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CHAPTER 1

SCIENTIFIC STUDIES IN THE COCOS (KEELING) ISLANDS: AN INTRODUCTION

BY

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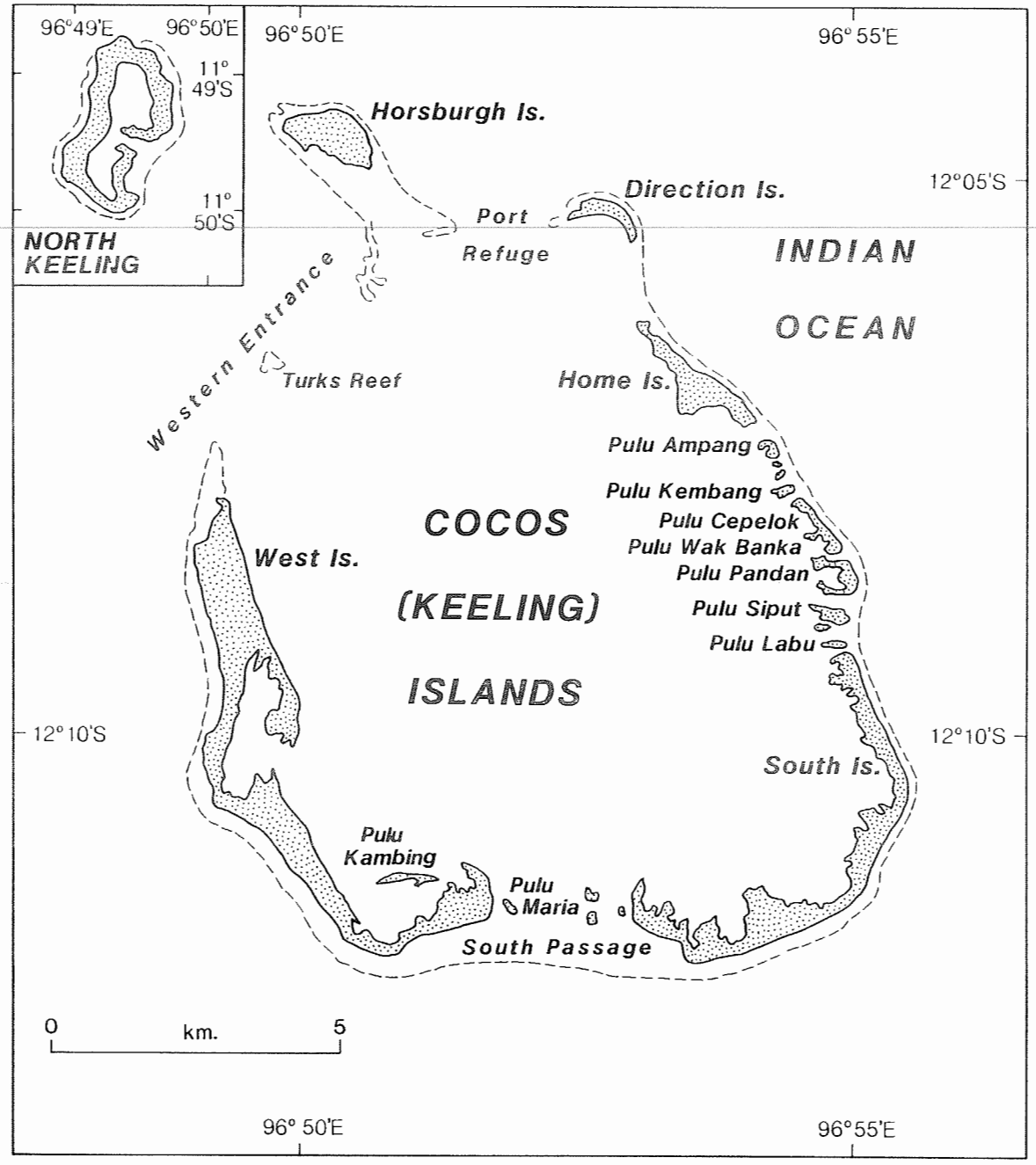
96°49'E
96°50'E
11° 49'S
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NORTH KEELING
96°50'E
96° 55'E
Horsburgh Is.
Direction Is.
12°05'S
Port Refuge
INDIAN OCEAN
Western Entrance
Turks Reef
Home Is.
Pulu Ampang
Pulu Kembang
Pulu Cepelok
Pulu Wak Banka
Pulu Pandan
Pulu Siput
Pulu Labu
COCOS (KEELING) ISLANDS
West Is.
12°10'S
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South Is.
Pulu Kambing
Pulu Maria
South Passage
0
km.
5
96° 50'E
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CHAPTER 1
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INTRODUCTION

The Cocos (Keeling) Islands are a particularly isolated group of islands in the eastern Indian Ocean (Fig. 1). They comprise a southern group, the South Keeling Islands (12° 12' S, 96° 54' E), which form a coral atoll with a shallow lagoon fringed by a series of reef islands. A single horseshoe-shaped island (atollon), North Keeling (11° 50' S, 96° 49' E) is located 26 km to the north of the main group. They lie 900 km west of Christmas Island and 1000 km southwest of Java Head.

