909	06-12-63	N - U	Sand, Johnston	04-08-64	S - U
558-83233	06-13-63	A - ♂	At Sea 19°02'N x 163°03'E	02-17-64	A - U (dead)
568-71265	08-13-65	N - U	Sand, Johnston	03-20-66	S - U
			Sand, Johnston	05-24-66	S - U
568-71275	08-14-65	I - U	Sand, Johnston	05-11-66	S - U
568-71893	06-17-67	L - U	Kure Atoll	04-21-69	S - U
568-72457	06-17-68	L - U	Sand, Johnston	05-31-69	S - U
568-72732	06-18-69	L - U	Kaena Point, Kauai	01-08-70	U - U (dead)

Appendix Table 5b. Blue-faced Booby movement to French Frigate Shoals

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Johnston Atoll, Sand Island</u>					
737-44193	02-26-65	A - U	Trig	06-08-67	A - ♀ (on egg)
			Whale-Skate	06-22-69	A - ♀
737-44199	02-27-65	A - U	Whale-Skate	08-14-65	A - U
737-44731	04-22-65	S - U	Whale-Skate	06-20-68	A - ♂
			Trig	06-24-69	A - ♂
<u>Kure Atoll, Green Island</u>					
737-92943	06-02-65	L - U	East	05-27-67	A - ♀

Appendix Table 5b. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Kure Atoll, Green Island</u>					
737-92943	06-02-65	L - U	Kure Atoll	11-30-68	A - ♂
			Kure Atoll	06-10-69	A - ♂
<u>Laysan Island</u>					
757-23150	07-19-65	U - U	Little Gin	06-07-69	A - ♀ (with chick)
<u>Lisianski Island</u>					
587-80221	08-21-64	I - U	Whale-Skate	06-21-68	A - ♀
587-80277	08-22-64	I - U	East	08-05-65	A - U
			East	06-10-66	A - U
<u>Pearl and Hermes Reef, North Island</u>					
558-83080	06-23-63	A - U	Whale-Skate	08-16-65	A - ♀
			Whale-Skate	06-26-66	A - ♀
			Whale-Skate	06-03-67	A - ♀
<u>Wake Atoll, Wilkes Island</u>					
767-48248	06-19-66	S - U	East	05-26-67	A - ♂

Appendix Table 6a. Red-footed Booby movement from French Frigate Shoals

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>East Island</u>					
737-30792	06-07-63	A - U	East	08-05-65	A - U
			Kure Atoll	06-27-67	A - U
737-38012	06-08-63	A - U	Johnston Atoll	02-22-66	A - ♀
			East	06-10-66	A - U

Appendix Table 6a. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>East Island</u>					
767-43003	08-05-65	N - U	Johnston Atoll	02-22-66	I - U
			East	06-11-66	S - U
767-43027	08-05-65	N - U	Johnston Atoll	03-31-66	S - U
767-43028	08-05-65	N - U	Lisianski	10-19-66	S - U
			East	06-06-68	A - U
767-43032	08-05-65	I - U	Johnston	04-15-66	I - U
767-43036	08-05-65	I - U	At Sea 16°12'N x 170°22'W	01-30-66	I - ♂
767-43042	08-05-65	I - U	Johnston Atoll	02-23-66	I - U
			East	08-20-66	S - U
767-43043	08-05-65	I - U	Johnston Atoll	02-23-66	I - U
			Johnston Atoll	06-12-66	S - U
767-43050	08-05-65	S - U	Lisianski	10-19-66	S - U
767-43067	08-05-65	I - U	Johnston Atoll	02-23-66	I - U
			East	06-10-66	S - U
			East	08-23-66	S - U
			East	05-30-67	S - U
			East	06-06-68	A - U
			East	06-05-69	A - U
767-43068	08-05-65	I - U	Johnston Atoll	04-15-66	I - U
767-43085	08-05-65	S - U	Johnston Atoll	04-15-66	S - U
			Lisianski	10-19-66	S - U
767-43098	08-05-65	I - U	Eastern Midway	06-13-66	S - U
767-43103	08-05-65	S - U	East	06-11-67	S - U

Appendix Table 6a. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>East Island</u>					
767-43103	08-05-65	S - U	Lisianski	10-19-66	S - U
767-43115	08-05-65	S - U	Johnston Atoll	07-13-66	S - U
767-43136	08-05-65	A - U	Johnston Atoll	03-21-66	I - U
			Whale-Skate	06-23-66	A - U (on chick)
			Trig	06-08-67	A - U
767-43138	08-05-65	A - U	East	06-12-66	A - U
			Johnston Atoll	04-21-67	A - U
767-43147	08-05-65	I - U	Johnston Atoll	05-27-66	S - U
767-43185	08-05-65	I - U	Johnston Atoll	05-11-66	S - U
767-43257	08-06-65	I - U	Johnston Atoll	03-24-66	I - U
767-43301	08-07-65	S - U	East	06-11-66	A - U
			Laysan	10-20-66	A - U
			Laysan	09-07-67	A - U
767-43325	08-08-65	S - U	Kure Atoll	06-22-66	S - U
767-43328	08-08-65	I - U	Johnston Atoll	03-21-66	I - U
767-43662	08-23-65	A - U	Johnston Atoll	04-15-66	I - U
767-43851	08-25-65	S - U	Laysan	10-22-66	S - U
			Trig	06-19-67	S - U
767-43878	08-26-65	I - U	Johnston Atoll	05-03-66	S - U
			Trig	06-19-67	A - U
			Whale-Skate	06-17-68	A - U (on egg)
			Whale-Skate	06-16-69	A - ♀