DISCOVERY AND SETTLEMENT

The group is named after the coconut (*Cocos nucifera*), which grew there in profusion, even before deliberate planting of all of the southern atoll as a part of the Clunies Ross estate, and Captain William Keeling. Keeling is believed to have been the first European to sight the islands in 1609 on his return from Bantam, on behalf of the East India Company, though there is no record of that sighting. The islands are not shown in the 1606 edition of Ortelius *Theatrum Orbis Terrarum*, but do appear in Blaeu's appendix to the third edition produced about 1631. They are recorded with the name *Cocos Eylanden* in a manuscript map drawn by Hessel Gerritsz in 1622, and on Dudley's *Arcano del Mare* (1646) on which it says that they were discovered by the English. On a Dutch chart produced in Amsterdam in 1659 they are called the Cocos Islands; though around this time they were also called the Triangular Islands. The English hydrographer Thornton used the name Kelling Island in his *Oriental Navigation* of 1703. Captain Ekeberg from Sweden visited North Keeling in 1740. There is an account of the islands in van Keulen's *Zeefakkel,* (6th edition, 1753), with a map attributed to the Dutch navigator, Jan de Marre (1729).

In his sailing directory for this region of the Indian Ocean, compiled in 1805, the British hydrographer, James Horsburgh, called them the Cocos-Keeling Islands, and named one of the islands after himself. After settlement the early inhabitants called them the Borneo Coral Reefs after the supply vessel the *Borneo,* owned by John and Joseph Hare and Co, and captained by John Clunies Ross. They were also known as the Keeling-Cocos Islands, and after 1955 they became officially the Cocos (Keeling) Islands.

Despite knowledge of the islands for 200 years or more, it was not until the early nineteenth century that they were settled and an interest was taken in them because they lay

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on a trade route from Europe to the Far East. The first settlement was accidental, Captain Le Cour and the crew of the brig *Mauritius* lived on Direction Island for several weeks after their ship was wrecked on the reef. Captain Driscoll in the *Lonach* went ashore on 24 November 1825, shortly after the men were rescued, and noted the wreck of the *Mauritius*. Shortly thereafter, on 6 December 1825, Captain John Clunies Ross, a Scottish trader sailing the *Borneo* for Alexander Hare's company, made a brief landing on the islands. During his visit he sounded the main channel, cleared an area on Horsburgh and Direction Islands, and planted cereals and vegetables.

In the following year a settlement was established by Alexander Hare, a somewhat discredited trader and associate of Ross, who brought with him a crew of largely Sumatran and Javanese seamen and an entourage of women of various nationalities, on the *Hippomenes*. John Clunies Ross and his family returned on 16 February 1827 (this is the date given by Ackrill 1984; several other authors state that he returned on 27 November 1827, i.e. Hughes 1950; this error appears to have been perpetuated since an account in Gleanings in Science, Anon 1830; the correct dates are given by Gibson-Hill 1952), with the intention of commencing a settlement on the islands. Ross expressed surprise at finding Hare and a large group of people there, although it would seem that he should have known that Hare might already be there, since he had not found him at Cape Town on the outward journey. Relations between Ross and Hare deteriorated; Hare initially lived on Home Island, though with some occupation of West Island, Direction Island, and Horsburgh Island. Ross initially settled on Pulu Gangsa, just to the north of Home Island (presently joined onto Home Island, and the site of the cemetery); but he soon moved his house down to the central part of South Island. Hare, on the other hand, eventually moved from Home Island, to Prison Island, according to poorly substantiated reports because the women of his party were being molested. It appears that he maintained a party of womenfolk, and most of the children, under close supervision in the lower storey of his house. Rear Admiral Sir Edward Owen noted in a letter of 10 July 1830, that Hare engaged in 'unrestricted intercourse with such females of his establishment as he (might) deem worthy of his attentions' . The history of this time is particularly colourful, although it has also been subject to a lot of misrepresentation (Gibson-Hill 1947, Ackrill 1984). In part this results because the only records that survive reflect Ross' view of the circumstances, and his objectives and those of Hare differed. Ross endeavoured to establish a successful settlement, aspiring to a great trading 'entrepot'. Hare, on the other hand, sought obscurity and his behaviour, according to Ross, became increasingly unbalanced and debauched. Initially both claimed ownership of the islands, but in 1831 Hare finally left the atoll, and he died in Batavia in the following year. The Malay workers, who joined with Ross, are the ancestors of many of the Cocos Malays there today, and the Clunies Ross family, who became known as 'Kings of the Cocos', reigned over the islands for more than 150 years (Hughes 1950).

John Clunies Ross died in 1854. He was succeeded by his son John George Clunies Ross until 1871. After his death in 1871 George Clunies-Ross took possession until 1910. John Sydney Clunies-Ross ruled from 1910 to 1944, and John Cecil Clunies-Ross thereafter. The papers of the Clunies-Ross family contain much useful information on the islands. The early papers of John Clunies Ross are particularly valuable for their description of the islands, although some were lost in a fire.

In 1857 the islands were declared a part of the British Dominions by Captain Fremantle who arrived aboard H.M.S. *Juno,* having misread his directions which instructed that he annex Cocos in the Andaman Islands (Gibson-Hill 1947). Responsibility for supervision of the islands was transferred over the years to the Governments of Ceylon (1878), the Straits Settlements (1886), Singapore (1903) and

Ceylon again (1939-1945). In 1886 Queen Victoria granted all of the islands, under certain provisions, to John George Clunies Ross, in perpetuity. They became a Territory of the Commonwealth of Australia in 1955, and in 1978 Australia purchased all of the lands, excepting the family home, from the Clunies Ross family for Aus$ 6.25 million. In 1984 the Malay population voted to become a part of Australia. Initially the Territory was administered by the Commonwealth government, but it is now being transferred to the responsibility of the state government of Western Australia.

Today the islands are inhabited by the descendants of the original (Malay) settlers, though there have been several additional intakes of workers from various parts of Southeast Asia. There are about 400 Malays living in the kampong on Home Island. The Great House of the Clunies Ross family, Oceania House, is also on Home Island, set amongst 5 ha of grounds. Across the lagoon on West Island more than 200 people, associated with various departments of the Australian Government, live alongside the airfield, which was used as an important refueling stop on commercial air routes between Europe and Australia until the advent of larger aircraft in the 1950s allowed Cocos to be by-passed.

NATURAL HISTORY AND SCIENTIFIC DESCRIPTION OF THE ISLANDS

The Cocos (Keeling) Islands have held a special place in the literature on coral atolls because they represent the only atoll that Charles Darwin visited, and they played a central role in his discussion of his theory of coral reef development. The natural history of the islands was, in fact, uncharacteristically well-known by the turn of the century, because of the visits of a number of naturalists in addition to Darwin. It is interesting to note that rather than confirming Darwin's observations and interpretations of the atoll, many of the works of subsequent naturalists lead them into conflict with Darwin's views, and that Cocos was also subject to interpretations completely contrary to Darwin's. Thus, Guppy (Guppy 1889, 1890a, 1890b) subscribed, at least in part to the views of John Murray, who funded his visit. Wood-Jones put forward an entirely alternative view to Darwin's, in his book *Coral and Atolls* (Wood-Jones 1912). However, the strongest criticism of Darwin came from John Clunies Ross himself, who was absent at the time of Darwin's visit. His review of Darwin's book, published posthumously, was a bitter, vitriolic attack on Darwin's ideas (Ross 1855).

Early accounts of the nature of the islands (Anonymous 1830) include a paper on the formation of the islands by Ross (1836), and descriptions from short visits. Owen's description (1831) appears to be based upon observations by Captain Sandilands who visited in February 1830 in the *Comet* (Owen, 1831), and the account in Holman (1840), is based largely on the accounts of Keating who left the atoll in November 1829 after less than a year there with Hare, and those of Captain Mangles. Van der Jagt (1831) visited and mapped the islands in 1829 in the *Blora*.

H.M.S. Beagle called into the Cocos (Keeling) Islands on its way home, in its third year at sea, arriving off the islands on 1 April, and leaving on 12 April 1836 (Darwin 1842, 1845, Fitzroy, 1839). The visit lasted only ten days, and for much of that time Captain Fitzroy and the crew of the *H.M.S. Beagle* were engaged in survey work; this forming the basis of many of the subsequent charts. A more thorough hydrographic survey was undertaken in June and July 1983 by *RAN Moresby*. Darwin's visit has been analysed in detail by Armstrong (1991).

The islands were subsequently visited by Henry Forbes, who arrived at around 17 January 1879, and left on 9 February 1879. Forbes speculated on the origin of the islands, and devoted two chapters (chapters ii and iii) to Cocos in his book on the Eastern Archipelago (Forbes 1879, 1885).