Appendix Table 6a. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>East Island</u>					
757-26028	06-10-66	S - U	Lisianski	10-19-66	S - U
757-26078	06-10-66	S - U	Kure Atoll	07-02-67	A - U
757-26094	06-10-66	A - U	Laysan	09-10-67	A - U
757-26100	06-10-66	A - U	Southeast, Pearl and Hermes	03-22-67	A - U (on egg)
			Southeast, Pearl and Hermes	03-31-67	A - U
757-26106	06-11-66	N - U	East	06-05-69	A - U
			Johnston Atoll	05-12-67	S - U
757-26107	06-11-66	N - U	Johnston Atoll	04-03-67	S - U
757-26113	06-11-66	N - U	Johnston Atoll	05-06-67	S - U
757-26118	06-11-66	N - U	Johnston Atoll	05-12-67	S - U
757-26126	06-11-66	N - U	East	06-10-67	S - U
			Johnston Atoll	05-12-67	S - U
757-26127	06-11-66	N - U	Johnston Atoll	02-24-67	I - U
757-26141	06-11-66	N - U	Johnston Atoll	05-12-67	S - U
757-26159	06-11-66	S - U	Johnston Atoll	04-03-67	S - U
757-26175	06-11-66	S - U	Laysan	09-07-67	A - U
757-26187	06-11-66	A - U	Laysan	10-20-66	A - U
757-26472	06-13-66	S - U	Kure Atoll	04-19-69	A - U
757-26478	06-16-66	S - U	Kure Atoll	07-20-68	S - U
757-26498	06-16-66	A - U	Mokapu Point, Oahu	05-02-67	A - U (dead)
757-26786	06-16-66	A - U	East	05-26-67	A - U
			Lisianski	10-19-66	A - U

Appendix Table 6a. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>East Island</u>					
757-26803	06-17-66	S - U	East	06-10-67	S - U
			Johnston Atoll	02-21-67	S - U
757-27641	08-18-66	I - U	East	06-14-68	S - U
			Johnston Atoll	07-05-67	S - U
757-27648	08-19-66	S - U	Johnston Atoll	05-06-67	S - U
757-27651	08-19-66	S - U	Kure Atoll	07-30-68	A - U
757-29061	05-26-67	I - U	Johnston Atoll	01-04-69	A - U
757-29135	05-28-67	A - U	At Sea 18°35'N x 164°18'W	02-11-68	A - ♀ (dead)
757-36120	06-11-67	A - U	Kure Atoll	01-14-69	A - U
757-36152	06-12-67	N - U	Johnston Atoll	09-19-68	S - U
757-43160	06-09-68	N - U	Kure Atoll	06-06-69	S - U
757-43169	06-09-68	L - U	Johnston Atoll	06-15-69	S - U
757-43171	06-09-68	L - U	Johnston Atoll	03-19-69	S - U
757-43182	06-09-68	L - U	Johnston Atoll	06-15-69	S - U
757-43196	06-09-68	L - U	Johnston Atoll	08-08-69	S - U
757-35415	06-15-68	A - U	Kure Atoll	12-15-68	A - U
<u>Trig Island</u>					
767-43605	08-16-65	I - U	East	06-16-66	S - U
			Johnston Atoll	04-03-67	S - U
767-43608	08-16-65	N - U	Johnston Atoll	03-24-66	I - U
767-43615	08-16-65	I - U	Johnston Atoll	04-22-66	S - U
757-27495	07-03-66	S - U	Laysan	09-08-67	A - U

Appendix Table 6a. (continued)

Band No.	Date	Age Sex	Island Recaptured:	Date	Age Sex
<u>Trig Island</u>					
757-27502	07-03-66	S - U	Lisianski	10-19-66	S - U
			East	06-10-67	S - U
757-27551	07-04-66	N - U	Johnston Atoll	05-06-67	S - U
757-27615	08-13-66	S - U	Laysan	09-10-67	S - U
757-27618	08-13-66	S - U	Southeast, Pearl and Hermes	02-10-69	A - U
757-35819	06-08-67	A - ♀	Johnston Atoll	09-18-68	S - U
757-35801	06-08-67	A - U	Johnston Atoll	02-18-69	A - U
757-35854	06-08-67	S - U	Laysan	09-06-67	S - U
757-36552	06-19-67	N - U	Johnston Atoll	03-10-68	U - U (dead)
757-37036	06-18-68	L - U	Johnston Atoll	05-17-69	S - U
757-37972	06-22-68	L - U	Johnston Atoll	06-25-69	S - U
757-37982	06-22-68	N - U	Kure Atoll	06-17-69	S - U
757-37983	06-22-68	L - U	Johnston Atoll	04-01-69	S - U (dead)
757-37999	06-22-68	L - U	Johnston Atoll	05-17-69	S - U
757-37025	06-24-68	L - U	Johnston Atoll	05-11-69	S - U
757-37047	06-24-68	L - U	Johnston Atoll	08-30-69	S - U
757-37051	06-25-68	L - U	Johnston Atoll	06-16-69	S - U
<u>Whale-Skate Island</u>					
737-38030	06-14-63	S - U	Kure Atoll	09-06-66	A - U
			Eastern, Midway	04-26-68	A - U (on egg)