Henry Brougham Guppy visited the Cocos (Keeling) Islands in 1888, his visit being funded by John Murray. Murray had examined a series of rock specimens collected from Christmas Island (Indian Ocean) by Captain Pelham Aldrich who had been there in *H.M.S. Egeria* in 1887, and had found some that were rich in phosphate. He sent Guppy to visit Christmas Island for a further examination. Guppy needed fine weather for a landing on Christmas Island, and took passage on the Clunies Ross vessels as the only way to get there. The weather was apparently not calm enough within the period that Guppy could stay to get to Christmas, and Guppy spent 10 weeks on Cocos waiting, before returning to Europe without getting to Christmas. Gibson-Hill (1947) suggests, however, that during the 5 months that Guppy endeavoured to get to Christmas, George Clunies-Ross' brother managed to visit the island and establish a settlement of a group of Malays in Flying Fish Cove. As a consequence of that settlement, the Clunies-Rosses began with about half of the shares (with John Murray) of the Christmas Island Phosphate Company when that commenced in the 1890s. Guppy meanwhile undertook an extremely detailed account of the Cocos (Keeling) Islands, with extensive observations on the nature and rate of operation of geological processes (Guppy 1889, 1890a, 1890b).

There were other visits and accounts during this time; W.E. Birch, with Rev E.C. Spicer as naturalist, was on Cocos 20-28 August 1885 (Birch 1866). The lone round-the-world sailor Joshua Slocum arrived on 17 July 1897 in the *Spray*, and considered that 'if there is a paradise on this earth it is the Keeling-Cocos' (Slocum 1899).

Wood-Jones was the medical doctor at the Cable Station on Direction Island, and was on Cocos from June 1905 to September 1906. This afforded him ample opportunity to look around the atoll. He revisited Cocos briefly in 1907 as a guest of George Clunies-Ross, and subsequently married one of his daughters. He wrote a book, *Coral and Atolls,* incorporating his observations. However, the book suffered 'in parts from a considerable carelessness, and an over-optimistic acceptance of unconfirmed visual records' (Gibson-Hill 1947 p.159). His view of the mode of formation of the reef differed both from that of Darwin, and that of Murray which received some modification from Guppy.

The detailed observations of Wood-Jones are surpassed only by those of Gibson-Hill. Gibson-Hill was medical officer on Direction Island from 20 December 1940 until 10 November 1941. He made various collections of organisms, some material of which disappeared from the Raffles Museum during the Japanese occupation of Malaya in the World War II. Nevertheless his fascination with Cocos persisted, and Gibson-Hill published a series of notes on the islands, including both his own observations and collections (Gibson-Hill, 1947, 1948, 1949, 1950a, 1950b, 1950c, 1950d, 1950e, 1950f, 1950g), and his reprinting of earlier literature on the atoll (Gibson-Hill 1953).

Since Gibson-Hill's reviews of Cocos natural history, there have been expeditions by the Academy of Natural Sciences of Philadelphia (1963 and 1974) and the Western Australian Museum (Berry 1989), as well as some visits from individual naturalists (e.g. Alfred 1961). Williams has produced an annotated bibliography of the natural history of the islands, which appears in a recent *Atoll Research Bulletin* (Williams 1990). A summary of major collections on Cocos is given in Table 1.

BIOGEOGRAPHICAL RELATIONSHIPS OF THE COCOS (KEELING) ISLANDS BIOTA

The Cocos (Keeling) Islands are not only extremely isolated, but they also lie at the western extension of the Western Pacific marine biogeographic province. For many species Cocos represents their western limit of distribution. The biota is derived, therefore, primarily from that of the tropical Indo-West Pacific; taxa from the western Indian Ocean are poorly represented. The plants contain a large component of drift-dispersed pantropical species, found throughout the Indian and Pacific Oceans, but the major source is western Java (Guppy 1890a). Similarly, in the case of the marine biota, the most likely source of larval recruitment is also the Indonesian and eastern Indian Ocean region.

For all groups covered of marine biota described in subsequent chapters in this volume, significant additions have been made to existing knowledge of taxa occurring at Cocos (Table 1). Total numbers of taxa in the groups discussed in this volume are summarised in Table 2. The level of collecting now undertaken at Cocos means that the terrestrial ecology is relatively well-known, and in the marine groups is such that significant numbers of additional taxa are unlikely to be added. On this basis several generalised conclusions can be drawn regarding the biogeographical relationships of the Cocos (Keeling) Islands.

There is almost no endemism in the Cocos biota. The Buff-banded Rail, *Rallus philippensis andrewsi,* is considered an endemic subspecies, restricted to North Keeling, and the rat on Direction Island, *Rattus rattus keelingensis,* has been accorded subspecies status, and was considered by Wallace (1902) to be an example of rapid divergence; it can be traced back to the *Mauritius* which was wrecked in 1825. The angelfish *Centropyge joculator* is recorded only from Christmas and the Cocos (Keeling) Islands. The Cocos subspecies of *Pandanus tectorius,* which is only localised in occurrence, is also considered endemic (Williams 1990, this volume).

This lack of endemism may reflect the effect of rapidly oscillating sea levels during the late Quaternary, and the pattern of development of coral atolls, whereby the limestone plateau which was exposed at the last glacial maximum perhaps resembling the modern-day Christmas Island, was rapidly flooded during postglacial sea-level rise and all land was submerged in the early Holocene (10,000-8,000 years ago). The present reef islands appear to be no more than 4000 years old (Woodroffe et al. 1990a, 1990b). This implies that all the terrestrial biota must have recolonised the atoll in the last few thousand years. These sea-level fluctuations would also have had substantial implications for shallow-water marine biota, as the nature of the habitats must have altered drastically over that period also.

Some taxa which might be expected are conspicuously absent from Cocos. Guppy (1890a) has drawn attention to the absence of mangroves and *Nypa* palm, despite the arrival of propagules on the shore (The stand of mangroves on the northern end of Horsburgh Island can be attributed to planting by John George Clunies Ross). Some shallow marine taxa usually common on coral reefs are conspicuously absent in apparently suitable habitat (i.e. there are no benthic skates or rays in the lagoon). Marine taxa must either be pelagic as adults or have long-lived larvae or juveniles to reach Cocos.

Christmas Island is the nearest island to Cocos, and there is less similarity than might at first be expected between the biota found at Cocos and that at Christmas (Table 2). Undoubtedly this results from the contrasting physiography of the two islands.

Christmas Island is an uplifted (and apparently still uplifting) limestone island with outcrops of volcanic rocks on it. It reaches a maximum elevation of 361 m, and has probably been above water since the Eocene. It is covered by dense forest, and has only poorly-developed reef fringing its cliffed coastline. There are not the extensive reef flats or shallow lagoonal sandy or muddy areas which are found on Cocos.

In addition to the very different late Quaternary history, and the great contrast in the time available for establishment of terrestrial biota, the Cocos (Keeling) Islands are probably more subject to periodic catastrophic influences on the biota. The atoll has experienced several devastating tropical cyclones, which tend to have an impact all over the restricted land area of Cocos, as well as in shallow parts of the lagoon and reefs. There have been a series of coral and fish kills in the lagoon. Darwin (1842) noted an extensive area of dead coral in the southeastern corner of the lagoon. He speculated initially that this might have been due to slight emergence of the atoll, but then attributed it to the closure of a series of interisland passages through South Island and more resticted circulation in this part of the lagoon. Forbes recorded that in 1876, inky and foul smelling water had spread through the lagoon from the islands on the eastern rim (Forbes 1885). A similiar fish and coral kill has recurred, most noticeably in 1983, but also in intervening years. Its cause is still unclear. Forbes considered that the 1876 event may have been caused as a result of an earth tremor. The 1983 event was correlated with El Niño in an incisive, but unpublished account of it by Blake and Blake, who attributed it to an 'algal bloom' (red tide). An alternative explanation, considered more likely by members of the Western Australian Museum expedition (Berry 1989), is that it was caused by mass coral spawning at a time of poor circulaton as has been described by Simpson et al. (in press) on the Western Australian coast. It is significant that the mortalities at Cocos and Western Australia both occurred in March and this hypothesis for the cause of mass mortality of corals and other organisms in the Cocos lagoon would be further supported if it could be established that coral spawning occurs there in March. A minor episode of fish kill was also observed in 1992 (J. Tranter, pers. comm.). Infestations of *Acanthaster* have been reported from the reefs (Colin 1977), and are reviewed in more detail by Marsh (this volume).

Present diversity and abundance of reef organisms closely associated with living corals may have been reduced by the reduction of coral abundance and diversity on the reef slopes and in the lagoon as a result of these events. In view of the isolation of Cocos and the distance to be covered by propagules, if species are lost from the atoll as a result of such events, they are likely to be slow to recolonise.

Human impact on the Cocos (Keeling) Islands has been most devastating on the South Keeling Islands (the southern atoll), where the vegetation has been almost totally altered to coconut plantation. The birds which once characterised the atoll have all but disappeared, and it is the absence of large numbers of seabirds, which strikes one as the most conspicuous difference between North Keeling and the southern atoll. There have also been impacts on marine organisms which are eaten, *Tridacna gigas*, *Lambis lambis* (gong gong), *Birgus latro* and the palinurid lobsters, though it is to be hoped that management measures prevent the total elimination of any more of these species. At the same time occupation of the atoll has resulted in an influx of new species to the Cocos (Keeling) Islands. These vary from ornamental and food plants, and deliberate animal introductions, such for instance as the Green Jungle Fowl on West Island. Sheep, cattle, alpacas and black rhinoceroses and other animals have been temporarily contained within the Quarantine Station on West Island. Accidental releases, include the rats and the lone King Parrot on West Island. In addition there are numerous insects which have been introduced, and a large number of insect pests (Gibson-Hill 1950f, Holloway 1982).