Appendix Table 6a. (continued)

Band No.	Date	Age Sex	Island Recaptured:	Date	Age Sex
<u>Whale-Skate Island</u>					
737-38033	06-14-63	S - U	Whale-Skate	06-23-66	A - U
			Laysan	10-20-66	A - U
767-43620	08-16-65	I - U	Johnston Atoll	05-19-66	S - U
767-43982	08-31-65	S - U	Lisianski	10-19-66	A - U
			Lisianski	08-31-67	A - U
757-27135	06-23-66	S - U	Johnston Atoll	05-06-67	S - U
757-27251	06-24-66	A - U	Laysan	10-21-66	A - U
757-27347	06-26-66	N - U	Johnston Atoll	05-06-67	S - U
			Whale-Skate	06-17-68	S - U
757-36462	06-17-67	N - U	Johnston Atoll	06-17-68	S - U
757-36470	06-17-67	N - U	Johnston Atoll	06-17-69	S - U
			Johnston Atoll	06-25-69	S - U
757-36478	06-17-67	S - U	Kure Atoll	12-19-68	A - U
757-35426	06-17-68	S - U	Kure Atoll	07-18-68	S - U
757-35439	06-18-68	L - U	Johnston, Johnston Atoll	04-??-69	U - U (dead)
757-35442	06-18-68	L - U	Johnston Atoll	05-17-69	S - U
757-35447	06-18-68	L - U	Johnston Atoll	03-19-69	I - U

Appendix Table 6b. Red-footed Booby movement to French Frigate Shoals

Band No.	Date	Age Sex	Island Recaptured:	Date	Age Sex
<u>Johnston Atoll, Sand Island</u>					
737-44131	02-12-64	S - U	East	08-06-65	A - U
			East	06-17-66	A - U

Appendix Table 6b. (continued)

Band No.	Date	Age Sex	Island Recaptured:	Date	Age Sex
<u>Johnston Atoll, Sand Island</u>					
737-44145	02-12-64	I - U	Johnston Atoll	06-15-65	S - U
			East	08-15-65	A - U
			East	06-10-66	A - U
737-44156	02-26-64	I - U	East	06-10-66	A - U
			Laysan	10-20-66	A - U
			East	05-27-67	A - U (on chick)
737-44161	03-05-64	I - U	East	06-10-66	A - U
737-44577	03-30-65	I - U	East	06-05-69	A - U
737-44705	04-14-65	I - U	Whale-Skate	08-23-65	S - U
737-44706	04-14-65	I - U	East	06-19-66	S - U
737-44747	05-04-65	I - U	East	08-05-65	I - U
737-44755	05-18-65	I - U	East	08-05-65	S - U
737-44756	05-18-65	I - U	East	08-05-65	S - U
737-44764	05-23-65	I - U	East	06-12-66	S - U
			Trig	06-24-69	A - U
737-44786	05-26-65	I - U	East	08-05-65	S - U
			Johnston Atoll	04-15-66	S - U
			East	06-11-66	S - U
			East	05-29-67	A - U (on egg)
			East	06-06-68	A - U (on chick)
737-44812	06-02-65	I - U	East	08-23-65	S - U

Appendix Table 6b. (continued)

Band No.	Date	Age Sex	Island Recaptured:	Date	Age Sex
<u>Johnston Atoll, Sand Island</u>					
737-44818	06-02-65	I - U	East	08-05-65	S - U
			Trig	06-08-67	A - U
737-44828	06-10-65	I - U	East	08-25-65	S - U
737-44838	06-18-65	I - U	East	08-26-65	S - U
			East	10-11-66	S - U
737-44840	06-18-65	I - U	East	06-12-66	S - U
737-44847	06-24-65	I - U	East	08-24-65	S - U
737-44947	12-11-65	A - U	East	06-12-66	A - U
737-44953	12-12-65	A - U	Trig	06-08-67	A - U
			Trig	06-24-68	A - U (on chick)
737-43522	02-17-66	I - U	Whale-Skate	06-06-67	S - U
737-43526	02-19-66	I - U	Whale-Skate	06-26-66	S - U
737-43537	02-19-66	S - U	East	08-19-66	S - U
			East	05-27-67	A - U
737-43561	02-22-66	S - U	East	06-10-66	S - U
737-43564	02-22-66	S - U	Whale-Skate	06-28-66	S - U
737-43570	02-22-66	S - U	East	05-26-67	A - U
			Kure Atoll	01-09-69	A - U
737-43584	02-22-66	S - U	East	06-12-66	S - U
			Whale-Skate	06-03-67	A - U
737-43594	02-22-66	I - U	Whale-Skate	06-18-67	S - U