STUDIES IN THIS VOLUME

The frequent visits of naturalists, and the detailed studies that they undertook, ensured that the Cocos (Keeling) Islands were perhaps the best-known, and certainly the most hotly debated group of reefs in the world, by the end of the nineteenth century. This continued in the first half of the twentieth century. Since the overviews of Gibson-Hill, however, there has been relatively little extension of knowledge about the islands. The terrestrial ecology of the South Keeling Islands has changed markedly since settlement as large areas have had their natural vegetation replaced by coconut plantation (now sadly largely overgrown), and as birds and other food resources have been exploited.

It is now possible to look in greater detail at the geological history of the atoll, and the marine ecology of its reefs and lagoon as the result of the development of several new techniques. Radiometric dating allows a new insight into the age of formation of coral limestones. Subsurface drilling, seismic profiling and dating allow geomorphological insight into those questions which intrigued the early naturalists to study Cocos. In the case of marine ecology, the development of more sophisticated underwater research methods, and particularly the use of SCUBA, has enabled the extension of collections into water depths that were previously only examinable by dredge, or not at all. It is thus in the areas of geological investigations, and in terms of the numbers of marine species on the atoll that the greatest advances in knowledge have been made in recent years.

This volume brings together a series of recent studies on the Cocos (Keeling) Islands. A preliminary examination of the birds of Cocos was undertaken by T. Stokes of the Australian National Parks and Wildlife Service (ANPWS) and others in 1982. Since that time ANPWS has carried out a number of studies of birds, particularly at North Keeling. Vegetation and marine habitats of the atoll have been mapped by D. Williams, who was seconded as Environmental Resource adviser to the Territory of the Cocos (Keeling) Islands in 1986-7. Mapping was undertaken using SPOT satellite imagery, aerial photographs and ground survey on a habitat data sheet, used by Williams and ANPWS staff.

A field survey of the inshore marine fauna and habitats of the Cocos (Keeling) Islands was undertaken 7-28 February 1989 by the Western Australian Museum under the leadership of P. Berry, sponsored by the Australian National Parks and Wildlife Service. During that fieldtrip a total of 37 stations was occupied (some more than once), in order to sample the major marine habitats (Fig. 2), which had been partly described and mapped by D. Williams. The survey of marine fauna involved SCUBA, snorkelling and reef walking, as well as the use of an ichthyocide and a small hand spear in the case of fishes and the photographing of habitats. Specimens have been lodged in the Western Australian Museum. Accounts of the corals, collected and identified by J.E.N. Veron, and of marine molluscs by F. Wells, echinoderms by L. Marsh, fishes by G. Allen and W. Smith-Vaniz, barnacles by D. Jones, and decapod crustaceans by G. Morgan appear in this volume.

Water Resources represent an important aspect of the present settlement of Cocos, and have been studied over the last 6 years by A. Falkland. He describes the climate of Cocos, and the implications for Water Resources in this volume. Drilling undertaken for the water resources study has also provided data for a geomorphological study of the Cocos (Keeling) Islands by C. Woodroffe and R. McLean. Their geological reassessment of Cocos has involved detailed descriptions of reef islands and subsurface stratigraphy and chronology, as well as other studies. The results of seismic profiling are described by

D.E. Searle, lagoon hydrodynamics by P. Kench and lagoonal sediments by S.G. Smithers.

There are some aspects of the ecology and geomorphology of the Cocos (Keeling) Islands which have not been adequately treated in this volume. There is no account of the insect fauna, for instance, nor have the marine algae been studied in any great detail. It is hoped that the studies which are presented here provide a stimulus for continued scientific study and research on the Cocos (Keeling) Islands.

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Table 1. Summary of collections of flora and fauna from the Cocos (Keeling) Islands

Date	Expedition/ Collectors	Group Collected	Publication
1836	*H.M.S. Beagle*	crustacea	Darwin 1845, Chancellor et al. 1988
		fishes	Jenyns 1842
		plants	Henslow 1838
		shells	Marrat 1879
1854-5	A.J. Anderson and G. Clunies-Ross	fishes	Bleeker 1855
1878	H.O. Forbes	corals	Guppy 1889, Ridley 1884, Ridley and Quelch 1985
		plants	Forbes 1885
1905-6	F. Wood-Jones	brachyurans	Wood-Jones 1909
		corals	Vaughan 1918
		echinoderms	Clark 1912
		plants	Wood-Jones 1912
1940-1	C.A. Gibson-Hill	fishes	Marshall 1950
		brachyurans	Tweedie 1950
		stomatopods	Tweedie 1950
		anomura	Forest 1956
		cephalopods	Rees 1950
		echinoderms	Clark 1950
		molluscs	Abbott 1950
		corals	Wells 1950
		birds	Gibson-Hill 1949, 1950e
1963, 1974	Academy of Natural Sciences of Philadelphia	molluscs	Maes 1967
		fishes	Randall 1975, Smith-Vaniz and Randall 1974
1961	A.E. Alfred	birds	Alfred 1961
1985	I.R. Telford	plants	Flora of Australia
1986/7	D.G. Williams	plants	This volume
		marine algae	
1989	Western Australian Museum	coral	Berry 1989, This volume
		echinoderms	
		fishes	
		molluscs	
		barnacles	
		decapod crustaceans	