Appendix Table 6b. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Johnston Atoll, Sand Island</u>					
737-43608	02-25-66	A - U	Trig	06-19-67	A - U
			Whale-Skate	06-18-68	A - U (on egg)
737-43659	03-24-66	I - U	East	06-11-67	S - U
737-43660	03-24-66	A - U	East	06-12-66	S - U
737-43697	04-03-66	I - U	East	06-10-66	S - U
			Whale-Skate	06-05-67	S - U
737-43708	04-10-66	I - U	Whale-Skate	06-02-67	I - U
737-43709	04-10-66	I - U	East	06-10-67	S - U
737-43772	04-22-66	S - U	East	06-11-66	S - U
737-43804	04-23-66	S - U	Whale-Skate	06-22-69	A - U
737-43807	04-23-66	S - U	East	05-26-67	S - U
737-43815	04-23-66	I - U	East	06-12-66	S - U
737-43910	06-07-66	I - U	East	05-26-67	S - U
737-43923	06-12-66	S - U	Whale-Skate	06-02-67	S - U
587-90358	03-03-67	S - U	Whale-Skate	06-02-67	S - U
587-90371	03-14-67	S - U	East	05-27-67	S - U
587-90384	03-29-67	A - U	Whale-Skate	06-16-67	A - U
			Trig	06-24-68	A - U (on chick)
587-92333	06-16-69	S - U	Trig	06-24-69	S - U
<u>Kauai, Kilauea Point</u>					
597-12603	03-26-64	A - U	East	06-12-66	A - U
			East	03-11-67	A - U

Appendix Table 6b. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Kauai, Kilauea Point</u>					
597-12485	07-07-64	N - U	East	05-29-67	S - U
757-89226	07-07-64	N - U	East	08-05-65	S - U
587-80787	05-05-65	N - U	East	06-11-66	S - U
767-45028	09-03-65	I - U	East	06-11-67	S - U
587-84929	07-14-67	N - U	Trig	06-24-68	S - U
<u>Kure Atoll</u>					
697-70758	08-08-62	L - U*	Whale-Skate	06-12-63	S - U
737-45396	09-28-63	I - U	Whale-Skate	06-27-66	A - U
737-98440	07-25-64	L - U	Johnston Atoll	02-24-65	I - U
			East	08-05-65	S - U
737-98480	09-08-64	I - U	Whale-Skate	08-29-65	S - U
737-98180	11-11-64	I - U	Kure Atoll	12-23-64	I - U
			East	05-27-67	S - U
			Kure Atoll	06-27-68	A - U
737-95932	12-12-64	I - U	Whale-Skate	06-27-66	S - U
			Kure Atoll	06-27-68	A - U
737-99674	08-28-66	N - U	East	06-06-68	I - U
737-99721	08-30-66	N - U	Trig	06-08-67	I - U
767-50767	07-08-67	N - U	Trig	06-24-68	S - U
767-50799	07-08-67	N - U	Whale-Skate	06-20-68	S - U
767-50991	07-07-67	N - U	East	06-06-68	I - U
767-51409	07-23-68	N - U	Trig	06-23-69	S - U
767-51426	07-27-68	N - U	Trig	06-23-69	S - U

* Banded by C.S. Robbins

Appendix Table 6b. (continued)

Band No.	Date	Age Sex	Island Recaptured:	Date	Age Sex
<u>Laysan Island</u>					
587-80553	09-17-64	A - U	East	06-11-66	A - U (on chick)
			East	03-11-64	A - U
			East	05-28-67	A - U
			Trig	06-24-68	A - U (on chick)
587-80575	09-17-64	I - U	Trig	08-13-66	S - U
			East	08-23-66	A - ♀
			Whale-Skate	06-05-67	A - U
587-80580	09-17-64	I - U	Whale-Skate	08-31-65	S - U
587-80643	09-17-64	I - U	Whale-Skate	08-16-65	S - U
587-80700	09-17-64	A - U	East	06-12-66	S - U
767-41241	03-08-65	A - U	East	06-10-66	A - U
			East	05-26-67	A - U (on egg)
767-41401	03-10-65	A - U	Trig	06-24-68	A - U
767-41411	03-10-65	A - U	East	06-12-66	A - U
			Laysan	10-20-66	A - U
767-41469	03-10-65	A - U	Laysan	10-20-66	A - U
			Trig	06-19-67	A - U
757-25650	08-09-65	I - U	East	06-10-66	S - U
			Whale-Skate	07-02-66	S - U
			Trig	08-13-66	S - U
757-25667	08-09-65	I - U	Johnston Atoll	12-28-65	I - U
			Whale-Skate	08-15-66	S - U

Appendix Table 6b. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Laysan Island</u>					
757-25742	08-09-65	I - U	Whale-Skate	06-26-66	S - U
757-25754	08-09-65	I - U	East	06-10-66	S - U
			Lisianski	10-19-66	S - U
			Johnston Atoll	04-03-67	S - U
757-25759	08-09-65	I - U	East	05-26-67	S - U
757-25769	08-09-65	I - U	Whale-Skate	06-25-66	S - U
757-25843	08-09-65	I - U	Whale-Skate	06-04-67	S - U
757-25853	08-09-65	I - U	East	06-10-67	S - U
			Whale-Skate	06-17-67	S - U
757-25987	08-09-65	I - U	Whale-Skate	06-03-67	S - U
757-25693	08-10-65	I - U	Trig	06-08-67	S - U
757-25791	08-10-65	I - U	Whale-Skate	06-05-67	S - U
757-28513	10-22-66	A - U	Trig	06-08-67	A - U
757-28533	10-22-66	A - U	Trig	06-19-67	A - U
<u>Lisianski Island</u>					
757-27938	10-19-66	S - U	Whale-Skate	06-16-67	S - U
757-27968	10-19-66	S - U	East	06-10-67	A - U
757-28266	10-19-66	A - U	Johnston Atoll	04-12-67	S - U
			Whale-Skate	06-04-67	S - U
587-84330	08-31-67	I - U	East	06-06-68	I - U
587-91162	08-31-67	A - U	Whale-Skate	06-22-69	U - U
587-90247	09-01-67	L - U	Whale-Skate	06-16-69	S - U
587-90250	09-01-67	N - U	Whale-Skate	06-17-68	I - U
			Trig	06-23-69	S - U

Appendix Table 6b. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
587-90936	09-02-67	A - U	Trig	06-23-69	A - U
757-28757	09-03-67	I - U	Whale-Skate	06-17-68	S - U
<u>Midway Atoll, Eastern Island</u>					
767-40023	07-22-65	I - U	East	08-05-65	S - U
767-40242	07-22-65	N - U	East	06-06-68	A - U
767-40269	07-22-65	N - U	East	06-11-66	S - U
767-40293	07-22-65	N - U	East	06-12-66	S - U
			Whale-Skate	06-04-67	S - U
767-40186	07-24-65	N - U	Whale-Skate	06-06-67	S - U
767-40342	07-24-65	N - U	East	06-16-66	S - U
			Trig	08-13-66	S - U
<u>Oahu, Moku Manu</u>					
587-85450	09-26-67	N - U	Whale-Skate	06-17-68	I - U
757-60563	11-27-63	I - U	East	08-05-65	S - U
597-12722	07-05-64	N - U	Whale-Skate	08-29-65	S - U
597-12773	07-05-64	N - U	East	08-05-65	S - U
597-12775	07-05-64	N - U	East	08-05-65	I - U
767-42718	06-01-65	N - U	East	06-16-66	S - U
587-80384	07-14-65	A - U	East	06-13-66	S - U
767-47104	06-08-66	N - U	Whale-Skate	06-06-67	I - U
767-48529	07-14-66	N - U	Johnston Atoll	04-03-67	I - U
			Whale-Skate	06-05-67	I - U
767-48744	07-14-66	N - U	East	05-29-67	I - U

Appendix Table 6b. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Pearl and Hermes Reef, Southeast Island</u>					
737-30100	02-26-63	A - U	Kure Atoll	01-29-65	A - U
			Kure Atoll	06-09-67	A - U
			East	06-07-68	A - U
			Kure Atoll	07-24-68	A - U
<u>Pearl and Hermes Reef, North Island</u>					
587-80060	08-20-64	N - U	East	06-17-66	S - U
<u>Wake Atoll</u>					
747-55013	01-02-65	I - U	East	08-05-65	S - U
			Wake	12-30-66	A - U
747-55034	01-05-65	I - U	Trig	06-08-67	A - U (on nest)
747-55052	01-05-65	I - U	East	06-10-66	A - U
587-84494	12-31-66	S - U	Trig	06-24-69	A - U

Appendix Table 7a. Great Frigatebird movement from French Frigate Shoals

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>East Island</u>					
767-43172	08-05-65	A - ♀	Sand, Johnston	02-19-69	A - ♀
767-43690	08-23-65	A - ♀	Whale-Skate	06-02-67	A - ♀ (on chicks)
			Sand, Johnston	11-27-68	A - ♀
767-43767	08-24-65	A - ♀	Lisianski	09-02-67	A - ♀
767-43830	08-25-65	A - ♀	Sand, Johnston	09-09-67 to 03-13-68	A - ♀ (dead)

Appendix Table 7a. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>East Island</u>					
767-43855	08-26-65	I - U	Quezon, Philippines	11-11-67	U - U (dead)
757-26800	06-16-66	A - ♀	Sand, Johnston	10-12-68	S - ♀
757-26854	06-18-66	A - ♀	Lisianski	09-02-67	A - U(?)
757-27675	08-21-66	I - U	Green, Kure	06-26-67	S - U
757-36110	06-11-67	I - U	Green, Kure	06-11-69	S - U
<u>Trig Island</u>					
757-36527	06-19-67	A - ♀	Green, Kure	06-10-69	S - U
<u>Whale-Skate Island</u>					
737-37257	06-13-63	N - U	Sand, Johnston	04-01-68	S - ♀ (dead)
737-37278	06-13-63	N - U	Sand, Johnston	04-23-66	I - U
737-37295	06-13-63	N - U	Sand, Johnston	04-23-66	I - U
			Whale-Skate	07-02-66	I - U
			East	05-26-67	I - U
737-37326	06-13-63	N - U	Sand, Johnston	01-03-67	A - ♀ (dead)
737-37352	06-13-63	N - U	Sand, Johnston	05-28-66	S - U
			Whale-Skate	06-28-66	S - U (dead)
737-37356	06-13-63	N - U	Green, Kure	04-22-66	S - U
737-37366	06-13-63	N - U	Sand, Johnston	05-31-65	I - U
737-37382	06-13-63	N - U	Green, Kure	05-13-66	S - U
737-37466	06-14-63	S - U	East	06-12-67	S - ♀
			Lisianski	08-31-67	S - U
767-43430	08-13-65	N - U	Green, Kure	05-12-67	S - ♀