Table 2. Number of species recorded at Cocos (Keeling) and Christmas Islands.

GROUP	Cocos Is.	Christmas Is.
Reef-building coral	99	85
Decapod crustaceans	198	204
Molluscs	c 610	c 490
Echinoderms	88	90
Fishes	c 550	568
Native birds	38	88
Plants	130	386

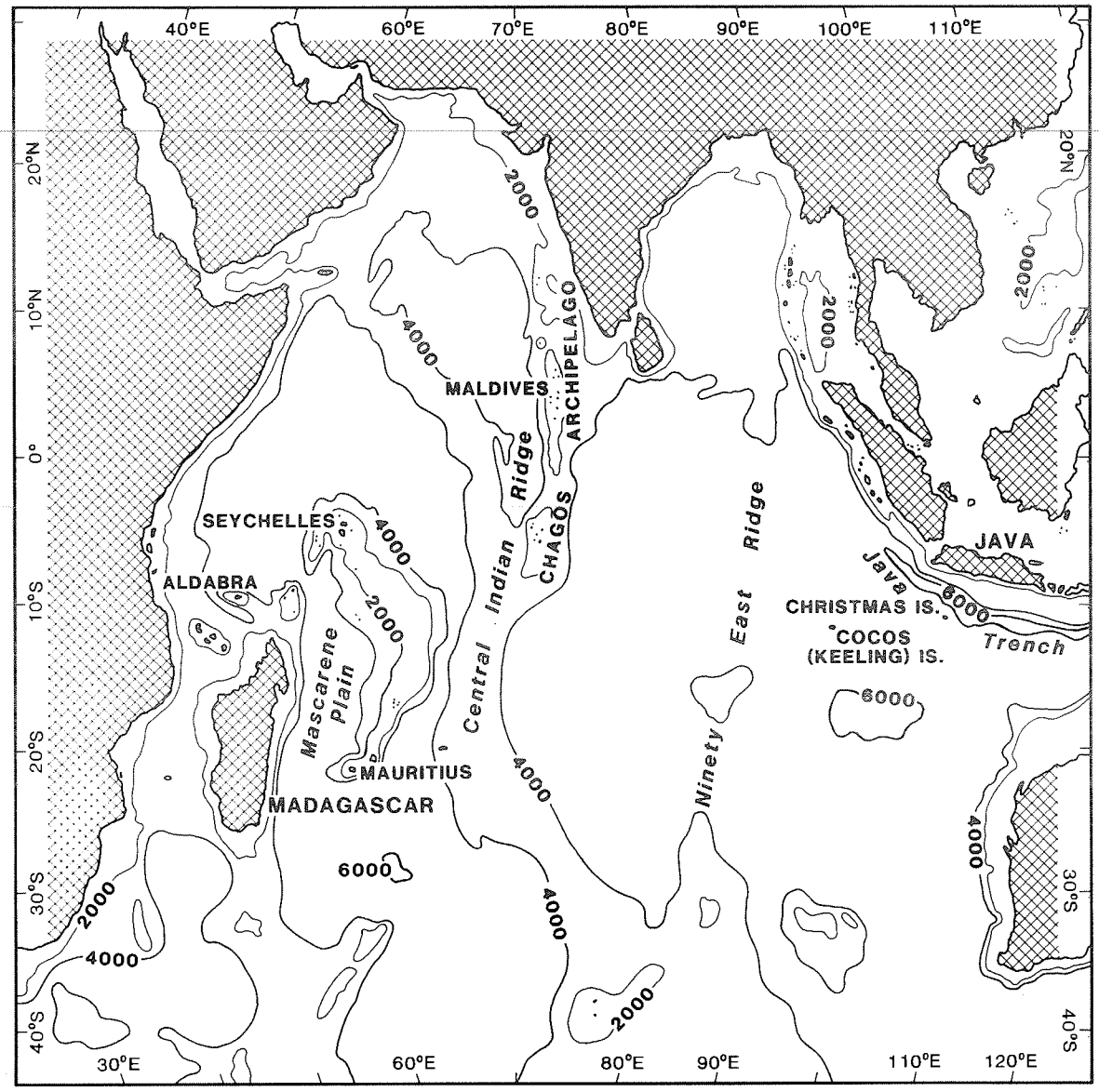

Figure 1. The Indian Ocean, showing the location of the Cocos (Keeling) Islands.

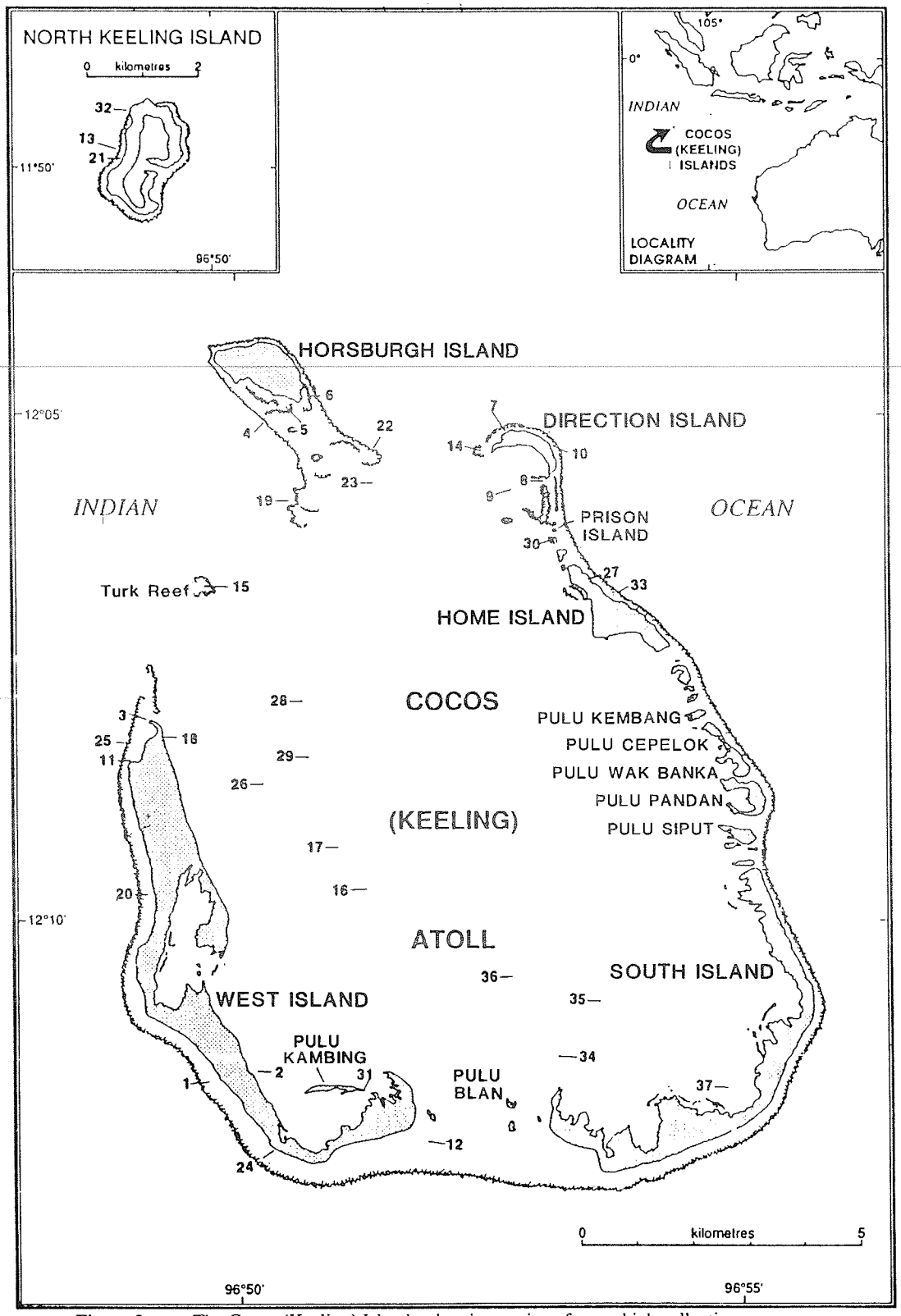

Figure 2. The Cocos (Keeling) Islands, showing stations from which collections were made during the Western Australian Museum expedition in 1989. These stations cover a series of different marine habitats (see Chapter 8, Fig. 1), which can be summarised as: Outer Reef Slope (9 sites: stations 4, 7, 13, 15, 19, 22, 25, 32, and 33), Reef Flat (13 sites: stations 1, 3, 6, 8, 10, 11, 12, 14, 20, 21, 24, 27, and 30) and lagoon (14 sites: stations 2, 9, 16, 17, 18, 23, 26, 28, 29, 31, 34, 35, 36 and 37).