Appendix Table 7b. Great Frigatebird movement to French Frigate Shoals

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Johnston Atoll, Sand Island</u>					
697-69603	02-21-63	A - ♀ (on egg)	Whale-Skate	06-18-68	A - ♀ (on chick)
737-44950	02-11-65	I - U	East	05-27-67	S - ♀
737-44737	04-26-65	I - U	East	06-07-69	S - ♀
737-43713	04-10-66	I - U	East	06-11-66	I - U
737-44730	04-21-66	I - U	Trig	07-03-66	I - U (dead)
737-43873	05-11-66	I - U	Whale-Skate	07-02-66	I - U (dead)
<u>Kure Atoll, Green Island</u>					
667-39708	11-04-63	I - U	East	06-16-66	I - U
			Whale-Skate	06-04-67	S - ♀
737-95911	11-26-64	I - U	East	08-19-66	I - U
767-45410	04-20-66	S - U	Whale-Skate	06-05-67	I - U
767-45428	04-22-66	S - U	East	06-18-66	A - ♀
767-45463	05-06-66	S - U	Whale-Skate	06-19-69	S - U
767-45469	05-06-66	S - U	East	06-16-66	I - U
767-45658	05-23-66	S - U	Whale-Skate	06-25-66	I - U
767-50530	05-11-67	A - ♀	East	06-12-67	A - ♀
<u>Laysan Island</u>					
587-80708	09-20-64	A - ♀	Trig	06-24-69	A - ♀
757-25564	06-12-66	A - ♂(?)	East	05-30-67	A - ♀(?)
<u>Pearl and Hermes Reef, North Island</u>					
737-37178	06-23-63	N - U	Whale-Skate	09-29-65	I - U

Appendix Table 7b. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Wake Atoll</u>					
757-89782	05-05-65	I - U	Whale-Skate	06-23-66	I - U
757-28096	10-19-66	L - U	East	06-07-69	S - ♀
<u>Whale-Skate Island</u>					
767-43470	08-13-65	N - U	Sand, Johnston	06-12-69	S - U
767-43381	08-14-65	N - U	Green, Kure	05-27-67	S - U
767-43503	08-14-65	N - U	Whale-Skate	06-26-66	I - U
			Green, Kure	06-05-67	S - U
767-43591	08-15-65	A - ♂	Sand, Johnston	11-16-65	A - ♂ (dead)
587-91315	06-02-67	I - U	Green, Kure	06-10-69	S - U
587-91316	07-02-67	I - U	Sand, Johnston	10-12-68	S - ♀
			Irwin, Eniwetok	12-01-68	S - ♀
587-91326	06-02-67	I - U	Sand, Johnston	07-13-69	S - U
587-91330	06-02-67	I - U	Sand, Johnston	10-16-68	S - U
587-91345	06-02-67	I - U	Sand, Johnston	10-14-68	S - U
587-91361	06-02-67	I - U	Sand, Johnston	07-18-69	S - U
587-91381	06-02-67	A - ♂	Sand, Johnston	06-12-69	A - ♂
757-29279	06-02-67	A - ♀	Sand, Johnston	02-05-69	A - ♀ (dead)
757-29282	06-02-67	A - ♂	Sand, Johnston	10-22-68	A - ♂
757-35574	06-03-67	A - ♂	Sand, Johnston	11-25-68	A - ♂ (dead)
757-35674	06-04-67	A - ♀	Sand, Johnston	01-04-68	U - U (dead)
757-36475	06-17-67	I - U	Green, Kure	06-10-69	S - U
757-37944	06-21-68	L - U	Sand, Johnston	07-15-69	S - U

Appendix Table 8. Ruddy Turnstone movement to French Frigate Shoals

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>St. George Island, Alaska</u>					
712-03566	08-01-65	A - U	Tern	09-02-65	A - U
712-06593	08-23-65	A - U	St. George I., Alaska	08-27-65	A - U
			Whale-Skate	08-31-65	A - U
722-10061	07-29-66	A - U	East	08-19-66	A - U
722-10241	08-02-66	A - U	East	08-29-66	A - U
722-11825	08-11-66	A - U	Tern	08-26-66	A - U
722-11945	08-12-66	A - U	East	09-12-66	A - U
722-13226	08-12-66	A - U	East	09-12-66	A - U
722-14149	08-18-66	A - U	Tern	09-14-66*	A - U

Appendix Table 9a. Sooty Tern movement from French Frigate Shoals

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>East Island</u>					
723-62369	06-09-63	A - U	Sand, Johnston	08-05-65	A - U
723-62872	06-10-63	A - U	Sand, Johnston	04-28-64	A - U
863-20004	08-05-65	A - U	Sand, Johnston	06-13-66	A - U
863-21535	08-07-65	A - U	Sand, Johnston	06-25-66	A - U
			East	08-27-66	A - U
			Sand, Johnston	08-16-67	A - U
863-21564	08-07-65	A - U	Sand, Johnston	08-05-66	A - U
863-22294	08-09-65	A - U	Wake	06-19-66	A - U
863-22459	08-09-65	A - U	Sand, Johnston	08-16-66	A - U
863-23219	08-14-65	A - U	Lisianski	06-04-67	A - U

*First seen 09-10-66; last seen 09-16-66

Appendix Table 9a. (continued)

Band No.	Date	Age Sex	Island Recaptured:	Date	Age Sex
<u>East Island</u>					
863-24412	08-23-65	A - U	Midway Atoll	06-22-66	A - U
863-26728	08-25-65	A - U	Laysan	06-10-67	A - U (on nest)
863-26796	08-25-65	A - U	Laysan	06-10-67	A - U (on nest)
			East	06-12-67	A - U
			East	06-11-68	A - U
863-27198	08-26-65	A - U	Sand, Johnston	06-10-66	A - U
923-19802	08-18-66	A - U	Sand, Johnston	06-24-68	A - U
923-20248	08-18-66	A - U	Sand, Johnston	08-12-67	A - U
923-22999	08-21-66	A - U	Sand, Johnston	06-24-67	A - U
923-23562	08-21-66	A - U	Sand, Johnston	06-10-68	A - U
923-26436	08-26-66	A - U	Lisianski	06-04-67	A - U (on egg)

Whale-Skate Island

923-18795	08-16-66	A - U	Sand, Johnston	06-10-68	A - U
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Appendix Table 9b. Sooty Tern movement to French Frigate Shoals

Band No.	Date	Age Sex	Island Recaptured:	Date	Age Sex
<u>Johnston Atoll, Sand Island</u>					
753-11023	07-24-63	A - U	East	08-05-65	A - U
753-16965	08-06-63	A - U	East	08-07-65	A - U
753-21240	08-27-63	A - U	East	05-27-67	A - U
753-21583	08-31-63	A - U	East	08-26-65	A - U
753-21730	09-01-63	A - U	East	08-07-65	A - U

Appendix Table 9b. (continued)

Band No.	Date	Age Sex	Island Recaptured:	Date	Age Sex
<u>Johnston Atoll, Sand Island</u>					
753-21799	09-01-63	A - U	East	08-26-65	A - U
753-21986	09-03-63	A - U	East	08-21-66	A - U (on chick)
753-22677	09-05-63	A - U	East	08-09-65	A - U
753-22908	09-06-63	A - U	Whale-Skate	08-11-65	A - U
753-23115	09-06-63	A - U	East	08-09-65	A - U
753-24159	09-15-63	A - U	Whale-Skate	08-13-65	A - U
			Whale-Skate	06-24-66	A - U (dead)
753-24474	09-17-63	A - U	East	08-23-66	A - U
823-24654	04-26-65	A - U	East	06-10-67	A - U
823-44091	06-22-65	A - U	East	08-26-65	A - U
823-47769	07-13-65	A - U	Whale-Skate	08-11-65	A - U
823-47773	07-13-65	A - U	East	05-30-67	A - U
823-47774	07-13-65	A - U	East	08-26-65	A - U
823-49634	07-15-65	A - U	East	08-21-66	A - U
843-78763	07-18-65	A - U	Whale-Skate	08-11-65	A - U
			Whale-Skate	06-28-66	A - U (dead)
843-79284	07-19-65	A - U	Whale-Skate	08-13-65	A - U
			Whale-Skate	06-25-66	A - U (dead)
843-79924	07-19-65	A - U	Sand, Johnston	07-03-66	A - U
			East	06-10-67	A - U
843-82515	07-22-65	A - U	Whale-Skate	06-25-66	A - U (dead)

Appendix Table 9b. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Johnston Atoll, Sand Island</u>					
843-83376	07-24-65	A - U	Whale-Skate	08-31-65	A - U
843-92242	08-09-65	A - U	Whale-Skate	07-02-66	A - U (dead)
843-92527	08-10-65	A - U	East	08-25-65	A - U
			East	08-21-66	A - U
843-94066	08-12-65	A - U	East	08-20-66	A - U
843-94401	08-13-65	A - U	Sand, Johnston	06-27-66	A - U
			East	06-11-68	A - U
843-98723	08-19-65	A - U	East	06-16-66	A - U
			Sand, Johnston	08-05-66	A - U
853-98025	02-10-66	A - U	Whale-Skate	06-25-66	A - U
933-02718	02-18-66	A - U	East	06-11-66	A - U
933-80511	06-11-66	A - U	Trig	07-03-66	A - U
933-40717	07-05-66	A - U	East	08-23-66	A - U
933-95326	07-30-66	A - U	East	08-23-66	A - U
933-99405	08-14-66	A - U	East	08-23-66	A - U
<u>Laysan Island</u>					
843-65340	07-18-65	A - U	East	06-15-68	A - U
893-09661	08-06-65	A - U	East	05-28-67	A - U
903-33483	06-11-66	A - U	East	08-23-66	A - U
903-64636	06-14-66	A - U	East	05-28-67	A - U
<u>Lisianski Island</u>					
923-58868	09-(01-05)-67				
		A - U	East	06-10-68	A - U

Appendix Table 9b. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Midway Island</u>					
713-70953	08-09-62	N - U*	Whale-Skate	08-16-66	A - U
863-05273	07-21-65	A - U	East	05-30-67	A - U
863-13734	07-25-65	N - U	East	08-23-66	A - U
863-14432	07-25-65	N - U	East	08-20-66	A - U
863-15652	07-25-65	N - U	East	08-23-66	A - U
<u>Oahu, Manana</u>					
923-09462	05-31-66	N - U	East	05-30-67	A - U
<u>Palmyra Island</u>					
753-05409	04-01-64	N - U	East	06-14-68	A - U

Appendix Table 10a. Brown Noddy movement from French Frigate Shoals

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>East Island</u>					
863-20176	08-05-65	A - U	At Sea 20°17'N x 174°49'W	01-02-66	U - U
<u>Trig Island</u>					
923-48963	06-08-67	A - U (Nesting)	Near Cape Lambert, New Guinea, 04°00'S x 15°30'E	10-10-67	U - U
<u>Whale-Skate Island</u>					
723-61862	06-12-63	A - U	Sand, Johnston	04-22-66	A - U
723-61999	06-12-63	A - U	Sand, Johnston	02-13-64	A - U
			Whale-Skate	08-30-65	A - U
723-60758	06-13-63	L - U	Lisianski	08-21-64	A - U
723-63100	06-14-63	A - U	Sand, Johnston	10-21-63	A - U
923-48796	06-06-67	A - U (Nesting)	Sand, Johnston	11-19-68	A - U

*Banded by C.S. Robbins

Appendix Table 10b. Brown Noddy movement to French Frigate Shoals

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Johnston Atoll, Sand Island</u>					
753-30305	11-11-63	A - U	East	05-28-67	A - U (on nest)
753-30349	11-12-63	A - U	East	06-11-66	A - U
753-30396	11-14-63	A - U	Whale-Skate	06-04-67	A - U
753-24852	12-15-63	A - U	Sand, Johnston	01-11-66	A - U
			Whale-Skate	07-02-66	A - U (dead)
753-24943	12-23-63	A - U	East	06-16-66	A - U
753-25509	01-14-64	A - U	Whale-Skate	08-30-65	A - U
853-99578	12-19-66	A - U	East	06-10-67	A - U (on egg)
853-99778	06-15-66	A - U	Whale-Skate	06-25-66	A - U
<u>Necker Island</u>					
793-29149	09-24-65	L - U	Trig	06-08-67	A - U

Appendix Table 11a. Black Noddy movement from French Frigate Shoals

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Whale-Skate Island</u>					
863-23412	08-15-65	A - U	Kure Atoll	07-18-66	A - U
863-23696	08-15-65	A - U	Laysan	03-18-68	A - U
712-01712	08-16-65	A - U	Johnston Atoll	06-17-66	A - U
712-01782	08-16-65	A - U	Laysan	03-17-68	A - U
712-01362	08-29-65	A - U	Laysan	10-22-66	A - U
712-01477	08-29-65	A - U	Laysan	10-20-66	A - U
863-27548	08-29-65	A - U	Laysan	03-18-68	A - U

Appendix Table 11a. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Whale-Skate Island</u>					
863-27576	08-29-65	A - U	Johnston Atoll	06-19-69	A - U
863-28037	08-30-65	A - U	Whale-Skate	06-25-66	A - U
			Johnston Atoll	05-29-67	A - U
863-28097	08-30-65	A - U	Kure Atoll	05-15-66	A - U
863-28352	08-31-65	A - U	Lisianski	10-19-66	A - U
712-58155	06-25-66	A - U	Johnston Atoll	02-17-67	A - U
712-58324	06-26-66	A - U	Laysan	03-18-68	A - U
712-58386	06-26-66	A - U	Pearl and Hermes Reef	05-31-67	A - U
923-19192	08-16-66	A - U	Lisianski	09-03-67	A - U
642-03817	06-05-67	S - U	Kure Atoll	07-07-67	S - U
712-51776	06-20-68	A - U	Johnston Atoll	03-15-69	I(?) - U

Appendix Table 11b. Black Noddy movement to French Frigate Shoals

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Gardner Pinnacles</u>					
723-63208	06-16-63	L - U	Whale-Skate	08-31-65	A - U
<u>Johnston Atoll</u>					
642-01001	08-25-63	A - U	Whale-Skate	08-15-65	A - U
753-25537	02-03-64	I - U	Whale-Skate	06-03-67	A - U
642-01347	04-22-66	A - U	Whale-Skate	06-25-66	A - U
<u>Kure Atoll</u>					
682-47167	07-18-66	A - U	Whale-Skate	06-06-67	A - U

Appendix Table 11b. (continued)

<u>Band No.</u>	<u>Date</u>	<u>Age Sex</u>	<u>Island Recaptured:</u>	<u>Date</u>	<u>Age Sex</u>
<u>Laysan Island</u>					
723-60413	02-12-63	A - U	Trig	06-24-68	A - U
723-60424	02-12-63	A - U	Whale-Skate	08-30-65	A - U
723-60446	02-12-63	A - U	Whale-Skate	08-15-65	A - U
<u>Lisianski Island</u>					
773-40847	03-12-64	N - U	Whale-Skate	08-16-66	A - U
773-40867	03-12-64	N - U	Whale-Skate	08-30-65	A - U
773-40868	03-12-64	N - U	Whale-Skate	08-11-65	A - U
773-40880	03-12-64	N - U	Whale-Skate	06-05-67	A - U
773-40883	03-12-64	N - U	Whale-Skate	08-30-65	A - U
<u>Midway Atoll</u>					
662-05625	02-02-64	A - U	Whale-Skate	08-15-65	A - U
<u>Pearl and Hermes Reef</u>					
632-20082	06-18-63	A - U	Whale-Skate	08-30-65	A - U
632-20751	06-21-63	A - U	Whale-Skate	06-26-66	A - U
652-42283	08-20-64	N - U	Whale-Skate	08-13-65	A - U



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